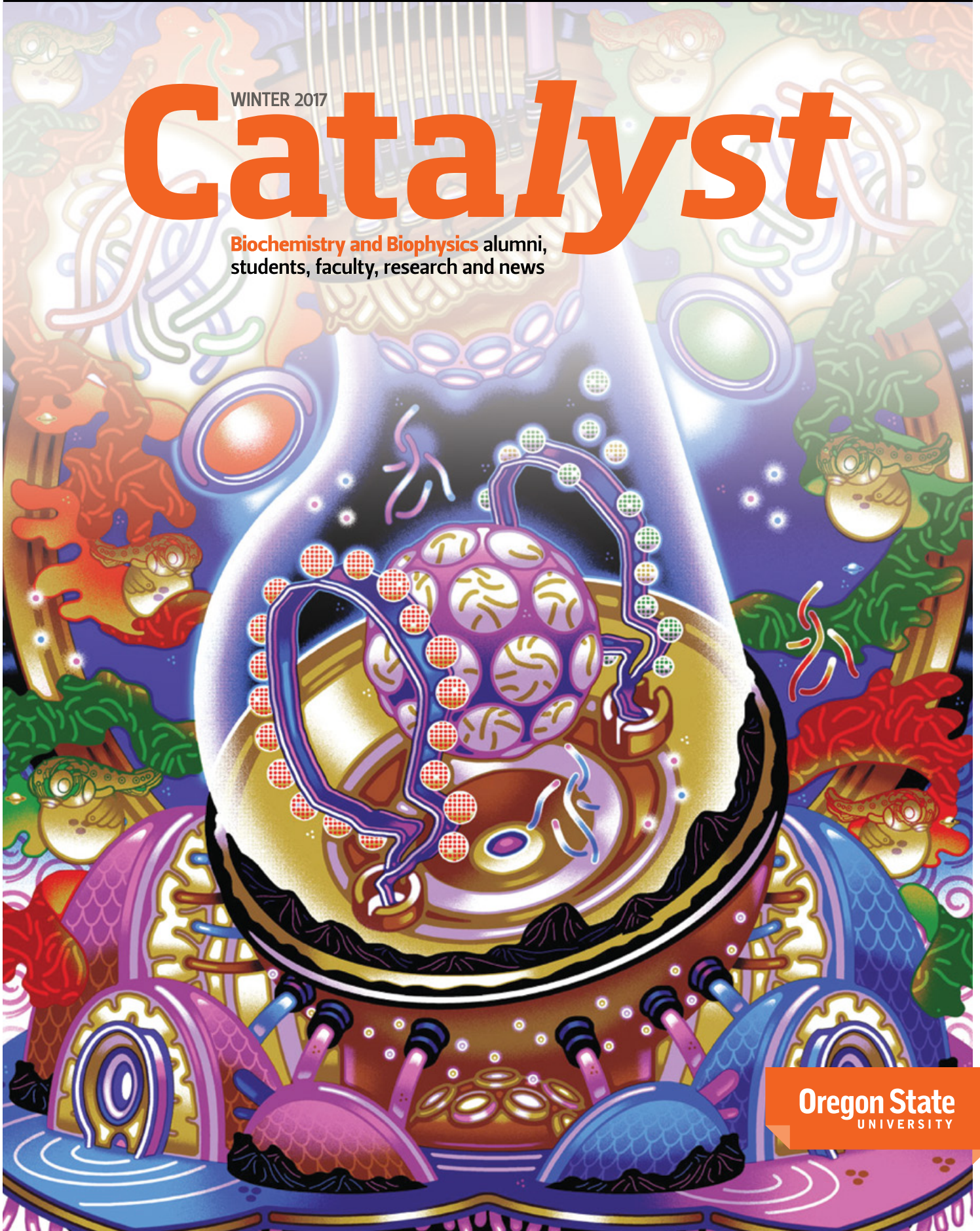


WINTER 2017

Catalyst

Biochemistry and Biophysics alumni,
students, faculty, research and news



Oregon State
UNIVERSITY

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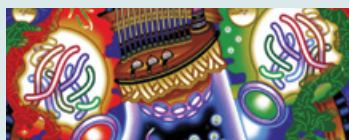
Sharon Betterton

**Department of Biochemistry
and Biophysics**

P. Andrew Karplus, Head

Publisher

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On the cover

This image by Portland
illustrator Guy Burwell depicts
the structure of an auditory
receptor cell that senses
sound and transduces the
information to the brain,
based on research in Colin
Johnson's Lab by Biochemistry
and Biophysics graduate
student Paroma Chatterjee on
hearing and deafness using
zebrafish as a model organism.
Chatterjee's research was
chosen as a Thermo Fisher
Scientific promotional display
set to travel worldwide.



Catalyst

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Evolution of a department by Chris K. Mathews

The background of the entire image is a light blue sunburst pattern with rays emanating from the center. The text is centered over this pattern.

50TH ANNIVERSARY CELEBRATION

Celebrate the 50th Anniversary
of the Department of
Biochemistry and Biophysics
on homecoming weekend

Best + Brightest

Our talented faculty

NEW FACULTY, NEW PERSPECTIVES

The journey of a biochemist from Ghana

Afua Nyarko grew up in what she describes as a “curiosity-driven environment” in Accra, Ghana. Her engineer father encouraged her early interest in science and mathematics, which she excelled in. She would go on to study biochemistry at Kwame Nkrumah University of Science and Technology in Kumasi—one of Ghana’s top science universities.

Nyarko joined the Department of Biochemistry and Biophysics as an assistant professor this year. However, she is no stranger to Oregon State. Nyarko has been a postdoctoral associate and a senior researcher in Biochemistry and Biophysics since 2008 after spending time as a postdoctoral scholar at University of York, England. She earned her Ph.D. from the University of Ohio in Athens.

Nyarko’s research focuses on protein interactions and their role in the formation of tumors. She is one of many scientists worldwide studying proteins from a structural biology perspective, whereby detailed information on the structure of specific amino acids can reveal how tumor suppressor proteins inhibit specific growth-promoting proteins. Nyarko explains that her research will help scientists to better understand how to treat tumors and know what drugs to administer for more effective treatment. Her research

is funded through a Medical Research Foundation Grant awarded by Oregon Health and Science University.

Nyarko counts as her influences women scientists—her peers and predecessors—who have successfully balanced career and family. As a minority woman scientist, she stands out in the sciences—she is one of only a few black female scientists on campus and the only full-time faculty of African descent in her department. The significance of her identity is not lost on Nyarko.

“I see myself in a position to help others.”

“I have a lab now and there is an opportunity for students and young scientists to come and work in the lab. Sometimes minority students feel they don’t blend in very well, but working in the lab of another minority would really encourage them to get into the science,” said Nyarko.

New bioinformatics hire

David Hendrix and his lab employ a broad range of computational approaches, from machine learning to data mining, to investigate questions concerning genomics and gene regulatory systems. They use computational biology and bioinformatics to uncover new mechanisms of gene regulation, as well as to validate known biology.

Hendrix earned bachelor’s degrees

in applied mathematics and in physics from the Georgia Institute of Technology. He earned his Ph.D. in physics from the University of California, Berkeley.

