Chapter 1

Commercialization of Molecular Electronics

1.1 Introduction

I have chosen to begin this book on molecular electronics with the business section. If that does not interest you, I understand. Simply skip on to Chapter 2 where a light introductory hors d'oeuvre to molecular electronics is served followed by ~350 pages of gut-filling scientific beef for the chemist, surface scientist, device physicist, computer scientist and applied mathematician, in that order.

Forget not molecular electronics' experimental historical progression. Many from the chemical and solid-state electronics establishments were pontiffs of skepticism. They capitalized on the easiest thing to do in science; namely, they offered a dozen scientific reasons why this new field will never break ground and thereby decreed its unworthiness of financial support. But, as always, the movers and shakers tried it anyway, with backing from risk-taking federal research program directors that were not bound by the traditional, and often good, peer-review evaluation processes. Once the scientific results were manifested, traditional grant-funding routes became more available, though it took over a decade to see general acceptance as a worthwhile exploratory science. As commonly occurs, many of the initially nay-saying pontiffs have converted to become avid researchers in the field, though never having confessed their past offenses. Therefore, I begin with the funding and commercialization aspects of molecular electronics since it suspends the canvas upon which the foundational scientific portions of molecular electronics were crafted.

This chapter is written in somewhat of a personal letter format, from an academic scientist to my academic scientist or engineering colleagues. Beginning with an outline on the commercialization landscape for molecular electronics and methods for insertion into such a well-developed electronics industry, it will cover some basic business concepts. These principles might seem pedestrian to the seasoned businessperson; nonetheless, they are foundational and critical for my non-businessperson colleagues to consider if they plan on launching a company of their own. Secondly, advice and forewarnings are provided to the academician interested in starting a company based upon their research. For example, all in the name of your company, you will subject your ear-sore cranium to hundreds of hours of phone conversations, fend off equity-ravenous attorneys, perform repetitive dog and pony shows for information-sucking venture capitalists (VCs), spend dozens of mealtimes smiling at the moneyed who want to press the flesh of the famous scientist, bear good-intentioned investors seeking updates on when their holdings will reach the 1999 e-commerce level, wrestle with financial spreadsheets that appear more confusing than chaos theory, and suffer repeated totalitarian episodes at the gloved-fingers of the cheeseburger-breath and orifice-examining airport security guards as they stroke their wands across your loins. Starting companies is not for cowards! Finally, a quick education is offered to the prospective Chief Executive Officer (CEO) so that he/she can become familiar with the far-too-typical idiosyncratic academic mindset before accepting a position with a university-founded startup.

1.2 Commercial Challenges of Molecular Electronics

The advances in the semiconductor industry came through Herculean efforts involving thousands of person-years of work and trillions of dollars of investment, hence any direct frontal assault by a new technology on the semiconductor industry will fail, period—end of discussion. Should we therefore retreat and leave the future to an industry that is struggling to meet the ever-increasing demand for electronics using a half-century old technology? Never! We must simply realize the facts for what they are, and devise a strategy that can overcome the hardened sites of the silicon fortress by focusing upon its weaknesses and leveraging its strengths. We must never lose sight of the fact that an insertion is possible if the fundamental and financial barriers facing the semiconductor industry are driving it to consider other options. And since molecular electronics has been demonstrating an impressive set of properties that have stunned even the greatest critics, the initial results could be a harbinger of the consumer electronics world to come.

A complementary technology for the electronics industry that is not solid state semiconductor-based will require the following.

Investment. More than just a few hundred million dollars of overall investment will be needed by a few laboratories or startup companies to compete with the trillions of dollars invested in the silicon market.

Insertion Strategy. A strategy, or business plan for insertion is needed that does not initially target the impenetrable high-end of logic and memory, i.e., there must be an assault on the unprotected or hitherto unforeseen product areas.[1]

These will be considered in succession.

1.2.1. *Investments in Molecular Electronics*

When considering investments in molecular electronics, there are noticeable similarities between molecular electronics and the biotechnology startup companies of the late 1970s and early 80s, which investigated areas that were outside the domain of the big pharmaceutical companies of their time. Angel investors and VCs filled the funding void even though the gestation periods (or time to market) for biotech companies' products were long, often on the order of 10-15 years. The lag in commercialization was due in part to Food and Drug Administration (FDA) approval guidelines needing to be fulfilled; nonetheless, much money could be raised and made. Once the startups showed prospects of insertion into markets by addressing fundamentally different biological mechanisms to bring health to the consumers, or simply the mega-companies feeling compelled to buy a "lottery ticket" to secure some hard-to-quantify future hopes, alliances and buy-outs became the order of the day. I believe that the funding trend for molecular electronics will be similar.

Angel investors are usually individuals or small consortia of investors, often the founder's friends, family or associates that have sufficient personal net worth to make high-risk investments. These investments generally follow trust in the founder of the company rather than a calculated assessment of the technology and the market risk vs. potential—it's "a bet on the jockey rather than the horse." Many characterize angels as unsophisticated investors and contrast them to "smart money", such as institutional or venture capital money which can bring domain experience and contacts to the table. Angel money can be simpler to secure and with lower dilution to the founder's interest. On the other hand, a network of angels rarely provides the asset base needed for further rounds of funding that are almost always required to bring a product to market. If a VC invests in a later financing round of a company that was originally angel-funded, regardless of the former terms of the deal with the angels, the VCs will generally be looking to give the angels a significant dilution to their money. In this manner, the VC's money buys more of the company per dollar than the angels' original money did, even though the risk could be considered lower at the later stage in the company's life. This is referred to as the angels "taking a haircut." It is not uncommon for the angels' investment to be worth only pennies on the dollar relative to the VC's money, and in this case it is referred to as a "cram down." Regardless of the angels' original terms, they have to accept the new terms for the ongoing of the company because their alternative is not rosy; namely, the company goes out of business. Hence the willingness of the angels to swallow the VC's terms, albeit with a lump in the angels' throats. So consider this before bringing your family and friends into the early stages of your corporate deal or else you might have nowhere to go for the holidays.

To prevent future funding trouble, it is advantageous to be associated with a lead VC firm that has the assets to further invest in the company through the entire series of funding phases (often four or five rounds of funding), to the point of commercialization of sellable product, public offering or other liquidity event. But if the company does not meet its milestones, the VC administers new haircuts, which give the VC a larger portion of the company per dollar invested.

