

Introduction: Daniel S. Friedman, PhD, FAIA

Dean, College of Architecture and Urban Planning, University of Washington

DANIEL S. FRIEDMAN: Matthew O'Donnell earned both of his degrees in physics at the University of Notre Dame. Following his graduate work, he moved to Washington University in St. Louis as a post-doc fellow in the Physics Department, working on applications of ultrasound to medicine and nondestructive testing. He subsequently held a joint appointment as senior research associate in the Physics Department, and he was also a research instructor in the Department Of Medicine at Washington University. In 1980 he moved to General Electric Corporate Research and Development in Schenectady, New York, where he continued to work on medical electronics, including MRI and ultrasound imaging systems.

Subsequently, he was a visiting fellow in the Department of Electrical Engineering at Yale, where he investigated automated image analysis systems. In 1990 he became professor of electrical engineering and computer science at the University of Michigan, and starting in 1997 held a joint appointment as professor of biomedical engineering. In 1998 he was named the Jerry W. and Carol L. Levin Professor of Engineering and later served as chair of the Biomedical Engineering Department.

In 2006 he moved here to the University Of Washington, where he is now the Frank and Julie Jungers Dean of Engineering, and also a professor of bioengineering. His most recent research has explored new imaging modalities in biomedicine, including elasticity imaging, in-vivo microscopy, autoacoustic arrays, autoacoustic contrast agents for molecular imaging and therapy, thermal strain imaging, and catheter-based devices.

One last word about Matt O'Donnell. We were at our first deans' retreat at a little spa about 45 miles east of here, sitting at a U-shaped table. It's Day 2. We're talking about faculty productivity, and we're going around the table. He's last. He says, straight face, "I measure my faculty's productivity based on how much they influence the gross domestic product." I'd like to introduce Matt O'Donnell.

MATTHEW O'DONNELL: Thanks, Daniel, and thanks for inviting me. I look forward to the rest of the day to hear about research in architecture. Daniel mentioned, ticked off a list of things, about population, about global warming, other things. Its page 1 of our strategic plan—exactly the same topics to be looking at. I'm sure, albeit from a very different perspective, they will be important for us. So, three qualifications before I get into this.

Number 1, this is an engineer's perspective. So, if there's a translation problem, if I speak French or German to you, or especially if I speak Swahili, please either interrupt or catch me at a break, and we can do that. I know; I've been there. I'm a bioengineer. I lived in two worlds of the life sciences and the physical sciences for a long time.

Second, I'm going to talk from an academic perspective. As Daniel said, I spent 10 years in industry myself. I've helped launch three companies, so I know small-company, large-company, and academic environments reasonably well. Again, I can help translate anything that's into that.

Third, again, this is meant to engender discussion and open it up for ideas rather than trying to give you absolute truth. So, if some of it looks that way, please, it is not intended that way. But slides have a tendency to make things look almost permanent.

So, what is research? So, I think there are really two ways of looking, as a broadest definition. First of all, it is a search for knowledge, so it's discovery, discovering new things, discovering how the world works. But in addition, another equally important component of it is the process. That is, how do we go about discovering, or what are the ways in which we collect information and data about a topic, and then, how do we view that and look at that and understand about our nature and our world around us from this process?

Second, as I said, I am an engineer and will speak from this perspective, and so this is a quote that I probably use about 10 times a week. It's tremendously overdone, but I think it captures the true spirit. And that is Theodore von Kármán. I don't know if you know who he was, rocket scientist who started the Jet Propulsion Lab at Cal Tech. He said, "Scientists discover the world that exists; engineers create the world that never was."

Engineers create, and so, in effect, we create the world that never was. I would think, naively at least, that architecture would fit more into that second category—the creation of things that never were. They didn't exist before. An "academic engineer" is almost an oxymoron because we have two pieces, which are the classic academic paradigm. That is, we're both scientists and discoverers. We're educators. We teach the next generation, both the concepts as well as the process.

The third perspective—which we do share with a number of cousins across campus, all the professions—is that we are professionals. We do design. We create technologies. This is very, very different from the traditional academic model of simply looking at—at least on the scientific side

What is research?

- Search for knowledge - **discovery**
- Systematic **process** of inquiry – collecting information and data about a topic

What is an engineer?

Scientists **discover** the world that exists;
engineers **create** the world that never was.

Theodore Von Karman

What is an academic engineer?

- Scientist
- Educator
- Engineer – **professional**

and the physical and life sciences—looking for new knowledge.

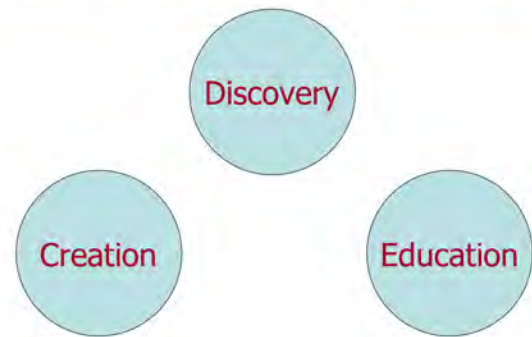
There's a tension that comes about, then, as a professional in an academic or research environment. The tension, first of all, is that you're fundamentally driven by discovery, that is, the search for new knowledge. At the same time, you are trying to teach the next generation how to do things. At the same time, you're changing dynamically and daily what you're going to teach them as part of the discovery. And, then the third piece is that we create. We create our portfolios. We create our technologies that are in there, which, again, has this tension between the basic discovery, the search for, the quest for new knowledge, and educating the next generation.

