TO EDUCATE, TO LEARN, TO INSPIRE: BECKMAN CENTER EDUCATIONAL PROGRAMS HELP SCIENTISTS EXPLORE NEW IDEAS

By Sarah C.P. Williams

As they probe how the universe works, from the tiniest atoms to the vast reaches of outer space or the complexities of human cognition, scientists are quintessential lifelong learners.

Scientists have chosen a profession that lets them straddle the known and the unknown; to stay current in their fields they must, in many ways, never leave the classroom, never stop learning. And yet, for any one scientist to stay on the forefront of all scientific advances is impossible. So the best scientists don’t just read manuscripts focused on their own areas of study—they turn to colleagues, mentors, and their own departments and institutions to continually explore new ideas across many disciplines.

The Arnold and Mabel Beckman Center for Molecular and Genetic Medicine plays a crucial role in such explorations for the scientists and students at Stanford University. Indeed, the mission of the Beckman Center is to “promote discovery and innovation in the basic sciences,” as well as inspire and encourage interdisciplinary collaboration and accelerate the connections between the research bench and the patient bedside. To fulfill that mission, the Beckman Center has developed a diverse array of educational programs that help scientists and students stay on the leading edge of discovery.

“The purpose of our educational programs is to keep our faculty, staff, students, and postdocs aware of the most exciting new experimental approaches and scientific breakthroughs, and to enable them to use all of that to make their own research better,” says Lucy Shapiro, Ph.D., the Virginia and D.K. Ludwig Professor of Cancer Research and director of the Beckman Center.

Through seminars, symposia, courses, and sponsored scholarships, the Beckman Center gives Stanford researchers and students a vast number of opportunities to learn about what is happening in the worldwide scientific community, from the latest experimental instruments and technologies to the most cutting-edge scientific theories. Each lesson they learn has the potential to enhance how they carry out their own research, making them better, more inspired scientists.

“Science is taking a lot of bricks and putting them on top of each other,” says Dr. Shapiro. “Each nugget you take away from a talk or a class helps you build up and strengthen your own research, even if it’s not obvious right away.”
BECKMAN SERVICE CENTERS AS CLASSROOMS

For researchers across the Stanford community, some of the most valuable assets of the Beckman Center are its service centers, four specialized facilities that provide scientists with shared, state-of-the-art technologies. The centers—the Cell Sciences Imaging Facility (CSIF), the Protein and Nucleic Acid (PAN) Facility, the Fluorescence Activated Cell Sorting (FACS) Facility, and the Computational Services and Bioinformatics Facility (CSBF)—offer equipment, software, expertise, and training. The expertise and training services take many forms: one-on-one consultations with staff scientists, training before a researcher uses new equipment for the first time, classes and lectures for Stanford students, and regularly scheduled seminars and speakers.

"With our service centers, we don't want to just provide a product for someone; we don't want to just hand them something they ordered and have that be the end of the conversation," says Dr. Shapiro. "We want them to become educated about what they need and why they need it, and how to design an experiment to get answers to the questions they're asking."

Researchers, of course, can turn to textbooks, colleagues, or the internet to learn the basics of an experimental approach, but the service centers offer something unique—in-depth, targeted, and personalized education on how to integrate the latest technology into one's own research.

"There are numerous YouTube videos out there," says Lisa Nichols, Ph.D., director of the FACS Facility. "If you want that, you know how to find it. That's not what we're trying to recreate."

Two seminar series sponsored by the service centers—Get the FACS and What's the Scope?—are especially focused on helping scientists make the best use of the advanced technologies at the facilities, as well as learn from other researchers.

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GET THE FACS SEMINAR SERIES

Fluorescence activated cell sorting (FACS) lets researchers purify subsets of cells from a mixture, based on the cells' fluorescent labels—or the lack thereof. Getting useful and pure populations of cells requires not only an understanding of how the physical cell-sorting machinery works, but also how to design the best combinations of fluorescent tags and prepare cells for sorting. This complexity is why Dr. Nichols launched the Get the FACS Seminar Series.

