

MCB



TECHNOLOGICAL BREAKTHROUGHS TRANSFORM BIOLOGICAL INQUIRY IN NEUROSCIENCE



LETTER FROM THE DIRECTOR



Dr. Stephen G. Sligar

Fifty-three years ago, Bob Dylan released the song “The Times They Are a Changin’.” Today, times are indeed different at the University of Illinois. Many of you know that I earned my Ph.D. in Physics in the College of Engineering here, matriculating in 1970. This was the height of the Vietnam War and the draft took several fellow graduate students – some not returning, while others were forced to change from experiment to theory due to loss of multiple limbs. Those were polarized times, and they remain so. The campus is putting in place financial models that call for a reduced reliance on the State for resources. Despite these challenges, MCB remains a bright and shining jewel. Campus resources are committed to two exciting academic projects: A new Carle-Illinois College of Medicine and a cross-campus Siebel Design Center. MCB will play important roles in these and other initiatives. The School of MCB is on solid financial ground, with high demand for the MCB major and undergraduate enrollments limited only by the availability of instructional space. The research prowess of MCB faculty has translated into MCB leading in the receipt of external funding from the National Institutes of Health, the main source of the United States investment in health related research. That said, we increasingly rely on support from our alumni and friends, as demonstrated in several articles in this issue of the MCB Magazine.

I believe one of the benefactors represented in this issue deserves a special comment. As described, Dr. Kris Jenner provided an endowed professorship in my name. It is highly unusual to recognize a currently appointed individual with this honor. While Dr. Jenner is well known to the University of Illinois as a quarterback in the early 1980s, I was blessed with having him as an undergraduate researcher in my laboratory. Not only an excellent athlete and an “A student,” he was a dedicated independent scientist. He continued his outstanding level of accomplishment through a Marshall Scholarship, earning a Ph.D. in biochemistry at Oxford, followed by an M.D. from Johns Hopkins and subsequent transition to leadership in the investment community. Although the details escape me, he credits me with advice I provided during various times in his career path. This is one example of the real rewards of being an educator: Seeing one’s “children” succeed at the highest level. Most often we do not realize the influence we are having on our students, and it is only decades later when they come forward that we are reminded of the benefits of choosing academe as a profession.

This will be my last introduction to the MCB Magazine. I have been Director of the School for 10 years, and I believe that administrative positions need to change in order to bring new thoughts, directions, and visions to the forefront. I have been fortunate to have enjoyed over 40 years of continuous NIH funding for my own research, and was recently awarded a type of grant that guarantees at least five additional years of support for my entire laboratory, with the important benefit that I can work across a broad spectrum of endeavors without being limited by individual specific aims. I have also accepted a role in the new Carle-Illinois College of Medicine in delivering an advanced “capstone” course to medical students that integrates what they have learned in the basic medical sciences with fundamental engineering and clinical concepts to realize a system-wide understanding of the mechanisms of disease. Hence, while missing the role as Director after August, I look forward to making a continuing contribution to the excellence that is Illinois and the School of Molecular and Cellular Biology.

A handwritten signature in black ink that reads "SgSligar". The signature is written in a cursive, flowing style.

Stephen G. Sligar

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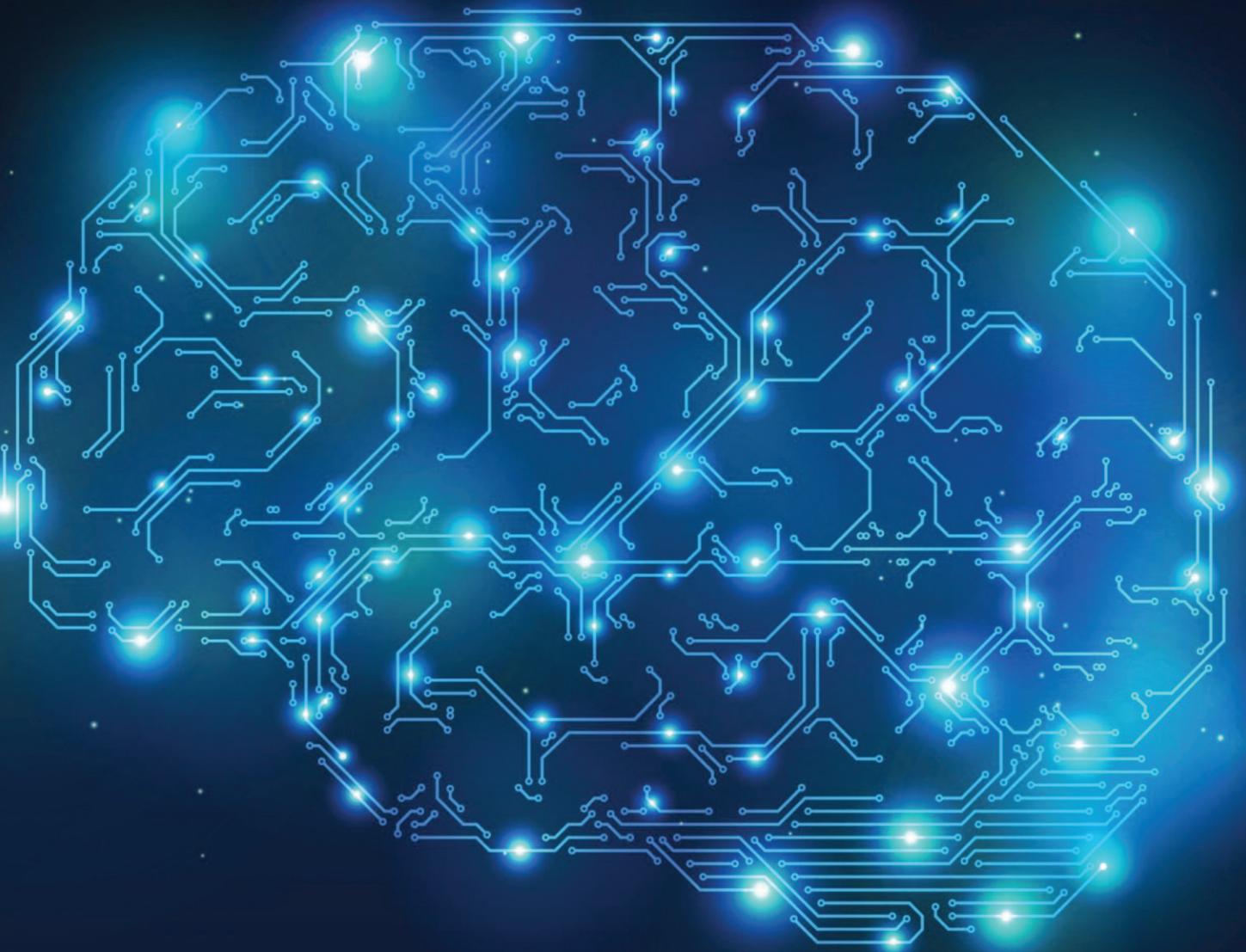
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TECHNOLOGICAL
BREAKTHROUGHS TRANSFORM
BIOLOGICAL INQUIRY IN
NEUROSCIENCE



By Deb Aronson

The infinitely complex workings of the human brain have intrigued researchers for centuries. Our understanding of its workings have been limited, not by our curiosity, but by our tools. Now, with the growth of new molecular biology and genomics approaches, big data, and engineering advances that improve imaging, researchers are making advances they could only dream of even a few decades ago.

“Technological breakthroughs have begun to transform neuroscience,” says Catherine Christian, assistant professor of molecular and integrative physiology.

MCB faculty members are deeply involved in all aspects of these efforts, working closely with faculty in chemistry, physics, the Beckman Institute, and elsewhere. Some MCB researchers choose to focus on a specific protein to learn how it interacts within the system; others try to look at the big complicated system in its entirety.

Stephanie Ceman: RNA Sequencing



Stephanie Ceman, associate professor of cell and developmental biology, started out wanting to understand the molecular basis for intelligence. By studying Fragile X, a type of cognitive impairment

caused by a single missing gene, she thought she had a relatively simple model, the missing gene codes for FMRP, a protein that binds to RNA. FMRP is highly expressed in neurons, but what does this protein do? Like so many things in biology, the answer turned out to be complicated. In this case, that is because FMRP binds to about four percent of all brain RNAs. That means that the protein helps regulate the translation of numerous RNAs; not so simple after all. Helped by next generation sequencing, Ceman, undaunted, has been helped able to sequence those RNAs.

“Probably the bottom line is that revolutions in sequencing that were driven by the challenge

of rapidly and cheaply sequencing human genomes led to the development of technologies that allow people like me to sequence RNAs (the expressed products of DNA),” says Ceman. “Those RNA sequences give insight into cell function. For the first time ever, scientists can sequence RNA to uncover previously unknown regulatory events that affect protein expression in specific cell types like neurons and fascinating tissues like brain.”

This means Ceman can study what happens when the Fragile X protein is turned on or suppressed and also what happens downstream, when the protein is formed. Recently, for example, she has demonstrated that a novel helicase, *mov10*, is recruited to an RNA that FMRP commonly binds to. The helicase then unwinds it, enabling it to make the protein.

Aided by the use of improved precision of mass spectroscopy in this project, she could more easily identify molecules by their mass on an increasingly fine scale.

The story just becomes more and more complicated, but that energizes Ceman. “Complexity drives ingenuity,” she says.

Hee Jung Chung: Genome Wide Sequencing, Micro-array Analysis



Like Ceman, Hee Jung Chung, assistant professor of molecular and integrative physiology, looks at a disease model to see what she can discover about how the brain works. In her case, Chung studies epilepsy.

“Better understanding of the pathogenesis of epilepsy is critical to develop novel therapeutic interventions and early diagnostics for epilepsy,” says Chung.

Epilepsy is a broad term for when neurons misfire chaotically, causing seizures. For Chung, and for most epileptologists, the gateway to understanding is through the ion channel

because their input controls the firing of neurons.

One of the projects her lab is focusing on now has to do with the effects of silencing a neuron. When a neuron stops receiving stimulus, it up-regulates its excitability.

“If I were a neuron and I’m not firing, I’m worried (if I’m not receiving any stimulus),” says Chung. “I’m not doing my job. I adjust to up-regulate, to fire more. So after the blockade, now the neuron is more sensitive.”

This is just what homeostatic plasticity is supposed to do. However, if the nerve is silenced for an extended time, then the neurons become hypersensitive and homeostatic plasticity becomes maladaptive.

Chung’s hypothesis is that if homeostatic plasticity does not work properly then it will lead to disease, such as epilepsy. Chung’s lab is making progress uncovering the molecular players.

Using gene-expression profiling and micro-array analysis of those genes affected when a neuron is blocked, the Chung lab found genes that encode potassium ion channels were “highly represented.” This makes sense given the role potassium ion channels play in neuron function. Chung’s hypothesis is that when a neuron is silenced, the transcription of potassium ion channels is reduced. With few potassium channels to inhibit excess electrical activity, the neurons will now fire in an uncontrolled way. Using both gene analysis and electrophysiology, Chung found this to be the case not just for potassium ion channels on the axon, but in all regions of the neuron.

Chung’s next step is to study the effects of homeostatic plasticity *in vivo*. Her lab has created a model, using chemical tools, by which specific neurons in a mouse brain can be silenced or stimulated at a specific time. She can observe those neurons by tagging them with green fluorescent protein (GFP) and using a comprehensive gene expression array to figure out what genes are affected, all of which will help her team understand structural changes that might be implicated in some forms of epilepsy.

Catherine Christian: Chemogenetics, Optogenetics and UV Uncaging



While Ceman and Chung have focused on synapses, one of the areas Catherine Christian, assistant professor of molecular and integrative physiology, is investigating involves astrocytes, those “other” cells in the brain. It was thought for a long time that astrocytes, or glia, were merely the glue holding the neurons in place. It turns out they have their own role to play. Thanks to new technologies, that is changing.

“Research in the last 10 or 15 years has shown that astrocytes play major roles in modulating synaptic transmissions,” says Christian

Research has shown that glia are like the housekeepers and interior designers of the brain. They remove and recycle neurotransmitters, including GABA (an inhibitor) and glutamate (an excitatory molecule), and buffer ions to maintain proper concentration around the neurons.

However, research has been impeded by the lack of techniques to study the glia.

“Astrocytes have been underappreciated because it is hard to manipulate their function without also affecting neuronal function,” says Christian.

