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The Society of University Patent Administrators wishes to express great appreciation to Ms. Jean Rittmueller who wrote the text of this Journal. Readers of the Journal wishing information on any of the presentations can contact Ms. Rittmueller through the Office of Technology Licensing and Industry-Sponsored Research, Harvard Medical School, 221 Longwood Avenue, Room 202, Boston, MA, 02115 (617/732-0920).

The 1986 annual meeting of SUPA, which met February 2-4 at the Stouffer Concourse Hotel in Crystal City, Washington, D.C. had 259 attendees, the largest number ever, and included 35 speakers and more than 50 industry representatives. Conference looked at the complementary "Roles of Universities and Industry in Technology Innovation, Development and Commercialization." University (and corporate) attendees whose job it is to find and develop technology for commercial use found much to interest them in the general sessions, guest speakers, and workshops.

GUEST SPEAKERS

The featured guest speakers, Mr. Jack Schuler and Dr. Bruce Merrifield, provided the economic and philosophical background for the conference.

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In his "University-Industry Partnership: The Marriage of Heaven and Hell," **Mr. Jack W. Schuler**, Executive Vice President, Abbott Laboratories, asked whether the differing philosophies of the university and the corporation will keep them from collaborating successfully. He suggested how the university should choose its corporate partners and ways to nurture the partnership. He emphasized that a relationship must be mutually profitable for both parties.

He listed the articles of a creed that SUPA members and members of industry should share. Close cooperation in commercializing new technology is (1) necessary, proper, and (2) highly productive. He rejected the view that universities would lose their independence by working with the corporate world. Furthermore, (3) the need for cooperation is growing, primarily because of the cutback in federal spending in basic research. Federal cutbacks in basic research are "a big loss" because the "sporadic research breakthroughs" in the university require "long-term unprogrammed research, the kind of thing industry is not interested in, in general." It is easy to get research support from industry for a product, an identified chemical, but hard to get 10-year basic research funding. "Yet that is what the university can do best and where it can make its greatest contribution." Industry currently funds only 4% of university R&D; this may eventually rise to 10%. Industry cannot be expected to replace the government in funding basic research and will continue to concentrate the bulk of it R&D spending in its own facilities, but universities can support their research via royalty income from successfully commercialized products of academic research.

Schuler indicated that the university-industry relationship can be filled with "tension, mistrust, red tape, and, sometimes, agony." He asked whether corporations and universities are so different that cooperation sometimes appears to be impossible? He referred to the William Blake poem "The Marriage of Heaven and Hell," which makes the points that (1) "something has meaning only in terms of its opposite," and (2) "without contraries, there is no progression," (3) and "innovation, greatness, existence itself is achieved only by fusing opposites together through a bond that causes neither to lose its individual identity, but that creates instead a new and more

powerful whole." He asked the audience to determine whether the attraction and repulsion between the two institutions can work together "to create the promise of something new, something that enriches the distinctly individual characteristics of each."

Industry and university differ in three ways: profit vs non-profit, secrecy vs publicity, product development vs basis research. Their differing modes of operation reflect the corporate purpose of protecting its profitability and the university mission of education and expanding human knowledge for its own sake. Yet, each institution has things that can benefit the other: from the university, new knowledge that can meet a need in the market; from the corporation, profits that can be invested in more research. "Many great things can come from a blending of opposites. We should not be afraid to mix heaven and hell."

A number of characteristics and attitudes--and hard work on both sides--spells the difference between a mutually profitable relationship and a failed one. A university should look for the following traits in a corporate partner:

(1) A company willing to enter into a long-term relationship. At the University of Utah, for example, Abbott is the principle sponsor of a unit where clinical trials are performed on new products. Utah may contract with other organizations when an Abbott project is not fully occupying the unit. Abbott is able to perform clinical trials faster and at a lower cost while Utah gains revenue and a valuable teaching facility.

(2) Flexibility regarding the type of agreement appropriate to a given technology. No two of Abbott's 150+ contracts for diagnostic R&D are alike. They include arrangements for consultants, adjunct facilities, clinical test sites, simple contracts to commercialize, and sometimes a direct relationship with both the researcher and institution.

(3) A company that is technology driven. Look for solid year-to-year increases in R&D spending and for a high percentage of revenues and profits on products less than 5 years old. A short product life cycle is a result of continuing innovation.

(4) A historical commitment to technology and a record of commercializing ideas from outside.

(5) A record of innovation in diverse areas. Ideally, it should include high levels of basic and applied research.

(6) The ability to move quickly.

(7) Fully-developed business support functions. Essential support services, such as marketing, distribution, customer service, cannot be built overnight. A few dozen people cannot do the job in today's global marketplace.

(8) The human and financial resources to do your technology justice.

(9) Success at innovating. Some organizations are better at innovating than others. One cannot, should not, and need not manage innovation in the workplace. If left alone, innovation will "reach its full beauty and will fertilize the environment with new growth and creativity." The university has such a remarkable record of

scientific breakthroughs because, even though it has "a lot of red tape and bureaucracy," its "science component" has the least amount.

An organization desiring innovation must recognize, identify with, and embrace its essential characteristics. "The organization that tries to capture and explain innovation will quickly destroy it. Typically, those that rise to the top of an organization quickly in the western world are men of action. For every action, they want a reaction. As members of an occidental culture, we feel that we can do something specific and create something innovative as a result. But we cannot create it. To truly understand the nature of innovation, we must understand that our objective is simply to stop destroying it."

Many corporate leaders want no surprises. "But innovation by its very nature is a surprise." The organizations that recognize and look for surprises to happen and capitalize and adjust the organization to these windfalls are the ones that have the best record for innovation. Large corporate entities world-wide have the worst record on this criteria, and small companies have the best.

More and more corporations are dropping rigid structural bonds that have prevented true innovation. If your corporate partner plans to develop your technology through a small business unit or venture group, you may find it easier to work with this group, get to market faster, and have a higher chance of success.

30-40% of Abbott's new product development ventures are start-up ventures. Abbott enables them to operate independently by providing money, time, and off-site rented facilities space away from the bureaucracy. The team leader, usually a scientist, is head marketer, salesman, strategist, and manufacturer in getting the product to market. The start-ups are not required to to use Abbott resources (the sales force, quality control, purchasing) although 70% of the time they do. Abbott has never co-ventured with a non-profit partner in supporting a start-up venture. Although more than 1/2 of its new products have a university component, it has never split the profits, other than royalty income.

The university has two basic responsibilities to its industry partner. It should tell its likes and dislikes, and it must protect discoveries through early patent applications. Moreover, the eventual cost of development justifies filing foreign patents in the top 6 or 7 countries. The public domain offers no competitive advantages to a corporation, which needs patent protection to justify its multi-million dollar decision to bring a new product to market. Patents are important to pharmaceutical companies, for a unique compound can be clearly defined. The biotechnology industry may be different. A patent on a compound with a 1-amino-acid difference buys time rather than keeping other companies out of the market. A patent may give a 5-10 year lead over a competitor.

Schuler concluded that the university-industry partnership can "create something both powerful and beautiful." It can both "strengthen the fabric of our civilization and help preserve the American tradition of basic research in the universities."

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In describing the world economy as being "in the most incredible period of rate of change" in human history, Dr. Bruce Merrifield, Assistant Secretary for Productivity, Technology and Innovation, U.S. Dept. of Commerce, identified the four forces of change that would continually restructure the present and future U.S. and world economies: taxes and inflation, the technology explosion, the targeted industry strategy, and the petrochemical shift.

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TAXES and INFLATION comprise the first great force of change in the U.S. In the last decade the adverse synergism between former tax laws and inflation eroded the assets of 80% of the companies making up the Dow-Jones Averages.

The Kondratiev Long Wave, developed in the early 1920s by the Russian economist, Kondratiev, plots the past, present, and future of capitalist economies. It is a controversial, somewhat inaccurate, and inadequately documented theory, but it is not a bad representation for much of smokestack America. MIT professor Jay Forrester has identified the four phases of the Kondratiev Long Wave, with its 54-year cycle of buildup and collapse, going back 2 centuries. The U.S. is thought to be in the last cycle because of the demise of the 50-year product life cycle. Furthermore, the U.S. will not experience the destructive end of this cycle.

PHASE 1: A 15-year period of collapse (1929-44) where obsolescent facilities and overcapacity are written down or taken into Chapter 11. For example, between 1929 and 1932 the GNP dropped about 30%, and unemployment was at 25%.

PHASE 2: By the end of Phase 1 a tremendous excess demand over supply in the capital sector fuels a massive reinvestment period. Whatever is state-of-the-art at the beginning of that period fuels the entire cycle. New technology for a given industry is rejected since the current technology is producing tremendous increases in productivity and profits. The classic example is the steel industry, in which U.S. companies made huge profits by investing in new facilities and economies of scale based on the then state-of-the-art open-hearth furnace. In 1950 the Austrians developed the more efficient, basic oxygen furnace, which was installed in Japan and Germany. By the end of this period (1965) there was a world balance in supply and demand for steel.

PHASE 3: Steel capacity is overbuilt 25-30% worldwide. The U.S. steel industry, operating at 75-80% (85-90% is the break-even point), is eroding its assets in real terms, a fact disguised by incipient inflation. Overcapacity leads to a decline in productivity and a start-up of inflation. The materials industry is increasingly served by engineering plastics and specialty compounds, which are beginning to take markets away from older materials (steel, aluminum, wood).

PHASE 4: This is one of economic turbulence in which the recession cycle deepens and the next collapse occurs. The steel industry has 50% overcapacity worldwide. Underdeveloped countries have added to their steel capacity and are subsidizing it to hold jobs and price the product below its true cost. The U.S. can now

import steel from Brazil for $30 per ton less than it can make it. Overcapacity in machine tools, aluminum, timber, commodity petrochemicals forces write-downs of excess facilities.

Because 1983 was the final year of the Kondratiev cycle, the U.S. should be in a terrible depression. U.S. companies are currently writing down a massive collection of obsolescent facilities. The GNP should be dropping, but instead it is going up. Why? The same process that rejected new technology also built a pool of underutilized technology that is already fueling the next cycle: electronics, communications, engineering plastics, specialty chemicals, genetics, aerospace, pharmaceuticals. These rapidly growing, high-asset-turnover, low-capital-intensive businesses are offsetting the decline of older industries. Therefore, the U.S. has two economies: one going down; the other going up. About 75% of U.S. capital is in the down-economy; about 25% is in the up-economy, but the second is already offsetting the first. As U.S. companies complete writing down the older industries or turn them around with automation, this country is experiencing its most explosive growth period ever.

Most people do not yet understand the "new" economy. In 1983 it created 600,000 new U.S. companies, against about 40,000 that failed; in 1984 about 634,000 against about 15,000 that failed; in 1985 684,000 new companies were formed. Though new jobs are being created at a tremendous rate, a skill shortage exists. In the last 3 years 15 million new jobs were created, 4 million of which remain unfilled. The job force has grown from 99 to 109 million, and about 1 million people have been recycled. After dropping from about 11% to 7%, unemployment has been static for 1 1/2 years. 4% is structural unemployment (people not looking for jobs), 1-2% is float (the average unemployment period is 6 to 10 weeks), and 1-2% is the truly unemployed in declining industrial areas where people are looking for work that doesn't exist. Yet, people are being imported into other economically expanding areas of the country, particularly New England. To generate jobs in new businesses in declining industrial areas, the federal government is establishing incubation centers, getting the technology out of the federal labs into the private sector.

The mismatch between skills and available jobs is a critical problem for the economy. Lifelong continuing reskilling must be a national priority. Since any set of skills can be obsolete in 5-10 years, we must continually learn new skills. Videodisk computer interactive educational systems can address this need; they also have the potential of eliminating entrenched inner-city poverty by revolutionizing the K-12 curriculum.

Merrifield emphasized the strength of the current. U.S. economy. He amplified this by explaining how the money supply controls the economy. GNP rises a year after the money supply increases. Traditionally, inflation rises a year later. The GNP always seems to peak at presidential election time. But, since the 1981 Economic Recovery Tax Act took effect, inflation for the first time is uncoupled from the other two and is decreasing, primarily because of a number of factors, one of which is largely unmeasured--the unprecedented increases in productivity achieved through automation.

The economy is still cycling independently of inflation, and about 1 year ago the money supply was released, so the GNP is about to rise, with a possible 1986 growth rate well above 5% GNP; this, in turn, will make a $35-50M difference in the federal deficit.

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The TECHNOLOGY EXPLOSION is the second great force of change. 90% of all scientific knowledge (and scientists and engineers) has been generated in the last 30 years and will double again by 2000. The U.S. with about 5% of the world's population in 1975 was generating about 75% of the world's technology. Its share has dropped to about 50% and will drop to 33% in 1995, not because the U.S. is generating less--it is generating more--but because the rest of the world also views technology as the essential ingredient for expanding the economy and improving quality of life. Superimposed on this explosion of knowledge is the unexpected interaction between disciplines that produces the surprise factor, interventions not anticipated in the original work.

Collapsing product life cycles of 3-5 years in electronics and 5-10 years in most other areas are also going to change our lives. Countries will have to structure their economies to manage change; management, by definition, will be the management of continuous change. The U.S., for example, must remove internal anti-trust barriers and provide incentives for innovation, its management, and its commercialization.

The innovation process involves the basic research on an initial idea, early-phase development of the idea, and the commercialization phase. Commercializing an idea is a high-risk, long-term process, taking an average of 7 to 10 years, and only 1 in 20 laboratory ideas ever makes a profit. The federal government provides about $13 billion per annum to its universities and government laboratories to expand the basic pool of knowledge, ten times more than any other country, but it does not mobilize this knowledge effectively for public use.