VCs do not relish deals where large numbers of angels having invested in the company at earlier rounds. There are several reasons for this, but it gets back to the unsophistication of the angels and commonly their inability to heavily fund future rounds. There are often hard business decisions that are required by the VC as a company moves through its early phases of growth. The unsophisticated angel can be a thorn in the VC's flesh because it is difficult for the angel to comprehend the necessity of the corporate changes in direction and recapitalizations, particularly when the recapitalization is at the angel's expense. Moreover, a disgruntled angel can pose a litigation risk to the VC, especially if the angel is forced to take a dilution.

There is an old saying, "Never forsake the one who brought you to the dance." Don't be too eager to drive off with the VCs in their Corvette while leaving the angels to walk home. If the founder honors the angels and defends the angels' interests to the self-centered VCs, even at the expense of the founder's stock if need be, the angels will stand with the founder through the roughest times and the founder will never fear litigation from them. Recall, the angels bet on the founder when all the founder had was a vision, and they will be far less prone to forsake the founder than would an institutional investor. Never leave the angels at the dance; deal honorably with them and they'll stick closer than a brother.

Commercialization costs in excess of $100 million to VC consortia for a specific product line do not deter the larger firms from making investments as long as a clear path to product revenue can be identified and projected to undercut the cost of silicon in the commercialization timeframe. A single VC firm would rarely, by itself, write a check for $100 million even though their funds could be in excess of $1 billion. Although most VCs pride themselves on the ability to make assessments and insert top-notch board members and business teams to guarantee milestone deliverables, once it comes time to writing an investment check, the lead VC seeks other VC partners, even at the early stages. The partnership is not through benevolence to share the wealth, but to dilute the risk if failure is encountered and it expands the base of expertise available to make the company a success. Hence, VCs are often referred to as "lemmings" because they have a tendency to stand back and wait for another to take the lead, but when the lead is taken, especially by a larger and more well-known VC fund, there are dozens of smaller firms willing to throw their shoulder to the plow, praising the company's prospect for growth and accordingly writing supporting checks.

Angels are not alone in placing extraordinary value on the individuals. VCs do the same. If the company is led by a CEO that has a proven track record in the product domain of the company, i.e. has brought other such high tech companies from startup stage to become billion dollar market cap companies, the VCs are far more likely to fund that company. The VCs generally want to see (1) a first rate scientific team of founders with strong intellectual property (IP), (2) a first rate management team with a proven success record in the field, and (3) a business plan with a definable path to a manufactured product that has definite advantages over competitive mainline products at the time of insertion into the market. If a company lacks any one of these three fundamental building blocks, it is unlikely to be funded, unless the VC firm feels that it could build the business team itself or provide the skill set needed to define the product line. It is essential, however, that all three pieces be in place before a VC will fund the company.

Various other vermin-like names have been used to characterize VCs' modes of operation. But it is important to realize that the bottom line for a VC is their return on investment (ROI). In fact, they are mandated by law to bring the optimal return, within legal bounds, to the investors in their funds, who are referred to as "limited partners". Therefore, it is their primary objective to maximize ROI, regardless of the angels, even if the angels are friends and family of the founder. The reality is that only one or two in 10 VC investments, regardless of the field of investment, will ultimately be big winners. Therefore, the VC can justify, at least in their own minds, the dilution of others in each deal.

In general, if the VC sees the founder as a key component to the long-term survival and vitality of the company, the founder will be properly "incentivized" with stock or options to keep him/her properly engaged. Good VCs realize that people are their best assets. It is not equipment or their own experience. It is people—always has been and always will be. So incentives to the founders and management are needed to ensure the utmost ROI to the VC. Realize, however, if the founder becomes less important or even a liability to the ongoing progress of the company because of their waning interest or unneeded expertise, a re-capitalization can leave the founder with infinitesimal percentages of the company in comparison to the VCs and the essential business officers. There are examples where the VC and their officer buddies have well padded their stock portfolios while the scientific founder can't even afford a new suit.

The good VC can secure the expertise needed at the board and senior management level to propel the company to success in a manner that few scientists alone have the ability to do, regardless of the founder's reputation in the scientific arena. There are early-stage VC firms that will help the founding scientist through many of the initial planning phases as well as aiding in the insertion of an appropriate domain-experienced CEO and formulating a business plan. Some feel that the founder sacrifices too much of the company when approaching VCs at the very early stage before a business structure can be put in place. That might be the case, but I do not generally agree. I liken it to the experienced manager of a prizefighter. Sure, the manager receives a hefty cut of the champ's hard-earned winnings. But in return, the champ can focus on hitting and dodging and need not be overly concerned with bottom-dwelling lawyers, event promoters, scheduling, advertisers, maximization of prize negotiations etc. In the case of a startup, teaming with a good VC can result in a far more streamlined company where the VC manages the business plan, CEO selection, board constitution, real-estate decisions, legal concerns and the like. They do this, of course, after extracting their pound of flesh. But most VCs are quite good at establishing management, monitoring expenditures, minimizing legal expenses, etc. It is similar to university administration. The professor pays a significant part of their research funding to the university in indirect costs in return for laboratory space, utilities, maintenance, salary and benefits administration, insurance, tax statements, legal counsel etc. Therefore, there can be a significant upside to the founder for early VC partnership, not to mention some measure of stress relief, so that the academic scientist can focus on the technical side of product development. In return, the good VC provides sufficient incentive to the founder to keep them fully engaged in the technical aspects. As long as corporate founders and their angels realize the ultimate mission of the VCs, a healthy relationship can be enjoyed because "a small part of a big pie is much better than a large part of a small pie." If properly structured and financed, all can see substantial returns on the big winners.

Unlike the biotech industry, molecular electronics startup activities will not generally need FDA approval for their products to come to market. However, the products' time to market will often exceed the 2-4 year time frame that has become the main diet of the typical high tech VC. This is especially true in cases when the ultimate targets seek a market share dominated by advanced silicon manufacture, such as memory and logic. Therefore, another method to consider funding of the molecular electronics startup is through early alliances with major electronics companies that often (not always) can demonstrate a more patient time horizon, such as 10 years, until ROI is realized. The early alliance can provide the startup company, which is usually heavy on the academic side, with a healthy dose of commercial reality in understanding the enormous barriers to taking a blip on a laboratory oscilloscope into a scalable and marketable device. The alliance partner can use its domain-based infrastructure to carry out the needed marketing and product insertion through its established customer base.

