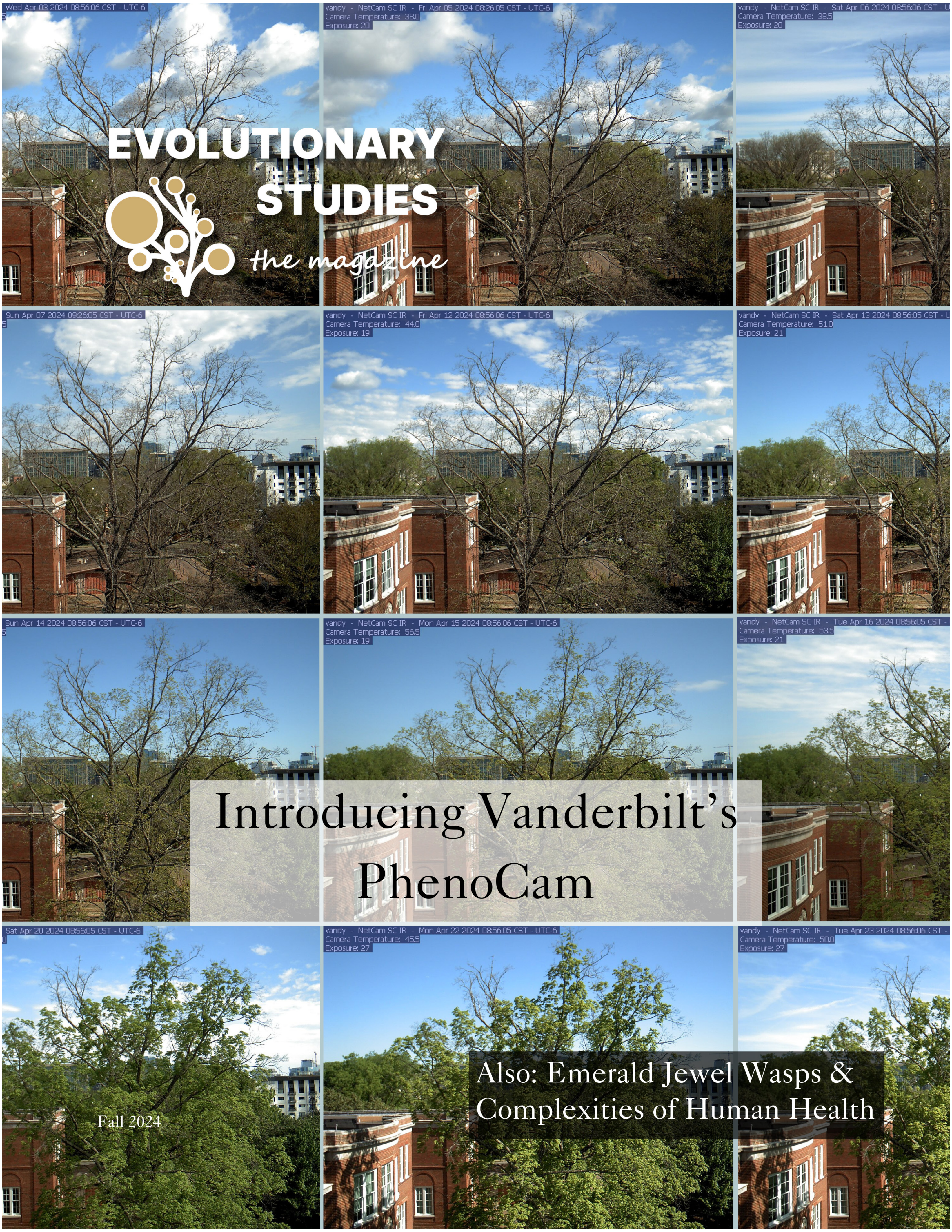


EVOLUTIONARY STUDIES

the magazine

Introducing Vanderbilt's PhenoCam

Also: Emerald Jewel Wasps & Complexities of Human Health

Fall 2024

IN THIS ISSUE

CONNECT WITH US ON SOCIAL AT:

@EvolutionVU

EVOLUTIONARY STUDIES

VANDERBILT UNIVERSITY

VANDERBILT ESI

Dear Readers,

As the Director of the Evolutionary Studies Initiative, it is my honor and privilege to witness the remarkable progress and contributions made by our faculty, staff and students.

One of the many measures of our success is the outstanding achievements of our faculty and trainees. For the faculty, recent achievements include, but are not limited to, Dr. Lin Meng's appointment as the Steven and Bunny Fayne Dean's Faculty Fellow, Dr. Keivan Stassun's well-deserved MacArthur Fellowship, and Dr. Carlos Taboada's Packard Fellowship (Vanderbilt's first ever!). Two of our faculty in biological sciences, Ann Tate and Nicole Creanza, were promoted recently to associate professors. For our trainees, recent notable achievements include, but are not limited to Dr. Kyle David's Early Career Investigator Award from the American Society of Naturalists, Dr. Sarah Worthan's Zuckerkandl Prize from the Journal of Molecular Evolution, Ximena Leon's Student Research Award from the American Society of Naturalists, Katie McCormack's Dissertation Grant from the Wenner-Gren Foundation, Kat Turk's Winifred Goldring Award for an outstanding female paleo PhD student from the Association for Women Geoscientists and the Paleontological Society, and Sarah Ward's AAAS Mass Media Fellowship.

July 2025 will mark the centennial of the infamous Scopes "Monkey" Trial, where high school teacher John T. Scopes got convicted for teaching human evolution in Dayton's high school. To mark the occasion, learn, reflect, and explore the importance of science and evolution in today's world, we are organizing a Festival for the Spring and Summer of 2025 in partnership with the Chancellor's Office and various partners within and outside our university, most notably the National Center for Science Education.

The Festival will kick-off with our Darwin Day lecture on February 12 (Darwin's birthday!), which will be delivered by world-renowned evolutionary biologist Richard Dawkins. On February 25, Judge John E. Jones III, now President of Dickinson College, will deliver the Scopes Lecture, sharing his experiences as the Judge of the 2005 trial of intelligent design in classrooms from Pennsylvania (Kitzmiller v. Dover Area School District). We are working with a cross-campus team to put together non-academic events as well.

Other highlights include hosting the 2025 meeting of the International Society of Evolution, Medicine, and Public Health (July 8-10, 2025), followed by a two-day academic symposium, organized in partnership with the National Center for Science Education, focused on the history of the Scopes trial, modern challenges to teaching evolution, the modern science of evolution and its applications, best practices for teaching evolution, and the relationship between evolution and religion. You can find the full line-up of speakers, which include a Pulitzer prize-winning book author and several National Academy members, on the pages of this issue.

I want to express my sincere gratitude to our dedicated faculty, staff, and students for their active participation and engagement in our journal clubs, named lectures, and outreach activities. I invite you to join us in our journey of discovery and advancement within evolutionary studies. Together, we can continue to make meaningful contributions to science and shape the future of our field.

Thank you for your continued support and dedication to our shared mission.

Sincerely,

Antonis Rokas

Antonis Rokas, Director
Evolutionary Studies Initiative
Cornelius Vanderbilt Chair in Biological Sciences
Vanderbilt University

Photo credit Prosanta Chakrabarty

Dr. Antonis Rokas and Dr. Prosanta Chakrabarty at LSU in 2024

EVOLUTIONARY STUDIES the magazine

Executive Editor
Dr. Andy Flick
andrew.j.flick@vanderbilt.edu

Join our mailing list at
vanderbilt.edu/evolution/faq

Unattributed photos and stories credit to Dr. Andy Flick

View the latest stories online at
vanderbilt.edu/evolution

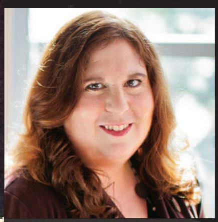
Evolutionary Studies - the Magazine is published twice yearly for members, alumni and friends of the Evolutionary Studies Initiative.

Vanderbilt University
2201 West End Ave
Nashville, TN 37235

2025 Events

February 11 - Richard Dawkins
University of Oxford, Emeritus Faculty, Charles Simonyi Professor,
Public Understanding of Science
Darwin Day Lecture

February 25 - Judge John E. Jones III
Dickinson College, President
J.T. Scopes Lecture
Kitzmiller v. Dover Area School District



March 6 - Sarah Tischkoff
University of Pennsylvania, David and Lyn Silfen University Professor,
Perelman School of Medicine
Vanderbilt Prize Lecture (VUMC)
Evolutionary Genetics and Human Disease

April 16 - Paul Koch
University of California, Santa Cruz, Distinguished Professor,
Earth and Planetary Sciences
Earth Day Lecture

INTERNATIONAL SOCIETY FOR EVOLUTION, MEDICINE & PUBLIC HEALTH

July 8-10 - ISEMPH Annual Conference

NCSE National Center for Science Education

July 12-13 - Scopes Symposium

*Photos submitted by the speakers

GeneMAP discovery platform will help define functions for 'orphan' metabolic proteins

By Leigh MacMillan, VUMC News author

A multidisciplinary research team has developed a discovery platform to probe the function of genes involved in metabolism — the sum of all life-sustaining chemical reactions.

The investigators used the new platform, called GeneMAP (Gene-Metabolite Association Prediction), to identify a gene necessary for mitochondrial choline transport. The resource and derived findings were published in *Nature Genetics*.

"We sought to gain insight into a fundamental question: 'How does genetic variation determine our "chemical individuality" — the inherited differences that make us biochemically unique?" said Eric Gamazon, PhD, associate professor of Medicine in the Division of Genetic Medicine at Vanderbilt University Medical Center. Gamazon is the senior and co-corresponding author of the study with Kivanç Birsoy, PhD, of The Rockefeller University.

Metabolic reactions play critical roles in nutrient absorption, energy production, waste disposal, and synthesis of cellular building blocks including proteins, lipids and nucleic acids. About 20% of protein-coding genes are dedicated to metabolism, including genes that code for small-molecule transporters and enzymes, Gamazon said.

Abnormalities in metabolic functions are associated with a range of disorders including neurodegenerative diseases and cancers.

"Despite decades of research, many metabolic genes still lack known molecular substrates. The challenge is in part due to the enormous structural and functional diversity of the proteins," Gamazon said.

To discover functions for "orphan" transporters and enzymes — proteins with unknown substrates — the researchers developed the GeneMAP discovery platform. They used datasets from two independent large-scale human metabolome genome-wide/transcriptome-wide association studies and demonstrated with in silico validation that GeneMAP can identify known gene-metabolite associations and discover new ones. In addition, they showed that GeneMAP-derived metabolic networks can be used to infer the biochemical identity of uncharacterized metabolites.

To experimentally validate new gene-metabolite associations, the researchers selected their top finding (SLC25A48-choline) and performed in vitro biochemical studies. SLC25A48 is a mitochondrial transporter that did not have a defined substrate for transport. Choline is an essential nutrient used in multiple metabolic reactions and in the synthesis of cell membrane lipids.

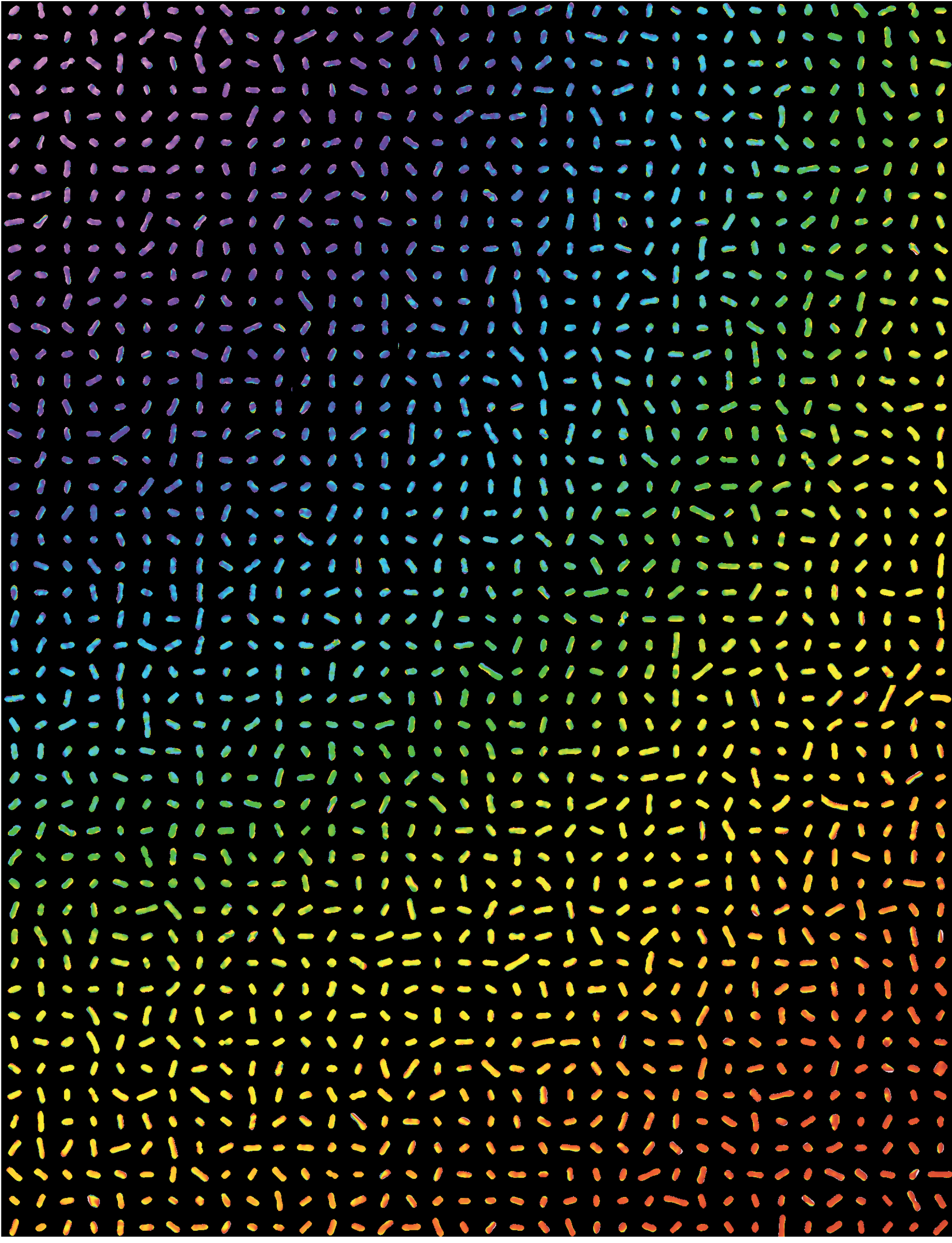
The researchers showed that SLC25A48 is a genetic determinant of plasma choline levels. They further conducted radioactive mitochondrial choline uptake assays and isotope tracing experiments to demonstrate that loss of SLC25A48 impairs mitochondrial choline transport and synthesis of the choline downstream metabolite betaine.