Translating an idea into a product consumes 90% of the total cost, risk, and time of development. Private-sector collaborative efforts that pool resources and share the risk are the only way to fund the innovation process in its early phase before second-and third-round venture capital financing begins. Unfortunately, although the 1981 Economic Recovery Tax Act incentives created $20 billion in venture capital and $25 billion in initial public stock offerings by cutting capital gains from 50% to 25%, this venture capital was used primarily for second-and third-round financing and other capital investments. Few incentives for the commercialization of university ideas in their early phase existed until the creation of the the R&D Limited Partnership (RDLP). OMB sees this as the most effective device available for stimulating innovation. DOE, for example, now leverages its grant money, using the RDLP model, a practice that will probably be extended to other federal laboratories. (With regard to the 28,000 government-owned patents, only 4% of which have ever been licensed, Merrifield has been instrumental in allowing inventions to be exclusively licensed to the private sector for development.)

The RDLP is based on a 1954 tax law that allows investors to fund research in the early phase, pre-prototype stage--2 to 3 years from commercialization--and take it as a tax deduction. This area had virtually no funding, but since late 1982 $3 billion in RDLPs have been formed. The financial houses have raised blind pools of $25-$100 million to invest in RDLP portfolios, greatly reducing investor risk. (If Congress would allow the 25% R&D incremental tax credit for RDLPs, this would raise the tax deduction to 75% and undoubtedly increase the amount of high-risk money going into them.) Royalties are ultimately treated at a capital gains tax of 20% instead of 50%. The university, in establishing RDLPs for its technology, can receiving private-sector money to fund its basic research, faculty salaries, and equipment.

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The third great force of change is the TARGETED INDUSTRY STRATEGY (TIS), so effectively modeled in the Japanese National Strategy. It has had a major impact on significant segments of the U.S. industrial base. The Boston Consulting Group developed this strategic planning device in the late 1960s. It plots the log of a product's cost against the log of cumulative volume. The cost goes down 15-20% whenever volume doubles. Theoretically, economies of scale would increase volume and lower prices below every other company's cost. Even a late entrant could forward price, take over the market, drive competitors out of business, and then raise its price to just below the entry point of any new competitor.

This strategy does not work for individual corporations even if the U.S. anti-trust laws would allow it. (In 1970 Merrifield's company decided to use this strategy to take over the polyvinylchloride business but abandoned the idea after projecting a cost of $7 billion in negative cash flow.) But Prime Minister Nakasone, head of MITI in the late 1960s, understood that a nation could develop a TIS even though a company could not. Japan was BCG's first big customer, targeting steel, consumer electronics, and motorcycles.

TIS involves seven steps:

(1) Concentrate the business for the targeted industry among the large corporations and eliminate the smaller companies in the home market.

(2) Parcel out R&D among the remaining few players to eliminate redundancy and use manufacturing technology that focuses on robotics and economies of scale.

(3) Leverage the results 80-90% with 4% or 5% capital.

(4) Close off imports into the home market.

(5) Use two-tier-pricing. Put all costs into the captive home market, but price products 15-20% less for the export market.

(6) Manipulate the exchange rate, undervaluing the native currency vis-a-vis other world currencies.

(7) Subsidize exports to make a product available at below the export market's manufacturing cost.

Japanese companies are selling the 64K and 256K memory chip far below the U.S. companies' cost. No individual U.S. company can compete with a nation that targets an entire industry and takes

advantage of 100-year-old anti-trust-laws, designed for a slow-moving domestic economy, that prevent companies from collaborating and are anti-competitive in the global economy. Since the anti-trust laws were changed in the National Cooperative R&D Act of 1984, about 40 U.S. industrial consortia have registered with the Justice Department. Currently, the Commerce Dept. is trying to change the Clayton Act, Section 7, and the Sherman Act, Sections 1 and 2, which inhibit pro-competitive mergers but may also inhibit development of flexible automated shared-manufacturing facilities.

Countries using TIS may be in more trouble than is realized because of two fallacies of TIS:

(1) The assumption that the product life-cycle will be long enough for a business to recover investment costs. This may not happen when a product life-cycle decreases to 3-5 years. The Japanese will never recoup their memory chip investment because of the development in the U.S. of the ballistic transistor and the 4 MB chip.

(2) The assumption that only one nation will target a given industry. When a number of nations target an industry, overbuild capacity, and subsidize it to retain jobs, they destroy the entire industry. Consequently, the Japanese, with the best steel technology in the world, are operating at 65% capacity and losing money on every ton. They are operating at 45% capacity in aluminum, 50% in commodity petrochemicals, less in shipbuilding, and textiles. Their debt is 70% of GNP and will go over 100% in the next few years as they write down excess facilities that will never pay off.

TIS is a destructive zero-sum game. The U.S. must take the lead in persuading nations to abandon TIS in favor of joint development of new technology that expands the global economy rather than destroys existing industries.

Dr. Merrifield stressed the benefits of automation for corporate productivity and credited the investment tax credit and rapid depreciation schedule with enabling U.S. corporations to upgrade factory automation and hence volume. (Of the variables involved in manufacturing productivity--energy, labor, price, material cost, volume--, only material cost and volume are controllable, with volume being the most critical.) The consequent $50-$80 billion per annum investment in automation since 1983 by U.S. corporations has created unprecedented increases in productivity. A U.S. tire company, for example, was able to automate only because of the credits and depreciation schedule. Productivity on its newly automated line improved by 1000%, and unit cost dropped by 30%. Labor dropped from 23% to 3% of tire cost. The company is now profitable, has paid off its long-term capital debt, and is expanding another operation.

Dr. Merrifield predicted that within a decade very few manufacturing operations will survive global competition that are not flexible automated computer-integrated systems. The plant of the future will make 500-1000 different products for different companies in different industries, will be less than 5% of the manufacturing cost, will be reprogrammable to make new products or modify old, and will have sister plants around the world that can be satellite-programmed to make the same thing.

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The fourth great force of change is the PETROCHEMICAL SHIFT. The U.S. cannot prevent underdeveloped countries from using their cheap natural resources and labor to capture major segments of world markets. Even advanced technology will not compensate for cheap natural resources although any labor-intensive industry could be recaptured through flexible automated manufacture. The U.S. will lose its entire $80 billion commodity petrochemical industry in the next few years because the natural gas and naphtha feed stocks consume 50-80% of the cost of manufacture. It cannot compete with underdeveloped countries, which once flared 90% of their gas because they could neither use it or pipe it, but are now making commodity petrochemicals at zero cost and are also willing to subsidize the industry. Any labor-intensive industry and much of the primary reduction of metal will also go offshore.

The U.S. must respond by eliminating counter-productive regulatory barriers to innovation and productivity, by changing product liability laws, by reducing the cost of capital, and by providing more incentives for innovation. If the U.S. is to maintain its scientific expertise and productivity, collaborative corporate efforts to pool resources and close the gap in the innovation process are also important, as are the computer-aided educational systems for reskilling the work force.

In answer to a question about how the U.S. can overcome foreign cultural barriers and compete successfully in world markets, Merrifield explained that he is arranging industrial R&D arrangements between the U.S. and about 35 other countries. The pilot model, started five years ago with Israel, saw 71 of 78 projects succeed. The number of jobs in Israel increased, and the U.S. made $100M in foreign exchange. A catalytic office is set up in each country that matches a U.S. company with a local one to jointly develop new technology. An RDLP or funding through AID or the World Bank provides the seed funding. His department hopes to create an array of small businesses that will create local jobs and also open foreign markets to U.S. companies. This modern Marshall plan helps these countries develop their infrastructure and raise their quality of life, and also helps us.

Merrifield closed on an upbeat note in listing this country's resources to compete in the global market. The U.S. has advantages over the rest of the world in its vast pool of knowledge, in the depth and breadth of its technical and industrial infrastructure, in the entrepreneurial culture that gives permission to fail and try many times until success, in its flexible capital development capability, in having access to the world's largest market with a common language.

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GENERAL SESSION

The General Session provided an overview of the differences and similarities between university and corporation research and innovation. Four speakers, two from the chemical and pharmaceutical industries (Drs. Peter Boer and Julius Vida) and two from universities (Dr. Joseph Ballantyne and Mr. George Dummer) described their organization's reasons for conducting research; how research operations are organized and managed; the cost of conducting research; the differences between basic and applied research; how and why innovative ideas surface and are protected; how research differs from product development; how success or failure of research efforts is evaluated and/or acted upon; and, finally, how and why research and innovation in their organization differ from counterparts in academia or industry.

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Dr. Peter Boer, President, Research Division, W.R. Grace & Co. described his company's two-fold mission. Grace looks for new business and investment opportunities in areas where its present divisions lack the commercial skills or facilities. It does more than 50% of its own new-product research. Another 45% are products consistent with its existing businesses. It resists pressure to do basic research (5%) and support work (less than 5%).

Grace spends $90M/annum for R&D: 1/3 at its research division site in Columbia MD, and most of the rest in its Industrial Chemicals Group. Its cumulative rate of increase in funding research over the last five years has been a generous 25%, with a projected 11-12% rate of growth slightly above Grace's five-year projected earnings rate.

The Industrial Chemicals Group (with a very profitable 20+% return on investment on annual sales of $2.5B, and gross margins in the 45-50% range) does R&D in eleven areas: hydro-treating catalysts to clean up heavy oils; optical storage media; fermentation for the biotechnology industry; composite materials; new materials for construction, such as cement technology; technical ceramics; medical devices, such as the artificial implantable pancreas; gas separation membranes to purify natural gas; photopolymers; water treatment chemicals; adhesives, sealants, coatings, ranging from heavy-duty industrial adhesives and coating for auto industry and smokestack industry to conductive adhesives in the semi-conductor industry.

Universities do 75% of Grace's contract research (c. 50 contracts with c. 25 universities). 70-80% of that is done to invent new concepts, which Grace develops internally. With the rest Grace obtains specialized services in which it is not prepared to invest, e.g., animal testing or pre-clinical hospital studies. Grace raised its level of contract research when it entered the biotechnology area ($500,000 before 1983, $5-6M range 1983-84). Although 24% of its total research budget at its peak, the rate of growth of contract research will drop to 15% by 1989.

Boer stressed the corporation's need for an exclusive license over the life of a patent (17 years) as an important element of a successful relationship. He used a spreadsheet analysis to show why it is more beneficial to both parties when the university grants an exclusive license for the life of the patent than when the university grants an exclusive license for 10 years after which it has the right to convert that to a non-exclusive license. He made five assumptions typical of the specialty chemical industry:

(1) 5 years of R&D prior to initial product sales, using up 5 years of the patent life (in practice, 12 years is a more reasonable assumption);

(2) A fixed-capital investment to annual sales of about 70% (100% means trouble; below 70% means an attractive business that will attract competition);

(3) A royalty of 3% of net sales during exclusivity; 1% royalty, preferably less, during non-exclusivity;

(4) Gross margins of 50% during exclusivity and of 40% during non-exclusivity;

(5) 100% market penetration in 4 years, with 8% annual rate-of-growth during exclusivity; 50% market share during non-exclusivity.

Boer's analysis showed that during years 5-10 of the exclusive license the product would have a 20+% return-on-investment in the 7th year of exclusivity and would be very attractive in the 12th year. Cumulative cash flow would not turn positive until the ninth year of exclusivity. He then sketched the product performance during the period of the non-exclusive license (years 11-17): a royalty of 1% on 50% market share and 40% gross margins; cumulative cash flow that looks better than it should because investing in new capacity stops; 6% return-on-investment with loss of exclusivity, down from 20%.

Competition may increase the size of the market about 20-25%, but that effect wears off. A competitor coming in after 10 years and paying 1% royalty is taking no risks because the market is established. He need only build a plant. Many companies accept an average return (5%, 10%, 15%). The initial licensees' advantage is that it has some depreciated plant, but the competitor may have a technical advantage because research has been done for a long time, and it can build a plant based on the latest technology.

In summary, since the product developed under the 17-year exclusive license has a projected 19.3% total return, Grace would probably decide to develop it. The product developed under the exclusive/non-exclusive license arrangement has an unacceptable 13.6% return, and Grace would not consider developing the product under these terms. Boer showed that the Net Present Value to the university is higher for the exclusive license even when income from all non-exclusive licensees is added in. Net Present Value shows that 3% gives the investor taking the risk a little over 50% of the "total reward" and the university a little under 50%. If the royalty rate is 2%, the investor would get c. 70% and the university 30%. A 5% royalty would mean a drop below 50% at a certain level for the investor. Grace uses this type of analysis to consider whether a royalty rate is fair.

Different businesses have different royalty rates. An 8-9% royalty may be reasonable in the genetic engineering business, but for the specialty chemicals business with its 50% gross margin products even 3% is high. Medical devices have a higher margin; commodity petrochemicals have a lower margin. Grace tries to maintain a reasonable division of the rewards to the investor taking the financial risk vs the scientist who had the idea.

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Dr. Julius A. Vida, Vice President, Licensing, Bristol-Myers Co., described the pharmaceutical industry's mission, research, products, and relationship with universities.

The primary purpose of pharmaceutical R&D is to help in the prevention, diagnosis, and treatment of diseases, and general improvement in health. Companies believe new products and therapies resulting from the R&D investment will produce profits and defend the company's position in the changing scientific and economic environment.

The pharmaceutical industry is particularly subject to market forces. "It is always possible that some other firm will come up with a new product which is so superior that demand for other firms' competing products will decrease.... Companies that do not devote adequate resources to developing new products or modifying existing products to improve their performance or expand their range of applications will be squeezed out of the market, will suffer a reduction in profits" and possible bankruptcy.