From physics to biohealth

The physics department welcomes new assistant professor **Weihong Qiu**. His research team specializes in single molecule biophysics and studies biophysical mechanisms of cellular processes by developing and applying powerful molecular and biophysical methods in to better understand their function in living cells.

Qiu earned his Ph.D. at The Ohio State University followed by a postdoctoral fellowship at Harvard Medical School.

Alumnus Rick Cooley joins faculty

After earning his Ph.D at OSU in Biochemistry and Biophysics with Andy Karplus as his mentor, **Rick Cooley** was a postdoctoral scholar at Cornell University from 2012–16 and completed a National Institutes of Health Ruth L.Kirschstein Postdoctoral Fellowship from 2013–15 before joining us as assistant professor, senior research last fall.

His research is focused on understanding protein function at the molecular level to gain insights into how cellular life works in order to create proteins with new or enhanced functions for scientific, medical and biotechnological purposes.

A second area of focus in Cooley's research is bacterial biofilms. Approximately 80% of chronic bacterial infections are caused by biofilm forming pathogens, in large part because the self-produced biofilm matrix surrounding the bacteria protects the community from their environment, the host immune system and antibiotic insult.

His team uses non-canonical amino acid incorporation, a growing technology in which amino acids with unique functionalities are incorporated into proteins. They use this innovative method to study transmembrane proteins and other receptors to develop new strategies to manipulate their activity and help treat chronic infections.

RETIREMENTS

Balz Frei, Professor and Director of the Linus Pauling Institute, retired in June 2016 after nearly 20 years of service along with **Weijian Zhang**, his long-time collaborator and research assistant professor.

Linda Benson, a lab manager for Chris Matthews and then Ryan Mehl, retired in 2015.

Yujuan Song served as a lab manager for Elisar Barbar from 2005–2014 and decided to pursue her longtime passion in interior design.



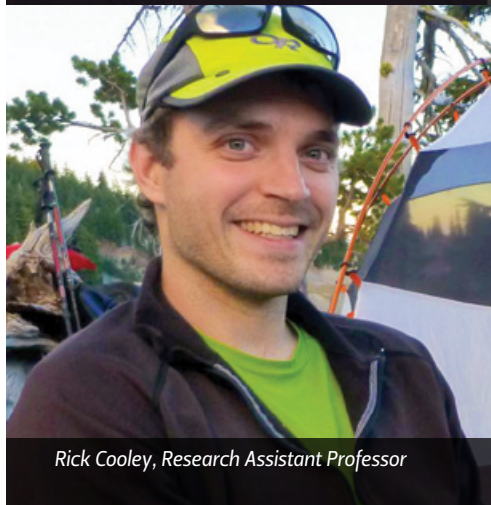
Afua Nyarko, Assistant Professor



David Hendrix, Assistant Professor



Weihong Qiu, Assistant Professor



Rick Cooley, Research Assistant Professor

WELCOMING MATTHEW ANDREWS!

Matthew Andrews arrived last summer from the University of Minnesota-Duluth (UMD) as the new College of Science [Associate Dean for Strategic Initiatives](#). Andrews was the McKnight Presidential Professor of Biology and founding director of the Bio-Translational Research Center at UMD.

A Biochemist by training, he has joined our faculty and looks forward to being part of the community even while focusing on college-level projects. Specifically, he will help advance the educational, research, diversity and outreach missions of the College of Science and will provide leadership to faculty in developing policies and programs to improve student and faculty success.

A world leader in genetic control of mammalian hibernation. Recently his research on blood loss therapy that began back in 2005 at UMD is helping to expand the window for life-saving medical treatment by giving patients more time to reach the emergency room. In December, the technology received \$2.5 million in funding to conduct the necessary preclinical work to file for clinical trial approval from the Food and Drug Administration.

On the move

Our students are making a difference!

HAVING IT ALL

How does OSU Presidential Scholar and Biochemistry and Biophysics major **Arianna Kahler-Quesada** do it all? Not only is she an accomplished violinist and flutist who plays with the OSU Symphony, a traveling OSU Ballroom Dancer, a peer mentor for the LSAMP (Louis Stokes Alliance for Minority Participation) Program, a College of Science student ambassador, and a peer mentor for the OSU STEM Leaders Program, but she also pursues a rigorous course of undergraduate study in biochemistry and biophysics.

She has won the prestigious UHC Wiesner Award for undergraduate women in science and the American Chemical Society's International Research Fellowship, as well as received Honorable Mention as an OSU nominee for the national Barry M. Goldwater scholarship.

Arianna plans to pursue a career in international medicine, serving troubled areas through Doctors Without Borders, and is a current semi-finalist for a Fulbright Scholarship. If her achievements to date are any indication, she will also be one of our most distinguished alumni! Arianna also starred in a recent [video for the OSU President's Dinner](#).

Brian Josephson received Honorable Mention for the national Barry M. Goldwater scholarship, and plans to pursue a Ph.D. in a field related to

biochemistry. A 2015 SURE Science Scholar who has studied abroad in Australia, Brian hopes to eventually run his own research lab investigating the inner workings of human pathogens. He will present his research at a national fungal biology meeting thanks to a donation by College of Science alumnus Joel Peterson that supports undergraduate travel.

Trisha Chau received OSU's Undergraduate Research, Innovation, Scholarship and Creativity award for Characterization of FerIL-6 and a Phi Kappa Phi Study Abroad Grant last fall.

A strong leader, Trisha is former vice president of the Biochemistry and Biophysics Club and administrative chair of the University Honors College Student Association. She is also active in many other student organizations, including the Honors College Leadership Circle, Event Coordinator of the Taekwondo Club, Mortar Board Senior Honors Society, Phi Kappa Phi and the Archery Club. Her mentor is Colin Johnson.

Lubna Khan and **Deepthika Ennamuri** received [2014 Student Leader Awards](#) from the Women's Center for their outstanding contributions of scholarship, leadership and service.

Lubna has excelled in not one but two research labs and was instrumental in creating the Ettihad Cultural Community, a Middle Eastern cultural resource center on campus, the first

of its kind in Oregon, a place, as she says, "to create mutual ties of respect and understanding between people of different cultural backgrounds. She has also served in multiple roles in Student Government and lobbied for affordable tuition in Washington, D.C.

Deepthika served as a teaching assistant, as chief editor of OSU's undergraduate research journal, and secretary of the senior honor society Mortar Board. She was featured student speaker for President Ed Ray's annual commencement dinner, a high honor given to one graduating student each year.

Hayati Wolfenden, a Biochemistry and Biophysics recent alumna from Bend, OR, took top honors at the 2016 Celebrating Undergraduate Excellence competition. Her research in advisor Ryan Mehl's Lab on "Site-specific Modification of Glucose Proteins Enabling Precise Surface Orientation for Glucose Sensors" was supported by a 2015 SURE Science award and a 2014 Cripps Undergraduate Research Experience (CURE) award. Hayati was also the student speaker at the Campaign for OSU Celebration.

GRADUATE STUDENTS

Meet our new graduate students!

Kasie Baker has experience working with NMR spectrometers, synthesizing fluorinated sphingosine analogs and dimethyl sulfolubylated beta-



OSU Presidential Scholar and Biochemistry and Biophysics major Arianna Kahler-Quesada

cyclodextrin. She is interested in microbiology and anti-cancer drug development.