One must also realize that even the mega-companies terminate far more exploratory projects than they ultimately convert to commercial product. Therefore, even with the deep pockets of the larger corporations, market factors drive them to make hard choices that must be in place to optimize return to their investors, which is often viewed in the short-termed quarterly bites. Additionally, depending on the structure of the alliance, the startup usually must negotiate terms on its technology that give that one mega-company a large portion of the rights to the IP. Therefore, the alliance has its restrictions.

In the context of a corporate alliance discussed so far, there is an understanding that the alliance is within a business sector of the large company. There are naturally other singular or hybridized relationships that can come through investments by the large company's VC wing into the startup. The VC units of the mega-companies have much the same ROI and focussed view that other VC firms maintain. When a mega-company's VC wing makes a small investment in a startup, in the $1-2 million range, this is more of a lottery ticket and or a placeholder to see the technology progress with a front-row seat via a board observer post. This level of investment might also give certain "rights to first refusal" to the mega-company wherein they have the rights to buy the technology before any other company could acquire the rights. Hence, there is an immediate limitation on the startup's future that must be balanced against their short-term cash needs and the prospects for development and commercialization aid that could ensue from the relationship. The large company will often prefer a board observer seat rather than a full board seat with voting rights. This results because a full board seat would cause the mega-company to have a fiduciary responsibility to the maximization of startup's shareholder value, which might conflict with the mission of the mega-company. An investment by the mega-company in an early stage startup in the $5-10 million range often comes with much deeper restrictions to the startup. Specifically, the startup becomes more of a subsidiary of the large company and gross limitations of the startup's interactions with other companies will be imposed. Again, such a relationship might be best for the startup once the long-term objectives are assessed with a desire to maximize return to its small pool of investors.

An alternative funding route available to molecular electronics startup companies during their early stages are through federal grants such as the NSF's Small Business Innovation Research (SBIR) grants, and other programs available through, for example, NIST and DARPA. The good thing about these grants is that they are exploratory in both the scientific and investment sense. Also, there is no formal payback needed to the government since it is an effort to spawn new industry with a very long-term vision of ROI. The ROI would come through job creation and an expanded tax base. Once a specific path to product for expectable ROI is realized, then private sector funding can ensue.

In summary, there are several funding mechanisms available to the startup molecular electronics companies including angels, VCs, alliances with larger corporations, and federal grants. They are not mutually exclusive and they each have their advantages and disadvantages. Maximization of shareholder value is the responsibility for any company, therefore several factors must be weighed accordingly.

1.2.2. *Molecular Electronics Market Insertion Strategy*

As described above, the semiconductor industry is so well entrenched that the near-term key to new technology insertion is integration through complementation, not substitution. Supplementation can occur, supplanting can not, at least in the next two decades. The silicon industry also moves at lightening speed with respect to other industries. Products are constantly being replaced by updated versions, which harries even the most emotionally stable process engineers and marketers.

The electronics industry is also like a well-balanced and integrated ecosystem. Insertion of a new technology that solves one problem will have to interface well with the other existing pieces of that overall product. There must be acceptance by the industry as a whole before insertion by even a complementary technology could ever take place. Therefore, although startup companies have the advantage of being able to turn on a dime and move swiftly through a new landscape like reconnaissance troops, alliances between the pocketed forces of the startup companies and the major electronics superpowers will be needed—and sooner rather than later. This can provide a win-win situation for all parties by capitalizing on the insertion experience, integration expertise and established markets of the major players. Moreover, the major electronics firms can absorb and justify the outlay of hundreds of millions of dollars for a single product line, while looking for avenues to configure this new technology with their existing manufacturing and marketing capabilities.

It is critical to realize that while molecular electronics holds the promise of smaller devices that can be assembled with greater ease, the initial adoption decisions by the industry will require cost advantages coupled with technological superiority. Most companies spend four times more on cost reduction programs (materials or manufacture processes) of present products than they do on developing new products. This makes good sense. Their markets and customer bases are established for these products, therefore any cost reduction in an existing product immediately impacts their bottom line. Most strategies would be welcomed that would use molecular electronics to reduce the cost of an existing product while maintaining or increasing the product's performance (i.e. speed, densification, resiliency). *Minimally*, a two-fold cost reduction in process or materials, or a two-fold technological enhancement at the same cost will be required before any mega-company would consider insertion of molecular electronics into its higher end systems. However, for simpler bulk consumer applications where products are sold on the millions of units scale, even a 10% cost reduction can be attractive because the margins are tighter.

Another way to view the insertion is by the development of products for niche markets where there is little interest by the mega-corporations and in areas where current products do not serve well. This is actually the method by which most "disruptive technologies" insert. Then, clever engineers see the technology and apply it to other applications. In that way, the disruptive technology gradually moves up the sophistication food chain taking larger and larger market shares of well established and deeply entrenched product lines, as described by Christensen.[1] Disruptive technologies are never successful when they immediately target the high-end applications. So initially keeping the target application "simple, cheap and stupid (unsophisticated)" is the key.

Initial products in molecular electronics will be silicon complements, for example hybrid silicon/molecular devices that are outside the mainstream targets for the traditional semiconductor industry. Using either small molecule or nanotube (nanotubes are small in diameter yet relatively large in length) systems, biological and chemical sensors could provide a venue for insertion of molecular electronic devices for medical diagnostics or chemical/biological weapons detection. It would involve the perfect union of a molecular-based technology with conduction, impedance, capacitance, or other simple electronic function responses resulting from molecule-molecule or molecule-cell interaction processes. A device response time in seconds is generally adequate, rather than having to cater to the state-of-the-art demands of the high-end computing and memory needs of billionths of a second per operation. Additionally, sensing functions on the order of once to a few hundred times can be adequate whereas traditional computing/memory functions often need to exceed trillions of operations for their resiliency specifications. The margins for sensors can be large for "first movers" (first to market), although the market sizes are generally smaller. These early applications would permit researchers in this embryonic field to hone their commercial skills while refining their talents to address higher-end products.

An even simpler commercial entry point for a molecular electronics market might be the use of molecule or nanotube-based systems for interconnects, namely molecular electronic entities serving as the conduit for electron flow between two solid state devices. The molecules could be passive, thereby merely serving as nano-scale wires. Or they could be active so as to pass current at certain voltages and retard electron transport at other voltages, for example. In this manner, a long-needed kick could be given to a technologically stagnant $40 billion interconnect industry that has seen little change in the past 30 years.