Okay, so why do we do research? To discover new knowledge. To educate students. We also create new technologies. We create new things, new ideas. And we connect with the profession. So, an important piece of our charter, through our professional organizations, is to push those organizations forward in terms of new technologies and how those technologies can affect the practice of engineering.

So, how does research by professionals fit into the traditional academic model of discovery and education? Well, there was a famous report that was written at the end of the Second World War. Does anybody know who Vannevar Bush was? He was probably one of the most influential people of the 20th century. He was the singular scientific advisor to FDR during the Second World War. At the end of the Second World War, starting in 1944 and actually published after FDR died, he wrote the definitive study, "Science, the Endless Frontier: A Report to the President for the Program for Post-War Scientific Research," which defined how science ran for the next 50 years as both an intellectual discipline and a business.

His view in this report was a one-dimensional or linear prescription for how science is done and how the science that

Tension for Academic Professional



Why do we do research?

- Discover new knowledge
- Educate students in research process
- Create new technologies
- Connect with the profession

Key Question

How does research by professionals fit into the traditional model?

is done affects the economy. First of all is the basic or pure research, which you all know is this quest for knowledge, as we've just talked about. But then, in this one-dimensional view, the output or the discoveries that come from that [quest] drive applied research, where applied research means that you're interested in an end product of some form.

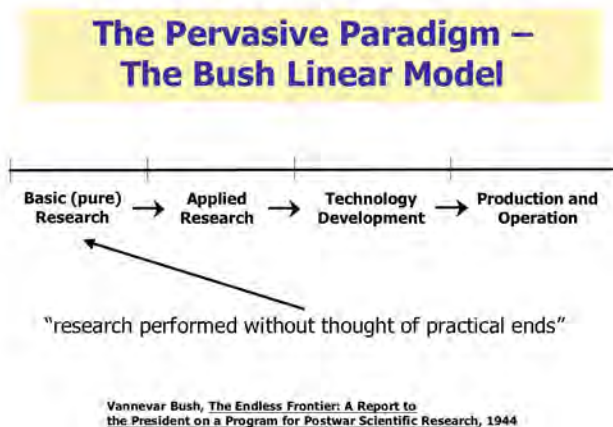
So, there's a use that will come of that, which then drives the next stage of this process, development of specific technologies, which then drives actual products into production operation. The classic view, how this is presented, was not by Bush. He was looking more at nuclear research at the time and nuclear power. The one that probably fits the best into this is the semiconductor world.

So, the research that went on right at the end of the Second World War and the early 1950s—a lot of it actually in industrial laboratories, Bell Telephone Laboratories in particular—brought the invention of the transistor. The invention of the transistor then went into an applied view of trying to develop transistor systems into integrated circuits, which then drove technological development of the circuits as chips, integrated chips, and computational devices and ultimately led to the computer industry and the information technology age that we now live in. That's what this linear view, starting from three sprockets of guys who were in the lab with suits and ties on. I love those photos from the '40s—three guys looking over the top of this thing with wires sticking out of it—and now the modern information age totally dominates our day-to-day lives with the little things that are on your table right here.

This linear model is all based on the idea that the first stage of this, the initiation of this entire process, is research performed “without thought”—love that phrase—of practical ends. The way it got rephrased in the '50s and '60s, and especially with the molecular biology revolution in the '60s and in the '70s with recombinant technologies, has been that “without thought of practical ends” is curiosity-driven. Right? I got an idea. I'm just going to follow that curiosity, and I'm going to discover what's going on.

This one-dimensional view of the world really dominated the thought, the approach to science, and also the funding mechanisms. The whole Defense Department “6.1, 6.2, 6.3.1.2” system is based on this linearly derived view of the way in which research proceeds and the way it affects commercialization and the economy. Who participates? Again, in this one-dimensional view, the start is always with university researchers. I find it interesting when this is proposed because I've heard this talk in the negative, the way I'm doing it now, as this is the way the world works, is they always say, oh, the university researchers, (unintelligible) sit in the back and raise my hand to the first question and said, “So what's one of the biggest revolutions?”

And somebody will say “semiconductors.” They go, where were those first three guys?

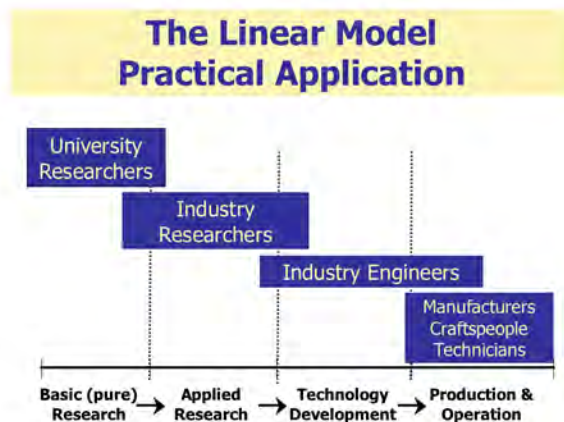


Where did they work? At the Bell Telephone laboratories. Okay? So it doesn't have to be university. Anyway, the singular view of this is university researchers with a significant overlap in this transition zone, industry researchers go on to industry engineers, to manufacturers, craftspeople and technicians who are actually developing products. So you can from the basic pure research, applied research, to technology development and finally out into real products that go out into the world.