Daniel Breyse, who was raised in a family of scientists, previously worked on ELISA tests for dust mites and studied a monosaccharide transporter in *Arabidopsis*. Dan may follow his master's degree with either medical school or a Ph.D.

Heather Forsythe is interested in research on aging, cancer, and epigenetics. She worked on a cystic fibrosis study at Arkansas Children's Hospital and studied the effects of stress and nutrients on lifespan.

Elise van Fossen joined Afua Nyarko's Lab for a summer rotation after finishing her master's degree in 2015. She has research experience in bioorganic chemistry and is interested in new treatments for Type 1 diabetes.

Rosalyn Huard, originally interested in veterinary medicine, has decided to pursue biochemistry at OSU after teaching chemistry at Montana State

University and a high school in Panama.

Isabelle Logan is from Belgium and studied the mechanisms and kinetics of ethionamide oxidation at Portland State University. Isabelle is interested in cancer research and speaks English, French and Flemish fluently.

Student profiles

Paroma Chatterjee's thesis research project was selected for a Thermo Fisher Scientific poster display in a collection that travels to international airports promoting research that uses the company's products. It will certainly make a global impact! The image artistically visualizes Paroma's research findings on hearing and deafness using zebrafish as a model organism (*see more about zebrafish as models on page 11*). In her research, she uses the larval zebrafish as an *in vivo* model system to study otoferlin, a protein expressed in the sensory hair cells and essential for hearing (*see cover art*).

Paroma recently received her Ph.D. from OSU's Molecular and

OUR STUDENTS GET THEIR HANDS DIRTY

The Department of Biochemistry and Biophysics and the College of Science is dedicated to delivering excellent instruction through experiential learning in our research labs. Under the leadership of lab instructor Kari van Zee since 2011, our teaching labs have engaged students in the intriguing, and at times frustrating, but ultimately impactful "hot mess" that is real science by integrating lab work assignments with the Freitag, Gombart, Johnson, Mehl and Merrill Labs.

Each year, we host high-school teachers in our teaching labs and middle-school students at our biochemistry camp.

Scholarships and fellowships provide valuable "real-life" opportunities for our undergraduate students to engage in cutting-edge research with faculty that can lead to publications for the student. Such experiential learning opportunities greatly increase the future success of the student in their career.

Cellular Biology graduate program where she worked as a Graduate Research Assistant in the labs of Assistant Professor of Biochemistry and Biophysics Colin Johnson and Distinguished Professor of Molecular Toxicology Robert Tanguay.

In 2015, she co-authored a study in the journal *Molecular and Cellular Biology* with Johnson and Tanguay. Paroma received her M.S. from University College of Science and Technology in Calcutta, India.

Nathan Waugh is a rare example of a high school dropout who reclaimed the value of his own education and is now pursuing a Ph.D. in Biochemistry and Biophysics after four years in the workforce doing “one generic job after another” and deciding that, surely, “a more interesting life must exist.”

Paying his own way as an undergraduate physics major at Weber State University (WSU) with the help of numerous scholarships, Nathan finished as a star student, winning the Department of Physics Outstanding Graduate Award and WSU’s Excellence in Community Engagement Award. He designed an astrophysics-themed hike in the Wasatch Mountains, helped plan WSU’s new science building, and helped run the department’s annual Physics Open House.

At Oregon State, Nathan, a Provost’s Distinguished Graduate Fellow, rotated through several departmental labs before settling in Ryan Mehl’s Lab. He explores protein function using unnatural amino acids to turn proteins off and back on again outside living cells. Recently, the NSF awarded Nathan a Graduate Research Fellowship providing guaranteed

funding for three years. Despite a rigorous program, Nathan continues his outreach to others, ever grateful for the opportunities the academic community has provided him. He guides undergraduates through the Biochemistry and Biophysics mentorship program, and helps with an annual Biochemistry Camp for middle-schoolers.

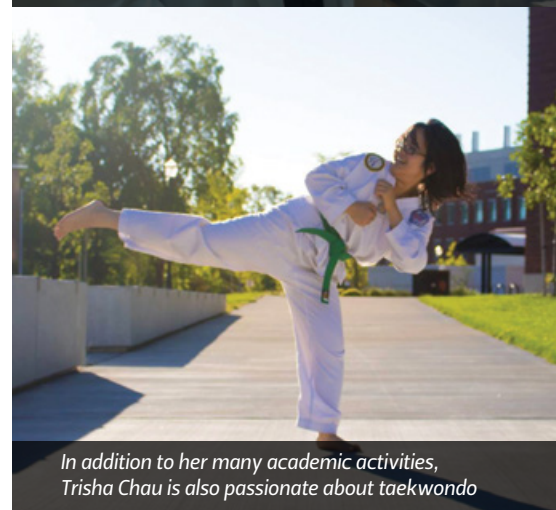
Andrew Brereton won the OSU 2016 Lenore Bayley Graduate Fellowship for academic merit and promise. Now a 4th-year student, Andrew has an extremely strong background in molecular genetics from the University of Guelph, Ontario, and was attracted to conduct research on aging. During his first year though, he was bitten by the structural biology bug, joined the Karplus Lab, and is already the lead author or co-author on four papers. Andrew focuses on computational work, and his published project defining exactly how peptide geometry distorts in a high-energy conformational transition state in *Science Advances* garnered him a Gordon Conference poster prize.

Chelsea Holman Wolk worked in Colin Johnson’s Lab studying the membrane-trafficking protein Fer1L6 in zebrafish and graduated with a Ph.D. last December. She also worked with Kelsey Kean (see below) on curriculum design. This January she began work as Assistant Director of Strategic Programs in the College of Science, developing internship programs for undergraduates seeking career exploration and professional development training.

Kelsey Kean won the OSU 2016 P.F. and Nellie Buck Yerex Graduate Fellowship, which is awarded annually



Brian Josephson received Honorable Mention for the national Barry M. Goldwater scholarship



In addition to her many academic activities, Trisha Chau is also passionate about taekwondo



At the Celebrating Undergraduate Excellence competition, Hayati Wolfenden took top honors



Lubna Khan was instrumental in creating the Ettihad Cultural Community



Andrew Brereton won the OSU 2016 Lenore Bayley Graduate Fellowship



Chelsea Holman Wolk studied the membrane-traffic protein Fer1L6 in zebrafish



Kelsey Kean is the 2016 P.F. and Nellie Buck Yerex Graduate Fellowship awardee



Michelle Wiley with Professor Emeritus Christopher Mathews

to an outstanding graduate student in science or technology. Kelsey grew up in Buffalo, New York, and was a top scholar-athlete (rowing crew) at the University of Tulsa. Across the country in grad school, she continues to excel.

As a 5th-year student in the Karplus Lab, she has lead authored or co-authored four papers; helped organize a Biochemistry and Biophysics Grad Student Association and was elected its first president; and developed and led middle-school Biochemistry summer camps the last three summers. Kelsey enjoys teaching and she developed innovative curricula with Chelsea Holman to transform the General Biochemistry course using active learning pedagogy for student success.

Allyson (Ally) Erlendson, a second-year graduate student, was awarded the 2016-2017 Christopher and Catherine Mathews Graduate Fellowship, based on her academic merit, teaching acumen and research potential.