Breakthroughs such as optogenetics, chemogenetics and UV un-caging, are enabling researchers to selectively manipulate very specific cells, says Christian. In optogenetics, different wavelengths of light can activate or inhibit cells of interest because the cells are engineered to contain a light-sensitive protein. Using optogenetics on astrocytes, Christian is looking at how astrocytes regulate GABA transmission in the hippocampus.

Experimentally, she is “putting those (light-sensitive) proteins in astrocytes, then triggering them and watching how the astrocytes affect GABA transmission on nearby neurons. Interestingly, we see different effects depending on brain area,” says Christian.

“These findings support the emerging model that not all astrocytes are the same and emphasizes that it’s really important to look at things in different brain areas,” she adds. “That is especially important in clinical application.”

One drawback to optogenetics is that the experimenter has to put a light fiber in the brain, which is invasive. So Christian’s lab also is using chemogenetics, in which cells can be excited or suppressed using chemical means. This procedure is noninvasive and the chemicals can cross the blood-brain barrier, making chemogenetics ideal for Christian’s work and enabling her to manipulate the action of brain cells in real time.

“One can always fix and stain brain tissue to see connections between the cells, but what

Other MCB faculty doing research in neuroscience

Rhanor Gillette (MIP)

One way to understand something complex is to begin with something simple. Gillette discovered a basic decision-making circuit in the sea slug *Pleurobranchae* that involves a cost-benefit analysis. It’s possible that understanding this circuit will provide insight into the same or similar decision making in higher level animals, and it indicates that the slug nervous system is more complex than previously thought.

Claudio Grosman (MIP)

“In order to understand the whole we need to understand the parts,” says Grosman, who uses single molecule approaches to understanding ion channels, which are fundamental to the nervous system. Using the patch-clamp technique, Grosman studies why individual ion channels let some ions through and not others, for example.

Graham Huesmann (MIP)

As an MD/PhD student at Illinois, Huesmann studied how caspase -3, normally associated with killing off neurons, helps make new memories. Now Huesmann, who also works at Carle Hospital, is looking for a biomarker for seizures and also using magnetic resonance elastography, a novel imaging technique, to identify good candidates for epilepsy surgery.

Xin Li (CDB)

How does the brain develop, in all its complexity? Li has shown that time is a factor; that the expression of certain neural types is at least partly dependent on temporally expressed transcription factors. Her work now is to characterize the molecular basis for controlling that sequential process.

Mark Nelson (MIP)

Using weakly electric fish — fish that use electricity to sense their environment, but not for protection or predation— Nelson seeks to understand how these creatures’ neurons acquire and interpret information about their environment. Nelson looks at the brain from a computational, or information-processing perspective, rather than a cellular or molecular approach.

Erik Procko (BIOCH)

Can we determine the effects of tens of thousands of mutations, before those mutations are even discovered in a human patient? By combining technologies for protein evolution with modern sequencing, Procko catalogs mutations of neuronal receptors and transporters on a massive scale. Protein mutagenesis is starting to use Big Data methods to explore human genetic diversity as it relates to disease and pharmacology.

these techniques allow us to do it in live tissue and see the connections as they are working functionally.”

A third technique that is being used quite successfully in Christian’s lab involves ultraviolet (UV) uncaging. In this case a desired molecule, such as a neurotransmitter, is chemically attached to another molecule (“cage”) by a UV-sensitive bond. When a shot of UV light, such as from a laser, is applied to a tissue bathed in a solution containing the caged neurotransmitter, this releases the neurotransmitter so that it can then bind to receptors in nearby cells.

For example, by tagging GABA, an inhibitory transmitter, Christian can move the molecule to a certain part of the neuron, uncage it, and see how GABA affects the receptors expressed on different parts of the cell.

“We can also prepare small pieces of neuron membranes that contain GABA receptors and examine the response to GABA uncaging when these receptors are placed in different areas of a brain slice, which allows us to look at how

GABA receptors are modulated by local factors, and how this is specific to certain brain regions,” says Christian.

Dan Llano: Optogenetics



Dan Llano, assistant professor of molecular and integrative physiology, like Chung, is investigating plasticity gone bad as he works to elucidate the micro-structure of the brain in the auditory region. In his case, Llano’s model has to do with cochlear degradation with aging. As the auditory system ages it can receive wrong information or new information (like tinnitus, which is both wrong and new) and it can lose the ability to focus on a specific stream of sound, for example, in a crowded room. Llano is interested in how those deficits affect

connections in the brain’s auditory system.

He is hoping that by uncovering the brain’s microstructural connections he can determine when an auditory malfunction is due to a molecular or structural problem or something else entirely.

Llano uses high-resolution optical stimulation, or optogenetics, which enables researchers to use lasers to stimulate or inhibit specific neurons and, thus, see the connections those neurons make. He keeps brain slices alive for 8-12 hours and studies how the individual circuits are connected by using lasers to activate small groups of neurons. Like Christian, Llano also uses UV uncaging techniques for this work.

“We have so much to learn about the organization of any brain system,” he says. “For me, the big question is how one (brain sub-structure) communicates with another. If we can figure out how to label individual sub populations of neurons we can answer this question.”

Lisa Stubbs (CDB)

Only 5-10 percent of the genome codes for genes. The rest, once called “junk DNA,” regulates the expression of those genes. This is where Stubbs, using mice, focuses her efforts. Among her projects is one investigating whether common social responses and behaviors among various animals are regulated by highly conserved molecular mechanisms.

Nien-Pei Tsai (MIP)

Using mice with Fragile X Syndrome, Tsai is studying the molecular and cellular mechanisms of synapse development, which is implicated in several neurodevelopmental disorders. He is investigating the possibility that there is “unique and parallel crosstalk between protein synthesis and degradation” when it comes to synapse development.

Phyllis M Wise (MIP)

Wise’s work in the role of estrogens in the brain suggests that subtle changes, as the central nervous system ages, begin early and can contribute to changes in ovarian function. Her data suggest that estrogens play a big role in the cerebral cortex, attenuating and delaying neural death, and inducing neurogenesis after stroke. Her data further suggest that these functions are mediated by estrogen receptors.

Kai Zhang (BIOCH)

Can we tackle the signaling codes during embryonic development and use that information to rescue damaged neurons resulting from neurological diseases or injury? Combining genetic and protein engineering, live-cell imaging and optogenetic technologies, Zhang modulates growth factors-mediated signal transduction during cell differentiation and embryonic development.

Jonathon Sweedler (MIP affiliate)

Sweedler specializes in developing analytical measurement techniques, many of which are unique to his lab. The focus of Sweedler’s work is cell-to-cell signaling in the central nervous system because that is the basis for behavior, learning, and memory. His work characterizes what molecules are in what cells and networks, and how they change depending on the activity of the neural network, the animal’s behavior, or the presence of drugs.

Ed Roy (MIP affiliate)

If the body’s own immune system could be activated against brain tumors, it would be both potent and precise. The trick is to reliably activate that system. The Roy group works on that problem, focusing on T-cell mediated immunotherapies.

Thomas Anastasio: Process Algebra Analysis in Biology



Other MCB researchers are working to understand neural systems as the complicated and messy networks that they are. Until very recently researchers could only imagine attempting to perform these kinds of analyses.

Thomas Anastasio uses computer modeling to address what he calls the brain's "extreme complexity," and harnesses large quantities of data in the service of a predictive model.

"Big data approaches (e.g. gene chip analysis) will tell you that a thousand different things are potentially important in the functioning of some neural system, and even if you verify a few hundred of those you still end up with a very, very complicated set of interactions," says Anastasio. "And you can look at the complicated diagram depicting those interactions, and there's no way you could figure out what is going on. We have to address this complexity computationally."

Anastasio, associate professor of molecular and integrative physiology, instead takes "factors we know experimentally are involved and try to pull all those together. My whole *raison d'être* in science is to take concepts and techniques from more technical areas such as math, computer science, and engineering and bring them to biology. As a computational neuroscientist, that's why I was hired here. That's what I love to do."

Anastasio has most recently borrowed techniques such as process algebra and a declarative computer language known as Maude from computer science.

"Imperative computer languages are used to write programs that execute statements in a pre-specified order along a single pathway," says Anastasio. "Declarative languages, in contrast, are used to write programs that can execute statements in all possible orders, thereby elaborating the pathways of all possible orders of statement executions."

Maude is one of only a few declarative languages, says Anastasio. Developed by Jose

Meseguer, professor of computer science, and others, Maude can model complex and dynamic multi-parameter systems.

"I like Maude because she is extremely powerful, and she was developed here in the computer science department. I was able to get help from her developers when I was first learning."

Among his many projects, Anastasio has built several models for neurodegeneration using Maude. Most recently, he looked at the effect of hypoxia as a trigger for beta-amyloid accumulation in the brain.

"There is a great deal of experimental and clinical evidence showing that loss of blood flow to the brain, which causes brain hypoxia, can increase the rate of production of amyloid-beta," says Anastasio.

This model is one of several he has built. "Alzheimer's, like all neurodegenerative diseases, is highly multifactorial," he says. All of his Alzheimer's models offer "therapeutically relevant predictions in terms of drug combinations that would be more effective than single drugs for reducing amyloid-beta-induced inflammation or synaptic plasticity impairment or for reducing amyloid-beta accumulation itself."

Whenever someone has had a brain trauma or major surgery, for example, the hypoxia model predicts that a combination of NSAIDs and a drug that blocks Hypoxia Inducible Factor, HIF, should reduce the rate of accumulation of beta-amyloid in the brain.

The next step is to find a bench scientist to test his model and provide results that he can then incorporate back into the model.

Martha Gillette: Noninvasive Computational and Chemical Imaging



investigator projects such as the BRAIN Initiative (Brain Research through

Another way to confront the complexity, says Martha Gillette, professor of cell and developmental biology and director of the neuroscience program, is through large, multi-

Advancing Innovative Neurotechnologies), a collaborative, public-private research initiative announced by the Obama administration in 2013.

Gillette leads a BRAIN project based on a noninvasive real-time imaging method developed by her collaborator, Gabriel Popescu, associate professor of electrical and computer engineering. The challenge is to image sub-cellular dynamics in tissue that is dense and has a high refractive index. This project also involves high-resolution measurements of neurotransmitter release and stimulation by biocompatible flexible electrodes, technologies developed by Jonathan Sweedler, professor of chemistry, and John Rogers, professor of materials science and engineering, respectively.

The second BRAIN project involves using chemical techniques to analyze composition of cells in the parts of hippocampus where learning takes place. Using Raman Spectroscopy combined with mass spectrometry, Rohit Bhargava, professor of bioengineering, and Jonathan Sweedler, professor of chemistry, are working to measure the vibrational spectra in a cell and then use that to identify the comprehensive chemical profiles of cells and brain tissue. Gillette's lab provides the essential functional data that are coupled with these high-resolution chemical signatures. Their work will produce a kind of "functional chemical histology" of the brain, she says.

"We can do this because we're at Illinois," says Gillette, professor of cell and developmental biology. "All our progress is because of technology," she adds.

Funding for much of Gillette's work is through various BRAIN initiatives. One of the most compelling aspects of BRAIN is that the various federal agencies involved are investing in a diversity of projects. This is, says Gillette, because "they understand there is no guarantee where the next breakthrough will come from." ■

Private funding continues to provide a large number of scholarships to both domestic and international students.

The School of Molecular and Cellular Biology (MCB) is a pivotal center for biomedical research on campus, and our program attracts more funding than any other unit in the College of Liberal Arts and Sciences. Our energetic, top-notch graduate students and faculty, and high caliber research projects have a strong reputation for producing results worthy of further external funding.

However, the stagnation of federal funding over the last decade has led to extreme competitiveness for government-funded research in the United States. In particular, there are increasing concerns that science will suffer, as more risky and exploratory projects are less likely to get funded.

Although the University of Illinois is a state-funded institution, state revenues are only responsible for approximately 12 percent of the total operating budget. The gracious support from our alumni and philanthropists helps fill this financial gap, enabling faculty and students to continue with their excellent research.

A number of scholarships and fellowships are available within MCB, and the opportunities continue to grow every year, as well as the number of graduate students receiving these awards.