Is this real? No, it's not real at all. Is it historically based? Some of the justification of Vannevar Bush of this view of the world dated back to the Greeks and the concept for pure knowledge, the concept of isolation, Plato's idea of the separation of the intellectual from society in order to have the pure, curiosity-driven thinking process subjected to pure reason and reason alone.

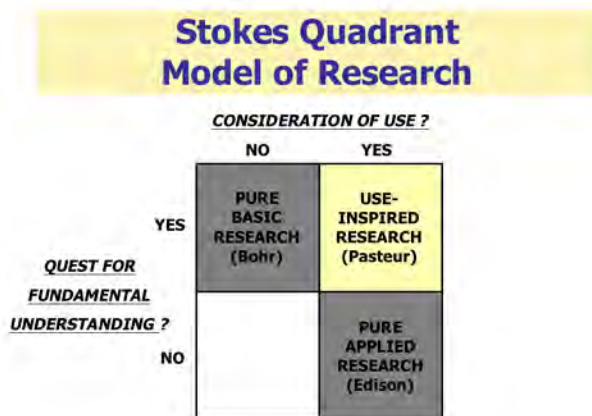
When Louis Pasteur was about 22, 23 years old in Paris, he was a 100-percent curiosity-driven researcher who looked at racemic acids, actually chirality [from the Greek, "handedness," a property of some molecules to be "left-handed" or "right-handed"]. He showed one of the earliest principles that molecules can have precisely the same chemical composition, exactly the same molecular weight, exactly the same size, exactly the same constituents, but if one is left-handed and the other is right-handed, the way in which they interact with light can polarize light one direction versus another direction. He showed that this was not a funny phenomenon but, rather, a super imposable phenomenon, and so you could actually get material, and racemic acid was the example, where you could have equal left and equal right, so it looks like it didn't polarize light at all, but if you separated out the left-handed stuff and the right-handed stuff, you could have one going one way and one going the other way, one of the most fundamental discoveries in science.

You never heard of that, right? What do you hear about Louis Pasteur? That he pasteurized the milk of France and the wine industry of France, right? Well, that was the middle[-aged] Louis Pasteur. So this question is often raised: Was Louis Pasteur a pure or an applied researcher? This question was addressed in a book that came out about 10 years ago and is becoming an underground cult item among some people who are involved in research administration and try to set research agendas. The 1997 book by Donald Stokes [*Pasteur's Quadrant: Basic Science and Technological Innovation*] explored this question—whether Louis Pasteur was a pure or applied researcher—and showed that, in fact, he was both. It's a



Was Louis Pasteur a pure or applied researcher?

slightly different model, however. [Stokes] really called into question (and this is why it's become a cult book over the last decade) the fundamental analysis of Vannevar Bush from the end of the Second World War, which has driven scientific growth since that time. The takeaway message was this: that the one-dimensional world of Vannevar Bush (remember, it went from curiosity-driven research to applied research to technology development to product) was really a two-dimensional world.



So, how is it a two-dimensional world?

The two axes are, first of all, a consideration of use; what you're looking at is driven by what the ultimate use is going to be. The second axis is a quest for fundamental understanding, discovery of fundamental knowledge. Now, if you think of it in this two-dimensional way, then in a simple binary world, you can have four possibilities for this.

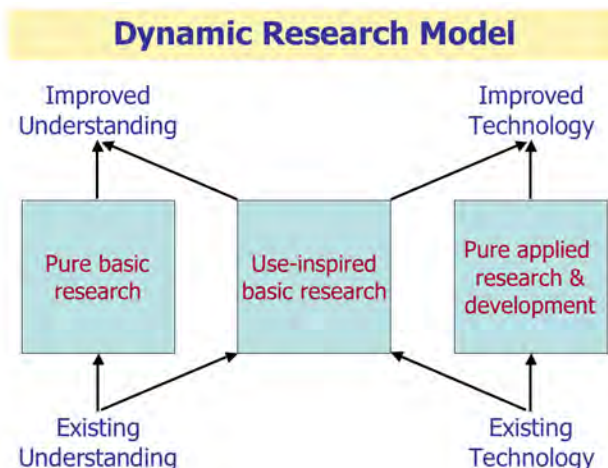
First of all, is there a quest for fundamental understanding? Yes. Is there a consideration of use? No. That's the classic example of curiosity-driven research, and one of the prime examples in the book is Niels Bohr, who, looking at the structure of the atom in one of the first models, completes models of the atom and the generation of quantum mechanics. He didn't care how the atoms were used. He didn't care about the concept of what ultimately became nuclear energy or anything like that. All he cared about, fundamentally, was what the structure of the atom was and whether he could describe certain optical phenomena from this.

At the other extreme is pure applied research, and the classic example I give is that of Thomas Edison. Now, I lived in Michigan for more than 16 years, and we used to always go to the Henry Ford Museum in Greenfield Village. So there you go into Edison's lab, and one of the first things to strike you is that it looks more like a kitchen than a lab. His approach: Don't worry about a quest for fundamental understanding; let's just keep trying something until we get the right material that gives us the light and the conversion efficiency that we need and the lifetime that we need. There's really no questioning, and if you look at his notes, they're the same way. They're more like a checklist. Like I said, it's more like a recipe than a scientific prescription. "Just try this." "Did we try it?" "Yes." "Did it work?" "No." "All right, try this." "Did it work?" And so on—systematized, all right, but no question for fundamental understanding.

