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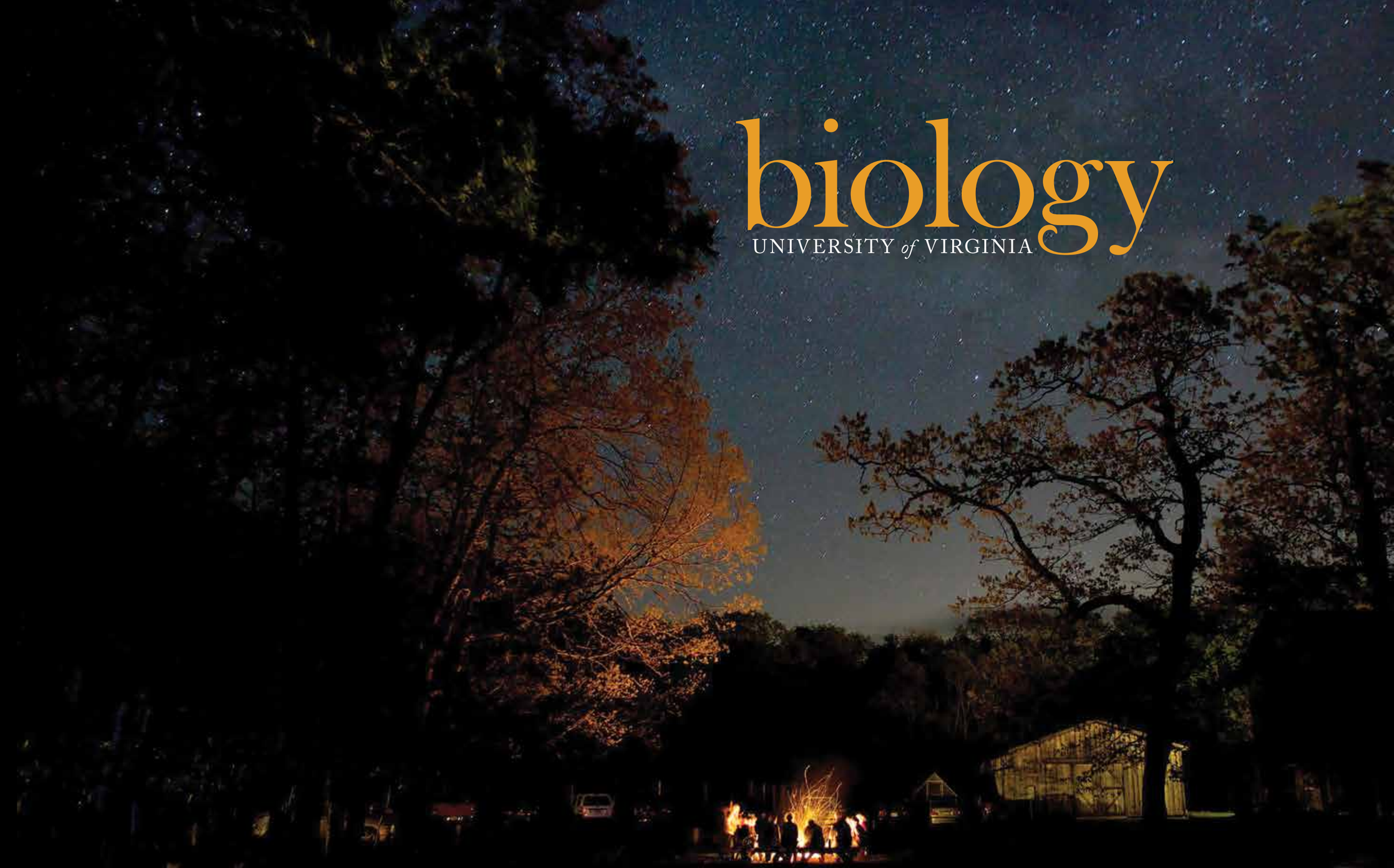

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Fall 2024

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The Importance of Foundational Biological Research

It is hard to overestimate the power of fundamental biological research, the kind that aims to uncover foundational truths about life. Virtually every advance in medical treatment over the last 100 years had its origins in biologists' painstaking efforts to understand the remarkably complex mechanisms of life. Vaccines for COVID, immunological treatments for cancer, and the use of gene therapy for cystic fibrosis and other diseases all owe their success to the cumulative breakthroughs of many scientists over decades of research. Equally important, foundational research satisfies the quintessentially human impulse to explore profound questions about our world and better understand our existence.

The pressures of the marketplace and the demand for short-term returns make this kind of research difficult for the private sector to sustain—which is why research universities like the University of Virginia are so important. Universities allow faculty leeway to explore new ideas and tackle complex projects that may require years of effort. But it is this endeavor that the private sector, with its deeper pockets but shorter timeframes, depends on for the advances that sustain our quality of life.

This potential synergy can be seen in our department's research programs. As I walk down our hallways, I pass foundational research programs that have the potential to fuel new treatments for obesity, addiction, birth defects, infectious diseases, Alzheimer's disease and other neurodegenerative conditions. The creativity and ingenuity that drives these efforts is also in evidence. Our faculty does not hesitate to supplement typical lab models like fruit flies and mice with nontraditional models like tree shrews and fungus beetles when they more vigorously advance the foundational questions they are studying.

If society is to sustain this level of foundational research, universities must train the next generation of researchers and share the value of basic research with the larger community. In addition to highlighting research underway in our labs and in the field, this newsletter offers examples of faculty members helping to launch graduate students and postdoctoral fellows on research careers as well as the many outreach efforts undertaken by members of this department.

There are far more stories to tell about all these initiatives than can be contained in a single publication. If you want to learn more, please reach out, stay connected, and arrange a visit.

Douglas R. Taylor
Commonwealth Professor and Chair of Biology

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welcoming faculty at the start of their careers

The study of biology—like its subject—is constantly evolving. New technologies and new perspectives breed new questions and new hypotheses. While the best scientists remain vital and creative throughout their careers, there is no denying the energy and enthusiasm young researchers bring to the field. Supporting them as they embark on their careers is probably the most important thing we do as a department. In 2023 and 2024, the following young researchers joined the department.

PHOTO CREDIT?

Placing Germline Stem Cells in Context

WHEN ASSISTANT PROFESSOR Daniel McIntyre graduated from UVA as a biology major, he never intended to return to the University or make a career as a scientist. He moved to Boston and became a skiing instructor. After relocating to Ann Arbor a few years later, he happened into a job as a lab technician at the University of Michigan, an experience that both rekindled and redirected his interest in biology.

"While at UVA, I primarily took courses in ecology and evolutionary biology," he recalls. "At Michigan, I found that developmental biology better matched my interests." After completing a doctorate at Duke and a postdoc at the New York University Medical Center, McIntyre rejoined the department in 2023.

McIntyre's choice of research subject—germline stem cells, which give rise to eggs and sperm—takes him to the heart of developmental biology. He studies the complex dynamic microenvironment that modulates the activities of these stem cells—for instance, whether they replicate or differentiate—so that they respond appropriately to the needs of the organism.

This niche is composed of specialized cells, the proteins they secrete, and the extracellular matrix, which all interact with stem cells through chemical and mechanical signaling while excluding harmful signals. "If we want to use stem cells to treat disease and for regenerative therapies," McIntyre says, "we need to understand more about how these interactions work."

Investigating the Dynamics of Niches

Among other questions, McIntyre is interested in exploring how stem cell niches form during development. The niche cells must move, change shape, reorganize, communicate with each other, and produce extracellular matrix. As part of this process, niche cells extend their membrane around the surface of a stem cell. As McIntyre describes it, the stem cell looks like a softball sitting in a niche cell glove. "By increasing the contact area, the niche cells may be amplifying necessary signaling with the stem cells while limiting inappropriate ones. Or they could be heightening the biomechanical feedback between them," McIntyre says.

McIntyre is also interested in the basement membrane, a sheet-like extracellular matrix structure that forms in the niche and controls stem cell proliferation. Basement membranes are ubiquitous in the body and, among other functions, generate chemical signals and mechanical feedback. But in the stem cell niche, stem cells do not come in direct contact with the basement membrane. Rather, the niche cells serve as an intermediary. "We know how niche cells receive a signal from the membrane, and we know how they transmit that signal to a stem cell," McIntyre says. "I'm interested in what happens to that signal as it moves within the niche cell."

This additional step in the exchange of information highlights the unusual complexity of the niche cell environment. "You can imagine that this kind of complexity could add vulnerability to the system—there are more things that could go wrong," McIntyre says. "But you can also imagine it contributing to the system's robustness, serving as an added check that the signals delivered to the stem cell are appropriate."

The Tug of War between the Sexes

ONE MIGHT THINK THAT it would be advantageous for a well-adapted organism with a winning combination of DNA to reproduce clonally and pass on an exact copy of its genome. In most cases, however, organisms, particularly multicellular organisms, reproduce sexually. "There are many good hypotheses about the benefits of combining genomes," Assistant Professor **Katja Kasimatis** notes. "My interest is in how this works out in practice." In particular, Kasimatis focuses on the sexual antagonism that arises because the two sexes often have different and conflicting strategies for reproduction.

A Three-Part Approach

As Kasimatis looks at this issue, she moves back and forth among three different perspectives. At the genomic level, Kasimatis is exploring how strong sex differences—such as a peacock's elaborate tail and a peahen's short one—evolve as a result of sexual antagonism. For instance, an allele, or version, of a gene that produces long tails, favoring males and disadvantaging females, is in conflict with an allele that produces short tails, advantageous for females but detrimental to males. Kasimatis is trying to understand how the increased prevalence of one allele affects the fitness of each sex and of the organism as a whole. "We are also trying to determine how a resolution of this conflict, which would correctly couple the beneficial version with its correct sexual environment, might occur," Kasimatis says.

Kasimatis also examines sexual antagonism in terms of behavior, focusing initially on differences in mating rates. Because sperm are less metabolically taxing to produce, males tend to develop traits that favor frequent mating. On the other hand, females pay a higher metabolic price to develop eggs, so they develop traits that counter the males' influence. When males respond in kind, this sexual antagonist coevolution spirals out indefinitely. "We want to map the genetic basis of this coevolution and examine how it contributes to genome evolution," Kasimatis says.

