Vestigo

VANDERBILT UNIVERSITY **SCHOOL OF MEDICINE | BASIC SCIENCES**

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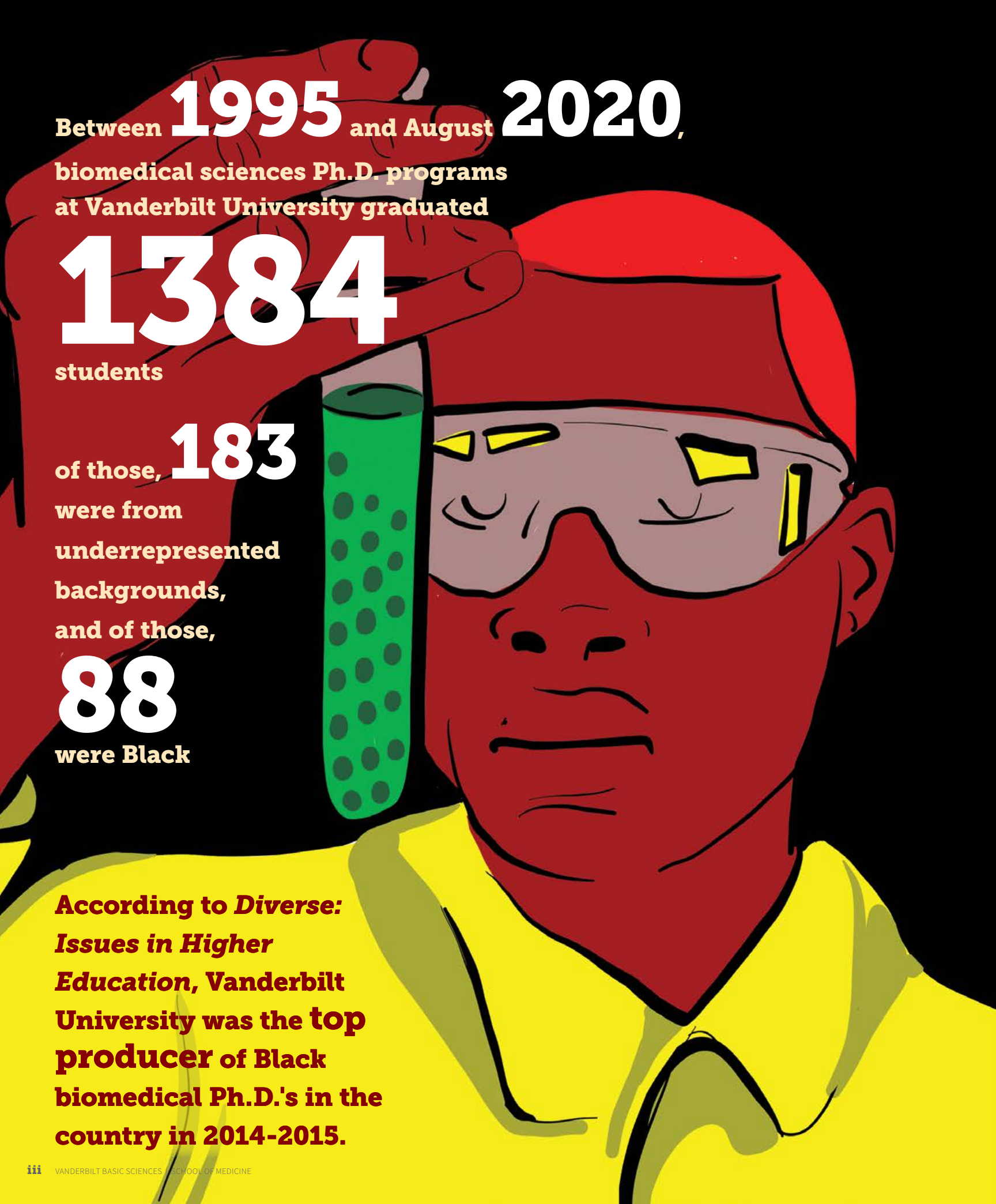
Between 1995 and August 2020,
biomedical sciences Ph.D. programs
at Vanderbilt University graduated
1384
students
of those, 183
were from
underrepresented
backgrounds,
and of those,
88
were Black
According to *Diverse: Issues in Higher Education*, Vanderbilt University was the top producer of Black biomedical Ph.D.'s in the country in 2014-2015.

In this issue

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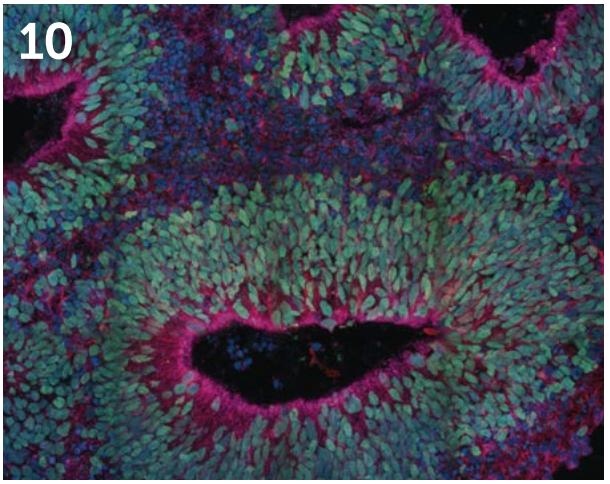
Cover: The color palette used in the creation of the cover was generated by graduate student Jacob Steenwyk (laboratory of Antonis Rokas , professor of biological sciences), who was inspired by the *Laccaria amethystina* fungus. You can find more of his palettes by searching for the hashtag #FungiColorPalettes on Twitter. Learn more about Steenwyk and his research, peer-reviewed publications, science art, and more at jlsteenwyk.com.

Left: February was Black History Month, a time dedicated to celebrating, learning, and appreciating Black history and heritage. The colors used to represent BHM are a reference to two sets of Pan-African colors: red, yellow, and green and red, black, and green. Traditionally, red represents sacrifice and blood spilled; yellow represents hope, justice, and equality; green represents the rich, fertile, and luxuriant vegetation of the African continent; and black represents the color of the noble and distinguished Black race.



IN EVERY ISSUE

Vestigo, (ves-TEE-go) the name for our new magazine, comes from the Latin "vestigare": to discover, search after, seek out, inquire, investigate. It encapsulates the spirit of discovery and dedication to research we strive to embody at Vanderbilt University School of Medicine Basic Sciences.

Every month we email a newsletter, *Basically Speaking*, summarizing recent achievements, awards, and discoveries of our trainees, staff, and faculty. Sign up to get it in your inbox: http://vanderbi.lt/BasicallySpeakingSignup

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vubasicsciences

Correction: In our previous issue, we summarized a research paper from the labs of **Brandt Eichman**, department chair and professor of biological sciences who holds the William R. Kenan, Jr. Chair, and **David Cortez**, interim department chair and professor of biochemistry who holds the Richard N. Armstrong, Ph.D. Chair for Innovation in Biochemistry, and identified **Petria Thompson** as the first author. However, Thompson was in fact co-first author with **Katherine Amidon**, a graduate student in the Eichman lab. We regret the omission.

COVER STORY

DISCOVERY

INNOVATION

IMPACT

SPECIAL FEATURE

Dear alumni and friends:

JOHN RUSSELL

Welcome to the second edition of *Vestigo*, the magazine that celebrates the people and programs of the Vanderbilt University School of Medicine Basic Sciences. The importance of basic biomedical science has been on display like never before as the world struggles with responses to COVID-19. Pharmaceutical companies, biotech companies, and government collaborated in record time to generate vaccines that are safe and effective. The successful path from RNA sequence of the virus to effective vaccines was made possible by earlier structural biology studies that identified the conformation of the coronavirus spike protein that was best able to generate an immune response.

Responses to the coronavirus pandemic consumed much of our attention in the past six months. In addition to an aggressive combination of PCR testing, masking, and physical distancing to minimize transmission on campus, we made other adaptations to enable us to conduct science during the pandemic (page 32). Our scientists are developing novel approaches to killing coronaviruses based on fragment-based discovery of small molecule drugs (page 16). And the resilience of the members of our community helped us deal with the stress of the pandemic. Our annual talent show went virtual but effectively showcased the incredible talents of the members of our community and gave us a night of fun and relaxation (page 26).

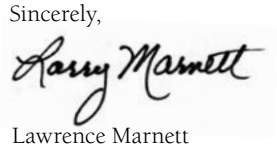
February was Black History Month, and this issue of *Vestigo* celebrates the legacy of past and current members of the Vanderbilt research community, including the first Black Ph.D. and M.D. graduates (page 29). Our alumni feature highlights the first Black person to earn a Ph.D. in human genetics and traces her path to her current position as a senior bioinformatics specialist at Illumina (page 35).

Data from around the country indicate that biomedical Ph.D.'s end up in a very diverse array of careers and that a relatively small percentage become faculty members. To help our students and postdocs appreciate the range of careers they might pursue and to prepare them for the possibilities, Basic Sciences has developed a career development program called ASPIRE. It provides an amazing suite of courses, activities, internships, and externships that acclimate our students and postdocs to their next steps once they leave Vanderbilt (page 19).

The School of Medicine Basic Sciences is dedicated to research, and this issue highlights a lot of work currently underway, including a feature on the role of mitochondria in aging and diseases (page 10), a new drug discovery program funded by Ancora Innovation to treat Charcot-Marie-Tooth disease (page 8), and a sampling of work led by students, postdocs, and research staff (pages 4-7). To share the beauty of their discoveries, our scientists reach out to our local and regional communities (page 24). In addition, our Artist-in-Residence program engages artists in communicating science and, with funding from the NIH, will be exporting its model throughout the country (page 22).

We hope you enjoy this issue of *Vestigo* and wish you a safe spring and summer.

Sincerely,



Lawrence Marnett
Dean of Basic Sciences

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Determining choice: How proteins pick and choose their partners

Cells respond to environmental stimuli through surface receptors. In particular, G protein-coupled receptors are like light switches, and are activated or "turned on" by agonists outside of the cell. GPCRs interact with intermediary signaling proteins such as G proteins or arrestins to initiate signal cascades, series of chemical reactions that transmit a message and result in a biological response. Many biological processes rely on signaling by GPCRs, and pathologies such as addiction can arise when signaling goes awry.

But how do GPCRs choose which intermediary proteins to use to start any given signaling cascade? Researchers from the groups of **Tina Iverson**, professor of pharmacology and biochemistry who holds the Louise B. McGavock Chair, and **Vsevolod Gurevich**, professor of pharmacology who holds the Cornelius Vanderbilt Chair in Pharmacology, used biochemical techniques that monitor the phosphorylation—or addition of phosphate groups—of the dopamine-1 receptor, a well-studied G protein receptor. The researchers also monitored how phosphorylation affects interactions between GPCRs such as D1R and their intermediary signals, and were able to manually choose which signaling cascade to activate.

COURTESY OF ALI KAYA

Ali Kaya, research assistant professor

Looking at signaling cascades in the cell, the investigators determined that phosphorylation of D1R at specific sites biased the protein toward an interaction with arrestin-3, and that this interaction was sufficient to activate two downstream protein partners of arrestin-3. The researchers hypothesize that this downstream activation is due to something called the phosphor-barcode, which suggests that selective phosphorylation of certain locations on a G protein receptor biases it toward specific interactions with other proteins. Their findings suggest that phosphorylation of D1R at certain locations affects arrestin-3 binding and steers the signaling cascade toward specific interaction partners down the line.

These results provide a clear pathway to uncover how GPCRs promote certain signaling pathways over others. Unlocking how arrestin interacts with its protein partners can lead to a better understanding of the basic biology of cell signaling, but also possibly can lead to insights into the pathology of addiction. — **Nicole Kendrick**

Modifying the modifier

Ubiquitin, a small 76-amino acid molecule, is added to damaged proteins to tag them for degradation. Recent research now points to ubiquitin itself as a protein that can be modified with even smaller molecules, although scientists do not know much about the roles of these modified ubiquitins in cells or even which proteins modify ubiquitin.

ELAINE CHEN

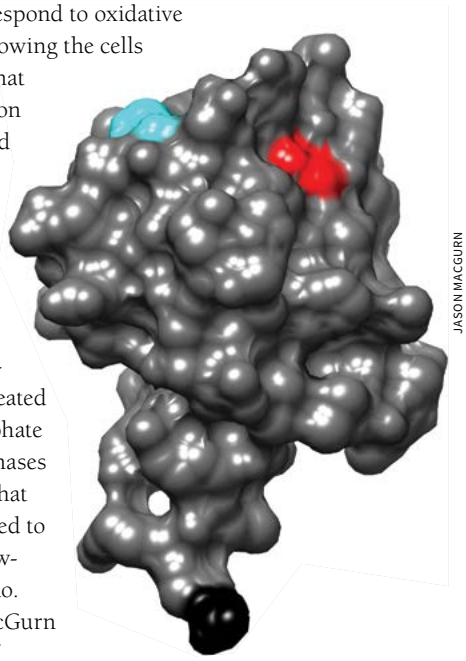
Trainee first author: Nathaniel Hepowit, postdoctoral fellow

Reporting in *eLife*, postdoctoral fellow **Nathaniel Hepowit** and colleagues from the lab of **Jason MacGurn**, assistant professor of cell and developmental biology, have identified enzymes that modify ubiquitin, thereby regulating the oxidative stress response in yeast. By using a unique screening technique in which both ubiquitin and a library of enzymes were expressed in the bacterium *Escherichia coli*, the researchers discovered that ubiquitin was modified at one amino acid by two specialized enzymes called Vhs1 and Sks1 that add phosphate groups to, or phosphorylate, proteins. Proteins that can phosphorylate are called kinases.

Oxidative stress can occur when environmental factors such as UV radiation or pollutants lead to metabolic byproducts that can cause cellular damage. Yeast normally respond to oxidative stress by arresting cell growth, allowing the cells to assess and repair any damage that might be present. However, deletion of the genes that code for Vhs1 and Sks1 in yeast led to cell growth even during oxidative stress, meaning that the ability of the cell to phosphorylate ubiquitin is tied to its ability to respond to oxidative stress. To further confirm the importance of ubiquitin's phosphorylation, Hepowit created a ubiquitin molecule with a phosphate mimic at the same location the kinases phosphorylate. When yeast cells that expressed the mimic were subjected to oxidative stress, they stopped growing—just like normal yeast cells do.

This recent work from the MacGurn lab shows that phosphorylation of ubiquitin is important for oxidative stress response in yeast, and highlights how even proteins used to modify other proteins after translation from RNA can be post-translationally modified themselves. Developing a better understanding of the codes that guide cells to make certain decisions can help us decipher how things go wrong not only in yeast, but ultimately in human cells as well. **— Sarah E. Glass**

JASON MACGURN



Ubiquitin (pictured) can be phosphorylated at several sites, including the amino acids labeled in cyan and red, to regulate different cellular processes.

A counterintuitive discovery

Researchers from the lab of **Ian Macara**, professor and department chair of cell and developmental biology, have reported the counterintuitive discovery that certain chemotherapeutic agents used to treat tumors can have the opposite effect and can lead to tissue overgrowth in normal, intact mammary glands, epidermis, and hair follicles. The researchers also are the first to report the discovery of an innate immune signaling pathway in fibroblasts—the spindle-shaped cells responsible for wound healing and collagen production—and that it causes cells to proliferate. Such signaling pathways previously were attributed only to immune cells.

COURTESY OF LINDSEY SELDIN

Trainee first author: Lindsey Seldin, postdoctoral fellow

The findings of this work, led by postdoctoral fellow **Lindsey Seldin** and published in *Developmental Cell*, have broad implications for diseases associated with the immune system, such as psoriasis, as well as for cancer and stem cell research.

By testing perturbations to the epidermis, mammary gland, and hair follicles—whether mechanical damage or DNA damage through chemotherapeutic agents—the researchers saw a paradoxical response: stem cells, which otherwise would divide slowly, instead divided rapidly, promoting tissue overgrowth.

"This was a very perplexing result," Seldin said. "We were determined to figure out if this was a direct response by the stem cells themselves or by inductive signals within their environment." The key clue was that stem cells isolated from the body did not behave the same way as they did in intact tissue—an indication that the response must be provoked by signals sent to the stem cells from other surrounding cell types.

The investigators turned their attention to fibroblasts, the predominant component of the tissue microenvironment. When fibroblasts in the epidermis were removed, the stem cell responsiveness to DNA damage was diminished, indicating that they played an important role.

RNA sequencing revealed that fibroblasts can signal by way of inflammasomes—complexes within cells that help tissues respond to stress by clearing damaged cells or pathogens—and that in this case they caused stem cells to divide. "This is an astounding discovery," said Macara , who also holds the Louise B. McGavock Chair. "Inflammasome signaling has previously been attributed only to immune cells, but now it seems that fibroblasts can assume an immune-like nature."

Seldin intends to replicate this work in the mammary gland to determine whether fibroblasts initiate the same innate immune response as in the epidermis, and more broadly how fibroblasts contribute to the development of cancer and other diseases associated with the immune system. **— Marissa Shapiro**

New culprit of developmental disorders in infants and children found

Vanderbilt pharmacologists have reported the first evidence that aberrant spontaneous release of neurotransmitters in the brain can cause a range of severe intellectual and neurodevelopmental disorders in infants and children.

Ege Kavalali, professor of pharmacology who holds the William Stokes Chair in Experimental Therapeutics and is acting chair of the Department of Pharmacology, and postdoctoral scholar **Baris Alten** describe their research in an article published in the journal *Neuron* in November.