Get the FACS rotates between a set of basic repeating topics that new FACS Facility users frequently need training in, plus other, more advanced, one-time sessions. But even the most basic “Intro to Flow” seminar can provide new insight for experienced FACS Facility users.

“We have had some of our very experienced scientists come listen to ‘Intro to Flow’ and learn something new that changes how they think about their experiments,” says Dr. Nichols.

In one instance, she recalls, an advanced FACS Facility user did not recognize how using cells too large for the selected stream nozzle affected the sort until they heard it discussed in a seminar. When the scientist learned the symptoms, they realized that some larger cells had likely been disrupting the stream stability and droplet formation during their experiments, impacting their results. Dr. Nichols was able to explain how to fix the problem—a solution as easy as adjusting nozzle selection on the machine.

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More advanced Get the FACS seminars sometimes delve into complex tools that push the limits of current cell-sorting technology. Most FACS experiments, for example, use several fluorescent markers to differentiate cell types. If a scientist wants to obtain more in-depth information, such as function, they often run multiple sets of sequential experiments. With the current cytometers available, however, such steps are often unnecessary. Dr. Nichols and her staff can teach advanced users how to analyze/sort using more than 30 independent measurements—simultaneously.

“That kind of experiment might give someone the same information, but save a lot of time and resources,” she says.

The Get the FACS seminars also serve to bring together scientists tackling similar issues, which can lead to new solutions, collaboration, and comradery, Dr. Nichols says. “It’s really been a great opportunity for users to not only network with us, but network with each other,” she says.

Valuable conversations often emerge after the formal seminar presentation is completed, notes Dr. Nichols. At each event, scientists have an opportunity to ask questions that have been niggling at them or chat with others about how the FACS technology is or isn’t working well for them. Often, they discover that other seminar participants have faced the same challenges or have tips on how to improve their experiments.

Those connections and conversations are why Dr. Nichols put the seminars on hold during the COVID-19 pandemic; so much of the value of the seminars is their in-person nature and the casual receptions that follow them, she says. For the last two years, prerecorded training videos and seminar slides were still available, and the FACS Facility staff members were available to answer questions. This fall, however, Dr. Nichols was happy to once again offer in-person seminars that can foster connections.

Dr. Nichols also plans to add new topics to the slate of lectures.

“We want to get to a point where our users are more comfortable working out all the kinks in not only their data collection, but their data analysis,” says Dr. Nichols. “Right now, we often help users collect data, but then they disappear and there’s no connecting back to see if their experiments worked or they need more help.”

To that end, Dr. Nichols is hoping to launch small, advanced workshops on the analysis of FACS data; she also wants to collect more detailed information from scientists about other topics they want to delve into. She has also invited industry representatives to give educational talks about their FACS analysis software—the workgroups will provide data sets or have users bring their own data, and will walk them through analysis workflows.

To round out their educational mission—and reach students who may not yet be regular users of the center—the FACS Facility also supports two hands-on graduate courses that introduce science and engineering students to cell-sorting technology. Through those classes, Dr. Nichols says, she has a chance to pique students’ interest about how FACS might help them in the future; she hopes they’ll return later to learn more.
WHAT’S THE SCOPE? SEMINAR SERIES

At the Cell Sciences Imaging Facility, the What’s the Scope? Seminar Series, similar to Get the FACS, rotates monthly through several topics that users of the facility might want to explore.

CSIF director Jon Mulholland echoes Dr. Nichols’ thoughts on the high value of in-person seminars. Each seminar includes plenty of time for questions, as well as a meet-and-greet reception.

“We do have lots of website pages that people can go to if they want to learn about our different technologies, but the interactive part of our in-person lectures are really valuable,” says Mulholland.

After a hiatus during the COVID-19 pandemic, Mulholland says he’s gearing up to restart the What’s the Scope? series. In the meantime, he’s focused his attention on boosting other educational efforts at CSIF. In early 2022, he won funding through Stanford’s Community of Shared Advanced Research Platforms (c-ShARP) program to not only buy new microscopes for CSIF, but also to cover the cost of graduate courses that use the facility. In the fall of 2022, Mulholland and his staff are teaching Biological Light Microscopy—in collaboration with Richard Lewis, Ph.D., professor of molecular and cellular physiology, and Gordon Wang, Ph.D., director of the Neuroscience Microscopy Service at Stanford’s Wu Tsai Neurosciences Institute—as well as giving guest lectures in two electrical engineering courses.