Finally, Kasimatis wants to better understand the ecological influence on sexual conflict. In the lab, she works with *Caenorhabditis elegans*, a species of nematode that has long been used to study evolution. To gain a clearer picture of the ecological context driving the types of sexual conflicts she studies, Kasimatis has begun to sample wild worms in the Charlottesville area, finding *C. remanei*, another species in the *Caenorhabditis* genus that reproduces only sexually. "Our research aims to highlight instances where sexual conflict affects evolution in nature so that we can determine the conditions under which this evolutionary force is relevant to genome evolution," she says.

Off to a Good Start

One reason that Kasimatis came to UVA is the department's strong ecology and evolutionary biology group and its extensive experience working with *C. elegans*. "The research other faculty members are doing complements my own," Kasimatis says, "creating many possibilities for collaboration."

Having joined UVA in January 2024, Kasimatis feels she is still learning what it means to be a principal investigator and run a lab, but she's very much enjoying the process. "There are few more positive experiences than setting up a lab the way I want it," she says. "The department has been very supportive, enabling me to hit the ground running."

Regeneration in Real Time

ASSISTANT PROFESSOR **Melanie Worley** operates at the intersection of two powerful tools—single-cell analysis, or sequencing, and the *Drosophila melanogaster*, or fruit fly, model system. Her goal: to shed light on regeneration, a complex process that even after decades of study is only partially understood. "If we can learn more about the genetic pathways that regulate the capacity for regeneration, we may find ways to better heal our own bodies," Worley says.

Regeneration is a complex process. A mass of cells must be recruited, become more plastic, and ultimately be repatterned. Single-cell analysis gives her a printout of what happens at the cellular and molecular levels within different tissues throughout regeneration. The genetics of the fruit fly allows her to systematically test her hypotheses about the origins of the items on that printout.

Tracking Gene Expression

Over the last decade, researchers have made tremendous strides in refining single-cell analysis. Because older methods required pulling many cells together, they could yield only generalized results. With single-cell analysis, researchers can focus on genes that can cause disease or identify cell-to-cell variability.

Worley uses a specialized form of single-cell analysis to take a snapshot of a cell's RNA activity—and she can do so for thousands of individual cells simultaneously. This profile of the cells is essentially a record of the genes that are turned on, or expressed, at any given moment. "You can take a cell that is attempting to undergo regeneration and compare it to a cell that is not," Worley says. "This can help you pinpoint the genes that are being expressed."

Worley can then determine if these differences in expression are significant for regeneration by knocking them out in the fruit fly model and seeing if that makes a functional difference. "Because of its long history as a model system, we can readily manipulate *Drosophila* genetics," she says. "Another advantage of working with *Drosophila* is that we can easily scale up and test many genes at the same time."

Reconstructive and Rogue Regeneration

Using single-cell analysis, Worley has determined that cells in different areas of the blastema, a zone of increased plasticity that is a focal point for regeneration, upregulate different genes. Members of her lab are making CRISPR knockouts in *Drosophila* to eliminate these genes and then exploring whether they are critical for regeneration.

She has also discovered that the gene responsible for Ets21C, a protein that binds to DNA sequences to regulate gene transcription, is upregulated in the blastema. Using a CRISPR knockout, she found that this gene was essential for regeneration but not for normal development. "This highlights our growing understanding that regeneration is different in significant ways from development," Worley says.

In addition, she has discovered that inappropriate upregulation of Ets21C may also play a role in tumor growth. Using a tumor model in *Drosophila*, she found that Ets21C was expressed in a region of cells that seemed to promote proliferation, an organization reminiscent of the blastema. When she knocked out Ets21C, tumor growth slowed. This highlights that understudying how regenerative growth is regulated may also yield insights in cancer biology.

Worley believes that UVA will be a great location to pursue this line of research. "UVA has assembled a wonderful group of developmental biologists," she says. "They've been really helpful in getting me off to a great start."

The Coevolution of Predators and Prey

ANYONE WHO HAS EVER left fruit on the counter too long understands why evolutionary biologists prefer to work with model systems like *Drosophila melanogaster*, the fruit fly. They breed profusely, their lifecycle is short, their genetics are relatively simple, and their care and culture are straightforward and inexpensive. After over 100 years of study, their genome is well established, and there is a range of specialized tools to study them.

Assistant Professor **Drew Schield** takes a different approach. Schield came to biology as a child who loved the outdoors and who was fascinated by every "critter" he came across. Although in graduate school he became, as he says, "a card-carrying evolutionary biologist," his research has been shaped by these childhood encounters. His model organism of choice: speckled rattlesnakes, which are native to the arid basin-and-range country and deserts of the Southwest. They have few of the advantages of *D. melanogaster*, but for Schield's purposes, snakes—particularly wild venomous snakes—have advantages that far outweigh their obvious limitations. They enable him to draw on natural history as well as evolutionary and population genetic theory in fascinating ways.

"I use my inherent interest in these organisms to shape my research questions and to hopefully gain a broader perspective on how evolution works," he says.

A Genetic Arms Race

A case in point is the evolution of venom, which vipers use almost exclusively to kill prey. "If we knew nothing about the natural history of venom and its ecology, we would have a poor framework for investigating why it evolves as it does," Schield says. "But we know that snake venom is used to kill prey—and we also know that in many cases, prey species have evolved mechanisms to resist venom. This kind of coevolutionary antagonism sets up a variety of testable hypotheses."

BLAIR PERRY

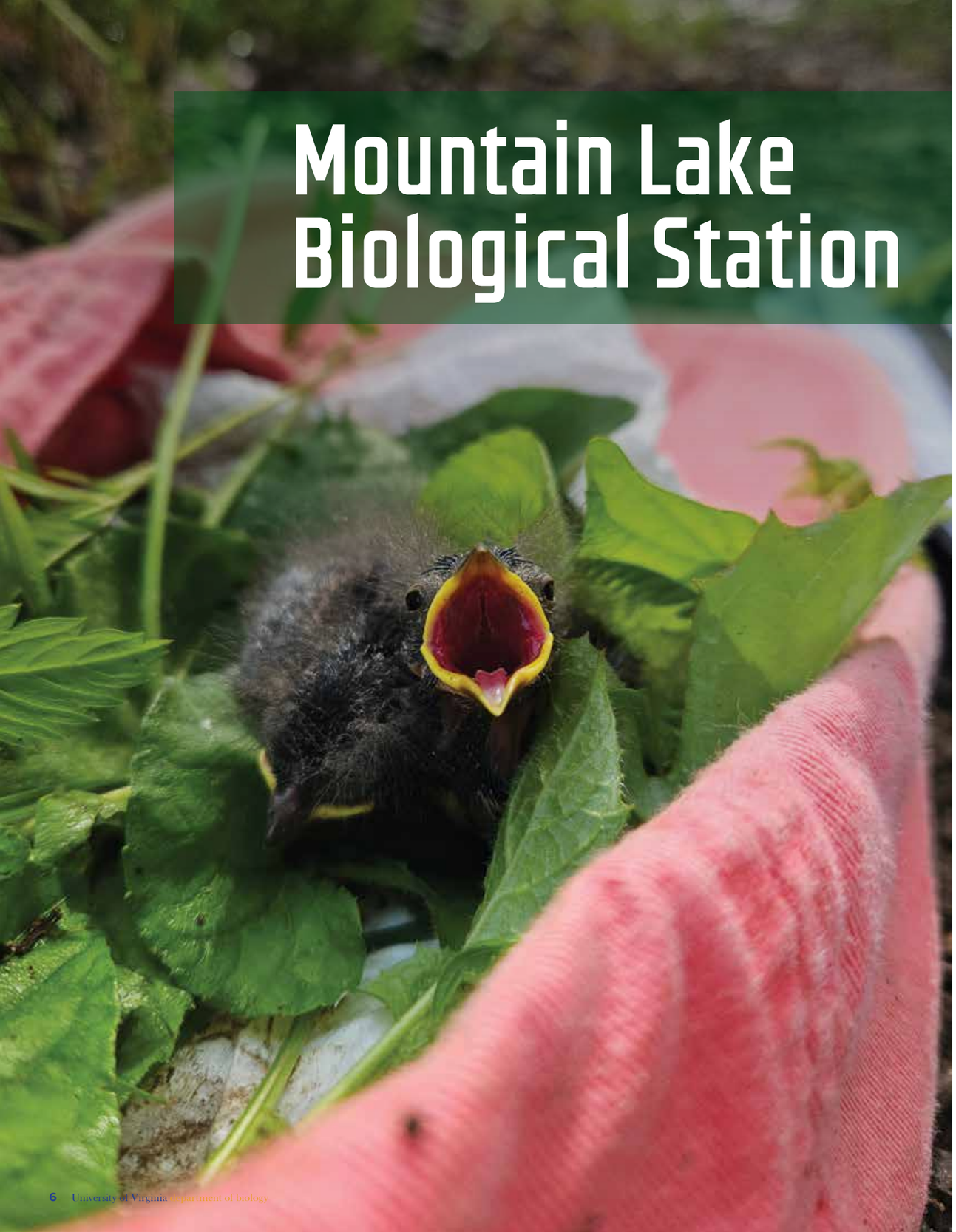
Collaborating with experts on such rattlesnake prey as ground squirrels and wood rats, Schield will employ evolutionary and population genetics theory to frame his investigation of how natural selection—as well as other factors like genetic drift, recombination, and mutation—acts in concert to shape the evolution of venom and venom resistance over time.

The parts of the genome that are responsible for venom composition are already well known. If Schield and his colleagues can discover the genes in the rattlesnake's prey that lead to venom resistance, they can apply the tools of population genetics to test whether predator and prey are experiencing similar selection pressures. "We will look at this issue in really fine detail," Schield says. "We want to identify the whole suite of components that contribute to these traits to better understand coevolution in nature."

A Home for Integrative Research

UVA Biology's receptivity to this kind of integrative work, Schield says, is why he was delighted to be offered a position at the University. "There are many people here whose work draws from different subdisciplines in biology," he says. "My goal is for my research to become even more integrative over time. The department is excited about that possibility."