ELAINE CHEN

Trainee first author: Baris Alten, postdoctoral fellow

Neurons, the billions of cells constantly sharing information within the brain, communicate with each other but do not touch. They release chemicals called neurotransmitters to talk to each other, orchestrated by the SNARE protein complex and triggered by a wave of electrical activity. With this "evoked release" of neurotransmitters, information jumps from one neuron to the next. This neurotransmission enables us to complete basic tasks, process sensory information and move our bodies. Mutations of one of the proteins in the SNARE complex, SNAP25, are known to cause a variety of neurodevelopmental disorders. These can present with recurrent seizures, intellectual disability and autistic features in infants and children.

By examining the electrical signals of 10 different SNAP25 mutations among 11 patients, the researchers found that mutations of SNAP25 encourage anomalous neurotransmitter release both in response to electrical activity and independent of electrical signaling in the brain. More importantly, they identified the single mutation that causes spontaneous neurotransmitter release even in the absence of appropriate electrical activity.

This discovery marks the first step toward developing specific treatments that can improve cognitive outcomes in youth and adulthood.

Traditionally, the diagnosis of cognitive disorders caused by SNAP25 mutations has been so clinically challenging that researchers assume that their incidence is underestimated. In addition, the complete lack of understanding of the disease mechanism has made it impossible to develop therapeutics tailored to patients.

This is the first known research finding that suggests spontaneous neurotransmission causes disease. Previously researchers thought only neurotransmission that had been evoked by electrical activity caused disease. The researchers intend to use this discovery to develop pharmacological therapeutics that target spontaneous neurotransmission.

"We are hopeful that treatments restoring both forms of release would have a clinical benefit, making the lives of our patients and their families a little easier," Alten said.
— Marissa Shapiro

Let it go, let it go!

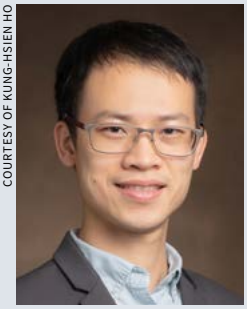
Tau's role in releasing insulin from the pancreas

The labs of **Irina Kaverina**, professor of cell and developmental biology, and **Guoqiang Gu**, associate professor of cell and developmental biology, recently found evidence that helps explain how cells in the pancreas release insulin, a hormone that regulates how the body breaks down carbohydrates, fats, and protein. Insulin levels must be carefully balanced in the body; the insulin release process is disrupted in type 2 diabetes, during which the pancreas is overstimulated and exhausted, eventually leading to cell death.

A certain protein called microtubule-binding protein tau appears to be crucial to the pancreas's response to high sugar, or glucose. This protein acts as a "glue" that holds microtubules, structural components of cells that also serve as "highways" for intracellular transport, together to help give them structure and aid in their functional performance. Tau binds to the microtubules in β-cells, cells in a region of the pancreas called islets, which store and release insulin after we eat. Sometimes tau appears to be responsible for releasing insulin, but sometimes it appears to be responsible for storing it. The Kaverina and Gu labs set out to determine how exactly tau is involved in both of these processes.

β-cells store insulin in packages called vesicles that release insulin into the body. When β-cells detect high glucose levels after meals, the microtubules grow and develop in the middle of the cell, in the same area where insulin vesicle packages are formed. Insulin vesicles then move along microtubules to the periphery of the cell to be released. The Kaverina and Gu labs determined how tau is necessary for this process: tau was chemically activated when glucose levels were high, making it release its hold on microtubules, which then broke apart at the periphery of the cell and released the insulin vesicles. Cells prepared for this event when glucose was low by concentrating tau at the outer edges of β-cells, ensuring that tau could release microtubules and quickly secrete insulin when glucose levels were high.

COURTESY OF KUNG-HSIEN HO



Trainee first author: Kung-Hsien Ho, postdoctoral fellow

The Kaverina and Gu labs manipulated the amount of tau present in mouse pancreatic islets. This allowed them to see what happened to the microtubules' ability to release insulin vesicles when tau was no longer regulating them. When islets contained less tau, the cells released more insulin at normal glucose levels compared to cells with normal levels of tau, but, paradoxically, they released less insulin than normal when glucose levels were high. The researchers hypothesize that they observed these results because tau is important for the even distribution of insulin vesicles throughout the cell: low levels of tau caused more insulin vesicles to congregate at the cell periphery—explaining the high amount of insulin release at low glucose levels—but this depleted the available insulin so that when glucose levels were high, there was less insulin ready for release. Based on the data, the researchers believe that tau is responsible for holding insulin vesicles in a "ready" state by properly dispersing them inside the cell along microtubules.

Tau stops insulin secretion at low glucose levels by binding and stabilizing microtubules at the periphery of β-cells, but when it is activated by high glucose, it lets microtubules go so they can release insulin. In type 2 diabetes, the cells in this process are overworked. Learning to regulate how and when tau releases microtubules after meals might lead to new treatments or prevention strategies for this disease. **— Deborah Roby**

Too much of a good thing

Graduate student **Justin Marinko** has illuminated the cause of Charcot-Marie-Tooth disease, putting scientists on the road to developing therapeutic approaches for the disease that affects one in 2,500 people. Marinko, who works in the lab of **Charles Sanders**, associate dean for research and professor of biochemistry, published his discovery in the *Journal of Biological Chemistry*. The significance and overall importance of the findings earned it the rare distinction of "Editors' Pick" at the journal.

JOHN RUSSELL

Trainee first author: Justin Marinko, Ph.D. graduate

Charcot-Marie-Tooth disease causes the peripheral nerves to stop working, leading to loss of dexterity and the sense of touch in the hands and feet. Over two decades, Sanders has been studying a targeted approach to treat Charcot-Marie-Tooth disease and other neuropathies by looking at rarely examined proteins.

The lab shutdown brought on by COVID-19 afforded Marinko time to analyze more deeply data previously collected in the lab. Marinko's work with this data showed that overproduction of the membrane protein PMP22 is too much of a good thing: it turns individual cells into traps.

In healthy cells, there are two copies of the gene encoding PMP22, a protein that snakes through the lipid bilayer of cells several times until it reaches the cell surface. Under disease conditions, a third copy adds more PMP22 to the cell in a way that overloads its path to the exterior of the cell, leading instead to most of the protein getting trapped within the cell; there it becomes toxic and disease-causing.

This research is the first experimental evidence that definitively points to the overproduction of PMP22 as the cause of the most common form of Charcot-Marie-Tooth disease. A similar phenomenon likely occurs for other proteins in other disorders involving unregulated cell behavior, including some forms of cancer.

This investigation is the outcome of a continuing collaboration between the Sanders lab and the lab of Bruce Carter, professor of biochemistry and an associate director of the Vanderbilt Brain Institute.

"Discovering this relatively new phenomenon was an important step and a highlight for our lab," said Sanders, who also holds the Aileen M. Lange and Annie Mary Lyle Chair in Cardiovascular Research. "I am thrilled about the future of this work with our friends in the Carter lab, translating our data and model cell line work to nervous system cells." **— Marissa Shapiro**

The discovery of a 'negative regulator' in the brain

The brain has an uncanny ability to enhance or reduce communication between brain cells, and whether or not communication is fast or slow changes the brain's overall function. Understanding how these cells communicate within the brain is critical to understanding how the body and mind work together.

Terunaga Nakagawa, associate professor of molecular physiology and biophysics, has spent years exploring how neurotransmission—communication between brain cells—is modulated in different parts of the brain. Neurotransmission is facilitated through glutamate receptors. One of these, the AMPA receptor, is responsible for the brain's ability to learn and remember information. Its functionality is directly connected to various cognitive disorders including autism, Alzheimer's, limbic encephalitis, schizophrenia, and strokes.

COURTESY OF AICHUROK KAMALOVA

Trainee first author: Aichurok Kamalova, Ph.D. graduate

Nakagawa's team of researchers, including former graduate student **Aichurok Kamalova** and colleagues from the Vanderbilt Brain Institute, describe evidence in *Cell Reports* that an auxiliary subunit of the AMPA receptor, GSG1L, which was discovered in Nakagawa's lab in 2012, slows down brain cell activity in the anterior thalamus. This section of the brain is critical for memory formation, navigational information processing, and seizure initiation.

Until this discovery, all auxiliary subunits of AMPA receptors were known as positive regulators. Certain mechanisms enhance or reduce brain regulation directly connected to motor function, and changing the efficiency of these communications regulates cognitive activity. Uniquely, negative regulators suppress the functionality and activity of neurons. The researchers' findings show that GSG1L, a subset of negative regulators in the anterior thalamus, is doing something important to overall brain health.

"Now that we identified GSG1L as a negative regulator, we are going to search for a way to understand in more chemical detail how it functions, with the ultimate goal of developing a new chemical compound that specifically targets it," Nakagawa said. Developing brain region-specific drugs could provide targeted benefits with limited health-related side effects or unintentional consequences on other parts of the brain.

The researchers also will continue to study how GSG1L operates in other parts of the brain beyond the anterior thalamus and how other auxiliary subunits work together with the AMPA receptor to orchestrate brain functionality. — **Marissa Shapiro**

Stimulating tuft cell production reverses intestinal inflammation

Researchers in the lab of **Ken Lau**, associate professor of cell and developmental biology, and collaborators have, for the first time, been able to trigger the specific immune system response required to reverse the course of inflammation in the small intestine by inducing the production of tuft cells, very rare epithelial cells that sense and respond to parasites. The breakthrough has the potential to provide Crohn's disease and inflammatory bowel disease patients a safe alternative to what's known as helminthic therapy, wherein parasitic organisms are introduced into the body to stimulate an immune response and calm inflammation.

During the past five years, there has been a flurry of scientific research around tuft cells—a cell type comprising less than 1 percent of all the cells that form the outer lining of the intestinal tract—adding to widespread scientific knowledge from over the past half century. Despite five decades of study, this research, led by former graduate student **Amrita Banerjee**, is the first that looks into how tuft cells can specifically address symptoms of CD and IBD.

COURTESY OF AMRITA BANERJEE

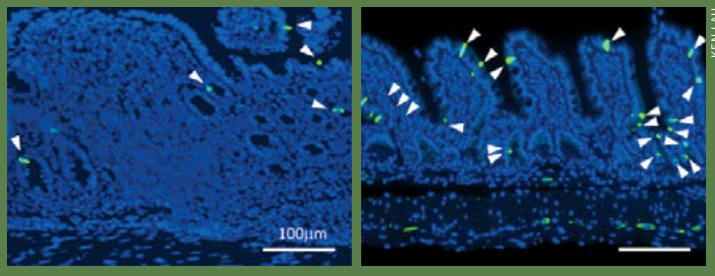
Trainee first author: Amrita Banerjee, Ph.D. graduate

By deploying single-cell RNA sequencing and microbiome analysis, the researchers determined that the microbiome can stimulate tuft cell generation in a positive feedback loop through specific molecules. When this strategy was applied to mice with CD, increasing tuft cell numbers ultimately reversed the course of intestinal inflammation.

"Next we will be looking closely at the mechanisms that enable tuft cells' functionality and how they can be clinically applied," Lau indicated.

Added Banerjee, "Using this research to address human disease was a goal of mine as a student, and to realize it has been a highly rewarding experience. We have applied a gamut of techniques to our research and then walked from the lab to the clinic to evaluate the human impact of our work. The Vanderbilt community has provided so many intentional and serendipitous contributions to this research."

The synergy between the collaborators has resulted in a provisional patent application that Lau worked on with the Center for Technology Transfer and Commercialization. The patent will enable them to pursue further investigation into tuft cells.— **Marissa Shapiro**

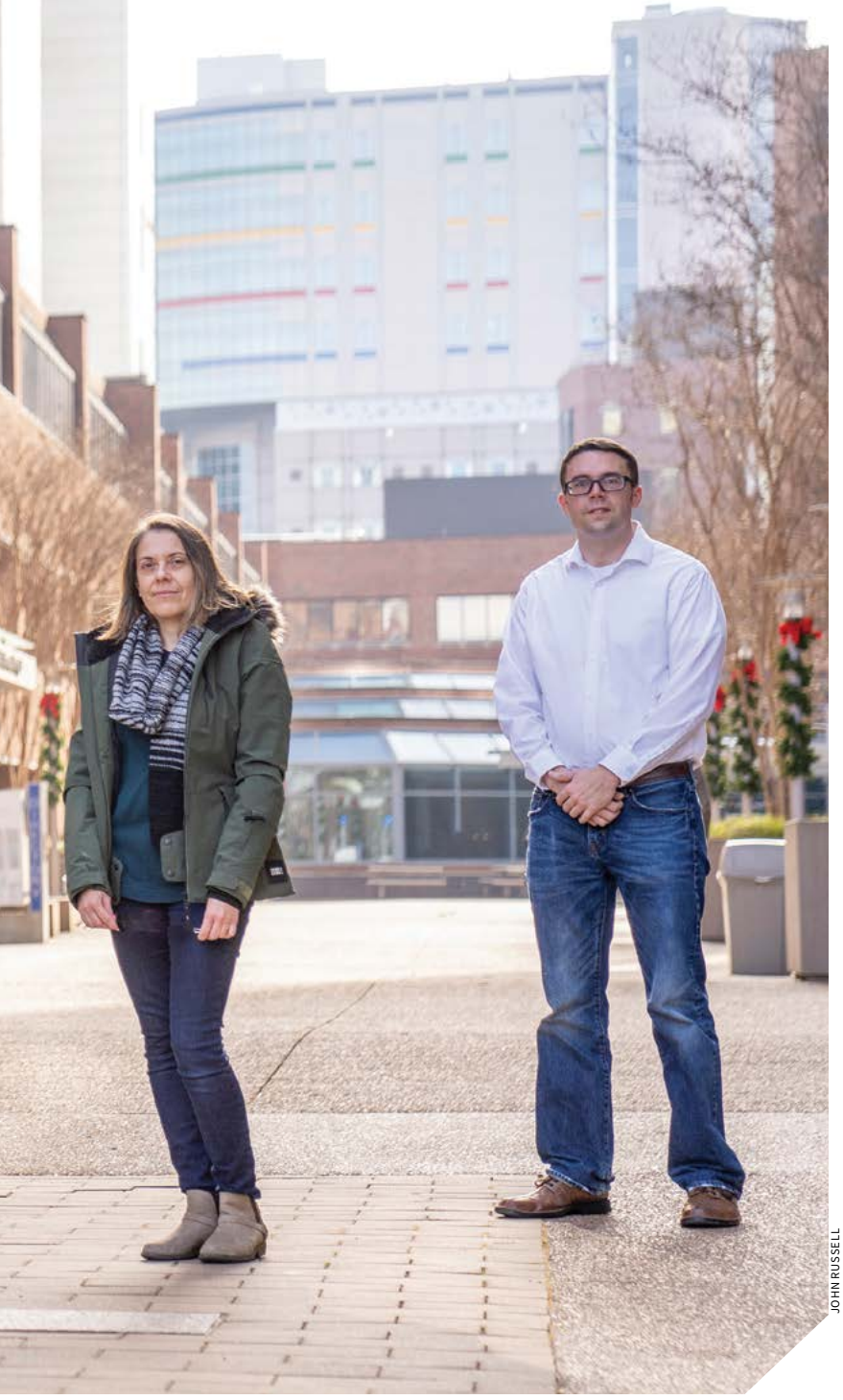


KEN LAU

Restoration of the finger-like architecture of the intestine upon tuft cell stimulation in a Crohn's disease model, untreated (left) and treated (right). Arrows point to tuft cells, labeled in green.

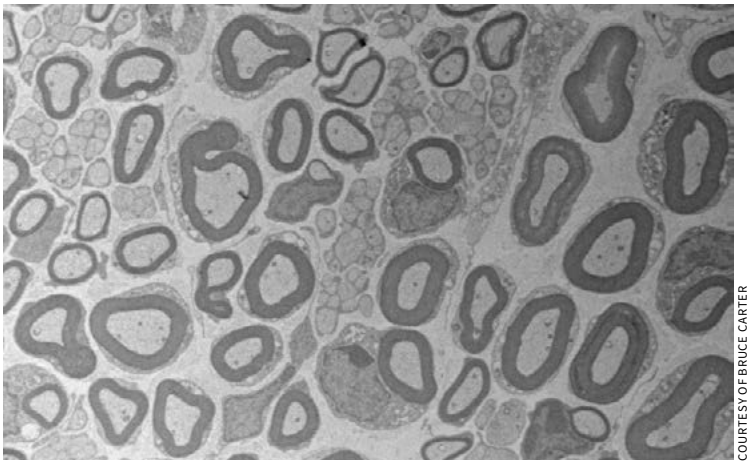
Vanderbilt-Ancora partnership advances research for Charcot-Marie-Tooth disease

By Marissa Shapiro



JOHN RUSSELL

Above: A team of researchers working on Charcot-Marie-Tooth disease has received funding from Ancora Innovation, LLC. From left, Sungjong Oh, Bruce Carter, Margaret Read, Charles Sanders, Arina Hadziselimovic, and Michael Goodman. Oh works in the Carter lab. Hadziselimovic is the lab manager for the Sanders lab. Goodman serves as the liaison between Ancora and the Sanders lab.



COURTESY OF BRUCE CARTER

Top right: A cross section of a peripheral nerve. Each nerve is surrounded by a dark myelin sheath, a protective coating that allows for the efficient transmission of electrical signals through our nervous system. The most common forms of Charcot-Marie-Tooth disease have defective myelin, which distorts or blocks signaling.

Vanderbilt University is consistently at the forefront of biomedical research, and thanks to a 2018 partnership with Deerfield Management, Ancora Innovation, LLC, was established as a company designed to support this leading-edge life science research. Now, Ancora will be funding further research into therapeutics for Charcot-Marie-Tooth disease, an inherited condition that damages peripheral nerves.