“Our alumni have provided enormous opportunities for MCB and our students. For example, the Westcott Biosciences Fellowship attracts top students to fuel our graduate program. In addition, alumni and colleagues have endowed graduate fellowships in honor of former faculty, including Professors Lowell Hager, Gregorio Weber, and Herb Carter,” says Susan Martinis, Sligar Professor and Head of the Department of Biochemistry.

Undergraduates have also greatly benefited from the generosity of alumni, such as William Jackson and Kris Jenner, who provide summer research fellowships, allowing young scientists to have early experience in a lab.

“These alumni-supported research opportunities for our undergraduate and graduate students are important first steps in their careers and have great impact in their long-term success,” says Dr. Martinis.

Private funding can help launch careers when federal funding is not available, particularly for students from international countries. The National Institutes of Health and the National Science Foundation support only domestic students, and a large number of distinguished international researchers are often unrecognized by these government agencies.

Amruta Bhate, a fifth year biochemistry graduate student from India who is ineligible for NIH or NSF funding, received the Herbert L. Carter Research Fellowship, which includes a full year stipend and tuition waiver.

“By receiving the fellowship, my tuition and stipend is covered for a full year. I do not have to work as a Teaching Assistant, and this frees up a lot more time for my work: research, literature search for a review, and the job search. It is a prestigious fellowship, which helps boost my resume as well,” she says.

The James R. Beck Fellowship in Microbiology, established by an alumnus from Indianapolis, will partially support four graduate students this year. The students benefit from the support, as well as the faculty who host the students in their labs.

“Private donations allow graduate students to pursue independent projects of their own design,” says Assistant Professor of Microbiology Thomas Kehl-Fie, an advisor to a graduate student who received the James R. Beck Fellowship. “It allows labs to explore new and exciting avenues of research.”

Private donations take many different forms. One type of private funding comes from deferred gifts, such as the June Aprille Fellowship, which was incorporated into Dr. Aprille’s estate planning to support graduate scholarships in the future.

Other funds have been set up by alumni trainees as a tribute to a professor. For example, the C. Ladd Prosser research award’s accumulated interest has supported annual awards to recognize outstanding student researchers in Molecular and Integrative Physiology laboratories since 2012.

“The Prosser award has given me a great opportunity to expand my research and knowledge of neuroscience, which includes providing me with support to attend a Computational Neuroscience course,” says Ekaterina Gribkova, a graduate student in the lab of Dr. Daniel Llano.

Howard Ducoff, the late professor and eminent radiobiologist in MIP, and James E. Heath, a former Head of MIP, set up fellowships in their own names to support best senior thesis and excellent Teaching Assistants, respectively.

Molecular and Integrative Physiology is able to support the research, teaching and travel awards of several students each year through the Department’s annual fund, an accumulation of gifts from a number of alumni and friends to MIP.

“Funds donated by alumni and friends of MIP are critical for maintaining the excellence of our graduate program,” says Milan Bagchi, Deb Paul Professor and Head of MIP. “We use these funds to support the travel of our graduate students to national meetings to present their work and to purchase shared equipment to improve departmental research infrastructure.”

Private donations not only provide excellent opportunities, but they also carry the prestige of being associated with the names of prominent scientists and alumni supporters who have made lasting contributions in their fields. In a competitive postdoctoral market, this funding elevates those who have excelled among their peers.

For further information on how to establish a scholarship, fellowship, or award to benefit students in MCB, please contact Trent Reed, Assistant Director of Development at reed15@illinois.edu or Trenton Blythe, Associate Director of Advancement at tcblythe@illinois.edu. To support existing funds, visit mcb.illinois.edu/giving. ■

Brenda Wilson: Turning the Tables on Toxins

By Deb Aronson

What do you do if you love figuring out how things work and you want to do something useful? In Brenda Wilson's case you spend your career figuring out how to outwit toxins.

"Toxins can be really bad," says Wilson, professor of microbiology. "But we're trying to harness them for good. We're taking a lesson from the toxins themselves." Wilson's lab works, among other things, to elucidate the structure and function of bacterial toxins, to understand how they interact with host cells, and to develop post-exposure toxin therapeutics.

Wilson's group has studied both neurotoxins (caused by pathogens like *Clostridium botulinum*) and dermonecrotic toxins (caused by pathogens like *Pasteurella multocida*).

Toxin-mediated diseases can be prevented with vaccines, of course. Children are vaccinated against the most notorious of these diseases: diphtheria, tetanus and pertussis. But diseases caused by most other toxin-producing pathogens, while potentially devastating, are rare enough that it doesn't make sense, financially or logistically, to vaccinate an entire population against that pathogen.

One of Wilson's goals is to understand the structure and function of the toxins in order to develop better post-infection therapeutics. Take the case of the botulinum neurotoxin. Growing *Clostridium* bacteria produce the neurotoxin. While there are fewer than 150 cases per year in the United States, 70 percent of them occur in babies. Because the neurotoxin paralyzes

"I'm not happy with waiting things out. I want to accelerate the recovery from paralysis."

muscles, it results in a "floppy baby" syndrome, as Wilson puts it. These toxin-producing bacteria are found in the environment as dormant spores.

Generally, these spores are harmless as they travel through the gut of an adult, but babies have slower digestive tracks — and are missing some of the protective gut microbes that adults have, such as the "good" bacteria that do not produce toxins, but instead help in digestion of food and compete with "bad" toxin-producing bacteria. The conditions in the infant's gut give the ingested spores a chance to germinate and grow and produce the neurotoxin that causes botulism. One common place where spores are found is honey; this explains the common warning against feeding infants honey.

Although there is an effective antibody-based antitoxin to botulism, it only prevents further paralysis by blocking toxin binding to cells; it can't neutralize toxins already in the nerve cells. That means even with the antitoxin, the patient must be put on a ventilator and fed intravenously until the toxin clears the body. That can take many months and the developmental delays can be severe for infants. Even adults who get botulism sometimes have to relearn to walk.

"I'm not happy with waiting things out," says Wilson. "I want to accelerate the recovery from paralysis."

But, in order to do this, Wilson needed to know how the toxin gets inside the neuron in the first place.

"How are these guys getting across the cell membrane?" she says. "What are the factors that allow it to get inside the neuron to cause paralysis?"

Once this was figured out, they had to find a way to neutralize the toxin once it was already inside the neuronal cell.

"The hard part then is getting the toxin inhibitor inside the neuron," says Wilson. "That is the holy grail. You can bring things to the neuron; you can bind things to the surface of the neuron, that's easy, but if you're going to try to block the activity of the toxin you have to get inside the neuron."

Happily, Wilson's lab has now found a way to enable the protein toxin itself to deliver the inhibitor cross the cell membrane and get inside the neuronal cell. Her group has successfully created a therapeutic approach they call "bacterial toxin inspired drug delivery" or BTIDD (pronounced "Beat It"). Using BTIDD principles they can create designer drug-translocators that cross the lipid membrane of virtually any targeted cell.

"The project was hard because the protein toxin is big [which makes it harder to find which tiny part of the protein changed to enable it to



The Wilson Lab: Dr. Mengfei Ho (research assistant professor), Sarah Bounab (MCB undergraduate student), Brenda Anne Wilson (professor), Dr. Melissa Pires-Alves (senior scientist), Nathan C. Clemons (microbiology PhD graduate student), Libby E. Haywood (microbiology PhD graduate student), J. Robin Dean (MCB undergraduate student) Sitting in front: Kimberly Nalley (MCB undergraduate student), Mathias Morales (MCB undergraduate student)

cross the membrane], and it's hard because it turns out host proteins are also engaged and a few other cellular things are going on," says Wilson. But Wilson's team remains energized by their progress.

"For a long time the major thrust had been figuring out how these toxins work. Now we know how they work and how to identify their targets," she says.

And with BTIDD they've got a handle on Wilson's "holy grail" as well.

"We stole the toxins' strategy and can now use our understanding of how it works as a tool for solutions to the drug-delivery problem," she says. "We know enough now that we can actually start working on targeted delivery of therapeutics."

Her group has even been able to modify their designer translocator so that it can enter HIV-infected cells. Using green fluorescent protein (GFP) as a colored tracking tag, they demonstrated that they can successfully deliver the GFP cargo into the target cell, as well. Research projects take a lot of time and "brute

"We stole the toxins' strategy and can now use our understanding of how it works as a tool for solutions to the drug-delivery problem. We know enough now that we can actually start working on targeted delivery of therapeutics."

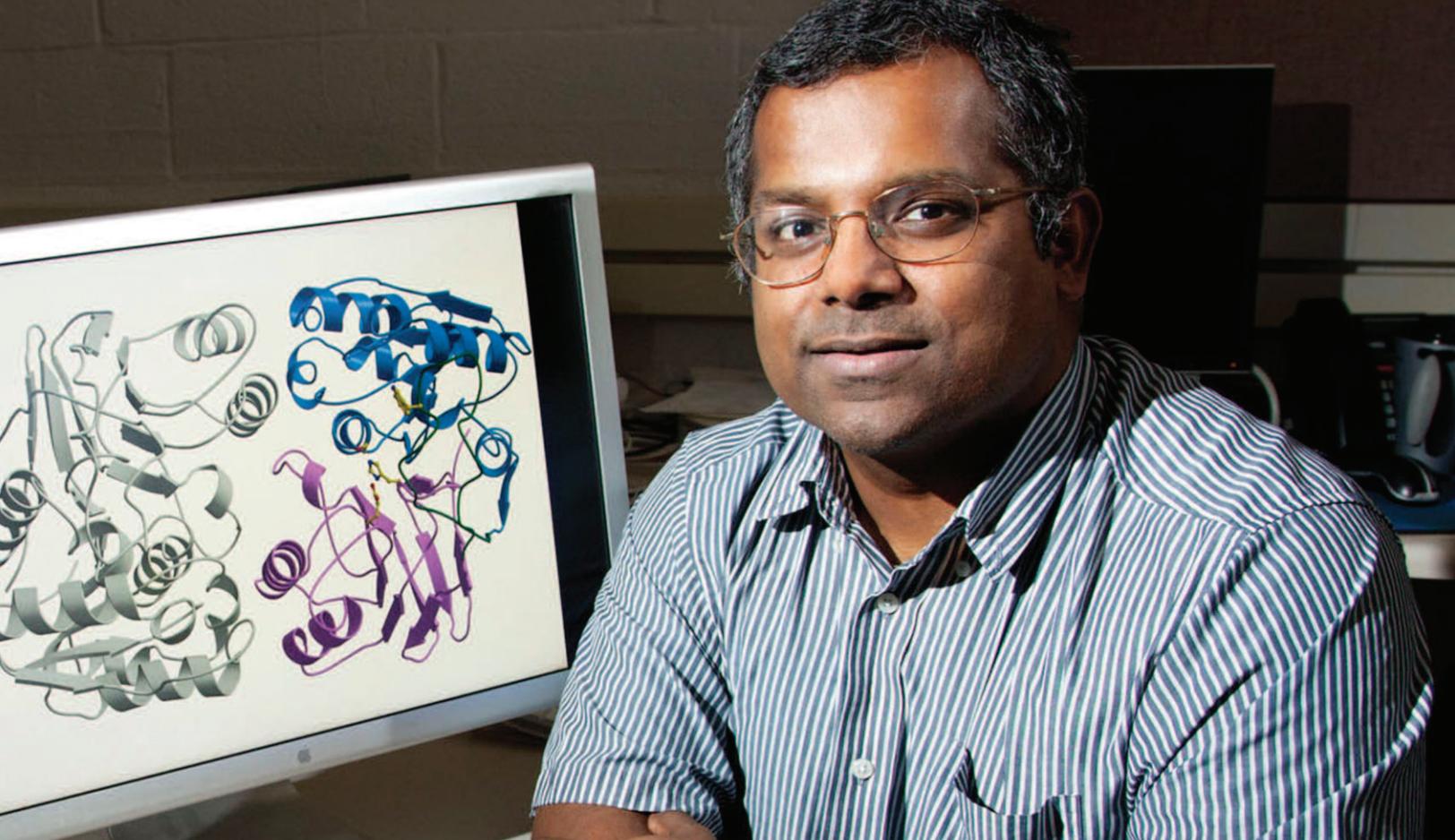
force," as Wilson says, but her hope is that within another five or ten years they'll "be able to use BTIDD routinely in animals and even start doing some trials."