Mountain Lake Biological Station



CARLIE SALINE

Mountain Lake was founded in 1930 as a way for UVA biologists to escape Charlottesville's summer heat and continue their laboratory studies in a cooler climate. It wasn't until the late 1960s and early 1970s that Mountain Lake attained national prominence as a field research station.

The station maintains over 30 buildings, including two laboratories, a dining hall, cottages and dorms, and an outdoor pavilion. But it is the mix of people and the culture established over many decades that set Mountain Lake apart. During an average high-season day, MLBS hosts between 50 and 75 people, including undergraduate and graduate students, research faculty from around the world, and family members. Everyone in the community works, eats, and lives together on a daily basis. "It's a rare instance of students and faculty getting to know each other as individuals," Mountain Lake Director Edmund "Butch" Brodie says. "It humanizes what we do in a way that's hard to achieve on a large campus."

Fertile Ground for Innovative Research

"Field stations are outdoor laboratories," Mountain Lake Biological Station (MLBS) Director **Edmund "Butch" Brodie** says. "For researchers who study organisms in their natural context and investigate such topics as the processes of genetic differentiation and adaption or anthropogenic impacts on the environment, they are as critical as a $300,000 microscope to a researcher in a traditional lab."

As one of UVA's three field stations—an unusually large number for a university—Mountain Lake has many distinct advantages. It is situated on a remote wooded ridge at 3,800 feet, precisely on the divide between the Atlantic and Mississippi drainage basins. The station itself is 600 acres in size, with access to 2,500 acres of the Mountain Lake Lodge Conservancy property and over 10,000 acres of wilderness area in the adjacent Jefferson National Forest.

The variety of rich and diverse habitats found across this landscape—including mixed deciduous forests, mountain streams, successional meadows, and sphagnum bogs—and its strong ecological gradients and fine-scale changes in habitat provide abundant opportunities for observational and experimental studies on scales relevant to the ecology and evolution of many plant and animal populations.

In 2017, Mountain Lake was designated one of 50 monitoring sites for the National Environmental Observatory Network (NEON). NEON was designed to collect long-term open-access ecological data to promote a better understanding of how U.S. ecosystems are changing.

"One of the great things about Mountain Lake is the diversity of researchers it attracts," Brodie says. "They range from senior researchers who have based their life's work at Mountain Lake to undergraduates being exposed to research for the first time. It's a unique experience—and most people who discover it are changed forever."

Accommodating an Evolving Research Agenda

Professor **Ellen Ketterson**'s experience highlights the ability of Mountain Lake to sustain a varied research program over the course of a scientist's career. A behavioral ecologist and evolutionary biologist at Indiana University in Bloomington, Ketterson first arrived at Mountain Lake in 1979 and has visited the station every year since then. She has pursued a succession of research questions that have arisen from her study of its dark-eyed juncos. "The place is the same, and the bird is the same, but the questions we ask about that bird have changed considerably over time," she says.

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Originally, Ketterson focused on differential migration, the tendency of females to migrate farther than males. She later explored the benefits to males of caring for offspring. In 1987 Ketterson began artificially raising testosterone levels in males to determine if the elevated levels

Facing page: Ellen Ketterson, a professor at Indiana University in Bloomington, has used Mountain Lake's dark-eyed juncos to investigate a range of research questions.

Virginia Tech Associate Professor Chloé Lahondère studies mosquito-plant interactions, creating a path to new methods of mosquito control.

Knowledge as Mosquito Control

Mountain Lake is also an important resource for Virginia researchers. Associate Professor **Chloé Lahondère** discovered the research station only after joining Virginia Tech's Department of Biochemistry in 2017. Looking for a site to conduct fieldwork on disease-vector insects like mosquitoes, she came across MLBS on Google Maps and decided to undertake the 25-minute drive from Blacksburg to see if there were populations to study. She was undeterred by assurances that the station was relatively mosquito free. "That simply meant that there were few mosquitoes targeting humans," she says. She found a species that targets blood hosts like frogs and another one, invasive in the United States, that attacks small mammals like chipmunks.

Lahondère subsequently decided to pursue a significant portion of her research at Mountain Lake. One ongoing project focuses on mosquito-plant interactions, which is critical because male mosquitoes feed on sugar from plants rather than blood. "If we can better identify the plants they are attracted to, we can develop new strategies for mosquito control, using plant scents for baits and traps," she says.

Because of the implications for human diseases, most researchers study mosquitos that feed on warm-blooded hosts. By studying adaptations for cold-blooded hosts, Lahondère hopes to learn more about how various mosquito species evolve to find and feed on their preferred hosts and transmit pathogens along the way.

The Evolutionary Impact of Social Networks

Mountain Lake also fosters long-term collaborations. Station Director Brodie and **Vincent Formica**, an associate professor of biology at Swarthmore College, have been studying the connection between social environments and evolution in the forked fungus beetle since 2012, when Formica was a postdoctoral fellow in Brodie's lab. "We're interested in how the process of natural selection shapes and is shaped by social behaviors," Formica says.

Forked fungus beetles conduct all of their fighting, mating, and reproductive behaviors on the surface of individual fungus brackets found on logs and snags. Through direct observation and genetic analysis made possible by a committed team of undergraduates, Brodie and Formica have been able to collect fitness data on roughly 500 adults each season. These data have revealed the structure of social networks from a variety of perspectives and have shown how properties like age and personality alter connections within networks and ultimately affect the fitness of individuals and the evolution of social behaviors and phenotypes.

IAN NICHOLS

Vincent Formica, an associate professor at Swarthmore College, examines the relationships between natural selection and social behavior.

Virginia Tech's Chloé Lahondère studies mosquito-plant interactions, which is critical because male mosquitoes feed on sugar from plants rather than blood. "If we can better identify the plants they are attracted to, we can develop new strategies for mosquito control, using plant scents for baits and traps," she says.

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Vincent Formica, an associate professor at Swarthmore College, examines the relationships between natural selection and social behavior.

Offering Undergraduates a Real Taste of Science

For 31 straight years, Mountain Lake Biological Station (MLBS) has hosted a Research Experience for Undergraduates (REU). This program, sponsored by the National Science Foundation (NSF), "seeks to attract a diverse pool of talented students to careers in science and engineering and to help ensure that they receive the best education possible." REU grants are offered on a competitive basis, and NSF judges tend to favor new applicants. But Mountain Lake has successfully renewed its grant at five- and, more recently, three-year intervals since 1993. "Our REU program is one of the jewels in our crown," says Butch Brodie, the director of MLBS. "It goes to the core of everything we do."

There are a number of reasons for Mountain Lake's success in securing NSF funding for this 10-student, 10-week summer program. Primary among them is its ambition and rigor. "Compared to many other REU programs, ours offers students a high degree of independence," says **Eric Nagy**, who oversees the program as associate director of the station. "We treat undergraduates like graduate students. They design their studies and write proposals, collect data and analyze their results, and, finally, interpret their results and prepare written and oral presentations."

Recent projects have looked at the role of microbes in helping their hosts adapt to a warming world, chemical communication cues among beetles selecting partners, and the development of a toxic sugar bait for mosquito control. Nagy estimates that more than half of the projects end up being included in a publication. Considering that many students arrive at Mountain Lake not knowing how to conduct research, this is an achievement—but it is not the only criterion for success. "Whether their work is publishable or not, the important thing for me is that students have ownership of their projects and feel that they succeeded in what they set out to do," Nagy says.

Structured Independence

Although his expectations of REU students are high, Nagy has designed the program to provide a framework to help them gain "the nuts-and-bolts skills they need to be good scientists." He kicks off the program with a four-day bootcamp during which students come together to collaborate on a project and go through all the steps they will follow in the course of conducting their research and writing up their conclusions. The REU also includes seminars on such topics as applying for graduate school, dealing with stress, and communicating with nonscientists.

In addition, the students have a series of milestones they must reach during the course of the summer. During their first two weeks at the station, students work closely with their mentors to develop research proposals they will deliver orally to the entire station. And starting 10 days before the end of the session, they focus on writing final reports and developing 15-minute oral presentations for the concluding REU symposium.

Students also receive support and guidance throughout their stay from faculty mentors conducting research at MLBS. Unlike other REU programs that allow students to choose their mentors, Mountain Lake pairs students with mentors as part of the acceptance process. As a result, mentors and students can begin developing a connection long before the session starts. Mentors often suggest background reading, and together they can explore potential projects over Zoom. "One of the things that makes the REU program so special is the close professional relationship that develops between students and their mentors," Nagy says. "It closely parallels that which graduate students have with their advisors."

JAIME JONES

For her REU project, St. Olaf's College student Hannah Marti studied cannibalism in the forked fungus beetle.

Changing Lives

Given the quality of the program, it is not surprising that the REU often receives more than 300 applications for just 10 spots. Selection is difficult. About half of the applicants qualify for the program, but Nagy and the mentors tend to favor those who come from small colleges without research opportunities and those whose career goals are relevant to the types of opportunities available at Mountain Lake. "We want to select those we can serve best," Nagy says.

All the effort that Nagy and his colleagues put into the program pays dividends in the long run. "My job satisfaction comes from receiving emails from former students telling me that the REU changed their lives and sent them down career paths they didn't know were available to them," Nagy says. "That's just magical for me."

The Arts & Sciences

JONATHAN DRESCHER-LEHMAN

It was like a rose in bloom. I thought to myself, 'Why wouldn't you pick it?'

When MLBS Director Butch Brodie approached faculty members at the UVA Department of Art's Studio Art Program in 2011 with the idea of starting an art program at Mountain Lake, he initially had no takers. But when Professor **Megan Marlatt** heard about it, she was intrigued. "I met with Butch, and he urged me to go up to Mountain Lake and see it for myself," she recalls. "It was October. I saw this beautiful place, and I knew artists would do really well up there. It was like a rose in bloom. I thought to myself, 'Why wouldn't you pick it?'"

Initially, Marlatt began by offering summer art classes at Mountain Lake, but that program soon morphed into ArtLab, a two-week summer residence program for seven established artists and six art students. Marlatt and her colleague, Associate Professor **Amy Chan**, coordinate the program.