Following these advances might be electronics and optoelectronics-based products in places where such functionality rarely exists today, for example, in clothing fabric, plastics and related flexible substrates for bendable displays and imagers. These are host platforms where silicon devices do not generally function well due to silicon's restricted solid and brittle nature. Consider conformal electronics, where the added electronics are embedded within or on the surface of the plastic housing, thereby adding nothing to the size of the final electronics package, but adding form rather than functional enhancement. One could envision molecular electronic antenna arrays in wallpaper that would permit cellular technologies, such as cell phones and mobile modems, to function distortion-free even within the traditionally shielded central recesses of an office building. Therefore, one need not increase the density or speed of a system with a new technology provided it adds a novel function, form or cost advantage.

Memory or logic systems might be developed that add functionality to traditional transistors. Some have termed these "silicon with afterburners" to enhance the functionality of the cost- or function-limiting components in present devices. For example, imagine a memory system where the signal isolation is based upon conventional complementary metal oxide silicon (CMOS) transistor technology with conventional word and bit lines. But atop each CMOS transistor is embedded a layer of molecules that serve as a nonvolatile memory storage unit. Therefore, the molecules do not increase the densification of the array. But they add functionality by making the volatile CMOS memory (which normally needs to have its memory refreshed 1,000 times per second) retain its memory for hours, days or more, through the use of the molecules for the bit storage. This would then make the volatile CMOS memory flash-like in its qualities, and minimally SRAM-like in its capabilities. Present-day flash memory, although able to hold its memory for years, requires a deep trench capacitor; hence it can not be fabricated on a normal CMOS fab line. The CMOS/molecular hybrid would obviate a dedicated flash memory line. Likewise, SRAM is a footprint-intensive memory that can only hold its state when the system's power remains on. Therefore, there is a foreseeable complement to silicon through the marriage of molecules to that parent platform.

Finally, entirely new generations of products could be envisioned that use molecules for the central processing and memory components of top-of-the-line computers in configurations that bear little relation to present-day solid-state architectures. There are high prospects for using molecular electronics in this venue; however, commercially relevant delivery times for such systems are minimally a decade away. Specific possibilities will be considered in Chapter 5.

1.3 Molecular Electronics-Focused Companies

Listed below is the current corporate landscape for companies involved in molecular electronics. Although the list is not comprehensive, it is illustrative of the companies that presently exist. The information here was obtained in the public domain and in non-confidential discussions with the companies' associates. However, the accuracy of the data received could not be verified in many cases, therefore, it is provided with the disclaimer of non-substantiation.

The 2001-2002 downturn in the capital markets has produced a skittish investment environment that has made ongoing financing difficult for many of these companies. As a results, some may fail due to lack of investment rather than lack of technical prospects.

Molecular Electronics Corp. (MEC). Molecular Electronics Corp. (http://www.molecularelectronics.com) was founded in 1999 to capitalize on molecular electronics. In addition to other breakthroughs in molecular technology, members of this scientific team developed the first self-assembled reversible molecular switch and reversible memory that has functioned for nearly 1 billion cycles at room temperature with no degradation. MEC views molecular electronics as a technological platform, enabling the creation of numerous diverse products. For instance, MEC's research and development in nanometer-scale electronics creates the potential for constructing electronic devices that are less expensive, consume less power, and are thousands of times smaller per device (and hundreds of times smaller overall) than existing technologies. MEC is presently forming strategic alliances with industry partners for commercialization of its IP, and for manufacturing and marketing of specific products based upon MEC's IP. MEC is working on conventional/molecular electronic hybrid interconnects in an alliance with Amphenol Corp., hybrid CMOS/molecule arrays in an alliance with Motorola, and seeking partners to develop molecular electronic displays and imagers based upon their patented and exclusively licensed technologies which date back to 1992 patent filings. The 1992 filings disclose the use of molecular arrays between electrodes that are further part of an integrated circuit; therefore, they are quite encompassing. After a hiccup-laden start in identifying domain experienced leadership, MEC is led by CEO Chris Gintz. Gintz is one of the famed original employees to leave Texas Instruments to begin the then high-risk VC-backed (Sevin-Rosen) startup called Compaq Computers. Gintz is the inventor of the first laptop computer (Compaq's LTE Notebook, US Patent 317,442) and he served as Compaq's Director of Technology, Planning and Development. MEC was initially privately funded through individual angel investors, but licenses, alliances and federal research grants are being used to support further efforts. No venture capital funding has been utilized to date, however, MEC is open to their investment.

Nanosys, Inc. (http://www.nanosysinc.com/). Nanosys is focused on the development of nanotechnology-based systems. These systems incorporate nanometer-scale materials such as nanowires, nanotubes and quantum dots as their active elements. These exploit the fundamentally unique electronic, magnetic, optical and integration properties associated with the materials. Devices constructed with these systems will be directed toward chemical/biological sensors, nanoelectronics (electronic memory and logic) and optoelectronics. These devices are proposed to offer performance gains in speed, sensitivity, power consumption, device density and integration. This company is well VC-backed. Nanosys' CEO is Larry Bock, a highly successful business entrepreneur with multiple proven successes in the high tech startup space, hence he comes with high praises from the VC community. Bock is surrounded by a top-notch scientific team. Nanosys has raised $17 million, to date, in venture financing, and is funded by five leading venture capital funds: ARCH Ventures, CW Ventures, Polaris Ventures, Prospect Ventures Partners and Venrock Associates.

Nantero (http://www.nantero.com/tech.html). Nantero is focussed upon the formation of NRAM™, a type of memory potentially faster and denser than DRAM, with ambitiously proposed lower power consumption than DRAM or flash, as portable as flash memory and resistant to environmental perturbations. And as a nonvolatile chip, it might provide permanent data storage even without power. The NRAM™ design, invented by T. Rueckes, Nantero's Chief Scientific Officer, based, in part, on Professor C. Lieber's approach (Harvard), uses carbon nanotubes as the active memory elements. The design integrates nanotubes with traditional semiconductor technologies for claimed "immediate manufacturability." Nantero is funded by VCs, primarily Draper Fisher Jurvetson, Stata Venture Partners and Harris & Harris Group.

ZettaCore (http://www.zettacore.com/). ZettaCore is developing ultra-dense, low-power molecular memory chips based on technology from the University of California and North Carolina State University. The technical approach to molecular memory is based on specific properties of porphyrin molecules to store information. These molecules, called multiporphyrin nanostructures, can be oxidized and reduced (electrons removed or replaced) in a way that is stable, reproducible, and reversible. In addition, each molecule can store more than one bit of information and can maintain that information for relatively long periods of time before needing to be refreshed. The ability to integrate ZettaCore molecular technology with silicon semiconductor technology will hopefully accelerated development of hybrid chips that leverage both the advantages of molecular storage and the substantial capital investment in the silicon semiconductor manufacturing industry. With a development plan that leverages the existing semiconductor industry infrastructure, it is believed that products could be brought to market as early as 2005. ZettaCore's venture backers include Draper Fisher Jurvetson, Radius Venture Partners, Access Ventures and Stanford University.