Growing up in Chico, CA, Ally attended California State University there where she double majored in biochemistry and exercise physiology and minored in chemistry and nutrition, analyzing natural products from microbes to identify novel bioactive compounds. She participated in the Chemistry Summer Research Institute at CSU-Chico with funding from a Eugene Reid Summer Research Award. As an intern at PathoLase, a medical and biophotonic research group, Ally used light-based technology to treat and identify fungal pathogens.

After graduation, Ally taught General Chemistry Labs at CSU-Chico for nearly four years before pursuing her Ph.D. She has done superb work in her first

year, completing research rotations with Michael Freitag, Joe Beckman, and Fritz Gombart while assistant-teaching upper level biology and biochemistry/biophysics courses.

As part of the Freitag Lab, Ally is currently investigating mechanisms of histone methylation in the cereal pathogen *Fusarium graminearum*. Ally's goal is to someday become a professor. Last September, Ally took on an even more demanding and important role: mom to Lucas Jerome Rozborski!

Michelle Wiley received the 2015-2016 Christopher and Catherine Mathews Graduate Fellowship. Currently in the third year of her program, Michelle is working with Assistant Professor David Hendrix on computational methods for identifying structural domains and predicting functional roles of long non-coding RNAs.

She was on the team, Pretty Terrestrial, which won first place for "Best Insights" in Datafest 2016, a nationally coordinated data analysis competition for students sponsored by the American Statistical Association and hosted at OSU.

Michelle earned her bachelor's degree in biochemistry and mathematics from the University of Idaho.

Inspiring the next, next generation

Kelsey Kean and **Rachael Kuintzle** organized and, with student and faculty assistance, led the Bioinformatics summer camps for middle schoolers the last two summers.

CATALYST: RESEARCH

From our labs

Revealing how life works



Why do zebrafish provide a key to unlocking a deeper understanding of human diseases in so many labs? Find out why on page 11.

BREAKTHROUGHS IN AGE-RELATED DECLINE

Tory Hagen and his research team have found that a specific detoxification compound, glutathione, helps resist the toxic stresses of everyday life – but its levels decline with age, setting the stage for a wide range of age-related and often fatal health problems, including cardiovascular disease, diabetes, and cancer.

His new study, published in the journal *Redox Biology*, also highlighted a compound, N-acetyl-cysteine, or NAC. Hagen and his team portend that NAC, already used at high doses in medical detoxification emergencies, might also help maintain glutathione levels and prevent the routine metabolic declines associated with aging.

“We’ve known for some time of the importance of glutathione as a strong antioxidant,” said Hagen, the Helen P. Rumbel Professor for Health Aging Research in Oregon State’s Linus Pauling Institute. What this study pointed out was the way that cells from younger animals are far more resistant to stress than those from older animals,” said Hagen.

“In young animal cells, stress doesn’t cause such a rapid loss of glutathione. The cells from older animals, on the other hand, were quickly depleted of glutathione and died twice as fast when subjected to stress. But pretreatment with NAC increased glutathione levels in the older cells and largely helped offset that level of cell death.”

Glutathione, Hagen said, is such an important antioxidant that its existence appears to date back as

far as oxygen-dependent, or aerobic life itself—about 1.5 billion years. It’s a principal compound to detoxify environmental stresses, air pollutants, heavy metals, pharmaceuticals, and many other toxic insults.

NAC is known to boost the metabolic function of glutathione and increase its rate of synthesis. It’s already used safely at extremely high levels in emergency medicine to help detoxify patients who have ingested poisonous levels of heavy metals, and scientists are hypothesizing that it might have significant value at much lower doses to maintain glutathione levels and improve health.

“I’m optimistic there could be a role for this compound in preventing the increased toxicity we face with aging, as our abilities to deal with toxins decline,” Hagen said. “We might be able to improve the metabolic resilience that we’re naturally losing with age.”

This research was supported by the National Institutes of Health, National Science Foundation and the Medical Research Foundation of Oregon.

LAB REPORTS

BECKMAN LAB: For the past 15 years, Joe Beckman has been using mass spectrometry and a proprietary protein fragmentation method that produces faster and more accurate results to understand how Lou Gehrig’s disease progresses at the molecular level and discover new treatments for this debilitating disease. In 2016, Beckman’s Lab [announced a startling result](#): they halted the progression of Lou Gehrig’s disease in mice for two years by using a compound called copper-ATSM (otherwise the mice

would have died within two weeks). Copper-ATSM appears to deliver copper, a key micronutrient, into the mitochondria of specific cells in the spinal cord that are weakened by the disease’s copper deficiency.

“We have a solid understanding of why the treatment works in the mice,” says Beckman, and “want people to understand that we are moving to human trials as quickly as we can.”

In a new venture, Beckman’s start-up company, e-MSion, will license and share a revolutionary new spectrometry fragmentation technique, called Electron Capture Dissociation.

“It changes how we measure molecules, how you study cancer, how you study drugs, the environments people are exposed to and much more,” Beckman said. The technique, he adds, promises to provide a “wealth of opportunities for new research across many disciplines.”

MEHL LAB: In addition to hosting the first Genetic Code Expansion Conference this past summer, Associate Professor Ryan Mehl and his Unnatural Protein Facility are busy with a productive flux of undergraduate and graduate student research. The team made excellent progress on understanding oxidative stress protein modifications and biorthogonal ligations.

In the last year, they also began exploring protein-material surfaces. Mehl was awarded a four-year, \$901K National Science Foundation (NSF) grant for his proposal, “Genetic encoding of tetrazine amino acids to develop ideal bioorthogonal ligations” as well as a five-year \$938K National Institutes of Health (NIH) for his proposal, “Defining

roles of nitrotyrosine in disease via genetic code expansion.”

FREITAG LAB: Mold and fungi can cause devastating plant, animal and human disease or inconveniences like spoiled bread or moldy black grout in the bathroom, but when domesticated, like yeast, they make bread and a variety of delicious drinks. Even more importantly, revolutionary drugs originate from fungi, like penicillin and the cholesterol-lowering drug lovastatin.

Using fungi as models, the Freitag Lab reveals the underlying principles and basic biology of chromatin. Eukaryotic organisms package their genomes into chromatin that contains genomic DNA and histone proteins. Genes in densely packaged chromatin are “silenced” while genes in less densely packaged chromatin are “active” and expressed. Molecular mechanisms by which chromatin structure silences or activates genes are called “epigenetic” because factors that influence how cells read the genomic DNA determine the appearance or phenotype (the sum of physical characteristics) of an organism.

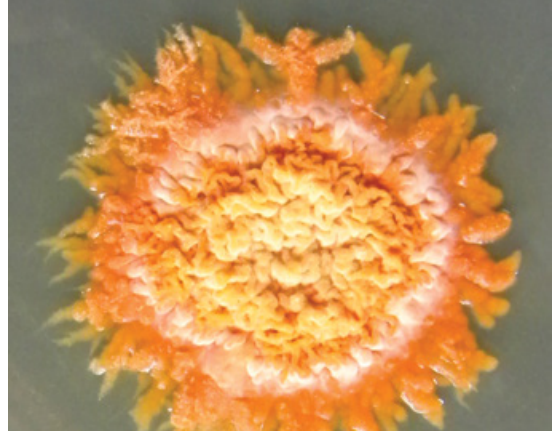
Freitag’s Lab has identified numerous factors that affect histone modifications, chromatin structure and the reading of the genomic DNA. By deleting the *kmt6* gene (encoding the catalytic subunit of a histone methyltransferase), they found that an additional quarter of all genes in the genome were turned on or increased in expression. The lab focuses on large newly expressed gene clusters that are responsible for the production of secondary metabolites and that may generate new bioactive compounds, including novel antibiotics to combat drug-resistant bacteria and other compounds beneficial to human health.