A Preserve for Artists

For professional artists, two weeks spent at Mountain Lake in the company of other artists and scientists is an irresistible opportunity to devote uninterrupted time to their work. "Although typically working alone, artists feed off each other's commitment and creativity," Marlatt says. "It's a very productive time."

All costs except dining are covered by the program. Six of the artists are chosen from an application pool, which this year reached 80. The seventh, the Lucile Walton Fellow, receives a small stipend and is expected to deliver a lecture to the station community. As part of the selection process, Marlatt, Chan, and MLBS Associate Director Eric Nagy choose a range of artists working in different media, not limiting themselves to the plein air painters often associated with working in nature. They choose artists whose work reflects the full breadth of contemporary art and try to have a balance of media within each year's group to foster exchange across disciplines. "As long as their work intersects with science or engages nature in some way, we consider them," Marlatt says.

Marlatt's goals for the undergraduate fellowship program are closely aligned with the station's educational mission. "We focus on students between their third and fourth years," she explains. "We want students to continue to improve as artists during their undergraduate years, but it is easy for them to lose momentum during the summer when everyone scatters. We see ArtLab as a way to bridge that gap." And by working side by side with professional artists, students gain a sense of what it means to make a career of art.

Faculty members directing each of the UVA Studio Arts Program's six concentrations submit recommendations, and the applications committee chooses from among them on the basis of merit. Students do not receive credit for participating, but all costs are covered.

A Shared Commitment to Creativity

While the artists benefit from their stay at Mountain Lake, Brodie's initial idea had as much to do with the resident scientists as it did with the artists. "Butch thought that by bringing artists to Mountain Lake, he could encourage them to see their work from different perspectives and to be more creative," Marlatt says.

For instance, the first Walton Fellow, Ana Golici, a mixed-media artist best known for digital prints inspired by science and nature, created a paper art piece based on the way Brodie's model organism, the forked fungus beetle, folds and unfolds its wings.

CLAY GONZALEZ

Pam Brown, a New York–based sculptor who also works in paper (top) and Julia Galloway, a potter from Montana, have been artists-in-residence at MLBS.

There have also been instances of artists and scientists initiating collaborations. Sound artist and electronic musician Stephen Vitiello is known for transforming incidental atmospheric noises into soundscapes. He joined forces at Mountain Lake with Associate Professor Kasey Fowler-Finn, an evolutionary biologist from Saint Louis University, to capture the sound of insect movement on the stems and leaves of plants. These recordings were manipulated at Virginia Tech's Institute for Creativity, Arts, and Technology and presented in the Cube, the institute's immersive environment.

"Although artists and scientists have different languages," Marlatt says, "they both share a deep commitment to creativity."

Mountain Lake Biological Station **Highlights**

Demystifying Science

When **Jaime Jones** assumed her position as Mountain Lake station manager in 2012, one of the first things she did was revive its annual open house. "The members of the local community really wanted it," she recalls. "And we feel that it's important to make the kind of science we do here accessible to people who are nonscientists. An open house is probably the best way we can do that."

Each summer, researchers, artists, and students welcome visitors to their labs and studios. They also organize tours, talks, and hands-on activities, developing a program that varies from year to year depending on who is at the station. "I'm always impressed by how good our residents are at conveying their enthusiasm for their work as well as its importance," Jones says.

JAIME JONES

MLBS faculty introduce open house guests to nature at high resolution.

There are, however, some constants. The pond is always a big hit with children, who love splashing around as they learn about salamanders and tadpoles. In recent years, adults have taken the short trek to the foot of the station's National Ecological Observatory Network tower, learning about the goal of the network and the specialized sensors researchers use to make their observations.

The open house attracts an average of 250 visitors each year. "We hope they come away not just with a better grasp of the natural world but also with a more informed understanding of research and its importance," Jones says. "We hope to convey an appreciation for the kind of science that generates new knowledge, regardless of whether it impacts human life."

Becoming Scientists

The Evolutionary Biology Graduate Student Workshop at Mountain Lake is designed for young scientists at a pivotal moment in their careers—just before they write their dissertation proposals. "Our goal is to challenge the participants not only to think about the big outstanding questions in evolutionary biology but to understand, on a fundamental level, what makes them big," says Assistant Professor **Amanda Gibson**, one of the founders and organizers of the workshop.

The workshop is an intense, student-driven experience. Over the course of six days, students, collaborating in groups of four, hammer out testable hypotheses, design targeted experiments, and draft their proposals. They challenge their counterparts to define and sharpen their ideas—and to convey them, orally and in writing, in a clear and compelling manner.

For most of the course, the four instructors take a hands-off role, monitoring the discussions, providing feedback when asked, and intervening only when groups get stuck. "This can be as challenging for the instructors as it is for students," Gibson says. "Most of are us are used to taking a more active role as teachers." But the course is not without structure. Students share their ideas on the third day, submit proposals on the fourth, revise on the fifth, and make final presentations on the sixth. There are also special sessions on scientific writing and effective presentations.

"A remote and biologically rich location like Mountain Lake is an ideal setting for the course," Gibson says. "The students benefit from its sense of community. I hope that they walk away with the feeling that they are part of a larger research enterprise."

JAIME JONES

novel model systems

MARK DAILY

Thanks to the conservation of genetic material and metabolic and developmental pathways over the course of evolution, biologists can feel confident that discoveries made in one organism can shed light on the workings of others. Scientists have gravitated to specific organisms because their characteristics make them particularly applicable to specific kinds of experiments. For instance, Drosophila melanogaster *is ideal as a genetic model. It has few chromosomes, reproduces easily, and has a short lifespan.*

But these systems are better for some questions than others—and this narrow focus can lead researchers to overlook organisms with important lessons to offer. The sample of novel model systems that follows is an indication of the range and creativity of the department's research.

Assistant Professor Tracy Larson
Gambel's White-Crowned Sparrow

During mating season, the male Gambel's white-crowned sparrow performs an amazing feat. As if flying thousands of miles to their breeding grounds in Alaska and Northern Canada were not enough, males increase the number of neurons in a region of the brain that controls singing behavior from 100,000 to 160,000 cells in just seven days. Bulking up this area, called the HVC, enables sparrows to produce a superior song, helping them attract a mate, defend their territories, and train the next generation to sing.

At the end of the breeding season, 60,000 HVC neurons undergo programmed cell death in just two days. The sparrows also stop singing, not because they have lost the ability, but likely because they are no longer motivated to sing.

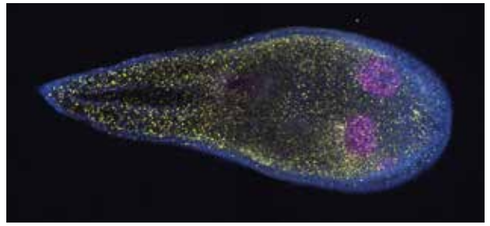
"One of the things we are interested in is how this loss of motivation compares to the changes in behavior we see as a result of seasonal affective disorder in people," Tracy Larson says. "Many of the changes we see at the neural circuit level in birds are reminiscent of what we see in people with depression."

Larson hopes that if she can find cues in the bird's environment or behavior that lead them to regenerate cells during breeding season, she might be able to identify treatments that could help patients recover from depression.

Assistant Professor Drew Schield
Speckled Rattlesnakes

As **Drew Schield** points out, the fact that snakes are essentially legless tubes has not prevented them from evolving an impressive variety of adaptations that enable them to live in many different environments—but from a scientific perspective, their genetic diversity is a largely untapped resource. "Snakes are an extremely diverse group of vertebrates that could contribute to our understanding of the biology of the genome and the evolutionary biology of vertebrates," Schield says. "I would argue that they are a really important model to compare with other traditional model groups."

Schield cites snake venom as an adaptive trait that could yield important insights. "Population genetics could help us understand how different processes contribute to its evolution, especially in the context of antagonistic coevolution with mechanisms of prey resistance," he says. Schield has recently used genomes from rattlesnake populations to quantify population genetic variation in venom gene regions. This finding provides evidence for a prominent role of long-term balancing selection in maintaining adaptive genetic variation.



Assistant Professor Ariel Pani
Roundworms and Flatworms

For much of his career, **Ari Pani** has studied *Caenorhabditis elegans*, a transparent roundworm. It is an inexpensive, easy-to-manipulate model system that has been widely used for almost 60 years to investigate diverse biological questions. *C. elegans* was the first multicellular organism to have its whole genome sequenced, and recent advances in genome engineering have provided a wealth of experimental tools.

While *C. elegans* is an extraordinarily powerful system, it has some limitations based on basic biology. For instance, the animals have a limited ability to regenerate after injuries. In looking for a model to investigate cell biological processes that underlie regeneration, Pani turned to *Acoelomorpha*, a subphylum of mostly marine flatworms known for their ability to regenerate. One species in particular, *Hofstenia miamia*, is an emerging model system that is easy to keep in the lab and amenable to many modern cell biology techniques.

The Pani lab's goal with these worms is to understand how adult stem cells are deployed to rebuild the entire body during regeneration, which may provide insights into fundamental mechanisms of stem cell regulation. "Most recent phylogenies place *Xenacoelomorpha* as the earliest branching phylum of bilaterally symmetric animals alive today," Pani says. "If you are trying to understand conserved features of biology, they provide a really important launching point."

Professor Robert Cox
Brown Anoles

The brown anole, a small lizard, exists at the intersection of several of Bob Cox's research interests. The dramatic differences between male and female anoles, which share a genome but follow two vastly different developmental trajectories throughout their lives, make them ideal for studying the evolution of sex differences.

Additionally, brown anoles have extremely high population densities, higher than most other terrestrial vertebrates. "We need high density to get the statistical power to accurately measure natural selection and the inheritance of selected traits," Cox says. To do this, his group studies wild populations of brown anoles on small manmade islands in the Intracoastal Waterway in north Florida.

A final attraction for Cox is that anoles are well studied. For example, Pietro de Mello, a postdoc in Professor David Parichy's lab, was part of a group that recently published the genome of the species, opening many new research avenues for the Cox lab.

JAY HIRSH

Professor Jianhua "JC" Cang
The Tree Shrew

From **J. C. Cang**'s perspective, biologists studying visual systems need diverse model systems. "The more models we have to validate scientific research, the better," he says.

