31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

# Bench to Beside: Motivation for University Industry Partnership

Nitish V. Thakor, *Fellow, IEEE*

*Abstract*— **This paper discusses the motivation for entrepreneurship in academia and for forging a relationship between an academic laboratory and a startup. University based personnel, faculty and students, priorities basic bench research. On the other side, industry, particularly startups, prioritize technology development for clinical and commercial translation. The paper presents personal experience as a case study. University based researchers, faculty and students, might participate in and benefit from such an entrepreneurial activity. A University spin off would facilitate translational of bench research ideas and results to technologies for bedside use. Attention to issues such as conflict of interest and concern and ethics of working with human subjects need to be managed by the investigators and the institution. While entrepreneurial activity is not for everyone, it does provide the benefit and satisfaction to see research reach practice.**

## I. Introduction

The central mission of the University based personnel, whether faculty or students, is to focus on education and research – essentially knowledge creation and dissemination. This worthy mission results in generation of new ideas, experimental results, novel theories and innovative technologies. Engineering research may be theoretical, technical and design oriented or experimental. The studies are typically limited to the laboratory settings, for example biological studies are done in cells or in animals. The studies tend to be rigorous and mechanistic. The output, in general, is in the form of publications. However, patenting the ideas is not uncommon. Success is measured by the impact of discoveries and ideas and their dissemination and adoption.

The mission of biomedical industries, startups in particular, is to produce products for clinical use and commercial benefit. To achieve this goal, a start up typically needs innovative ideas, production of intellectual property, and implementation of unique technologies serving real, and preferably unmet needs, clinical adoption and commercial success. Innovation is an important part but so is successful implementation of technology and product solution. The successful outcome is measured in terms of adoption of the technology as a widely adopted product, successful manufacturing and marketing and generation of profit.

These two missions may be complementary or may pose their own independent challenge to reconcile their independent and distinctive missions and goals. The focus of this article is to discuss how to synergize these two endeavors – or, in other words, how can the university (academicians and students) pursue entrepreneurship or how university and industry (startups) work successfully together.

Nitish V. Thakor is with the Department of Biomedical Engineering, Johns Hopkins University, School of Medicine, 720 Rutland Av, Baltimore, MD 21205 (Email: nitish@jhu.edu).

## II. A Case Study

### A. The Problem

My research involves study of brain injury from global ischemia after cardiac arrest. Roughly half a million people experience sudden cardiac death in the USA each year. If more than a few minutes pass, the brain is irreversibly injured. Cardiopulmonary resuscitation and eventual defibrillation can revive the heart. However an extended duration of arrest or a prolonged CPR results in poor outcome due to brain injury. Hypothermia or cooling the brain to between 32 and 36 Celsius is known to be neuroprotective. However, currently no methods that monitor brain during after resuscitation are currently deployed. Our research pertains to studying the mechanism of brain injury at the neuronal level, determining how neural activity in different regions of the brain are affected by ischemia and how revival of neural activity occurs upon resuscitation.

The problem of resuscitation in patients cannot be tackled through bench research alone. We need to take problems and solutions such as this at the bedside and take these to the patients. In our problem, we needed to develop a method to monitor patients whose brain injury would be monitored soon after defibrillation and resuscitation. We further needed the technology to monitor the brain activity throughout the recovery period, especially during the application of hypothermia. Therefore, our specific need was to find a way to develop a clinical grade, FDA approved device and to use it in clinical research. Of course, we could also see the potential for serving not only a clinical need but also a commercial need. Therefore this problem clearly needed transfer of technology to industry. Given the early stage, niche idea, the best solution seemed to be to hand this project to a startup and the best startup solution appeared to be home grown: starting own company with the team of inventors and interested participants, my former students. Thus was born our startup.

### B. The Solution

The process I went through was to start the company with the former students who were creative, entrepreneurial and industrious. They were also ready to devote their career to

entrepreneurship with the motivation to solve real clinical problems, serve the patients, take technology out of the lab, and to commercialize it through internal research and development.

The problem of funding was handled through the Small Business Innovations Research (SBIR) program. We wrote proposals to the National Institutes of Health's SBIR grant program. The SBIR program works in two phases: Phase I is the pilot or feasibility study phase and the Phase II is the more complete development and testing phase. In our specific project, we used the Phase I to do feasibility in animals (cardiac arrest and hypothermia experiments with EEG monitoring) and to develop algorithms to analyze brain rhythms (theory and computational methods). Our proposals generally have been fairly successful. We received a series of Phase I and II funding to take the basic idea of brain injury monitoring from animal to clinical study. We took the bench recording and data analysis to clinical recording and data analysis. Our prototype in Phase I consisted of laboratory EEG amplifiers, personal computer based data-acquisition systems. The brains or the innovation was the signal processing and the algorithms used for testing the performance of the instrument in the experimental and clinical setting. In Phase II we developed a customized EEG monitor suitable for this application as well as for recording and analysis of clinical data. In due course we obtained intellectual property protection and FDA approval for the device. The technology is still under clinical trials. Further progress towards commercialization would depend on the success of the clinical trials being carried out by my clinical colleagues, and of course further demonstration of the commercial product and the development of the market.

## III. BENCH TO BEDSIDE

The bench to bedside is a two step process. The first step is to do the academic work, i.e. identify the problem, the clinical need, develop the solution, creating intellectual property at the University and publishing the work. The second step is to create a commercial grade or clinical grade prototype, obtain an investigational device exemption, carry out safety and efficacy studies and eventually receive an FDA approval. Thus, a two phase process helps take the basic technical idea from bench to a prototype for the bedside.