Three examples of 1985 research investment as a percent of sales are Merck Sharpe Dohme with a ratio of 19.55%; Pfizer with 15.72%, Lilly with 24.04%. Similar investment by other companies has resulted in current development of 4000 products by 550 companies. Ciba-Geigy has 95 products under development, 73 from within and 22 licensed in, followed by Merck, Hoechst, Bristol- Myers, Hoffmann-LaRoche, SKF, J&J, and American Home Products. The UK's Wellcome and Japan's Takeda have replaced Pfizer and Lilly.

Research is traditionally organized into the various disciplines. Regardless of the approach to the drug discovery process, new chemical entities are synthesized or isolated "under the direction of the director of medicine and chemistry in all therapeutic areas. Usually, group leaders are designated for the various therapeutic areas." Pharmacologists, working under the director of pharmacology, screen them, and the director of molecular biology and biochemistry investigates their biological mechanism of action. "Selected compounds with therapeutic application potential are formulated under the direction of the director of pharmaceutical product development and submitted for toxicological studies. In parallel, selected compounds are then investigated in Phase I clinical studies in volunteers for safety and tolerance, followed by Phase II clinical studies in patients, the purpose of which is to determine the dose and to establish efficacy." Full scale clinical investigations are carried out in Phase III "in hundreds, sometimes thousands of patients to investigate the drug under conditions that

best approximate the environment in which the drugs will be used. These clinical studies are usually carried out under the direction of the director of clinical pharmacology and are most often monitored by clinical monitors under the direction of a medical affairs director. Lastly, the various regulatory aspects are taken care of by the director of regulatory affairs."

"The advantage of such organization is the grouping of researchers of the same disciplines into units" within which cross-fertilization within one discipline is at the maximum. The disadvantages are that the organization is too massive, and cross-fertilization between the various disciplines, such as chemistry and pharmacology or chemistry and biology, is at a minimum." Furthermore, responsibilities may not be clearly defined.

Bristol Myers had a traditional organization of 4 separate R&D units, each reporting to divisional R&D directors, until in 1982 the company decided to centralize R&D in one facility now being completed in Wallingford, CT. A single R&D director oversees the separate therapeutic area subgroups, the medical affairs unit, research support unit, and research administration unit. Bristol-Myers does R&D in six areas: anti-infectives, anti-cancer, cardiovascular, CNS, G-I and metabolic diseases, and dermatology. Its licensed-in technology represents a substantial percent of the total ongoing research projects. Of a total of 86 projects, 26 are licensed in, about 13 from universities.

The therapeutic area is responsible for the discovery (basic research) and development of new compounds "through pre-clinical and clinical studies to the point of submission and approval of health registration dossiers." Each therapeutic area has two directors. The pre-clinical director is responsible for the basic discovery process; the chemists, pharmacologists, biologists, molecular biologists, and biochemists report to him. The director of clinical research has the director of clinical pharmacology reporting to him. The advantages of this organization are: (1) improved productivity and efficiency in research, (2) concentration of basic researchers within therapeutic areas and better cross-fertilization, (3) single funding for each area, (4) centralized authority and responsibility assuring rapid development, (5) a clear chain of command and responsibility, (6) defining the responsibility of each area to assure world-wide development of drugs.

What are the differences between university and drug industry research? Size is one factor. A university department usually has between 20-50 researchers while a company usually has 600-800. More important is the difference in structure. Typically, a drug company has a "vertical structure," and a university has a "horizontal structure," one that "seldom produces a drug." In the horizontal structure, each department is independent, is concerned with its particular research specialty, and sees no need to integrate. The company, however, has a need to integrate each department's research since the company is goal oriented.

University "discovery research for new drugs is centered on investigating new biological mechanisms." Investigation of new chemical entities is secondary, and a therapeutic target is generally

not a goal. Furthermore, the university scientist "is drawn to physiology because publishable results are obtained more quickly ... thereby enhancing his or her personal image in the scientific community." On the other hand, company "discovery research for new drugs deals simultaneously with the pharmacological action of new chemical entities and the biological mechanisms that they affect."

University research plays a significant role in drug research "since many drugs' mechanism of action and discoveries are made at universities." On the other hand, it would be "highly unproductive" for industrial research to concentrate only on biological mechanism of action studies. New chemical entities, identified as a result of studies of these mechanisms of action, "must be synthesized with the objective that the new chemical entities will affect the biological mechanism of action."

Although "most companies approach new drug research from various angles" and "may not restrict their activities to one method," the companies listed below "have been known to apply the methods indicated to drug research":

(1) Synthesis of new chemical entities based on mechanism of action: Synthelabo (France), Roche, Squibb, SKF.

(2) Synthesis of new chemical entities that undergo broad screening; elucidation of the mechanism of action of any active entities: Janssen, Ciba-Geigy, Bayer, Knoll-BASF, Rhone-Poulenc, Hoechst.

(3) Isolation of natural compounds from microbial sources and screening for biological activities: Lilly, Merck, Bristol-Myers, Schering-Plough, Farmitalia Carlo Erba (Milan).

(4) Starting with a compound known to be active, its chemical structure is modified by logical steps: Glaxo, Upjohn, Pfizer, ICI, Sandoz, Takeda, Abbott, Roussel-UCLAF (France).

Vida believes the ideal approach is represented by the full circle. Approach #1 led to the development of beta-blockers for the treatment of hypertension and gamma-agonists for the treatment of epilepsy. The benzodiazepine receptor could not have been identified prior to the synthesis of benzodiazepine (#2). "We could not have described the mechanism of the cephalosporines if we had not isolated them from microbial sources" (#3). "We would not have obtained the H-1 antagonist and the ulcer agents" were it not for the observation "that all actions of histamines except during induction of gastric secretion are blocked by antihistamines. This led to the hypothesis that a receptor different from H-1 is involved in acid secretion." Modification of the antihistaminic molecule by researchers at Smith-Kline-Beckman led to Tagamet (cimetidine), which led to the definition of H-2 receptors and their role (#4).

Bristol-Myers researchers are currently using all four approaches. Often the mechanism of action is discovered after the new chemical entities have been synthesized, so the chemist's intuition is highly important. Equally important are "the elucidation of mechanism of action, the screening for new biological activities, for new chemical entities, and for a logical change in the structure of known chemical molecules."

What are the strategic and economic considerations in setting research priorities? The external strategic considerations are:

(1) therapeutic need (no satisfactory current drug means that the potential market for a new drug would be considerable),

(2) therapeutic benefit (a drug offering clear improvement in efficacy, safety, and/or convenience over current therapy), and

(3) competition at the time the product reaches the market. Internal strategic considerations are

(4) the long-term strategy regarding therapeutic areas and product type,

(5) in-house R&D expertise,

(6) probability of technical success,

(7) duration of patent protection.

The economic considerations are: (1) size of the market and market trends, (2) changes in environment and (3) technology, (4) cost to complete project, (5) time to complete project, (6) production costs, (7) peak sales and product life cycle, and (8) return on investment.

Pharmaceutical development costs are "staggering" and increasing. If one considers that 1 of 8 new chemical entities (NCE) makes it to the market, then the R&D cost (including marketing approval costs) is $54M ($30.4M in discovery costs, $23.6M in development) in 1976 dollars, $70M in 1980 dollars, and $92.4M in 1985 dollars. To see how costs have risen, consider that costs per NCE before 1962 are estimated to be approximately $6 1/2M in constant 1980 dollars.

Increased R&D expenditures have not, however, led to a "comparable surge of new products." Rather, the levels of innovative productivity "as measured by the number of NCEs brought to market have dropped sharply since the 1950s." Expenditures (in 1958 constant dollars) increased from $100M to $500M between 1955 and 1979. NCE introductions in the US peaked at about 60 around 1960 and dropped to about 24 in 1979. NCE introduction by the domestic industry peaked in 1960 at about 27 and dropped in 1979 to about 12.

"Decline in NCE introductions is not indicative of the decline in invasive pharmaceutical innovation," but of the decline in INDs. U.S. patent filings increased between 1963 (1500 pharmaceutical patents filed) and 1977 (over 4000 filings). INDs decreased from 1066 in 1963 to 925 in 1977. Greater expenses associated with pre-clinical and clinical testing have forced firms to be more selective of what compounds to bring to market. One indication of the greater selectivity is the decline in the ratio of INDs filed to patents granted to half of what it was before.

The pharmaceutical industry has played an enormous role in the drug discovery process, but the university role has also been of utmost importance. By one estimate (Schwarzman) the drug industry did 86% of pharmaceutical innovation between 1950 and 1959, and 91% between 1960-69. Another study (Schnee) concluded it contributed 54% of the discoveries between 1935-49, 62% between 1950-62, and 89% between 1963-70. The rate of progress in new drug discovery depends upon the "size of the information base in molecular biology, biochemistry, cell biology, chemistry, immunology and other related

fields of science. Methods using the synthesis of drugs have been developed largely by academic research. University departments of organic chemistry have elaborated both general approaches to synthesis and specific methods for achieving particularly different synthetic steps. Analytical tools developed by academic investigators in the departments of physical and organic chemistry have been important in the analysis of structures of natural compounds and in the monitoring of chemical changes produced in the process of developing drugs." The virtual explosion of biological knowledge also led to a new emerging biotechnology sector of the pharmaceutical industry. The discoveries that led to the formation of new companies were made virtually completely at academic institutions. It is clear that the contribution of academic research to the progress to be made in drug discovery is indispensable.

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Dr. Joseph M. Ballantyne, Vice President for Research & Advanced Studies, Cornell University, described Cornell, with 12,000 undergraduates and 5000 graduate students, as a private and state land-grant institution administered by a single president and board of trustees. It has 6 national laboratories on campus. In 1982 it ranked 5th among universities in total research expenditures with about $170M. 5 Cornellians received Nobel Prizes between 1978 and 1983. Its faculty has 50/50 teaching and research responsibilities.

Cornell does research for a number of reasons. The university has a commitment to search out truth through knowledge and make it available for society's benefit. Research is an integral part of graduate education. Furthermore, Cornell has an obligation to attract the most stimulating and up-to-date faculty for its undergraduates.

Cornell is composed of a number of public and private colleges containing smaller subdivisions or departments, further divided into sections, which report to two or three deans. Each section may have faculty with appointments from any of the different colleges. The graduate school enrolls all the graduate students at the university into a field of study, which may contain faculty from a number of different departments or may be nearly uniquely identified with a single department. A faculty member is selected by the graduate faculty to head a given field of study and reports to the graduate school dean. A faculty member may be a member of two or more graduate fields. Some fields take faculty from widely separated departments organizationally.

Not only can a faculty member belong to several graduate fields, he can belong to several research centers. A center promotes graduate research and provides funding and coordination of research. It can have a user community outside the university if it is a national lab as well as interact with university faculty and graduate students. Because Cornell has learned how to cross many kinds of public, private, and departmental boundaries, it has consequently become expert at running these interdisciplinary research centers.

Cornell follows a number of principles in running its research centers. Firstly, the departments, not the research center, appoint

faculty, and the graduate school, not the research center, admits graduate students. Secondly, the center's role is to support and promote research and education, to facilitate interactions with sponsors, industries, and national user communities, to facilitate interdisciplinary research, and to provide facilities and block funding which would be inaccessible to any single department or research group. Thirdly, the faculty members involved have to come from more than one college. New research center initiatives generally begin when faculty members decide they would like to compete for some new, major facility. After getting administration support, the departments select and hire the faculty and ultimately determine the overall research directions.

Cornell does mostly basic research. Most of the research has to be suitable for a graduate student's thesis work, which should be "published as an original contribution to knowledge." This precludes much applied research and most development work. A large fraction of Cornell's basic research, however, is aimed at some long-range problem in society. Although publication is still the single major driving force for Cornell's faculty and graduate researchers, more people in physics, chemistry, and math are becoming interested in working out problems that may be interesting to industry in 10 years. Today, most of Cornell's basic scientists think it is a positive thing if people can use their results. As a result Cornell is finding it much easier to work collaboratively with industry.

Occasionally, spinoffs, particularly in experimental programs, have produced useful industrial applications, such as instrumentation or animal vaccines. Cornell's biggest example of applied research comes from its agricultural extension service, a reflection of its land-grant status, whose mission it is to develop Cornell's basic research results and communicate the information to meet the needs of the individual user or business in New York state.

What is Cornell's motivation and procedure for trying to protect its research? Sponsor rights are its motivation. Federal, state, and industrial sponsors all require Cornell to protect its inventions in order to serve the sponsor's interests. Ownership of the patent is its procedure, with the sponsor receiving an exclusive or non-exclusive, royalty or non-royalty bearing license, as appropriate. Cornell has a 3-fold reason for owning the patent. First, since the patent is usually the result of multiple sponsorship, it is simpler for Cornell to own it and negotiate licenses with the various sponsors. Second, most university inventions depend on a large installed research capacity built up from the research contributions of many sponsors. The individual sponsorship of a given project that results in an invention did not pay for that installed base, which is a university resource. Third, most professors are at universities because they like its environment, are able to concentrate on their research, and need not worry about business matters. University ownership of patents can insulate the individual from exorbitant demands on his time that might result from commercial application of one of his inventions.

Cornell evaluates its success in research through publication, peer opinion and funding level. The private sector is sponsoring a

greater portion of its research. In both 1983 and 1984 industry funding increased by 40%. Industry is showing greater interest in supporting basic research and is also recognizing that it is cost effective to do basic research at a university. University research has built-in subsidies: graduate students accept low salaries, faculties take a somewhat lower salary, the institutions pay for buildings and equipment. "Cornell, for example, has 6000 professionals involved in basic research. Most industries have a ratio of people involved in development to research of about 7 to 1. Therefore, Cornell represents an R&D lab in terms of the basic research done of 42,000 professionals. No company or industry has a basic research lab of 42,000 professionals. Therefore, it is evident that by combining this huge resource for basic research with industry's capability to do applied research and development, we are beginning to realize more productivity in getting new products out for the benefit of society."