Cang decided to add tree shrews to the mix. They are highly visual animals that are closely related to primates and have a short reproductive cycle, making them an excellent choice for developmental studies.

Tree shews have highly refined binocular vision, which gives them the precise depth perception they need to move through arboreal environments. Cang is exploring links between their depth perception and activity in their visual cortex and eventually the development of depth perception. He hopes that the lessons he learns as he pursues these connections can be applied to children with issues like crossed or lazy eye that affect depth perception.

"I feel very strongly that by studying similar processes in tree shrews, we can help clinicians better understand how these issues develop and how to treat them," he says.

Professor Edmund "Butch" Brodie
The Forked Fungus Beetle

When **Butch Brodie** came to UVA, he was looking for a model system that would help him answer questions about how being part of a group affects an individual's fitness. For him, this would be an organism that was organized spatially, enabling him to study how an individual is influenced by its neighbors at progressively larger scales.

Brodie settled on the forked fungus beetle, which lives on fungus brackets that grow on dead wood around Mountain Lake Biological Station. He studied beetles at the bracket, log, and forest levels. "Because these populations are hierarchically spatially structured, we can ask questions about how neighbors affect the individual," he says. "For instance, if you hang out with bigger beetles, does it affect your fitness differently than if you are surrounded by smaller ones?"

Brodie developed a unique method of keeping track of individual beetles, which live for three years. As a fly fisherman, he was aware of a clear epoxy he and his graduate students could use to attach small three-digit codes to their bodies. "We have a thousand individually marked beetles in the woods," he says. "When we come back in the spring, we can quickly sort out who's who."

inspiring interdisciplinary research

Great mentors help students see the bigger picture and master the important details, but they do more than convey knowledge. They inspire and instill confidence. They recognize the strengths and aspirations of each individual and actively help them realize their goals. They are indispensable in launching students on the path to becoming established independent researchers and future collaborators.

Better Diagnostics for Eye Disease

"We want to make sure that what we see is significant, that we are not mistaking artifacts for a meaningful signal."

To help people with glaucoma retain their vision longer, clinicians need better ways of peering into the eye. "Currently, clinicians use near-infrared optical coherence tomography (NIR-OCT), which can reveal the telltale thinning of the retinal nerve fiber layer that is a hallmark of glaucoma," Associate Professor **Xiaorong Liu** says. "But by that point, the eye has been irreversibly damaged." Glaucoma is a group of eye diseases that are often associated with elevated eye pressure, which causes the death of retinal ganglion cells (RGCs), which encode and transmit information from the eye to the brain.

With the assistance of postdoctoral fellow **Marta Grannonico**, Liu is investigating visible-light OCT (VIS-OCT), a new technology with significantly better spatial resolution and sensitivity than current systems. It could be used to identify the subtle changes that mark the onset of glaucoma and other eye diseases when it is still possible to slow their progression. This is especially important, Liu points out, because glaucoma often does not cause pain or obvious symptoms. Lui and Grannonico are collaborating with Professor Hao Zhang, a member of the Department of Biomedical Engineering at Northwestern University, who developed the technology.

Mice, Tree Shrews, and People

Grannonico is working to demonstrate VIS-OCT's potential for early glaucoma detection, using mice and tree shrews as models and correlating her findings with what she sees in human patients. "VIS-OCT gives us unprecedented power to analyze the morphology of the RGC axons in detail," Grannonico says. Bundled together, RGC axons form the optic nerve. "We are proceeding carefully," she adds. "We want to make sure that what we see is significant, that we are not mistaking artifacts for a meaningful signal."

Grannonico uses VIS-OCT to study mice with damaged optic nerves to monitor the retinal nerve fiber layer as it deteriorates. "We were able to track the declining density of the axons and measure such parameters as height, width, and volume as the RGCs die," she reports.

Mice, however, are nocturnal, which is why Grannonico is also studying tree shrews. These small mammals are active during the day and have a highly developed visual system that is closer to a human being's. Because shrews are used in just a handful of labs around the world, Grannonico has had to establish a baseline for study. She imaged the retinal nerve fiber layer in living tree shrews with VIS-OCT and compared it to mice and humans. In addition, she validated the tree shrew VIS-OCT images by comparing them to the corresponding retinal tissue examined under a microscope. The next step is for her to develop a realistic glaucoma model for tree shrews.

With the cooperation of Dr. Peter Netland and Dr. Michael Krause from UVA's Department of Ophthalmology, Grannonico is also creating a baseline for clinical diagnosis. She is using VIS-OCT to image the retinas of glaucoma patients and comparing them to age-matched healthy volunteers. "We wanted to measure how much better VIS-OCT is than the NIR-OCT system now used in clinics," she says.

Finally, Grannonico has participated in experiments that demonstrated that VIS-OCT could detect inflammatory cells produced in both humans and mice in response to optic nerve damage. These may be a potential biomarker for retinal disease.

MINGNA LIU

Postdoctoral fellow Marta Grannonico is helping to develop new techniques to diagnose glaucoma and other eye diseases.

At the Start of a Promising Career

The quality of Grannonico's work has attracted recognition. She received a prestigious Pediatric Ophthalmology Career-Starter Research Grant from the Knights Templar Eye Foundation, one of the foremost private funders of eye research.

Grannonico is also branching out to study other eye conditions. The foundation awarded her $90,000 to use VIS-OCT to identify early biomarkers of aniridia, a genetic eye disorder that can lead to vision loss. In many instances, initiation of treatment can prevent additional neural damage and preserve long-term vision.

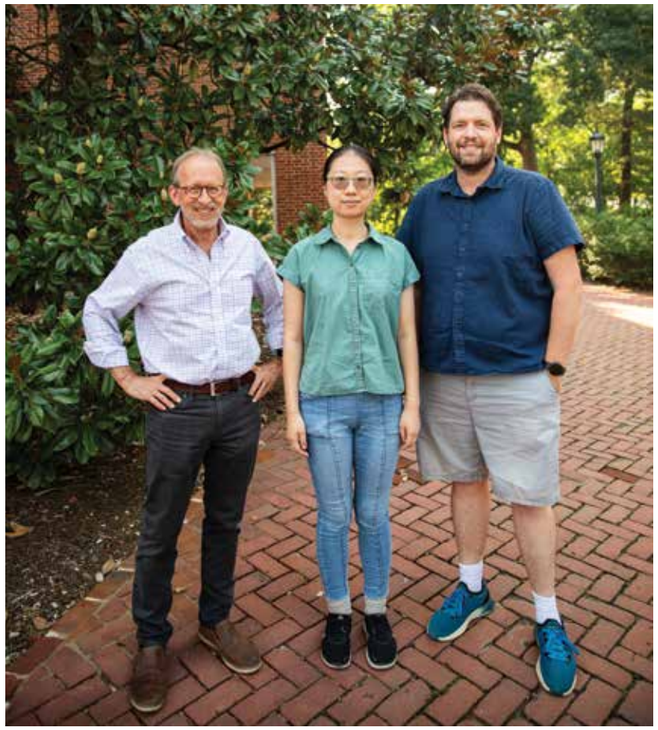
Grannonico attributes much of this success to Liu's mentorship. "Before I came to UVA, my primary focus was Alzheimer's disease," she says. "Thanks to Xiaorong's guidance, I developed the confidence to try something new."

A Circadian Strategy to Treat Alzheimer's Disease

One of the healthiest things a person can do is get a good night's rest. Inadequate sleep has been linked to increased risk of heart disease, high blood pressure, obesity, and stroke among other conditions. And as people who have trouble sleeping well know, insomnia can lead to decreased cognition, memory problems, and grogginess.

In some cases, broken sleep can itself be a sign of a deeper problem. People with Alzheimer's disease tend to wake up more often and stay awake longer during the night. Graduate student **Yu Shi** wondered if the regimens used to help healthy people sleep better might be beneficial for those with Alzheimer's disease.

"My hope is that by helping people suffering from Alzheimer's sleep better, we might be able to improve their quality of life and perhaps slow the disease's progression," she says. To do this, she enlisted the support of two faculty mentors: Associate Professor **Ali Güler**, a circadian rhythm expert, and Professor **George Bloom**, an authority on Alzheimer's disease.



Graduate student Yu Shi, working with Professor George Bloom (left) and Associate Professor Ali Güler (right), is investigating whether strengthening circadian rhythms can benefit those with Alzheimer's disease.

Strengthening Circadian Rhythms with LiFE

The daily sleep/wake cycle is one of the most prominent circadian rhythms, dependent on cues delivered to the superchiasmatic nucleus (SCN) in the brain. To address sleep issues, physicians recommend that patients strengthen these cues by regulating their exposure to light, maintaining regular mealtimes, and getting plenty of exercise, a process called entrainment. Shi is using an analogous approach. With Bloom's guidance, she is testing her hypothesis using a transgenic mouse model that mimics the pathology of Alzheimer's disease. Under Güler's direction, she is exposing the mice to optimal sequences of light, food, and exercise—she's coined the acronym LiFE for this treatment—to see if it improves their cognition and physiology.

In addition to assessing changes in behavior, Shi is refining a number of techniques to determine if these alterations are associated with an increase in the amplitude of the circadian clock. These include measuring electrical activity in the SCN as well as monitoring the transcription of the clock gene. In both cases, she is interested in ascertaining if there is a greater difference between night and day. "I am looking for the best technique to meaningfully quantify potential changes," Shi says. Working with Bloom, she will also use immunofluorescence microscopy to see if improved circadian rhythms can slow the actual progression of the disease.

A Collaboration Driven by a Graduate Student

Shi's decision to straddle the worlds of circadian rhythms and Alzheimer's disease is a testament to the department's policy of rotating new graduate students through faculty labs. Her first rotation was in Bloom's lab and her second was with Professor Christopher Deppmann, where she followed a senior graduate student studying Alzheimer's disease. She chose the Güler lab for her third rotation because it had a small project underway with Dr. Heather Ferris, a specialist in Alzheimer's disease in the School of Medicine.

Shi is driving the collaboration between the Bloom and Güler labs, and both faculty members are appreciative of her efforts. For Bloom, Shi's project has given him "an opportunity to look at an aspect of Alzheimer's disease that I never would have looked at." And for Güler, it has provided him "a chance to tackle questions that I would not have been able to approach otherwise and to learn new things."