Pasteur sits in another quadrant. Was there a consideration of use? Damn straight, there was, with the milk and the wine and all this. The government came to him with questions, and then he got real inspired about what's going on, went backward, and what did it lead to? Was there a quest for understanding? Yes, because he came into it with an attitude of wanting to know the cause, and from that came up with the pathogen theory of disease—again, one of the most fundamental things from the 19th century, which led into some of the biological revolutions in genetics in the early 20th century, which led to the molecular revolution of the end of the last century and this century. [Pasteur's research] had both of these characteristics:

consideration of use and a fundamental quest. This is use-inspired research.

Use-inspired research is the driving force of research by professionals—research by people who interact with the real world, deal with it daily, create for that world, and produce product. The second piece of research is the process. That's the concept, this idea, of the quest for knowledge but done in this way that's inspired by use. The process, when use-inspired, becomes dynamic instead of static. That one-dimensional world is static; you cannot launch into the applied-research stage until the fundamental stage is ended. You cannot launch into the technological development stage until the applied-research stage has ended. It's a very static view.



It's a much more dynamic view when you look at this two-dimensional world. And then you have the pure applied research leading to development. When you look at this dynamically, if you were doing pure applied research in Edisonian mode, you were fundamentally using existing technologies. You're trying different types of approaches to the problem, different types of technology, but you're fundamentally looking at existing technology.

When you're doing pure basic research that is curiosity-driven, your starting point is your current understanding. What's the basic understanding that you have at this time? That is, you start from the existing understanding, but you also start from what is the base technology, the developments that you have at that time to be able to address particular questions. The second piece of it—the output from pure research—is an improved understanding because you started with certain knowledge, you improved, and you increased that knowledge, so you have improved understanding of the nature of the world in which you exist. Use-inspired research takes this and can also improve the understanding.

I think a perfect example of that is right here in Seattle with Lee Hood, who founded the Institute of Systems Biology here. He is the guy who came up with the technology for the DNA sequencer. So almost all of the knowledge we've gotten in molecular genetics in the last 15 years was driven by a set of technology that was developed to say, "How am I going to go after and try to look at these base pairs in a DNA molecule as quickly and as rapidly as possible so I can ask fundamental questions?" Also too, when you're doing this, it will lead to improved technologies because with that understanding, you can change where you started with the existing technology. So use-inspired can do both.

Another way—and this is something which I am truly passionate about—is the concept that we've had in bioengineering for a generation, and [National Institutes of Health Director Elias] Zerhouni has lapsed onto the same phrase in the pure biomedical sciences. It's the idea of translational research; take the same model, but look at the outputs flowing the other direction. When you're working in a pure and applied area—almost always what happens in my area where we tried to translate something into the clinic—you find that there are limitations

to the technology. So it's not just what's the state of the current technology but also what are the limitations of the current technology.

When you have this view of use-inspired basic research, the limitations then frame new questions. To me, the key way professionals can influence research agendas is by framing the questions. That is the heart, in my opinion, in engineering and science education. To students, the hardest problem is showing how to ask the right question, how to frame it.

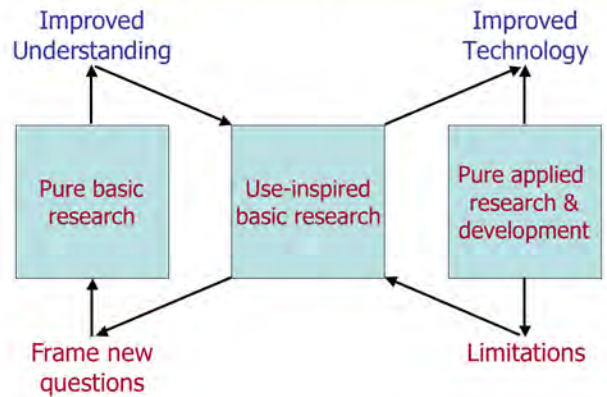
That, again, leads to improved understanding and improved technologies, but if you do it right, you can go back to another old dude, Francis Bacon. Francis Bacon is usually considered the inventor of the scientific method. The idea of hypothesis testing and all that really dates to Bacon. His motivation for developing the scientific method was that understanding begets control, meaning that to change stuff and make stuff work, you've got to understand it first.

You have this loop—and this is the translational loop that we have in bioengineering all the time—that is, you go to applied research and development, you find out the limitations that you have, and that frames new questions, which allows you to perform basic research. It's inspired by the use, but it's a basic question that you're attacking. It gives you an improved understanding, which allows you to improve the technology. You try to apply that technology again, you find the limitations, and you just ratchet, ratchet, ratchet, ratchet this thing up as you improve on that.