“This is really essential for training the next generation of scientists, in terms of how to use the technology and how it’s being applied to research. When they go off and start their own labs, I want them to be able to use microscopes appropriately for their experimental goals,” says Mulholland.

In the future, Mulholland plans to keep adding educational material to the CSIF calendar and website—microscopy is such a rapidly changing field that researchers must continually learn about new offerings, he says.

“It’s evolving and changing so quickly; it’s hard to keep the most cutting-edge instrumentation in the facility and it’s certainly hard for researchers to stay current,” says Mulholland.

John Perrino with the Leica EM ICE.

Jon Mulholland and Lucy O’Brien.
To launch collaborative, translational research projects, scientists need more than just training in the latest instrumentation. They need to learn how to think like a scientist, as well as how to stay on top of what new approaches to scientific thinking are emerging, and what the latest breakthroughs are that might change their own focus. They need to explore beyond their own disciplines.

“More and more of the work in biomedicine is based on physics and chemistry, and involves large databases requiring innovative new ways of working out problems,” says Dr. Shapiro. “At the Beckman Center, we want to help researchers have an interdisciplinary vision of the most important questions in the living world and how to tackle those questions.”

To pave the way for this kind of vision, the Beckman Center sponsors three seminar series that bring researchers together to hear scientists—from Stanford and from around the world—describe their latest findings. The Frontiers in Biological Research Seminar Series, the Cancer Biology Seminar Series, and the Regenerative Medicine Seminar Series each feature lectures that fall under large umbrellas in terms of research topics. The sessions are purposefully wide-ranging, with the goal of teaching scientists about ideas and discoveries outside of their own realms of expertise.

“You can accomplish a tremendous amount just by having fantastic researchers come together and become aware of what each other is working on,” says Margaret T. Fuller, Ph.D., the Reed-Hodgson Professor of Human Biology and professor of developmental biology and genetics, and an organizer of the Regenerative Medicine Seminar Series.
Stanford graduate students in the departments of Biochemistry, Developmental Biology, and Genetics have diverse academic coursework and research backgrounds, but they all share many things; not only do their scientific interests and techniques tend to overlap, they all must develop the same basic skills in analyzing literature, designing original research, and thinking critically. That’s why first-year students in the three departments convene for a seminar-based course, Frontiers in Biological Research. The students—as well as interested members of the entire Stanford community—attend weekly seminars that bring speakers from across all three disciplines, and around the world, to share their work.

“Students come in and are exposed to a broad range of science, and this can help them think more broadly about what labs they might like to join or what approaches they want to take in their research,” says Anne Villeneuve, Ph.D., professor of developmental biology and of genetics, and chair of the Department of Developmental Biology.

The afternoon before each seminar, students in the course meet to discuss a related manuscript—often a paper from the laboratory of the speaker, or a foundational paper in the field. In addition to making the students better prepared to learn from the talk the next day, Dr. Villeneuve says the class discussions impart valuable lessons on how to digest papers.

“Getting the students to learn how to critically read scientific literature is a really important educational goal,” she says. “It doesn't necessarily have to be coupled to something like a seminar series, but we've found that it works really well for us and it keeps the material fresh for those of us who have been teaching the course for many years.”

The pre-seminar discussions, Dr. Villeneuve adds, help the students prepare questions they might want to ask the speakers, either during the seminars or at the small discussion sessions that follow.

In recent years, Frontiers seminars have covered topics such as stickleback adaptation, protein-DNA interactions, membrane dynamics, and CRISPR genome editing—to name just a few of the many dozens of lectures. Speakers have come from within Stanford, but more often hail from other universities—some as far away as Europe or Asia. Attendance varies, Dr. Villeneuve says, but a wide range of faculty members, postdocs, and more senior graduate students usually attend in addition to students enrolled in the Frontiers course.

“A lot of our faculty think the habit of going to talks is really something to cultivate,” says Dr. Villeneuve. “There are several senior members of our community who set a wonderful tone of lifelong learning.”