In addition to neurotoxins, Wilson has always been quite interested in other large protein toxins, such as the "dermonecrotic" toxins. These toxins are not as well understood; even their crystal structures aren't completely

elucidated, but that only motivates Wilson more. Dermonecrotic toxins are uniquely threatening; there is evidence that exposure to them may, many years down the road, lead to cancer. The *Helicobacter pylori* bacterium is one documented example in which infection by this toxin-producing pathogen can lead to gastric cancer.

Of course, in the world of the wily toxin, nothing comes easy. Each toxin has its own idiosyncrasies, says Wilson, particularly when it comes to binding and crossing the target cell membrane. The dermonecrotic toxin is no exception.

"Every time we get a new toxin we realize 'oh, it's not quite the same way in this case,'" says Wilson, her face lighting up at the prospect of a new challenge. ■



Unassailable Strength

Center for Biophysics and Quantitative Biology Finds Strength in Collaboration

By Doug Peterson

Over a year ago, Satish Nair, director of the Center for Biophysics and Quantitative Biology, received a call from Arthur DeVries, retired professor of animal biology. DeVries, well known for discovering “antifreeze proteins” in Antarctic fish, wondered if Nair was interested in working with him to delve deeper into the protein’s unique qualities.

The antifreeze protein prevents fish in the Antarctic from freezing, but researchers did not fully know how it worked, Nair says. He joined the effort, and over the past year they have learned that this prism-like protein allows water molecules to bind to its sides, disrupting the formation of ice lattices in the fish’s blood.

This collaboration is a typical example of the kind of multidisciplinary efforts that pop up routinely in the University of Illinois Center for Biophysics and Quantitative Biology, says Nair, who became director in the summer of 2016 after serving as interim director for a year.

Collaboration is built into the center’s DNA.

“On any given day, someone might knock on your door and say, ‘Do you have a few minutes? Let’s talk a little bit about science,’” Nair says. “That might spin off into something that becomes a long-term project.”

Established in 1996, the Center for Biophysics and Quantitative

Biology has always made its home in the School of Molecular and Cellular Biology. The original idea of the center was proposed back in 1978 when Antony Crofts was recruited from the University of Bristol and appointed to lead the biophysics division in the Department of Physiology.

The Center became a formal manifestation of a “super highway” already existing between the departments of physics and the biological sciences in MCB through Professors Gunsalus, Hager, and Weber in Biochemistry and Professors Frauenfelder, Debrunner, and MuncK in Physics. Graduate students began to flow freely between both sides of Green Street, which separates the Colleges of Engineering and Liberal Arts/Sciences. The current Director of MCB, Professor Stephen Sligar, is a Ph.D. physicist who graduated from the University of Illinois in 1975 and has held positions in the Department of Biochemistry, Department of Chemistry, and the Center for Biophysics and Computational Biology.

Over the course of the next two decades, as interest in biophysical areas continued to expand on campus, multiple proposals for establishing an independent center were put forth. After several years of negotiations, the present structure of the center became reality under Colin Wraight’s leadership.

The biological revolution of the 1990s, with the major strides in gene sequencing, also helped to spur the creation of this new center.

“The artificial barriers that people put up between fields started to disappear at that time,” Nair says. “You had a lot of professors trained in classical physics wanting to move into biology, and you had biologists wanting to expand their research into other disciplines as well.”

Although the Board of Trustees did not approve the center until 1996, its roots stretch back to shortly after World War II, when the U of I advanced the life sciences by creating the Photosynthesis Lab. This lab’s research was known worldwide, and at the heart of the work was biophysics, Nair says. The Photosynthesis Lab led directly to the creation of a biophysics program at Illinois, which is one of the pillars of the Center for Biophysics and Quantitative Biology.

“It has been very exciting to watch biophysics grow from a program to a thriving center,” says Cindy Dodds, administrative coordinator of biophysics. “When I began in 1994, we had a core faculty who were primarily studying photosynthesis and electrophysiology. Now our faculty studies everything from single molecules to theoretical modeling.”

Over the years, the center has become a well-traveled bridge between engineering and life sciences. It draws on the expertise of over 40 affiliate faculty members from a variety of departments, including biochemistry, physics, chemistry, chemical engineering, molecular and integrative physiology, cell and developmental biology, computer engineering, bioengineering, microbiology, and more.

“I have had many wonderful students from biophysics over the years who have driven my research in new directions,” says Martin Gruebele, head of Department of Chemistry and James R. Eiszner Chair. “My earliest biophysics student, Wei Yang, showed how proteins can fold ‘downhill.’ He is now a faculty member at the Academia Sinica in Taiwan.”

In addition, the center has played an important role in supporting the Center for the Physics of the Living Cell (CPLC), a NSF-supported Physics Frontier Center that emphasizes quantitative aspects of single molecules. For instance, physics professors Taekjip Ha and Oleksii Aksimentiev, along with bioengineering professor Jun Song, are studying how single-molecule bending of DNA affects things like genome regulation.

“It’s amazing that you can combine disparate experimental, theoretical, and computational areas of expertise, and go all the way from single molecules to whole genomes,” says Paul Selvin, a member of the CPLC.

According to Nair, the Center for Biophysics and Quantitative Biology aims to play a big role in the U of I’s new medical college, which will also unite engineering and life sciences. As he puts it, the center’s collaborative spirit “gives us a strength that is unassailable.”

As an example of this unassailable strength, he cites the work on blood clotting done by Chad Rienstra in chemistry, and Jim Morrissey and Emad Tajkhorshid in MCB. Morrissey’s lab synthesizes a phospholipid known as PS, while Rienstra’s lab analyzes the lipid’s 3D structure using new approaches to nuclear magnetic resonance spectroscopy. Tajkhorshid’s lab then runs computer simulations of the interaction

between lipids and membrane proteins—a key interaction in the blood-clotting process.

“If you have three people who are world experts and they’re all focusing on the same thing, and they’re on the same campus, that is ideal,” Nair says.

Originally known as the Center for Biophysics and Computational Biology, Nair says that “Quantitative” was officially added to the name in 2015 as a way to expand its scope to include research in computational genomics, synthetic and systems biology, and quantitative proteomics.

“It is our hope that the new name will attract faculty who do not normally consider themselves biophysicists, but whose research would be perfectly synchronous with those of our other faculty,” he says.

The center is a degree-granting program, with the current contingent of Ph.D. students totaling 45. Sixteen of them are in labs of faculty with a primary appointment in MCB, 13 are in physics labs, eight in engineering, seven in chemistry, and one in math. According to Nair, the center attracts top-quality Ph.D. students with a unique and broad range of skills.

“It’s typical for us to get a student who might be a double major in astrophysics and biology,” he points out. “This kind of student usually wouldn’t apply to either physics or biology because they’re interested in doing both.”

More than 50 percent of the graduates go on to post-doctoral studies at top universities in the world, such as Harvard, MIT, Berkeley, and Stanford. Roughly 20 percent go into either industrial positions at places like Dow or Indigo, or software and hardware development at such companies as Intel, Advanced Micro Devices, and Lab7. Of the remaining students, about 15 percent go directly into academic positions or complete their medical degrees.

All Ph.D. students in the center are required to do two eight-week-long tutorials, and Nair says they are encouraged to do their tutorials with faculty completely outside of their specialty area. For instance, students well versed in computational biology might want to learn more about experimental methods, so their tutorial could take them into a lab setting.

This is just another way to get students out of their comfort zone and into a collaborative frame of mind. Nair says he saw this spirit from the very beginning of his time at U of I.

“When I was going through my interviews for the job at Illinois, there were people who already wanted to collaborate with me, even before I received the formal job offer,” he says.

This multidisciplinary emphasis brought Nair to Illinois in 2001, and it is the reason he joined the center immediately after arriving here.

As he explains, “I knew that if I came to a campus where other people were interested in working with me, I would certainly be much more successful than if I went to a campus where I was on my own.” ■



Photo by Elizabeth Innes

MCBees Help Recruit, Provide Student Support, & Share the Joy of Science

Left to Right: Maryam Kademian (Microbiology), President; Mara Livezey (Biochemistry), Outreach; Amruta Bhate (Biochemistry), Academic; Nayab Abidi (Cell and Developmental Biology), First-year liaison; Kirsten Eckstrum (Molecular and Integrative Physiology), Social; Omid Gholamalamdari (Cell and Developmental Biology), Treasurer. Not pictured: Pritha Rao (Microbiology), Secretary and Michelle Goettge (Microbiology) Communications.

By Elizabeth Innes

After six months of lab rotations, new MCB graduate students choose a lab in one of the four departments, Biochemistry, Cell and Developmental Biology, Microbiology, and Molecular and Integrative Physiology. Once settled in a department, students rarely see members of their cohort in other departments, “because you kind of get busy with your work,” admits Biochemistry grad student Amruta Bhate, “and you only meet people from your department.”

A group of MCB grad students decided to do something proactive about keeping their schoolwide cohort together. They got together and started a GSA (Graduate Student Association), calling themselves the “MCBees.” Their goals? To help MCB with recruitment; to become a source of support for graduate

students, especially incoming first-year students; to foster relationships among graduate students via social activities; and to do outreach.

Microbiology grad student Maryam Khademian proposed the idea, “we have 250 students here who are all potential friends,” she thought to herself.

“Grad school can be just as fun, and as cool, and as amazing as my undergrad experiences if we help students to know each other and to make friends.”

At the first meeting of the MCBees in November 2015, they chose their leadership, working to ensure that all the departments were represented. In January 2016, once they became an officially registered GSA, they started recruiting MCB grad students via email. So far, around 150 of MCB’s 250

students have become members. Following are the MCBees’ leadership team members, their roles/responsibilities, and their departments:

- Maryam Khademian, President, Microbiology
- Pritha Rao, Secretary, Microbiology
- Omid Gholamalamdari, Treasurer, Cell and Developmental Biology
- Michelle Goettge, Communications, Microbiology
- Amruta Bhate, Academic, Biochemistry
- Nayab Abidi, First-Year Liaison, Cell and Developmental Biology
- Kirsten Eckstrum, Social, Molecular and Integrative Physiology
- Mara Livezey, Outreach, Biochemistry

The MCBees also hope to do more than just network. They have big plans for the future: academic events, journal clubs, science-

“These are actual research images, actual data from somebody’s lab, but they are also visually appealing. So you’ll have a cool image that’s also actual raw data. It has both things going for it.”

based competitions, social hours, and outreach. Amruta Bhate, in charge of academic affairs for the group, adds that they also hope to “have an early source where the incoming grad students can just contact senior students just to know how this school works.”

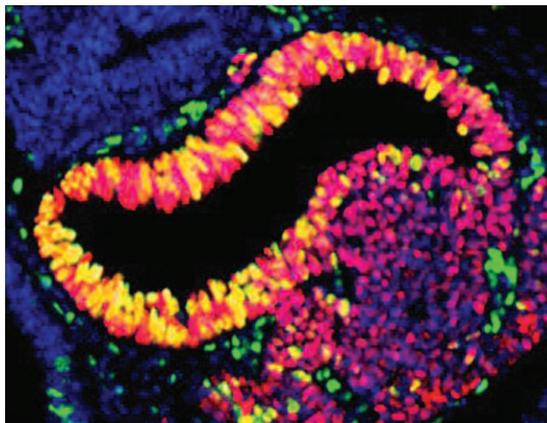
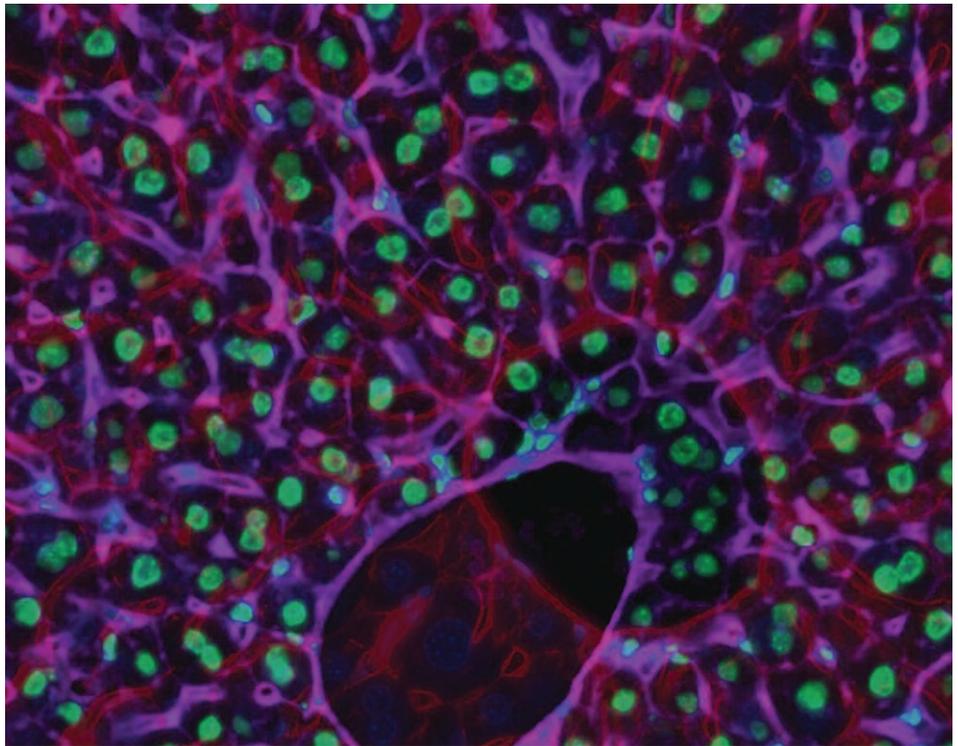
For prospective students who could not make the first visit in February, the School scheduled an alternate weekend in mid-March. For that event, the MCBees sponsored the MCB Rapid Fire competition, in the form of elevator speeches, where entire labs or individual graduate students had three minutes to present their research to the audience.

