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Q&A: OC Success Story – Bruce Tromberg. Went From Leading UCI's Beckman Laser Institute to Running one of the NIH Institutes…

by Deirdre Newman March 26, 2019 Home, Innovation, Q&A's

This Q& A is with Bruce Tromberg, whose innovation-fueled trajectory of science and innovation has guided him from running the Beckman Laser Institute at UCI to running one of the institutes at the National Institutes of Health.

His entire professional career has been spent working on developing new tech to treat and cure diseases, with principles based on engineering and the physical sciences.

This OC success story details that trajectory and delineates his goals for the NIH institute he leads — the National Institute of Biomedical Imaging and Bioengineering. He began his post there earlier this year.

OCSN: When did your interest in biomedical technology and biophotonics start?

Tromberg: Like a lot of scientists, I was always interested in science and tech and grew up tinkering with radios, microscopes, cameras, chemistry sets and model rockets. Read widely. Devoured anything I could find that was based on science and tech.

I've always been interested in gadgets, devices and tech and how they can be used to measure and understand biological systems – so, the interface between physical science, engineering, biology and medicine. In particular, through lasers and optics. They're really good measurement tools. I like to measure stuff.

It was a different era back then. I grew up in Washington D.C. Interesting completion of a circle moving back now. Volunteered at the NIH, (at the National Cancer Institute in Bethesda, MD) as a high school student, in 1973. I had a chance to work on one of the early "DEC PDP 11" computers, which was just moving into biomedical research. My mentor, Stan Shackney, was developing a computational model of cancer cell populations. The goal was to try to understand the relationship between the computer model and real cell growth to predict how different drugs could be used to treat cancer.

The lab I worked in was really pushing the envelope of state-of-the-art computer technology.

I became exposed very early on to physical and mathematical models within the context of biology. I was really lucky to have that experience.

This was just two years after former President Richard Nixon signed the "National Cancer Act," also known as the "War on Cancer," and I was thrilled to be part of the incredible excitement and activity in that community.

I also worked – during my summers in college — at the EPA, in the Non-Ionizing Electromagnetic Radiation Analysis branch. I know that's a complicated name, but it was a really fun job.

We had a giant RV full of electronic equipment and went around the D.C. area measuring and mapping radio and microwave radiation. My main job was to climb on the roof of the RV and assemble the giant antennas. Definitely attracted curious crowds!

OCSN: When did you first come to UCI?

Tromberg: I started at UCI in 1988 as a post doc. I was working in lasers in the field of laser spectroscopy and fiber optic sensors. I always wanted to figure out how to bring that into medicine.

The Beckman Laser Institute was brand new at the time. Mike Berns, the founder and director, was doing what I thought was amazing stuff. So I responded to his post-doc ad in "Science" magazine. I had several other offers in industry and academia, but there was something special about the institute and its potential, even though it was my lowest offer.

I also had an offer at that time to come to the NIH as a post-doc. The guy that I would have worked for, said, “We don’t really value engineering and physical science at the NIH, so you should go to California.”

I took his advice and eventually became a UCI professor starting in January 1990. I also directed the Beckman Laser Institute and Medical Clinic from 2003-2018, and ran an NIH-supported national biomedical technology center, the Laser Microbeam and Medical Program, part of the institute, from 1997 to 2018.

At Beckman, I got very lucky with being in the right place at the right time. I came to an institute that was just starting and had tremendous growth potential. Our field of lasers and optics in biology and medicine was also just at the beginning.

We’ve grown enormously over the past 30 years. One way to assess this is to look at our biggest conference in the field, SPIE’s Photonics West; it used to be in L.A., then San Jose, now it’s in San Francisco. I think the first one I went to was in ‘87. There were only a few hundred people in our topic area and the terms “biophotonics” and “biomedical optics” didn’t exist. Now there are more than 20,000 Photonics West attendees.

OCSN: You’ve pioneered the development of biophotonics technologies for characterizing and imaging tissue structure

(Biophotonics is a combo of biology and photonics, with photonics being the science and technology of generation, manipulation, and detection of photons, quantum units of light.)

Tromberg: One of the ways we apply biophotonics technologies is to take images beneath the surface of the skin. For example, we can measure deep into breast tissue to detect breast cancer, as well as image skin to detect melanoma and other skin cancers.

We’re also looking at how blood flows into your muscles and use these signatures to understand how your cardiovascular system and skeletal muscles are working.