At the height of the COVID-19 pandemic, the Frontiers seminars and corresponding course were moved online. While that allowed more flexibility for international speakers, Dr. Villeneuve says she’s glad to see the series back in person for the fall of 2022.

“It’s much more energizing to be there together in a room,” she says.

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CANCER BIOLOGY SEMINAR SERIES

Getting diverse researchers together in one room is a common theme for Beckman-supported seminars, and the Cancer Biology Seminar Series is no exception.

“Cancer biology is a pretty broad theme,” says Julien Sage, Ph.D., the Elaine and John Chambers Professor of Pediatric Cancer and professor of genetics, and co-director of both the Cancer Biology Ph.D. Program and the Cancer Biology Seminar Series. “We have people in the Cancer Biology program from over twenty departments, ranging from very basic researchers to clinician scientists and medical residents. The seminar series is one way we strive to bring people together in this broad interdepartmental program.”

First- and second-year Ph.D. students affiliated with the Cancer Biology program are required to attend a weekly Tuesday Cancer Talk Series. Some weeks, the Tuesday Talk is a casual presentation by one of the graduate students or a postdoctoral research fellow about their own research. But about a dozen times each academic year, the weekly talk features an invited speaker who shares recent advances in cancer research, as part of the Cancer Biology Seminar Series. These more formal talks by outside scientists are sponsored by the Beckman Center.

“To decide who to invite, we survey both students and faculty each year and compile an initial list of names,” says Dr. Sage. “From there, we make sure we select a balanced group of speakers—East Coast and West Coast researchers, some junior faculty along with senior professors.”

Like the breadth of the Cancer Biology training program, speakers range in their chosen topics—from basic science topics like single-cell epigenomics of cancer cells and the role of DNA repair proteins, to more clinical research topics on immunotherapy resistance and cancer vaccination.

Students are asked to help run the seminars—they introduce each speaker and then have lunch with them afterward, giving the students an opportunity to ask about not only science but their career trajectories.

“I think a critical part of it is that the students feel like they can ask a speaker about all these other things they might be wondering—How do you have a family and run a lab? How do you cope with moving far away for your career? How do you select a postdoc lab?” says Dr. Sage.

Faculty also get a chance to interact with invited speakers at breakfast and dinner on the day of the seminar, as well as schedule one-on-one meetings.
While the focus of many seminars at Stanford is on outside speakers, the Regenerative Medicine Seminar Series (ReMS) puts just as much emphasis on the inclusion of speakers from within the university.

"I wanted to do something that reached beyond building boundaries, beyond school boundaries, beyond department boundaries, to bring together Stanford researchers doing related work who can learn from each other," says Dr. Fuller. "I think there is a tremendous opportunity for sparking new collaborations."

ReMS is held most Thursdays during the academic year, and often involves talks by two different speakers whose work—very broadly—falls under the general umbrella of regenerative medicine, which might mean anything from basic cell biology to tissue engineering.

"A lot of it is developmental biology, but it might also be transcriptional decisions; it might be cell surface interactions, it might be how do you wire a nervous system, it might be how do tissues interact with each other," says Dr. Fuller.

Dr. Fuller and her co-organizers try to select speakers who might not often be represented in a seminar series—such as new faculty members without a long list of publications—and pair up two researchers with complementary work. With such diversity in researchers, their backgrounds, and their scientific expertise, it is inevitable that attendees learn about new techniques and approaches by attending ReMS, says Dr. Fuller.

"I've invited people to talk in the series specifically because I knew they had a new technique that others might like to use," she says. "We had W.E. Moerner, Ph.D., the Harry S. Mosher Professor of Chemistry and a Nobel Laureate, talk about being able to visualize single proteins in cells because, wow, wouldn't people working on differentiating cells like to hear about that?"

During the COVID-19 pandemic, ReMS temporarily merged with the Cancer Biology Seminar Series, expanding the breadth of the science discussed even further. Researchers involved in each department realized the large overlap in topics between, in particular, stem cell biology and cancer stem cells.