They also investigated the consequences of the relationship between SLC25A48 and choline on the human medical phenome (symptoms, traits and diseases listed in electronic health records) using large-scale biobanks (UK Biobank and BioVU). They identified eight disease associations.

"What's exciting about this study is its interdisciplinarity — the combination of genomics and metabolism to identify a long-sought mitochondrial choline transporter," Gamazon said. "We think, given the extensive in silico validation studies in independent datasets and the proof-of-principle experimental studies, our approach can help identify the substrates of a wide range of enzymes and transporters, and 'deorphanize' these metabolic proteins."

Read more >>

Top: Eric Gamazon (VUMC). Bottom: A cornecopia showing many of the foods that contain choline, like dairy, eggs, nuts, and seeds. Image generated with OpenAI's DALL-E.



Uncovering Hidden pH Sensing Abilities

In a groundbreaking study led by Sarah Worthan, a postdoctoral researcher in the Behringer Lab, scientists have successfully evolved microbial cultures that possess the ability to sense pH changes, enabling rapid responses to environmental fluctuations. Along with highlighting the power of lab-driven evolution, this discovery also led to finding similar mutations in nature in emerging pathogens and coral symbionts—organisms that navigate challenging pH shifts in their environments and are otherwise difficult to study.

The new paper, "Evolution of pH-sensitive transcription termination in *Escherichia coli* during adaptation to repeated long-term starvation," was published in the *Proceedings of the National Academy of Science*. The driving result from this work is the discovery of a mutation in the independently evolved populations of bacteria that occurs when the bacteria are exposed to feast and famine cycles.

According to the paper, this mutation, where an arginine amino acid is replaced with a histidine, occurred on the Rho protein, which is involved in terminating RNA transcription. Arginine to histidine mutations have also been observed in cancers and have been shown to confer an adaptive pH sensing ability to oncogenic proteins. In bacteria, these arginine to histidine mutations can sense pH and alter the activity of the Rho protein to rapidly impact how genes are expressed.

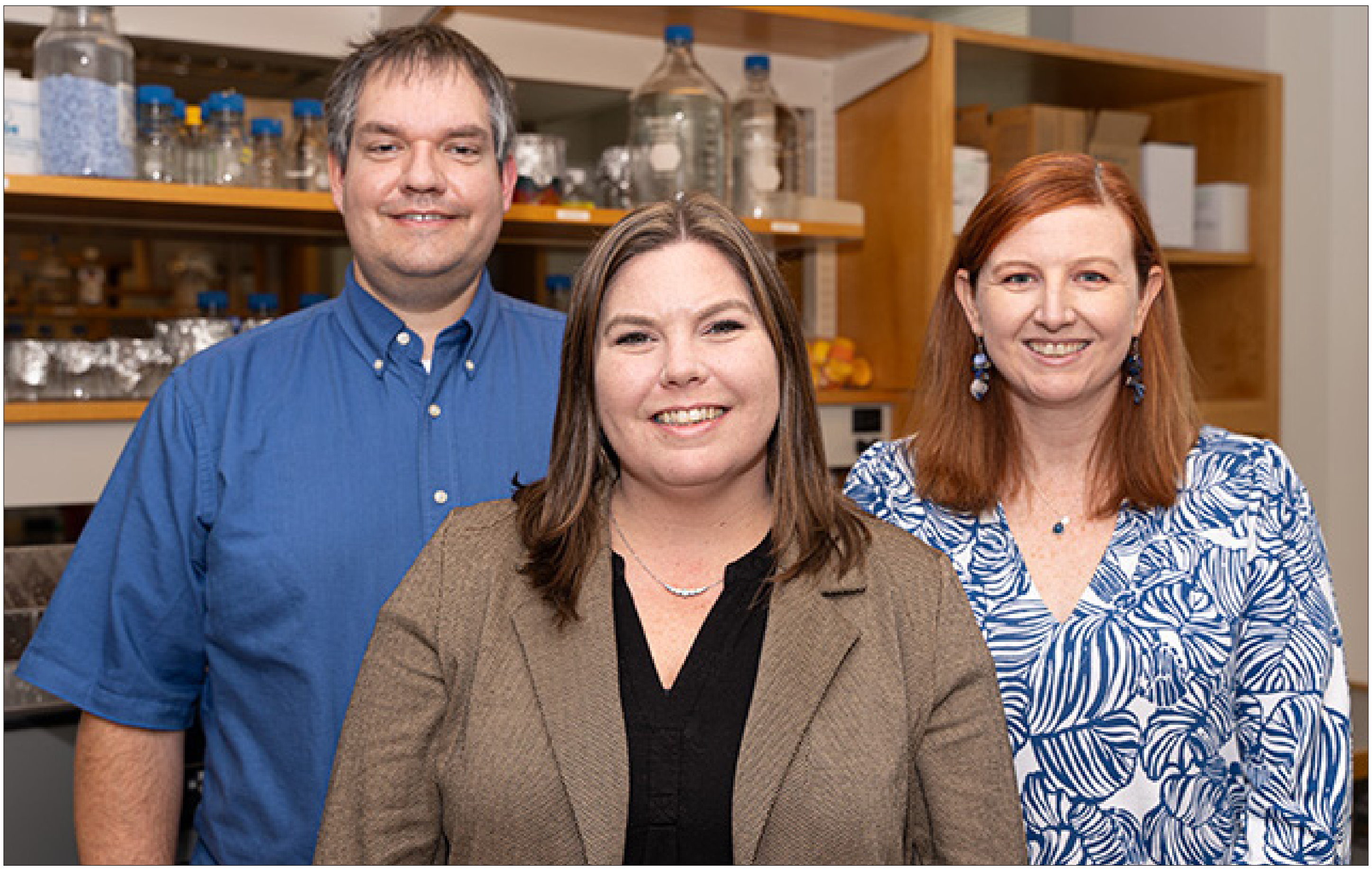
Evolved in the Lab

Co-author Benjamin Bratton, an assistant professor of Pathology, Microbiology and Immunology at the VU Medical Center, led imaging for the lab experiments and analysis of the pH assays while co-author Marc Boudvillain, CNRS Research Director at the Centre de Biophysique Moléculaire in Orléans, France and a chemist by training, led biochemical experiments demonstrating Rho's altered activity across pH environments.

According to Megan Behringer, assistant professor of Biological Sciences and the principal investigator of the study, "this mutation in *rho* repeatedly arose in our laboratory evolution cultures. We screened a lot of phenotypes and struggled to identify the Rho mutation's specific effects."

"Dr. Behringer reached out to me wondering if there was a way we could measure pH inside individual cells," Bratton said. "Measuring single bacterial cell physiology happens to be one of the major skills of my lab, so this collaboration has been great."

Read more >>



Credit: Anthony Czelusniak, VUMC

Opposite: A microscopic image showing numerous small, rod-shaped cells colored from purple through the rainbow to red (Bratton). This page: Bratton (left), Worthan (center) and Behringer pose in the lab.

The Evolution of Seasonal Anticipation

Being able to correlate changes in day length with seasonal weather patterns is crucial for many organisms to adapt to their environments. Trees shed their leaves, arctic foxes grow thicker coats, and bears prepare for hibernation. But what about smaller, short-lived organisms? New research led by BBSRC Discovery Fellow at the John Innes Centre, in the UK and recent Ph.D. alumna Maria Luísa Jabbur from the Johnson Lab, along with Johnson and assistant professor of Pathology, Microbiology and Immunology, Benjamin Bratton, has uncovered that even cyanobacteria—tiny organisms with a generation time of just five to six hours—can sense and respond to changes in light availability, or photoperiod, to gear up for winter.

The new paper, "Bacteria Can Anticipate the Seasons: Photoperiodism in Cyanobacteria," was published in the journal *Science*. According to the study, short days promote cold resistance in cyanobacteria.

Carl Johnson, Jabbur's advisor, spoke to the novelty of the work.

"To me, the most exciting thing about these results are their ramifications for the evolution of biological timekeeping," he said. "I think we 'chronobiologists' have always assumed that daily clocks evolved before organisms could measure day/night-length and thereby anticipate the changing seasons. But the facts that (1) photoperiodism evolved in such ancient and simple organisms, and (2) our gene expression results implicate stress response pathways that probably evolved very early in life on Earth, suggest that photoperiodism might have evolved before circadian clocks. This is because either long days or long nights are differentially stressful for photoautotrophs like cyanobacteria, and therefore these conditions would be expected to trigger stress responses differentially. As a result of these selective pressures, photoperiodic time measurement might have evolved even before bona fide circadian clocks appeared. That possibility blows my mind!"

The role of clock proteins

The bacteria prepare for these winter conditions using clock proteins. The Johnson lab has a long history of studying circadian rhythms, especially in clock proteins known as KaiA, KaiB, and KaiC. These proteins exist in cyanobacteria and are responsible for the circadian rhythms of these short-lived organisms. To this end, the results above were undone when the clock proteins were turned off – changing the day length did not better prepare cyanobacteria for future cold conditions, suggesting cyanobacteria need their circadian clocks in order to be able to measure the length of the day and interpret it accordingly.

The team also found that the expression of the clock genes did not change between long exposure to daylight and short exposure to daylight. However, they did observe changes in the expression of genes that control lipid and fatty acid metabolism. Exposure to short-day or cold conditions led to the cyanobacteria to produce less dense (desaturated) fats and proteins.

Read more >>

Credit: DALL-E

A cartoon of an anthropomorphized cyanobacteria enjoying a nice summer day, but seeing a snow cloud off in the distance.

Analyzing Evolutionary Trade-Offs in Immune Systems

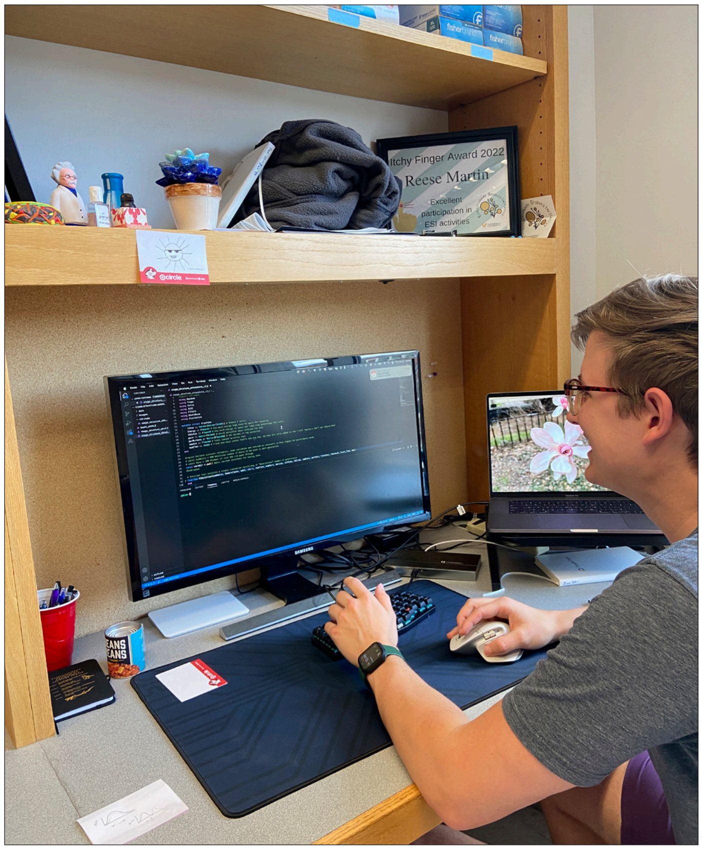
By Nick McCoy, Evolutionary Studies Communications Assistant

Reese Martin has always been drawn to biology and exploring the behaviors of different organisms. During his childhood, he dug in anthills, and now he observes the life history traits of flower beetles and other taxa. Martin's new first-author paper, "Pleiotropy Alleviates the Fitness Costs Associated With Resource Allocation Trade-Offs in Immune Signaling Networks," was published in the *Proceeding of The Royal Society B*. Working under the guidance of assistant professor of Biological Sciences Dr. Ann Tate, Martin explored the role of genetic pleiotropy in evolutionary biology and its impact on trade-offs among life-history traits in host and parasite populations.