Research Highlights

The Key to Longer, Healthier Lives

Associate Professor **Eyleen O'Rourke**'s research focuses on understanding the molecular connections between obesity and aging. Using the nematode *Caenorhabditis elegans* as a primary model organism, her lab investigates how genetic and environmental factors, including sugary diets, influence how long and how well we live.

In 2023, the O'Rourke Lab made significant strides in anti-aging research. Her team discovered that two fat by-products, glycerol and glyceraldehyde, increase in the body over time and contribute significantly to aging. Published in *Current Biology*, her team's study revealed that activating enzymes responsible for detoxifying glycerol and glyceraldehyde mitigates the harmful effects of these by-products, reducing cellular damage, delaying the onset of age-related diseases like neurodegeneration, and extending lifespan.

These anti-aging detoxifying enzymes are expected to be easy to target with chemicals or drugs, opening up possibilities for treatments that improve overall health and enhance longevity. The implications of O'Rourke's findings are profound, suggesting new therapeutic approaches that could target the root causes and potentially delaying or reducing the severity of many age-related diseases.

Associate Professor Eyleen O'Rourke focuses on the intersection of obesity and aging.

Exploring New Applications for *Cannabis*

While continuing to focus on the therapeutic powers of *Cannabis*, Professor **Michael Timko** turned the spotlight in 2023 to its use in creating sustainable building materials and biofuels. By optimizing cultivation techniques, he aimed to maximize the plant's high-quality fiber and biomass. His team's work could pave the way for eco-friendly construction solutions and renewable energy sources, potentially slashing the construction industry's environmental footprint and providing a new path for climate change mitigation.

At the same time, Timko continued to delve into the therapeutic powers of phytocannabinoids, an active compound in *Cannabis*. His team focused on the ability of *Cannabis* to combat chronic pain and inflammation, identifying specific phytocannabinoid compounds with promising therapeutic properties. Through advanced isolation methods, Timko's team worked to enhance the production and purity of these compounds. His findings are advancing the medical community's understanding of *Cannabis*' benefits and could lead to safer, more effective alternatives to traditional painkillers and anti-inflammatory drugs.

Associate Professors Jessamyn Manson and David Kittlesen are exploring ways to help students master the topics covered in Introductory Biology.

explorations in teaching

New methods of teaching reflect our better understanding of learning and our greater expectations of what can be accomplished in the classroom. In the Biology Department, we are committed to reconsidering and revamping our courses and classrooms to reflect our commitment to equity and the needs of new generations of students. We are doing so by finding ways to transmit knowledge more effectively and increase students' sense of engagement and belonging.

A New Take on Intro Biology

It is hard to imagine a more challenging class to teach than Introductory Biology, a two-semester course sequence for potential biology majors and students meeting their science distribution requirements. Classes are large—enrollments usually exceed 800—and faculty members leading the course from the stage of an auditorium classroom are at a distance, both literally and pedagogically, from their students. "It's hard to break through the anonymity of these intro courses," says Associate Professor **Jessamyn Manson**, who covers organismal and evolutionary biology during the second semester of Intro Bio. "This makes it difficult for students to connect to the class and the discipline."

Manson and her colleague, Associate Professor **David Kittlesen**, who teaches the first-semester cell biology and genetics segment of the course, have joined counterparts from physics, chemistry, math, and applied math to explore ways of redesigning introductory courses to better support student learning. They are participating in the Inclusive Excellence 3 (IE3) Learning Community, a multiuniversity initiative that the Howard Hughes Medical Institute (HHMI) created to make introductory science, technology, engineering, and mathematics (STEM) courses more inclusive. The hope is to establish a firm foundation for student success regardless of the preparation students receive before coming to college.

"We are thinking about how to increase student engagement through more active learning and create a more transparent connection to basic competencies in the sciences—such as data literacy—that will serve students regardless of whether they decide to become majors," Manson says. "We are also focusing on increasing students' sense of belonging. It is hard for students to feel supported when they are part of a such a large group."

Beyond Incremental Improvement

IE3 is encouraging participants to think big. Manson, for instance, has begun to work on a complete overhaul of her course. One of her responsibilities is to acquaint students with the full range of living organisms. Rather than progress step by step through what is known as the parade of the phyla, she hopes to find ways to link important concepts to contemporary challenges. In her discussion of protists, a large grouping of single-cellular organisms that include the parasite that causes malaria, she proposes reframing the conversation around human health. "We can include protists, bacteria, and viruses together," she says. "Rather than looking at an organism in isolation, we can view organisms as drivers behind important issues that affect student lives."

In the meantime, Kittlesen and Manson are introducing new tools that promote active learning. With HHMI funding, Kittlesen has designed a new way for students to review material before an exam. He has created what he calls an escape room adventure, where groups of students draw on their knowledge of cell division and genetic recombination to train an artificial intelligence model to combat an emerging viral outbreak. He found that students participating in the escape room adventure showed better mastery of some critical biological concepts—such as the replication fork and telomerase sequences—than those who participated in traditional review sessions.

Manson is also collaborating with a former doctoral student, Aaron Reedy, whose company, DataClassroom, developed a graphing and analysis tool for classroom use. Manson has introduced a number of exercises that use visualization to help students understand underlying properties of data. "As students work through the steps to arrive at a final graph, they gain a better understanding of the data behind it," she says.

Finding Colleagues across Disciplines

One of the advantages of IE3 is that it encourages collaboration. Thanks to the program, Manson and Kittlesen are exchanging ideas with colleagues teaching intro STEM courses across the University. They are also forging connections with on-Grounds groups like the Georges Student Center, the Center for Teaching Excellence, and the Learning Design & Technology group. "All these connections have opened doors that will enable us to continue rethinking our courses to better support our students," Manson says.

Helping First-Year Graduate Students Feel Part of the Department

Professor David Parichy and Assistant Professor Ariel Pani have developed a two-course sequence designed to help first-year graduate students quickly gain an appreciation for the range of research conducted in the department.

After first-year graduate students arrive at the Department of Biology, they branch out to follow curricular paths based on their research interests. However, graduate-level course offerings in biology have often been limited, and students who intend to focus in neuroscience or molecular and cellular biology have historically spent their first semester taking full-time coursework in the School of Medicine.

"Our department is distinguished not only by strong groups but also by the possibilities for collaborating across disciplines," says Professor **David Parichy**. "In their first semester, our graduate students were missing out on this."

Parichy, Assistant Professors **Ariel Pani** and **Tracy Larson**, and others took up the challenge and developed experimental courses in integrative biology designed to immediately introduce new graduate students to ideas and tools spanning the full spectrum of biology, foster an interdisciplinary mindset, and build a cohesive community.

Integrative Biology I was initiated in fall 2023, and the second half, Integrative Biology II, will be offered in alternating years, beginning in fall 2024. An advantage of this arrangement is that two cohorts will take the course together, widening relationships among students.

"In just one semester it has been game changing," Parichy says. "For the first time since I've been here, I've seen people from different labs just hanging out in the hall discussing all kinds of science."

Building Momentum for Change

A number of factors came together to create the ideal time to introduce new courses, including a strong desire to offer something uniquely possible in a wide-ranging department like Biology that would be especially enticing to prospective students. At the same time, Associate Professor Ali Güler, the director of graduate studies, encouraged the development of the program.

Faculty at large were quick to see the benefits. "There was a realization that the course would produce more informed, more motivated students with a broader frame of reference," Parichy says. "At the end of the day, that's what we all need to fuel our research programs."

The new courses focus on fundamental aspects of biology that reflect the breadth of research incoming students might undertake. "Dave and I encouraged faculty to send us their ideas about what they thought was important and exciting for students to know across fields," Pani says. Seven faculty volunteered to teach, including Tracy Larson, Eyleen O'Rourke, and Ray Keller. "Students had the opportunity to interact closely with a wider group of biology faculty members in their first semester than they would have otherwise," Pani adds.

An Experiment in Learning

Parichy, Pani, and contributing faculty think of this course as a work in progress. "We do experiments in our labs all the time," Parichy says. "We're conducting this one in a classroom." Going forward, they envision more opportunity for faculty to introduce topics. For instance, one of the tools for studying animals in nature is an ethogram, a chart summarizing behaviors over time. "If you are doing time-lapse imaging of cells, you need the same sort of technique," Parichy says. "But fundamentally, our goal is to expose students to different ways of thinking, allowing them to see their research from a different perspective and ask different questions."

Teaching Highlights

Confronting the Consequences of the DNA Revolution

Designed and taught by Professor **Douglas Taylor**, The DNA Revolution in Science and Society explores the profound impact of genetic research. Taylor's course examines the historical development of genome science from initial discoveries to genetic engineering and personalized medicine. The course involves a collaboration with Eric Green, the director of the National Human Genome Research Institute at the National Institutes of Health, who is developing no-cost educational resources to serve rural and community colleges as well as underserved communities.

Taylor aims to provide students with a comprehensive view of how advances in genetics influence and are influenced by broader cultural contexts as they explore the ethical, legal, and social impacts of DNA technology. These include human diversity and the role of genetics in shaping identity as well as advances in healthcare and the issue of genetic privacy. Taylor brings students' own experiences to the fore. He relies on the life histories of students from different backgrounds, who apply their own insights to discussions about the evolving impact of genetics on society.

Recognized for Outstanding Teaching

Since he joined the department in 2008, Professor **Martin Wu** has profoundly impacted thousands of biology students, thanks to his heartfelt commitment to teaching. Striving to develop more effective teaching methods, Wu worked closely with the University's Center for Teaching Excellence, earning its prestigious CTE Nucleus Program Award in 2014.

Wu's creativity and passion are clearly evident in his NextGen Sequencing: Minion the Microbe Detective course. He unified lecture and lab to enhance learning of microbial genomics, using custom-created illustrations and hands-on activities. By tapping into his own experiences and integrating cutting-edge technology and real-world applications, Wu makes complex topics accessible and fosters an inclusive classroom environment. Thanks to his commitment to teaching excellence, Wu received this year's Faculty Teaching Award from the UVA Office of the Executive Vice President and Provost.