Other methods are designed to look at your brain – both blood flow and how cells are using oxygen, to understand your body’s metabolic rate of oxygen consumption.

All these measurements require new tech. That’s the tech I specialize in. What my lab specializes in, and what the Beckman Laser Institute does very well, is understanding how light is interacting with biological tissues and then controlling the light by manipulating it in different ways.

For example, you can make it come out of a laser or light source in pulses or waves, you can get many different wavelengths of light, and have that interact with tissue in many different locations or patterns in space. We analyze those interactions, and we can say something about the cells we’re trying to interrogate or measure.

All of these technologies are at the convergence of engineering, physics, chemistry and computational science, with very focused applications in biology and medicine.

That is the mission of my NIH institute — the National Institute of Biomedical Imaging and Bioengineering — to bring engineering and the physical sciences, (physics, chemistry, and mathematics), into biology and medicine. We're the only NIH institute with that as the core mission.

OCSN: What does the market look like for photonics?

Tromberg: If you add up the total global medical market for optics and photonics — both therapeutic and diagnostic — more than $70 billion a year.

Medical devices that are being used include lasers for cutaneous skin treatments and eye surgeries; imaging devices based on endoscopy and optical coherence tomography to obtain cross-sectional, diagnostic images of internal organ tissues; and wearable/bedside spectroscopic sensors for tissue and pulse oximetry.

There are many very beautiful technologies that are out there. I've been very lucky to have been involved in many of these developments over the years and it's been fantastic.

Our area of optics and photonics recently was the subject of a national academy report that called it an essential technology for our nation. See that report **here**.

Optics and photonics is about a $3 trillion industry in the U.S. From the medical market point of view, optics and photonics accounts for about 15% of the global medical device market, which is about $460 billion per year.

OCSN: What interesting innovations happened at the Beckman Laser Institute during your tenure?

Tromberg: The institute is a multi-disciplinary center with more than 20 faculty. They're from various departments across UCI's schools of engineering, biological science, medicine, and physical science.

Kind of an old-fashioned, integrated institute.

A lot of commercialization comes out it. We started a photonics incubator in the late 90s. It's been very successful in starting new companies and licensing IP to existing companies.

We've generated more than $65 million in royalty revenue, a little less than half of the royalty revenue generated by the entire UCI campus.

Most of it has been from one big patent – the dynamic cooling device, which is connected to a therapeutic laser for skin surgery.

This device uses tech that our medical director, Stuart Nelson, and colleagues developed for treating disfiguring birthmarks in infants and children.

This challenging problem was, and remains, the core focus of his medical practice. The device is now part of more than 25,000 lasers, and has been used on tens of millions of patients around the world.

We developed a variety of other technologies, primarily diagnostic ones, and have done quite a bit of patenting with startups.

When I left the laser institute, we had about 12 companies in our photonics incubator. One that I co-founded was Modulated Imaging (aka ModuLim) (see related article on its Series B raise here).

The CEO, David Cuccia, and director of research, Amaan Mazhar, were both grad students in my research group where we first developed the tech.

We were able to create a unique environment at the institute that helped faculty, fellows and students get involved in commercialization, start companies, and build an innovation ecosystem.

To accomplish this we worked very closely with UCI Applied Innovation, UCI's innovation platform and physical hub at the Cove. Applied Innovation was formed by Chancellor Howard Gillman based on recommendations of a task force that was charged by him to rethink how to do innovation at UCI. I was fortunate to be part of this task force, and it ultimately led to the successful recruitment of its visionary leader, Richard Sudek.

I worked really closely with Richard and Associate Director Carolyn Stephens over the years and launched an initiative, which UCI provost Enrique Lavernia supported, to bring new faculty and technologies and companies to campus.

We called it the "convergence optical sciences initiative" and it will be housed, in part, in the Cove's new facility. (See related story on the Cove's move this summer to the former Broadcom HQ **here**).

For the new facility, we designed about 10.000 s.f. of space for faculty who are part of the laser institute, as well as new faculty to establish labs and be woven into Applied Innovation, along with those who are interested in commercialization, people who are starting new companies and people who are in the VC community.

It will be a seamless integration of discovery and entrepreneurship that will allow collaborative teams to address scientific, clinical and market needs in human health.

OCSN: What new innovation happened at the onco-imaging and biotechnology program at UCI's Chao Family Comprehensive Cancer Center under your watch?