"In cancer, you want to stop cells from growing, while in regenerative medicine you want to coax the cells to grow, and it's really two sides of the same coin," says Dr. Fuller.

As of the fall of 2022, the two series have once again returned to their normal—and separate—schedules, but Dr. Fuller suspects faculty and students affiliated with each topic will continue visiting each other's lectures.

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— Margaret T. Fuller, Ph.D.
Not everyone with the potential to contribute to the goal of the Beckman Center—efficient, translational research—is housed in the center itself or belongs to one of the Beckman basic science departments. Physicians in the Stanford community are also vital to the bench-to-bedside pipeline, and training doctors how to work with more basic researchers can only enhance this kind of collaboration.

The Beckman Center Medical Scholars Program helps to fulfill this need. It provides funds to Stanford medical students who are carrying out translational biomedical research, allowing them to spend time during their medical training immersed in basic science labs.

“It works in two directions,” says Dr. Shapiro. “The medical scholars learn to appreciate and use the results that are coming out of basic research, but at the same time, the basic scientists learn from our scholars—What are the most important questions and challenges in medicine right now? What are young physicians thinking about?”

Stanford is unique among U.S. medical schools in that all of its future doctors carry out research as part of a required Scholarly Concentration program. The scholarly work varies—some research revolves around social justice and health equity, global health, or quality improvement projects—but a significant portion of the medical students choose work in basic biomedical science.

“The idea behind this is really to provide an in-depth learning exposure for our students to develop critical thinking and get hands-on experience in a research area of their choice,” says Daniel Bernstein, M.D., the Alfred Woodley Salter and Mabel G. Salter Endowed Professor of Pediatrics and associate dean for curriculum and scholarship at the School of Medicine.

Medical students can choose how to fit their research projects into the rest of their medical curriculum. Some still complete their degree in four years, but many add a year or two to their time in school so they can fully develop and carry out a more detailed longitudinal project. Funds awarded to two or three Beckman Center Medical Scholars each year allow those students to add this time without incurring more debt.

“A big question for students is how they manage the financial aspect of taking on these longer research projects,” says Dr. Bernstein. “Medical school is expensive enough as it is.”

Beckman funds not only provide financial help for the students selected each year, but also establish important ties between Beckman researchers and the next generation ofclinician researchers, adds Laurence Baker, Ph.D., the Bing Professor of Human Biology and senior fellow at the Stanford Institute For Economic Policy Research.

“These students are future leaders in medicine; many of them will end up working in translational research from the clinical side for decades to come,” says Dr. Baker. “We often see them carry their research forward over multiple years, even after they’ve left Stanford.”

The training opportunity not only boosts their skills as researchers—it can also make them better doctors, more able to integrate the latest findings into how they treat patients.

“Having clinicians who have a good understanding of research and how to interpret medical developments is really valuable,” says Dr. Baker.

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— Laurence Baker, Ph.D.
BECKMAN SYMPOSIA EXPLORE BIG IDEAS

If the goal of Beckman educational programs is to bring together a wide swath of the Stanford community to share ideas, brainstorm, collaborate, and learn about the future of science, then the crown jewel of this effort is perhaps the Beckman Symposium. Held on a fluid schedule—whenever ideas emerge from the community—these day-long symposia tackle large themes from many angles.

A recent Beckman Symposium, “The Revolution in Diagnostics,” included presentations on how various approaches, from liquid biopsies to new imaging technologies, are changing medical diagnosis. Earlier symposia tackled diseases of the brain and the effect of emerging infectious diseases on global health, presaging a pandemic that has had a lasting impact on medical science.

“With our symposia, we’ve tried to incorporate all the latest and most exciting explorations in an area like diagnostics, genomics, or big data,” says Dr. Shapiro. “We couple the future of where we’re going in basic science with how it will help medicine and global health in the long run.”

The fluctuating schedule of the symposia—some are held just a few months apart while others are spaced years apart—means that researchers don’t force topics that aren’t yet ready. Instead, symposia ideas emerge organically, as Beckman scientists start to notice an area that they want to discuss in more depth.

“It’s a constant ongoing discussion among faculty in all the departments in the building,” says Dr. Shapiro.