“It’s like an elevator pitch, but in a fun way,” explains Bhate. “To be catchy, it has to be general so that people from every discipline can understand it, and it has to be short, sweet, and funny.” While still a competition, the plan was that “the candidates/recruits will get an idea of the breadth of research going on.”

Omid Gholamalamdari, the MCBees’ Treasurer, explains that they borrowed the idea from the Graduate College’s Research Live! competition, held for the public, during which Illinois grad students were given three minutes to talk about their research. “So this can be a kind of outreach someday if we just plan it for a public audience,” he explains. Khademian adds that doing “Elevator Speeches” for the February recruiting weekend was kind of a test run; the plan was to “do it on a smaller scale just to work out the nitty gritty details of the event, and then we’ll eventually go big.”

Gholamalamdari even wants to do an outreach to tackle the apprehension the general public often feels about research.

The MCBees also did another fun research-related event for MCB recruiting week: a research photo contest. They had students send



Above: Lack of ESRP2 hinders proper maturation of hepatocytes. Image credit: Amruta Bhate, Kalsotra Lab, Biochemistry, co-winner of the 2016 Graduate Student Association Research Image Contest.

Left: The pituitary is the Master Gland. Our gland tells your glands what to do. Image credit: Whitney Edwards, Raetzman Lab, Molecular and Integrative Physiology, co-winner of the 2016 Graduate Student Association Research Image Contest.

“We could use this as a platform to interact with other disciplines. One of the great things about Illinois is what a multidisciplinary campus this is, so we can really benefit from the other departments. “

them photos related to their research with a description, which they printed then showcased during the recruitment weeks, “so recruits would actually see what’s going on,” explains Khademian. “They see what research actually is like.”

“These are actual research images, actual data from somebody’s lab, but they are also visually appealing,” adds Bhat. “So you’ll have a cool image that’s also actual raw data. It has both things going for it.”

Some events are aimed purely at having the kind of interaction Khademian dreamed of, friendship and bonding. To that end, the McBees collaborated with the graduate college to show the “The Ph.D. Movie,” and held “monthly happy hours for all the grad students in MCB as well as for the new recruits,” says Kirstin Eckstrum, in charge of social activities.

Another emphasis of the McBees is outreach. According to outreach coordinator Mara Livezey, “We all do science; we all love science. But for one reason or another, we get into science because someone taught it to us, and I feel like we have to go out into the community and teach others because, how else can they be exposed to it really?”

The McBees also recently participated in Dr. Williams Elementary School’s STEM Night, doing two interactive activities for

students in grades 1-5. They taught the youngsters about the different parts that make up human cells, and had the students extract DNA from strawberries. In addition, they set up a microscope so the students could see live cells moving. The group has also participated in DNA day, and STEAMCation, science in medieval times.

The McBees have other big plans for the future. For one, they hope to collaborate or interact with other organizations or different departments on campus, not just in MCB. In the past, MCB did not have any student organization to do that; now they do.

Nayab Abidi, first year liason, would also like to take it a step further to foster multidisciplinary research collaboration. “We don’t interact a lot with other departments like, say physics or engineering... We could use this as a platform to interact with other disciplines. One of the great things about Illinois is what a multidisciplinary campus this is, so we can really benefit from the other departments. Who knows? Maybe we can set up different collaborations or team labs just by talking to different people that you might not know. The work that they’re doing could be beneficial for what you’re doing in your lab.”

Concrete plans for 2017 include a Bio Café at the Champaign Public Library, a science

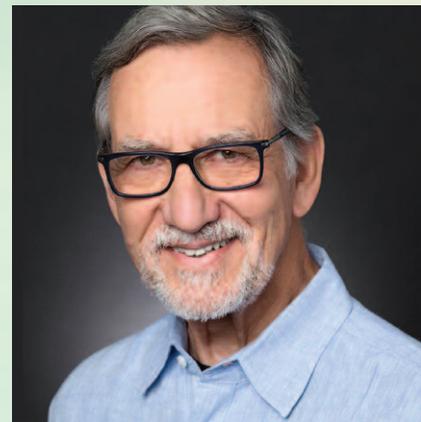
fair for an Urbana Champaign Girls and Boys Basketball team, and more social activities such as a seminar and a tailgating party.

Pritha Rao, the McBees’s secretary, explains why she got involved in the McBees, “This was a group dedicated to represent the graduate students in MCB program. I thought this was a good opportunity to interact with people from the department outside the classroom setting and meet as individuals who are interested in various cultural, academic and outreach activities so that we would all have something other than our research to look forward to during graduate school.”

Although the McBees have only been in existence for a few months, Rao believes the group has begun to have an impact. “We have already organized a couple of events highlighting our research and an outreach event with kids from elementary school,” she says. “I can say that these events have helped graduate students, including me, realize the importance of the work we do and think of simpler ways to describe complicated science.” ■

James Spudich Receives a 2016 Alumni Achievement Award

for his groundbreaking research on how we move



By Doug Peterson

The year was 1963, and the setting was Woods Hole, Massachusetts, renowned for its summer classes in biology. A standing-room-only crowd packed the room. James Spudich (BS, '63, chemistry) had just finished his bachelor's degree at the University of Illinois, and he stood at the front of the room, wiping the blackboard in preparation for the next speaker—U of I biochemist Woody Hastings.

As Hastings stepped up to the lectern, he suddenly threw a curve ball to the crowd. He introduced his young student, Spudich, who strode up to the podium and began giving the lecture, in Hastings's place, to the shocked audience.

"Nobody was expecting it," Spudich recalled. Only he and Hastings knew the secret, and the crowd responded enthusiastically.

Spudich has gone on to become one of the most respected biochemists in the world. He credits his two years in Hastings' lab at the U of I and two summers in Woods Hole, where Hastings headed the physiology course, as the sparks that sent him from chemistry to biochemistry.

Spudich made his mark with pioneering discoveries on molecular motors—the tiny powerhouses responsible for movement at the cellular level. For this research, he has won a 2016 Alumni Achievement Award—one in a long line of honors. He also won the prestigious Albert Lasker Basic Medical Research Award in 2012, an impressive honor as evidenced by the fact that almost half of the Lasker awardees subsequently won a Nobel Prize.

His two years in Woody Hasting's U of I laboratory was the first turning point in his career, followed by superb training in biochemistry and genetics at Stanford. Another turning point came during postdoctoral research in structural biology at Cambridge University in England. He worked with Hugh Huxley on muscle research from 1969 to 1971, setting him on the path of studying molecular motors.

Molecular motors are like microscopic automobiles, running along tracks in our cells and burning fuel called ATP. In a human muscle, the motor is called myosin, and the track is called actin.

In his early research, Spudich and his colleagues purified out both myosin and actin and then coated microscope slides with the purified myosin molecules. Then, in 1986, Spudich and his Ph.D. student, Steve Kron, proved that out of the 5,000 or so proteins in a cell, you only needed these two proteins—actin and myosin—to create movement that was the equivalent of a muscle contraction.

"This was a huge breakthrough because it simplified what you needed

to understand about how that movement was occurring," he said.

Today, scientists around the world who study molecular motors use the assay that he and his students developed from this research.

In a 1994 breakthrough, Spudich's team lowered a single actin filament onto a single myosin molecule, so they could watch what happens when one myosin molecule interacts with one actin. This helped open up a field of biology now called "single molecule biology." To do this work, Spudich's team built a laser trap with the help of Steve Chu, a Stanford physicist who won a Nobel Prize in 1997 for trapping atoms. (Chu also served as the Secretary of Energy from 2009 to 2013.)

The collaboration between Spudich and Chu was unique. Spudich had his team work part of the time for a year or more in Chu's physics lab, while Chu's physics students spent some of their time for several years in Spudich's lab learning biochemistry.

This student-swapping collaboration inspired Spudich and Chu to bring a new idea to Condoleezza Rice, the former Secretary of State who was then Stanford's provost. They suggested to the creation of a program that would bring together talent from physics, biology, chemistry, engineering, computational sciences, and the clinical sciences. They called it Bio-X. Spudich served as its first director from 1998 to 2001, and today over 600 faculty members across campus are part of the Bio-X program.

Spudich started his first company in 1998, developing a drug that makes the healthy part of a damaged heart work harder so that overall heart function remains the same. A second drug aims to improve muscle function for patients with ALS, or Lou Gehrig's disease. Both are in late stage clinical trials. Meanwhile, a second company, started in 2012, is developing a drug that slows down a racing heart in patients with a mutation that causes their heart muscle to overwork.

As for Spudich, he shows no signs of slowing down. Whenever he wants a break from this hectic pace, he goes to the air. He has been flying small planes for more than 40 years, and he even wrote a book on flying.

"You're 1,000 feet above the ground and suddenly your whole perspective changes," he said. "You realize there are all kinds of things going on down there, and it puts perspective on the things we spend all of our time worrying about. As Antoine de Saint-Exupéry expressed it, 'I fly because it releases my mind from the tyranny of petty things.'" ■

Collegial Environment Set Alumnus up for Success

By Brian Wallheimer

Since 1975, Keith Westcott has felt at home at the University of Illinois and with science.

Westcott grew up in New Jersey, where his father was a biochemist for a pharmaceutical company and his mother a librarian for the Atomic Energy Commission. Science was in his blood, so to speak.

After his father took a new job in Kankakee, Illinois, while Westcott was in high school, he set his sights on attending the University of Illinois, but he was not chosen for a spot in a lottery required to enter a liberal arts and sciences field back in the 1970s during the Vietnam War. Instead, Westcott attended the University of California Berkeley, where he thought about becoming a physician.

Once again, being met with a roadblock, Westcott found the biology course he needed was full, so he majored in chemistry instead and eventually made his way toward the best of both worlds—biochemistry.

With a bachelor's degree in hand, Westcott was ready to move on from the volatile Berkeley campus of the era and had enjoyed visits to the Champaign-Urbana campus over the years to see friends. Upon applying this time, he got in, culminating in a doctorate in biochemistry in 1980.

During those years, Westcott noticed that his peers in graduate school and the faculty that advised them were more than colleagues and students; the collegiality amongst faculty and students throughout the department changed how Westcott viewed a job in a laboratory.

"Lowell Hager was department head at the time, and he used to encourage all of the students, no matter who their major professor was, to interact with the rest of the professors," Westcott says. "It was a good social group, and he was always getting up in front of us and saying that you should be working hard at doing your science, but it should be fun at the same time."

Scientists shared instruments and graduate students asked questions of everyone, he said. It was the environment Westcott sought after he left school and completed his postdoctoral work. After a brief stint at Alpha Therapeutics in Los Angeles, Westcott found his fit at Amgen in



"I specifically attribute my financial well-being and the fact that I was able to spend time in the biotech pharmaceutical industry to my graduate training in biochemistry at Illinois."

1986, which, at the time, was a small startup biotechnology company.