Plants and the Human Mind

By integrating ethnobotany, pharmacology, and neuroscience in her course, Psychopharmacology of Plants, Assistant Professor **Ann Massey** offers students an in-depth exploration of the fascinating world of plant-derived drugs and their effects on the human nervous system. Massey provides students a comprehensive view of the pharmacodynamic and pharmacokinetic principles, structure, and function of the nervous system, as well as the impacts of psychoactive substances on neurochemistry and behavior.

Throughout the course, students engage in team projects, read the scientific literature, and discuss recent scientific discoveries. Massey's multidisciplinary approach equips future researchers and healthcare professionals with the knowledge to explore how the many natural substances derived from plants have been used historically and how they can lead to novel treatments to improve human mental health, enhance our understanding of brain function, and drive advances in personalized medicine.

supporting the scientific enterprise

The Department of Biology is a large and complex enterprise, with 730 undergraduate majors (the highest in the College of Arts & Sciences), 60 graduate students, 50 faculty members, and 60 postdoc, research scientists, and lab technicians. The accomplishments of our faculty and students—the degrees they earn, the experiments they conduct, and the funding they secure—would not be possible without the foundation provided by our staff. Without their belief in the research and teaching mission of the department and their determination to do their jobs the way they were meant to be done, this department would be a shadow of itself.

The following are profiles of just a handful of staff members who are united in their commitment to the best interests of the department and its students.

Kay Christopher–Senior Lab Preparer Coordinator

"You have one shot to get it right, because next week, they're on to something else."

Kay Christopher

Science truly comes alive for students when they experience it firsthand. That is why most undergraduate biology courses include a teaching lab, where instructors guide students step-by-step through experiments that shed light on the concepts they have covered in class. Making sure these experiments go off without a hitch falls to Kay Christopher and her colleague, Jackie Parker. "The faculty members draw up a list of experiments they want covered in a course," she says. "It's up to us to make sure the necessary supplies and equipment are ready when they need them."

This is quite an undertaking. There are 33 lab sections for Intro Bio alone. Every time students walk into their lab, everything has to be in place, ready and working. "You have one shot to get it right," Christopher says, "because next week, they're on to something else."

Christopher and Parker also work closely with the teaching assistants (TAs) who lead the labs. "We spend as much time as they need to understand each experiment," Christopher says. "We want them to feel comfortable guiding undergraduates through them."

But the TAs are not the only students who turn to Christopher and Parker for advice. Students taking upper-level courses often come in on their own time to make progress on their experiments—and Christopher or Parker is frequently on hand to answer their questions. "They are so appreciative when you take the time to explain things," Christopher says. "That makes all the work we put in worthwhile."

Lisa Ishler–Administrative Coordinator

Lisa Ishler

As a first-generation college graduate, Lisa Ishler feels strongly that she can make a real difference as undergraduate program coordinator. "When I first arrived at college, I had to navigate on my own, and I made a lot of mistakes," she says. "If I can point students in the right direction and help them reach their goals, I'm glad to do it."

Ishler works with students who are interested in becoming biology majors, assigns those who become majors to advisors, and serves as a resource for all questions they might have about academic policies and biology requirements. And when students complete the program, she makes sure that the Biology Department graduation ceremony proceeds smoothly, not a small task considering that its draws 1,000 students and family members.

Working for the department is also an outlet for Ishler's longstanding interest in science. Earlier in her career, she was a staff member at the College of Marine Science at the University of South Florida, where she became intrigued with biology. "When an opportunity opened up last year for me to join the Biology Department, I jumped at it," she says. "I am not a scientist or a biologist, but I enjoy working with people who are."

But Ishler does get to share her love of science. As a member of the Charlottesville Area Tree Stewards, she organizes tree walks to introduce community members to the diverse tree species in the area. "It's a really fun thing to do," she says.

"I am not a scientist or a biologist, but I enjoy working with people who are."

Sherrie Jones–Administrative Coordinator

Sherrie Jones

Sherrie Jones' superpower is keeping track of room availability, parking, keys, office supplies, and the daily flow of the office. She is the hub of the department; if she cannot answer a question, she knows where to find someone who can.

Napoleon's army was said to march on its stomach, and the same could be said for the Biology Department. Virtually all of the work done by the department is collaborative, and there is no better way to build teams than by sharing a meal. Jones is responsible for provisioning the many conferences, colloquia, lectures, seminars, meetings, celebrations, and other events that the department organizes. "The presentation is as important as the food itself," she says. "I want people attending an event to feel they are special enough that someone took the time to make everything look as attractive as possible." Jones selects the caterers and works with them to ensure a successful event.

Jones is also the power behind the department's dominance in the UVA STEM Food Drive. Each holiday season, Biology joins in a friendly competition with Astronomy, Chemistry, Environmental Sciences, and Physics to see which department can collect the most items for the Blue Ridge Area Food Bank. Thanks to Jones and Senior Fiscal Tech Mary Liberman, the department has won three years in a row, donating almost 650 items in 2023, more than four times the nearest competitor.

"Since COVID, a lot more people from all walks of life have been using food banks—and the need has not gone away," she says. "All of us in the department feel that this is one way we can contribute to the community."

"I try not to say no if I can avoid it."

Kristine Chaussée–Department Finance and Administration Manager

Kristine Chaussée is a problem-solver. As the department finance and administration manager, she is the person faculty and staff most often approach when dealing with an issue that defies obvious solution. Drawing on her two decades of experience at the University, Chaussée can often come up with an answer that satisfies all sides. "I try not to say no if I can avoid it," she says. "Having relationships around the University and broad institutional knowledge of UVA processes and procedures really helps."

Chaussée started at UVA as a fiscal specialist before moving into research administration. A self-described Type A personality, she found great satisfaction in helping researchers make the best possible case for their funding. "I saw myself as the Martha Stewart of grantmaking," she says. "It's so important to put the proposal together in ways that are accessible to readers." Although she is no longer directly responsible for grants administration in the department, she helped the department shift the major source of its funding from the National Science Foundation to the National Institutes of Health, which has a larger research budget.

Part of the unspoken job description for the department's finance and administration manager is taking

Kristine Chaussée

on the unexpected. When the University centralized human resources (HR) six years ago, it pulled a dedicated staffer out of the department. "For any business unit to operate effectively," Chaussée says, "you really need an HR person on the ground. And because my job is not as narrowly defined as others, I became that person." Along the way, Chaussée has learned new things—and applied her problem-solving skills to streamlining HR procedures.

David Glover

David Glover–Building Project Associate

Even by David Glover's high standards, the last five years have been exceptionally busy. As the department's building project associate, he played a major role in easing the department successfully through its most significant physical and organizational transformation in decades: the top-to-bottom renovation of Gilmer Hall and the relocation of the University's scattered neuroscientists to new labs there.

During the project, Glover served as the department's liaison with the University's Capital Construction and Renovations group. Thanks to his tireless efforts, the department was able to fulfill its teaching and research missions uninterrupted even as he helped redistribute researchers and their labs among Gilmer, the Chemistry Building, and the Physical and Life Sciences Building. Glover's reputation for placing the department's interest above all else proved invaluable in helping this process go as smoothly as possible.

"I try to keep everyone happy," he says. "If someone in the department needs something taken care of, I make sure it gets done." When he is responding to a request, Glover's approach is to look at the scope of the job, find out what the underlying needs are, and try to find a way, if possible, to suit everyone involved. Glover typically arrives at work at 5:30 in the morning, and if the task demands it, he'll stay as late as necessary or come in at midnight in case of an emergency.

For these reasons, the University named Glover one of 11 Leonard Sandridge Outstanding Contributor Award recipients in 2023. The Sandridge Award is UVA's highest individual honor for employees and recognizes those who demonstrate exceptional dedication to service through individual efforts, group contributions, and a commitment to the larger community.

Breaking Science Out of the Ivory Tower

"For most people, science is a black box," says Alexis Johnson, a neuroscience graduate student and co-president of the Biology Outreach and Inclusion Program (BOIP). "They might hear soundbites about the latest discoveries, but they lack the background to interpret these findings and put them in context." The result is a growing tendency to dismiss and distrust science at precisely the moment the world faces a series of challenges—from infectious diseases to climate change—that cannot be effectively addressed unless the general public and our leaders have a basic understanding of science and scientific methods. Through BOIP, Johnson and Co-President Rebeccah Messcher, a biology graduate student, are working to demystify science and to share their enthusiasm and excitement for scientific discovery.

The disconnect is apparent even in a city like Charlottesville, where thousands of researchers work every day to advance human knowledge. "We're trying to break science out of the ivory tower," Messcher says. "For BOIP, this means taking science into the local community."

Graduate students Alexis Johnson, Taylor Nystrom, and Rebeccah Messcher are helping to promote scientific literacy through the Biology Outreach and Inclusion Program.

Democratizing Science

BOIP's long-running Farmers Market Science program is a good example of the organization's outreach efforts. BOIP maintains a booth at the Saturday morning market at Ix Art Park in central Charlottesville, which it staffs with graduate students and faculty members recruited from around the University. "Just having a booth at the farmers market provides an occasion for people to come up and share their interest in science," says Taylor Nystrom, a biology graduate student and BOIP cofounder. "That gives us an opportunity to talk about the research we're doing in our labs. The booth is a great way to encourage conversations and connections through science."

Sparking an Interest in Science

BOIP members also organize programs to make science accessible for young children. Some have created exercises that illustrate how cells and organs function. Johnson, who studies neurodegenerative diseases such as Alzheimer's, designed an exercise for kids to build a model neuron from its components and see what happens to it during its lifetime. "We can ask them to hypothesize what may happen to a neuron when we get older or injured and how that could affect the different components of the cell that they constructed," she says.

Other BOIP members have brought live animals to the booth for children to examine. "You can tap children's innate curiosity and use the observations they make to illustrate a larger principle in biology," Nystrom says. For instance, members of Associate Professor Alan Bergland's lab brought hissing cockroaches to the booth. "Male hissing cockroaches have bumps on their backs while females don't," she says. "We asked them why they thought there was a difference, which gave us an opportunity to talk about sexual dimorphism and evolution."

An important goal of BOIP is to bring science to less commonly served communities. BOIP has collaborated with the Prolyfyck Run Crew, a Black-led running club in Charlottesville, to present science programs at its Wednesday kids meetings. "We focused on different forms of movement," Nystrom says. BOIP members have also made presentations about science at local schools.