This is the third Vanderbilt project that Ancora has funded. A project designed to discover and advance pharmaceuticals for the treatment of dystonia and other movement disorders and one designed to discover and advance pharmaceuticals for the prevention and treatment of opioid use disorders were selected for funding in late 2018. Several researchers from the Warren Center for Neuroscience Drug Discovery were behind those proposals.

Charles Sanders, associate dean for research and professor of biochemistry, will continue to lead research and pursue a therapeutic treatment for Charcot-Marie-Tooth disease, which affects 1 in 2,500 people. His lab is joined on the Ancora project by that of **Bruce Carter**, professor of biochemistry and associate director of the Vanderbilt Brain Institute.

"Professors Sanders and Carter are true innovators of a promising therapeutic for this debilitating disease," Vice Provost for Research **Padma Raghavan** said. "I am delighted that this project has been advanced through our Ancora partnership with Deerfield and grateful to the Center for Technology Transfer and Commercialization team—particularly **Alan Bentley** and **Margaret Read**—for their support to develop this project."

"Reviewing the work of Professor Sanders's lab was a strong reminder of the caliber and translational quality of research that comes from our colleagues in Basic Sciences," said **Peter Donofrio**, chief of the neuromuscular division and professor of neurology at Vanderbilt University Medical Center, who provided insight on clinical development opportunities for the project. "It was clear that the lab benchwork deserved to progress to a clinical study, so I am very pleased to see this partnership come to life."

"Our collaboration leverages the academic innovative life science research and Deerfield's expertise in accelerating state-of-the-art drug development," Deerfield partner **William Slattery** said. "We are thrilled to work with Professors Sanders and Carter and to support the translation of promising early discoveries into a potential treatment."

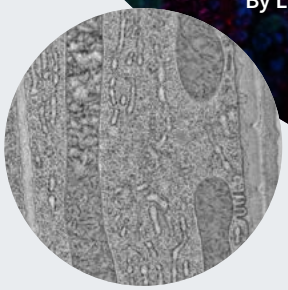
Beyond the Charcot-Marie-Tooth disease project, the Office of the Vice Provost for Research and the Center for Technology Transfer and Commercialization will continue to assist faculty interested in working with Ancora by providing advice and guidance and by sponsoring educational programming focused on drug discovery and development. ■

Not just the powerhouse of the cell

If you think back to the last biology class you took in high school, you might remember learning about the cell and its organelles—the specialized structures contained within. You likely remember the mitochondria, the "powerhouse of the cell." But mitochondria do much more than generate energy.

By Lorena Infante Lara

ALEJANDRA ROMERO-MORALES (GAMA LAB)



KRIS BURKEWITZ

Top: An image of a brain organoid. Typical cell cultures are two dimensional, but organoids grow in three dimensions so as to better resemble tissues such as the brain. Here, you can see the mitochondrial network in magenta, neural progenitor cells in green, neurons in red, and nuclei in blue. Bottom: Transmission electron micrograph of the mitochondria and the endoplasmic reticulum in C. elegans.

A vibrant group of young Vanderbilt researchers is delving into the different functions—and dysfunctions—of mitochondria and the types of mitochondrial diseases that can afflict the human body.

Present in all eukaryotic cells that have a nucleus, mitochondria contain within their two membranes the machinery necessary to generate the bear's share of ATP, the molecule that powers the cell. This earns them the "powerhouse" moniker, but mitochondria are responsible for a lot more. They play a role in processes ranging from apoptosis (programmed cell death) to immune signaling, regulation of cellular metabolism, steroid and heme biosynthesis, and even neurodevelopment and aging.

VANDERBILT UNIVERSITY

Breann Brown

"We're getting to this part of mitochondrial biology where people are really appreciating that there's so much more that we don't understand," said **Breann Brown**, assistant professor of biochemistry.

Beyond a failure of energy

Brown, who uses structural biology to understand how mitochondrial proteins assemble, focuses on two processes that can go wrong, and neither is directly related to the generation of cellular energy. The first—DNA depletion disorders—refers to problems that arise when a mitochondrion's DNA content is severely reduced. Most of our genome, inherited equally from both biological parents, is contained in the nucleus of our cells. However, mitochondria contain their own complement of DNA that is transmitted exclusively from the biological mother.

The genes contained in mtDNA code for proteins involved in the generation of energy. Critically, however, mtDNA lacks the genes necessary to replicate the mitochondrial genome and maintain it in good repair. Instead, the nuclear genome

codes for those genes, and mutations in them can lead to mtDNA depletion disorders.

DNA depletion disorders are predominantly neurologic diseases, with patients displaying developmental delays, hearing impairments, feeding difficulties, decreased muscle tone, uncontrollable muscle contractions, and more. These disorders exhibit an early onset, so children are affected.

The second focus of Brown's research is heme biosynthesis. Heme is best known as a key component of hemoglobin, the molecule present in red blood cells that binds to iron and carries oxygen throughout the body. Brown studies a mitochondrial protein, ALAS2, that plays a role in heme biosynthesis. Mutations of ALAS2 can give rise to two distinct diseases.

The first disease, X-linked sideroblastic anemia, occurs when mutations decrease the activity of ALAS2, causing iron to collect in mitochondria, which then cluster around the nucleus of red blood cell precursors. The result is a deficiency of healthy mature red blood cells and an inadequate supply of oxygen to the body. The second disease, X-linked protoporphyria, occurs when ALAS2 mutates to become hyperactive, causing an accumulation of heme precursors. These precursors are phototoxic, so patients with XLPP are severely sensitive to the sun. Both diseases primarily affect males because the ALAS2 gene is carried on the X chromosome—hence the "X-linked" designation. The presence of a mutation on a person's single X chromosome, such as in biological males, cannot be overcome by a normal gene on a second X chromosome, as occurs in biological females.

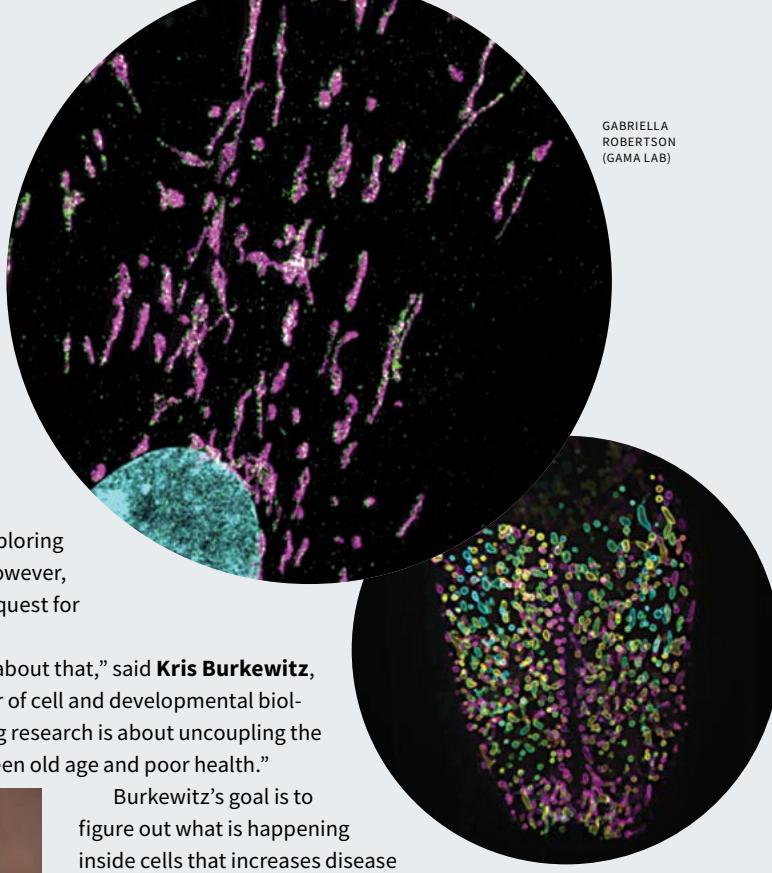
Brown's lab takes a structural approach to answering questions about the disorders she studies. Understanding the three-dimensional structure of a protein can tell scientists a lot about its function, including how it carries out its tasks and how it interacts with other cellular components. When a protein acquires a mutation, its shape can change, thereby affecting its functional efficiency, how it is transported within the cell, or how well it binds to certain binding partners, among other things.

"We know the mutations and we know the diseases, but we don't know what's going on in the middle. My lab looks at filling in those middle pieces to understand how disease mutations alter the structures that then result in a particular disease," Brown said.

This is getting old

What is the one condition that most increases your risk for other diseases and maladies? Advancing age. The risk for many of the hardest-hitting chronic diseases—Alzheimer's, heart disease, chronic respiratory and kidney diseases, and more—is low (in some cases zero) when a person is young but increases dramatically with age.

Although age inevitably affects the entire body, it is in large part mediated by what happens in mitochondria. Indeed, mitochondrial dysfunction is a hallmark of aging. Genes in the mtDNA start accumulating mutations, and oxidative phosphorylation—the chain of reactions responsible for the generation of energy in the mitochondria—declines in efficiency. Several Basic Sciences researchers are exploring this connection; however, they are not on "a quest for immortality."



GABRIELLA ROBERTSON (GAMA LAB)

KRIS BURKEWITZ

Top: Human fibroblasts showing their mitochondrial network in green and magenta and their nuclei in cyan. Bottom: This image shows a C. elegans *roundworm expressing a fluorescent marker on the outer membrane of its mitochondria. The colors change depending on the depth of field.*

"It's not really about that," said **Kris Burkewitz**, assistant professor of cell and developmental biology. "Modern aging research is about uncoupling the relationship between old age and poor health."

STEVE GREEN

Kris Burkewitz

Burkewitz's goal is to figure out what is happening inside cells that increases disease risk with age. Could blocking those processes lower that risk and increase the health of an aging organism?

Burkewitz began his quest to answer these questions in a circuitous way; he was broadly interested in the process of aging but eventually focused on mitochondria. Previous research showed that limiting caloric intake without activating malnutrition can prolong the lifespan and promote the metabolic health of organisms that range from single-celled eukaryotes all the way to primates. During his postdoctoral studies at Harvard University, Burkewitz and his colleagues developed a model that enabled them to turn on a low energy sensor in the neurons of *Caenorhabditis elegans*, a non-parasitic roundworm often used in biomedical research.

Molecular sleuthing using this model eventually led Burkewitz to determine that neurons tasked with communicating the energy state were doing so by reprogramming mitochondrial dynamics and function in the peripheral tissues. Mitochondria are not static organelles. They frequently

> "If the mitochondria are changing shape, changing their dynamics, maybe this is affecting the way that they communicate with different parts of the cell,"
>
> — **Kris Burkewitz**

fuse with one another, divide to form multiple, independent mitochondria, or undergo complete disintegration in the case of overwhelming damage. Together, these actions constitute mitochondrial dynamics. "If the mitochondria are changing shape, changing their dynamics, maybe this is affecting the way that they communicate with different parts of the cell," Burkewitz said.

Now, Burkewitz is investigating the connection between mitochondria and the endoplasmic reticulum, an octopus-like organelle that serves as a transportation system, site of protein and lipid synthesis, and director of protein folding. New research reveals that miscommunication between the mitochondria and ER and a general lack of coordination of their metabolic activities play a role in age-related mitochondrial declines. One of the major pursuits in aging biology is to find ways to protect or restore mitochondrial function in old cells. Burkewitz is working on targeting mitochondrial function indirectly, through its neighboring organelles.

"This helps to set up one of our guiding hypotheses that aging isn't—can't—be studied in the context of a single organelle," Burkewitz said. "It's really important to understand how these different organelles are interacting with each other and how those interactions change with age as well."

ANNE RAYNER

Erkan Karakas

'Paging the mitochondria!'

Besides aging, miscommunication between the mitochondria and the ER has ties to cancer and to neurodegenerative diseases such as amyotrophic lateral sclerosis, commonly referred to as ALS. **Erkan Karakas**, assistant professor of molecular physiology and biophysics, is also an expert in mitochondria-ER contact sites and communication with a focus on these diseases.

Karakas said of his lab's work: "How is this communication mediated? Understanding these mechanisms may help us find a cure or treatment for these diseases down the road."

Like Brown's lab, the Karakas lab uses structural biology approaches to explore mitochondrial biology. At contact sites between mitochondria and the ER, there are channels that help transfer calcium ions from the ER into the mitochondria. As calcium is essential for mitochondrial function, this allows the ER some control over mitochondrial dynamics. Cancer cells are addicted to this calcium transfer, and blocking it has been shown to selectively kill the cancer cells while sparing healthy ones. Karakas hopes to use his structural knowledge of the channel to find a means to control its activity, and in his words, "perhaps we may find a way to deliver an agent to humans to directly stop this calcium transfer" and attack cancers that way.

Another aspect of Karakas' work involves the proteins VAPB in the ER and PTPIP51 in the mitochondria, which tether the organelles together and have been implicated in ALS. A progressive and fatal disease, ALS affects nerve cells in the brain and spinal cord and eventually causes loss of muscle control. Development of ALS appears to be related to a dysregulation of mitochondrial function, and of particular interest is the finding that some ALS patients carry a VABS mutation that disrupts the ER-mitochondrial interface.

Currently, scientists do not know how VAPB and PTPIP51 interact, so it has been difficult to determine how the VAPB mutation is related to the development of ALS. Karakas' group is attempting to determine the structure of these proteins.

"If we can understand the mechanism behind this interaction, it may help us understand the molecular basis behind the disease and how ALS progresses," he said.

Dynamic fates

Another aspect of biology where mitochondria play a role is cell fate. While most cells in our body are highly specialized for a particular function—skin cells, heart muscle cells, liver cells, etc.—stem cells have the capacity to differentiate or specialize into many cell types. The lab of Assistant Professor of Cell and Developmental Biology **Vivian Gama**

VANDERBILT UNIVERSITY

Vivian Gama

studies how mitochondrial dynamics affect the ability of stem and neural stem cells to differentiate into all the types of cells that make up the nervous system in the developing brain.

Recent research from the Gama lab and others determined that neural stem cells differentiate into different cell types depending on whether their mitochondria have fused to become elongated or have divided into a fragmented network.

In rare cases, the genes that govern mitochondrial shape become mutated and lead to diseases that afflict children. Although these mutations occur throughout the body, the nervous system and brain development are particularly affected. Patients suffer from developmental delays, autism-like disorders, and seizures.

The Gama lab uses two systems to investigate mitochondrial dynamics and their relation to human disease. The first system is patient-derived induced pluripotent stem cells—that is, they take cells from patients and despecialize them so they once more have the potential to become many different kinds of neural cells. The second system is brain organoids, cultured clusters of brain cells that mimic the three-dimensional architecture of the brain. These brain model systems have allowed researchers to study early stages of development that were, until recently, inaccessible.

Coupled with different microscopy, imaging, cell biology, and biochemical techniques, the Gama lab fulfills its passion to conduct basic science that may ultimately have an impact on patient lives. The brain organoids they currently have and new ones that they are developing, for example, can be created from patient cells and used as platforms to test new therapeutics.

Into the future

It is clear that these Basic Sciences faculty have forged a vital new avenue of research at Vanderbilt. One major advantage of establishing a "critical mass" of researchers in a field is that it becomes easier to attract new talent. Thus, the Department of Molecular Physiology and Biophysics recently welcomed **Elma Zaganjor**, who joined their ranks as assistant professor in 2020.

COURTESY OF ELMA ZAGANJOR

Elma Zaganjor

Fresh from postdoctoral studies at Harvard University, Zaganjor centers her research on mitochondrial proteins known as sirtuins and the role they play in preventing age-related diseases such as diabetes, obesity, and cancer. She uses approaches such as metabolomics, small molecule screening, animal models, cell biology, and biochemistry to identify and rescue defects in mitochondrial metabolism that lead to disease.

Zaganjor's interest in mitochondrial metabolism and the different techniques her lab employs directly tie in to—and complement—the research of incoming Assistant Professor of Molecular Physiology and Biophysics **Antentor O. Hinton Jr.** Arriving later this year from the University of Iowa, where he currently holds a postdoctoral position, Hinton will be setting up his own lab to explore different aspects of mitochondrial metabolism, including connections to estrogen signaling. Hinton will focus on how mitochondria-ER communication relates to type 2 diabetes and to a related type of heart failure called diabetic cardiomyopathy. In particular, Hinton will be taking a look at the entire contact region between both organelles, known as mitochondria-ER contact sites or MERCs. MERCs are highly specialized regions that behave as signaling hubs: they can transfer calcium ions and lipids, control mitochondrial and ER shape, and regulate the recruitment of other organelles.

COURTESY OF ANTENTOR O. HINTON JR.

Antentor O. Hinton Jr.