"That sort of environment at Illinois resonated with me, and that's what it was like at Amgen in the early days," he says. "I drew a lot of parallels and strength from that."

Westcott was a protein chemist at Amgen, which grew to become one of the largest biotechnology firms in the world. But early on when Westcott was there, he crowded in with other scientists at work benches.

During those years, Westcott did not work on a product that went to market. He was part of a collaborative team and said he's most proud that he helped build up the protein chemistry group. He went from one supportive family to the next.

Being paid partially in stock options when the company was small, Westcott was able to retire early in 1999 when the company was in the

midst of rapid growth.

Westcott took courses in financial management to take care of his own assets and to help family. Besides his own financial well-being, Westcott wanted to ensure he invested in ways that would allow him to give back to those who had given him so much, including the University of Illinois.

"I specifically attribute my financial well-being and the fact that I was able to spend time in the biotech pharmaceutical industry to my graduate training in biochemistry at Illinois."

Over the years, Westcott has come back to Illinois to teach six-week courses in biochemistry and give seminars on working in the pharmaceutical industry to incoming students. His donations have supported several fellowships for graduate students in biochemistry, and Westcott makes it a point to meet with those students when he visits campus.

Westcott is also a voting member of the University of Illinois Foundation. In 2010, he received the LAS Distinguished Service Award and in 2013 the Loyalty Award for Exceptional Alumni Service.

Though he left the University of Illinois as a student long ago, Westcott said that one thing has not changed. He still feels like it is family, and that keeps him coming back.

"It allows me to feel I'm still part of the overall research effort even though I'm not working in a laboratory anymore myself," he says. "The fact that everyone's been so welcoming and encouraging, I appreciate that."

Westcott said he is proud of the Department of Biochemistry today because it has kept a culture of inclusivity, a trait he attributes to the leadership of Department Head Susan Martinis.

"It is particularly good that Susan Martinis is a graduate of the Biochemistry Department herself. She was a few years behind me, but in many ways we shared the same experiences," Westcott says. "She is working to make sure that the department feels like family. It has a bright future under her leadership." ■



“It gave me the skills — critical thinking, problem solving — which I think are critical to an individual’s ability to do anything today.”

Illinois Alumni Makes Lasting Mark in Physiology

By Brian Wallheimer

From his early days as an undergraduate, watching in amazement as Illinois professor F. R. Steggerda demonstrated the inner workings of the heart and blood vessels in a dog, Martin Frank wanted to make his own mark in science.

Frank has certainly accomplished that goal, though the road he took was not the one he imagined. From those early days in Steggerda’s class, Frank imagined himself as a professor in a Midwest town, riding a bicycle to campus with a brown bag lunch in his hand. He would spend his time in the lab and classroom, and sometimes under the cool shade of a tree discussing science with his students. It was a lofty goal for a young man from Chicago who came to Illinois through a scholarship program through the Western Golf Association after realizing his family did not have the means to pay for his education.

Taking advantage of his opportunities, Frank immersed himself in physiology, earning all his degrees, through his doctorate in 1973, at Illinois. He took positions as a teaching assistant, research assistant, and pre-doctoral research trainee before going on to take postdoctoral positions at the Michigan Cancer Foundation and Michigan State University.

As an assistant professor at George Washington University, the perfect picture in Frank’s mind started to fade. He could not afford a home close enough to campus to bike, and there were no musings under the tree.

About that time, Frank came to realize that for all the science he had learned in all those labs, he had gotten another education. Through grant applications, directing research programs, and advising graduate students, Frank had become an excellent administrator.

Instead of those bike rides into campus, Frank was driving in and listening to National Public Radio, which regularly carried stories about science policy and funding in Washington, D.C.

“It’s very easy to get enamored with what goes on at Capitol Hill, what goes on in the White House and how that all affects science policy,” Frank says.

Enamored, Frank applied for a program through the National Institutes for Health that trained bench scientists in research administration for a year. Instead of that program, however, NIH approached Frank to become executive secretary of the physiology section of the Division of Research Grants, where he spent seven years managing peer evaluation of hundreds of funding proposals.

During his last two years in government, Frank was also a member of the Department of Health and Human Services Senior Executive Service Candidate Development Program. As part of the program, he worked in the Office of Program Planning and Evaluation, Office of the Assistant Secretary of Health, working on Orphan Drug legislation. In 1985, he became the executive director of the American Physiological Society (APS), a position he has held ever since.

“I saw another path—a path that I thought would let me do more for my discipline. I came to realize that I could do more for physiology research in administration than I could do in the lab,” Frank says.

Over the last three decades, Frank has put particular emphasis on access to science through the APS.

The Porter Physiology Program, started in the

1960s to support minority scientists, has been greatly expanded. There is now a travel program that helps scientists attend the APS annual meeting, and the program supports up to a half dozen pre-doctoral fellowships per year.

The APS brings middle and high school teachers into labs during the summer and supports an undergraduate summer research program.

In the 1990s, the APS started publishing its scientific journals online and providing content free to the public one year after publication.

“We’ve carried a commitment to minority education and support of minorities to many of our programs, and we have championed the idea of expanding the reach of science by providing access to our publications and being active in classrooms,” Frank says. “When you really think about society and the world around us, we are surrounded by science. We need to get as many people knowledgeable about science and get them passing that enthusiasm forward.”

Frank found that his Illinois education put him in a position to succeed in ways he never imagined.

“It gave me the skills—critical thinking, problem solving—which I think are critical to an individual’s ability to do anything today,” Frank says. “While I may not have envisioned myself becoming executive director of American Physiological Society (APS), I realized that I was never going to win a Nobel Prize. What I’ve tried to do is use those skills to create an environment where maybe someone else can win a Nobel Prize.” ■



Growing Blood Vessels in the Lab

Laura Niklason receives 2016 LAS Alumni Achievement Award for groundbreaking work in tissue engineering

By Doug Peterson

Laura Niklason first came up with the idea of growing human blood vessels while she was doing her residency at Massachusetts General Hospital in the 1990s.

A patient was undergoing a heart bypass—a surgery in which a physician takes a blood vessel from another part of the patient’s body and then sews it on top of a clogged vessel, forming a bypass around the blockage. The problem, in this instance, was that doctors could not find a suitable replacement vessel in either the patient’s legs or arms, so they had to go into his abdomen to find one—not an ideal choice.

With the goal of providing a ready supply of vessels, she created a prototype engineered blood vessel in 1997, and in 2012 an advanced version was used successfully in the first human patient. The FDA has fast-tracked the engineered blood vessel, moving it into Phase 3 human clinical trials. Meanwhile, she has also begun work on finding ways to grow new lungs for transplantation.

For this groundbreaking work in tissue engineering, Niklason is a 2016 LAS Alumni Achievement Award winner.

Niklason, a professor of anesthesia and biomedical engineering at Yale University, grew up in the south suburbs of Chicago and says she was probably seven or eight years old when she decided to become a doctor.

“I wanted to be the person who saves the day, I guess,” she recalled.

Niklason skipped a couple of years of school, so when she arrived on the University of Illinois campus in 1979, she was only 16 years old. However, she said, “I didn’t feel that much younger than other people.”

As a 16-year-old physics major, she may have been an atypical student, but the advantage of a large school was that it was diverse enough that

she could find a peer group of like-minded budding scientists.

After graduating from Illinois, Niklason went through a combined PhD/MD program at the University of Chicago, but finished her MD at the University of Michigan where her future husband was on faculty.

During the third year of her anesthesia residency in 1995, she joined the laboratory of Robert Langer at MIT—another major turning point in her career. As she says, “At the time, his lab was one of the few in the country that was exploring this new world of tissue engineering.”

It was while she was working in Langer’s lab and doing her anesthesia training that she decided, “I am going to grow a blood vessel. At the time, it was a fantastical idea. Even my best friends thought it was kind of funny. But I didn’t know any better, so I started working.”

Once the vessel prototypes were developed, she decided that for the first clinical application they would target patients who undergo dialysis three times a week. In preparation for dialysis, doctors sew a replacement blood vessel just under the skin. Blood is drawn out through this replacement vessel, and the dialysis machine then cleans the blood, which is returned to the patient’s body through the same vessel.

Because replacement vessels are used so heavily in dialysis and are subject to failure, they are often made out of Teflon. But Teflon blood vessels are much more susceptible to infection, which is why Niklason’s team wanted to replace them with bioengineered vessels that are, basically, human tissue. To grow the new blood vessels, Niklason and collaborators place human vascular cells on a vessel-shaped scaffold, and then the tissue grows into the shape of a vessel inside of a specialized bioreactor.

After developing their first successful blood

vessel in the lab in 1997, her lab spent the next 15 years refining the technology. This culminated in the first patients being implanted with the laboratory-grown vessels in 2012. Three and a half years later, the first two dialysis patients are still successfully using the same replacement vessels grown using Niklason’s technology.

In all, a total of 60 dialysis patients in the United States and Europe have now received the engineered blood vessels, and an additional 175 patients will receive the vessels as part of the Phase 3 clinical trials. The vessel has proven to be mechanically strong, significantly lowering both the failure rate and infection rate.

In 2004, Niklason started a company, Humacyte, to move the engineered blood vessels forward. She has partnered with AlloSource, a tissue procurement organization run by Tom Cycyota, a 1980 LAS alumnus in biology who received the LAS Alumni Humanitarian Award last year. (Niklason didn’t know about the Illinois connection until after they started talking about collaborating.)

With engineered blood vessels showing so much success for dialysis patients, Niklason sees many other possible uses for replacing tubular tissues in the body, such as the windpipe or esophagus in cancer patients.

When Niklason started this work in the 1990s, she says, “There was a tremendous amount of irrational exuberance about tissue engineering. People were saying we’re going to grow a new arm in 10 years, and it’s all going to be fabulous.”

When that didn’t happen, the 2000s saw a wave of pessimism, but work such as Niklason’s has ushered in a new period of cautious optimism.

As she put it, “We are on the cusp of what I think is going to be a permanent change in medicine.” ■

GIVE to Unconventional Wisdom: Spotting HIV in the Blood

Deborah Paul receives 2016 LAS Dean's Quadrangle Award for commitment to her family, Illinois, and her fight against devastating disease

By Doug Peterson

A mysterious ailment struck Deborah Paul's younger brother, Tim, in 1982, when lymph glands all over his body suddenly became swollen. He recovered, but it took two years for doctors to finally figure out what had triggered the problem.

In 1984, Paul's brother developed pneumocystis pneumonia—a type of pneumonia that was beginning to affect many men in different parts of the country, particularly San Francisco and New York. This form of pneumonia was linked to AIDS.

Tim recovered from the pneumonia, which typically killed AIDS patients. But cancer struck her brother later the same year, and in March of 1985, just two months after Paul received her PhD in biochemistry, her brother passed away at the age of 28.

In honor of her brother's memory, LAS alumnus Paul has chosen to establish the Deb and Tim Paul Endowment Fund to support University of Illinois work in infectious disease and immunology.

For her commitment to her brother, her work, and the U of I, Paul is the winner of the 2016 LAS Dean's Quadrangle Award.

Paul's endowment at Illinois will eventually support a research chair, but there is no one yet in that position. So, in the meantime, the U of I is supporting a professorship out of the endowment fund. The first Deborah Paul Professor of Molecular and Cellular Biology is Milan Bagchi in the Department of Molecular and Integrative Physiology. Bagchi's lab is deciphering the molecular genetic basis of steroid action that affects female reproductive tissue—work that has implications in breast, ovarian, and endometrial cancers.

At the time of her brother's death, Paul had just begun her new job at Abbott Laboratories in Chicago, where she had begun looking for a way to find HIV—the virus behind AIDS—in the bloodstream. One year later, Paul succeeded, becoming the first to detect HIV in the blood. She said she just wishes it could have been discovered in time to help her brother.

Deborah Paul was very close to her brother, despite having completely opposite personalities. Paul is introverted, content to burrow away in her laboratory, while Tim was a complete extrovert. As she put it, "Tim could walk into a room of strangers and make everyone his friend." He was also creative—writing poetry and short stories and playing multiple instruments.

"He played piano beautifully and would accompany people who sang professionally at different venues."



Paul came to U of I for her master's in 1977 after receiving a bachelor's in biology from the University of Wisconsin at Parkside. While she was on the Illinois campus, Paul says one of the greatest influences on her career was the late Carl Woese, the acclaimed microbiologist who supervised her master's thesis.