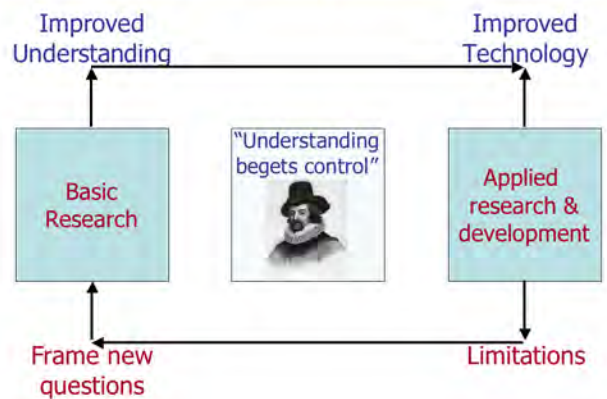
So let me give you an example. This is intravascular ultrasound, which was a technology developed by three or four groups independently in the late '80s, and my group was one of those. It's part of a larger area, which is interventional cardiology, which is delivery of [cardiovascular] devices, and the stent is probably the one most familiar to people.

The stent is to open, in the simplest case, a clogged artery. So you have the balloons

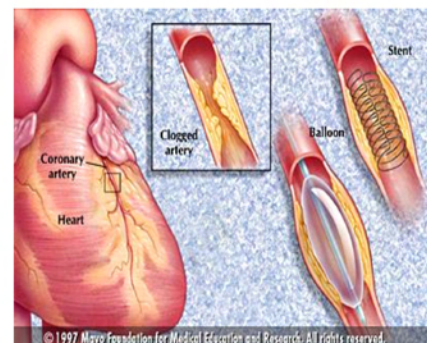
Feedback – Translational Research



Feedback – Translational Research



An Example: IVUS



for angioplasty, the stenting, which is delivered along the same type of balloons to open blockages. This is sort of underappreciated. The change in life expectancy since the Second World War has been almost exclusively driven by improvements in the care of cardiovascular disease. Our knowledge of cancer is infinitely better than it was a generation ago and will get much better as we learn more of the molecular basis, but the death rates have been fairly constant for a long time.

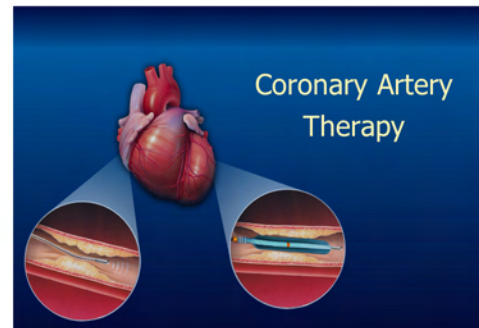
Cardiovascular disease is the place where we have made the major improvements over the last generation—and, as seen in the life expectancies, through devices such as this, which has driven a lot of those improvements. So what is IVUS, intravascular ultrasound? IVUS is the eyes of the system because once you snake a catheter inside, you can see on X-rays where you're going, but you can't see in any kind of detail what's in there, so you're driving blind. So we developed a technology in the late '80s which, on the same catheters, can be an imaging system. That's something that will make cross-sectional images of the artery as you're pulling this through using ultrasound.

For the ultrasound that's used to look at babies and the ultrasound you use to look at the whole heart, we developed a system that could be embedded in one of the catheters used for doing the procedure that will allow you to view it beforehand, stage the procedure, evaluate the effectiveness of the procedure, and allow the long-term follow-up on the procedure. Cool stuff, the worlds we created. This is from the early '90s, when I was at Michigan and we helped found a startup company called EndoSonics out in California that developed the world's smallest imaging system.

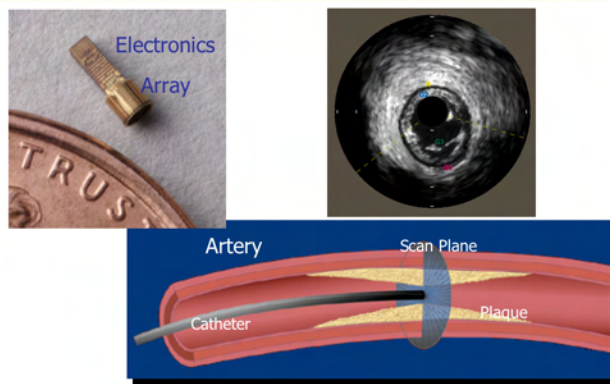
The entire ultrasound imaging device is about a millimeter in diameter. By the way, it's also disposable. You use it once, you throw it away. This thing costs virtually nothing to produce. It makes pictures such as this. You can't, in this light you can't see it very well, but you see that little guy right there? That's bad. So if you were watching this in real time—I didn't bring movies—you would see this thing flapping in the breeze as the bloodflow is going by. Not a good thing, okay?

However, you can then perform an intervention and look exactly back at this cross-sectional plane through the artery, and you can then derive a procedure based on that. Cool stuff,

An example: IVUS



World's smallest imaging system



right? Some problems, though. We've translated this technology into the clinic, and now it's about a \$300 million-a-year business, and EndoSonics, which is now called Volcano Therapeutics, is about \$100 million of that. The predictions were that this was to be a several billion-dollar-a-year business. Worldwide, this technology is used on only 10 percent of interventional procedures. Why? Well, it requires an extra device.

To get that catheter in, you know, you gotta stick another catheter in there. If you ever been in a cath lab, it's like clockwork. You stick in a device, so to stick another device in means you have to take the old one out. So somebody's in there, you know, there's this person on the table and you're going through their leg and there's five people around, and you start shoving a device in and you pull another device out and you stick your device in to image and pull that out.