Coatue Corp. (http://www.coatuecorp.com/). Coatue, a rather stealthy company with little public information being readily available, is developing microchips utilizing thin film organic polymers for non-volatile memory devices (possibly ferroelectric polymers) emanating in part from UCLA (not the Heath team). Coatue has received VC financing from Draper Fisher Jurvetson, New England and other investors.

Opticom ASA (http://www.opticomasa.com/). Opticom ASA is a Norwegian based research and development company. Opticom shares have been listed on the Oslo Stock Exchange since 1999. The subsidiary, Thin Film Electronics ASA (TFE), is a research and development company owned by Opticom ASA (87%) and Intel (13%) (Intel increased ownership in June 2001). TFE does research and development at its own facilities in Linkoping, Sweden and Albuquerque, New Mexico, and uses a network of institutions around the world, including academic labs in the US, for contract research. Opticom ASA technology is based on thin film electronics, and in some ways more of a molecular materials method for electronics rather than molecular electronics, per se, (vide infra). Opticom suggests that their layered technologies may be stacked, and there is potential for reel-to-reel production. Opticom ASA seeks early revenues through non-exclusive licenses of its technology.

Molecular Nanosystems, Inc.. Molecular Nanosystems (http://www.MolecularNanosystems.com) was founded in 2001 by Hongjie Dai, a Stanford University chemistry professor, and a group of other scientific and business professionals. Headquartered in Palo Alto, California, the company is engaged in research, development and production of carbon nanotube-based products. The core technology in controlled nanotube growth is slated to have a fundamental impact in electronic, biological and chemical industries. Early sales are hoped by marketing carbon nanotube-based scanning probe microscopy tips to researchers around the world through an alliance with NanoDevices Inc.

Interesting to note in this current landscape of molecular electronics companies is that most or all of them have derived their roots from academic research, especially federally funded research in the US. The funding by the US government is then built upon by private interests to transition the products into the market place.

Notice also a lead-funding role in several of these startups by the prominent Palo Alto-based VC firm, Draper Fisher Jurvetson, via the patriarch of nano-company ventures, Steve Jurvetson. A profitable exit strategy for Jurvetson might be to merge a subset of these venture-backed companies into a single entity that is then "flipped" (sold) to an Intel-like superpower semiconductor outfit. While that might not be the optimal financial outcome for the individual startups, it would combine the strengths of the various teams into a formidable force that downsizes the technical risk and capitalizes on the superpower's productization and marketing muscle.

Regardless of the hyperbole in the financial press, if one were to sum all the VC investments in molecular electronics and nanotechnology companies in general, it would be nano-sized relative to the federally funded and other private investments in the field. This is prudent to keep in mind when weighing fund-raising strategies and the time devoted to seeking support from each of the possible sources. It might even be better to initially label one's own company as a non-nanotech company and classify it as a "medical diagnostics" or a "sensors" company if seeking VC funding.

These companies have differing approaches to commercialization. The typical method for success of a small company is through focus, focus, focus. Specifically, choosing one particular target and driving toward that sole product target using every ounce of corporate energy that can be mustered. The reasons for the laser-focused business model are clear. Small companies have generally be unsuccessful when they strayed into trying to produce multiple products because of their inability to down-select one specific line; their resources were spread too thin. And any potential customer can cause an unfocused company to sway off course and thereby never hit any target. Like kids in a candy store, inability to choose candy fast enough can result in no candy at all.

Another strategy can be considered that exploits the platform technology—a base from which numerous product lines are spawned. Specifically, to have a parent company that generates technology based upon molecular electronics, and then spin-off companies are established for the focussed development. Each spin-off could have its own Board of Directors (BoD), CEO, business team, and even funding sources, which licenses the subset of IP needed from the parent company to build the particular focussed product. Personnel cross-fertilization, at the BoD level, would maintain the relationship, with some revenue flow from the spin-off back to the parent company. The advantage is that one can explore and exploit the newly discovered continent enabled by this platform technology rather than focussing exclusively on Plymouth Rock. Professors generally are good at identifying technologies but they have little experience in producing products to sell. The spin-off company can maintain the product focus.

Some VCs mandate the former model, namely the singular product focus. Others see value in capitalizing on the technology in its broader context while leaving the focus to independently funded spin-offs. Neither approach is all-correct, they each have value and dangers associated with them. Molecular Electronics Corp. is presently functioning in more of the spin-off mode, thereby leveraging its broad patent base for several applications. The danger, of course, is that the assets become too dispersed to remain effective. The upside is that a larger portion of the molecular electronics market can be secured. Conversely, ZettaCore appears, based on its publicly available information, to have the focussed approach to solely a memory-based product line based on porphyrin molecular arrays. This permits them to drive all their expertise and assets toward this singular desired target with overwhelming force.

As for the big companies, Hewlett-Packard and its outspoken proponent, Stan Williams, have a group of about 15 researchers working on developing memory arrays in conjunction with a first-rate academic team, headed by the talented Professor James Heath, formerly of UCLA and now the California Institute of Technology. The HP/Heath team has DARPA support for their joint research program. Motorola has a group of 12 scientist and engineers working on small molecule and nanotube molecular electronics systems headed by the productization expert, Herb Goronkin. In addition to Motorola working with MEC, they have had a nearly decade-long collaboration with Reed (Yale) and Tour (Rice) through the DARPA program, presently working toward the development of the NanoCell logic/memory system (see Chapters 5 and 6). Motorola has been a devoted believer in the prospects of this new technology with complementary programs in carbon nanotube research, small molecule devices and DNA-based diagnostic arrays. Hitachi has been involved in molecular electronics studies for nearly a decade, however, less is known about their recent developments. In the past they were working on multiple arrays of scanning probe tips and switching devices based on movement of single atoms—a steep hill to climb, indeed. More recent additions to the major players' list include the highly successful work by International Business Machines (IBM) with carbon nanotubes gates and nanoparticle memory work via teams headed by the eminent Phaedon Avouris and Chris Murray, respectively. Murray has the conviction that a small company will be the first entity to market a molecular electronic device, but never underestimate the prowess of IBM or the breadth of its IP portfolio. Many a bold CEO have sheepishly retreated when confronted with IBM's patent library—there are plenty of Rembrandts in their attic,[2] so an alliances might well rule in the end. Intel has shown investment interest in molecular electronics, as described above for Opticom, however, to date they have had little if any active internal program in the field, according to their officers. Intel is monitoring the technology's movement with an eagle eye—they'll not be caught off guard. Yet, in their conservative and possibly self-sustaining vein, they publicly point toward the challenges facing molecular electronics more than pointing toward the prospects of this new technology. Advanced Micro Devices (AMD) has invested in one of the above startup companies after seeing possible prospects for their successful implementation, while AMD itself has no formal research program in the area. At the highest levels within the corporate structure, AMD holds great hope for molecular electronics technology. Infineon has shown interest in molecular electronics and they have now assembled a research team. A large amount of recent work coming out of Lucent/Bell Labs has recently been disclosed on making organic transistors from self-assembled monolayers and even single organic molecules—initial presentations that have been stellar. However, some of the Bell Labs/Lucent work at molecular electronics and thin film electronics has been questioned for its scientific validity or accuracy. A competent external evaluation group organized by the commercial lab is presently assessing the work, and until that is defined, comment here will be withheld.[3] Therefore, mega-company validation of the prospects for molecular electronics is quite apparent—better late than never.