In the early 90s, UCI did not have a cancer center. Dr. Frank Meyskens was recruited from the University of Arizona to lead the formation of our first National Cancer Institute-designated program.

When you become recognized by the NCI, you get a grant to create a set of organized and innovative programs in many different areas related to cancer.

It also enables you to build unique resources so investigators can push the envelope and make discoveries that they wouldn't have made without it.

Meyskens and Professor Hung Fan, who led UCI's cancer research institute, asked me if I could join and help. So in 1993, I was part of the team that wrote our first successful National Cancer Institute-grant proposal.

I co-led a program called photomedicine, and a technical core called optical biology. These were the first of their kind in the country. Both my programs and the center did well in review. We maintained continuous funding and my program eventually became "onco-imaging and biotechnology". I did that for 25 years.

UCI's Chao Family Comprehensive Cancer Center, now led by Rick Van Etten, is OC's only National Cancer Institute-designated comprehensive cancer center — a huge achievement.

We developed, from a clinical and translational side, new ways to detect and diagnose cancer.

This includes distinguishing between malignant and benign tumors; new micro-endoscopic imaging tech to go inside the body and look at early disease processes, new ways to image and predict how people are responding to chemotherapy and new ways to understand and optimize radiation therapy. We also developed methods for combining light with drugs to selectively treat tumors.

Those are clinical things. We also developed a variety of advanced tech for basic science to understand the biological origins of cancer, i.e. what's the difference between a cancer cell and a normal cell? And, how do you image and measure that?

Ultimately, we've been able to generate new knowledge, combine this with new technologies, and introduce new devices into the clinic to help patients.

A recent example is our work in melanoma diagnostics. We developed some unique cellular imaging tech to see beneath the surface of the skin, with ultra-fast lasers, without having to do a biopsy. And, we can now do this in patients.

Most of my work is designed to be non-invasive without biopsy, but we do biopsies to validate the measurements we take. There's a progression, if you do want to develop new technologies without biopsies, you have to complete several studies with biopsies — to compare and contrast. That's where the tech development is.

OCSN: How has the institute you now lead evolved since its inception?

Tromberg: This institute was established 15 years ago. It's the second newest of the 27 NIH institutes and centers. We're not one of the big ones. We're kind of a smaller size. Our budget this

year is about $389 million. We were established to help promote and drive the movement of technology that comes from engineering and the physical sciences into biology and medicine.

The institute was created by congressional legislation from and signed into law by former President Bill Clinton in 2000. Our portfolio of programs and grants became active in 2002. From then until now, the growth of engineering and physical sciences in biology and medicine has been enormous.

In 2000, funding for departments of Engineering was a small fraction of the NIH budget. About 0.6%. Today it's about 2%. More than $700 million of the NIH budget now goes into engineering schools around the country to support biomedical research.

Schools of engineering have identified human health and biology as important areas to work on. And they're bringing people into engineering departments who can solve challenging biomedical problems.

My career in UCI's department of biomedical engineering has been a great example of that. The Beckman Laser Institute has been at the cutting edge of that movement.

OCSN: How did you get the job as director of this institute?

Tromberg: I knew the position was open and several people at the NIH encouraged me to consider it. This is probably the only thing – this opportunity – that could have gotten me out of OC.

With everything available at the laser institute and UCI's innovation platform, there aren't many better places in the world for doing this than OC, considering the region, the people, the university, the ambition. It's a fantastic place. And now that I've been in D.C., I have a renewed appreciation for the OC weather!

I wasn't interested in any other universities. I never expected to leave UCI. It's hard to communicate, but the NIH is the most important place on the planet for biomedical research. Francis Collins, who leads it, and the other institute and center directors, are superstars.

So, the opportunity to be able to work with Collins and his team on a regular basis, is hugely appealing.

It's also a great opportunity to think about how to contribute back to my community, which has grown enormously over the past 30 years. One of the things I'm excited about is helping tell the world about the remarkable things we do in merging engineering and physical science with biology and medicine.

Not many people are aware of that. Many understand research in cancer, heart disease and Alzheimer's disease, but the story of how diseases are detected and cured, using principles that come from engineering and physical sciences is less known. So, I think I'm in a good position to be an advocate on behalf of all the super-talented investigators we have all over the country.

It's an opportunity to advance and promote a movement that's important for not only the health of individuals in the country, but also forms the basis of OC's biomedical device community; this is the foundation for economic growth. And it's happening in universities and zones of entrepreneurship all over the country.