KARPLUS LAB: Proteins, proteins, proteins! Structure-based studies of how proteins fold and function remains the Karplus Lab theme. Some protein enzymes are foci for studies that could have significant applications for health. Graduate student Arden Perkins conceived of a novel way to target peroxiredoxins for developing new antibiotics, and Kelsey Kean is studying enzymes involved in the biosynthesis of a recently discovered compound (gadusol) made by some vertebrates that may function as a sunscreen.

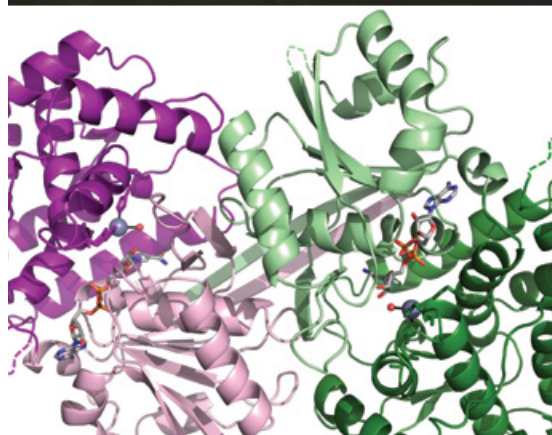
Another active area is probing ultra-accurate protein crystal structures to discover new principles of protein structure, such as mapping the details of “impossible” conformations that we discovered are occasionally trapped in native proteins.

GREENWOOD LAB: Glioblastoma is an extremely deadly form of brain cancer: 90% die within five years of diagnoses, largely because glioblastoma escapes tumor resection by fluid movement and metastasis throughout the brain. Julie Greenwood’s Lab pursues cell invasion mechanisms to slow or stop rampant cancer cell movement by injecting fluorescently labeled human glioblastoma cells into the brains of embryonic zebrafish. The translucent zebrafish brains allow researchers to see and understand glioblastoma cells in action, eventually aiming to discover specific proteins to inhibit cancer cell invasion.

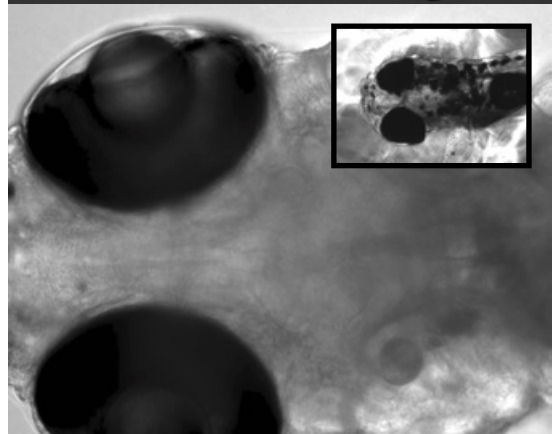
BARBAR LAB: The newly installed NIH-funded 800 MHz NMR (funded by a 1.3M High End Instrumentation grant, one of only two in the state of Oregon awarded over the last ten years, and a 504K grant from Murdock Charitable Trust) is boosting the work



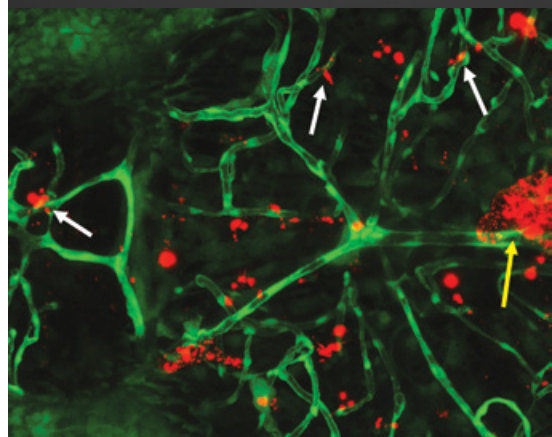
The mutant cereal pathogen Fusarium graminearum enables novel drug discoveries



Enzyme that makes an agriculturally useful fungicide and a newly discovered sunscreen



Pigment-suppressed zebrafish brains allow scientists to see glioblastoma cells in action



Glioblastoma cells (red) in zebrafish brain spread from tumors and along blood vessels (in green)



Tory Hagen, Professor



Elisar Barbar, Professor



Viviana Perez, Assistant Professor



Colin Johnson, Assistant Professor

of Elisar Barbar and her lab to develop innovative approaches to reveal how dynamic large protein complexes work. Thanks in part to the work of graduate student Jing Jie, Barbar recently received a five-year NSF grant to continue working on a longstanding question: how does the motor protein dynein, essential for the transport of chromosomes, the movement of cell vesicles and the migration of neurons, know when and what cargo to transport?

PEREZ LAB: Why do naked mole rats live eight times longer than similarly sized rodents? The Perez Lab showed that fibroblasts from naked mole rats are significantly more resistant to polyQ82 toxicity (a Huntington-type of protein prone to aggregate) than similar cells from mice. However, and contrary to all expectations, naked mole rat cells accumulate more polyQ82 aggregates than mouse cells. Unlike mice, the naked mole rat polyQ82 aggregates accumulate in the perinuclear region of the cell. Perez hypothesizes that naked mole rats modulate longevity through both resistance to toxicity and the ability of the cell to corral protein aggregates in harmless perinuclear clusters.

JOHNSON LAB: Colin Johnson's Lab investigates an ancient family of membrane proteins called ferlins that are involved in a wide variety of physiological functions and disease states ranging from hearing/deafness to muscular dystrophy, fertility and cancer. These proteins seem to act as calcium-sensitive triggers for vesicle fusion and intracellular trafficking, but their exact role at the molecular level remains largely unknown.

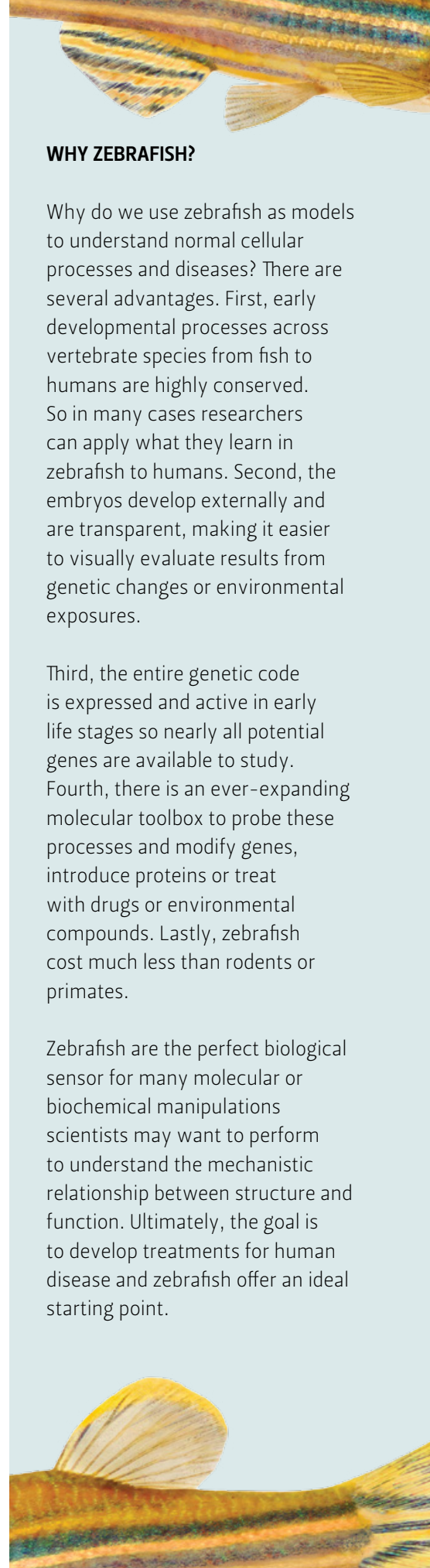
Collaborating with Robert Tanguay from the Environmental and Molecular