According to Tate, "genetic pleiotropy is when genes have multiple functions."

Pleiotropic genes also evolve slowly and are common in the immune system of humans, insects, and plants, and as Martin's findings note, "play double duty in defending against parasites and driving other important traits like development." Martin's published research focuses on understanding why these slowly evolving genes are so prevalent in a system that otherwise evolves quickly.

Martin was drawn to the Tate Lab because of its use of a diverse range of methodologies to address questions related to the evolution of the immune system. Martin's Ph.D. work focuses on the computational side of the lab's research, which utilizes an agent-based model — a simulation that studies the interactions between variables such as people, environments, or stimuli — to code for and simulate coevolution between parasites and hosts. Dr. Tate highlighted that another advantage of an agent-based model is its ability to adapt to various variations and provide optimal flexibility.



Credit: Nick McCoy

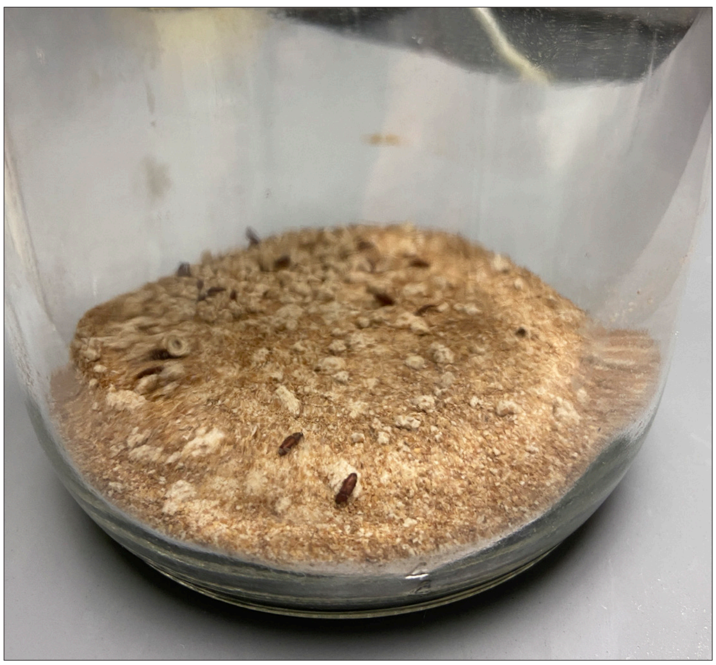
At the onset of this project, Martin's framework originated from the understanding that immune signaling networks evolve rapidly, driven by the need to keep up with evolving parasites. Martin explained that this dynamic is often referred to as an 'arms race' between the immune networks and the parasites.

The Toll and proPO signaling pathways in insect immune systems inspired Martin's model due to their crucial roles in both development and immunity, leading him to explore the evolutionary conditions favoring such configurations. The Toll pathway is involved in embryo development as well as the immune response to fungal and bacterial infections, while the proPO pathway is a critical part of melanization, which is necessary for defense against foreign materials and for the cuticle tanning process.

According to their paper, Martin and Tate establish that these "hosts are defined by a pair of signaling networks, one developmental and the other immune," prompting Martin to further investigate the role of pleiotropic genes and their influence on development, physiology, and disease.

Martin's model reflected a variety of organisms such as the common fruit fly, domestic sheep, thale cress, mice, spongy moths, and flower beetles.

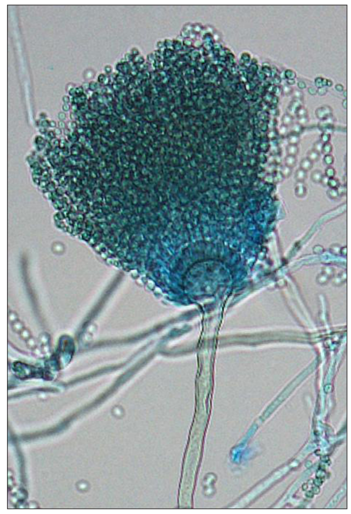
Read more >>



Credit: Nick McCoy

Top: Reese Martin working on a computational model. Bottom: flour beetles in a jar in the lab.

Wide Variation in Fungal Virulence



A new study led by research assistant professor David Rinker sheds light on how fungal pathogenicity might evolve. The article, “Strain heterogeneity in a non-pathogenic *Aspergillus* fungus highlights factors associated with virulence,” was published in the journal *Communications Biology* in September 2024.

According to Rinker, “different isolates or strains of *Aspergillus fumigatus* have already been shown to vary widely at the genomic level and some isolates of *A. fumigatus* are known to have greater pathogenic potentials than others.” The group set out to test if that wide range of virulence could also be found in the closely related non-pathogenic species *Aspergillus fischeri*.

The team, made up of members in the lab of Antonis Rokas, Cornelius Vanderbilt Chair in Biological Sciences and Director of the Evolutionary Studies Initiative, also includes collaborators from the University of North Carolina at Greensboro, the University of São Paulo in Brazil, and the Westerdijk Fungal Biodiversity Institute in The Netherlands. Members from the Rokas Lab include Rinker, postdoctoral researchers Thomas Sauters and Karin Steffen and research technician Adiyantara Gumilang.

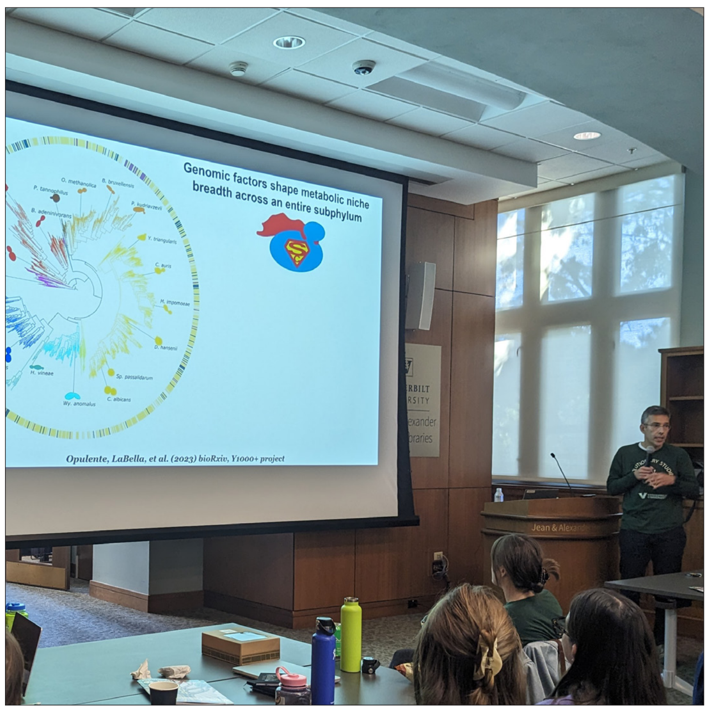
In this study, mice and mouse immune cells were infected with spores from many different strains of Aspergillus fischeri. By measuring mortality - or the ability for the fungus to kill its host or host cells, they were able to assess how each strain affected host survival. While infections by some strains had no impact, others significantly affected mouse survival. Thus, some strains appear to be non-pathogenic while others are highly pathogenic.

The study’s findings underscore the need for a broader perspective on fungal virulence that includes non-pathogenic species, which may harbor hidden pathogenic potential that could emerge under certain environmental conditions or in immunocompromised hosts.

“As far as we know,” Rokas said, “this is the first published study to show this variability in a non-pathogenic species of fungus. When we give research talks on our findings, people get really excited because our results suggest that we need to start thinking of these traits like virulence, not as a single point from a reference strain, but more like a distribution. That’s the really cool result!”

Rinker noted that, “fungal pathogenicity is not considered obligate, but rather opportunistic. Therefore, the potential for new, opportunistic fungal pathogens to make the ‘leap’ into the clinic may be greater than we previously realized.”

Read more >>



Above: *Aspergillus fischeri* from The University of Adelaide. Rinker (left) and Rokas talk about their research at the 2023 Evolutionary Studies Retreat.

Revealing How Selfish mtDNA Evolve and Thrive

Vanderbilt University researchers, led by alumnus Bryan Gitschlag, have uncovered groundbreaking insights into the evolution of mitochondrial DNA (mtDNA). In their paper in *Nature Communications* titled "Multiple distinct evolutionary mechanisms govern the dynamics of selfish mitochondrial genomes in *Caenorhabditis elegans*," the team reveals how selfish mtDNA, which can reduce the fitness of its host, manages to persist within cells through aggressive competition or by avoiding traditional selection pressures. The study combines mathematical models and experiments to explain the coexistence of selfish and cooperative mtDNA within the cell, offering new insights into the complex evolutionary dynamics of these essential cellular components.

Gitschlag, an alumnus of Vanderbilt University, conducted the research while in the lab of Maulik Patel, assistant professor of biological sciences. He is now a postdoctoral researcher at Cold Spring Harbor Laboratory in David McCandlish's lab. Gitschlag collaborated closely with Patel Lab members, including James Held and Claudia Pereira.

According to Patel, "in biology, 'cheater' is defined as an entity that benefits from a cooperative relationship without reciprocating. Selfish mtDNA are bona fide cheaters in this sense. They benefit from their symbiotic relationship with the nucleus, by being replicated using machinery expressed in the nuclear genome, but without conferring the usual metabolic advantages associated with being a mitochondrial genome."

Patel's faculty headshot (VU)

Experimental Studies

The study centered on mtDNA in Caenorhabditis elegans, a tiny nematode that has long served as a model organism in genetic research. With its simple structure and fully mapped genome, *C. elegans* provides an ideal system for exploring the dynamics of mitochondrial DNA, including the balance between selfish and cooperative genetic elements. A key focus of this research was the uaDf5 mutation, a deletion in the mtDNA that behaves selfishly by outcompeting healthy mitochondria, even though it reduces the overall fitness of the organism.

This discovery has wide-reaching implications for the study of mitochondrial diseases, many of which arise from dysfunctional mtDNA. Understanding how selfish mitochondrial elements evolve and persist offers new pathways for investigating mitochondrial disorders and developing therapeutic interventions. Additionally, these findings provide a framework for studying similar evolutionary dynamics in other systems where selfish and cooperative elements coexist.

Mathematical Models

The mathematical model developed by the team helps explain how the uaDf5 mutation in mtDNA persists despite reducing the organism's fitness, shedding light on how similar defective DNA might contribute to aging and disease. Following up, the team used this model to study other instances where mutations in mtDNA, which damage important genes, continue to persist and spread within cells, despite their harmful effects. The next step was to apply the model to other mtDNA mutations.

The researchers found that some mutations persist over time due to a balance between selection pressures operating both within and between individual organisms (multi-level selection), while other mutations persist due to a balance between selection pressures operating entirely within an organism. The paper suggests that mutations that have no effect would typically either become lost or become fixed in the population by random genetic drift. Accordingly, their model revealed that some mutations confer a net replicative advantage over unmutated mtDNA, causing the mutant mtDNA to proliferate within individual organisms.

Read more >>

Warming Quickens Aging-Related Mortality in Mosquitoes

Mosquitoes tread a thinning line in warming climates, where aging accelerates and infections intensify. New research shows that warming and aging act as a one-two punch, lowering mosquito lifespans and fanning the flames of bacterial infections. These findings highlight how climate change could alter the risks of disease spread by mosquitoes.

The new study, "Warmer environmental temperature accelerates aging in mosquitoes, decreasing longevity and worsening infection outcomes," was published in the journal *Immunity & Ageing*. The team, led by graduate student Jordyn Barr, used three temperature treatments, four immune response conditions, and conducted experiments with mosquitoes at four different ages. The rest of the team consisted of Barr's advisor, Julián Hillyer, lab mate Lindsay Martin, and Ann Tate.

The first results reported are no surprise, mosquitoes that are infected with bacteria survive less than those that are not and mosquitoes that are older survive less than those that are younger. A result that is captivating is that mosquitoes in warmer conditions survived less than those in cooler conditions. The paper notes that starting at 27°C, a mosquito's risk of dying increases a startling 40% for every degree warmer.

According to Hillyer, "that warmer temperature increases mortality was not surprising, but the magnitude of the increase certainly was!"

"In the lab setting, we had initially tried to measure survival at 33°C," Barr continued. "At this warmer temperature, mosquitoes had difficulty surviving past 10 or 11 days of age. Even at 32°C, it was challenging to have a sufficiently large population of mosquitoes survive to 15 days into adulthood!"

A previous study from the Hillyer lab found that rising temperatures accelerate aging in mosquitoes, which weakens their immune system. The work showed that mosquitoes reared at higher temperatures aged more quickly, resulting in a compromised immune response. But this early study did not scrutinize whether weakened immunity translated into worse survival or infection outcomes. Therefore, the new study goes further by measuring the combined effects of infection, aging, and warming on survival and the intensity of an infection.