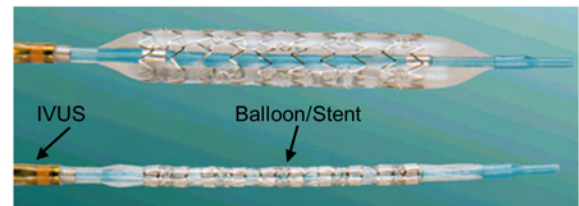
You stick the device back to do the intervention, and even though the reason it was adopted in 10 percent was because it was proven to significantly change outcomes, it was so damn hard to use that people would only use it for the most difficult cases, so that was 10 percent. It increased procedure time because they're pulling in, pulling out, and all that. Time is money in this ward, and that's added expense in addition to the expense of the device itself.

So it was not the flaming success we thought. What was the applied-research approach to this? Well, the first was, if you gotta pull a device out and stick another one in, let's combine the therapeutic device with this imaging device. We'll have one device, and that's what this is. This was developed in the late '90s; you can see it's a stent. That's the metallic—one of the older metallic stents, not the drug-eluting newer stents—a metallic stent delivered along a balloon, and it has the little imaging system. We were real excited about this until a marketing person, after going through a few clinical trials, noted that this is really great, but it costs twice as much.

Problems with technology

- Required an extra device
- Increased time of procedure
- Added expense

Applied Research Solution



Combined Balloon/Stent with IVUS

Use Analysis

- Can't have an additional device
- Can't increase procedure cost/time
- Can you image from the guidewire?
–frames basic research question

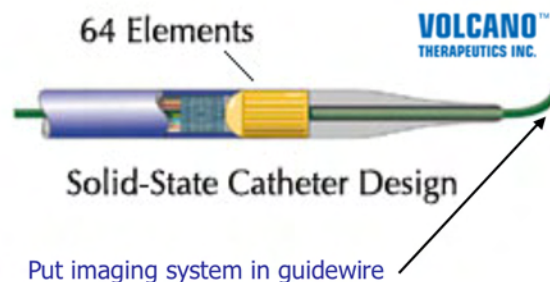
It turns out that there was little cost savings by integrating these two technologies, so again, the development of this took it from 7 percent just a few years ago up to about 10 percent today. It's not going further with this. So use analysis. Remember, use-inspired research. What's the analysis that we had out of this? One, we can't have an additional device. Whatever you do, you can't make a new gadget to go in there. Second, you can't increase the procedure cost or time because these folks are cowboys.

Unless it's the most difficult case, they're just going to do it blind. They'd rather do it blind than have the extra procedure cost, as long as they know it's not a difficult or complicated case, at least from the beginning. The cowboys can always go back, if they see some complication, and use it as they refine the procedure, but in the initial case, they won't do it. So what we came up with about 10 years ago was a framing of question: Instead of imaging from the device, can you image from the guidewire?

Well, what is the guidewire? Here's this picture of one of these devices. This is an imaging device. That little wire is about 300 microns in diameter; actually it's smaller than that because it's one-fifth of the diameter of this guy, which means it's about 1/25th the area of the actual catheter that's snaked down there because you deliver these devices back and forth. The way we framed the question was, can we just stick the imaging system in the guidewire? That way, whatever device comes in and out, we're there with our imaging system looking all the time. From the time that you go into the cath lab to the time you leave the cath lab, when the wire's in there, you're imaging and looking there all the time.

Wonderful question, right? How the hell do you do it? That was framing the question. There was no technology around that could come close to the dimensions because this is, remem-

Guidewire IVUS



Guidewire IVUS – How ?

- New ultrasound transduction technology – **light to sound** versus **electricity to sound**
- Over a decade of fundamental studies creating technology
- Devices being developed for clinical use

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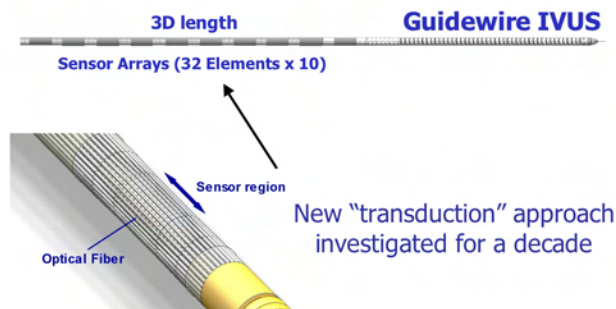
ber, 1/25th the area of what at the time was the world's smallest imaging system. So how do you do it? Well, we created a new technology. It was over a period of a decade, funded by the Navy, funded by the National Institutes of Health, funded by the National Science Foundation, because there were parts that had to do with materials; there was parts that had to do with systems and parts that had to do with the interactions with biological substances.

We created an imaging system now that is fully embedded within the guidewire of this. So it's an IVUS—intravascular ultrasound—but it's totally embedded within this guidewire. To do this was a decade of work, totally inventing a new technology to do that. Why? Because we knew, we were inspired, that if we didn't do this, it was never going to be used by practitioners. This is now actually a cartoon of a device that is in another startup company, and we're hoping that we can finally crack this nut and have a major impact on intravascular ultrasound.