In summary, the number of small and large research groups working in the area of molecular electronics is expanding rapidly. Although no commercial products have been realized, the hopes are high. The alliances between the startups and the major players are being established and the business strategies are becoming focused to pave the way for commercial success. The race has begun. Who will be the first to market and who will dominate in the long run? Bets are being placed. I have my favorites, as do most others.

1.4 Advice from the Trenches for the Wannabe Corporate Founder

Some lessons are provided here for the academician who is considering founding a company in molecular electronics. Naturally, these principles can also be applied beyond molecular electronics startups. At a minimum, reading the next few pages might spare you some sleepless nights. More importantly, it might save millions of wasted dollars, your embarrassment before your peers and litigation that could choke your scientific creativity for years to come. The examples are in generalities. There are plenty of exceptions, but knowing the terrain of possibilities is always an advantage. It is impossible to write without offending someone; therefore in an effort to minimize the affront, if anyone is offended by what is written, then consider that it is referring to your antithesis.

There can be great rewards for an academician in starting a business. For one, you can participate in taking your beloved research into the commercialization phase, for the good of humankind, in a timeframe that is shorter than if you had waited for another to recognize its potential and thereby capitalize upon it. The rewards further include fame, fortune, the envy of your peers, the meeting of people you would never normally have met if confined to the world of science, and an education in an area where few scientists ever delve. All these add significantly to life’s experiences, so the upside can be profound and it should never be belittled.

Of course there are those faculty who feel that the hallowed halls of the academy are tarnished by professors who seek corporate gain, and such a view should be respected. But there was a time when the receipt of federal grants was considered defiling to the pristine and independent mission of the university—so the world is constantly changing. Likewise the spawning of startup companies is becoming an order of the day, and it will likely remain. Certainly, the neglect of one's basic academic duties of teaching, research and service is unacceptable. But provided one is willing to burn the midnight oil to make their corporate dreams a reality, there are significant tangibles and intangibles that can benefit the entire college. The tangibles include a share of market income into the university that could add significantly to the positive cash flow, albeit conceding that only one in ten small startups will ever truly be a success. The intangibles include notoriety for the university and the exposure of students to the rigors of corporate governance and management as they see it lived out in their professor. If properly shared by the faculty member, the students can benefit enormously in the breadth of their education.

There are downsides as well to academicians starting high tech companies, which I will dwell upon for some time. Unlike your National Science Foundation grants, in business, nobody will simply send you a check in the mail and leave you alone. If you plan to start a company, realize that grueling years of business challenges await you. You'll be busier than a Bombay traffic cop, and your teaching, research, and familial duties will take the commensurate hit unless time management and multitasking become your ever-present companions. Furthermore, most business and sales people are much higher maintenance than are graduate students. They dwell far too long on their compensation packages or perceived insufficiency thereof, and they have threatening quick-draw attorneys slung to both hips who are ready to rifle through the penny-bare pockets of your moribund academic lab coat. Therefore, be forewarned before flippantly becoming a wishful Porsche-driving corporate founder.

Throwing caution to the wind, how does one begin the process of commercializing their molecular electronics research? I am writing specifically to address some of the US-mandated approaches, while the protocols will differ in other nations. First, understand what is legally permitted. The Bayh-Dole Act permits federally funded research that is done in academic institutions to have its IP ownership reside with the academic institution. Accordingly, startup companies that were founded by the academic investigator(s) can then license much of the IP from the institutions. In that manner, the ultimate appreciation of the technology can often occur since the very professor and students that generated the IP are involved in the further development of the research. In many respects, this liberal approach of federally funded research being assigned to the university has generated an enormous growth of technology startups in the US and it is the envy of many other nations who are now following the lead of the Bayh-Dole Act. Private investment funds then stand ready to support the best of the technologies in an effort to parlay them into usable products for commerce through direct manufacture, license or sale to a larger asset company. It is capitalism at its finest for the ultimate public good of job creation and tax base growth.

Second, take a visit to your Technology or Patent Office within your university and work with them to file an invention disclosure on your discovery. If there is no such office at your university, the university's general counsel can often guide you through the process. Maintaining good laboratory notebook records will be essential and be sure to note every inventor, including student inventors, who contributed to the idea-generating process. An inventor is different than a co-author. An inventor is not necessarily even the individual who executed the key experiment. It is the person or persons who had the intellectual thought process that generated and/or enabled the idea to the extent that one normally skilled in the art would not have considered. For example, if the faculty member thought of an idea, and he/she directed their graduate student to set up an experiment to test the hypothesis or make the key compound, the graduate student would not be considered an inventor unless the student generated some unusual protocol to enable the process. Simply following standard techniques to test the professor's hypothesis does not constitute co-inventorship. Next, following the specific procedure of your institution, which usually involves a presentation to their equivalent of their Patent and Copyright Committee, and thereby request that they file a provisional patent on the invention. The provisional patent filing is less that a few hundred dollars, and it secures a filing date on the invention for one year. During that one year, the invention can be further refined and an assessment can be made as to whether the university should spend the $5,000-$10,000 (or more) needed for a US patent filing with the associated international coverage. While some legal counselors advise against provisional patents and suggest immediate US patent filings, most universities prefer the provisional patent route.