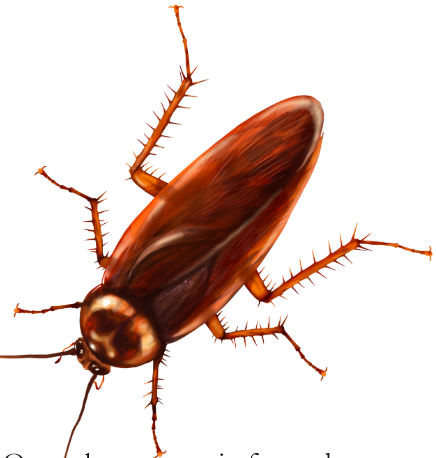
The results show that each of the categories measured negatively affect mosquito longevity and many effects are compounded. While infection always lowered a mosquito's likelihood of survival, an infection in warmer conditions was more detrimental than an infection in cooler conditions. The same is true for aging, older mosquitoes survived less than younger mosquitoes when infected. But importantly, unlike what happens for humans and other mammals that use metabolism to regulate their body temperature, changes in temperature greatly modified how fast mosquitoes aged. As a consequence, warmer temperature accelerated aging-related mortality and amplified the aging-dependent increase in the strength of an infection.

Read more >>

Photo submitted by Hillyer

Barr (left) and Hillyer in the lab.

Cannibalism, Zombies and Wasps



New research from Ken Catania, Stevenson Professor of Biological Sciences, shows another incredible result. The "Cocoon of the Developing Emerald Jewel Wasp (*Ampulex compressa*) Resists Cannibalistic Predation of the Zombified Host" was published in Brain, Behavior, and Evolution.

Catania's research program focuses on the weird in nature. His past works identified the role of the nose in star-nosed moles, the electricity of electric eels, and the free-will of parasitized cockroaches. This project focuses on the cockroach system.

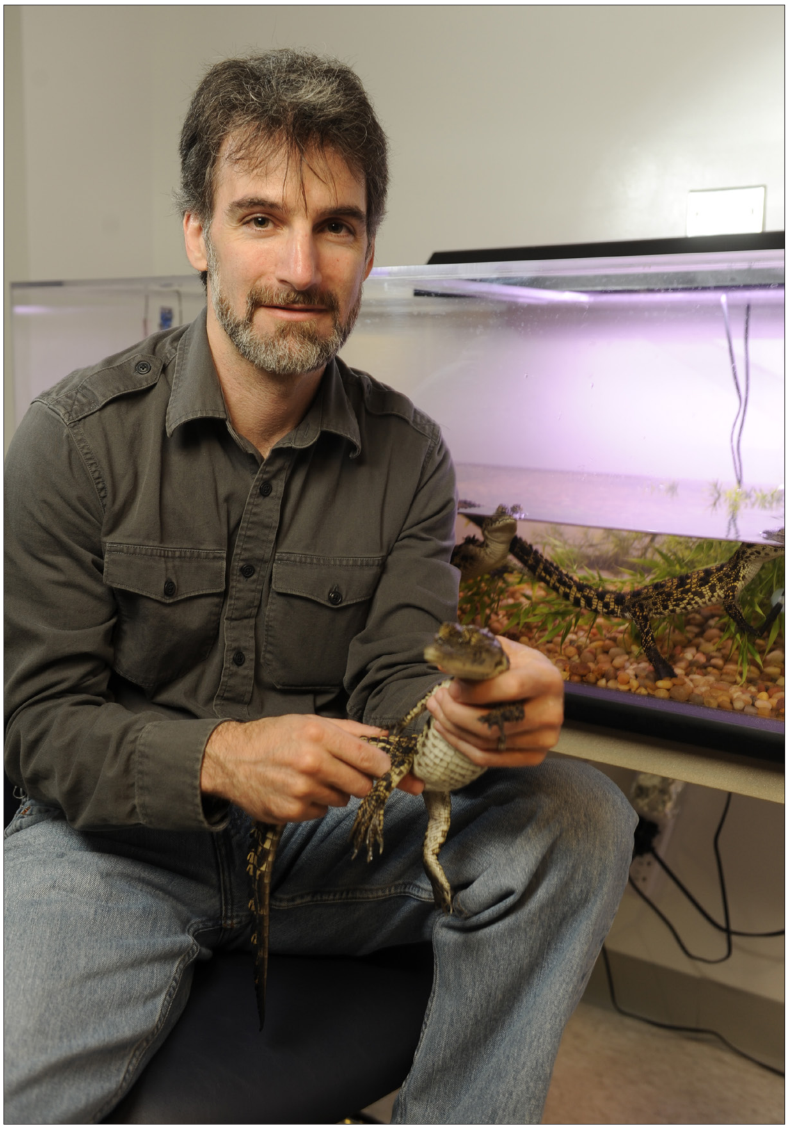
Emerald jewel wasps have a pretty standard lifecycle for a parasitoid. They attack cockroaches with venom, lay an egg on the paralyzed cockroach, and then the egg hatches, works its way into the cockroach, and eats the cockroach from the inside out. Parasitoids like these have been the inspiration for many sci-fi horror movies.

This particular project started as a bit of a mystery - not unlike Alexander Fleming's discovery of penicillin. Catania had just finished some experiments with cockroaches and jewel wasps. He set aside a parasitized cockroach and left for a few days. Upon his return, he discovered nothing more than a cocoon in the tray. What happened to the cockroach? Upon investigation, he found a live cockroach in the tray and deduced the story.

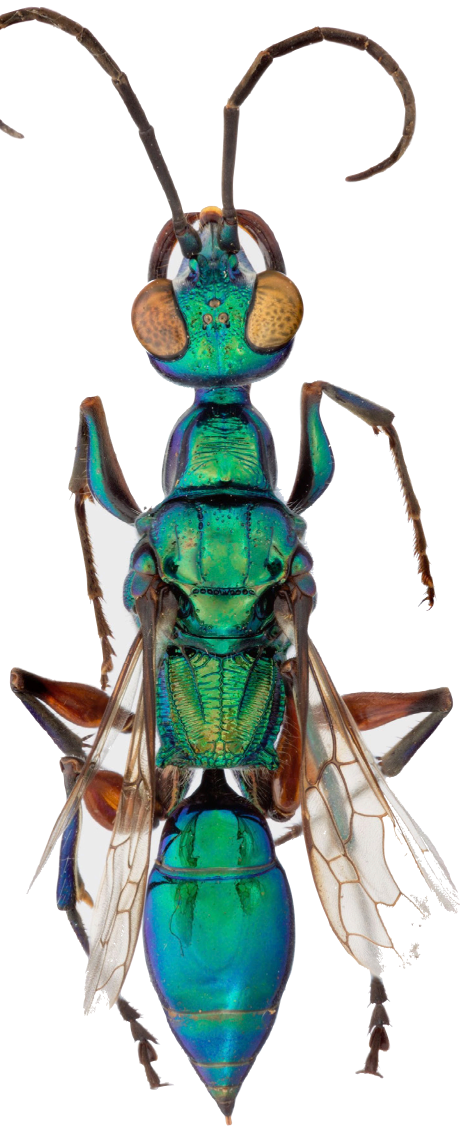
The live cockroach cannibalized the parasitized cockroach, yet the wasp survived.

Catania explained, "it turns out that if you offer a parasitized cockroach to other hungry cockroaches, you find that the jewel wasp is killed every time up until about day 10. Once the cocoon is formed, it's never killed."

Learn more >>



Catania holding a baby alligator (John Russell VU).



Examining Evolutionary Hypotheses for Modern Metabolic Health

A new review co-led by graduate students Layla Brassington and Audrey Arner of the Lea Lab discusses the formulation of the popular and impactful Thrifty Genotype Hypothesis. This hypothesis, proposed by James Neel in 1962, suggests that fat deposition and energy conservation were once useful traits in times of scarcity but are now increasing obesity-related health issues in urban, industrialized environments where food scarcity is not as common.The review discusses the evidence for this hypothesis and traces its impact to newer hypotheses at the forefront of evolutionary medicine. It also provides preliminary data from the Orang Asli Health and Lifeways study to highlight how evolutionary medicine hypotheses can be tested. The paper, "Integrating the Thrifty Genotype and Evolutionary Mismatch Hypotheses to Understand Variation in Cardiometabolic Disease Risk," was published in the journal *Evolution, Medicine and Public Health*.

The team identified a few key takeaways about the Thrifty Genotype Hypothesis in their review. First, some of the main predictions of the Thrifty Genotype Hypothesis remain untested, such as the idea that certain genes were once selected for due to health-related benefits during times of scarcity. Second, the hypothesis has sparked other hypotheses within evolutionary medicine, such as the Evolutionary Mismatch Hypothesis, which is a contemporary reimagining of the Thrifty Genotype Hypothesis. Critically the Evolutionary Mismatch Hypothesis is expanded to not just include obesity, but many other lifestyle-associated diseases and mismatches between humans' ancestral past and now.


Photo submitted by Arner

Using data to test key predictions

Arner and Brassington are assessing key knowledge gaps in the mechanisms underlying evolutionary mismatch by working with the Orang Asli, the indigenous peoples of Peninsular Malaysia, in collaboration with the Orang Asli Health and Lifeways Project (OA HeLP), of which Dr. Amanda Lea is a co-director. To date, OA HeLP has worked with over a thousand Orang Asli individuals to explore how their evolutionary history and current lifestyles impact health. The population has a wide range of lifestyles: some rely on wage labor and live in modern environments with market foods, while others maintain traditional practices like foraging and live in bamboo houses in the rainforest. This lifestyle variation correlates with proximity to Kuala Lumpur, Malaysia's capital city, where greater distance is linked to lower sugar intake, higher wild meat consumption, less formal education, and fewer visits to urban centers.

The team found that these lifestyle changes have mostly occurred within the last one to two generations, potentially exposing previously selected genes to new environments on short evolutionary time scales.

Read more >>

Top right: Lea (left) and Brassington collecting blood. Bottom: Image of rural to urban landscape (DALL-E).

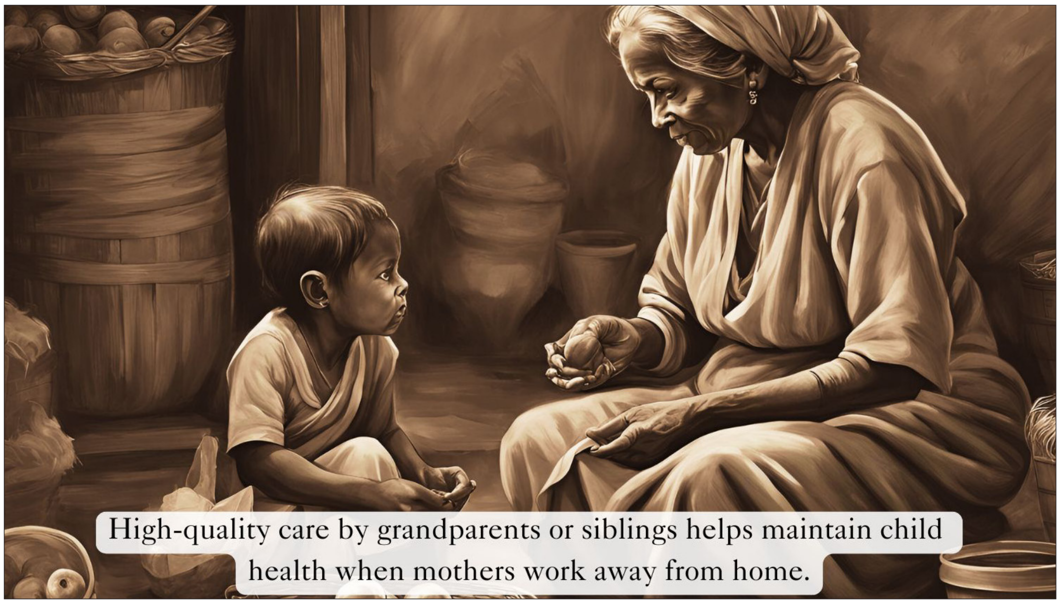
Child Health in Working Families

A new study co-authored by Monica Keith, Assistant Professor of Anthropology, provides insights into how different childcare models affect child health outcomes in working families. The research, focused on subsistence-based, semi-nomadic Shodagor communities in Bangladesh, highlights the crucial role of maternal care and effective substitutes in maintaining child health when mothers work. The paper, "Impacts of women's work and childcare on child illness among Bangladeshi Shodagor communities," was published in the journal *Social Science & Medicine*.