In the same manner, the research and the clinical studies and demonstration of the utility and benefits of the technology is also a two step process. The step one is to do animal studies in the lab where experiments are done in a highly controlled manner. Of course, such work is done with the approval of the Institutional Animal Care and Use Committee (IACUC). Publishable and statistically significant data are obtained. The step two is to do clinical studies. This requires, first of all, an institutional approval for doing the clinical study, or the approval of the Institutional Review Board (IRB). The clinical studies, even pilot ones, have to be well designed with considerations for patient safety and privacy. The many requirements of the IRB include patient consent forms and passing well defined courses or certification for ethical research and research study design.

## IV. FROM UNIVERSITY TO STARTUP

As mentioned before, this is a two step process. The first step of research and incubation of ideas is taken at the University. The second step of development of the technology, clinical trials, FDA approval, commercialization, and so on is taken at the startup. As a Professor, one's responsibilities and obligations lie with the University. That is, as a full time employee, the University's employment policies prevail and must be abided by. These policies include limits on consulting time and income and disclosure of all conflicts of interest. The conflict of interest is the most critical step. The conflict of interest exists in many forms: allegiance and focus on research versus development, time and effort spent on non academic activities, working with students and academic colleagues, doing clinical studies with full disclosure of the conflict of interest keeping in mind the safety and benefits to the volunteers and the patients.

Once the conflict of interest is disclosed and resolved, a faculty member may spend limited time (typically limited to the equivalent of one day per week) doing consulting on the project with the startup. The faculty member may also participate in founding the startup company, as I did with a former student, and may still be required to limit the time and effort. Thus, the logical role for the faculty member to play is to be the Chief Scientific Officer and provide advice on the company's research and development direction and serve on the board of the company. Among the most critical areas of conflict of interest are working with the students and the patients. Both require adherence to carefully defined guidelines and subject to institutional review. Another area requiring attention is disclosure of any inventions and possible assignment to the University if the University wishes to exercise this option.

The conflict of interest for the student is less clear. The students are not employees of the University. But they use the University resources and work on government funded projects. As such, they may be obliged to disclose their efforts and their inventions. The student is certainly free to work for the startup, which happens to be the most likely and common scenario. This employment is typically taken after graduation, although summer internship during the school year may also be an attractive path to gain exposure and experience before graduation. The student's own work, e.g. on the thesis and publications, are public domain. Any innovative work of potential commercial value must be patented before publication.

## V. DO'S AND DON'TS

The most important matter to keep in mind is to do the University-Industry partnership, especially entrepreneurship and technology translation or transfer under full disclosure and under fully managed conflict of interest. Do this first and get the blessing and the approval of the University. The second matter is professional – to devote the time and attention to the academic matters, the research, teaching, and mentoring and to carry out institutional and public service activities such as to one's professional societies. Being involved in entrepreneurship can be time consuming and distracting. The priorities cannot be mixed. That is, the first and foremost priority is to the educational mission and to the terms and expectations of the primary, full time appointment. The secondary priority is to the entrepreneurship and the commercialization process. The third matter is more personal. These multiple activities also compete for time and attention to the family, friends and community services. Being an academician in a highly competitive climate where excellence is necessary and expectations are high is demanding. Being an entrepreneur is equally or even more demanding, with continuing uncertainties of fiancés, job security, commercial success and profitability. These demand 'more than 100%' effort. They also compete for time devoted to the personal and family life. To purse academic research, and to purse entrepreneurship, while maintaining a health personal and family life certainly requires a major 'balancing act.'

The challenge is to do one's job well. To do research well in a University requires succeeding at competitive research grants, recruiting research personnel (mainly students and post docs), setting up the laboratory and the experiments, carrying out experiments and data analysis, publication, and dissemination and conferences. To do teaching well requires considerable planning of the curriculum, the reading material, the presentation material, problems, tests, grading, student meetings and discussions. Preparation to give good, well prepared and eloquent and informative lectures takes time and effort. Eventual success is measured by publications, success at grants, discoveries and their dissemination, peer recognition, and impact of the science and technology on society.

To do the entrepreneurial job well requires a comparable level of very intense passion and commitment. Any startup requires the effort to generate funding, to recruit industrious and talented personnel, commitment to developing innovative technology and intellectual property, to focus on developing high quality prototypes and eventual products, and of course the focus on the entire commercialization process from manufacturing to marketing to profitability.

In some ways, being a professor is also being very entrepreneurial, needing to generate unique ideas and raise funding and resources to pursue them, and being an entrepreneur is in some ways like being a professor who is dedicated to ideas, discoveries and dissemination of knowledge and pursuing benefit to the society. Therefore, clearly there may be synergies in the effort and the two can successfully feed on each other and achieve a very fulfilling path from bench to bedside or from lab to commercial success.

## VI. CONCLUSION

Bench to bedside is a worthy endeavor for academicians. The process takes one's work from laboratory to the patient, and helps one see the fruits of discoveries and inventions translate into products with clinical and commercial utility. Attention should be paid to the conflict of interest and other ethical practices and institutional policies. Successful execution of either profession, being an academic researcher or an entrepreneur, requires intense dedication and commitment to excellence and the will and desire to succeed and make an impact.