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According to **Mr. George H. Dummer**, Director of MIT's Office of Sponsored Research, MIT was founded with the expectation of a close association with industry. It has a strong industrial liaison affiliates program and a strong continuing education program. Members of the departmental and laboratory visiting committees are drawn largely from industry. Faculty may consult 1 day per week for industry (in schools such as engineering this is considered to be part of one's professional obligation). MIT has nearly 1000 full-time faculty, nearly 1900 other academic staff, roughly 4500 graduate and 4500 undergraduate students. In 1985 nearly 2500 undergraduates participated in sponsored research through the undergraduate research opportunities program. Nearly 1600 graduate students worked as graduate research assistants; another 900 were graduate research fellows. On-campus sponsored research dollars were $242M. Of the $49M in non-federal support, over $33M was sponsored by industry.

Dummer's office employs 15 professional research administrators with legal, financial, and business backgrounds. They interact with at least 20 academic departments, and more than 15 departmental and interdepartmental labs and centers. Since they work closely with the Patent, Copyright and Licensing Office (currently being reorganized after the Stanford Model), they have spent much time on issues relating to patents and other property rights, including revisions of MIT's copyright policy "to be more effective with regard to computer software; whether to allow a policy on tangible research products such as software and biological materials; how to deal with product liability; how to improve license agreements."

The university research environment has four chief characteristics. First, research is performed as an integral part of the educational program. Second, it encourages individual creativity. Rosabeth Cantor in a recent issue of Management Review identifies two circumstances that contribute to creative thinking:

(1) "contact with other people who do not share the same values, who challenge our assumptions, and force us to confront them, and sometimes to rethink them;"

(2) "the cross-fertilization of ideas which comes from cross-disciplinary contact because creativity often springs up at the boundaries of specialties and disciplines rather than squarely in the middle."

Dummer cautioned that when the university enters research projects and agreements, "it must avoid compartmentalizing the effort to the point that it goes against the grain of that kind of creativity."

The third characteristic is the imperative to publish research results. This affects the university's ability to protect proprietary rights, but faculty scientists and research engineers must publish to survive professionally. "They cannot stay current in their disciplines unless their ideas are exposed to their peers for critiquing, discourse, and verification.... Those sponsors, federal or private, who ask faculty members to move away from the arena of peer review and from the competition will in turn themselves lose much of the benefit from their interaction with industry."

The fourth characteristic is the long-term horizon. "Faculty and students do not wish to make the intellectual commitment to research that will be supported only on a short term basis or may be abandoned altogether. Once that intellectual commitment is made, they will find a way to pursue it because research is like an exploration that cannot be abandoned until a goal is reached."

The preponderance of MIT's funding from industry (about 14% [$34M] of MIT's on-campus funding) results from "personal contacts involving consulting relationships, participation in industrial liaison or affiliate programs, interaction between MIT and corporate executives on the visiting committees, and discussion by professional scientists at society meetings." Perhaps 90% of MIT's research contracts with industry are 2-page documents with minor variations among them. A few agreements (less than 10% of industry funding) provide multi-year, multi-million dollar support with extensive coverage of proprietary rights. These must be based on a professional scientist-to-scientist relationship. Dummer warned that even if the relationship exists, "after the first flush of an exciting technical interaction, the participating scientists may find themselves frustrated by unrealistic expectations or by divergences of interest in their own organizations, problems that might not arise if the relationship were not showcased in such major commitment."

Fortunately, MIT has a large agreement that works very well.

(1) It is based on a professional relationship between MIT faculty members and company scientists.

(2) The projects are carefully selected to insure their relevance to the interests and motivations of both MIT and the company.

(3) There is a commitment to stable, long-term funding. If the project expires and is not renewed, those post-docs still writing their theses are supported until they have completed their thesis work.

(4) Student involvement with company scientists is substantial.
(5) There is discretionary funding which the PIs may use to develop new research projects of their own choosing.

"If these factors are present, almost any relationship is going to work."

The multi-sponsored consortium, in which membership fees support a common research program, is a mode of corporate funding of MIT that has almost doubled in the last few years ($9M in 1985). It is not an externally organized consortium of the Semiconductor Research Type but is internally organized by the PI. For industry, it provides a less expensive way to have a window on university research. The university, in turn, receives more stable funding though industrial members may change. "The consortia have a longer-term focus than is often possible with single sponsors, and the research is likely to be more fundamental or generic." Giving members proprietary rights on a non-exclusive basis eliminates a variety of complications normally associated with dividing rights among sponsors. "Though some members are reluctant to share their research results with other members, the benefits of access to generalized research of the total membership often overcomes that reluctance." Consortia-owned research also enhances the interaction of scientists with member companies, including having company scientists participate in the on-campus research program. Although patents and other proprietary protections may always be issues in the technology transfer process, some companies have become more interested in such participation as a form of front-end technology transfer.

Dummer believes the research administrator's primary obligation is to ensure that commercializing the results of university research "does not get a higher priority than protecting ... the university research environment without which these results would not have been produced." With regard to university-industry relationships he should try to "maintain those characteristics of university research which are essential to a creative environment." He should also "help design collaborative mechanisms" which maintain the balance between the university's pursuit of truth ... and industry's search for useful knowledge.... Those familiar with research in other countries point to the litigiousness in this country as an inhibition to innovation and a risk-tolerant atmosphere which breeds creativity. We should facilitate the creative process by keeping agreements lean and readable and not drafting them as if litigation were inevitable. If we do our job right, we will also have the satisfaction of helping create an environment in which creativity and innovation will flourish."

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The Workshops dealt more specifically with the issues mentioned in the general session. The workshops centering on "university" issues are summarized first. Those explaining industry expectations and licensing practices follow.

UNIVERSITY PERSPECTIVES

Mr. Stephen H. Atkinson, Director of the Office of Technology Licensing and Industry Research at Harvard Medical School and the new president of SUPA, noted how successful academic institutions have been in creating a community of innovative people who are making contributions faster than either we or industry can absorb them. SUPA members in their jobs are responsible for maintaining and promoting that creative environment where innovation will continue to flourish. In the process they can make a real contribution to their institutions and to society.

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The speakers at the "Technology Protection and Management in Academic Institutions" workshop described the evolution of their university technology transfer programs, their current organization, management, and major activities.

The government's ineffectiveness at technology transfer led in the 1960s to the passage of the Institutional Patent Agreement, which allowed universities to take title to inventions made with federal research money, to license them, and to generate revenues. This led universities to develop new patent policies, which would enable them to protect research results having a commercial significance. In the late 1970s the Dole-Bayh bill enabled universities to grant exclusive licenses to develop research results.

According to **Mr. Howard Bremer**, Patent Counsel for Wisconsin Alumni Research Foundation (WARF), WARF is a non-profit foundation begun in the 1930s and separate from the University of Wisconsin. WARF invests the University share of patent royalties to increase the University endowment. Bremer sees the need for stronger university patent policies to safeguard inventions.

Mr. Edward L. MacCordy, Associate Vice Chancellor for Research, Washington University, said that when his university's technology transfer office was started 15 years ago, sizeable returns were not expected. He believes university innovations will increasingly be the foundation of more start-up companies than of traditional licensing arrangements with long-established companies, which he has found difficult to deal with.

Mr. Roger Ditzel, Director of the Patent, Trademark & Copyright Office, University of California, mentioned that UC has $1B/annum in research funding, not including Los Alamos and Livermore National Laboratories, and has first rights to title in all of its divisions, schools, and laboratories. The technology transfer office employs 9 professionals. It has 6 shared research agreements with Stanford. It has difficulty negotiating with RDLPs unless they have up-front money. Ditzel sees his job and that of other university technology administrators becoming more complicated.

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All institutions engaged in technology transfer face common problems of cataloging available technology and making the compilation accessible to potential users. "Date Base Management Systems for Cataloging Research and Innovation" focused on how different institutions are addressing these common concerns. The three panelists were from institutions of differing size, differing history and traditions, and with different target constituencies for technology transfer. They described the objectives of their systems, their "customers", how they obtain information from faculty, research staff, and facilities, and how they access the compiled data.

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The Harvard Medical School PC-based Research and Innovation Database was described by Mr. Laurence C. Bonar, Assistant Director for Technology Evaluation, Office of Technology Licensing and Industry-Sponsored Research (OTL), Harvard Medical School, Boston, MA 02115. OTL is responsible for technology transfer and industry relations for the School's pre-clinical faculty. Its database system is designed primarily to allow access to information on the research interests of the School's approximately 200 faculty members. Eventually, it will also contain entries for the additional 400 research associates and post-doctoral fellows in the pre-clinical departments. An auxiliary database contains brief entries on the research activities and clinical specialties of the 2,000 or so clinical department faculty members, who have primary appointments at one of the 11 hospitals affiliated with the Medical School, and whose technology transfer activities are handled by the hospitals.

OTL uses an IBM PC-compatible Compaq "DeskPro" with a 10MB hard disk. Using Ashton-Tate's dBASE III as a database manager, OTL has written custom programs to access the database contents, perform research-interest or similar searches, and transfer files to word-processing programs. Key words or concepts descriptive of each scientist's work are selected to use for research topic searches of the database. The present system accommodates up to 10 key words. The data base is accessible only to OTL personnel and is not designed for general access.

The database contains a comprehensive description of each faculty member's research, generally 2-3 pages in length, with a brief bibliography of recent publications. The OTL staff write this research description following a 1-2 hr interview with the faculty member. The interviewers try to read reprints of the faculty member's recent publications prior to the interview. (The faculty member receives a draft of the written research description for correction.) They discuss present levels of research funding and funding needs, and any industry contacts or consulting contracts the faculty member may have. They also attempt to elicit information on the research's clinical or commercial implications.

The interviewers explain the role of OTL and industry relations in general. They describe procedures and requirements for filing patent applications on inventions or obtaining other forms of intellectual property protection. Since academic researchers are

often unused to thinking in terms of patenting and commercially exploiting innovations arising from their work, the interviewers try to determine if any patentable inventions have been made or are likely to be made in the near future.

The OTL staff use the research descriptions to initiate contacts with industry to seek research support or to explore licensing possibilities. The written descriptions, which are targeted at an audience of non-expert scientists or scientific executives, are used as is, or as a basis for a briefer or more narrowly focused write-up, depending on the anticipated use. The research descriptions are also used to respond to inquires originating from industry.

Because the interview-based procedure is labor intensive, it is probably not practical for a faculty much larger than the 200-person HMS pre-clinical faculty. It takes about 2 person-days per faculty member, including the time spent reading reprints, conducting the interview, and writing the research description. About 50% of the faculty with independent active research programs have been interviewed in the past 12 months. The initial survey is expected to be updated approximately every two years.

The interview method has the advantage of providing a thorough and comprehensive description of each scientist's work, written in a consistent style designed to appeal to the industrial research executive. In addition, the interview affords an ideal opportunity to discuss technology transfer and industry relations concerns with faculty members and to alert them to patenting and other intellectual property protection considerations. Lastly, the interview gives OTL an opportunity to spot patentable inventions the scientist may not be aware of; several patent applications have already resulted from inventions uncovered during faculty interviews.

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The University of Wisconsin Database on Faculty Research Expertise and University-Industry Interaction was described by Ms. Jean Akhtar, Assistant Director and Data Base Administrator, University-Industry Research Program, University of Wisconsin, Madison WI 53075. The purpose of this database is to catalog expertise, research programs, and equipment that may be of use to industry and to keep track of the "hottest" areas, e.g., biotechnology, material research, NMR, fiber optics. The office can conduct quick searches to answer queries from industry (3-5 per day), state, and university administrators, or faculty. It also publishes annual reports of university research. Although expensive to produce, these publications have turned out to be "astonishingly good" public relations vehicles.

The database is updated through an annual survey of research centers and individual faculty in a mailing that goes to more than 7,000 people on campus. The data are edited and compiled using a relational database system of 3 files on a VAX 11/780. Each 15-20MB file has 2500 citations. The files are expensive to maintain; computer costs run about $7,000/annum. Akhtar believes it is probably not worth the storage money to maintain publication lists, official project names, and funding information (unless this is already in place).

The survey method presents certain problems. Should the questionnaire be designed to be "faculty-friendly" (narrative) or easy for the computer to process (keyword)? How does one get compliance? "Often the biggest fish don't bite." The office recruits 4 graduate students 3 weeks after the survey is mailed to call the most important non-responders.

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Database System Considerations at the University of Iowa Technology Innovation Center (TIC) were discussed by **Mr. Bruce Wheaton**, Director, Technology Innovation Center (TIC), University of Iowa, Iowa City, IA 52243. TIC maintains a data base of faculty research interests, which is used to compile a printed research directory and a University facilities directory. TIC also distributes information on University policies relating to sponsored research and technology transfer. Entries in the database are based on information provided by faculty members in response to a questionnaire and are edited by TIC for consistency. At present, about 800 faculty members (45% of the total) have supplied information. The faculties of medicine and engineering are most heavily represented. Probably 70% of faculty members with active laboratory research projects are included.

Several concerns have surfaced in connection with the compilation of the data base. There is some anxiety within the University over ethical questions of privacy and confidentiality relating to a publicly accessible data base such as the TIC system. Questions have also been raised about the proper role of academic research and scholarship in a state university, and about efforts being made to use academic research strength as a focus for economic development.