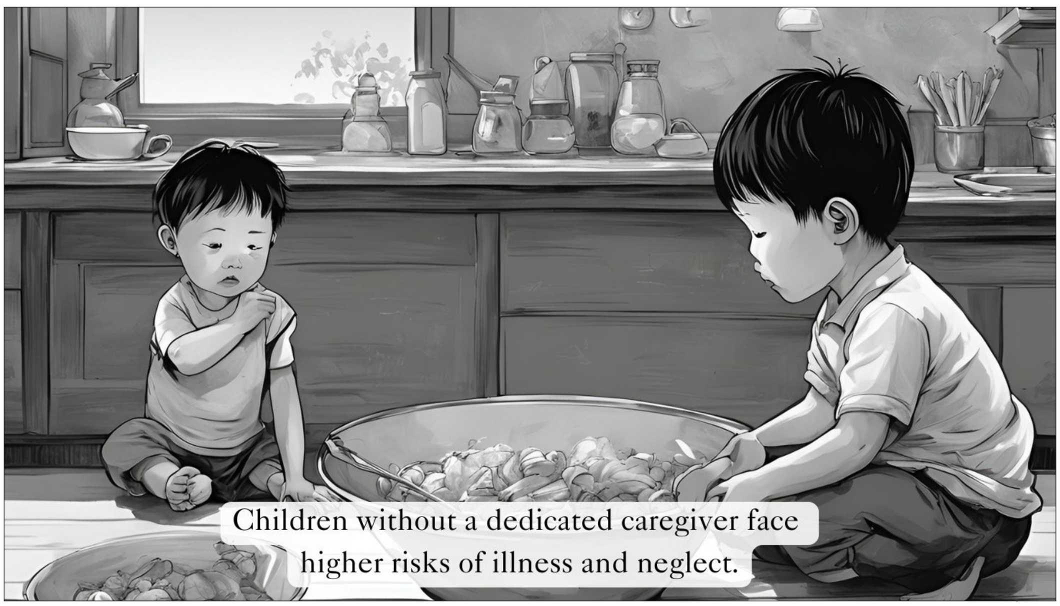
The study shows that children who receive consistent care from their mothers, especially when their work is compatible with childcare, experience fewer days of illness. It also highlights the significant role of alloparents, such as grandmothers or older siblings, who can effectively substitute for maternal care, helping to reduce the health risks associated with mothers working away from home. However, the research finds that children without a dedicated caregiver face higher risks of illness and neglect, underscoring the evolutionary importance of reliable and high quality childcare solutions.

Read more >>

Children receive consistent care and supervision when mothers work in roles compatible with childcare, leading to fewer illness days.



High-quality care by grandparents or siblings helps maintain child health when mothers work away from home.



Children without a dedicated caregiver face higher risks of illness and neglect.

Feeding Strategies of an Ancient Ediacaran Organism

A new study, led by alumnus Andrei Olaru in Paleobiology titled, “Functional morphology of the Ediacaran organism *Tribrachidium heraldicum*” sheds light on the functional morphology one of the earliest known large and complex animals. Using advanced computational fluid dynamics (CFD), the research explores how this 550-million-year-old organism, characterized by its triradial symmetry, likely fed and interacted with its environment in shallow-water ecosystems.

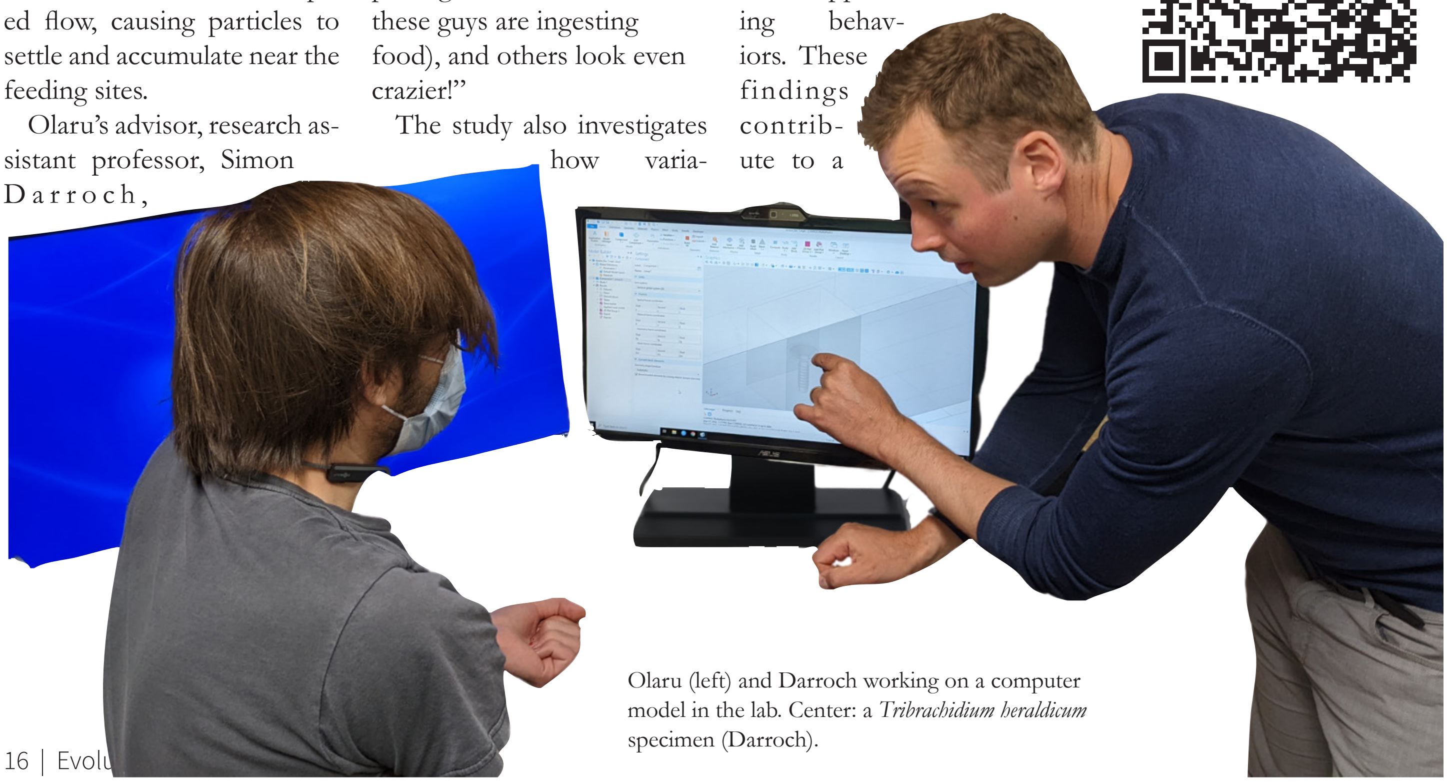
According to the paper, *Tribrachidium heraldicum* employed a suspension-feeding strategy, with specific anatomical features such as apical pits and triradial arms playing crucial roles in collecting food particles. By simulating fluid flow around digital models of the organism, the researchers demonstrated how these features interrupted flow, causing particles to settle and accumulate near the feeding sites.

Olaru’s advisor, research assistant professor, Simon Darroch, ever excited about this kind of research, said, “I think the most interesting parts of the paper are where Andrei floats broader hypotheses surrounding how widespread suspension feeding might be among other Ediacaran weirdos. Some have arms that don’t bend, while others have crazy arrangements of apical pits (which is what we are interpreting as the ‘mouths’ where these guys are ingesting food), and others look even crazier!”

The study also investigates how variations in flow conditions affected the feeding efficiency of individual organisms and groups. The results suggest that *Tribrachidium* was capable of thriving in various flow environments, whether living in isolation or as part of a larger population. Additionally, the research offers new insights into other Ediacaran taxa with similar body plans, suggesting that shared structures may have supported similar feeding behaviors. These findings contribute to a broader understanding of how suspension feeding evolved in early animal communities and how it influenced the radiation of Metazoans across the Ediacaran-Cambrian boundary.

“I think what stands out about Andrei is his intellectual curiosity. He was always asking questions not only about the methods and analyses he was performing, but also how this fit into the bigger picture,” he said. “I think that’s why this project was so easy to turn into a nice paper; because Andrei was always looking to build his own bigger-picture sense for what was happening evolutionarily in the Ediacaran.”

Read more >>



Olaru (left) and Darroch working on a computer model in the lab. Center: a *Tribrachidium heraldicum* specimen (Darroch).

Ancient Worms as Early Ecosystem Engineers

Graduate student Kat Turk from Vanderbilt University's Department of Earth and Environmental Sciences, along with an international team of collaborators, has uncovered new evidence that ancient priapulid worms, through their burrowing behavior, may have been some of the earliest ecosystem engineers. The study, "Priapulid neoichnology, ecosystem engineering, and the Ediacaran–Cambrian transition" published in *Palaeontology*, highlights the significant impact these tiny creatures may have had on the evolutionary landscape of the Ediacaran-Cambrian transition—a period marked by the first appearance of complex life on Earth.

This newly published study involves priapulid worms, a poorly understood group of marine organisms that first appear in the Cambrian approximately 510 million years ago and still exist today. Turk and colleagues at the Senckenberg am Meer marine laboratory in Germany observed the burrowing of modern priapulids in controlled environments, recording behaviors previously unknown from the group that may suggest significant impact on seafloors when extrapolated 500 million years into the past.

In particular, the authors found that when given adequate subsurface space and sediment, priapulids will create burrows very similar in form to the trace fossil Treptichnus pedum – a little understood fossil which is used to mark the Ediacaran-Cambrian boundary and thus the advent of our modern, animal-dominated biosphere.

Turk described the study as "a major step forward in our study of modern animals and environments to better understand fossil record questions," a discipline also known as 'neoichnology.' "Here we've shown that not only do priapulids create these burrows so similar in shape to those we find from 538 million years ago, but also that these newly documented behaviors may have had outsize impacts on their sedimentary environments via the downwards transport of oxygen and other nutrients," Turk added.

Understanding how these behaviors emerged and evolved can provide valuable insights into early ecosystems and how life on Earth adapted to environmental changes. "Ecosystem engineering is a powerful concept in evolutionary biology," said co-author Simon Darroch.

Read more >>

Top right: Turk's experimental setup (Turk). Left: A container full of priapulids (Turk) Bottom left: Turk collecting the worms on board the F.K. SENCKENBERG in 2022 (submitted by Turk).

Vanderbilt's PhenoCam

In an innovative effort to monitor climate change's effect on local ecosystems, Vanderbilt University has recently joined the PhenoCam Network—a powerful collection of over 700 cameras stationed worldwide, gathering data on vegetation dynamics. The newly installed PhenoCam, positioned above the School of Nursing, captures images of Vanderbilt's tree canopy every 30 minutes. These images, which anyone can access online, provide researchers, students, and the public with real-time insights into how seasonal shifts affect our environment.

Assistant Professor of Earth and Environmental Science Lin Meng, who leads this project, sees Vanderbilt's involvement as a step toward more comprehensive climate data and valuable student research.

"Our site contributes one data point to a network of over 700 sites globally," she said.

She went on to note that as data accumulate, undergraduates can begin their own projects on how vegetation dynamics vary over years and relate to conditions here on campus. This growing image library will eventually allow analyses that reveal seasonal patterns, like leaf color change and drop, for comparisons across ecosystems worldwide.

The PhenoCam Network was founded to close critical gaps in climate data. Before PhenoCam's existence, researchers mainly relied on broad-scale remote sensing and labor-intensive manual observations, which both presented challenges. She explained that remote sensing data is good for big picture projects, but bad for detailed analysis while manual observations require someone to physically visit a site up to every other day for years at a time.

"PhenoCams offer near-surface monitoring of phenology with incredible accuracy," Meng explained. "This technology bridges gaps left by remote sensing or manual data collection and gives us a standardized, high-quality dataset."

Meng expalined that Vanderbilt's PhenoCam is distinct within the network due to its setting. Most PhenoCam sites are located in remote natural areas—like mountains, forests, or grasslands—where human influence is minimal. However, Vanderbilt's camera is stationed within an urban environment, which Meng sees as a unique feature.

"Most PhenoCam sites are in natural environments, but our urban location—with all its buildings, roads, and human influences—gives us a unique view on how climate impacts vegetation in cities," she pointed out.

Urban vegetation, such as trees, often experiences additional stressors like urban heat, air pollution, construction activies, and irregular watering, which can compound seasonal climate effects. This setup lets Vanderbilt researchers study how these urban factors influence vegetation's response to climate, with implications for urban planning. Over time, data from this site could inform projects aimed at reducing urban heat, enhancing air quality, and supporting biodiversity.

In addition to enhancing research, the PhenoCam has a significant educational impact. Meng sees it as an opportunity for students to engage with real-world data and learn analytical skills firsthand.

"Having a PhenoCam on campus supports not just research but also teaching and outreach," Meng noted. "Students are often excited to know they can engage with this data directly, and it opens up countless project possibilities."

Meng plans for undergraduates to study how factors like construction dust or artificial light impact vegetation patterns.

The potential for student

research is substantial. Using PhenoCam data, students can explore correlations between temperature or precipitation changes and patterns of vegetation growth and dormancy. By comparing Vanderbilt's data with other sites, they can learn how environmental factors shape plant responses globally. Meng hopes these projects will inspire a new generation of climate researchers and environmental scientists.

PhenoCam data is an excellent teaching resource for students in ecology, environmental science, and data science. "This dataset is incredibly valuable for both research and education," Meng said, adding that as classes incorporate PhenoCam data, it could become a central educational tool in the Earth and Environmental Sciences department. In this way, PhenoCam provides students with hands-on experience in connecting climate science with ecosystem health.