Technology that's feeding growth of emerging companies — this ecosystem that's now happening – that' s appearing both in OC and in other places all around the country is driven largely by advances in engineering, computation, and physical science…this all becomes devices and software that can be used to drive basic science discoveries and help patients in the clinic.

My institute supports about 800 grantees around the country. Our goals are to continue to nurture and grow this community so the next generation of biomedical imaging and bioengineering technologies can continue to be developed for improving human and economic health.

OCSN: What is the status of the NIH as a whole these days?

Tromberg: All of us in academia who do biomedical research are impacted by the NIH.

It's about a $39 billion/year organization that supports biomedical research in labs all over the world.

The NIH campus has more than 30,000 people. Our programs support labs in universities, companies, medical centers and research institutes everywhere. In fact, most of the money goes out to these research programs around the country.

UCI and OC companies, for example, receive hundreds of millions of dollars from the NIH each year.

Major research labs all around the country are receiving these grants. They're competitive peer reviewed grants that provide investigators with resources to discover new things and move discoveries and technologies from the bench to the bedside.

If you look at the work at the Beckman Laser Institute, and all the commercialization that took place, all the initial discovery was seeded by government funding from the NIH and other federal agencies such as the Department of Defense and the National Science Foundation.

The institute has also had significant support from the Department of Defense.

And, it's not just a one-way street. Active investigators who receive NIH funds also do extensive service.

I've been engaged in service at the NIH on committees and councils for over 25 years.

Most recently, from 2012-2016, I was a member of the advisory council for the institute I now lead. Rod Pettigrew, the founding director of this institute, appointed me to the advisory council.

That gave me yet another kind of perspective on the operations of this specific institute and the NIH in general. It was a key experience that gave me the insight and confidence to apply for the director position in the first place.

OCSN: Now that you're seeing things from a more national perspective, what does OC need to do, to compete with other innovation hubs?

Tromberg: From my experience in OC, and surveying from my time on advisory boards at universities around the country, we have outstanding academic-industry partnerships and a strong culture of biomedical innovation.

As an organization that provides about $1.1 billion in seed capital per year for biomedical innovation, the NIH is a great source and partner for facilitating economic growth.

I'm hopeful that starting with connections in OC, I can create a better understanding of these activities all around the country, and make the case to decision makers, who ultimately will impact our budget — that science and discovery, from a tech point of view, is important for economic and human health.

We need to build a national effort to help educate – need to get our stakeholders involved, including professional societies in bioimaging and engineering, and really help people understand the importance of what we do – in the context of biomedical research and human health.

Our work clearly drives the future of heath and how healthcare will be delivered in the next five to 10 years, so it improves the lives of patients all around the country.

OCSN: What is your status at UCI now?

Tromberg: I had to officially separate from UCI in order to take my position at NIH, so I've retired as an emeritus professor. My lab still exists but over the course of the next one to two years, we'll wrap up projects and have students finish programs and graduate.

OCSN: Do you still have ties to OC?

Tromberg: We lived in OC for 30 years. I have two sons in OC (the other is in San Diego) and we'll keep our house there.

My mom and sister live in OC. My wife, Patti, is traveling back and forth from OC to D.C. until we get settled. She's a special education teacher. She stopped teaching and is spending a lot of time planning how we'll complete the transition. Right now we're living in Bethesda, close to the NIH campus.

OCSN: How does the current political climate affect the NIH?

Tromberg: Another reason why I'm so excited to be at the NIH, is that there's tremendous bipartisan support. Our mission is widely appreciated by everyone here. I've had a chance to experience that.

We had a big Congressional visit day recently. I met with several members.

And, we had a major reception for the Children's Inn, a nonprofit inn on our campus that provides critical services to children who are patients at our clinical center.

It's the most important and ambitious center in the world for treating various complex and rare diseases. It's all free. Everything is covered. An amazing array of services are available. Had a chance to meet adults who were children when they were here and who were cured. Just a remarkable thing.

I've seen nothing but tremendous support, and, personally, have heard from staffers and members of congress. There's a lot of admiration and respect for what we do at the NIH and how important and impactful it is for the country.

I attribute a lot of that to the people here. The level and quality of leadership, scientists, investigators and staff – everyone is exceptionally dedicated to the mission of advancing human health.

The NIH Director, Collins, was first appointed by former President Barack Obama and reappointed by President Donald Trump. This really underscores how extraordinarily talented and widely respected he is.