Cheers for collaboration

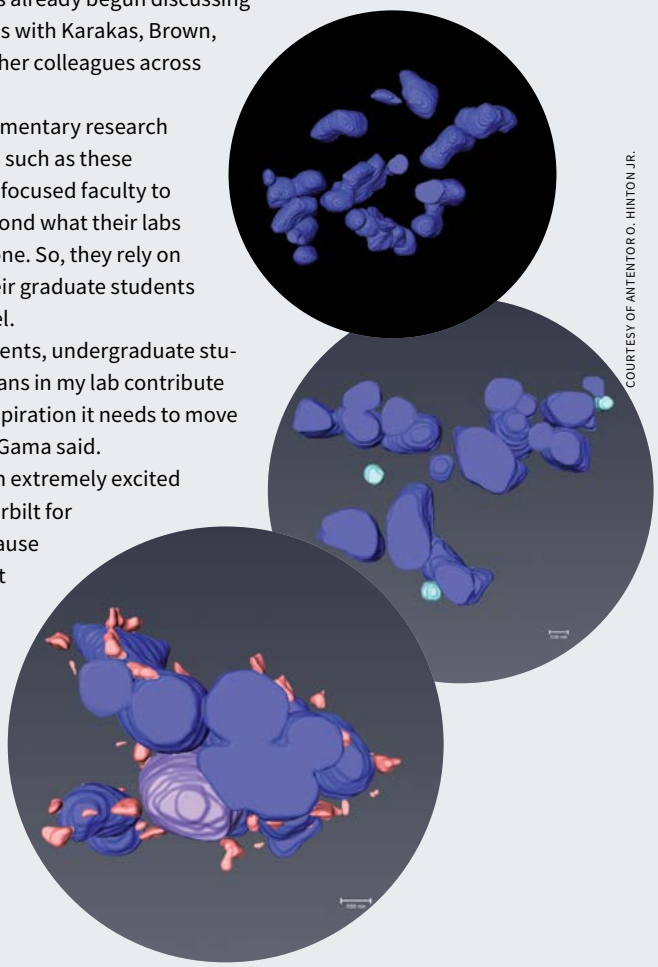
None of this research happens in a vacuum. Eventually, each researcher's work ties into the work of the others, fostering internal collaborations instead of competition. "One of the strengths of Vanderbilt is the ability to collaborate with others," Gama said.

Hinton agrees. Although he's not arriving on campus until September, he has already begun discussing potential collaborations with Karakas, Brown, Gama, Zaganjor and other colleagues across Vanderbilt.

Working on complementary research tracks allows scientists such as these mitochondrial disease-focused faculty to expand their reach beyond what their labs would be able to do alone. So, they rely on each other—and on their graduate students and other lab personnel.

"The graduate students, undergraduate students, and lab technicians in my lab contribute the brainpower and inspiration it needs to move our projects forward," Gama said.

Hinton added, "I am extremely excited about coming to Vanderbilt for the research—and because Vanderbilt is the largest producer of minority Ph.D.'s in the country. Mentoring minority students is something that is very near and dear to my heart." ■



COURTESY OF ANTENTOR O. HINTON JR.

These three images are taken from a video generated by Hinton with SBF-SEM (serial block-face scanning electron microscopy), a technique that allows researchers to generate high-resolution, three dimensional images of small samples. Here, the images show fruit fly muscle cells with certain components highlighted in different colors: the mitochondria in blue, lipids in cyan, an autophagosome (a site for degradation of cellular components) in purple, and the ER in pink.

Cohen Innovation Fund bolsters memory research

By Bill Snyder

Ever since its inception in 2017, the Stanley Cohen Innovation Fund has been supporting high-risk, groundbreaking research that has the potential to open new fields of scientific inquiry and biomedical impact. The awards honor Stanley Cohen, the late Vanderbilt emeritus professor of biochemistry and 1986 Nobel laureate, whose discovery of epidermal growth factor, as well as its mechanism of action, revolutionized our understanding of cellular signaling and led to high-impact therapies across a range of diseases.

The Cohen Fund has helped subsidize projects designed to explore the potential for pharmacological targeting of proteins in different membrane domains, study how the energy of brain astroglia cells may be harnessed to prevent neuronal aging, and test a new therapeutic strategy for peanut allergies.

Now, for its latest iteration, the Cohen Fund has selected **Cody Siciliano**, assistant professor of pharmacology, to receive a one-year, $100,000 research award to support his studies of the neural substrates of memory.

"Cody is an exceptional young scientist we were fortunate to recruit to Vanderbilt," said **Larry Marnett**, dean of the School of Medicine Basic Sciences. "He will be integrating frontier technologies of imaging and neuro-science to identify precise circuits in the brain that underlie decision-making, motivation and behavioral flexibility."

"Dr. Siciliano's work on neural circuits will advance innovative concepts and tools to establish causal relationships between specific circuits and memory formation, tackling one of the larger problems in fundamental brain science," added **Jennifer Pietenpol**, executive vice president for research at Vanderbilt University Medical Center.

Siciliano earned his Ph.D. in neuroscience from Wake Forest University School of Medicine in Winston-Salem, North Carolina, and was a postdoctoral research fellow at the Massachusetts Institute of Technology before joining the Vanderbilt faculty in 2019.

His work focuses on understanding how neural circuits in the brain orchestrate decision-making and memory, how these processes can become dysregulated due to trauma or disease, and how normal regulation of these circuits could be restored through various interventions.

Siciliano's approach combines the detection of electrochemical neurotransmitters and the dissection of optical circuits, both in vitro techniques, with complex behavioral tasks in live animals to define the neural dynamics that underlie decision-making in animal models of disease.

"These experiments have the potential to greatly expand our understanding of how the brain stores memories, and the neurobiology underlying post-traumatic stress disorder," said **Ege Kavalali**, professor and acting department chair of pharmacology who holds the William Stokes Chair in Experimental Therapeutics, in his recommendation letter supporting Siciliano's proposal.

Siciliano is a highly productive scientist, Kavalali added, who has published more than 20 first- or last-author papers in major journals since 2014 and who has received research funding from the National Institutes of Health and the global biopharmaceutical company Alkermes.

In 2020 he also received the Daniel X. Freedman Prize for contributions to neuro-psychiatric disease research from the Brain and Behavior Research Foundation.

Siciliano's neural circuitry project "is precisely the kind of high-risk, high-reward research that the Cohen Fund was established to stimulate," Marnett said. "It celebrates the memory of our beloved colleague Stanley Cohen, who passed away last year." ■

Cody Siciliano

STEPHEN DOSTER

Chan Zuckerberg Initiative grant expands access to imaging knowledge

By Marissa Shapiro

Bryan Millis, research assistant professor of cell and developmental biology and biomedical engineering, has been awarded a grant from the Chan Zuckerberg Initiative's Imaging Scientists program. The proceeds will go toward building an immersive virtual education platform to expand instruction and accessibility of high-end microscopy techniques within and beyond the Vanderbilt research community.

The Chan Zuckerberg Initiative is a charity established by Facebook founder **Mark Zuckerberg** and his wife, **Priscilla Chan**. Through the CZI, the couple aims to invest 99 percent of their wealth from their Facebook shares over their lifetimes. The CZI focuses its work on several areas, including five areas of science—imaging, science in society, neurodegeneration, single-cell biology, and the universal and open sharing of science.

Over the years, Millis—who develops microscopy and imaging technologies within the Vanderbilt Biophotonics Center and is part of the Cell Imaging Shared Resource—began noticing that students interested in imaging science would regularly approach him with in-depth microscopy questions outside of class. He is now translating that interest into a self-propagating mentorship program.

Enabled by support from the CZI, Millis will extend the accessibility of specialized microscopy equipment and expertise within Vanderbilt University to a broader pool of curious students who have limited access to high-end imaging expertise. The only requirement of Millis' program is that trainees share the knowledge they gain within their institutions by leading an imaging-based interest group the semester following their participation.

"CZI wants to fund the highest-impact elements in a given subject area, and in imaging science, that is the knowledge base behind the equipment," Millis said. "This grant is supporting the growth of interest and education in a field where there are a limited number of places to learn on high-end custom platforms."

"Our goal is to support the advancement of imaging technologies and provide access to and training on these state-of-the-art tools so that researchers can drive toward discoveries," CZI Imaging Program Officer **Stephani Otte** said. "By collaborating closely with the imaging community and providing both funding and expertise in technology development, we hope to help make the next breakthroughs in imaging possible."

Millis' grant—totaling approximately $850,000 over three years with an option for a two-year extension—is one of 22 projects funded through the CZI Imaging Scientists grant. **John Gore**, director of the Vanderbilt University Institute of Imaging Science and University Professor of Radiology and Radiological Sciences, also received a grant through the CZI Deep Tissue Imaging fund.

Millis is spending the first few months of the project developing content and exploring interactive virtual environments, and he plans to launch the program nationally within the next academic year. Ultimately, his goal is to inspire biomedical graduate students—especially within populations underrepresented in imaging science—to pursue careers in the field.

"There is a beautiful career option in imaging science for people who want to work with the technology on a deeper level, participating in the collaborative and pathbreaking biomedical work happening at research institutions like Vanderbilt," said Millis, also an affiliate faculty member of the Vanderbilt Data Science Institute. "I am very enthusiastic to be bringing this program to life and to share our cutting-edge resources with burgeoning imaging scientists." ■

"This grant is supporting the growth of interest and education in a field where there are a limited number of places to learn on high-end custom platforms."

STEPHEN DOSTER

Bryan Millis

A secret weapon against SARS-CoV-2

By Aaron Conley

When COVID-19, the disease caused by the SARS-CoV-2 virus, hit the United States, **Stephen Fesik**, Orrin H. Ingram II Professor of Cancer Research and professor of biochemistry and pharmacology, was struck by its devastating impact. "I saw people losing family members, friends losing their jobs or businesses, and I said, wait a second, I can do something about this," Fesik said.

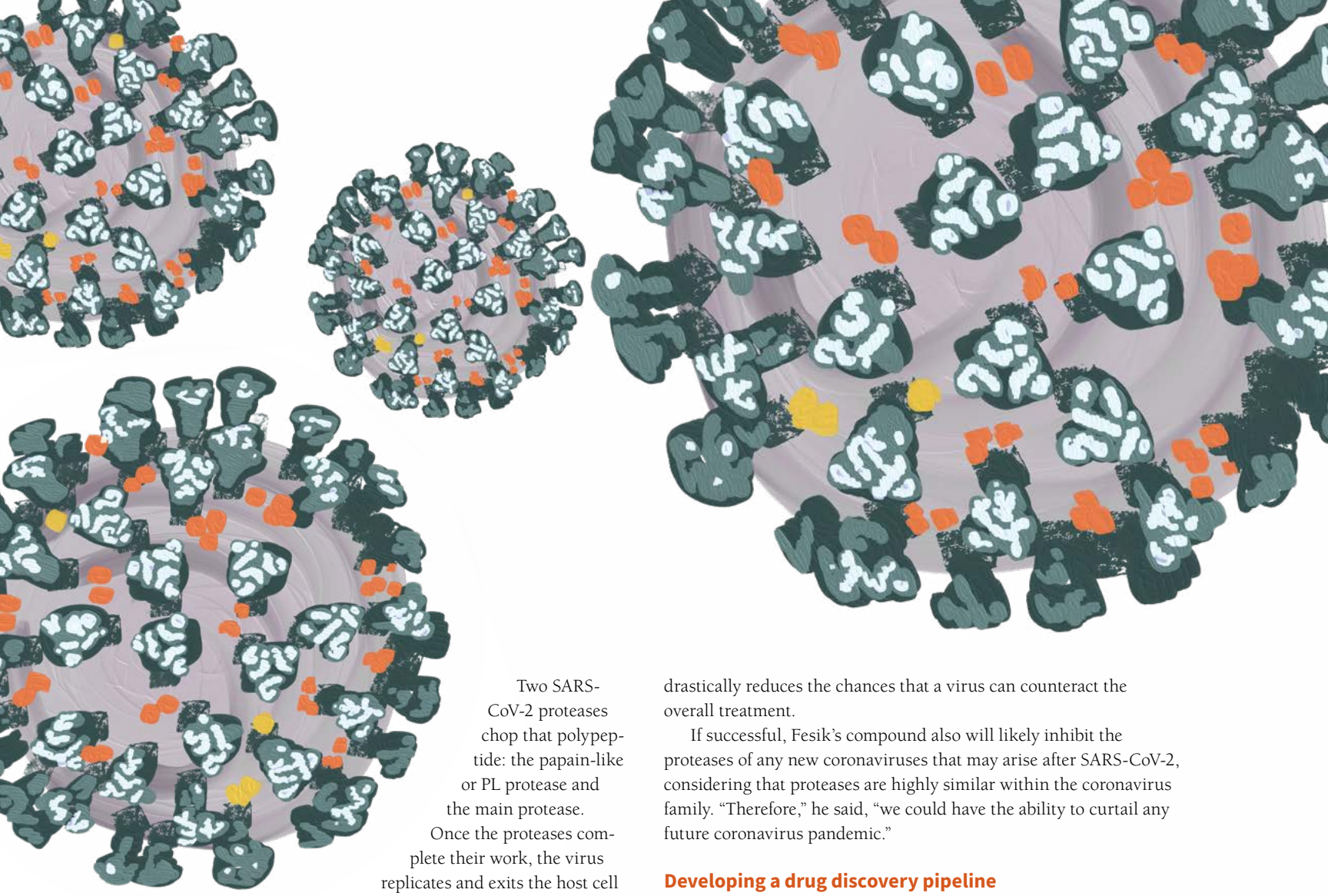
COURTESY OF STEPHEN FESIK

Fesik is an international leader in drug discovery who uses cutting-edge techniques to develop innovative drugs to treat cancer. "We had a methodology in hand and an experienced lab that knew how to apply these methods to discover cancer drugs," Fesik said. "I knew we could easily make the transition to target SARS-CoV-2."

Informed by his history with antiviral targets, including prior work on severe acute respiratory syndrome coronavirus (the original SARS) and efforts on the discovery of some of the first protease inhibitors for HIV, Fesik was well prepared to initiate research on SARS-CoV-2. He began reading everything he could on the virus and decided on targeting a viral protease, a protein that's necessary for the virus to replicate in the human body. His goal is to create a protease inhibitor in pill form that can kill both the current virus and future coronaviruses.

The target

Like all viruses, SARS-CoV-2 uses host cells (in this case, human cells) to replicate because it does not have all the machinery it needs. The virus's spike protein—a protein located on the surface of the virus—must first interact with a receptor on the surface of a human cell so that the virus can enter it and release its genetic material. The virus then hijacks ribosomes, which make protein from an RNA template. The resulting polypeptide, a long protein molecule, is immature: Nothing can happen until it is chopped into smaller, functional proteins.



Two SARS-CoV-2 proteases chop that polypeptide: the papain-like or PL protease and the main protease. Once the proteases complete their work, the virus replicates and exits the host cell to move throughout the body and replicate further.

We chose to block the PL protease," Fesik stated, "because without this protease, the virus cannot produce the proteins in a form necessary for viral maturation, replication, and survival. This is analogous to the drugs we developed that revolutionized the care of AIDS." In the case of SARS-CoV-2, an inhibitor would ideally bind with the protease—occupying the exact location where the viral polypeptide needs to bind—and would thereby inhibit the cleavage of the polypeptide and block the virus's ability to replicate.

The PL protease has an insidious, alternative purpose: it targets and cuts a human protein that is part of the immune system. The current thinking suggests that the inactivation of that protein deadens the immune system against the virus—a situation that a protease inhibitor could readily remedy. Fesik believes that vaccines are of utmost importance and that their uptake in society is key to reining in the pandemic. "But," he asks, "if you get the virus, what do you do then?" This question demonstrates why protease inhibitors need to be part of our COVID-19-fighting toolkit. They can prevent the virus from spreading in the body of those who are already infected. When used in combination with other treatments, protease inhibitors could limit the development of resistance, create better responses to overall treatment, and induce a quicker recovery. Although viruses can mutate their way around any single intervention, inhibiting different targets with two or three drugs drastically reduces the chances that a virus can counteract the overall treatment.

If successful, Fesik's compound also will likely inhibit the proteases of any new coronaviruses that may arise after SARS-CoV-2, considering that proteases are highly similar within the coronavirus family. "Therefore," he said, "we could have the ability to curtail any future coronavirus pandemic."

Developing a drug discovery pipeline

Before joining Vanderbilt in 2009, Fesik was the divisional vice president of cancer research at Abbott Laboratories, where he developed several new nuclear magnetic resonance spectroscopy techniques, which focus on observing the local magnetic fields around atoms and can help scientists determine the structure of molecules or monitor changes in protein shape under various conditions. One of the methods for drug discovery that Fesik pioneered is called "structure-activity relationships by NMR," or simply "SAR by NMR." With this method, the Fesik lab first identifies a target that, if inhibited, could stop or reverse a disease. They then determine the structures of these targets using NMR and another technique called X-ray crystallography.

Using SAR by NMR, the Fesik lab can screen thousands of small molecules to determine whether they could possibly become drugs against a particular target. NMR, due to its sensitivity, shows if binding occurs between a target and a particular small molecule—and where. Once the group finds promising small molecules, they are "placed" within a model of the 3D structure of the target that shows all the "pockets" that need to be blocked so that the target is inhibited. Ultimately, they optimize and connect these small molecules so that they occupy all the pockets within the structure of the target site and form a drug candidate. This fragment-based approach to drug discovery has opened up targets that were previously considered "undruggable."

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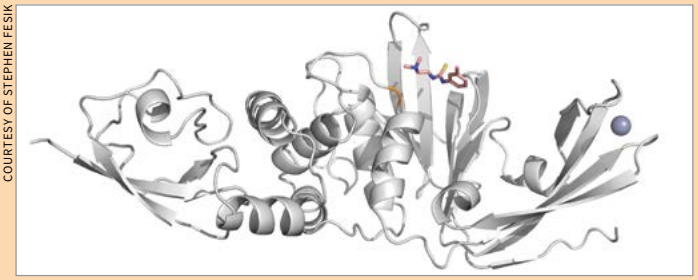
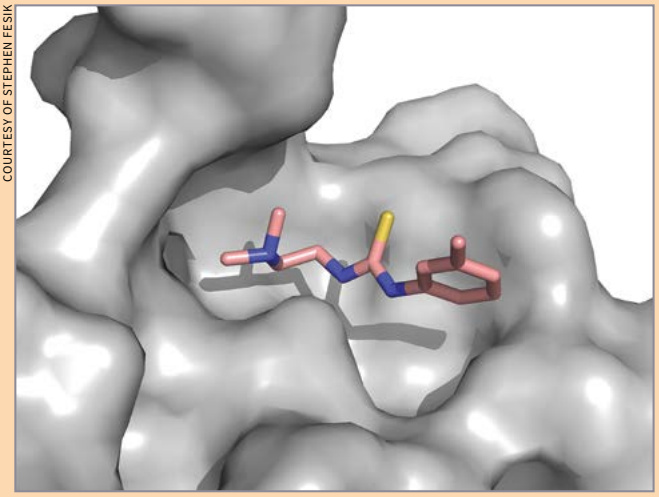
COURTESY OF STEPHEN FESIK



COURTESY OF STEPHEN FESIK



This experiment-derived structure shows a fragment identified in the small molecule library (in colors) as it occupies the site where the substrate would bind to the viral protease (in gray). When fragments bind to the substrate binding site on the protease, they inhibit the protease and prevent it from chopping up the viral polypeptide into the segments necessary for viral replication. Structures like these reveal how the small molecules may be improved by optimally filling the protease's pockets or by identifying new ones.