Beyond Vanderbilt, the PhenoCam Network's data supports global climate research, with consistent, long-term records of plant phenology across diverse ecosystems. Meng collaborates closely with the PhenoCam Network's principal investigator, Andrew Richardson of Northern Arizona University whose team continues expanding the network with more sites globally. By sharing data with other institutions, researchers can track phenological trends worldwide, a vital step for addressing climate impacts on ecosystems.

As Meng highlighted, these records are essential for tracking phenological events such as bud break in spring or autumn leaf senescence, both of which are crucial for entire ecosystems. Shifts in these rhythms can ripple through the ecosystem, affecting plant-pollinator interactions, animal migrations, and nutrient cycles. Such shifts can cascade through the food web, ultimately affecting biodiversity.

The open-access nature of the PhenoCam Network stands out, inviting citizen scientists, educators, and policymakers to engage with climate science. Meng hopes Vanderbilt's PhenoCam will also encourage local interest in climate research.

"PhenoCam data is publicly accessible, and we encourage anyone interested to explore it," she said, adding that "making this information available might inspire people to think about climate change's local impact."

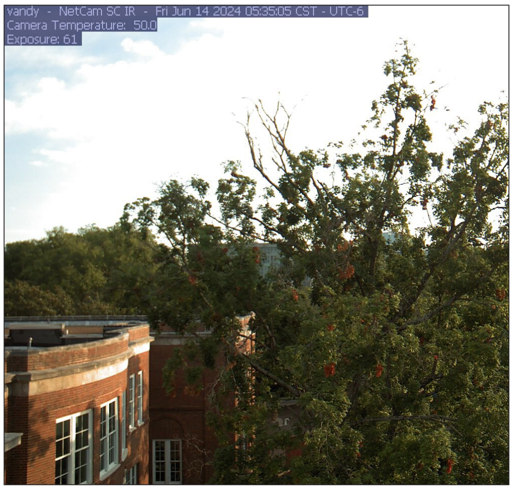
In the years ahead, Vanderbilt's PhenoCam will continue capturing and cataloging seasonal changes on campus. Over time, this stream of data could uncover new insights into how campus vegetation adapts to urban pressures and broader environmental shifts. Each image tells a part of the story of how trees on campus respond to climate events, from drought to unseasonably warm winters.

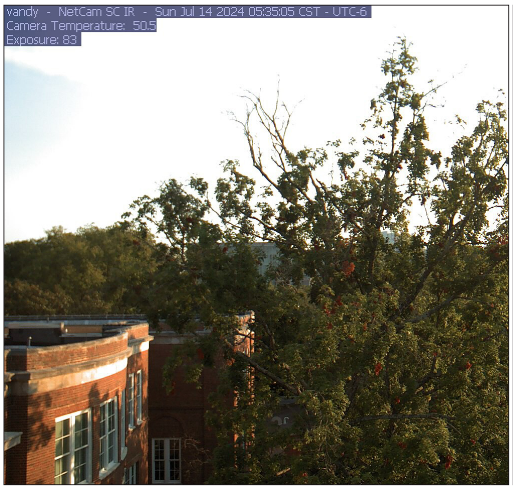
> "THIS DATASET IS INCREDIBLY VALUABLE FOR BOTH RESEARCH AND EDUCATION"

With climate change driving transformations across ecosystems worldwide, efforts like the PhenoCam Network emphasize the need for local monitoring of vegetation responses. Whether it's a tree conserving water by dropping leaves early or new green shoots in an extended warm period, each PhenoCam snapshot reveals a piece of the puzzle of how plants adapt to our changing world.

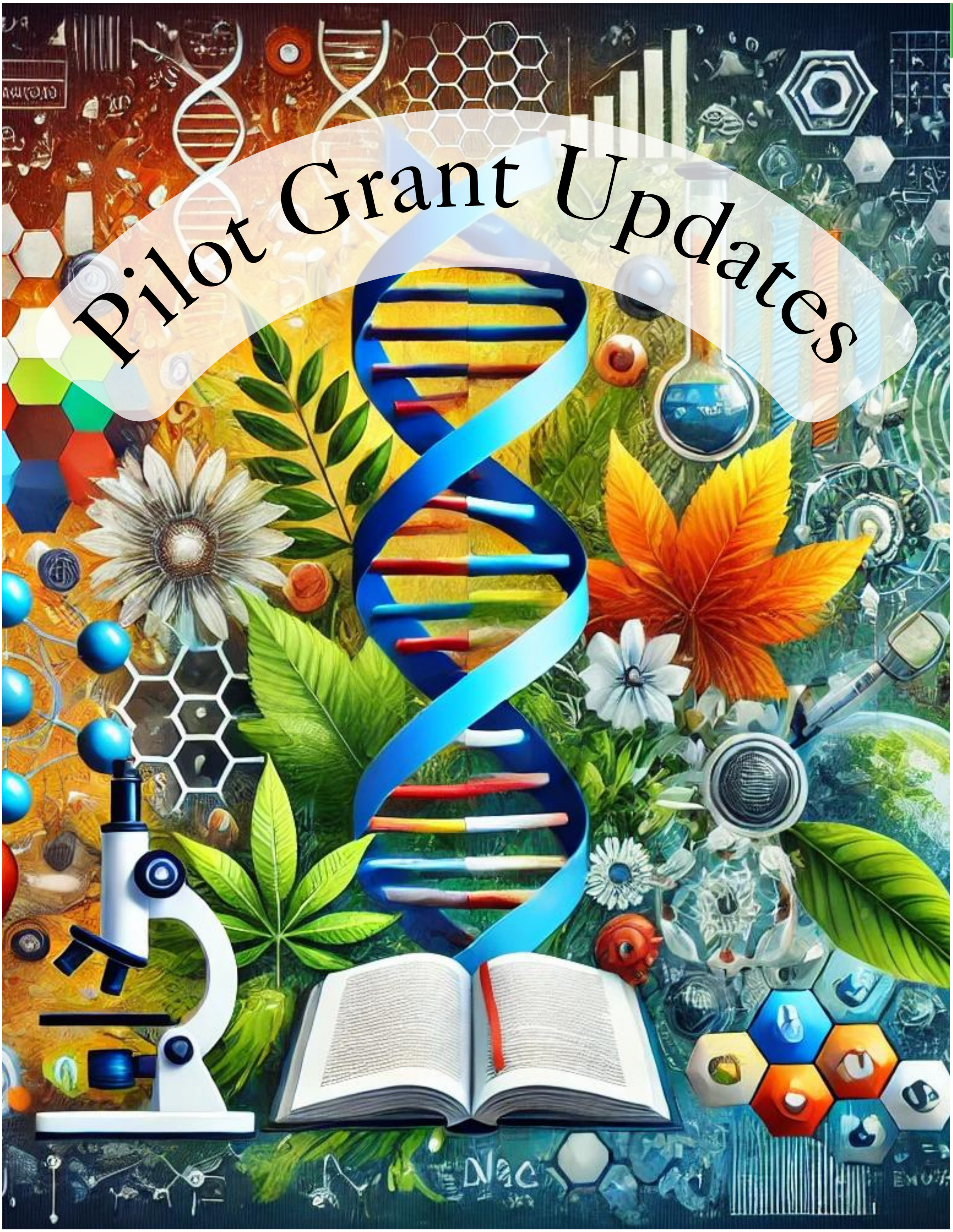
By joining the PhenoCam Network, Vanderbilt University has committed to a global mission of documenting and understanding climate impacts on plant life. Meng's work with the network not only bolsters this mission but also serves as a model for combining environmental research, education, and public engagement, establishing Vanderbilt as a vital contributor to climate science.

Check out our PhenoCam video here >>





Pilot Grant Updates



Meng Lab

Brandt Geist

By Alexandria Leeper, Evolutionary Studies Communications Assistant

Imagine you are trying to stargaze. You live in a suburban area where there are little streetlamps, and the darkness of the night envelops most of the sky, making the stars visible. However, you are adjacent to a major city. When you turn your gaze toward that city's skyline, you notice the stars disappear from sight. Instead, there is a soft haze above the city, a phenomenon known as sky glow.

Brandt Geist, a Ph.D. student in the Department of Earth and Environmental Sciences advised by Assistant Professor Dr. Lin Meng, explained that "sky glow" is caused by light pollution, in which artificial light at night (ALAN) is scattered by the particles in the air. Light pollution alters the natural day/night cycle in cities, but even areas without direct light pollution are affected by sky glow from cities, according to Meng. Light pollution, stemming from the Industrial Revolution and subsequent urbanization, continues to be a growing problem across the globe, increasing by an average of 2.2% annually, based on a previous study. Stargazing is not the only activity affected, however, as Geist emphasized that many living organisms are sensitive to the amount of light they receive within a 24-hour period.

Geist asserted that ALAN disrupts the natural life progression of urban plants, including growth cycles, the timing of leafing, flowering, and fruiting. Following such, a domino-effect of ecological network disruption and evolutionary changes can occur.

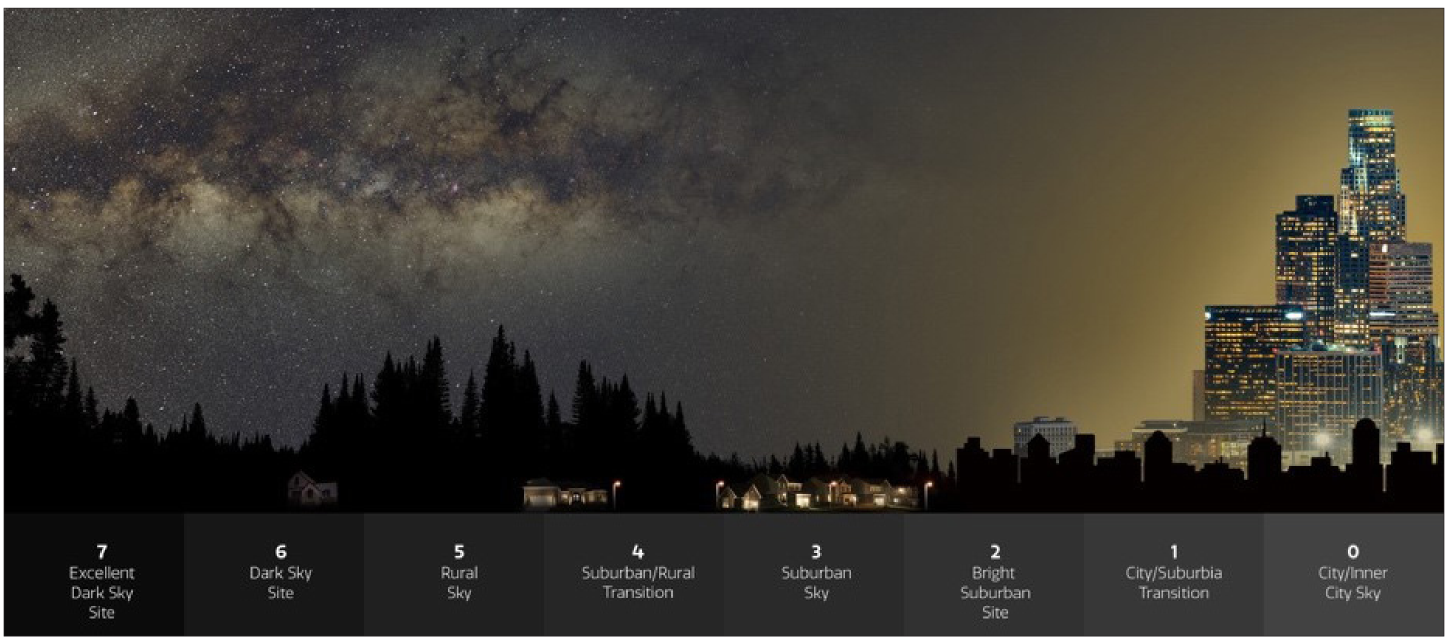
Geist explained, "the timing of plant growth cycles originally matches that of other organisms, but when plant phenology changes or changes at a different rate, it leads to a mismatch. For example, in a disrupted plant-pollinator relationship, insects that rely on the buds of trees for food may need to adapt if these resources become unavailable at their usual times. This disruption can force insects to alter the timing of their life cycles, which in turn can impact their predators and have cascading effects on the ecosystem."

According to Geist, healthy trees are required for human survival, as they are essential components of the global ecological landscape, absorbing the excess carbon contributing to global warming and climate change, moderating temperature, in addition to enhancing air quality.

Geist stated, "ALAN disrupts ecosystems by indirectly impacting the carbon cycle, water cycle, and other natural processes. These disruptions affect ecosystem services that trees provide and that humans rely on."

Geist received pilot grant funding from ESI to quantify the efficacy of ALAN mitigation policies in reducing light pollution and preserving plant phenology in two pairs of Northeastern U.S. cities, New York City and Washington D.C. (with policies) and Newark and Philadelphia (without policies).

Read More >>



Top: Geist (submitted photo). Bottom: The effects of light pollution on star visibility. (NOIRLab / NSF / AURA, P. Marenfeld. Available under CC Attribution 4.0 International)

Benn Torres Lab

Katie McCormack

By Neomi Chen, Evolutionary Studies Communications Assistant

As Katie McCormack meticulously extracted calcified dental plaque from ancient Peruvian teeth, she felt the weight of centuries of history in her hands. This intricate work, part of her groundbreaking research in the Jada Benn Torres Lab, aims to unravel the secrets of ancient oral health. With the support of the Evolutionary Studies Initiative (ESI) and a recent Vanderbilt Dissertation Enhancement Grant, McCormack has made significant strides in her study of ancient pathogens and their impact on human evolution.