During the provisional patent filing period, or at any point along the process, you might wish to consider starting a company to exploit the technology. All universities differ on the level of involvement that their faculty can have in companies and they have policies that surround those interactions. Be as forthcoming as possible with the administration as they work with you to chart a mutually acceptable course which balances the strictures of federal and state grant support and student research labs with corporate commitments. There are always ways to structure deals and discussions with universities, regardless of their current policies. There is great liberality within the Bayh-Dole Act, therefore universities have substantial leeway on how they choose to function. In negotiations with the university, as difficult as they might become, do not let grace and truth leave you, and your university will be an ally to the end.

Next, seek some free counsel from the Technology or Patent Office and from business school faculty because they have few, if any, secret agendas. Have them guide you in the corporate governance process, and deeply consider their advice. You will appreciate their fellowship all the more as the corporate challenges begin to mount, and mount they will. So establish the university relationships early and if you ultimately choose to disregard their advice, at least do it graciously. (In every case, however, when I chose to disregard their counsel, I regretted it because they ultimately proved to be correct.)

After an investigation of the corporate landscape, discussions with your university's personnel, meeting with a lawyer, and a thorough psychiatric examination, if you still feel the need to start a company, begin to assemble a corporate BoD. A balanced initial BoD should be comprised of one founder, two individuals with experience in the specific field of commercialization, one with a legal/accounting background with startup expertise, and ultimately the senior company officer such as the CEO. The appointment of the CEO to the board will follow a BoD-directed search (see below). Generally, the corporate legal counsel should not be a member of the BoD. Keeping an odd number on the board can simplify tough votes. Never seek your academic scientist comrade to be a co-board member unless they have years of commercialization experience in the field of your product's insertion. I repeat, if you value your friendship and research relationship with that colleague, never invite them to join you on the board! Business governance hassles have destroyed many fine research relationships. If there is more than one founding scientist, establish a Technical Advisory Panel (TAP) on which they all will serve to advise the BoD. Selected individuals from the TAP can even fill the founder's seat on the BoD as they rotate in 12 month increments to serve on the BoD, for example. Undoubtedly, the senior investors will want strong board representation by selections of their choice, but that can await the first major funding round. Initially invite people onto the BoD that you trust and that have the array of expertise outlined above. Certainly, you might have to reach out to people you know in industries or other startup companies to fill these roles. But the building of the initial BoD is critical for the establishment of proper board governance and the selection of the CEO (see below). For early stage startups, compensation for board members should be limited to performance-based stock options or stock grants, never cash.

Use legal and accounting counsel for matters on which they have expertise. That does not generally include the establishment of a BoD or its governance practices, although all lawyers would willing chip in their 2¢ worth (or $2,000 worth). And be alerted that if your technology is attractive, most of the lawyers you engage will try to negotiate a decrease in their fees for a stock grant. Proceed with much caution because legal fee structures are difficult to assess. You will often end up paying the lawyers the same amount regardless of the stock you have given to them. Unless they are willing to carry out *all* their legal work for you for the first year, for example, in exchange for the stock grant, you would be advised to give them no stock at all.

Angels, due to their personal investment concerns, could have mixed motivations, especially when making painful decisions regarding dilutions. Therefore, an angel investor should only be considered as an early stage "stop-gap" board member before more permanent members can be secured, and only if they bring some level of expertise as outlined above. Typically, angels should have limited input into the governance of the firm.

Therefore, a balanced BoD is the first essential entity that should be established. Once that is in place, they can guide with the selection of proper legal counsel and the assessment of fair legal rates that should be paid for certain jobs. More importantly, the BoD can serve as the focal point for the selection of the CEO.

When a company based on molecular electronics is started, the prospects can be so exciting that there will be numerous people with business/management backgrounds who will suggest to you that they would be the "perfect" CEO for your company. The academic professor's credentials and passion for their research can make the would-be CEO see dollar signs and think that their *Forbes Magazine* cover-story fame is just around the corner. It is utterly amazing how many perfect CEOs, in their own eyes, immediately rise to the surface, especially if the founder should give a zealous presentation in a forum attended by under-employed "consultant-based" MBAs. The MBA's competency may be well-assured for certain types of companies, but high tech startups targeting insertion into a world dominated by silicon technologies, are unique businesses that demand inimitable expertise.

Why is CEO-based experience in the electronics world essential for a molecular electronics startup? First, because the electronics industry moves at a pace and intensity that is unlike any other industry. Outsiders, although they might initially concede the fact, really have no idea of the realities of the speed and intensity of the industry. The field-experienced CEO understands the barriers to product insertion in such an environment and they can help to refine or redirect the startup's target for a more acceptable application. The experienced officers are not overly impressed by the zealous pledges of the academician because they demand the specification chart comparisons. The inexperienced CEO either does not ask for precise projections until it is too late, or once it is provided, they have little way to assess it. One might argue that this is the VP of Engineering's job. Not in a small company. Small company CEOs must wear multiple hats; large staffs are not an option with the cash flow chokeholds that must be maintained in a startup. When the businessperson is solely dependent on the academician for technical assessment of the field, the CEO's failure is certain. The failed CEO might even pull the company down with them, while the founder and CEO are pointing fingers at each other en route to their respective legal counsels. Belaboring this point is needed because it is utterly essential: unless the CEO has technical experience in the domain where you hope to carry out your product insertion, they are not the CEO candidates for your company. Period. Good-hearted business-experienced candidates are ubiquitous and MBAs are a dime a dozen, while those with experience in the required field are much harder to find, but they are essential as you drill-down on specific product insertions.

Second, personal connections within the electronics industry are indispensable; outsiders garner no respect, and cold calls almost never lead to substantive long-term investments or alliances. The inexperienced will hunt down all prospects, from Persian rug salesmen to cattle ranchers, seeking bits of investment required to keep a comatose business on life-support. Electronics domain-experienced officers accomplish more with one phone call than a month of airport-hopping, door-knocking, ring-kissing CEOs with backgrounds in baking or candlestick making. It is not due to inferior intelligence or lack of hard work on anyone's part. Try as they might, the domain-lacking will spell corporate demise at the expense of time and money. Although many contacts will be initiated, no meaningful deal will close when the sphere-inexperienced is at the helm.

Third, without the domain experienced person, sophisticated investors are likely to pass on the deal, regardless of the science, because they must be assured of a first rate domain-experienced senior officer. A field-proven CEO for molecular electronics would be a person that has spent several years in the high tech solid state silicon world, for example, but holds promise for a new technology—you certainly do not want a pessimistic, nay-saying, silicon-stiff-necked CEO leading a molecular electronics company. The technically astute CEO will walk into any VC office or alliance presentation with confidence in their step that they have identified a specific product line with all the needed detail. Although open-minded, they are not storm-tossed by every potential investor's view on how the company should focus their productization.