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Thanks to fragment-based methods and structure-based design, Fesik developed a pipeline of novel anti-cancer compounds while at Abbott, resulting in the discovery of several drugs such as Venetoclax. Venetoclax inhibits a protein that keeps cancer cells alive and limits the ability of other treatments to kill the cancer cells. The drug has been approved by the U.S. Food and Drug Administration for the treatment of chronic lymphocytic leukemia and acute myeloid leukemia, with clinical trials currently running for use against other cancer types.

When Fesik first came to Vanderbilt, he built one of the best and largest fragment libraries in the world—encompassing approximately 14,000 small molecules—roughly seven times larger than the typical fragment library. The Fesik lab can use high-throughput methods, which rely on automated equipment to process samples much faster than humans can, to screen the fragment molecules of this library.

Since his arrival, Fesik has continued to make major drug discoveries in cancer through five current cancer drug development programs. He has partnered with Boehringer Ingelheim, a research-driven pharmaceutical company, to move two of these compounds, which target an oncogene called RAS, toward clinical testing. RAS is mutated in about 30 percent of all cancers, including in 90 percent of pancreatic cancers and in around 40–50 percent of lung and colon cancers. "RAS is the holy grail of cancer targets," Fesik said. "It has been difficult to find compounds that can inhibit it and develop a useful drug against RAS-driven cancers."

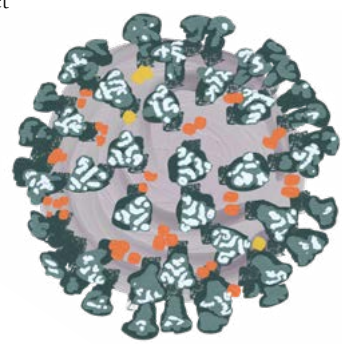
A new focus on SARS-CoV-2

Fesik's team shifted to working on the virus that causes COVID-19 in the beginning of May 2020 and has made significant progress since then. "We have cloned, expressed, labeled, and purified large quantities of the PL protease," Fesik said, describing the process by which researchers isolate specific proteins by inducing other organisms such as bacteria or yeast to make those proteins. "Using this protease, we have screened most of our fragment library using NMR and have identified several candidates, including some that we are particularly excited about since they bind to different pockets in the protein." Linking these fragments together to form an entirely new compound could significantly increase how strongly the inhibitor binds to the virus, and, consequently, how efficiently it functions.

But creating a molecule that binds well to its target in computational modeling or even in test tube experiments with isolated PL protease is not enough. Moving forward, Fesik will be collaborating with **Dr. Mark Denison**, professor of pediatrics at Vanderbilt University Medical Center and holder of the Edward Claiborne Stahlman Chair in Pediatric Physiology and Cell Metabolism. Denison, an international expert who currently leads multiple COVID-19 intervention studies and who has been researching coronaviruses since 1984, is also working on the vaccine clinical trial led by the biotechnology company Moderna.

Once Fesik's group generates an inhibitor candidate, they test its ability to inhibit the PL protease. Promising candidates are sent to the Denison lab to see how well they stop viral replication. Denison and his group also test whether the inhibitors are synergistic with other COVID-19 treatments—if coupling the inhibitors with other treatments remains beneficial—and determines the mutation rate of the virus when the inhibitors are used in combination with other drugs. The Fesik group has now been working with the Denison lab on this project for a few months.

Thanks to their unique combination of equipment, methodology, and experience, Fesik's group of structural biologists, medicinal chemists, and cell biologists is one of the best labs in the world at rapidly obtaining potent inhibitors. Yet Fesik knows that progress in science does not rest on the shoulders of a single group. "The more labs that go after SARS-CoV-2 targets—such as proteases, other enzymes responsible for the replication of the virus, or proteins that facilitate viral entry into cells—the merrier," Fesik said. ■



ALL PHOTOS COURTESY OF ASPIRE

Case session and site visit at Digital Reasoning in Franklin, TN as part of the "Data Science Essentials" module in the spring of 2019. The host for the site visit was alumna Christi French, PhD'15.

Training the biomedical workforce of the future

By Ashley Brady

Graduate school and postdoctoral experiences are centered on the acquisition of hard skills—growing cells, developing assays, imaging tissue with microscopes—and some soft skills—analytical thinking, generation of hypotheses, time management. But not all training programs prepare trainees to transition into a career, and few teach industry-specific skills.

Vanderbilt University's ASPIRE program has focused on developing innovative ways to broaden the training of biomedical Ph.D. graduate students and postdoctoral fellows since its inception in 2013. That year, the School of Medicine's Biomedical Research Education and Training Office of Career Development received one of just 17 non-renewable, five-year grants from the National Institutes of Health. The Broadening Experiences in Scientific Training, or BEST, awards challenged the biomedical research community to develop and test approaches to improve its trainees' preparation for the wide range of research and research-related careers that they ultimately pursue.

Vanderbilt's BEST grant program was branded ASPIRE, and it offers one-on-one advising, career seminars and symposia, skill building workshops, site visits, internships, and more. One major facet of ASPIRE is its array of noncredit short courses, or "modules," which provide trainees significant exposure to professional skills and experiences that are relevant to both faculty and nonfaculty careers, and can help them decide if a particular career is a good fit for them.

More than 850 participants have completed at least one of the 13 modules currently offered, which cover themes of communication, teaching, business and entrepreneurship, clinical research, and data science.

"Graduate students and postdoctoral fellows who participate in an ASPIRE module may learn that they don't like the tasks of a particular career path, or the exposure may help them hone the directions they wish to go. Either way, this is hugely informative in career decision-making," says **Kim Petrie**, assistant dean for career development.

In addition to helping guide career decisions, ASPIRE modules teach trainees transferrable skills that serve them well in many different career paths. For example, understanding the technology commercialization process, which brings new scientific discoveries into the market, is useful not only to researchers in academia, but also to those working in many different sectors of the biopharma industry.

Branden Stansley, a former postdoc at Vanderbilt, took both the "Technology Commercialization" and "Business and Management Principles for Scientists" modules. Stansley felt that the modules complemented the scientific foundation that he received in the laboratory and were key to successful interviews for pharmaceutical medical affairs roles.

Graduate student **Jennifer Gribble**, who recently completed the "Data Science Essentials" module, has found the experience thus far to be invaluable to her career planning, but also helpful for her research. "I can't tell you how much this information has helped me solidify my career interests. Plus, with all the things I learned, I've managed to put together real scripts for my lab's bioinformatics projects."

A fellow graduate student who also took the data science module, **Tamar Kavlashvili**, agreed. "This was by far the best ASPIRE module and the best course I've taken at Vanderbilt. It has been so helpful for me to decide my career interests and has exposed me to the surprisingly not-so-scary world of coding."

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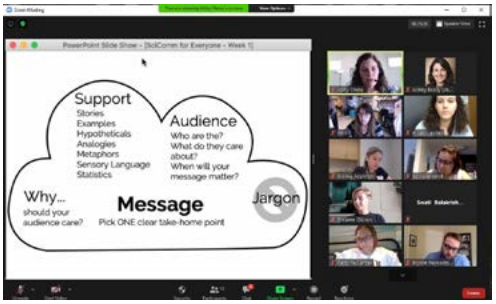

Top row: (Left) A panel of judges prepares to provide feedback to teams as they present their business or management solution during the project-based portion of the "Management and Business Principles for Scientists" module during the spring of 2019. (Center) The new "SciComm for All" module, taught by alumna Abby Olena, PhD'15, was held virtually in 2020. (Right) Graduate student Benjamin Conrad at his home workstation. Conrad was a virtual participant of the "Data Science Essentials" module in the fall of 2020.

Bottom row: (Left) Case session and site visit at Ingram Content Group, LLC, in La Vergne, TN, as part of the "Data Science Essentials" module in the spring of 2019. The host was postdoc alumna Shruti Sharma. (Right) Trainee participants listen to Kim Sheehan, then program manager at HCA Healthcare in Nashville, TN, where they had a case session and site visit as part of the "Data Science Essentials" module in the spring of 2019.

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Walking the walk

A key component of the modules is experiential learning, as most modules involve completing a deliverable or a project. For example, participants in "Biomedical Research and the Media" write three news pieces that get published in the *VUMC Reporter*, which helps aspiring science writers build writing portfolios that are required for successful application to science writing internships, fellowships, and jobs.

Participants in the business and management principles module consult with the director of a shared resources core facility at Vanderbilt and work to propose a solution to an identified business challenge. The module culminates with groups presenting their proposals to the core staff and a panel of judges composed of local entrepreneurs, business consultants, and faculty. These proposals have already led to impacts within some facilities, including through the submission of a large instrumentation grant for recommended automation to support a biobanking core and the launch of a 3D printing service tailored to biomedical labs.

Graduate students and postdocs who take the "Data Science Essentials" module work in groups to present on their use of publicly available data to try to answer or inform a health care-related question. They also attend case study sessions at local data science companies, where they learn about data science careers from professionals in the field. These sessions will be conducted virtually during spring 2021.

Jump starting careers

As a postdoctoral fellow, **Ralph Hazlewood** participated in several ASPIRE modules. Now, as an associate manager with Regeneron Pharmaceuticals, he particularly appreciates how the "Business and Management Principles for Scientists" and "Clinical Laboratory Medicine" modules impacted his career trajectory.

"These experiences not only augmented my leadership and project management experiences, but also extended my transferable skills such as communication, teamwork and collaboration, and creative problem-solving that helped me stand out during interviews," Hazlewood said.

Sometimes learning these new skills opens up career avenues that trainees had not considered before.

"I discovered my new interests and potential during the 'Business and Management Principles for Scientists' module," **Neha Sawhney** said. "Now, I want to learn about the careers I can go into while using these skills." Sawhney, who also took the data science module as a postdoc, is currently a staff scientist at Vanderbilt University Medical Center and is eager to consider new roles in the scientific enterprise that incorporate business and management themes.

Long-term impacts

Magda Grabowska, currently an assistant professor in the Department of Urology at Case Western Reserve University, participated in the "Introduction to the Principles and Practice of Clinical Research" module—led by the NIH Clinical Center and coordinated by the ASPIRE program—as a postdoc at Vanderbilt. She included this module as part of her training plan in a successful application for an NIH Pathway to Independence Award, which is

granted to outstanding postdocs who are transitioning into independent researcher careers.

"This course covered everything from clinical trial design, to implementation, to safety monitoring, and was perfect for satisfying my career exploration and development," Grabowska said. "Listing the module in my award application gave me a leg up, but more importantly, it has continued to help me design randomization schemes in our preclinical experiments and better appreciate the path for our discoveries from bench to bedside."

A recognition of excellence

Vanderbilt trainees aren't the only ones to recognize the value of the ASPIRE module program. In fact, two ASPIRE modules, "Business and Management Principles for Scientists" and "Data Science Essentials," were developed with competitive funding from the Burroughs Wellcome Fund and have now been recognized nationally for their impact and innovation.

Each of these modules won second place in the American Association of Medical Colleges Innovations in Research and Research Education Award program. These awards are given annually by the AAMC to highlight high-impact innovations in biomedical graduate education that support the next generation of researchers to launch and maintain scientific careers. The business module was recognized in 2016 and the data science module in 2019.

"Clinical Laboratory Medicine," in which participants shadow clinical diagnostic laboratory teams, has provided unparalleled exposure to this career path and given Vanderbilt trainees an edge when competing for the small number of highly competitive clinical laboratory fellowships offered annually across the nation. Over the past four years, six module participants have secured these coveted positions.

Stephanie Carnes, who participated in the module in 2017 and is in her second year as a clinical microbiology fellow at the University of Washington, said, "The clinical diagnostic laboratory has a different structure, end goals, and communication style than a research lab, so this module experience was crucial for my interviews, and certainly helped me transition to my new position."

As further testament to the innovative nature of the both the clinical laboratory and the business modules, the ASPIRE team has shared knowledge regarding their development, execution, and outcomes with the biomedical community through the publication of a peer-reviewed paper. Other institutions from around the world can now reference these papers and develop similar initiatives for their own trainees.

A team effort

Many of the ASPIRE modules were developed and are led by members of the ASPIRE team. However, to deliver the full breadth of topics necessary for preparing the biomedical workforce of the future, the ASPIRE program has also sought content experts to lead many of its modules. **Kathy Gould**, senior associate dean for biomedical research, education, and career development, said, "Execution of these modules would not be possible without our multiple partnerships with faculty, staff, alumni, campus entities, and outside organizations such as the Nashville Software School and Life Science TN."

Then graduate student Dikshya Bastakoty during a mock interview conducted at Vanderbilt's VUStar studios as part of the "Biomedical Research and the Media" module during the fall of 2014. Bastakoty now works at the Vanderbilt Institute for Clinical and Translational Research at VUMC.

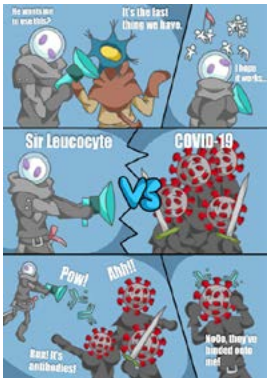
Since the inception of the ASPIRE program, the number of modules has grown thanks to feedback from trainees and input from faculty and industry partners about the skills and experiences that trainees need for a successful career. With an ear to the ground, the ASPIRE team continues to listen for new areas of interest and to look for new partners to help deliver these valuable programs for the benefit of Vanderbilt trainees. ■

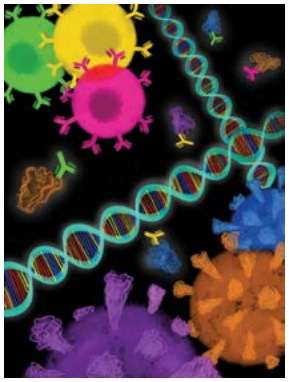
ASPIRE MODULES BY THEME

	ASPIRE Module	Instructor/Partner
Business and Entrepreneurship	Business and Management Principles for Scientists	VU partner
	Technology Commercialization	VU partner
Communication	Biomedical Research and the Media	VUMC partner
	Creating Effective Scientific Talks and Delivering Them with Confidence	ASPIRE team member
	EQ + IQ = Career Success	ASPIRE team member
	Networking Pacing	ASPIRE team member
	Practical Strategies for Strong Writing	VU partner
	SciComm for All	Alumna
	Maximizing Your Potential: Leading and Managing People, Projects, and Your Career	ASPIRE team member
Clinical Research	Introduction to the Principles and Practice of Clinical Research	NIH Clinical Center
	Clinical Laboratory Medicine: Applying your Ph.D. to Patient Care	VUMC partner
Teaching	STEM Teaching in K-12 Schools	VU partner
Data Science	Data Science Essentials	Community partner

Vanderbilt's Artist-in-Residence program to expand regionally

By Leigh MacMillan





JOHN RUSSELL

Eric Skaar

For the past two summers, undergraduate student artists have immersed themselves in the science of some of Vanderbilt's top research laboratories. They've been part of an Artist-in-Residence Program—a partnership between the Vanderbilt Institute for Infection, Immunology and Inflammation and ArtLab, which explores the intersection of art with science, technology, engineering, mathematics, and medicine through a cross-disciplinary approach that draws from media, art, and design.

The VI4-AiR program has resulted in artwork that has been featured on the covers of journals and in graphical abstracts, has been used to promote research on websites and social media, and decorates the walls of the VI4 headquarters in Medical Center North.

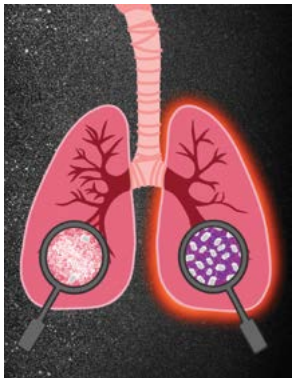
Now, this innovative program, which brings together scientists and artists with the shared goal of communicating science, is set to expand with support from a three-year grant from the Burroughs Wellcome Fund.

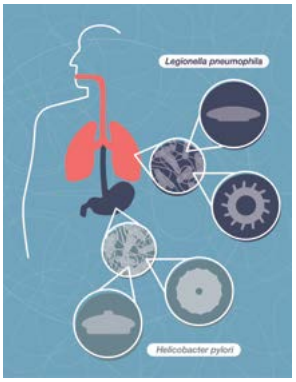
"The success of the VI4-AiR program motivated us to consider expanding it in the hopes of building sustainable hubs around the country that are focused on merging art and science and generating interest among the public in the process of discovery," said **Eric Skaar**, director of VI4 and Ernest W. Goodpasture Chair in Pathology and professor of pathology, microbiology and immunology.

Kendra H. Oliver, an assistant professor of pharmacology and an artist, established ArtLab in 2017 to support visual science communication approaches and outreach. ArtLab embodies a cross-institutional partnership and is supported by multiple internal funding sources from Vanderbilt, including the Curb Center for Art, Enterprise and Public Policy; the Wond'ry; the Communication of Science and Technology program; and Basic Sciences. Oliver and Skaar launched the VI4-AiR program in 2019.