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Since many of us frequently are dealing with new technology where we do not have a detailed scientific background or marketing expertise, we must often quickly identify resources that will bring us up to speed. This session about **"Systematic Approaches to Finding Licensees"** focused on the technical and marketing resources that are available to evaluate an invention, its market applications, and potential licensees.

Ms. Robin Adams, Information Resource Specialist, Bell Communications Research, described relevant information resources, including on-line data bases, library resources, and industry sources. A typical search strategy has three parts: defining the invention (potential applications, advantages of similar products, required accessories), market setting (state-of-the-art technology, price and characteristics of similar products, trends, lay-person description of the field, key companies, market share, and projections), and action information (company profiles, mailing list, company activity in a given field, background on key personnel).

Mr. David Stein, Technology Transfer Officer, Harvard University, presented a case study showing how to use data bases, purchasing guides, industry handbooks, journal advertisements, and

patent assignments to evaluate an invention with broad application and to locate potential licensees.

The following questions were also addressed: when to use on-line data bases vs more conventional resources, how to know when you have gathered enough information, the best timing for using personal contacts and making telephone calls, how to keep track of a resource search in an organized way, building your own data base vs using existing ones.

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Ms. Carol M. Taylor, Assistant Director of Marketing, Office of Technology Licensing, Harvard Medical School, opened the workshop on **"Investment Vehicle Alternatives for Raising Capital to Support Technology Development"** by saying that the technologies most likely to require alternative investment vehicles are those that "are beyond the traditional sources for basic research, but are in many cases too embryonic for licensing for product development. Many of these projects fall into this limbo, and many never escape." This "development gap" has caused several different groups to enter this field in the last few years. Several traditional venture capital groups specialize in drawing technology transfer projects into the university environment, such as the Channing-Weinberg fund, which specializes in health-care related projects, the Hambrecht and Quist Life Sciences Funds, and the Montgomery Securities Fund, which also specializes in health care. These have all successfully raised large sums of money, mostly from corporate investors. "In common with most venture capital groups, most are interested primarily in technologies which are further along in development than many technologies coming out of the university. There have been some major problems in terms of interactions with traditional venture capital groups."

Hence, universities are increasingly exploring ways to exercise their own initiative in this area. The three speakers gave an idea of the wide range, modes, and scale of their institutions' initiatives, and some of the alternatives that are available.

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Mr. R. Winslow Young, Director, Patent & Product Development, University of Utah, described the techniques by which UU transfers technology into the commercial marketplace, why it uses those techniques, and the investment opportunities available.

He explained that universities are operating at the bottom of the development curve of product commercialization. Major industrial concerns and venture capitalist at the top of the curve address the second- and third-round financing for a product. The major problem is how to bridge the gap in the middle. Young's office has 70+ license agreements, 50+ done since he came five years ago. About 1/2 of the licenses are with small companies, which have the capability of bridging that gap.

Young always asks what is the best way to get a given technology into the marketplace. He negotiated the license for the artificial heart with a small company because a large company would have considered the product "too risky, the market not well defined. There

are too many issues that large companies are incapable of dealing with that a small company is." (1) He prefers the licensee to give an equity position rather than a license fee. This equity is carried by the wholly-owned, non-profit University of Utah Research foundation at $1 per certificate, but its audited value is over $2M. UU equity is not shared with the inventor, but the inventors receive their own share as consideration in a new company. (2) He looks for royalties to put back into UU. Total 1985 royalty income was $95,600. (3) He asks the licensee to pay patent expenses. He feels that patent decisions (what, why, where to file) are "business judgments, not legal judgments" and tries to license before he has a patent application filed because of the great expense ($500,000 in last 5 years). (4) He seeks research support and has received subcontracts worth about $3M in the last five years. (5) He encourages licensees to make sales to bring in royalties and increase the value of our stock. (6) He encourages licensees to sublicense and asks for a fraction of the sublicense fees. If the licensee can only get a 5% sublicense royalty, UU might get 30% of that, for a 1.5% total royalty.

His funding vehicles have so far brought in $30M from small companies, "a significant amount but not all that much." Young explained that UU is "in the middle of the great American desert," and the state does not have a significant venture capital presence. He has been "notoriously unsuccessful" in trying to get venture capital funding for UU technology (only $1M from one small fund). He believes that venture capitalists are interested only in the upper part of the development curve, where "in a short period of time they can infuse capital and quickly get out," letting other people "hope the technology gets into the marketplace." How many of the original venture capitalists are still with the early genetic engineering companies? "They made a lot of money, but no product has come out. They were not really interested in the long haul." He believes more venture capitalists should create seed capital funds like the Channing-Weinberg fund.

Young has had more success with other funding vehicles. Some UU technology has had public offerings. Most, however, have gone into "the private placement area," where the university personnel are involved with a small company. The SBIR program has also awarded small licensees with 26 or so Phase I award; one small company has four Phase II awards. No products have appeared as yet, however. Corporate investment has also been a factor.

Young closed by saying that he tries to create "a reward vehicle" between university and small company that ensures the researchers an adequate reward. UU wants to ensure that researchers will stay at the university. Good researchers are "always being wooed" by outside firms, "so why not create the rewards to allow them to stay at the university, doing what they do best? Give them a reason to stay and be more creative."

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Like Winslow Young, the bias of **Dr. David W. Mueller**, Interim President, BCM Technologies, Inc., is toward equity deals. He gave some background on BCMT before describing some of its agreements. Two

years ago, Baylor College of Medicine (BCM) formed BCM Technologies as a wholly-owned, for-profit subsidiary with an independent board of directors composed chiefly of operating officers of Houston companies, and officers that are not necessarily officers of BCM. BCMT holds BCM's portion of any equity. A for-profit company, BCMT can engage in profit-making activities and incur losses, which offset some of the company's profits, and still protect BCM's non-profit status. BCMT began selling or packaging deals last year.

BCM provided initial operating funds, and profits from current agreements also supply a portion. BCMT hopes to be financially independent of BCM in the next two years; this will depend on royalties received. Its 4-person staff, 3 deal makers and 1 administrator-secretary, is "multi-disciplined and come from the commercial world." One staff member has experience in disposables. Another has extensive experience in marketing and had an operating position in a biotech company. Mueller's background is in engineering management and corporate development, and corporate technology licensing. Commercial experience is considered very important because of BCMT's many dealings with the corporate world. It has provided them with a ready-made network of corporate contacts. It also helps them, as they negotiate on behalf of BCM, understand what drives deals, negotiations, and corporate interests and is an important factor in BCMT's success.

BCMT's charter, in the process of getting final approval, has five key clauses. BCMT is to be run "in a profitable manner," giving it a bias that other organizations connected with academia do not have. It provides several services (described below). It limits itself to technology from BCM (with a possible option to change that later if necessary). It uses funds from outside investors. Baylor contributes only operating funds. Its goal is to generate income for the Baylor endowment. "Baylor gave BCMT the charter and the time to do the kinds of deals, which typically offer long-term payoff for higher return."

BCMT provides the following services to BCM:

(1) It identifies new technologies within BCM in conjunction with BCM's Office of Technology Assessment, whose purpose is to identify and catalogue the school's technologies. The office has a patent counsel and a patent committee, of which Mueller is a member.

(2) It evaluates the technology's potential, that is, the technical and market probability of success. It may do its own market analysis or hire an outside consultant, such as BDI or Channing-Weinberg, to do it. This is especially important if BCMT were to do a deal with venture capitalists, who are very concerned about the market potential.

(3) It prepares business plans.

(4) It will structure deals. One technology consists of a system that images the heart. A radioisotope is injected into the body, and a gamma camera takes the image. Since BCMT cannot find a company that would take licenses on both, it is going to do an equity deal to form the isotope company and will license the camera technology to a camera company. Setting up the strategy to orchestrate this is a

significant part of being able to package a deal that in one case would be salable and in another case would not be.

(5) It will arrange funding either through private investors, venture capitalists, or other means.

(6) It will lease facilities and recruit officers from outside the university to manage the start-up companies. BCMT's goal is to keep people at Baylor.

(7) It provides project management capability. During a transition period if it is necessary to do some interim or contract management with an outside firm, BCMT will manage that. Members of the staff also serve as members of the boards of director of companies.

BCMT has arranged several kinds of deals, including equity deals, licensing deals, RDLPs when tax benefits are needed, combinations, as in the case of the gamma camera, which is really a licensing and an equity deal. What documents are required for building companies and doing deals that go beyond straight licensing agreements?

(1) If it is a venture deal and BCMT incorporates the company, the articles of incorporation are required.

(2) If there is private money or the need for some kind of tax benefit, BCMT puts together an RDLP in order to channel any tax loss back to the investors.

(3) Most agreements include an R&D contract, which goes back to the BCM department or researcher. These are very specific contracts that spell out a specific area; they are not open or unrestricted contracts, but neither are they development contracts. For example, a BCM researcher might have a technology to do a cancer diagnostic on a tissue slide. That is transferred into the new company; then the new company contracts with the researcher to do the basic research on transforming that technology now to a serum sample." The research is directed in that it is set up on a time table, and the company has an option, if certain milestones are not met, to cancel the balance of the research," but it is not compromising the university because it is basic research.

(4) Consulting agreements.

(5) Management service agreements.

Mueller described seven of the projects he had worked on in past year, the first four completed and the last three pending. Cardiovascular Systems, a $2M equity deal, is an example of how taking equity is a good way to protect or get a return on technology that cannot be patented or licensed. Its technology uses an instrument for interoperative blood recovery processes that reinfuses the blood back into the patient. This technology is not proprietary, has no associated patents and very little know-how; it could not be licensed. Yet, BCMT has equity in the company, and BCM will receive a return from this. Oncos Ltd., which produces a cancer diagnostic test, was done in an RDLP as a joint venture with Phillips Petroleum. Amnion & Rhinovirus, both early stage, seed fund projects, were done much in the form an RDLP, with funding from an outside investor (a foundation) in return for rights to the technology. At some point each technology will be transferred to another company, or an equity

company will be formed, and any return that the foundation receives will go to BCM through BCMT. Amnion's technology uses amnionic membrane for reconstructive surgery; Rhinovirus is developing the delivery system to deliver a drug called enviroxin, which treats the rhinovirus that causes 50% of the common colds. Nuclear Imaging Camera is two deals combined as one. It takes a lot of coordination of effort to do a combination deal when there is an existing equity company, a technology, and investors. Neurotrophe, an early stage, seed fund project, will develop a neurotrophic agent that will diagnose and treat ALS and Alzheimer's Disease. Metabolic Carbon Analyzer, an early stage, seed fund project, could have been licensed, but with a minimal infusion of cash ($20,000) BCM can develop it further to where it can become an equity company and create much greater value. BCMT licensed rights to a patent from an outside company to give BCM's technology more value. It will be packaged as a single deal, probably an equity company, in which BCM will have a significant equity position.

Mueller summarized BCMT's financial position from "one year's deals in selling and packaging." The royalties and fees, such as management fees, that come directly to BCMT and hence to BCM over the next 5 years (and beyond, of course) will have a value of about $1 1/4M. Other income, mostly in the form of R&D contracts with researchers at BCM, will be about $5M. The present value of equity holding in these companies, based on the current market (sale) value, is about $1.3M. Their potential value based on a relatively conservative estimate of 8 times earning when the company is sold, is over $10M. Few of these deals represent licensing. This is not to demean licensing, but BCMT feels equity has greater value than licensing. BCMT does some licensing to provide short-term cash flow to help offset the operating expenses, but BCMT's bias is towards long term equity deals.

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Mr. Richard Olson, President, Foundation for Applied Science and Technology (FAST), University of Pittsburgh, focused on the formation of university consortia-based RDLPs. He described how FAST deals with opportunities that are further along the development curve and with expansions of scale. FAST itself began as a non-profit subsidiary of the University of Pittsburgh and acquired a for-profit management role, with acquisition of the Gulf Oil research facility to use as a private research base for technology beyond the point of campus development. He suggested that if universities have an interest in acquiring a private research base for the same purposes, they should inquire with industries in their communities.

FAST prefers equity. It generally begins with a royalty agreement with a start-up company because Olson is "not wise enough to figure out what equity means when a company hardly exists." Olson finds that it is often possible to negotiate a "downright abusive" royalty agreement with a royalty of 4-5% on gross sales. Then, when a company wants to go public, its underwriters say "My God, you can't go public paying those guys that royalty on gross." FAST then converts to equity once it knows what the value will be.

Although its primary focus is on developing university intellectual property, it also looks aggressively outside the university for research/intellectual properties that can be advantageously developed in the university research environment. FAST began with $400,000, part of a gift from Gulf Oil and PPG and is just barely self-supporting. Since it had to become self-supporting very quickly (the university does not invest), it had to look for deals that would mature more rapidly than most that exist in the Univ. of Pittsburgh patent files. FAST goes to NY for its venture capital money because Pittsburgh's 17 fairly large venture capital firms are tied up with leveraged buyouts and second- and third-level financing; they are not interested in university technologies.

FAST's first venture was with a NY venture capital group that was looking at a gas sterilant to replace ethylene oxide. They estimated it would cost about $750,000 and 18 months to prove technological feasibility, beyond which the program would become very expensive. FAST gave the group a proposal for a 3-month job at the cost of $18,000, 250,000 shares of stock, and 1% residual, and did the job in 3 months. The group is delighted and has given the university $1M in contract research to look at specific facets of the technology. Another group came with the skeleton of an idea for a speech prosthesis for laryngectomies. It is now in patients, has FDA clearance, will begin marketing soon, and FAST has 15% of the company. One of FAST's "inside" deals came from a professor with an idea for an anti-stuttering device. FAST put up $3000 to build the model out of vacuum tube amplifiers in Olson's basement. The first test 3 months later was an immediate success--"a fellow who couldn't put 2 words together without stuttering, stopped stuttering." FAST has an "abusive" 5% royalty on gross sales plus 20% equity on the venture, which was funded by a NY venture capital group.