WHY ZEBRAFISH?

Why do we use zebrafish as models to understand normal cellular processes and diseases? There are several advantages. First, early developmental processes across vertebrate species from fish to humans are highly conserved. So in many cases researchers can apply what they learn in zebrafish to humans. Second, the embryos develop externally and are transparent, making it easier to visually evaluate results from genetic changes or environmental exposures.

Third, the entire genetic code is expressed and active in early life stages so nearly all potential genes are available to study. Fourth, there is an ever-expanding molecular toolbox to probe these processes and modify genes, introduce proteins or treat with drugs or environmental compounds. Lastly, zebrafish cost much less than rodents or primates.

Zebrafish are the perfect biological sensor for many molecular or biochemical manipulations scientists may want to perform to understand the mechanistic relationship between structure and function. Ultimately, the goal is to develop treatments for human disease and zebrafish offer an ideal starting point.



Toxicology program and the Sinnhuber Aquatic Research Laboratory that houses OSU's state-of-the-art zebrafish facilities, the Johnson Lab pioneered the use of zebrafish as a model to study how mutations in a protein known as otoferlin result in deafness.

Zebrafish are genetically engineered to have mutations creating hearing, balance and locomotive deficiencies. Reintroduction of functional otoferlin corrects these defects. Using zebrafish as a model, Johnson's group can identify functional domains of the otoferlin protein and the genetic mutations that alter its function.

The journal *Molecular and Cellular Biology* featured this novel work on the cover of a recent issue. In addition, Johnson received a five-year NIH grant totaling \$1.7M to support this research. Ultimately, this research may lead to innovative treatments for deafness and hearing loss in humans.

GOMBART LAB: Fritz Gombart's Lab discovered that vitamin D and three plant-derived compounds, resveratrol, curcumin, and xanthohumol (XN) could provide some health benefits by increasing cathelicidin antimicrobial peptide (CAMP) levels in both immune and gut cells. In a collaboration with the groups of Dr. Stevens in the College of Pharmacy and Dr. Maier in chemistry, Gombart's team in the Linus Pauling Institute recently received a five-year, \$2.64 million NIH grant from the National Center of Complementary and Integrative Health to determine how XN consumption reduces obesity by increasing CAMP levels and influencing the gut microbiota.

QIU LAB: Weihong Qiu's Lab investigates the mechanism and

regulation of unconventional motor proteins using an interdisciplinary approach that combines single-molecule light microscopy with physics-based modeling, protein biochemistry, and cell biology. In collaboration with Bo Liu's Lab at The University of California, Davis, the Qiu Lab received a three-year NSF collaborative research grant to study how a particular motor protein called OsKCH2 contributes to cell division plane determination in plants.

HENDRIX LAB: The Hendrix Lab employs computational genomics, machine learning, and data mining to investigate questions concerning gene regulatory systems. A major objective is to understand the still largely unknown functions and mechanisms of non-coding RNA. Recently, in collaboration with Jaga Giebltowicz in Integrative Biology, Hendrix received funding to study the relationship between aging, circadian rhythms, and neurodegenerative diseases. He also received funding to study the toxicological impact and function of key non-coding RNAs in zebrafish.

HSU LAB: Interactions between biomolecules—protein:protein, protein:DNA, ligand:receptor, among others—are essential events in virtually all biochemical processes, and manipulating these interactions can result in altered function, phenotypic changes, or disease. The Hsu Lab investigates the underlying molecular properties of specific biomolecular interactions using spectroscopic and computational methods.

NYARKO LAB: How does the liver grow back to its original size when two-thirds of it are removed surgically? What dictates the size of an organ?

Fundamental questions like these drive research in Afua Nyarko's Lab. Recent work using nuclear magnetic resonance spectroscopy to gain atomic-level insight has focused on Yorkie, a potent tissue-growth-promoting protein linked to tumorigenesis. Ultimately, research aims to develop small molecule modulators of Yorkie as a therapy for both cancer and regenerative medicine.

ANDREWS LAB: Studying the genes responsible for inducing and maintaining hibernation in mammals helps to identify key molecules regulating metabolism, body temperature, and food intake. Applications for this research include therapeutic interventions for hypothermia, ischemia/reperfusion injury, cardiac function, and organ preservation.

HAGEN LAB: Why is age the greatest risk factor for a number of chronic diseases? The Hagen Lab discovered that the levels of Nrf2, a key transcription factor that controls expression of more than 200 anti-inflammatory and detoxification genes, declines with age. Studies are now underway to address whether levels of Nrf2 can be increased (by antagonizing the accumulation of three micro-RNAs that slow Nrf2 production) to maintain cellular resistance with advancing age.

MERRILL LAB: After a four-year term as Department Chair, Gary Merrill spent a sabbatical year at Terry Kavanagh's Lab at the University of Washington, working to identify enzymes that convert the potent cancer drug doxorubicin to the cardiotoxic metabolite doxorubinol. The hope is to target these enzymes with drugs that would permit the use of stronger doses of doxorubicin to fight cancer. Now back in Corvallis, the collaboration continues!

News

Honors, updates and impact

BIOCHEMISTRY FOR THE NEXT CENTURY

After 10 years of planning, a new major in Biochemistry and Molecular Biology was launched in 2016! The program offers students in-depth training in molecular and computational biology preparing them for successful careers as modern molecular biologists.

Students can select from options in Advanced Molecular Biology, Computational Molecular Biology, and Pre-Medicine.

AWARDS AND HONORS

Andy Karplus was named a [2015 OSU Distinguished Professor](#). One of the top structural biologists in the world, Karplus studies enzyme catalysis, protein evolution and structure, and crystallography. Other scientists have cited his work more than 15,000 times. He maintains rigorous standards in teaching, yet consistently gets top ratings from student evaluators. Karplus teaches a range of courses, from core offerings in the department, to a course on protein evolution – the department's most influential advanced elective.

Senior Instructor **Indira Rajagopal** received the 2014 OSU Women's Center Award as a role model who strives for STEM diversity and excellence by participating in mentorship programs for middle and high school students, supporting undergraduate women in the sciences,

and training high school science teachers. Also, in recognition of her exceptional and sustained instructional achievements, Indira won the 2016 College of Science Fred Horne Award for Excellence in Teaching Science.