"There is a disconnect between the science, technology, engineering and mathematics communities and the public, and yet we know that the public is eager to

To see a gallery of artwork from the program, go to www.artlab-air.com/explore-by-art.





engage with scientists, particularly amid a global pandemic," Oliver said. "We believe that science-based visual art is a practical and untapped approach through which researchers can engage broader communities and employ new perspectives for advocating for STEM."

The BWF-AiR program will recruit faculty—prioritizing early-stage investigators who use multidisciplinary approaches to study human infectious diseases—who applied for, but were not necessarily awarded, the BWF Investigators in the Pathogenesis of Infectious Disease award. The program will pair the selected faculty members with two undergraduate student artists each.

BWF-AiR aims to recruit at least half of its participating undergraduate artists from groups that are underrepresented in the science disciplines, particularly students who currently attend historically Black colleges and universities or who don't have access to high-caliber research opportunities.

During the 10-week summer program, which will be conducted virtually, the undergraduate artists will meet with mentors from the labs they are working with to learn about research projects and approaches. They will also work with Oliver to develop visual science communication skills. By the end of the program, the students will have created two art pieces that are representative of the laboratory's research, adding to the already impressive gallery of science art created by previous VI4-AiR artists. ■


JOHN RUSSELL

Kendra H. Oliver

"HIV and HCV co-infection," by Anjali Kumari for the lab of Ivelin Georgiev (human immunodeficiency virus, HIV; hepatitis C virus, HCV); cover art for "Sir Leucocyte," a short comic by Lauren Wong for the lab; "Reactivity information through sequencing," by Qi Liu for the lab of Ivelin Georgiev; "Interconnectedness," by Navya Thakkar for the lab of Meena Madhur; "Positive and negative rewards based on sex," by Maggie Xu for the lab of Erin Calipari; "Salmonella piece,"by Skylar Cuevas for the lab of Mariana Byndloss; "Therapeutic targets for A. baumanii," and "Virulence" by Alexa Marcus for the lab of Eric Skaar; "Similarities to complexity," by Jessica Cascio for the lab of Borden Lacy; "IGA skies," by Dayana Espinoza for the lab of Bradley Richmond.

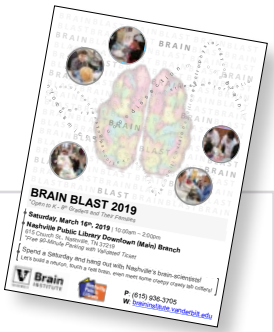
Getting the knowledge out

By Kendra H. Oliver

What is science outreach?

Engaging public audiences of all ages is an effective way to promote interest in science, with the goal of establishing the process of scientific research as a relevant human endeavor. Many Basic Sciences community members support and participate in "science outreach" to achieve these goals and to foster connections with our local and national communities.

Public outreach is an opportunity for our scientists and partners across Vanderbilt to impact community members through education, communication and policy. By partnering with teachers, programs and centers that specialize in outreach, scientists can make an even more meaningful impact than by working alone.

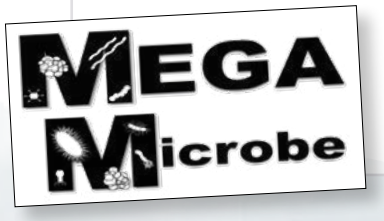


Brain Blast

Brain Blast is a half-day event filled with activities for children and adults. It is an opportunity for children and their families to explore the brain, ask questions, and learn independently at booths designed by Vanderbilt Brain Institute researchers. Although the event did not occur last year due to the pandemic, organizers are looking forward to offering the program virtually with various activities, including a Lego brick brain-building activity, simple experiments students can do at home, and more.

MEGAMicrobe

MEGAMicrobe is a free, community-focused annual event for 5- to 14-year-olds hosted by the Vanderbilt Institute for Infection, Immunology and Inflammation to demonstrate how science is essential, fun, and accessible for all. Students, parents, and teachers learn about microbes and their critical role in human health in an interactive setting with real scientists. Hosted each fall, MEGAMicrobe has partnered with local schools to conduct an annual, in-person event. In 2020, due to the COVID-19 pandemic, the event was entirely online.



Who is the audience?

Basic Sciences scientists engage with various audiences using many approaches. Like any relationship, effective science outreach fosters a connection between the scientist and their audience, which ranges from kindergarteners to high school students to adults; the type of outreach—such as in-classroom partnerships, kid-friendly events or hands-on research experiences—depends on the particular audience.

Your addicted brain

The Vanderbilt Center for Addiction Research conducts vital research and works to educate surrounding communities, especially teenagers, about addiction. In partnership with the Collaborative for STEM Outreach and Education, VCAR supports programming that aims to improve middle school students' understanding of the brain and how it is affected by addiction through learning and the production of three-minute animated videos.

High school students take a turn at the bench

A handful of programs across the Basic Sciences support high school student engagement and research.

Currently, the **Vanderbilt Brain Institute** is working with an Advanced Placement class in Kentucky to support student-developed projects on topics ranging from hydroponics to space travel. This one-on-one mentoring program helps connect students with real scientists to discuss approaches to problem-solving.

The **Research Experience for High School Students**, organized through the Collaborative for STEM Education and Outreach, is an intensive, six-week scientific research internship at Vanderbilt centering on full immersion in a university or Vanderbilt University Medical Center research lab.

Discover Biomedical Science is hosted and designed entirely by graduate students from the Initiative for Maximizing Student Diversity, and invites high school students from Nashville and neighboring counties for two weeks of immersive research experiences at Vanderbilt. Participating students—mostly rising juniors—interact with current graduate students who share their career paths and encourage them to go to college and major in a STEM field. At the end of the program, the students and their parents are welcomed to a college admissions open house with staff from the Vanderbilt admissions office.

The **Aspirnaut Program** is an opportunity for high school students, particularly from rural backgrounds, to immerse themselves in a hands-on research experience. The students participate in independent research projects under the mentorship of a research faculty member.

Undergraduates

Thanks to the pandemic, summer programs were challenged to drastically adapt their approaches to undergraduate training. While many programs chose not to offer research experiences, the PAECER-SURE program, supported by the National Institutes of Health and the American Heart Association, was wholly transformed to focus on science communication and engagement regarding health disparities and inequities of cardiovascular disease. Students created 10-minute videos on topics related to cardiovascular health and distributed them broadly to family members, friends, and community groups. In the fall, the videos were included in the Riverbend Maximum Security Institution intranet system, which allows inmates in the Nashville prison to access various educational resources.

Public lectures and courses supporting lifelong learning

The Vanderbilt Brain Institute, through partnership with the Osher Lifelong Learning Institute, offers a public course for learners interested in how the brain works. "Our Brains: An Operator's Manual" has previously included lectures on topics like neuroscience and law, auditory and visual processing, and mindfulness. The course is offered every two years, and the content is continuously updated. The next offering of the course will likely be in the fall of 2021.

Talent beyond the pipet

By Beth Bowman, Jeffrey Jian, and Caroline Cencer

All images, unless specifically noted, were kindly provided by the Winter Showcase organizers.

Vanderbilt University has historically been renowned for the extraordinary breadth and depth of its fundamental biomedical research. The four Basic Sciences departments—Biochemistry, Cell and Developmental Biology, Molecular Physiology and Biophysics, and Pharmacology—have generated two Nobel laureates, receive more NIH funding annually than any other similar departments across the nation, annually induct faculty fellows into the American Association for the Advancement of Science, and produce hundreds of highly skilled Ph.D.'s, among other accomplishments.

But did you know that our scientists' talents continue beyond the bench?

Science demands creativity to be successful, but our community's talent extends deep into the arts. Among our scientists, there are fantastic singers, great dancers, talented artists, and more. To celebrate these endeavors and bring these artistic abilities into the spotlight, the three of us—**Beth Bowman**, assistant director of graduate programs in the biological sciences, and **Jeffrey Jian** and **Caroline Cencer**, graduate students—teamed up to carry out a new kind of experiment we called the Vanderbilt Winter Showcase.

Started in 2018, the VWS is now an annual program and art gallery created thanks to our researchers' artistic proclivities. For its first two iterations, the VWS organized an evening that blended artistry,

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We hope you enjoy this razzle-dazzle reel from our 2020 show, featuring the following artwork (clockwise from top left): "The Old and the New," by Esha Dalvie, graduate student in biochemistry; "Tree of Knowledge," by Christine Konradi, professor of pharmacology; "Immunocytochemistry," Margaret Fye, first-year graduate student; "Have Yourself A Merry Little Christmas," Jonathan Davies, graduate student in biochemistry; "Cell Complexity," Julissa Burgos, first-year graduate student; "Crochet Baby Yoda," by Xin Tong, postdoctoral fellow; "Painted Cephalopods," by Alexandra Mulligan, first-year graduate student.

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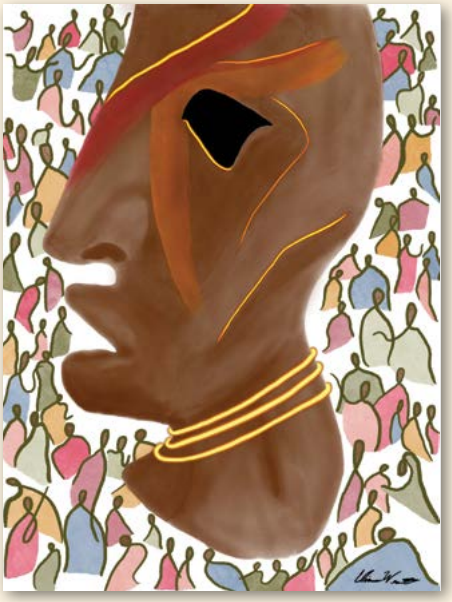
culture, and performance at the Blair School of Music. Attendees from within Basic Sciences and beyond gathered to behold the works created or performed by faculty, students, postdocs, and staff in a show hosted by the charismatic duo of Erin Calipari, assistant professor of pharmacology, and Carlos F. Lopez, professor of biochemistry. Based on the available data, we can confidently say: the experiment was a success!

This winter, despite the COVID-19 pandemic, the motto for the 2020 VWS was "The show must go on!" The VWS went virtual last December—we collaborated with Vanderbilt's ArtLab director, **Kendra H. Oliver**, also an assistant professor of pharmacology, to create a website where we hosted a livestreamed show. This included a virtual art gallery that allowed for a welcome break from the challenges of the year for the attendees. Even held virtually, we had a banner year with more than 30 artists and performers participating.

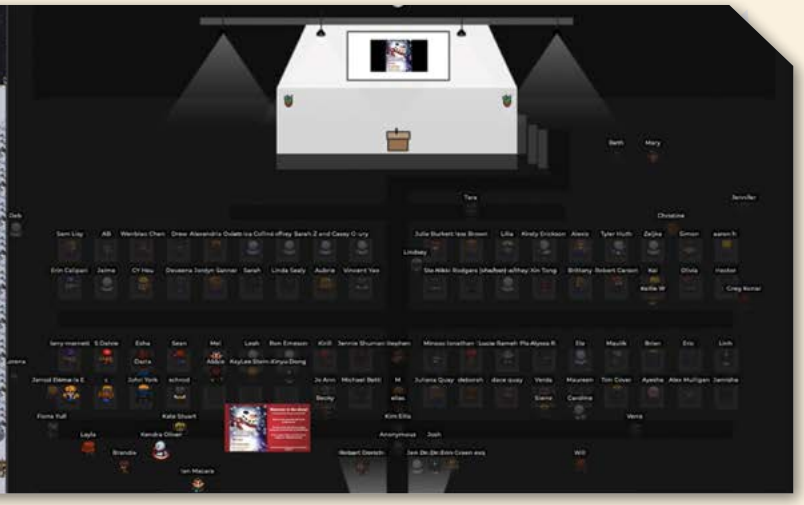
As the years progress, VWS hopes to become a perennial staple of the Vanderbilt Basic Sciences community.

> Science demands creativity to be successful, but our community's talent extends deep into the arts and past the lab.

Left: "Hurricane," Kristen Gilliland, staff scientist. Right: "Inspiration from the National Gallery of African Masks," Elias West, first-year graduate student.



SCREEN CAPTURE COURTESY OF KENDRA H. OLIVER



Left: The 2020 Winter Showcase was hosted in a virtual snowy castle where attendees could mingle with one another. Right: Inside the castle was a lounge, a gallery where the submitted pieces were on display, and an auditorium where attendees enjoyed the show.

Black History Month and STEM

What's science got to do with Black History Month?

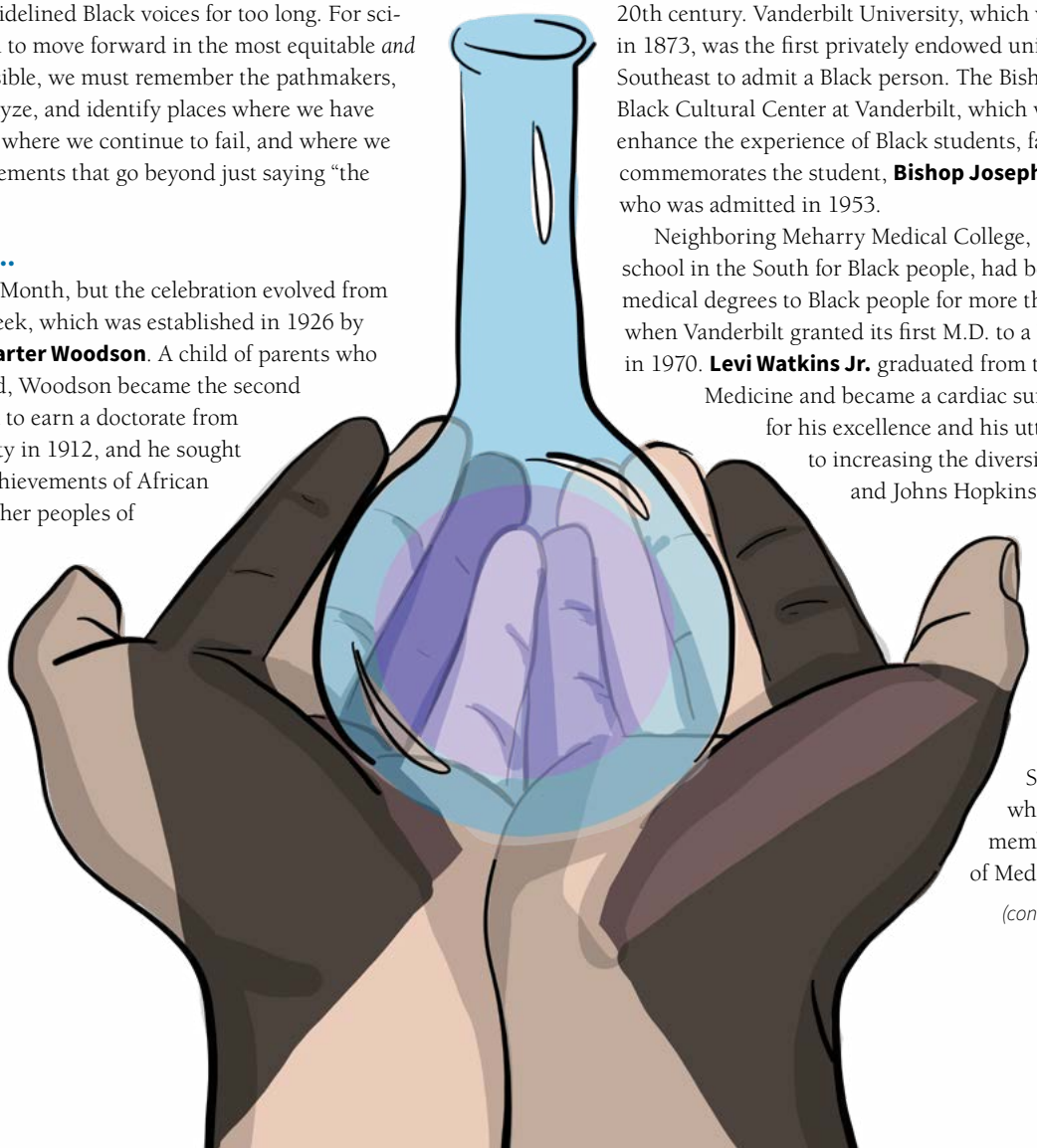
By Lorena Infante Lara

Although issues of diversity, equity, and inclusion have been at the forefront of many people's minds—even more so after last summer's social and racial justice protests—the annual Black History Month celebration helps remind us that creating a diverse, equitable, and inclusive environment does not happen overnight. It is something that we must actively and constantly work on.

Science requires diverse voices to succeed, and academia has ignored and sidelined Black voices for too long. For science and research to move forward in the most equitable *and* effective way possible, we must remember the pathmakers, critically self-analyze, and identify places where we have failed in the past, where we continue to fail, and where we can make improvements that go beyond just saying "the right thing."

From the past...

Black History Month, but the celebration evolved from Negro History Week, which was established in 1926 by Black historian **Carter Woodson**. A child of parents who had been enslaved, Woodson became the second African American to earn a doctorate from Harvard University in 1912, and he sought to promote the achievements of African Americans and other peoples of African descent. In a manuscript discovered in 2005, decades after his death, Woodson wrote, "If a race has no history, it has no worthwhile tradition, it becomes a negligible factor in the thought of the world, and it stands in danger of being exterminated."