FAST utilizes the R&D Limited Partnership. The RDLP allows the limited partner-investor to write his share of the investment in the research off on his taxes. If an investor puts in $100,000 and $90,000 goes into research, he can write off the $90,000 that goes into research and really diminish the effective investment he has in that property. Since an investor also has a good chance of getting capital gains treatment on the end product, there is just enough tax leverage to persuade him to take a somewhat higher risk than he might otherwise. Because most university intellectual properties are at a very early stage of development and constantly perceived as having higher than average risk, these RDLPs are a good deal for the university and the investor.

FAST became very uncomfortable with some of their single-venture RDLPs. If the technology is good, they are great, but it is difficult to stop a bad project under an RDLP, where the investors commit to meet the at-risk provisions. People that do single-technology RDLPs have gone to very high leveraging to try to reduce the risk. "It is a good vehicle but people abuse it."

In order to reduce risk, FAST proposed a formation of a "rather large" pool of capital of $50-100M. The investors perform through a consortium of research resources that are nominated by universities and university-affiliated research parks. The limited-partner

investors put the money into a capital investment pool for current tax losses in anticipation of future capital gains. General partners will manage that money and fund research that is drawn from the following institutions: (1) The universities have the greatest potential to provide research with "really significant upside potential"; (2) Industry will provide projects that are good technology transfer deals, "not a lot of upside potential, very little downside risk"; (3) Trade groups are putting together a $500M endowment from which they will fund $50-60M in research annually. They expect to be organized in 3-4 months and want to locate in a university research park. They are good sources of deals and through their membership are an instant way to market a partnership product; (4) Federal laboratories; (5) Venture capital; (6) Entrepreneurs; (7) Technology transfer groups.

Selecting the ventures is an equally important part of a successful RDLP pool. FAST plans to use university faculty on a consulting basis in a peer-review mode to review the quality of the research, to examine general technological feasibility, and to judge the ability of the researchers involved to execute that project. FAST then intends to ask Channing-Weinberg and other consulting groups to judge projects from a marketing perspective. To perform the research FAST will go to the the university consortium and research park consortium rather than the federal laboratories or private R&D labs.

In sum, FAST has packaged something "as a conservative investment that gets conservative by being big and not underfunded." This RDLP pool of capital has a "greater source of ventures and of performing resources available to it than anything that has ever been put together." Olson believes that the RDLP will continue. The new tax bill with a possible tax ceiling of 35% would make the write-off less significant, but capital gains would still be intact. "Nothing in the new law benefits RDLPS except that other tax shelters will be hurt worse, so money may move from other shelters into the RDLP."

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"A Financial and Scientific Profile of a Research Project in an Academic Institution" used the Center for Communications and Signal Processing at North Carolina State University (NCSU) to illustrate how an industry/university cooperative research center is defined (scientifically and financially), funded, and directed.

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Mr. Alexander Schwarzkopf, Program Manager of Industry-University Research Programs at NSF, began the workshop by talking generally about centers and then focusing his remarks on the industry-university cooperative research center. A research center or institute is a collection of individual efforts which span several departments and/or divisions in an academic setting and involve both educational and research activities. NSF's contribution to the cooperative research center is its logo, prestige, and experience in operating other centers. Membership fees of $35-50,000 from companies support the center's research program. NSF provides some seed money for the start up but phases out its financial contribution within 5

years. NSF also looks to the states and other funding sources for matching funds. NSF is currently recommending the formation of university research consortia, which offer a larger research base in a given field than a single university can usually offer; this added research depth is more attractive to industry. New Jersey, North Carolina, and Florida have or will soon have consortia that include their public and private research universities.

Leveraging is the important factor in all centers. The only way to put together a large research program is to have contributions from a large number of companies, the state, and any other participants. A center with a reasonable research base will eventually gain the necessary recognition to become a national center. Multi-industry support usually forces the center to do basic research relevant enough to the member companies to maintain their interest. If the research is too applied, however, and aims at any one company, the other companies don't want to be part of it.

Some centers offer a reduced membership fee to small businesses with a reduction in rights to license any inventions. In some centers large companies will not allow small businesses that pay a smaller fee to be members because they do not like to subsidize a small business, which "competes just the same as a big business." Other centers need the small businesses to meet operating expenses and will invite them to be members at a reduced fee. Most centers handle patent matters in a manner similar to that of NCSU (described below).

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Dr. Franklin D. Hart, Vice Chancellor, Research Programs, North Carolina State University discussed the purpose and programs of his university's cooperative research centers, which enabled NCSU to increase its industry research support and university-industry cooperation in the schools of engineering and physical sciences and to create centers of excellence with a recognized faculty. NCSU graduate students still have an academic home in one of the departments but they can participate in center activities. NCSU already had a graduate educational program in place and four or five faculty members who had contracts or consulting arrangements with industry, giving it a relationship with a small number of companies around which to build the center. NCSU's four centers used the NSF model and expertise but no NSF money. One received seed money from ONR. The fourth, now being planned, will involve two universities, utilizing the resources of both.

With regard to filing patents, NCSU's patent committee receives an invention disclosure when member companies believe the technology is worth patenting. If the outside patent firm decides the technology is not patentable, or if the center or member companies are not willing to pay patent expenses, the committee dedicates it to the public or releases it to the inventor. If patentable, and if the center or each company is willing to pay patent expenses, each company gets a royalty-free, non-exclusive license. The technology can theoretically be licensed to others outside the center for a royalty-bearing, exclusive license. If only one company pays patent costs, it receives an exclusive, royalty-bearing license after other companies have waived their rights.

The key to the center's success is the relationship between it and the university departments. The extent to which the center provides additional capability to achieve a department's educational purpose determines whether that department will participate in the center. Some departments like to work within their own boundaries and to determine faculty salaries and tenure decisions on the basis of what a faculty member has done in the department. NCSU, however, believing that interdisciplinary contributions should be a factor in departmental promotion decisions and raises, has changed the way faculty are evaluated. Departments must now consider whether faculty members "have participated in an interdisciplinary, multi-departmental or multi-school program, and, if so, were they involved in the overall program development, are they doing research, are they doing a co-project with somebody, and have they had joint publications with people?" Only one department in the school of engineering does not participate in center programs. Its philosophy is geared toward the classic faculty-student organization. Hart sees that changing in the next two years.

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Mr. Sirus Chitsaz, Director, Center for Communications and Signal Processing, North Carolina State University, explained the center's organization and how industry members influence the process within the university with financial leveraging. The Center is an agreement, bylaws, and operating procedures, rather than a separate facility. It has 20 associated faculty members (including 1 to 15 PIs) and 35 graduate research assistants from 3 departments and 2 schools at NCSU and Wake Forest University, plus the director and a three-person administrative staff. The administrative staff is paid from the NCSU's central administrative fund. Faculty and graduate students are paid through their department. The Center does mainly basic research in the following areas: image processing, transmission, modulation techniques, VLSI algorithms & architecture, computer communications, image analysis, speech processing. 15 companies belong to the Center: Carolina Power and Light, DEC, IBM, GE, ITT, Westinghouse, Northern Telecom, Rockwell, M/A-COM, United Telecommunications, Sperry, FiberLAN, Harris AT&T, Tellabs.

The Center has a functional organization that looks complex on the surface but works well. Each university scientist belongs to a department and reports to a department head. The Director reports to the dean of engineering and to his department head. The Academic Policy Committee's inclusion of a department head and an assistant dean of research from both schools helps to ensure that the Center research agenda does not deviate from NCSU's academic mission. The Center PIs are on the University Research Program Committee and discuss what research proposals to offer and what expertise is available to the Center for a given project. Industrial Board members help the Center maintain its 3-5 year, long-range agenda, to which researchers contribute annual short-term proposals. If Industry Monitors and observers also do research in the Center, a university department must decide that the person has the qualifications necessary to be a Co-Director. The Center Evaluator evaluates all aspects of the Center to see whether the Center is accomplishing its

overall goals. The Program Managers for the Center's 6 programs coordinate Center research. They must be professors and PIs in their own projects.

How are new projects added to Center programs? A long-range goal based on industry interests and requirements is proposed; if approved, 30 annual projects acceptable to industry are proposed, from which 18 are chosen by the department heads involved. Industrial Board Members, meeting two times a year, give feed back on the short list, and final projects are chosen by the departments heads from those the industry members approve. The more basic the research, the more say professors have in deciding what will be done next. The more applied the research, the more say industry has in what projects will be done. It is always a challenge to match the desires of the university and industry. Yet, NCSU has found that industry members are more interested in having the Center work on research with a basic slant than on research with an applied slant, which they are capable of doing themselves. Industry is not interested in having the Center duplicate what they can do better and in a more proprietary fashion in-house or in a direct one-to-one contract.

An NCSU professor may be working on a number of different projects, only one of which is Center oriented and with Center funding. Other faculty members may work on a Center project full time for one or two semesters. Faculty members cannot get involved in Center activity without the knowledge of the department head. A faculty member's Center-funded project has the same paper trace as a project funded by NSF, DOD, etc. The award structure is the same, but the award is made by the Center.

Center financing is through a membership fee of $50,000 per annum for three years, depending on the number of members. This buys into $2M of ongoing research. The university and the state also contribute to the Center financially by waiving indirect costs (about 42%), a substantial savings to the industrial members and the Center. Furthermore, once the Center has identified the Core Projects, it proposes Enhancement Projects, to which member companies can contribute additional funding to enhance and expedite research areas of interest to them. The results of the Enhancement Projects can be extended to more applied, company-specific research through a contract or grant administered by Dr. Hart's office outside the Center.

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INDUSTRY PERSPECTIVES

In the "Financial and Technical Profile of a New Biomedical Product" workshop, Dr. Warren Stern, President of Pharmatec, Inc., a firm specializing in organ-selective drug delivery, began by defining the two major classes of biomedical products: drugs and diagnostics. Drugs, both human and animal, prescription or over-the-counter, have a 5-10 year development time and a 10-20-year product life cycle. Diagnostics are invasive or non-invasive and can take the form of a reagent, assay, or device.

Dr. Stern profiled what a major U.S. drug house with $100M annual sales typically spends to bring a new pharmaceutical product to market:

R&D (including trials)	$10.0M
Production Costs	$10.0M
Selling Costs	$25.0M
Royalties	$ 5.0M
Pre-tax Profit	$50.0M
After-tax Profit	$25.0M

He described in more detail the related costs of a typical new-product R&D sequence of an Investigational New Drug (IND).

Development Sequence	% Success	Years	Cost ($ mill)
Pre-IND	10	1.0	$ 1.0M
Phase I	20	0.5	$ 0.5M
Phase II	50	1.5	$ 3.0M
Phase III	95	2.0	$ 5.0M
NDA Review	100	3.0	$ 0.5M
	10% chance of success	8.0 years average	$10.0M actual)*

He noted that $70.0M to $90.0M are average estimates for developing a new pharmaceutical. The major discrepancy between the $10.0M figure* and the $70-90M figure results from the averaging in of the failures.

Stern discussed financial, product, and production factors that make a potential product attractive for development. Development time should fall well below the term of the patent in order to recoup costs and turn a profit. The minimum projected sales should be within a range of $10-$20M per year, and the return on investment should be over 10% (since government bonds yield 10%). Product features concern patient need (number of patients, and treatment of acute or chronic illness), advantages over competitors (efficacy, safety, improvements in formulation, dosing, delivery, cost, and/or extension of product use into other application areas), and product liability considerations. Production factors include volume/costs, premium pricing, shelf life (at least 2 years).

Dr. Stern said that small companies and venture start-ups are able to undertake partial development of some products (possibly as far as Phase IV) and then license to a major drug house. They are also capable of fully developing and marketing other products, particularly orphan drugs, for which there are few patients.

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Ms. A. Dale Stratton, Director, Biotechnology Systems Division, E.I. du Pont de Nemours & Company, confirmed that the cost of developing a new biomedical product can range from a few hundred to several million dollars and that development time varies from months to years. Both cost and time are affected by the end-use market--research, in-vitro or in-vivo diagnostics or therapeutics. "The

commercialization decision is based on a risk/reward analysis in which many of the factors are subjective and judgmental. This inability to precisely forecast ultimate sales and profits leads to conflicts in negotiating licensing agreements and establishing royalties." In negotiating licenses, universities should remember that drug development is risky, costly, and requires a huge investment of capital by the drug house.

What does each phase of product commercialization cost, and what technical questions are asked?

(1) INVENTION ($50TH-MILLIONS);

(2) PATENT PROTECTION ($5TH-$50TH): filing decision, countries, scope, defense;

(3) Product DEFINITION ($10TH-$50TH): expected result, method of use, cost constraints to meet pricing and profit goals;

(4) MARKET NEED ($10TH-$100TH): what market, what geographical areas, projected sales, current competition/

(5) PRODUCT DEVELOPMENT ($25TH-MILLIONS): system of use, performance vs specifications, market trials;

(6) REGULATORY PROCESS ($100TH-$1M): extent (U.S., worldwide), clinical trials, constraints;

(7) MANUFACTURING PROCESS ($600TH-MILLIONS): what type, how achieved, cost, quality assurance;

(8) MARKET INTRODUCTION ($10TH-$750TH): product literature, advertising, sales & services training, pricing (based on value to the customer), competitive positioning (cost of manufacturing; determination of reasonable payback);

(9) PRODUCT SUPPORT ($25TH-$100TH): customer training, applications literature, trouble shooting, service (manuals);

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The "Commercial Evaluation of a New Invention" is a people-oriented process. What is needed to focus our attention is the champion in a company. The inventor has to be a champion, and someone in the company has to be a champion, seeing it as a good idea and pushing it further.