Elisar Barbar was named a 2014 Erskine Fellow from the University of Canterbury and also received the Milton-Harris Award for exceptional achievement in basic research from the College of Science in 2014.

Kevin Ahern was one of four 2014 semifinalists for the Baylor University Robert Foster Cherry Award for Great Teaching.

While on sabbatical last year, Ahern published the first edition of the open access textbook [Biochemistry Free For All](#) with biochemistry instructor Indira Rajagopal (his wife) and alumna Tari Tan.



IN MEMORIAM

Bob Becker, August 25, 2013

A beloved and OSU Distinguished Professor from 1962–89, Bob's contributions to Oregon State, the department, the community at large, and his family remain timeless. He served on countless OSU committees and was one of the first presidents of the Faculty Senate.

Bob was a highly regarded instructor and advisor, evidenced by his many awards, including the Ritchie Distinguished Professor Award, OSU Alumni Association Distinguished Professor Award, College of Science Loyd F. Carter Award for Outstanding Teaching, Curtis D. Mumford Faculty Service Award and the Maurine Neuberger Award for Distinguished Career Achievement.

Bob realized his childhood dream of becoming a professor at Columbia University, where he taught for eight years. He worked as a biochemist at Oak Ridge National Laboratory and Union Carbide. It was during the Columbia years that he met Mary, who received a Ph.D. in biochemistry and nutrition, and shared an enthusiasm for proteins. Married in 1956, they formed an inseparable bond, sharing a rich and productive professional and domestic life together.

Alumni + Friends

Our strongest supporters

CHRISTOPHER AND CATHERINE MATHEWS GRADUATE FELLOWSHIP

In 2015, the department established the Christopher and Catherine Mathews Graduate Fellowship, awarded annually to a student in the second year of his/her Ph.D. program, through the generosity of Distinguished Professor Emeritus **Chris Mathews** and his wife **Kate** to help the doctoral program recruit and retain extraordinary students.

Allyson Erlendson received the award in 2016 and is studying the cereal pathogen *Fusarium graminearum* in Michael Freitag's Lab. Michelle Wiley received the award in 2015 and works on computational methods for identifying structural domains and predicting functional roles of long non-coding RNAs in David Hendrix's Lab.

Mathews is an internationally recognized leader in biochemistry with a focus on enzymology, virology, and genetics. He has received significant attention for his work with nucleotide and coenzyme metabolism, DNA synthesis and replication, and nucleic acid enzymology.

He was a professor and chair of the department before retiring after 24 years of service. While chair, he successfully grew the department while continuing his own research into enzymatic reactions, publishing several successful textbooks, teaching and mentoring graduate and postdoctoral

students. Retired in 2002, Matthews continues to be an active researcher, author, mentor and friend.

RAY, FRANCES & DALE CRIPPS STUDENT SUPPORT ENDOWMENT FUND

Frances Cripps connected with Professor Kevin Ahern 10 years ago at a College of Science fundraising event, eager to learn anything she could about how biochemistry could halt her progressive blindness. Kevin invited her to his class and was delighted when she attended every single lecture and became a good friend, revealing that she had been very interested in science as a young girl, but was dissuaded by the advice of the time that girls should only pursue careers in teaching or nursing.

"I was amazed at her curiosity...and her generosity," said Ahern. "She soon realized it was too late to save her failing eyesight, because the technology wasn't far enough along, but she began talking about how she wanted to make a difference."

Frances passed away in 2008 at 93, but she continues to support future generations of students in perpetuity through her generous bequest in support of the Ray, Frances & Dale Cripps Student Support Endowment Fund. Gifts from our late friend now total more than \$5 million. Each year the fund provides research scholarships to more than 20 undergraduates in the department

who are interested in the life sciences and careers in human health.

WOODSTOCK SCHOLARSHIP IN BIOCHEMISTRY AND BIOPHYSICS

The department established the Woodstock Scholarship in Biochemistry and Biophysics through a generous gift from our friend and alumna **Carollee Woodstock ('81)**. The annual award supports an outstanding undergraduate student.

WHERE ARE THEY NOW?

Grace Sun received her Ph.D. in Biochemistry at OSU. After seven years as a research scientist in Cleveland, she was recruited to the University of Missouri in 1974 and joined the Department of Biochemistry in 1977.

She is now a Professor Emerita of Biochemistry. Sun is an internationally renowned neuroscientist for her research on neurodegenerative diseases and aging, specifically on the malfunctioning of central nervous system signaling pathways. Sun maintained NIH funding throughout her career and is the director of a successful NIH program project grant "Cell Models for Alzheimer's Disease: Lipids and related signaling pathways."

Alumnus **Thomas Sharpton ('03)** received a Ph.D. in microbiology from the University of California, Berkeley. He returned to Oregon State in 2013 as an Assistant Professor with joint



Chris and Kate Mathews at The Bungle Bungles National Park in Australia



Alumnus and Macromolecular NMR Facility Director Patrick Reardon

appointments in the Departments of Microbiology and Statistics. His research is focused on how the gut microbiome influences human and animal health and evolution. Specifically, his lab is working on a new study of the salmon gut microbiome and the role it plays in salmon ecology. Sharpton was lead author on OSU's response to the White House Office of Science and Technology Policy's call for new commitments on microbiome research and participated in the announcement of the National Microbiome Initiative in May.

Jeremy Cutsforth-Gregory ('05)

was named Teacher of the Year in 2014-2015 by the Mayo Medical Students. Jeremy graduated summa cum laude from both the Honors College and College of Science, triple majoring in Spanish, international studies in addition to biochemistry and biophysics. He is currently doing a clinical fellowship on autonomic disorders at the Mayo School of Graduate Medical Education in Rochester, Minnesota.

BOOMERANGING BACK

We are excited to welcome back alumnus **Patrick Reardon ('01)** as the Director of the new Macromolecular Nuclear Magnetic Resonance (NMR) Facility. An NMR spectroscopist, Reardon will oversee the operation of OSU's new NMR Facility, which currently includes five NMR spectrometers, the new 800 MHz NMR and others ranging from 400 to 700 MHz. He will provide training and support to users of the facility, assist them with experimental design and implementation of research plans that utilize NMR spectroscopy, and work with faculty and the administrators to continually improve the NMR facility instrumentation.

The only one of its kind in the region, the 800 MHz NMR was installed last summer and is expected to attract scientists from across the region, nation and beyond.

Reardon received his Ph.D. in biochemistry from Duke University, where he focused his thesis on NMR spectroscopy and its application to

complex biological systems. After completing his Ph.D., Reardon received the William Wiley Post-Doctoral Fellowship from the Environmental Molecular Sciences Laboratory located at the Pacific Northwest National Laboratory. As a postdoc, Reardon applied and expanded his knowledge of NMR spectroscopy and biochemistry, working in a wide range of research areas including structural biology, metabolomics, metabolic flux analysis, and soil science.

THANK YOU!

Our labs depend on stable funding from the University as well as grants, donations, and scholarships from private and federal funding but also from generous private gifts from alumni and friends. Please visit osufoundation.org/bb if you would like to make us a part of your giving this year!