The opportunities available for Black people in the United States have been consistently limited and outright curtailed throughout our history, especially in predominantly white spaces. As a result of racist and segregationist practices, many institutions of higher learning kept their doors closed to Black people until well into the 20th century. Vanderbilt University, which was established in 1873, was the first privately endowed university in the Southeast to admit a Black person. The Bishop Johnson Black Cultural Center at Vanderbilt, which was established to enhance the experience of Black students, faculty, and staff, commemorates the student, **Bishop Joseph Johnson Jr.**, who was admitted in 1953.

Neighboring Meharry Medical College, the first medical school in the South for Black people, had been granting medical degrees to Black people for more than 70 years when Vanderbilt granted its first M.D. to a Black person in 1970. **Levi Watkins Jr.** graduated from the School of Medicine and became a cardiac surgeon celebrated for his excellence and his utter commitment to increasing the diversity at Vanderbilt and Johns Hopkins University, where he worked for most of his career. Today, Vanderbilt honors his legacy through the Levi Watkins Jr. Faculty and Student Awards, which are granted to members of the School of Medicine each year.

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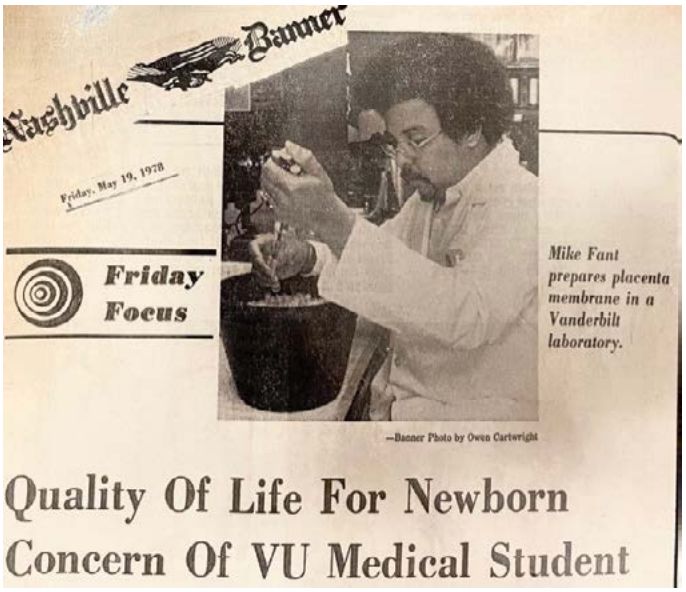

Nashville Banner

Friday, May 19, 1978

Friday Focus

Mike Fant prepares placenta membrane in a Vanderbilt laboratory.

—Banner Photo by Owen Cartwright

Quality Of Life For Newborn Concern Of VU Medical Student

COURTESY OF MICHAEL FANT

Newspaper clipping of a Nashville Banner *story featuring Michael Fant, originally published in 1978. Fant's interest in newborn health led him to a career as an academic neonatologist and developmental biologist until retiring in 2019.*

Recipients—including six faculty and nine students affiliated with Basic Sciences—are lauded for promoting opportunities for underrepresented minorities in our educational or research programs and for fostering a more diverse environment that is enriching, encouraging, and embracing of all students, faculty, and administrators.

It was not until 1980 that Vanderbilt granted its first biomedical science Ph.D. to a Black person; the student, **Michael Fant**, also earned an M.D. from Vanderbilt. "I was the first Black biomedical Ph.D. and the first Black M.D./Ph.D. student at Vanderbilt. I was also among the first seven students to enter the M.D. program," Fant said. At the time, there was no structure in place to help Black students thrive and succeed. "We had to create our own supportive environment on the fly," he said, referring to himself and the other Black medical school classmates. "It was not an institutionalized process."

This recognition of our past, of course, must be coupled with the knowledge that we continue to benefit from work that exploited Black people, directly and indirectly. For instance, take **Henrietta Lacks**, a Black woman diagnosed with cervical cancer in 1951. Unbeknownst to Lacks, a white male scientist at The Johns Hopkins Hospital took her tissue, grew her cells in vitro, and shared them with colleagues for widespread use in biomedical research. Since then, these cells, known as HeLa cells, have been instrumental to research in cancer, immunology, in vitro fertilization, and even COVID-19. This is true even within the Vanderbilt School of Medicine Basic Sciences: 40 of the 71 queried primary faculty have used HeLa cells in their labs.

To the future...

Thanks in part to countless hours of effort by Black people and their allies, Americans are becoming increasingly aware of the disparity in opportunities and the contributions of Black people to the progress of science and this country. Recent examples within STEM are the "Black in X" movements that have taken over social media, including Black In Microbiology, Black In Immunology, Black In Chemistry, Black In Neuro, and more. These social media movements seek to bring visibility to, elevate, and celebrate Black researchers and Black excellence within their respective fields during a designated week, and beyond.


COURTESY OF HENRY HENDERSON III

Henry Henderson, III

One of these movements, Black In Cancer, was co-founded by a postdoctoral fellow at the Vanderbilt University Medical Center, **Henry Henderson, III**. Together with a colleague from the United Kingdom, Henderson planned and led a Black In Cancer Week in October 2020. The event focused on topics ranging from addressing cancer disparities to debunking myths about cancer treatments.

"My favorite event was the roll call," Henderson said. "We had the most Black people that I have seen in cancer careers in my life. It is absurd that it would be on social media. I've gone to these large conferences, but you don't see that." Black In Cancer will carry the intensity of 2020 into 2021 with a year filled with career talks, professional development workshops, and mini science symposia as part of a new, ongoing effort called the Black in Cancer Pipeline Program.

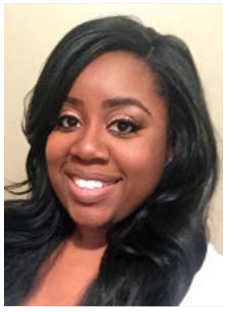
Another endeavor to bring visibility to Black researchers comes from **Antentor O. Hinton Jr.** (page 13), a current postdoc at the University of Iowa and incoming assistant professor of molecular physiology and biophysics here at Vanderbilt. Last February, Hinton, along with two colleagues, compiled and published a list of 100 inspiring Black scientists in America. The list, which was designed to elevate Black scientists, arose following a conversation one of Hinton's colleagues had with an undergraduate student who wondered: are there any other Black science professors, and, if they do exist, why aren't we learning about their accomplishments in our curricula?


SUSAN URMY

Lilian Brady

Assistant Professor of Biochemistry **Breann Brown** (page 10) merited a mention in this list. Subsequent lists (not compiled by Hinton) also recognized Hinton himself; Henderson and fellow Vanderbilt postdocs **Jessica Thomas**, **Lillian Brady**, and **Jamaal James**; and seven other colleagues from across the university.

Basic Sciences actively continues its efforts to increase diversity, equity, and inclusion within its own walls and in academia as a whole through a number of programs. One of the most exciting is the Discovery Science Emerging Scholars program, which highlights outstanding young scientists from underrepresented backgrounds. The scholars are invited to Vanderbilt to give a talk and engage with our students. This program is now in its fourth year and has become a national model for highlighting rising talent in the scientific community. You can keep up with all our speakers with the #EmergingScholarsVU hashtag on Twitter.


LAB.VANDERBILT.EDU/COLBRAN-LAB

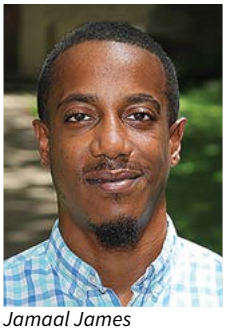
Jessica Thomas

A vital program for Black and other underrepresented students is the Initiative for Maximizing Student Diversity, which provides a holistic admissions route, as well as extensive and careful mentoring

"If a race has no history, it has no worthwhile tradition, it becomes a negligible factor in the thought of the world, and it stands in danger of being exterminated."

– Carter Woodson

STEPHEN DOSTER

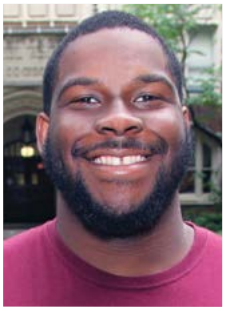


Jamaal James

throughout the entire graduate training period, from first year to dissertation defense.

"The IMSD has definitely helped me engage with other Black graduate students across the biomedical sciences," said **Logan Northcutt**, a third-year student in cancer biology. "It has even helped me build my network with other Black scholars across the country in biomedical research."

The IMSD is home to incredibly talented students, reflected in the fact that up to 90% of them successfully acquire outside funding and fewer than 5% of them leave the program before degree completion. IMSD alumni go on to have successful careers in a variety of fields within science. This issue of Vestigo alone features at least two IMSD alumna—**Janina Jeff**, a Black bioinformatician highlighted on page 35, and myself, a Latina science writer!



STEPHEN DOSTER

Logan Northcutt

Yet, even before the establishment of the IMSD, the Basic Sciences departments were committed to the development of Black scientists and scientists from other underrepresented groups. Between 1995 and August 2020, we granted 183 Ph.D.'s to students from underrepresented groups, including 88 to Black students, a remarkable achievement considering the fact that prior to 1980, no biomedical department at Vanderbilt had granted a Ph.D. to a Black student.

Crucially, some efforts to facilitate the development of trainees from underrepresented groups are driven by our own students, including recent recipients of the coveted Gilliam Fellowship for Advanced Study from the Howard Hughes Medical Institute. Beyond granting research funds, Gilliam Fellowships require that students and their advisors submit a proposal designed to foster the development of a healthier, more inclusive academic scientific ecosystem.

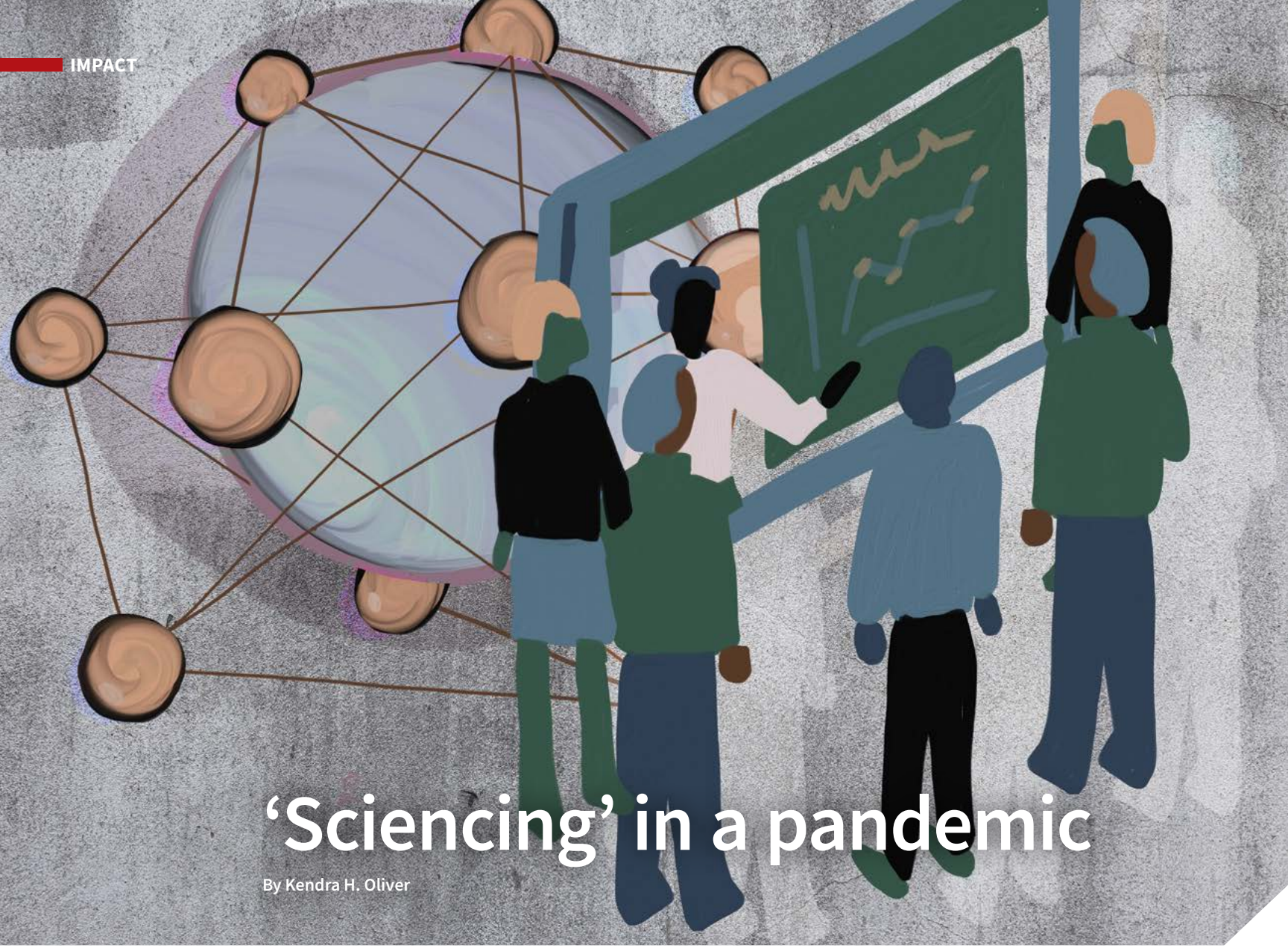
Kellie Williford, a Black, fifth-year Ph.D. student and IMSD member, is one of Vanderbilt's seven Gilliam Fellowship recipients since 2018. In coordination with her mentor **Danny Winder**, Bixler-Johnson-Mayes Chair in Basic Sciences and professor of molecular physiology and biophysics, Williford recently launched a tiered mentoring program designed to serve, among others, individuals identifying as Black, indigenous, people of color, LGBTQ, or disabled. The Leaders Advancing the Development of Diverse Educators and Researchers in STEM, or LADDERS, program groups together trainees and faculty members to discuss topics related to success in academia as part of underrepresented groups.

MEDSCHOOL.VANDERBILT.EDU/BRAIN-INSTITUTE

Kellie Williford

"Black History Month is not only about celebrating our roots as Black people, but also lifting each other up in the here and now, and making sure things are better for those coming after us," said Williford. "We're excited that LADDERS can serve as one way to continue in this tradition of learning from our past and our experiences to reach a better future."

LADDERS is only one of the myriad Vanderbilt programs that help budding scientists to thrive and succeed. Seeing others who look like you doing the things you want to do is empowering, which is why knowledge of Black history and the impacts of Black individuals in our society and within science are worthy of remembrance. Not only that, but they serve as examples and role models for Black people and for the rest of us. With support and the best training we can provide, we hope to pave the way for our students to become the historical figures of tomorrow, so they can continue inspiring scientists-in-training for generations to come. ■



‘Sciencing’ in a pandemic

By Kendra H. Oliver

We live our lives expecting that “business as usual” will change only incrementally and infrequently. Few people expected the traumatic changes this generation is learning to survive. Even with our current adaptations, it is not clear what long-term effects will linger in our futures—and science is not immune.

As the point person in charge of digital science communication for Basic Sciences, I have worked with many people during this time to make the most of the transition, and I have coordinated virtual seminars, dissertation defenses, workshops, poster sessions, and community engagement events. In previous years, my role would have been primarily focused on building online courses and resources behind the scenes. Yet, since early last year, the low burn of the digital frontier has turned into a wildfire as people have adapted to and begun experimenting in digital communication, collaboration, and engagement.

“Can you all see my screen?”

March 2020 began with a rapid transition from in-person to virtual meetings. Students who had planned public dissertation defenses had to pivot to videoconferencing. Restrictions on meeting sizes threatened to disrupt this rite

> "I am always proud of our students for their work, but this has been even more salient this year and last year as they tackle the pressures of graduate school along with the weight of a pandemic."
>
> **– Beth Bowman**

of passage, which marks the end of the Ph.D. training; yet, since then, there have been more than 40 successful virtual defenses within Basic Sciences.

Most virtual defenses have been well attended, with some reaching 100 or even 250 attendees. One recent graduate noted, "I really appreciated the option to present over Zoom. That made it much easier and safer for my friends and family to attend."

The downside, of course, was the lack of live feedback. "I tend to thrive off a crowd and didn't have that experience," another graduate said. "Plus, I was looking forward to celebrating afterward but didn't get to because of the pandemic."

Despite some of these drawbacks, scientists can continue to expand efforts that amplify, simplify, and diversify the extent of their public engagement in the long term. Even before the pandemic, the public's trust in science was growing. Now, its confidence that medical scientists act in the public's best interest has gone up from 35 percent to 43 percent, according to a recent Pew Research Center survey. There is increased interest and opportunity for scientists to facilitate dialogue about the work they are doing at the bench.

Our newly minted Ph.D.'s have demonstrated their tenacity by adapting to new technologies, and they and their colleagues can capitalize on the public's increased receptiveness to science by continuing to broaden their reach through virtually accessible public presentations, videos, blogs, and social media.

Creating and maintaining community

After suffering through forced isolation, many of us are now acutely aware that there is no substitute for meaningful engagement among people. Although many folks embrace the work-from-home lifestyle, others sorely miss social interactions with coworkers and lab mates that used to mark their day-to-day routines. Traditional Western narratives would have us believe that science is a collection of individual achievements by great scientists. Yet, with few exceptions—especially in modern times—science is a social activity.

"My collaborations have been negatively impacted in regard to knowledge exchange and the training that take place during person-to-person interactions," said **Carlos F. Lopez**, assistant professor of biochemistry. "In my experience, person-to-person interactions enable individuals to connect and build trust, which is necessary to both be open minded about others' ideas and to accept their criticism. The lack of person-to-person interaction leads to second-guessing interchanges and, overall, slows down progress. Video conferences can help alleviate this somewhat, but they are definitely not a replacement for in-person interactions."