One of Messcher's goals as copresident is to step up these activities. Growing up in a small rural community, she often had questions about the natural world but never realized she could turn to science for an answer. "No matter what their age or background, I think people should know that science is available to them," she says.

Artwork by Charlottesville High School students Sylvie Semmelhack (top), Bella Burton (bottom), and Emma Bevacqua (top right).

Engagement **Highlights**

Combining Art with Science

Not everyone gets science. Magnify, a collaboration between Charlottesville High School art classes and UVA biology and neuroscience researchers, unites artistic expression with scientific inquiry, making complex biological research more accessible and visually compelling. By using art as an access point, Magnify creates opportunities for more thought-provoking, expressive, and reflective conversations about sophisticated life science principles and the scientific process with high school students less likely to be reached through typical courses.

Through scientific presentations, hands-on activities, and artistic interpretations, local high school students work with UVA scientists to integrate artistic practices with scientific research. The initiative aims to inspire a new generation of thinkers who appreciate and utilize the synergy between art and science to foster a deeper understanding of science using the creative potential of artistic expression.

An Ambassador for Biology

Associate Professsor **David Kittlesen**'s 25-year commitment to innovative teaching has made him a pillar of the undergraduate biology program. As one of the faculty leaders for Intro Bio, Kittlesen is a "gateway ambassador" for biology and STEM majors, teaching over 800 students each fall. He and his colleagues continuously revamp the course to emphasize critical thinking over rote memorization. His extraordinary dedication to teaching in the Biology Department has earned him an All-University Teaching Award from the UVA Office of the Executive Vice President and Provost.

Kittlesen's contributions extend beyond the classroom. He is a trusted advisor, mentor and supportive colleague and has played a crucial role in shaping departmental policies through his longstanding membership in the Biology Undergraduate Committee.

2023 Grants, Awards, and Honors

Grants

Cox, Robert

- Eco-evolutionary Dynamics of Parasitism Mediated through Variance in Host Fitness. U.S. National Science Foundation (NSF). $1,004,225.

Gibson, Amanda

- Using Genomics to Manage Plant-Parasitic Nematodes in Agricultural Fields. Eppley Foundation for Research. $29,875.
- Awards for Support of Regional Meetings in Ecology, Evolution, and Behavior. American Society of Naturalists.

Güler, Ali

- R35 equipment supplement, National Institute of General Medical Sciences (NIGMS), PI, one year. $133,014.
- R35 diversity supplement NIGMS, PI, two years. $170,000.

Kittlesen, David

- An Innovative Pedagogy Project: Using Escape Rooms to Enhance Belonging and Inclusion in Large Lecture Courses. A&S Learning Design & Technology Incubator Grant. Co-PI with Erin Clabough, Department of Psychology. $5,465.

Kozminski, Keith

- iGEM Program at the University of Virginia. NSF. $104,236.

Larson, Tracy

- Mechanisms of Cyclical Degeneration and Regeneration in an Avian Model System. National Institute of General Medical Science, ESI MIRA. $1,986,650.

Liu, Xiaorong

- Novel Non-invasive Imaging for Tracking Retinal Changes in Young Aniridia Patients' Eyes. Vision for Tomorrow Foundation. $17,500.
- In Vivo Tracking of Developmental Damage in Aniridic Retina. Knights Templar Eye Foundation. $90,000.
- In Vivo Biomarker to Monitor Glaucoma Progression. Glaucoma Research Foundation. $50,000.
- Investigating Axonal Transport Defects in Glaucoma. UVA 4-VA Collaborative Research Grant. $30,000.
- Modulating Aqueous Humor Outflow with Engineered Nanoparticles for Glaucoma. Co-PI, National Institutes of Health (NIH) R01. $242,781.
- Clinical Glaucoma Management Enabled by Visible-Light Optical Coherence Tomography. Co-PI, NIH U01. $156,706.

Pani, Ariel

- Investigating FGF Signaling Dynamics in Migrating Cells. NIH F31, National Institute of Child Health and Human Development. $44,739.
- R35 equipment supplement award for GM142880. $110,018.

Parichy, David

- Developmental Origins and Homeostatic Mechanisms Underlying Adult Phenotypes. Administrative supplement. NIH R35. $250,000.

Siegrist, Sarah

- R35 supplement for equipment, $95,767, and summer undergraduate training. NIH. $11,846.

Timko, Michael

- Molecular Breeding and Capacity Building in the Kirkhouse Trust African Cowpea Programme (ACP). Kirkhouse Trust. $241,061.
- Regulatory Factors and Pathways Controlling Trichome-Specific Gene Expression of Enhanced Flavor and Aroma Metabolites. Altria Client Services LLC. $596,962.

Faculty Awards and Honors

Gibson, Amanda

- State Council for Higher Education of Virginia (SHEV) Outstanding Faculty Award.

Kucenas, Sarah

- Named the Owen R. Cheatham Professor of Biology.

Liu, Xiaorong

- Shaffer Award from the Glaucoma Research Foundation.

O'Rourke, Eyleen

- Elected to the Board of Directors of the Genetics Society of America.

Wu, Martin

- Department of Biology Award for Teaching Excellence.

IAN NICHOLS

Student/Post-Doc Awards and Honors

Bergland, Alan

- David Bass awarded a Harrison Undergraduate Research Award.

Brodie, Edmund

- Sarah McPeek awarded the Rosemary Grant Award from the Society for the Study of Evolution.

Cang, J. C.

- Jenny Fu awarded an NIH F31 from the National Eye Institute.

Deppmann, Chris

- O. Yipkin Calhan awarded a Minerva Award and UVA Brain Institute seed funding.
- Heeran Karim awarded a Harrison Undergraduate Research Award.
- Shreya Nagarajan awarded a Harrison Undergraduate Research Award.
- Ekaterina Stepanova awarded a UVA Double Hoo Award, a Presidential Fellowship through the Brain Institute, and selected as a UVA Society of Fellows Junior Fellow.

Gibson, Amanda

- Caroline Amoroso earned the College Council's Minerva Award.
- Juliana Jiranek awarded a Society for the Study of Evolution Fellowship.

Larson, Tracy

- Kathryn Chung awarded a College Council Grant and a Harrison Undergraduate Research Award.
- Alexandra Perez awarded a Harrison Undergraduate Research Award.

Liu, Xiaorong

- Jason Borst awarded a Harrison Undergraduate Research Award.
- Charlotte Zhang awarded a Harrison Undergraduate Research Award.

O'Rourke, Eyleen

- Olivia Yang (Jefferson Scholar) awarded a Harrison Undergraduate Research Award.

Pani, Ariel

- Theresa Gibney awarded an NIH F31 grant from the National Institute of Child Health and Human Development.

2023 Publications

BERGLAND

Nunez, J. C., Lenhart, B. A., Bangerter, A., Murray, C. S., Yu, Y., Nystrom, T. L., ... & **Bergland, A. O.** (2023). A cosmopolitan inversion drives seasonal adaptation in overwintering Drosophila. Genetics: 10.1093/genetics/iyad207 (published online 2023).

Porter, R. J., Gutierrez, G. M., Barnard-Kubow, K. B., & **Bergland, A. O.** (2023). Maternal control of spontaneous dormancy termination in Daphnia pulex. *Hydrobiologia*: 10.1007/s10750-023-05361-w.

Rakes, L. M., Delamont, M., Cole, C., Yates, J. A., Blevins, L. J., Hassan, F. N., **Bergland, A. O.**, ... & Erickson, P. A. (2023). Spatial and temporal variation in abundance of introduced African fig fly (Zaprionus indianus) (Diptera: Drosophilidae) in the eastern United States. *bioRxiv*. https://doi:10.1101/2023.03.24.534156.

BLOOM

Best, M. N., Lim, Y., Ferenc, N. N., Kim, N., Min, L., Wang, D. B., ... & **Bloom, G. S.** (2023). Extracellular Tau Oligomers Damage the Axon Initial Segment. *Journal of Alzheimer's Disease, 93*(4), 1425–1441. https://doi:10.3233%2FJAD-221284.

Bloom, G. S. & Baas, P. W. (2023). A half-century of tau. *Cytoskeleton, 81*(1), 7–9. https://doi:10.1002/cm.21783.

Bloom, G. S. & Norambuena, A. (2024). Dysregulation of mTOR by tau in Alzheimer's disease. *Cytoskeleton, 81*(1), 30–34. https://doi:10.1002/cm.21782.

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Rajbanshi, B., Guruacharya, A., Mandell, J. W., & **Bloom, G. S.** (2023). Localization, induction, and cellular effects of tau phosphorylated at threonine 217 1. *Alzheimer's & Dementia, 19*(7), 2874–2887. https://doi:10.1002/alz.12892.

Sharlow, E. R., Llaneza, D. C., Tewari, B. P., Mingledorff, G. A., Mendelson, A. J., Sontheimer, H., **Bloom, G. S.**, ... & Lazo, J. S. (2023). Pharmacological profiling identifies divergent chemosensitivities of differentiating and maturing iPSC-derived human cortical neuron populations. *The FEBS Journal, 290*(20), 4950–4965. https://doi:10.1111/febs.16901.

BRODIE

Cook, P. A., Costello, R. A., Formica, V. A., & **Brodie III, E. D.** (2023). Individual and population age impact social behavior and network structure in a long-lived insect. The *American Naturalist, 202*(5), 667–680. https://doi:10.1086/726063.

Gilbert, A. L., Cabrera, S., Hague, M. T., Stokes, A. N., Feldman, C. R., Hanifin, C. T., ... & **Brodie III, E. D.** (2023). Phenotypic outcomes of predator–prey coevolution are predicted by landscape variation in climate and community composition. *Functional Ecology, 37*(8), 2170–2180. https://doi:10.1111/1365-2435.14360.

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Coverdell, T. C., Abbott, S. B., & **Campbell, J. N.** (2024, March). Molecular cell types as functional units of the efferent vagus nerve. In Seminars in Cell & Developmental Biology (Vol. 156, pp. 210–218). Academic Press. https://doi:10.1016/j.semcdb.2023.07.007

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