Retrospect

Evolution of a department by Chris K. Mathews

1962: Visionary biochemistry professors **Vernon Cheldelin**, **Bob Newburgh**, **Tsoo King**, **Don MacDonald**, and **Dave Loomis** begin talking about a biochemistry-biophysics field of study. Key hires **Bob Becker** (protein structure), **Don Reed** (redox biochemistry and toxicology), and **Wil Gamble** (lipids) join the Biochemistry Department, followed by **Derek Baisted** (plant biochemistry) a year later.

1967: The Department of Biochemistry and Biophysics is formally established with Bob Newburgh as its founding chair. **Ken van Holde** (ultracentrifugation, respiratory proteins, chromatin) joins the faculty.

1967-76: The department continues to grow with new faculty recruits **Sonia Anderson** (proteins, fluorescence methods), **Curt Johnson** (spectroscopy), **Henry Schaup** (ribosomes), **George Pearson** (molecular virology), **Bob Dyson** (physical biochemistry), and **Janet Cardenas** (enzymology). The department reaches a steady state of about 14 faculty members by 1976.

1978: Impressed by the quality of the graduate students and the congenial faculty, yours truly, **Chris Mathews**, moves his laboratory (nucleotide enzymology, bacteriophages) after 11 years at Arizona to Oregon State. **Mike Schimerlik** (enzyme mechanisms, neurochemistry) joins the department.

1982: OSU President Robert MacVicar designates molecular genetics as a

growth area. Chris Mathews and **Ralph Quatrano** (Botany) create a “paper organization,” the Center for Gene Research and Biotechnology (now the Center for Genome Research and Biocomputing) to apply for foundation support to fund three new positions.

1984: **Gary Merrill** (eukaryotic gene expression) joins the department. A large NIH grant in environmental science funds the recruitment of **David Barnes** (cell growth factors) and, after David resigned in the late 1990s, **Julie Greenwood** (cell adhesion). 1992: The department moves out of Weniger Hall and into spacious, custom-designed laboratories in the new Agricultural and Life Sciences building.

1990s: Retiring faculty provide opportunities for new hires **Phil McFadden** (proteins), **Shing Ho** (physical chemistry of nucleic acids), **Victor Hsu** (NMR), **Isaac Wong** (enzyme kinetics), and **Andy Karplus** (protein structure, crystallography). Hsu brings in a 600-MHz NMR spectrometer, at the time the largest instrument in the Pacific Northwest.

Balz Frei (biochemistry of atherosclerosis) joins the department and assumes directorship of the Linus Pauling Institute (LPI) that moved to OSU in 1997. Frei recruits **Tory Hagen** (mitochondrial metabolism aging). **Indira Rajagopal** shifts from post-doctoral work to become an award-winning instructor for both Biochemistry and Biophysics and Biology.

2001: **Joe Beckman** (redox biochemistry, ALS) joins the Biochemistry and Biophysics and LPI faculty as the Ava Helen Pauling Professor and soon becomes Director of the Environmental Health Sciences Center.

2002: After 25 years, Christopher Mathews retires as Department Chair, replaced by Shing Ho. **Chrissa Kioussi** and **Michael Gross** (Ph.D., '88), both of whom study gene expression in vertebrate development, join the faculty.

2003-06: Ho recruits **Elisar Barbar** (NMR spectroscopy and motor proteins). **Michael Freitag** (fungal genetics, epigenomics) joins the department. Andy Karplus replaces Ho (who leaves for Colorado State University) as Chair.

2008: LPI funds new recruit **Adrian “Fritz” Gombart** (vitamin D, innate immunity).

2011: Karplus is drawn back to his research, and is followed by Gary Merrill as Chair. Improving finances attract new recruits **Kari van Zee** (Instructor), **Viviana Perez** (LPI, comparative biochemistry of aging) and **Colin Johnson** (membrane biophysics, ferlins), and mid-career hire **Ryan Mehl** (genetic code expansion), who establishes an “Unnatural Protein Facility” for making this kind of protein engineering technology more accessible.

2012: The new Linus Pauling Science Center building expands space for the

department housing labs for Balz Frei, Fritz Gombart, Tory Hagen and Viviana Perez.

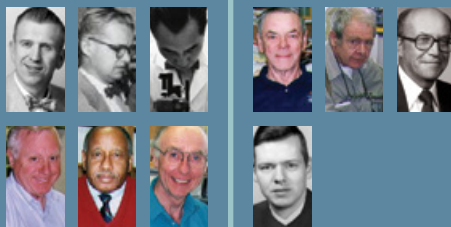
2013: David Hendrix (joint appointment with Electrical and Computer Engineering), Weihong Qiu (TIRF microscopy, motors; appointment in Physics), and Afua Nyarko (protein interactions) join the department.

2014: Kevin Ahern (Ph.D. '86)—who was originally hired as a business manager, but blossomed over 20 years as an instructor, student advisor, biochemical songwriter, textbook author (with his wife Indira Rajagopal), and won every teaching and advising award for which he was eligible—is appointed full professor. Rick Cooley (Ph.D., '12) joins the faculty and Mehl's Lab. Karplus returns as Department Head.

2016: Under the leadership of Elisar Barbar, the first 800-megahertz nuclear magnetic resonance (NMR) instrument in Oregon is installed at OSU. Alumnus Patrick Reardon ('01) returns to OSU to run the new Biomolecular NMR Facility. (See page 15).

Christopher K. Matthews, an internationally recognized leader in biochemistry with a focus on enzymology, virology, and genetics, led the Department of Biochemistry and Biophysics for 25 years starting in 1977. Although he formally retired in 2002 as a Distinguished Professor Emeritus, Chris actively continues to advance the department's mission and more broadly serves the public and the profession.

1960s



1970s



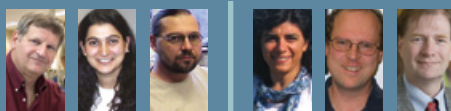
1980s



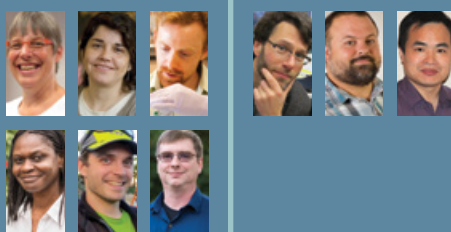
1990s



2000s



2010s



FUN FACTS

Six of the 55 faculty appointed as OSU Distinguished Professors, the highest title awarded by the University, are in the Department of Biochemistry and Biophysics, the largest number from any department on campus.

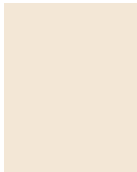
Star instructors like **Kevin Ahern**, **Indira Rajagopal**, and **Kari van Zee** were instrumental in transforming rote “cookbook” undergraduate labs into cutting-edge, real-world research labs under the direction of Fritz Gombart, Ryan Mehl, Michael Freitag and Gary Merrill.

In the 70s and 80s the entire department bonded at the annual “Hunter-Gatherer Balls” on the Oregon Coast. Bounty from a day of fishing, clamming, crabbing, and prying mussels from rocks was pooled to make a huge pot of bouillabaisse for a Saturday night feast.

Ken van Holde's Lab suite included a secret room known as “the Cave,” where a dozen of us would meet on Friday afternoons to drink beer and discuss science. Although likely illegal, it was great fun until someone ratted us out and President MacVicar ordered it closed.



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