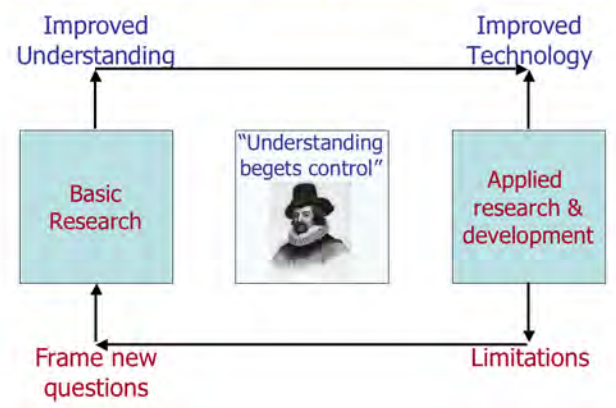
So, again, we invented a new technology, and it turns out this technology now is in a startup company to go after this problem. A bunch of groups now are looking at this as a whole different way to do molecular medicine technology. We have a new model for research by professionals, use-inspired—there's translation into actual practice, framing new questions—and what I'm really interested in hearing the rest of today is that in engineering, clearly now at the high-technology fringe of engineering, this entire process totally drives the profession, the concept of an investigation.

So if you go into Microsoft, if you go into Intel, you go into Medtronic, you go into a major engineering company, every single engineer around will know the concept of an investigation. What it means is usually, in Silicon Valley parlance, that we framed a question, we don't know what's going on, you got two weeks. Go. Tick, tick, tick, tick, tick. Because a Silicon Valley company can't wait two years to find out the answer, but you do it for two, and the result of a

Guidewire IVUS



Feedback – Translational Research



New model for research by professionals

- Use-inspired
- Translation frames new questions
- Process drives the profession

March 23 KEYNOTE ADDRESS:

THE CULTURE OF RESEARCH

Matthew O'Donnell, PhD

Dean, College of Engineering, University of Washington

lot of investigations are, “Here’s what the problems are, we tried a couple things, and here’s where we think you should go for the future.” That process is totally embedded now within the profession.

So let me end up in the last five or six minutes here to come back to the original title and theme of the talk, which is “the culture of research.” In the research culture in the professions, use-inspired concepts drive programs. So everybody knows nano, right? Everybody hears the word nano. This is your 787, your Boeing 787. The entire electrical system will be driven by the mechanical flopping of the flings, because energy-harvesting nano materials will be embedded within the composite materials for the wings.

Fascinating, this robosurgery, which, right now coming out of our electrical engineering department, is completely remote surgery; these robot sort of surgical devices are completely remote devices. The short-term focus is at the high end in the developed world. Within a decade, these things are going to be absolutely robust for third-world and global health issues. Again, so the use of this is inspiring the way this is going to go.

At the University Of Washington, the College of Engineering has 7.5 percent of the faculty members in the university. We have more than 50 percent of the intellectual property developed for the university. My goal is to make it 75 percent within a couple of years. Now, that assumes everybody else is constant. Also, too, our bioengineering department here is shared by the medical school and the engineering school. In fact, much of the school of medicine consists of bioengineers. The core value for us is the connection to our profession.

Here are two other examples. Farecast, is used to know when to buy afares. It’s a computer automata that will search all

Research Culture in the Professions

- Research: use-inspired drives programs

Research Impact



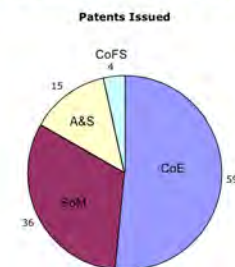
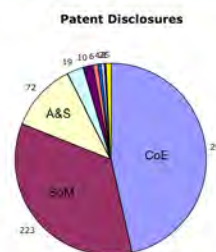
Energy harvesting and storage systems and their integration to aero vehicles



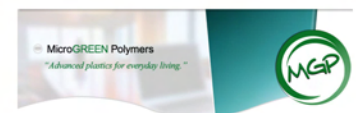
Research Culture in the Professions

- Translation: connection to profession

UW Disclosures and Patents in FY 2005



Societal Impact



Farecast
Know When to Buy

March 23 KEYNOTE ADDRESS:

THE CULTURE OF RESEARCH

Matthew O'Donnell, PhD
Dean, College of Engineering, University of Washington

the airline fares and will come up with an optimization of exactly when you should buy your ticket. It will find you the cheapest fare, guaranteed. Another example is micro-green polymers. These are your coffee cups, which are degradable, totally green technologies for simple paper and cardboard type of products developed.

The other place where you can influence size through obvious commercialization is in the way that people learn. We've done a lot of work as part of our research culture because we look at the way we change what we teach our kids; we look at how our kids learn. That impacts dramatically the way in which we think about educating people in science and math.

So how do you integrate [research] with your academic core missions? The biggest piece of a research culture within an academic place is to not view research as orthogonal to the undergraduate experience, in the same way—and I'm sure this is true of architecture as it is in engineering—that the idea of doing practical internships is core to the way in which we teach.

Teaching them how to do research is now core to how we approach undergraduates. Why? Because they're going to be in a Silicon Valley company, and the boss is going to come up to them and say, "You've got two weeks to do this investigation." They have to know how to approach that.

The scientific method, Bacon, and the design process with which you are all familiar. They are almost identical; it's just the way in which it's emphasized. What I would like to say is that they really are not orthogonal to each other. They're essentially the same thing. The last piece on this is that research drives the operation. Once you go into a research culture, even though you have these other components, the research really drives the entire culture.