"I had never met anybody like him," she said. "He was the most original thinker, and it was because of him that I saw you could challenge ideas."

Woese went on to discover an entirely new domain, or kingdom, of life, despite many scoffers. Likewise, Paul faced similar skepticism when she began her pursuit of a way to detect HIV in the blood. When she

started this work, the conventional wisdom was that HIV did not circulate in the bloodstream.

"People thought: 'Why even bother looking for it?'" she said. Undeterred, Paul set up her lab in the basement of Abbott, where she initially had the entire floor to herself. But being alone was heaven for this introverted scientist. Within a year, she had developed a test to detect HIV in the blood, but skepticism outside of Abbott continued. When the team submitted a paper to get the technology out there, one reviewer responded with four blunt words: "I don't believe it."

But the test proved to be a success and was patented in 1988. Although it has since been replaced by nucleic acid tests, this initial test helped in the fight against HIV. Paul's test identifies during the initial infection, and when the virus reemerges after going dormant. It was also used to monitor therapies because by monitoring viral levels in the blood with the test, scientists could determine if the drug was killing HIV, or if the virus was becoming resistant to the therapy.

In fact, by using this test to screen new potential therapies in viral culture, Abbott Laboratories developed Norvir, the first protease inhibitor to target the HIV virus. The medication was approved in 1996, and even today it continues to be used in combination with other drugs to combat AIDS.

Paul retired from Abbott in 2016, but she remains active as a group fitness instructor, teaching aerobics and toning classes, pilates, and barre, a ballet-based form of exercise—"ballet for the masses," she says. In addition, she golfs three times a week, and when she travels on golf trips, she will often shoot 27 holes in a day. Two years ago, she even had a hole in one.

On a professional level, Paul set up the Illinois endowment to foster breakthroughs on intractable infectious diseases—the kind of work she did on AIDS. But on a personal level, she said the research she is supporting takes on deeper meaning because of her brother, who was so proud of her. ■



Milan Bagchi, Deborah Paul, and Stephen Sligar

Faculty Member Named Deborah Paul Professor of Molecular and Cellular Biology

Milan Bagchi's research has provided fundamental insights in his field

Following years of groundbreaking and important research, Milan K. Bagchi, a professor of molecular and integrative physiology at Illinois, has been named the Deborah Paul Professor of Molecular and Cellular Biology.

An investiture is one of the highest honors that a faculty member can receive, with the recipient chosen by a committee of peers. A generous gift from the Deb and Tim Paul Endowment Fund made this position possible.

Bagchi earned his doctoral degree in biochemistry from the University of Nebraska-Lincoln and served as a professor at the Center of Biomedical Research of the Population Council at the Rockefeller University before coming to Illinois in 2001. From 2008 to 2014, he served as the director of the Center for Research in Reproduction and Infertility, supported by the National Institutes of Health at Illinois.

Bagchi's research has provided fundamental insights into the mechanisms of steroid hormone action controlling mammalian reproduction. He has published more than 100 peer-reviewed articles in top journals such as *Nature*, *Science*, *Proceedings of the National Academy of Sciences*, *PLoS Genetics*, *Development*, and more. Each year he teaches a highly popular endocrinology course to more than 100 undergraduate and graduate students. Bagchi is also the current head of the Department of Molecular and Integrative Physiology.

"I am deeply touched by this honor, which recognizes the research efforts of my team to decipher the molecular genetic basis of steroid hormone action that controls cell proliferation, differentiation and immune response in female reproductive tissues," Bagchi said. "Abnormal hormonal signaling is responsible for various human diseases ranging from reproductive dysfunctions and infertility to breast, ovarian and endometrial cancer. We are performing translational biomedical research in collaboration with clinical partners to improve our understanding of the

underlying causes of these diseases. This generous gift will help us to continue to pursue these translational research goals."

Bagchi has been recognized previously with appointments as a University Scholar and Richard and a Margaret Romano Professorial Scholar.

"In addition to Dr. Bagchi's outstanding record of translational research, as department head, Dr. Bagchi has provided key guidance to the Department of Molecular and Integrative Physiology, recruiting physician-scientists and key faculty hires active in translational research," said Stephen G. Sligar, director of the School of Molecular and Cellular Biology.

The position is named for Deborah Paul (MS, '79, biology) and her late brother, Tim. After earning her degree at Illinois, Deborah Paul went on to earn a doctoral degree and then spent 34 years at Abbott Laboratories. She authored 42 journal articles, four book chapters, 80 abstracts and has three issued patents.

She spent 14 years with Abbott Diagnostics doing hepatitis/retrovirus research, where she pioneered HIV research. Paul also worked on diagnostic immunoassays for hepatitis B, C, and E, and from 2005 until her retirement, she was director of licensing and business developments for Abbott Molecular.

Paul's late brother, Tim, who died of AIDS, was a major inspiration for his sister's work. (See a profile of Paul and her brother on page 21 of this magazine).

"I am privileged to be able to provide this gift to support the important work of Dr. Bagchi and to play a part in continuing the academic excellence at the University of Illinois while also benefiting the new College of Medicine," said Paul. ■

Susan Martinis Named Stephen G. Sligar Professorship

Alumnus Kris Jenner endows the professorship in honor of his mentor at Illinois

When Susan Martinis studied at the University of Illinois as a doctoral student in the late 1980s, she had no idea that she would someday become a professor here, let alone the head of the Department of Biochemistry. Now, she has also received a professorship—one of the highest honors bestowed upon faculty at Illinois.

Martinis has been named the recipient of the Stephen G. Sligar Professorship, which was created in 2016 by Dr. Kris Jenner, his wife, Dr. Susan Cumming, and his family, through the Jenner Family Fund.

Professor Martinis is an internationally respected scholar in the field of RNA-protein interactions and aminoacyl-tRNA synthetases whose work is most currently supported by the National Institutes of Health, National Science Foundation, and the W.M. Keck Foundation. She was a founding member of the National Institutes of Health Molecular Genetics A study section and is known for high-quality teaching and mentorship. Professor Martinis provides key guidance to the Department, School, College, and University as well as critical leadership in the recruitment and mentoring of faculty. She is currently involved in the transition to the new Carle Illinois College of Medicine.

After graduating with a PhD ('90) from Illinois in Biochemistry working in Dr. Sligar's laboratory, Dr. Martinis joined Paul Schimmel's laboratory at MIT as an American Cancer Society Postdoctoral Fellow. Dr. Schimmel is the founder of multiple successful biotech startups and recruited Martinis as one of the initial members of Cubist Pharmaceuticals. Martinis left Cambridge in 1995 for the University of Houston and was recruited back to a tenured position at Illinois in 2005. Since 2009, Martinis has been Head of the Department of Biochemistry and served for one year as interim Associate Dean for the Sciences in the College of Liberal Arts and Sciences. She is currently President-Elect of the American Association of Medical and Graduate Departments of Biochemistry.

A professorship is intended to encourage promising faculty to expand their careers at Illinois, and this one is unique as it was funded by an alumnus, Kris Jenner (BS, '84, biochemistry), in honor of a current faculty member. Sligar is a Swanlund Chair and professor of biochemistry, chemistry, and biophysics and computational biology. He also directs the School of Molecular and Cellular Biology.

Originally from Mascoutah, Illinois, Jenner came to Illinois on a football scholarship and was part of the 1983 Rose Bowl team as a quarterback. In the classroom, however, he was inspired to pursue a



Kris Jenner, Susan Martinis, Stephen Sligar

career in medicine, as well as research, which was fostered by his undergraduate research project in Sligar's biochemistry laboratory. He credits Sligar with helping him become a Marshall Scholar, one of the most prestigious fellowships for a college student, which enabled him to attend the University of Oxford for a Master's Degree in molecular biology.

Due to his accomplishments, he was offered the opportunity to stay on for an additional year to complete a D.Phil. He then matriculated and graduated from Johns Hopkins with his medical degree and completed two years of a general surgery residency before making the decision to pursue his interest in finance. Following a successful career at T. Rowe Price as a health care portfolio analyst and Vice President, Dr. Jenner founded Rock Springs Capital Management, a hedge fund based in Baltimore, MD, in 2013.

Dr. Jenner credits his research experience as an undergraduate at Illinois as an important factor in his career successes in medicine and business, which led him to create the Jenner Family Fund. The fund provides the income to launch an annual awards program for five Molecular and Cellular Biology (MCB) and Biochemistry undergraduate students to work in a research laboratory for the summer in order to provide the basis for a Senior Research Thesis in MCB or Biochemistry.

"It is an honor to recognize Dr. Martinis' contributions to science and, importantly, her dedication to teaching and mentorship," said Dr. Jenner. "Dr. Sligar's early influence on my career was profound, and this gift reflects our family's strong belief to give back to those whose tireless efforts are, in part, responsible for our well-being today. It is great to support the career of another one of Dr. Sligar's mentees." ■

Susan Lindquist, Scientist Who Made Genetic Discoveries Using Yeast, Dies at 67

By William Grimes, *New York Times*

Susan Lindquist, a molecular biologist whose conceptually daring work with yeast proteins opened new avenues to understanding gene functioning and degenerative diseases like Parkinson's and Alzheimer's, died on Thursday in Boston. She was 67.

The cause was cancer, her husband, Edward Buckbee, said.

Dr. Lindquist devoted most of her career, first at the University of Chicago and later at the Whitehead Institute in Cambridge, Mass., to studying how proteins changed shape during cell division to carry out genetic functions.

This process, known as protein folding, can go awry, causing such neurological disorders as Parkinson's, Alzheimer's and Huntington's chorea, as well as cystic fibrosis and some cancers. Certain malformed proteins, known as prions, enlist recruits and attack the brain in the class of diseases called spongiform encephalopathies, which include Creutzfeldt-Jakob in humans and scrapie and mad cow disease in animals.

Her research demonstrated that protein-folding errors occurred in all species and that biological changes could be passed from one generation to the next through proteins alone, without the participation of RNA or DNA—a process previously thought to be impossible.

"Her work has provided paradigm-shifting insights into the most basic aspects of cell biology, genetics and evolution," the Genetics Society of America stated in awarding her its annual medal in 2008.

Her work with yeast proteins generated a multitude of insights into neurodegenerative disease, drug resistance, cancer, evolution and prion biology. In a series of experiments described in a 2006 paper in the journal *Science*, she and her team introduced a Parkinson's gene into a yeast cell and, after testing 5,000 genes, isolated one gene with a protein that saved the yeast cell. Later experiments with other labs were successful in saving the neurons of fruit flies and rats. Together the studies opened a promising line of research for an eventual cure for Parkinson's.

"I do a lot of what you would call high-risk, high-payoff research," Dr. Lindquist told an audience at Angelo State University in Texas in 2002. "Some of my projects don't work, but when they do work, they are pretty fabulous."

Susan Lee Lindquist was born on June 5, 1949, in Chicago. Her father, Iver, was a tax preparer, and her mother, the former Eleanor Maggio, was a homemaker.

As a child, she conducted experiments by gathering berries and mixing them in a bowl to see what happened when they fermented.

After graduating from Maine South High School in Park Ridge, Ill., she earned a bachelor's degree in microbiology from the University of Illinois in 1971 and a doctorate in biology from Harvard in 1976.

At Harvard, she became interested in the process by which genes provided the information to create a protein. "We knew we had all these



genes, and there was pretty good evidence that they got turned on and off, but we didn't know why," she told *The Boston Globe* in 2004. "Each cell was using a different set of them: How does that happen? It was pretty much a black box at the time."

She focused initially on fruit-fly tissue, acting on a tip by Sarah Elgin, a junior faculty member. "She told me about this cool phenomenon in fruit flies where you can see puffs on salivary gland chromosomes in response to heat," Dr. Lindquist told the magazine *The Scientist* in January. "If you labeled the salivary glands, you could see new proteins being made. I wondered if tissue-culture cells would make similar proteins. If so, it would make molecular analysis possible."

After completing a postdoctoral fellowship at the University of Chicago, she joined the university's department of molecular biology and began working with yeast, despite warnings by a colleague that she could ruin her chances for tenure by switching organisms. Because she had never thought tenure was a possibility in the first place, she later said, the threat seemed moot.

"So this was an aspect of gender inequality that was extremely positive," Dr. Lindquist told *The Scientist*. "It allowed me to be fearless." She added, "My highest aspiration then, if I did really well, was to have a corner of a lab and write grants under the auspice of a male professor."