Oral Microbiome Project at La Real Site in the Yungas Zone of the Peruvian Andes

Data Collection

"Two scientists wearing full-body protective suits, gloves, masks, and hair coverings, standing in a laboratory. One has 'Katie' written on their suit and is wearing green Crocs, while the other has 'Jada' written on their suit and is wearing green shoe covers. They are standing next to laboratory equipment, including a fume hood labeled 'AirClean 600' and various lab supplies." alt text generated by ChatGPTIn December 2021, McCormack began removing microbial DNA from five sets of archaeological teeth to screen for respiratory and oral pathogens and study the oral microbiome of prehistoric humans—early humans who lived before recorded history. In the ancient DNA lab at the University of Oklahoma (OU), McCormack suited up in full Tyvek gear, a stark reminder of the precautions necessary to handle precious, degraded samples. She received oral microbiome paleogenomics training from Dr. Tanvi Honap who worked in the Laboratories of Molecular Anthropology and Microbiome Research headed by Dr. Cecil Lewis.

Preliminary Results

When McCormack received the genomic sequencing back from OU, she embarked on the initial taxonomic classification stage. By comparing the DNA of the oral pathogens to known databases, MetaPhlAn4 and KrakenUniq determined the identities of these pathogens, allowing McCormack to gain a deeper understanding of the microbial communities. The presence of Red Complex pathogens in three individuals—Tannerella forsythia, Treponema denticola, and Porphyromonas gingivalis—sheds new light on the prevalence of periodontal and endodontic disease in ancient Andean communities. Due to changes in diet around that time, McCormack highlighted the potential association between periodontal diseases and maize consumption in South America. In April 2024, McCormack presented this preliminary data and findings at the Society for American Archaeology conference.

Next Steps

As McCormack riffled through the metagenomic data, she found that one of the individuals had evidence of tuberculosis (TB). That discovery propelled her to use her recently awarded Vanderbilt Dissertation Enhancement Grant to collaborate with Anne Stones' lab at Arizona State University and her graduate student Adele Crane for the capture work and target enrichment of mycobacterium tuberculosis—a complex of closely related bacteria that causes TB.

"Tuberculosis has co-evolved with humans for millions of years," McCormack explained, emphasizing the disease's deep-rooted presence in our evolutionary history.

Read more >>

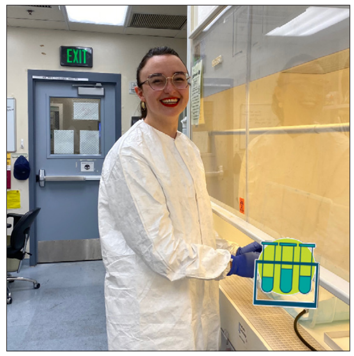
McCormack with Dr. Benn Torres in Tyvek suits at the University of Oklahoma ancient DNA lab (photo submitted by McCormack).

McCormack preparing samples (photo submitted by McCormack).

Tung Lab

Sylvia Cheever

By Alexandria Leeper, Evolutionary Studies Communications Assistant



Sylvia Cheever, a Ph.D. student in Biological Anthropology at Vanderbilt University, is uncovering the hidden stories of indigenous communities affected by colonial exploitation in Peru. Supported by a pilot grant from the Vanderbilt Evolutionary Studies Initiative, Cheever's research focuses on measuring mercury levels in ancient human bones from Huancavelica, a region impacted by Spanish colonial mining practices. This groundbreaking study seeks to understand the health effects of forced labor conditions on indigenous populations during the Spanish occupation.

Under the supervision of Dr. Tiffiny Tung, Professor of Anthropology and Vice Provost of Undergraduate Education at Vanderbilt, Cheever's research delves into a painful chapter of history. The Spanish conquest of Peru led to the exploitation of indigenous populations, forcing them to extract silver using mercury amalgamation—a dangerous process that left a toxic legacy. "History is not exclusively colonial," said Cheever. "The Spanish came in and wanted to mine silver, but it was poor quality ore. Mercury amalgamation led to more efficient extraction. Workers died in the mines."

Dr. Tung emphasized the importance of this research in telling a fuller story of the indigenous experience during this period. "What I love about this collaboration between anthropology and the Evolutionary Studies Initiative is that it's using science to understand the human experience," Tung said. "This research project is going to help us understand what that experience was like from the indigenous perspective."

New Methods for Ancient Remains

Cheever's project is pioneering in its application of modern analytical techniques to ancient remains. She is working with Dr. Gwyneth Gordon at Arizona State University to quantify mercury concentrations in the bones of individuals who labored in these hazardous conditions. "Old bone can be degraded, and this is a large reason why I wanted to do this pilot study," Cheever explained. "This method, once refined, will be broadly relevant to bioarchaeological research, the evolutionary study of heavy metal uptake in biological organisms, and the environmental cycling of mercury over time."

The method Cheever uses involves careful analysis to ensure the mercury detected is from the bones themselves, not from environmental contamination. This meticulous approach is key to understanding the true impact of mercury on the health of these communities.

The implications of Cheever's work extend beyond historical analysis. By examining how mercury exposure affected indigenous populations in the past, her research provides insight into the long-term health consequences of toxic working conditions. "Not only are we learning about the specific indigenous population involved, but we're also learning about how laboring and toxic environments harm communities," said Tung.

Read more >>

Top: Cheever in the lab excited about a new result (photo submitted by Cheever). Bottom: Cheever preparing samples (photo submitted by Cheever).

Lea Lab

Robert Tennyson, Jonathan Lifferth, Amy Longtin

By Alexandria Leeper, Evolutionary Studies Communications Assistant

Three Vanderbilt University researchers, all recipients of Evolutionary Studies Initiative (ESI) pilot grants, are investigating the relationships between the genome, the environment, and health. Dr. Amanda Lea's lab leads this research, exploring the impacts of lifetime environmental exposures and evolutionary processes on human health outcomes. The ESI-funded work focuses on how inflammation, genetic ancestry, and epigenetic modifications shape the body's responses to modern environmental challenges, using populations from across the globe as models. These research efforts hope to reveal insights into human evolution and contemporary health, particularly in non-industrialized communities.

Dr. Amanda Lea and the Evolutionary Perspective on Health

Lea, an assistant professor in Vanderbilt's Department of Biological Sciences, has built a lab focused on blending anthropology, genetics, and evolutionary biology. Her research focuses on the evolutionary mismatch hypothesis—the idea that many modern diseases stem from the stark differences between the environments in which humans evolved and those we live in today.

"Our work is based on trying to understand how modern lifestyles, which are dramatically different from the environment humans evolved in, impact our health," said Lea. "By studying populations like the Orang Asli of Malaysia, who live across a gradient of urbanization, we can investigate how varying exposures to traditional, subsistence-level versus modern, urban environments influence health outcomes."

The Pilot Grant Recipients: Tackling Key Questions

This year, three members of the Lea Lab—postdoctoral researcher Dr. Robert Tennyson and graduate students Amy Longtin and Jonathan Lifferth—were awarded ESI pilot grants to further their work on how the environment influences the genome and genotype-by-environment interactions.

Dr. Robert Tennyson: Early Life Environments and Inflammation

Tennyson's project focuses on understanding how early life environments influence inflammation in adulthood. Working with indigenous Orang Asli communities, Tennyson is exploring how different early life environments—ranging from sterile and urbanized to traditional, natural pathogen exposures, and subsistence-based lifestyles—affect inflammatory biomarkers like C-reactive protein measured in adulthood.

The goal is to assess whether inflammation in adulthood correlates with early life environments and whether individuals whose lifestyles have changed over time experience worsened health outcomes. His work has the potential to contribute to our understanding of inflammatory diseases like diabetes and cardiovascular disease.

Jonathan Lifferth: Genetic Ancestry and Immune Response

Lifferth, a graduate student in the Lea Lab, is examining how genetic ancestry influences immune responses among the Orang Asli. His study focuses on how genomic variations in ancestry affect gene expression, particularly when cells are mounting an immune response to bacterial infection.

"The Orang Asli population presents a unique opportunity to investigate how genetic ancestry modulates immune responses, particularly because they live across such diverse environments," Lifferth said.

Lifferth is particularly interested in identifying ancestry-specific gene expression and genotype-by-environment interactions that may explain differences in disease susceptibility across populations. His research will help identify how the immune system has evolved in response to different environmental pressures and could have important implications for understanding population-specific health risks.

Amy Longtin: Epigenetic Evolution Across Primates

Longtin, another graduate student in the lab, is leading a project comparing DNA methylation patterns in immune cell lines across six primate species: humans, gorillas, bonobos, macaques, orangutans, and chimpanzees. Her research aims to uncover how these patterns influence gene regulation and how they have evolved over time.

"I recently optimized a new, cost-effective protocol to measure DNA methylation, allowing us to now compare methylation across a broad spectrum of primates," Longtin explained. "This will help us understand the conservation and divergence of gene regulatory mechanisms across species, giving insight into phenotypic variation throughout evolutionary history," she added.

This study aims to help answer key questions about how epigenetic modifications influence immune responses and environmental adaptation in primates.

A Unified Goal: Bridging Evolutionary Biology and Human Health

Together, these three projects offer a comprehensive look at how genetics and environment interact to shape gene regulation, immune physiology, and ultimately health outcomes. Lea's lab combines evolutionary theory with cutting-edge genomic techniques to answer some of the most pressing questions in human biology. From understanding inflammation to exploring epigenetic evolution, their work is pushing the boundaries of how we understand health and disease in the context of our evolutionary past.

Lea noted, "our goal is to combine anthropology, genetics, and evolution to explore how these factors come together to influence health. These pilot projects represent key steps in understanding how the human evolutionary past interacts with modern-day environments to shape our health, and we appreciate the confidence ESI has in our work."

By advancing research in these areas, Vanderbilt's Lea Lab is uncovering insights that may not only explain current health disparities but also pave the way for new approaches to personalized medicine and public health.

Headshots from opposite left to right: Lea, Tennyson, Lifferth, and Longtin (submitted photos). Right: a rural area (top) compared to an urban area experienced by the Turkana. (Photos submitted by the Lea Lab)

DeSantis Lab

Katharine Walls

By Neomi Chen, Evolutionary Studies Communications Assistant

Kangaroo feces. Zebra hair. What can we conclude about the diets and environments of these two species from their scat and hair samples? Katharine Walls—a Ph.D. student in Dr. Larisa DeSantis' DREAM lab—is determined to find out. Walls recently earned a pilot grant from the Evolutionary Studies Initiative (ESI) to study conservation biology, specifically the reconstruction of the dietary ecology of marsupials and equids at local zoos.

Research Plan & Overview

Zoo Collaboration

Walls' pilot study will involve traveling to local zoos every two weeks for six months to gather fecal and hair samples from five animals. They will specifically be collecting data from adult red kangaroos (*Osphranter rufus*) and two species of equids: plains zebras (*Equus quagga*) and horses (*Equus caballus*). These animals are fed similar diets and will experience the same environmental factors at the zoo. However, they have different physiologies and are on different evolutionary branches.

Submitted photo.

Walls' commitment to initiating non-invasive zoo-based research stems from their five-year background working in zoo education at the Atlanta Zoo.

Walls highlighted the largely untapped potential of zoos: "I've witnessed many successful collaborations between researchers and the zoo. When done right, we can learn a lot from these animals without disrupting their lives."

Data Preparation and Analysis

After collecting the samples, Walls will prepare them with an undergraduate mentee and ship them away in tin capsules for isotopic analysis. At the University of Wyoming campus, their collaborators will use the Elemental Analyzer Isotope Ratio Mass Spectrometer to combust the samples and analyze the ratios of carbon-13 to carbon-12 and nitrogen-15 to nitrogen-14. Based on the results of the carbon and nitrogen ratios in each species, Walls can then investigate the extent to which variation is due to diet, climate, or species traits such as physiology.

Walls at the 2024 Earth Day event. Below: Walls digging in the field.

The historical and future implications of this project are notable. Walls explained the significance of stable isotopes and how to interpret them when working with fossils.

"They won't decay and won't change over time," they said. "Different plants have different photosynthetic pathways and stable isotope ratios. If an animal's isotopic signature in their teeth is really close to the isotopic ratio of C3 plants, then they likely ate a lot of that type of plant."

More broadly, Walls is excited to contribute to marsupial research and gain a more nuanced understanding of reconstructing dietary ecology as the climate and species change.

"We have a lot of literature on goats, horses, and cattle. It would be great if all that applies to marsupials, but I don't think that it will. Going forward, we will need a controlled study to help us interpret existing and future kangaroo and marsupial isotopic data," they said.

Evolution in Action: Zoo Outreach Initiatives

Inspired by their previous zoo employment, Walls has several ideas for potential ESI outreach at the Nashville Zoo, whether at pop-up events or on a monthly basis.

Walls described how a "Day at the Zoo" event would look: "labs all over the southeast region could come to highlight their zoo-based research. The sky is the limit of where things can go, but it's a great starting point for the frontline education team to convey the relevance of conservation and biology." Walls' passion for education is palpable: "our goal is to help people understand conservation evolution and care about it."