Even before the pandemic, academics had been plagued with increasing feelings of loneliness. For trainees, virtual meetings are not enough to assuage these feelings or even to enable their professional and scientific development. Trainees, like so many others around the world, are facing personal and professional challenges marred by a curtailed ability to carry out in-person relationship building. The lack of authentic connectivity could be one major contributor to a general sense of reduced mental well-being. **Roger Chalkley**, senior associate dean for biomedical research education and training, is currently working with staff within the BRET Office to examines trainees' responses to the pandemic, including the effects it has had on their motivation and time management, to see how faculty and staff can continue to support them.

"Graduate school is challenging," said **Beth Bowman**, assistant director for the graduate programs in biomedical sciences. "I am always proud of our students for their work,

(continued on next page)

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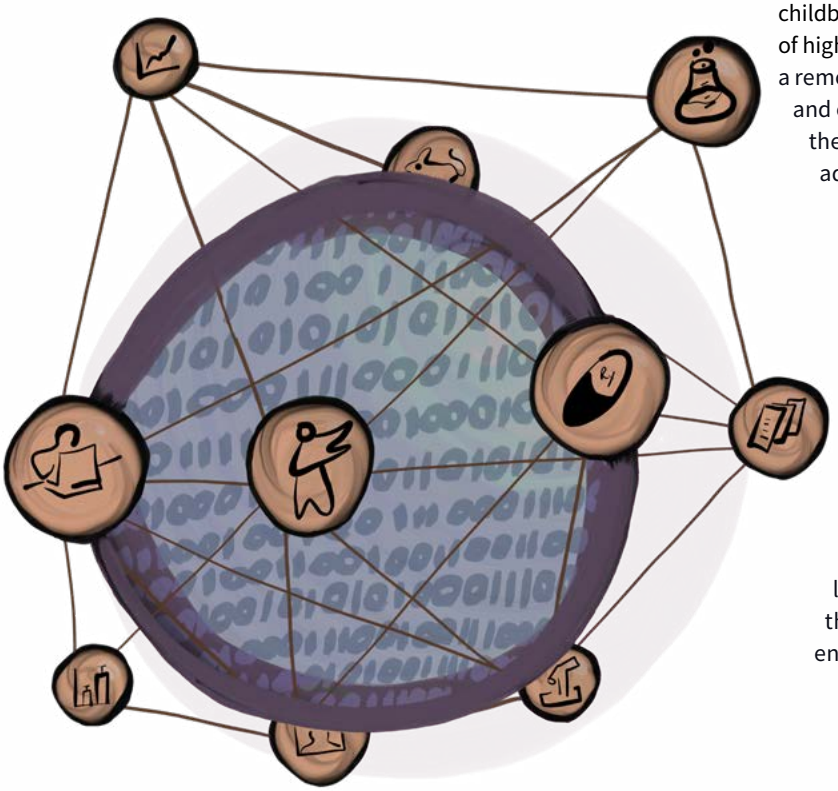
but this has been even more salient this year and last year as they tackle the pressures of graduate school along with the weight of a pandemic." To help alleviate the isolation, she has worked diligently to build and maintain community among current students, including the first-year students who moved to Nashville from all over the country to start a new program alone. To do this, Bowman set up virtual games, such as charades, fishbowl, and trivia, and other virtual gatherings. "Thursday virtual game nights have helped them build community and bring some levity to a challenging couple of semesters."

Lab work—remotely?

The adaption of virtual communication has had consequences that go beyond the training environment, including the normalization of remote work. For many of our employees, skipping the obligatory commute has been a welcome consequence of the pandemic. However, for many laboratory researchers, working from home is not an option.

Restrictions such as limiting the number of people who can share a lab space at one time complicate how researchers like my partner, **Max Joffe**, can carry out their daily work. "Although we can do several things at home, including holding meetings, writing, and conducting data analysis, many of us need to be present in the laboratory to take care of animals, train colleagues, and perform new experiments," said Joffe, a research instructor in the laboratory of Jeffery Conn. "I'm proud of how our lab has fostered a safe work environment, but I've felt the looming risk of catching or spreading COVID-19 throughout the past year."



Thankfully, through the stringent application of COVID-19 transmission prevention measures—such as mandatory mask wearing, physical distancing and limiting of the number of people allowed in lab spaces, and the mandatory asymptomatic testing of all graduate and professional students, among other measures—none of the few COVID-19 cases we've seen within the Basic Sciences community has been transmitted within our lab spaces.

The pandemic is inherently—and naturally—stressful, but these feelings are particularly pronounced within notorious harbors for workaholic cultures, such as science and academia. **Tina Iverson** , who holds the Louise B. McGavock Chair and is a professor of pharmacology and biochemistry, has felt the strain needing to balance work and her personal life. "Particularly from March through September, when school was out and there was no summer camp, I was balancing full-time child care with full-time work," Iverson said. "I didn't think that it would be good for my son to stare at me working and/or play video games all day, so I would spend quality time with him during the day, then work between 8 p.m. and 3 a.m." This meant that Iverson often communicated with her students and postdoctoral trainees during late-night phone calls.

To help reduce burnout, we are now faced with the opportunity to rethink how the academic environment supports the mental and physical well-being of trainees, faculty, and staff, particularly through the intentional design of the work environment. The move to remote work has demonstrated that workers can retain productivity while remaining off site. Flexible working also allows mothers to maintain their working hours after childbirth and to remain in intensive jobs even in times of high family demand. Lamentably, though, moving to a remote work environment has fostered the perception and expectation that people are accessible at all hours of the day, and the lack of in-person connectivity is likely adding to feelings of isolation.

As we think about the future of the work environment and culture within science, promoting flexibility and experimentation—all while ensuring that expectations and boundaries are clear—is essential for supporting the health of the community, which, in turn, fosters innovation.

Undoubtedly, this era of instability and uncertainty will have a long-lasting impact on us as individuals and as members of society. The pandemic, which has been an accelerant for long-overdue workplace changes, has forced us to completely reimagine what healthy workplaces can look like, even within academia. Now is the time to think about changes that can persist even beyond the end of the pandemic. ■

Of genes and podcasting

By Jan Read

Janina Jeff, PhD'12, was the first African American to earn a doctorate in human genetics at Vanderbilt University. A sought-after speaker, she keeps a dual focus on research and education. In 2020, she was the youngest-ever and first African American winner of the American Society of Human Genetics Advocacy Award, and her "In Those Genes" podcast won the Third Coast/Richard H. Driehaus Foundation Competition International Impact award.

COURTESY OF JANINA JEFF

What is your current job?

I'm a senior bioinformatics scientist at Illumina, the leader in next-generation sequencing technology.

Your career focuses on the genomics of certain populations. Why is it important to bring the idea of diversity into the field of human genetics?

No one wins when there is a lack of diversity in research. As a population geneticist, I design genotyping technology that allows us to see how the genetic makeup of populations impacts the course of a disease or infection. Genetics is behind Vanderbilt's commitment to personalized medicine: getting the patient the right medicine at the right time.

The challenge is to get more representation in research without introducing more bias and inequity into the system. To do that, we need to address the distrust that exists in the Black community about how research data is gathered and used. One thing we can do is to make sure people understand what participation means and what the benefit is for the individual. It's a beautiful thing—when people have the education they need, they become empowered to be a collaborator in research as opposed (it being) to a transactional relationship.

I came to Vanderbilt for my Ph.D. supported by the Initiative for Maximizing Student Diversity, an extension of the Interdisciplinary Graduate Program, after I earned my undergrad degree at Spelman College. I did a rotation in human genetics, and that was it—I was hooked. I worked with **Dana Crawford** and her genetic epidemiology research into diverse populations. She was also my Ph.D. adviser.

Genetics can be complicated for the general public to understand. What do you see as your role in helping educate people?

Teaching has always been a part of who I am. I began teaching by starting a tutoring program in high school. And now I frequently go back and guest lecture at Spelman. I am also a public speaker and recently gave my first TED talk. During my Ph.D. program at Vanderbilt, I taught first-grade science one day a week through the Scientist in the Classroom Partnership Program. That particular experience was so hard because I was deep in the weeds with my research and then had to zoom out and teach 6-year-olds. I had to learn how to make something really complicated accessible.

That's the idea behind my "In Those Genes" podcast. It's a hip-hop-inspired podcast that uses genetics to uncover the lost identities of African-descended Americans through the lens of Black culture.

How did you jump from classrooms and a TED talk to podcasts?

In 2018, Spotify launched a boot camp to uplift and amplify voices of women of color. I was one of three women chosen from 18,000 applicants, and that was the launch pad for my podcast.

I wanted to talk about genetics, DNA testing, data privacy and research in a way that was accessible to the Black community, and using Black culture to do this was key.

The podcast launched in late 2019. We were in the middle of producing our season—each episode usually takes a month to put together—when the pandemic hit. At that point, we needed to address all the misinformation going around. We pulled together the "Dat Rona" episode in three days and nights and dropped it on March 19, 2020. The work paid off, and that episode later was a winner in the international 2020 Third Coast/Richard H. Driehaus Foundation Competition!

What's next on the horizon?

I've been thinking about writing a book—a quick read into genetics with my personal story woven in. I also want to keep the podcast going and growing. To date, we've got more than 36,000 listeners, and I'd like that to be more like half a million. I'm finding my newfound secondary career in science journalism very rewarding because I am able to provide space for Black scientists and talk about topics we've never talked about before. ■

Celebrating Excellence

By Aaron Conley

The Vanderbilt University School of Medicine Basic Sciences is consistently one of the top places in the world for academic biomedical discovery. The work that our researchers do is frequently recognized through a variety of awards and appointments. Here is a small sampling:

JOHN RUSSELL

Nancy Carrasco's pioneering public health work was recognized with a National Academy of Medicine election. Current members stated that they elected Carrasco, Joe C. Davis Chair in Biomedical Science and professor and department chair of molecular physiology and biophysics, "for making exceptional contributions" that have "broad impact and significance across biomedical fields" such as cancer, metabolism, molecular endocrinology, and public health.

Scott Hiebert, Hortense B. Ingram Chair in Cancer Research and professor of biochemistry, has been appointed the acting chair of the National Cancer Advisory Board, which comprises scientists hand-picked by the president of the United States. Hiebert was appointed to the board in 2016 by President Barack Obama.

JOHN RUSSELL

Craig Lindsley, William K. Warren, Jr. Chair in Medicine and University Professor of Pharmacology and Biochemistry, was named editor in chief of the *Journal of Medicinal Chemistry*. "JMC is the most trusted and cited medicinal chemistry journal in the world, and my highest priority is to preserve its legacy while further expanding its scope, authorship, and impact," Lindsley said. "I plan to increase the journal's visibility, actively solicit content globally, and embrace the next generation of medicinal chemists across gender and ethnic lines."

JOHN RUSSELL

Charles Sanders, Aileen M. Lange and Annie Mary Lyle Chair in Cardiovascular Research and professor of biochemistry, was elected president of the Protein Society, and will serve a three-year term.

ANNE RAYNER

Alissa Weaver, Cornelius Vanderbilt Chair and professor of cell and developmental biology, and her team have received a $500,000 Future Manufacturing Seed Grant from the National Science Foundation to develop technologies for the production of "designer" extracellular vesicles that can be packaged with specific cargo to create drug delivery systems with "exquisite targeting."

The International EPR (ESR) Society awarded the 2019 IES Silver Medal for Biology/Medicine to **Hassane Mchaourab**, Louise B. McGavock Chair and professor of molecular physiology and biophysics.

The International Society for Advancement of Cytometry has awarded **Caroline Roe**, managing director of the Mass Cytometry Center of Excellence and Cancer & Immunology Core, the title of Shared Resource Education Emerging Leader.

The Burroughs Wellcome Fund announced the 2020 fellows of their Postdoctoral Enrichment Program, which include Valeria **Marie Reyes Ruiz**, a postdoc in the lab of Eric Skaar, and **Jessica Thomas**, a postdoc in the lab of Roger Colbran. Reyes Ruiz and Thomas were among 14 fellows selected from across the country.

Andrea Cuentas-Condori, a cell and developmental biology graduate student in the lab of David Miller, was named one of 10 recipients of the DeLill Nasser Award presented by the Genetics Society of America.

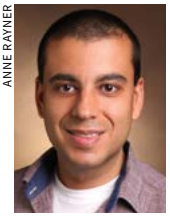
Gabriella Robertson, a graduate student in cell and developmental biology, was announced as a recipient of a 2020 HHMI Gilliam Fellowship for Advanced Study. Along with dissertation advisor Vivian Gama, Robertson is developing a project to improve inclusive scientific spaces.

Angela Kruse, a postdoc in the lab of Richard Caprioli, received a 2020 Human Islet Research Network Scholarship. Nine graduate students and postdocs were selected for this scholarship from a nationwide pool of abstracts.

JOE HOWELL

JOHN RUSSELL

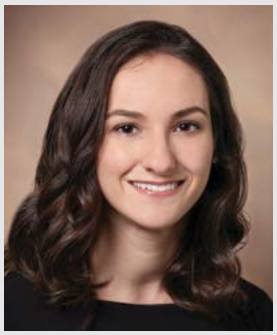
ANNE RAYNER



COURTESTY OF JENNIFER BELOW

Vanderbilt's chancellor, Daniel Diermeier, recognized 10 newly tenured faculty as 2020 Chancellor Faculty Fellows. The selected faculty included **Ken Lau**, associate professor of cell and developmental biology, **Carrie Jones**, associate professor of pharmacology, **Ivelin Georgiev**, associate professor of pathology, microbiology and immunology, and **Jennifer (Piper) Below**, associate professor of medicine. Naming faculty members as Chancellor Faculty Fellows means investing in a select group of younger scholars from across campus, not only advancing their careers at a critical time, but also providing a forum for them to share their academic interests with others on campus to build and enrich our One Vanderbilt community. Each academic year, Chancellor Faculty Fellows must attend at least four events aimed at building interdisciplinary connections and fostering a broader intellectual community, allowing them to share academic interests and expertise. The designation also comes with $40,000 of funding per year for two fiscal years to support the professional development of the awardees.

Thanks to their high academic and scientific achievement, eight graduate students were presented with the Dean's Award for Exceptional Achievement in Graduate Studies in 2020:



Slavina Goleva (Molecular Physiology and Biophysics); advised by Lea Davis

Jooeun Kang (Human Genetics); advised by Douglas Ruderfer

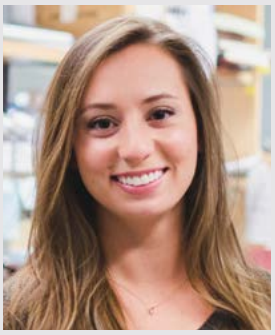
Anna Kasdan (Neuroscience); advised by Reyna Gordon

Tiffany Richardson (Molecular Physiology and Biophysics); advised by Al Powers

Sarah Glass (Biochemistry); advised by Fred Guengerich

Andrea Shiakolas (Microbe-Host Interactions); advised by Ivelin Georgiev

Kim Thibeault (Neuroscience); advised by Erin Calipari



Paige Vega (Cell and Developmental Biology); advised by Ken Lau

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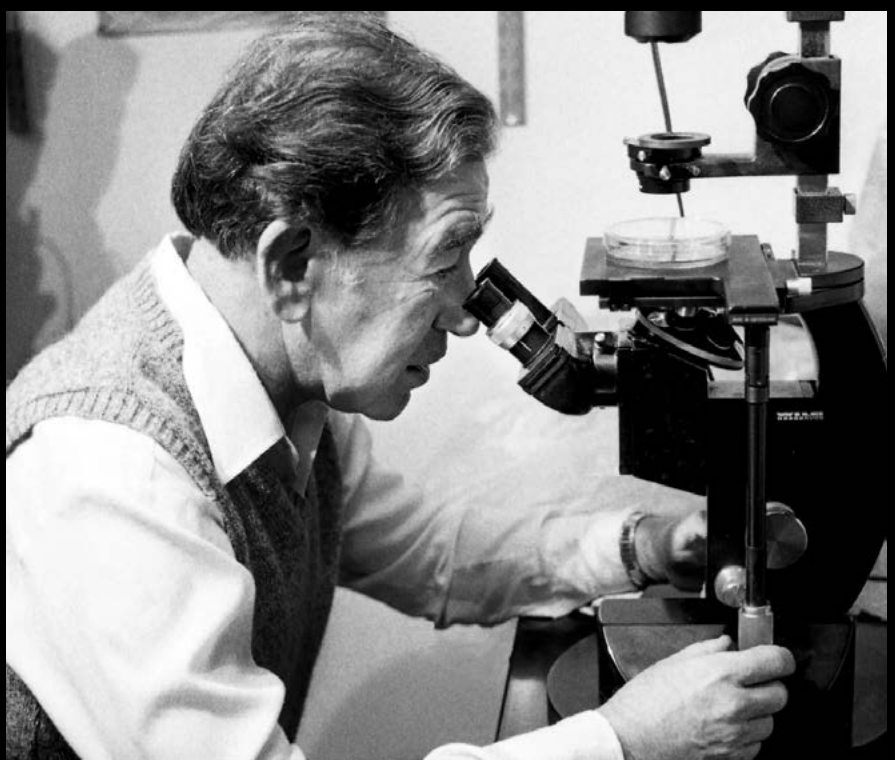

Established in 2019 and named in honor of Nobel laureate Stanley Cohen, emeritus professor of biochemistry, the Stanley Cohen Innovation Fund supports high-risk, high-reward research in perpetuity. With your help, we will accelerate the pace of discovery science at the School of Medicine Basic Sciences.

Basic Sciences has pledged to double the impact of our generous partners by matching all eligible gifts of $50,000 or more through June 2021. For more information, call (615) 343-1635 or email basicsciencesgiving@vanderbilt.edu.

Make your gift to the Stanley Cohen Innovation Fund today by visiting giving.vanderbilt.edu/cohenfund.

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