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Mr. John Abele, President of Medi-Tech, Inc., described Boston Scientific as a "family of companies" (Medi-Tech, Microvasive, Mansfield Scientific) that makes devices for the less-invasive surgery business and disposables (catheters, small metal devices that open up vessels, remove stones, treat tumors) to treat cardiological, gastrointestinal, pulmonary, and urological illnesses. BSC's organization into separate companies rather divisions of a main company enables it "to be successful and responsive in a dynamic field." (BSC has "a maniacal focus and commitment to the customer" and to current medical device activities). It also does made-to-order "special" devices--variations on its existing products-- that enable a physician to do a particular type of procedure. BSC, therefore, can easily make prototypes for inventors. If the cost to develop is low, and it is a small but prestigious market ($120,000 annum), BSC will

look at it. A specialized market must keep its costs low, "but today's specialists' markets are tomorrow's major markets."

In the specialty medical device field, as in other fields, "ideas are cheap; it is the implementation that is critical to the success of a product." In evaluating a potential product, BSC looks at the long- and short-term MARKETS: the potential margins, the strategic fit with company, whether it will have the same customer as for BSC's other products, whether the product will encourage use of BSC's other products. It considers the various DEVELOPMENT ISSUES: cost to develop, risk to develop, whether resources required to develop this product are the same or different from those used in other BSC products; whether the project research has application in other areas. It does a RISK AUDIT. Particularly in a diagnostic product, BSC uses the "1600" formula (MCCCCM), "the Medical Change Capable of Changing the Clinician's Mind." If BSC doesn't get to this point, it doesn't have a product. If it goes too far, its product is too expensive and will not be used.

As important as evaluating an invention is evaluating the inventor and the contribution he can make to developing the invention. Do the inventor and his institution have realistic expectations about the device? Does he have credibility with other physicians, and can he communicate the value of his invention to his colleagues? Will he participate in developing the product's market by talking about it, giving papers, traveling, getting his name associated with his device? Many companies name products after a doctor not simply because the doctor's name lends value to the product, but because the ego-satisfaction from having his name associated will make that doctor work harder to make the product successful. Will he work with other doctors? A lot of inventors are so paranoid that they will not talk to anybody. Will he help to solve the problems as they come along? Does he have an appreciation of what BSC can contribute?

Evaluating the invention is almost easier than evaluating the inventor. The greater the invention's REDUCTION TO PRACTICE (proof of principle? prototype? clinical experience? sales?) the more value it has because some of the development risks are removed. DEGREE OF PROTECTION is also important in the disposable device business, where getting good patent protection is difficult. Sometimes the manufacture of the device will have trade secret elements. In addition, a truly novel device with a doctor's name associated with it gives an element of protection because "colleagues will be reluctant to copy it directly." In fact, Meditech has successfully had the inventor call up the copier doctor and "lay a guilt trip on him." Inventor NAIVETE can be a problem for a company. Medi-Tech, which apparently has many physician-inventors who may or may not have academic ties, has a Q&A pamphlet telling doctors how to proceed if they have a novel idea that would make a good product: "Are you afraid someone will steal your idea? Who do I talk to at the company? What do I say? How do I 'deal with' my administration?" It also provides invention disclosure forms. Medi-Tech has found that many invention disclosures and patent applications they receive are poorly

done, narrow, and lack a good understanding of what else is going on in the field.

In answer to a question Abele indicated that Medi-Tech's brochure does not "in so many words tell the inventor to see the institutional technology administrator." A member of the audience responded that his academic institution has "more trouble with companies talking to our staff" to the point that by the time "we get together <with the inventor>, there is a lot to be untangled." Abele noted that the "adversarial spirit" existing in many cases between inventor and university is the nature, particularly, of hospital environments. "The engineer is an independent personality." Medi-Tech wants to have a good relationship with both the inventor and institution and so tries to have a Medi-Tech representative go with the inventor and meet together with his administrator, but the inventors tend to resist having these meetings.

Experiences such as these led to some of Abele's suggestions. Primarily, he felt the institutional technology administrator must do a better job of educating the medical staff by distributing information about how to deal with companies (who to see, what to say), how to value an invention, how to develop the necessary information for a patent, the nature of the product development cycle. Secondly, the administrator should provide case studies and a network of consultants who can get the invention to the right person in a company. Thirdly, university inventors and commercializers should belong to the institutional patent committee. Abele asked whether any university inventors have ever contributed to the development of their institutions' patent policies. Patent policies he has seen do not reflect this.

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Ms. Linda Cahill, Vice President of New Business & Development at Johnson & Johnson Development Corporation, said that although J&J has a "not invented here" attitude, it is comfortable with licensing in and has received much of its growth and profits from licensed-in products. She admitted that it is difficult to bring new concepts into a large company because it is difficult to find where they fit. A product R&D cycle can, in the embryonic stage, take from 5 months to 5 years. It is hard to fit that into a research budget that is decided in June of the preceding year.

She described how a product gets licensed in to J&J. Not through the unsolicited letter that tells nothing about the product or the inventor. Possibly through a telephone call if the caller and the J&J representative have met before. "Once I know you, it is much easier for us to develop a relationship." Most probably, if the project has a champion within the company. "If you know somebody you worked with successfully in the past, he is going to help you push a project through in the future." J&J also likes to have a good relationship with the inventor because the development of an invention can go through so many changes on the way to becoming a product. "The final product is always at least 50% different from how it started out."

Cahill gave her perspective on the costs of bringing a product to market. Researchers always think they have a $500M deal and that the company is a "bottomless pit" into which research dollars are

going to be poured. Unlike Medi-Tech, however, J&J does not have many small markets. It has large markets, and product development is expensive: (1) longer R&D; (2) the cost of animals used for animal testing; (3) longer toxicology testing (2-3 years instead of 6 months); (4) 400-page clinical reports for each patient participating in a trial; (5) the DRGs, a problem in all medical drug development, which has traditionally developed by introducing a new product that offers a small improvement on an older product. DRGs make it difficult to demand an increased price for anything if it is only somewhat better. "Only revolutionary things are going to be able to support the tremendous amount of clinical development that it takes to produce many new medical products today"; (6) more competitive pricing; (7) increasing marketing costs; (8) an average decrease of 4% in return-on-equity in the last decade in most medical companies. In sum, big companies are risk averse because 95% of new ideas don't work, and the successful products have to pay for the ones that failed.

Cahill gave examples of how costs can mount on a project. The catheter you may be interested in developing is made from a product that has to be licensed from another company. The cost of stability testing for pharmaceutical now takes 6 months to a year, added to other product development costs. "It is not uncommon to see three or four groups working together in order to get a product out. In genetic engineering you need one group to clone; another group to do gene expression; you might need to go to another university to get a monoclonal antibody; to attach the monoclonal to the drug you might need to work with another university. It is not uncommon to see three to four multi-level licenses and multi-level royalties." This cuts into profits, making it more difficult for large companies to justify negotiating dual arrangements.

Cahill had some recommendations for university administrators who were interested in licensing products to J&J.

(1) Get as broad patent coverage as possible, based on information from the inventor, not from the administrator. Patents are extremely important to most drug development and the larger medical markets.

(2) Introduce the company representative sooner to the researcher involved. The researcher believes in what he is doing and can convince the company more quickly than the administrator of the level of support he is going to put behind the product.

(3) Have more face-to-face meetings with the corporate representative and decision-makers within the company. Consider doing some traveling to meet some of the major people in corporations, to introduce them to your institution's portfolio of inventions, and to see what a product goes through in product development.

(4) Find a champion for each project. "The only way things get done in this business is if somebody in a corporation believes in it. It is not going to go right, and as soon as it needs additional funding or as soon as the first series of tests don't work, somebody has got to be there to champion it."

(5) Be more realistic about an invention's potential, development, and market.

(6) Keep a file of annual reports. Know the company and its product lines.

(7) "Don't sell products you wouldn't use yourself or on your children."

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Dr. Zsolt Harsanyi, President of Portan, Int'l., Inc., gave his personal perspectives on how companies evaluate inventions. "A single decision, whether by a champion or chairman of the board or whoever is in power, can completely negate the results of any assessment." An invention must have a champion. Therefore, the university technology administrator must know the structure, interests, and markets of the companies he deals with in order to find that champion. Would the invention in question improve a company's present product, expand a product line, move into the next generation, start a new line? Read Chemical Week or the Wall Street Journal to find out what company strategies may be.

The company does the actual evaluation after deciding whether the project fits the corporate strategy. What is its stage of development? The more developed it is, the more it is worth to a company. What else needs to be done? How important and difficult is that to do? The inventor and institution must ask themselves the same question that the company will ask about the invention: "What is the value of what I have? What is the chance of its success?"

You must be able to answer the question: "Why should anybody be interested in this product at this particular time?" The more you know about the other competition, the better chance you will have in the negotiations. What edge does your product have on the competition? Is it further along in development? Is it unique? Is it patented? Is there associated know-how? You must point out the advantages your invention has over other products and not assume that the company will see them without being told about them.

It helps to know if a company has committed to be in a certain field even if the company is not sure what products it will be marketing.

Will a company pay for what you have? "Don't be completely dazzled by very large figures" of how much product development will cost. The actual cost of bringing your product to market may be far less than the company tell you because the value it puts on the product also covers the failed products. Some pharmaceutical products may cost $10-$20M to bring to market, but Harsanyi has seen some in the $2M range. The important thing again is that "you have to know what you have and what has to be done for that product."

Finally, the best product is not necessarily the one that is licensed. When you present a product, try to understand how the company might use it so you can be on the best footing when you negotiate. Harsanyi explained that if the best product is not available, a company will take the second best. If the second best isn't available, it will take the third best because ultimately it "will tie the sale of that diagnostic to the sale of this pharmaceutical. Any time a physician prescribes my drug, he's going to sell my diagnostic test."

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The "Technology Licensing Practices within Industry" workshop began with a presentation by Mr. Jon S. Saxe, Vice President (responsible for patenting and licensing) at Hoffmann-LaRoche (HLR). HLR is a multi-national company with $4.5B revenues split evenly between 3 businesses, each generating about 1/3 of revenues: prescription pharmaceuticals (Roche Labs); fine chemicals for animal and human health (HLR is the largest manufacturer of vitamins and feed additives); diagnostic reagent kits, products, & services (Roche Diagnostic Systems makes test and lab equipment; Roche Biomedical Laboratories provides diagnostic services; Medi-Physics, Inc. makes radiodiagnostics and radiochemicals.) HLR is heavily committed to internal research ($2M/day on in-house R&D). Approximately 15% of corporate R&D ($60M) goes to biotechnology research. (HLR has the largest biotechnology research unit in the world.) Its four R&D groups include the Institute of Molecular Biology, a basic research institute where scientists from HLR and universities pursue their research without any company direction or any necessity that it have a commercial payoff; the Exploratory Research Group, which readies the molecular entity for development; development; and clinical research.

Why and what kinds of technologies do companies license? Companies license to grow and diversify more quickly at less risk, to complement its own R&D efforts, to fill a product line gap, and to acquire different kinds of subject matter. The new molecular entity has the biggest impact on a drug company's profit picture. Delivery systems technology can make a differentiated product out of a molecule that previously had not been useful. New process technology that makes a product more cheaply does not have as important an impact on long-term profits as a new product does. Sometimes, though, a new process opens up a new area of end products.

HLR evaluates technology for licensing by determining the probabilistic chances of its scientific and commercial success. A project in the basic research stage rarely has more than a 1 in 10 chance of scientific success (i.e., getting federal regulatory approval). When looking at a 15% rate or return (reasonably common in the industry), HLR asks for a 30% projected rate of return because it undertakes projects that do not have a better than a 1 in 2 chance of succeeding after $5M has been spent. Regulatory approval does not guarantee commercial success. HLR may not sell the first item for 10-12 years after approval, by which time its competitors may have something better.

A desirable licensing venture has a company champion, represents a unique opportunity, offers an operating fit, a strategic fit (positive and growing cash flow), and a financial fit (meets cash flow). The goal of the financial evaluation of a licensing venture is "to establish the minimum price that the company, as licensor, is willing to accept, or to establish the maximum price that the company, as licensee, is willing to accept." The company also calculates the project's "opportunity cost". Its economic benefit (net present value) must be greater than the economic benefit for

doing the next best project. Valuing projects on a "net present value" basis telescopes timing and risk. It takes future revenues and expenses, uses the cost of capital, and calculates their current value. The net present value does not tell whether the revenues will come in 2 or 10 years. A financial evaluation considers four kinds of information: (1) the time until revenues begin; (2) the investment phase before revenue begins (front-end payments, R&D, fixed capital, working capital, promotion, infrastructure); (3) the return phase (volume price, production costs, operating expenses, royalties, residual value of business); (4) assessment of risk.

The negotiators' goal is to find an arrangement satisfactory to both parties that can work practically. University negotiators should be aware of the particular areas of concern to corporations in their dealings with universities. First, the availability of exclusivity gives the corporation the framework in which to invest profitably. Second, front-end payments are difficult because of the risks involved. Industry can promise payouts downstream if the product is a success, but universities must share the risk. Instead of a front-end payment a university might might consider agreeing to delaying the payment until the risk period has passed; including contingency clauses in the contract for certain events; step-rate royalties. Third, there is a dangerous trend in federal and state legislation to add clauses requiring a product to be produced the U.S. or a given state. Fourth, the technology may lack a clear title because of multiple sponsorship. Fifth, inventor claims should be settled before money is involved rather than 5-10 years later when substantial royalties ensue.