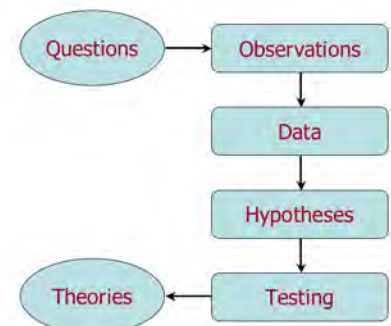
Research Culture in the Professions

- Integrate research and academic programs
- Teaching & service: academic norms

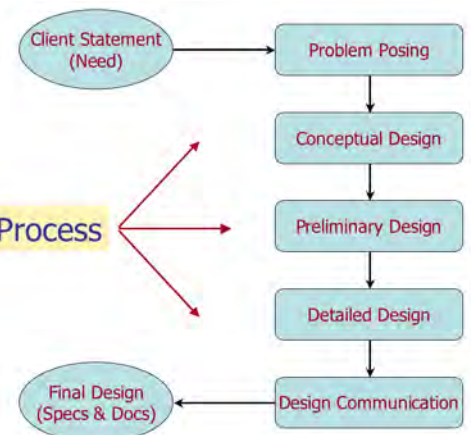
Integrating research into education

- Teach research methodology – parallels design methodology
- Research culture at BS level – **practical experiences**
- Use latest research examples to teach fundamental concepts
- Large graduate program – must connect with undergraduates

Scientific Method



Design Process



Our research expenditures are going off the wall. We'll [have] more than \$100 million in research expenditures. That's nice. That's just a number. What does it mean? Let me focus on this: Our facilities and equipment expense plus our direct research expense is about 54 percent, so more than 50 percent of our operation is driven by research.

We have more than 3,000 undergraduates and more than 15,000 graduate students who run through our college, but more than 50 percent of our operations are funded by research. So it becomes a management issue, a financial issue as well as an intellectual issue. You have to know where the money goes when you're being driven by research and what the rules are.

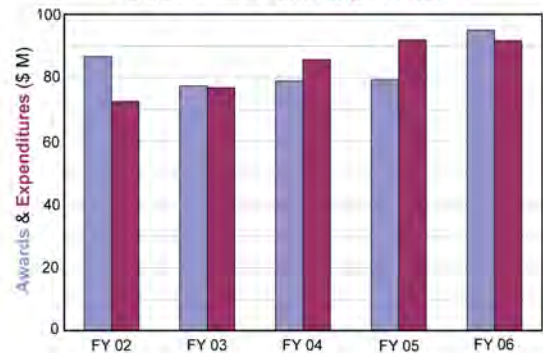
Again, these are the major pieces when you're in the research culture for the professions. This idea of use-inspired research really should be driving a lot of the projects. Translation is a connection to your profession. You must integrate it with whatever your norms are and within the academics we teach. Finally, if you are going into a research thing, it's sort of a jump, going over the precipice. Research tends to drive your operations.

All you have to do is go to any major medical school in the country right now, and you know how research tends to drive almost all operations. I'll close with a couple of ideas of what constitutes a truly successful research culture. First, you go after the big stuff, right? Go after large, societal issues. You know, go after global warming. Again, it's inspired by the use. Second, use the research. Don't think it as foreign. Use successful research to continuously revitalize the academic program. We fight this battle all the time in engineering. As you progress this way, you're going to be fighting this battle all the time.

Research Culture in the Professions

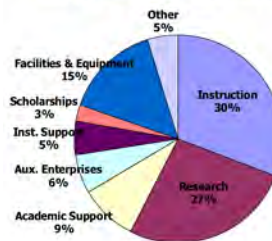
- Research drives operations

COE Awards and Expenditures

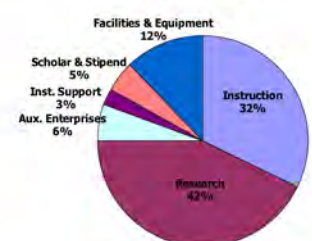


Research drives operations

UW (Excluding UWMC) – FY 2005



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Research Culture in the Professions

- Research: use-inspired drives programs
- Translation: connection to profession
- Integrate research and academic programs
- Teaching & service: academic norms
- Research drives operations

It has to do with accreditation, and it also has to do with the expectations of some of the industries where your kids are going to go to work.

Do it right, though, and the research can continuously revitalize and help reinforce some of the fundamental concepts that you have in your academic program. You must manage it. It is a business. It's not somebody showing up with a checkbook and giving you funds to do things. It's a business, and it has to be managed like any other piece of your business.

The last one I'll leave you with is the part that has driven me for well over 30 years—and I think drives all successful research engineers and scientists—and that is when you're in the mode of continuously looking in that loop of use-inspired research heading toward translation, framing fundamental use driven loop is about as entrepreneurial as you can get.

Every aspect of this involves both risk and significant reward, which is sort of the definition of entrepreneur. If you embed everything you do with risk taking, you take risk as a new way of educating. Our chemical engineering department right now is totally rewriting their graduate curriculum based on nanoscale and molecular engineering. You can take risks like that if you have that kind of spirit.

That's where I'm going to end. Thank you very much.

Successful Research Culture

- Attack big issues: use-inspired
- Use research to continuously revitalize academic programs
- Manage business of research
- Entrepreneurial spirit