The prospective CEO must have demonstrated successes in small company management, which is very different than having successfully functioned solely within big businesses. If the CEO candidate expects to have office space in a city's prime towers of real estate, fly first-class, rent stretch limos or stay at top-tier hotels, he/she is not the CEO for you. In the startup world, investors esteem cash flow conservation while they'll grind their teeth at other's lavish living at their expense. It is up to the CEO to manage and control cash flow by anyone associated with the company, including themselves, the founders and board members. To do otherwise is grossly irresponsible and the epitome of weak or misdirected management. The founding scientist is often not well versed in careful fund management, therefore the CEO must exercise restraint over the corporate funds even on behalf of the founder. Those who would argue to the contrary have been infected with the disease of big-business or big-ego. Either is fatal. Avoid such people lest you too catch that plague which initially attacks the mind of the unsuspecting to make them think that they are more than they really are. Remember that you are spending others' money, so respect it even more than you would your own, and hire a CEO that esteems those investments and the investors behind them.

There is a tendency for inexperienced founders to fall into a place termed "satisficing," namely accepting the immediately available option without searching the field for a more acceptable candidate.[4] You should be prepared to make phone calls and study the CEO candidate's past. The tendency to fall into the "satisficing" mode is enormous since there is hope on the part of the founder that he/she can be free of the business burden and thereby focus once again on the science or engineering. Be sure, however, if you make the wrong CEO selection, the business burdens will come right back to your doorstep and there might be litigation awaiting you from a disgruntled former CEO or frustrated investor.

So how does one locate the proper CEO? The BoD should have the contacts within the electronics domain that can identify key candidates and set performance-based compensation packages that are commensurate with the CEO's expertise and the job's challenges. If the BoD positions are properly filled, the CEO candidate will be far more likely to seriously consider the offer. A professional search firm can be used to locate a CEO but their fees can be quite substantial. However, search firms often make concessions for startup companies for stock rather than large amounts of up-front cash. But even using a search firm, there are no guarantees of suitability and the proper CEO choice is often one of the greatest growing pains of a startup company. Furthermore, the CEO choice for the initial phase may be different than the best person for the ongoing stages.

Although rewarding, the challenges in running a company can be substantial. Form an alliance with those in your university that can be a support to you at the early periods. Surround yourself with a skilled BoD that can help to absorb the burdens and provide the required corporate governance and funding advice. And select only a CEO that has domain experience. You'll sleep far better that way.

1.5 From a Front Row Observer to the Aspiring CEO of an Academically Founded Startup

Becoming the senior officer of a company that could be a world-changer is a once-in-a career opportunity, which few savvy businesspeople can resist. The potential for establishing fame and wealth are truly enormous if some of the proposals for molecular electronics technology insertion can be birthed. But before accepting an offer to become the senior officer of an academically founded startup, you would do well to read on. I am speaking stereotypically here, there are exceptions—some academics are wise and superb business partners. It will be up to you to make an informed evaluation.

The new CEO must be well aware of the academic scientist's mindset because it is often highly irrational from the business perspective. If there is more than one academic founder, the CEO's hemorrhaging is exponentially exacerbated. Many competent and experienced CEOs have met their match when dealing with teams of academic scientists because the scientists can vacillate in nanosecond increments. Likewise, founding scientists can find it grueling to function within constraints that are clear to any businessperson, namely, that if they start a company, they have a fiduciary responsibility to maximize shareholder value in the company. The academic-like investigations must often take a back seat to the business decisions. That is hard for the scientist to accept, although they often nod in agreement until the reality is thrust upon them.

It is not solely interactions with the founding professors that can be rough. University administrators have a propensity to believe their faculty's pontificating of the near-term commercial prospects of their over-inflated embryonic technology, even though their faculty have never even brought a single thimble to market, and there is nobody else on earth seeking to license the patents. Negotiating rights to the founder's patents can be nightmarish for the new CEO as he/she pleads with the university administration to accept some business realities of the risk at these early stages. Hence, the CEO can be faced with a university-based rationale that is utterly ridiculous from a business perspective.

In defense of the universities, often business people do not appreciate the concerns of the university and their requirements as a not-for-profit institution. Understanding the universities' constraints as an educational institution is therefore critical.

What is the solution for the prospective CEO? Realize that the CEO must have lots of energy left in him/her. It's not a semi-retirement job. Finding time for family will be like finding hens' teeth. Second, the CEO must establish clear lines of demarcation in initial discussions with the founding scientist, thus defining each other's respective roles and setting in stone the corporate objectives. Third, the CEO should ensure there is a competent BoD to whom they will be accountable and that will provide balance to the overall mission of the company. A board that is dominated by founding scientists or academicians will, in many cases, cause the CEO to become ineffective while ensuring that no institutional funding will be received. Support from a properly balanced board can be the key to keeping the CEO free from the cardiac-care unit as they slug through the waist-deep thicketed morass of the academic world. Therefore, definition of specific individual tasks and objectives with incisive and decisive board-level oversight by the domain-savvy business team can provide the stability to maximize the energetic CEO's likelihood of triumph.

Another thing to know is that university professors have trouble with focus because they are trained to think broadly. They are always dreaming up new ideas and tangential models. Every morning that they think of a new application, they defocus from the previous day's target. Even if the professor says that he/she will devote 90% of their corporate time to the product deliverables and 10% of their efforts to expanding the corporation's science base, don't believe them. When they wake up in the morning, they'll be dwelling on the 10% basic science part, which will then consume 90% of their brain's central processing capabilities. A VP of Engineering, on the other hand, will blow right past a Nobel Prize-winning idea if it will distract him/her from the product delivery date—they are laser-focussed, and rightly so. There is no other way to be when product delivery is expected. You do not sell technologies, you sell products that are generated from new technologies. Therefore, it makes enormous sense to keep the ethereal professors on the technology development efforts and the tobacco-chewing product engineers on the device delivery side.

In conclusion, although the benefits can be enormous, the prospective CEO should be aware of the academic mindset and motivations. Even with that understanding, however, be prepared for lifelong battle scars and lead-ridden limbs resulting from business-irrational dealings with hardheaded business-illiterate academicians who fear no hand-to-hand combat of opinions, even when their opinions are devoid of experience and fact.