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Ms. Jill H. Krafte, Patent Attorney, W.R. Grace and Co., began by offering the lawyer's perspective on negotiating a license. First, the parties are partners, not adversaries, in a mutual cooperative effort to achieve a common goal. Both parties should get down to specifics early and understand each other's position on each issue. Second, the university negotiator should understand that the position of the corporate attorney is to represent the corporation's interest as well as to reach an agreement. Third, legalese should not be allowed to take over the negotiations. Negotiate in English. The completed agreement can later be drafted in appropriate legal language.

The two parties can take a number of approaches to resolving differences. First, keep corporate and university starting perspectives in mind. The university is contributing the invention, but company is contributing the dollars and "feels that the ultimate product is theirs, particularly in sponsored research products." Second, negotiate one issue at a time. Resolve the smaller, easy points first. It is "psychologically useful" to agree on something. "If you can agree on one issue, you are more likely to agree on the next issue." talking about one issue rather than the overall relationship makes it easier to see what the difference in the position is. Explain specifically why you want a certain provision. "If you can communicate the real basis of the difference, the problem may resolve itself. It may turn out you are talking about a small

difference in position, or the difference may be something the other party does not care about ... Just putting the problem into clearer terms may prompt a solution." Third, if you come to terms quickly, you are more likely to agree. When the negotiations get bogged down, the parties lose interest. "Either the professor has gone on to other interests, or the window of opportunity is passed, and the corporation has decided it doesn't want to bother anymore."

Corporations have a number of concerns in agreements with the universities. First, the intended relationship between the parties should be defined at the outset. Will it be a licence or a long-term relationship involving joint development of a basic idea? Second, the corporation will want exclusivity and royalty terms that will its maximize profits. Despite some universities' fears to the contrary, "the corporation is not going to sit on a hot product if that product has commercial value. Third, a corporation prefers to have exclusive rights to practice the invention though this is not always possible or warranted. An alternative is to have exclusive rights in a limited geographic area or specific field of use. The large corporation finds a project less attractive if federal funding is involved; the university cannot offer it as wide rights, e.g., statutory preference to licensing small businesses. Fourth, intellectual property should be protected in a timely manner. It takes about 90 days to file a patent; a 30-day period is not a realistic estimate. Fifth, enforcement of patent rights must be addressed. Corporations want the right, but not obligation, to sue infringers. The university will probably be protected from spending money to pursue an infringer, but if an important patent is in question, it should litigate if the corporation decides not to. During litigation royalties are suspended or a minimum annual royalty is paid. If neither party wants to sue an infringer, that reduction of royalty would become permanent because the corporation would have non-exclusive position in market.

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Ms. Elizabeth H.S. Wyatt, Manager, Corporate Licensing, Merck & Co., Inc., described Merck as a $3.7 billion, world-wide pharmaceutical company with unit sales roughly equivalent outside and inside the U.S., with a $400 million research budget covering approximately 4,000 research employees. She herself is responsible for licensing in the following areas: virology, biotechnology, delivery systems, animal health, ophthalmology, specialty chemicals, and chemical processes.

The more developed a compound or technology is, the more it is likely to be of commercial interest to a large, respected pharmaceutical company. The licensee will also be better able to define the commercial value and the financial terms which it can offer. More specifically, a licensed technology should (1) have "a strong research concept, which can be explained by logical, biological pathways," (2) have novelty, and (3) be patentable. "In the chemical pharmaceutical area some key factors are: is there a chemical structure which is identified; is there some degree of safety data; does the licensor have efficacy data in one or more species of animals; is it obvious what the commercial utilization might be; and, have patents been filed."

While Merck does give grants for basic research, they are only in the tens of thousands of dollars and are given to further good ideas and to generate good will for the company. They have either no or minimal commercial ties. Typically, Merck undertakes commercial negotiations when there is an identified product entity, which might come some years after basic exploratory research.

The spectrum of potential licensees includes small, medium, and large-sized companies in the health care business. The smaller companies, such as those in the biotechnical industry and other subsets of the health care industry, are sometimes in a position to license-in basic conceptual research and bring it to the stage where at least limited animal efficacy data is generated. At this point the smaller company and Merck may have a more meaningful discussion. Wyatt suspects the growth of the biotechnical industry has resulted to a large degree from reduced federal funding of basic research and from the expectations of the scientist- inventors that "their rewards will be larger if they commercialize their ideas through profit-making institutions. As a result, these biotechnical companies may frequently act as intermediaries for the larger pharmaceutical companies."

The type of terms a company such as Merck may offer relates to the level of product development, the degree of diligence it can offer in developing the product, the degree of exclusivity in terms of patent protection and likelihood of avoiding substantially similar competition, the risk each party will have to bear, and the size of the commercial target. Merck would be interested, for example, in licensing a novel and patentable prospective cure for diabetes, which has shown efficacy in one animal species, or at least hypothetically should show efficacy because the licensor has done sufficient basic research to understand what metabolic pathway is being influenced and how. Merck would be less interested in funding a project to develop a vaccine against parasites since there is so little likelihood that common antigens can be identified to protect against the 10-15 very different worms and insects, such as roundworms and ticks, which afflict animals. Although such an invention would be revolutionary, there is no clear pathway to the goal.

Wyatt has found that the most effective "prospective licensor representatives" are those who understand the application of the invention to a particular area of science and are "somewhat more dispassionately able than the inventor to define the value of the invention." They are astute about targeting the right possible "buyers" of the inventions; that is, they have a good sense of the therapeutic classes and the businesses in which the targeted companies are engaged, and "they go to as few as necessary to achieve a reasonable selection of possible licensees." While they understand the patenting process very well, they are practical and businesslike with regard to a commercial agreement. Finally, they act as the single spokesperson for the institution they represent.

Wyatt reminded the audience that negotiators for their respective institutions must recognize that at Merck arriving at an agreement can take up to two years although the average is one year from the time Merck begins serious evaluation of an invention.

Reaching an agreement is time consuming because much investigative work must be done to understand the invention's value and because resolving the often conflicting needs of a number of interested parties.

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The conference closed with a "Case History of a Successful Product Resulting from University-Industry Collaboration", which described the history of three successful commercial products that resulted from a university-industry relationship. The panelists described the technology, patent status, and agreements under which they were developed.

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Dr. David F. Kiszkiss, Director for Research, Dana Farber Cancer Institute (DFCI), described the three test kits for ovarian cancer, breast cancer, and small cell carcinoma of the lung that were developed under agreements with Centocor and that were based on monoclonal antibody technology (MA). The first two kits were not patented; the last has a patent pending. The breast cancer test has no patent protection because DFCI decided that protection limited to one specific antibody would not be terribly valuable to it or to any potential licensee. The lung cancer kit is a different circumstance because coverage is somewhat broader because the invention identified "an antigenic determinant that might be the reactive component for a variety of monoclonals that might be produced." DFCI felt this broader patent would have more commercial significance.

Although a MA technology might be patentable, it is not always a good decision to go ahead, particularly when a MA is identified prior to entering a licensing agreement. If you can pass patent expenses on to a licensing partner, the decision to patent is an easy one. If DFCI has to bear the patenting expenses itself and the ability to license is still unknown, it is fairly cautious in proceeding with a patent application. DFCI produces a large number of MAs, up to a couple dozen per week, many of which prove to be of little value. If DFCI tried to patent all of its MAs, it would be filing a couple hundred applications yearly, not a good financial decision in DFCI's opinion.

DFCI tries to protect non-patented technology by retaining control of the clones of the hybridoma cells which produce the MAs. It provides the clones to other investigators under a waiver form in which they agree not to use the clones for commercial purposes or to pass them onto any third parties. DFCI does not have an institution-wide policy covering the distribution of biological materials. Therefore, it lets the individual scientist decide how to distribute the clones. Some will not distribute them. Others register theirs with the ATCC, which will do the distribution for them. If DFCI has a licensing agreement involving a MA, it tries to maintain a reasonable level of "research purpose" distributions with other researchers. Again the PI has the last word on the distribution.

The technology is treated as though it were patented for the purpose of royalty distribution and administrative tasks.

A licensing agreement must be advantageous to both sides so that both sides are happy. Elements of DFCI's agreement with Centocor include (1) multi-year funding at an appropriate level, i.e., the amount of support that one would expect to get from the NIH; (2) the freedom to publish; (3) institutional approval of other academic participants. Before Centocor provides cell lines or an antibody to other basic research academic investigators, they have to touch base

with DFCI; (4) the ability to distribute reagents to academic colleagues; (5) a requirement for diligence in commercial development. A university can put itself in a difficult position by specifying unrealistic development hallmarks especially if it has never had any experience in industry; (6) an arbitration clause, which is the second-to-last resort before actually bringing suit; (7) an appropriate royalty rate; (8) designation of the antibodies. Centocor must use the designations given to the MAs by the DFCI investigators unless the DFCI investigators agree differently. This is in order to retain recognition of the scientists who do the research.

No agreement can cover everything. Unanticipated problems will occur. A good working relationship can usually work out any problems. What are its components? First, "begin with a known quantity," in DFCI's case a MA already made and partially characterized. Second, design an agreement "advantageous to both parties." Third, have the scientist-to-scientist and administrator-to-administrator relationships be ones of "mutual trust and confidence." Centocor administrators have not tried to negotiate with DFCI scientists. When something has come up, DFCI has been able to discuss the problem full, with its scientists and go to the "negotiating table with a common purpose." It can be demoralizing to sit down to negotiate a point in the agreement and "your own scientist is on the other side." Fourth, have rapid product development. "Investigators get very disgruntled if they feel the company has not made its best effort to develop the product." Fifth, have patience. Sixth, try not to burden each other with unnecessary paper work. Seventh, deal with a person who has the authority to make decisions. Finally, have good luck. The Centocor-DFCI agreement is about six years old. Dr. Kiszkiss "would not want to neglect the role that good luck has had in that."

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Mr. Spiro G. Rombotis, Manager, Corporate Development, Centocor, Inc., briefly profiled the pharmaceutical industry. It has excess capacity in manufacturing and sales, a product shortage because of inadequate in-house R&D with resultant increased acquisitions and licensing as mainstream rather than complementary activities. A new factor in the drug industry picture is the growth and consolidation of the 10-year-old biotechnology industry, which has provided a tremendous amount of money for research and development. Of the total $2B invested in biotechnology in 1984, specialty biotech houses received 20% ($400M), public sector (NIH) and universities received 35% ($700M), and in-house industrial firms received 45% ($900M).

The smaller biotechnology firms differ from the large drug houses in their sales strategies, a difference which affects their research-and-licensing arrangements. As regards MANAGEMENT, a university negotiator is able to deal with a company officer who has the authority to make decisions. As regards FINANCIAL STRENGTH, a smaller company can make its capital resources a real factor in negotiation since its research areas are less diffuse than those of the large drug houses, which have more diffused in-house research priorities. As regards TECHNOLOGY, what is the quality of a company's technology and its track record in product commercialization? As

regards REGULATORY EXPERTISE, a small company cannot always match large companies, but if it can use its resources in a specialty area, "where the regulatory environment has not clearly been shaped yet," and have the "right rapport" and contacts in the regulatory apparatus, it can at least have an equal footing with a larger organization having "a traditional or different class of agents that would go through a different approval process."

Rombotis outlined the factors that lead to a successful TT arrangement. The university should try to understand the corporate perspective and have realistic agreement milestones in order to achieve a mutually satisfactory agreement, which is an important first-step in establishing a long-term relationship). The right rapport and level of relationship must exist before proceeding into long-term relationship.

The QUALITY of the corporate partner is important. A company's ability to produce products is the telling mark of whether it can convert the technology into successful commercial products. The parties can argue about royalty amounts or front-end payments, but a $10,000-20,000 difference in positions on up-front money may become academic if a successful company can millions of royalty dollars later. A university negotiator should try to shift away from the purely quantitative aspects of an agreement and look at the quality of the segment of a large company, or the quality of an entire small company and its ability to deliver the particular segment of technology concerned.

The SPEED with which a company can commercialize a product is another success factor. Since the product life cycle of an in-vitro diagnostics product is 3-4 years, long before a patent is generally allowed, a company must be able to commercialize a product very quickly, as Centocor did with DFCI's two unpatented technologies.

The quality of SCIENCE on both ends is a success factor. The Centocor scientist is a hybrid, a person who has certain basic research interests, but also uses his talents in industry in order to commercialize his basic research.

The FLOW OF INFORMATION must be continuous and proactive. Centocor tries to prevent issues from arising. It tries to resolve any problems early. This requires keeping each other informed about any snags in the commercialization program, the regulatory approval system. There must be multi-level contact with the people who can make the administrative and scientific decisions. The university people should deal with a corporate scientist who has the clearance to proceed with a given research project.

The key factor is to see a LONG-TERM RELATIONSHIP vs. a one-time deal. In a small company the licensing relationship is when relationship begins. Centocor and DFCI did not see their first product as their only product, but foresaw a "continuous collaboration" though neither knew what form it would take. Centocor saw the quality of the science and the advantage of supporting the DFCI scientist, which would put them into a position to license any ensuing DFCI technology.

A final success factor is the COMPANY'S POSITION IN THE TECHNOLOGY TRANSFER PROCESS. In many ways Centocor's position is to

be a corporate developer--to speed up a product's development and ready it for a large drug house that has the scale-up capacity and vast distribution channels, but does not have the ability to quickly commercialize a promising technology with a short product life cycle. A company in this position must obtain a licensing deal reasonably quickly.

Reasonable corporate development milestones vary from technology to technology. The university negotiator should request the company to provide market forecasts in order to estimate the royalty stream and be more realistic about royalty rates. This is not a game where the cards should be played close to the chest. The aim is to reach an agreement beneficial to both parties that will develop a commercially useful product.

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