She ended up running her own molecular genetics lab with a staff of 20. In 1997, she was elected to the American Academy of Arts and Sciences and the National Academy of Sciences.

Interviewers often expressed puzzlement that a medium as unpromising as brewer's yeast could be a scientific gold mine. Dr. Lindquist sympathized.

"Even people in my laboratory thought we were crazy to try to study neurodegenerative diseases with a yeast cell," she told *The New York Times* in 2007. "It's not a neuron. But I thought we might be looking at a very general problem in the way proteins were being managed in a cell. And yeasts are easy to study because they are such simple cells."

In 2001, Dr. Lindquist accepted the joint appointment of professor of biology at the Massachusetts Institute of Technology and director of the Whitehead Institute, best known for its work on sequencing the human genome. She served as director until 2004. In 2010, President Obama presented her with the National Medal of Science.

Dr. Lindquist lived in Cambridge. In addition to her husband, she is survived by her daughters, Alana Buckbee and Eleanor Buckbee, known as Nora; and her brothers, Alan and John.

"I have to tell you that the sheer intellectual joy of finding out how life works is really cool," Dr. Lindquist told *The Times*. "This is the greatest intellectual revolution, and it is happening right now, and I'm lucky enough to be in the middle of it." ■

“Klaus Schulten was a giant amongst giants, a true pioneer, As a physicist, he made significant advances in the core programming and hardware needed to advance computational modeling of biological systems... His passing is indeed a loss to the entire scientific community”

In Memorium: Klaus Schulten

Klaus Schulten, professor of physics and Beckman Institute faculty member for nearly 25 years, has died after an illness. Schulten, who led the Theoretical and Computational Biophysics Group, was a leader in the field of biophysics, conducting seminal work in the area of molecular dynamics simulations, illuminating biological processes and structures in ways that weren't possible before.

His research focused on the structure and function of supramolecular systems in the living cell, and on the development of non-equilibrium statistical mechanical descriptions and efficient computing tools for structural biology. Schulten received his Ph.D. from Harvard University in 1974. At Illinois, he was Swanlund Professor of Physics and was affiliated with the Department of Chemistry as well as with MCB's Center for Biophysics and Computational Biology; he was Director of the Biomedical Technology

Research Center for Macromolecular Modeling and Bioinformatics as well as Co-Director of the Center for the Physics of Living Cells.

“Klaus Schulten was a cornerstone of the Center for Biophysics since its foundation in 1996,” said Satish Nair, director of the Center for Biophysics and Quantitative Biology. “He was instrumental in nurturing Biophysics in general, and Computational Biology specifically, and helped to establish one of the world's top programs. Klaus was also a phenomenal mentor to generations of students and post-doctoral fellows, most of whom have gone on to set up prominent research labs of their own. His influence and legacy to the Center was singular.”

“Klaus Schulten was a giant amongst giants, a true pioneer,” said Stephen Sligar, director of the School of Molecular and Cellular Biology. “As a physicist, he made significant advances in the core programming

and hardware needed to advance computational modeling of biological systems. In the application of these advances, Klaus chose the most challenging problems to provide key insight into molecular function. He was a voice for the close collaboration between experimentalists and theorists to advance understanding that is grounded in reality. As an administration, he led numerous efforts to recognize the cross-unit excellence in biophysics at Illinois, nationally and internationally. His passing is indeed a loss to the entire scientific community.”

He is survived by his wife, University of Illinois chemistry professor and physics affiliate Zan Luthey-Schulten; his daughter, Charlotte Schulten, Glendale College professor of mathematics; her husband, Dr. S. Case Bradford at the Caltech Jet Propulsion Laboratory; his brother, Christoph Schulten in Aachen; and his sister, Karin Balmer in Mainz. ■

MCB GRADUATES

Doctor of Philosophy

Biochemistry

Jason Bouvier, Summer 2015
Rodney Burton, Summer 2015
Salehe Ghasemper, Fall 2014
Yue Hao, Fall 2015
Carleigh Hebbard
Parissa Hosseinzadeh, Fall 2015
Zhongyi Li
Aidas Mattis
Daiva Mattis, Summer 2015
Daryl Meling
Ismacel Muhamed, Fall 2015
Ranjani Murali
Manuel Ortega, Fall 2015
Shyamal Subramanyam
Chang Sun
Seyed Torabi, Fall 2014
Richard Travers, Summer 2015
Padmaja Venkatakrishnan
Peiwen Wu, Fall 2015
Sophia Yi

Yi Yu, Fall 2015
Hanchao Zhao

Biophysics & Quantitative Biology

Sylvia Choi, Fall 2015
Kiran Girdhar, Summer 2015
Amanda Marciel, Summer 2015
David Park
Joshua Vermaas
Hang Yu, Fall 2015

Cell and Developmental Biology

Edwin Arauz Diaz, Summer 2015
Derek Caetano-Anolles
Yijie Geng, Summer 2015
Sumanprava Giri
Amir Saberi, Summer 2016
Alvin Thomas

Microbiology

Maria Bautista Chavarriaga
Courtney Cox, Summer 2015
Tulip Mahaseth, Summer 2015
Katie Molohon Hess, Fall 2015

Molecular and Integrative Physiology

Gwendolyn Humphreys, Summer 2015
Lily Mahapatra

Neuroscience

Alexander Iordan
Jennifer Kim
Patricia Weisner, Fall 2015

Master of Science

Biochemistry

Mingxi Han
Lingbwei Hu
Joseph Ly
Xuan Wang, Fall 2015

Biophysics and Computational Biology

Gurcan Kayikcioglu, Fall 2015
Laura Stoolman

Cell and Developmental Biology

Veena Chatti, Summer 2015

Microbiology

Adam Kolakowski

Molecular & Integrative Physiology

Shayan Tabe Bordbar

Undergraduate Degrees—Bachelor of Sciences

Academic Distinction

Scott Anderson, MCB, Fall 2015
Emmanuel Asow, MCB Honors Conc.
Connor Booker, MCB
Leah Brackensick, MCB, Fall 2015
Mengqian Bu, MCB
Albert Chang, MCB
Aaron Chen, MCB
Liyushang Chou, MCB Honors Conc.
Gandhar Datar, MCB
Michael Fessler, MCB
Samantha George, MCB Honors Conc.
Sebastian Graca, MCB, Fall 2015
Jennifer Graze, MCB, Fall 2015
Ryan Gundersen, MCB
Bredesen Hartmann, MCB, Fall 2015
Sarah Imran, MCB
Ayana Jamal, MCB, Fall 2015
Wangsoo Lee, MCB
Michelle Leong, MCB, Fall 2015
Michael Leventhal, MCB Honors Conc.
Abhijith Matur, MCB Honors Conc.
Michael McGrath, MCB
Andia Mitri, MCB, Fall 2015
Brett Nelson, MCB Honors Conc.
Shannon O'Brien, MCB
Michael Pajor, MCB
Jeonghun Park, MCB
Akash Patel, MCB, Fall 2015
Ricky Patel, MCB
Ana Petracovic, MCB
Allison Schartman, MCB
Parshva Shah, MCB Honors Conc., Fall 2015
Dillon Svoboda, MCB, Fall 2015
Robert Tsang, MCB, Fall 2015
Sarah Tucker, MCB, Fall 2015
Gage Winger, MCB
Lukas Wu, MCB
Stephanie Youssef, MCB, Fall 2015
Omar Zaki, MCB, Fall 2015

Highest Distinction, Research

Oludemilade Akinrotimi, MCB, Fall 2015
Madison Barker, MCB
Jesse Black, MCB
Philip Cannizzaro, MCB
Yanbo Chen, Biochemistry
Gandhar Datar, MCB
Austin Deets, Biochemistry
Caitlin Dingwall, MCB, Fall 2015
Diana Fan, MCB
Jennifer Graze, MCB, Fall 2015
Ayana Jamal, MCB, Fall 2015
Valerie Jaroenpuntarak, Biochemistry
George Mastorakos, Biochemistry
Abhijith Matur, MCB Honors Conc.
Michael Pajor, MCB
Megan Patton, MCB Honors Conc.
Robert Pipal, Biochemistry
Edrees Rashan, Biochemistry
Allyson Ray, MCB
John Rouck, MCB

Jessica Strzepka, MCB
Sarah Tucker, MCB, Fall 2015
Nicholas Zanghi, MCB
Amanda Zhang, Biochemistry
Jun Zhang, Biochemistry

High Distinction, Research

Vincent Abejuela, MCB
Daniel Berger, MCB, Fall 2015
Alison Camden, Biochemistry
Ellen Cho, Biochemistry
Han Gil Jeong, MCB
Melissa Grana, MCB
Ekaterina Gribkova, MCB Honors Conc.
Kevin Grudzinski, MCB
Farid Kadyrov, MCB
Wiktoria Kasprzyk, MCB
Jason Laman, MCB
Wangsoo Lee, MCB
Andrew McInerney, MCB
Ashabari Mukherjee, MCB, Fall 2015
Alay Parikh, MCB
Jeonghun Park, MCB
Janie Perry, MCB
Justin Podowski, MCB
Aditya Ravindra, MCB, Fall 2015
Samantha Reed, MCB
Wilhelm Salmen, MCB
Stacy Sons, MCB
Amanda Sul, MCB
Robert Thompson, MCB
Kevin Yu, MCB
Jamie Zhu, MCB

Distinction, Research

Kimberly Allen, MCB
Burak Cetin, MCB
Camille Garcia, MCB
Gregory Harpring, MCB
Mary Hong, MCB
Cole Lewis, MCB Honors Conc.
Jeremy Quinones, MCB Honors Conc.
Hao Sun, Biochemistry
Carlos Vega, MCB
Lucy Wan, MCB, Fall 2015

Molecular and Cellular Biology Honors Concentration

Guanglin Chen
Andrew Knapp
Krishna Kudaravalli
Sarah Osmulski
Arun Raderman
Swetapadma Tripathy

Biochemistry, Specialized Curriculum

Joshua Choi
Frank Gambino Jr.
Lijo Luka
Jessica Mattick
Kelly Mehan
Linda Nguyen
Michael Schaible
Cameron Shahnazi
Bradley Smith
Francois-Marc Truc
Gina Yao

Michelle Famakinwa
Venus Fan
Katherine Favia, Fall 2015
Gail Fernandes
Eric Fernandez
Ellie Fishbein
Ryan Flanagan
Alice Foltyn
Daniel Foody
John Fronczak
Jia Fu
Andi Garcia
Alexander Geddes
Dominic Gentile, Fall 2015
Daniel Gillespie
John Goin
Felisha Gonzalez
Michael Gonzalez, Fall 2015
Sravya Gourishetti
Dylan Grillaert
Elizabeth Grogan
Mercedes Grove, Fall 2015
Patricia Grzyb
Stephanie Guan
Jessica Gubala
Anushrav Gulati
Hannah Guzwiller
Dylan Gutzman
Kevin Ha
Despina Hadjiagiapiou
Syed Haider
Mohammed Hamad, Summer 2016
Raia Hamad, Fall 2015
Emily Hamm
Jane Han
Sean Haney
Sheeri Hanjira, Fall 2015
Kent Hanson
Nadia Hatoum
Madison Havel, Fall 2015
Rachel Heiberger, Fall 2015
Stephanie Hein
Michael Heldak, Fall 2015
Lucas Heliaker
Matthew Hensen
Norma Hernandez
Janell Herrera
Sharell Hicks
Kyle Hirschfelder
Daniel Ho
Matthew Holaday
Zachary Holmbeck
Aaron Hong
Angela Hong
Jingling Hou
Kevin Huang
Henry Huynh
Ikenna Ifearulundu
Christina Im
Ericson Imarenezor
Morgan Ivy
Akshay Jain
Kiley Janas
Seung Jang
Camille Johnson
Tressa Joy
Esther Ju
Jacob Kacmar
Tejasvini Kapa
Daniel Kim
Kyung-Youn Kim, Fall 2015
Michael J Kim, Fall 2015
Jeffrey Kinka
Kyungwon Ko
Rachel Kohn
Steven Krauklis
Lauren Kunkel, Fall 2015
Oleksiy Kyrychenko
Thomas Laabs
Nasli Lane

Molecular and Cellular Biology

Mudassir Ali
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