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— Lucy Shapiro, Ph.D.
WHERE SCIENCE MEETS ART

The cover of this annual report is more than an eye-catching mash of colors and words; it’s a look into the brain of artist Neil Murphy, who has painted and designed custom art for Beckman publications and symposia for more than 15 years. Look at the cover—or any art he’s done for the Beckman Center—more closely, and details emerge that you might have missed at first.

At his home studio in San Carlos, acrylic paintings of neurons hang alongside sketches of tiny beasts. In many pieces, constellations and trap doors hide in the shadows. In some, he places detailed diagrams of scientific ideas on top of fluid, colorful fine art paintings.

The inclusion of Murphy’s art in Beckman publications is not mere happenstance. Art that merges the beautiful with the scientific, and makes people look twice, is an aspect of scientific education, says Dr. Shapiro.

“The wonderful artwork that he does for us is a way of advertising and attracting attention,” she says. “But it also stands for who we are; it conveys this excitement we have behind the science and puts our research into this broader context.”

Murphy has been an artist since his Hawai’i childhood; he attended the San Francisco Art Institute in the 1960s, before shifting to a career in audio engineering, graphic design, and web development. But when his day job had him spending hours on Photoshop designing corporate websites, he started to miss art—and wondered what would happen if he combined traditional art with new digital tools. About 20 years ago, he started more seriously creating art again, using a technique that merged acrylic painting, ink, and Photoshop.

“With traditional media, if you want to change the color of an area, you have to paint over it,” says Murphy. “But in Photoshop, you can highlight something and play with the colors. You can add layer after layer and then delete it if it doesn’t work.”
At the same time, Murphy’s absolute fascination with the natural and biological world drew him to scientific topics, and the blend of painting and digital manipulation let him easily capture both the fluid beauty of the world and the more concrete patterns of basic science.

“I love to express my infinite wonder of the complexities and beauty of nature by combining fine art and scientific illustration,” he says.

Most of Murphy’s projects—the cover of this report being no exception—begin with washes of acrylic paint flooding across a thin canvas. Slowly, wash after wash, an image builds up. Then, both on canvas and on screen, he adds shapes, lines, dots, diagrams, or words. But Murphy doesn’t just have an eye for the attractive; his art is full of both metaphors for human biology and precise representations of science. A tiny creature outlined in ink might represent the stigma that people with neurological differences face, for instance.

2015 BECKMAN SYMPOSIUM ARTWORK: INNOVATION IN THE BIOSPHERE

“The 2015 Beckman Symposium brought together what may seem to be disparate biological fields of discovery, and showed how they overlap, influence one another, and unify shared knowledge to develop new treatments and understanding of biological processes.” — Neil Murphy

NEIL MURPHY
Artist and designer

2020 BECKMAN CENTER ANNUAL REPORT ARTWORK

“The 2020 annual report cover was inspired by the collaboration and coordination demonstrated by the four Beckman Centers as they worked together to find solutions to the Covid-19 pandemic.” — Neil Murphy
"When scientists look at my paintings, they’re often just delighted by them," says Murphy. "They’re able to see the real science—the ion channels, the molecular diagrams—but they also appreciate the chaos and the wonder and craziness that goes beyond the science."

For each piece of Beckman symposia art, Murphy does extensive research; he not only talks to scientists who will present at the symposia, he also watches online lectures on related subjects.

"I try to just be a sponge and absorb a lot of these ideas about the research," says Murphy. "And then I get an idea and run with it."

There are similarities between the way Murphy works and the way Beckman scientists work—in both, ideas from different disciplines merge to captivate us and move us forward. Whether it is the combination of art and neuroscience, Photoshop and painting, new technology with traditional biological methods, or two fields of science, these innovative connections are what inspire and educate.

"Science is beautiful in and of itself and you could always find a striking microscopy image to use as art on its own," Murphy says. "By there's something about the juxtaposition of science and fine art that is fascinating and adds new dimension."

"The Beckman Center educational programs, with contributions from so many different people, disciplines, and venues, are enriching the scientific community at Stanford by helping current and future scientists to explore the universe of the living world," says Dr. Shapiro.