Alumni Update: Carly Stewart

By Alexandria Leeper, Evolutionary Studies Communications Assistant

Photo credit: Rachael and Ralph Stewart

Carly Stewart completed her undergraduate career at Vanderbilt with a Bachelor of Arts in Molecular & Cellular Biology and Communication of Science & Technology and a minor in Medicine, Health, & Society in May 2023.

In June 2023, Stewart matriculated into the University of Cincinnati Medical Scientist Training Program (MSTP), where she will be earning both a Doctor of Medicine and Doctor of Philosophy.

"What drew me to Cincinnati in the first place was the Children's Hospital, which has always been one of the top children's hospital in the country. The fact that I can get my Ph.D. through their programs is really amazing," Stewart said.

Stewart's research interests converge in aiming to understand the genetic drivers of human disease. Stewart aspires to pursue a combined pediatrics/medical genetics residency following her M.D./Ph.D.

Time Well Spent at Vanderbilt

"I always knew that I was interested in biology, especially genetics," Stewart said. A connection with a Vanderbilt M.D./Ph.D. graduate ignited Stewart's interest in the dual degree. "I was looking in the Vanderbilt database for alumni in research areas I was interested in and came across the Director of the Case Western M.D./Ph.D. program who was himself a Vanderbilt M.D./Ph.D. graduate, so I talked to him. He was telling me about his experiences with an M.D./Ph.D. I thought that it was interesting, and the more I thought about it, the more I realized I wanted to see patients in my career. I really liked the research I was doing, but there was something missing with that aspect." Stewart finalized her decision to pursue an M.D./Ph.D. as a Junior at Vanderbilt.

Stewart commented on her time in the Tate lab learning about the evolution of the immune system in beetles, "sometimes my experiments didn't work as intended. I know that definitely happens in research—It can be very frustrating when it happens—but I think those experiences will end up being really good preparation for my upcoming Ph.D. in learning how to deal with negative results. I am also able to connect what I was working on in the lab with what I'm learning now. When we got to our immunology section in one of our basic science courses in this past year and they started talking about all these different cells, I was able to apply some of the concepts I learned with the beetles into that course." Stewart added, "because of the different skills I was taught at Vanderbilt, it was easy for me to pick up new skills in my current lab rotations."

While at Vanderbilt, Stewart took public speaking and science writing courses in the Communication of Science & Technology major that equipped her with a unique skill set from her M.D./Ph.D. cohort. The resources at Vanderbilt assisted Stewart's application preparation more directly, as well; mentorship from an M.D./Ph.D. student at Vanderbilt was coordinated through the Health Professions Advisory Office.

Dr. Thomas Clements, a senior lecturer in Biological Sciences, taught Stewart's Genetics course at Vanderbilt, where he witnessed her eagerness to learn and understand. He recalled, "she would talk to me about her research and connect it to the class. She was motivated to pursue the dual degree because she not only wanted to help people from a medical side, but actually understand the process of treating patients."

Top right: Stewart poses with her white coat for students entering the medical profession in Cincinnati. Bottom left: Stewart working in the Tate Lab.

Undergraduates

Fall 2023

- Tara Autumn Stanley - Bachelor of Arts in Anthropology and Ecology, Evolution & Organismal Biology

Spring 2024

- Minju Ahn - Bachelor of Arts in Ecology, Evolution & Organismal Biology
- Sheila Chau - Bachelor of Arts in Anthropology and English
- Bryce Kylan Emanuel - Bachelor of Arts in Communication of Science & Technology and Cognitive Studies
- Dante Eric Hernandez - Bachelor of Arts in Ecology, Evolution & Organismal Biology
- **Sarah Kay Hourihan** - Bachelor of Arts in Ecology, Evolution & Organismal Biology (*cum laude*, Highest Honors)
- Juniper Matea Koehler - Bachelor of Arts in Biological Sciences
- Abigail Thyra Parker - Bachelor of Arts in Ecology, Evolution & Organismal Biology and Medicine, Health & Society (Highest Honors)
- **Ashley Deniece Rogers** - Bachelor of Arts in Ecology, Evolution & Organismal Biology
- Jailei Wei - Bachelor of Arts in Ecology, Evolution & Organismal Biology (*magna cum laude*)
- **Joyce J. Sanks** - Bachelor of Arts in Earth & Environmental Sciences (Highest Honors)
- Chuyuan Xu - Bachelor of Arts in Communication of Science & Technology and Ecology, Evolution & Organismal Biology

Featured Undergrads

Submitted photo.

Sarah Hourihan is a first-generation college student and Beckman scholar who did research in Nicole Creanza's lab studying the evolution of bird song. She presented her research at the Evolution Conference in Albuquerque in 2023 and received honorable mention on her first attempt at an NSF GRFP. Her research leaned on machine-learning techniques to identify differences in song patterns among individuals of different sub-species. She is off to grad school at the University of Southern California.

Joyce Sanks (top) worked in the Evolutionary Studies labs of Rachel Racicot (bottom) and Simon Darroch. She was selected as a semifinalist Fulbright Study student and worked through the SyBBURE Searle undergraduate research program. She spent time in Australia working on the effects of urchin barrens on fish biodiversity. She presented her work at numerous conferences and was awarded best poster twice. After graduating, she spent the summer working with sea turtles off the coast of Georgia as she prepares for graduate school.

Submitted photo.

Ashley Rogers worked on evolution-focused research projects during her time at Vandy. First, she worked in the DeSantis DREAM Lab studying marine mammals and teeth. She is going to UT-Galveston to pursue graduate school in this vein. Additionally, she worked for ES to uncover and tell the story of Alexander Winchell, a once great geologist who co-founded GSA and had problematically racist views. Her story is featured in the last two magazines. Finally, similarly she published a note in *Marine Mammal Science* titled, "A call to rename *Ziphius cavirostris* the goose-beaked whale: promoting inclusivity and diversity in marine mammalogy by re-examining common names."

Graduates

Summer 2023

- Kerri-Ann Margo Anderson (Biological Sciences) Nashville, TN Ph.D.
  Dissertation: Modeling the Spread of Vaccination Beliefs and Behaviors Through the Lens of Cultural Evolution
- Nikita Tsyba (Biological Sciences) Kostanay, Kazakhstan Ph.D.
  Dissertation: Tissue-Specific Heteroplasmy Segregation Is Accompanied by a Sharp Mitochondrial Genome Decline in *Caenorhabditis elegans* Soma
- Sarah Ward (Earth and Environmental Science) Chevy Chase, MD M.S.

Fall 2023

- Justin T. Critchlow (Biological Sciences) Nashville, TN Ph.D.
  Dissertation: The Role of Immune Regulation in Host and Parasite Fitness
- Jinger Haynes (Biomedical Sciences) Caseville, MI M.S.
- Maria Luisa De Melo Tupinamba Jabbur (Biological Sciences) São Paulo, Brazil Ph.D.
  Dissertation: A Clock for All Seasons: Ecology and Evolution of Circadian Clocks
- Keila S. Velazquez Arcelay (Biological Sciences) San Francisco, CA Ph.D.
  Dissertation: The Role of Ancient Genetic Variation on Human Adaptation: Insights From Trans-species and Introgressed Variation

Spring 2024

- Alec Brown (Biological Sciences) Franklin, TN Ph.D.
  Dissertation: Characterization of Non-coding Regions in the Human Pathogen *Aspergillus fumigatus* and Its Close Non-pathogenic Relatives
- Elizabeth Anne Hatmaker (Biological Sciences) Knoxville, TN Ph.D.
  Dissertation: Examining the Role of the Opportunistic Pathogen *Aspergillus flavus* in Human Infections
- Yakov Pichkar (Biological Sciences) Brooklyn, NY Ph.D.
  Dissertation: The Co-evolution of Learned Behaviors and Genetic Population Structure
- **Linhe Xu** (Psychological Sciences) Beijing, China Ph.D.
  Dissertation: The Evo-devo of Variations in Neuronal Cell Size: From Comparative Genomics to Firing Activities

Submitted photo.

Featured Grad

Linhe Xu earned his Ph.D. in the lab of Suzana Herculano-Houzel studying the evolutionary and developmental origins of neuronal cell size variation. Linhe was an active participant in ES activities and even worked with Dr. Rokas to continue ES efforts to measurably improve the experience of graduate students working on evolution-themed projects at Vanderbilt.

Submitted photo.

Spring Undergraduate Research Fair

Ahmed Imami & Enzo de Jong

VUAA Based Excito-Repellent for Malaria Carrying Mosquitoes, *Anopheles coluzzii*
Mentor: Laurence Zwiebel, Biological Sciences

Sakshma Saksena, Seokin Yang & Norbu Shastri

The Effects of Warming and Aging on Mosquitoes
Mentor: Professor Julián Hillyer, Department of Biological Sciences

Alyssa Kovalski

Sclerochronology of Late Cretaceous Bivalves and Implications for Paleoclimate Reconstruction
Mentor: Professor Neil Kelley, Earth & Environmental Sciences

Chuyuan Xu

Dietary Variability in *Lynx rufus* **from Pleistocene to Present**
Mentor: Professor Larisa R.G. DeSantis, Biological Sciences

Jakob Heiser

Coinfection Dynamics in Tribolium Beetles
Mentor: Professor Ann Tate, Biological Sciences

Iman Byndloss

Effect of climate and season on wild mammal activity
Mentor: Professor Malu Jorge, Earth and Environmental Sciences

Lillian Baker

Heat Stress and Hydration Status among Daasanach Semi-Nomadic Pastoralists in Northern Kenya
Mentor: Professor Tiffini Tung, Anthropology

Corey Wiseman

De Novo Genome Assembly of *Aspergillus coreanus*
Mentor: Professor Antonis Rokas, Biological Sciences

Kwan Nok Adrian Wong

Effect of Spatial Frequency and Filter Condition on Visual Imagery Vividness
Mentor: Professor Frank Tong, Psychology

Left: Kovalski in their graduation gown (submitted photo). Right: Shastri (left) and advisor Hillyer at the Spring Research Fair (submitted photo).

Scopes "Monkey" Trial Centennial Symposium



DAY 1 - SATURDAY - 7/12/25

- *The History of the Trial:*
  - The History of the Scopes Trial
  - The Life of John T. Scopes
  - Fundamentalism in the 1920s
- *Modern Challenges to Teaching Evolution:*
  - Creationism's Trojan Horse
  - Kitzmiller v. Dover
  - Challenges to Teaching Evolution
- *Evolution Today:*
  - Chance in Evolution
  - Natural Selection and Design
  - Evolution of Behavior
  - Fossil Record
  - Human Evolution


Ed Larson
Pepperdine


Randy Moore
Minnesota


Adam Laats
Binghamton


Sean Carroll
Maryland


Jonathan Losos
WUSTL


Marlene Zuk
Minnesota


Barbara Forrest
SE Louisiana


Ken Miller
Brown


Amanda Townley
NCSE


Stephen Brusatte
Edinburgh


Briana Pobiner
Smithsonian

DAY 2 - SUNDAY - 7/13/25

- *Evolution-informed Research:*
  - Applications to Other Fields
  - Evolution & Global Food Security
  - Evolutionary Medicine
- *Teaching Evolution:*
  - Science Denial
  - Children Intuitively Understand
  - Teaching using Museums
  - Evolution and the Media
  - Misteaching & Misusing Evolution
- *Evolution and Religion:*
  - Reconciling Evolution and Belief
  - Science, Ethics, and Religion
  - Religious Cultural Competence
  - Inclusive Evolution Education


Owen Jones
Vanderbilt


Sophien Kamoun
Sainsbury


Paul Turner
Yale


Jamie Jensen
BYU


Katy Hinman
AAAS


Gale Sinatra
USC


Patricia Hawley
Texas Tech


Corrie Moreau
Cornell


Liz Barnes
MTSU


Lee Meadows
AL STEM


Riley Black
Author


Joesph Graves, Jr.
NC A&T State

NCSE National Center for Science Education

Awards

Faculty

- Jada Benn Torres - Elected to the American Association for the Advancement of Science
- Lin Meng - Steven and Bunny Fayne Dean's Faculty Fellow
- Keivan Stassun - MacArthur Fellow
- **Carlos Taboada - Packard Fellow for Science and Engineering**
- Allison Walker - Steven and Bunny Fayne Dean's Faculty Fellow

Postdoctoral Researchers

- Kyle David - Early Career Investigator from the American Society of Naturalists
- Sarah Worthan - Zuckerkandl Prize from the Journal of Molecular Evolution

Graduate Students

- Audrey Arner - Vanderbilt Award for Doctoral Discovery, Harold Stirling Vanderbilt Fellowship
- Ximena Leon - Student Research Award from the American Society of Naturalists
- Katie McCormack - Vanderbilt Dissertation Enhancement Grant, Wenner Gren Dissertation Grant
- Sam Schaffner - Student Council's Graduate Leadership Anchor Award
- Kat Turk - Winifred Goldring Award for an outstanding female paleo PhD student from the Association for Women Geoscientists and the Paleontological Society
- Sarah Ward - AAAS Mass Media Fellowship

Undergraduate Students

- Ashley Rogers - Diversity at Evolution Award from the Society for the Study of Evolution
- Norbu Shastri - Runner Up - Best Research Fair Poster, Basic and Natural Sciences


Submitted photo.

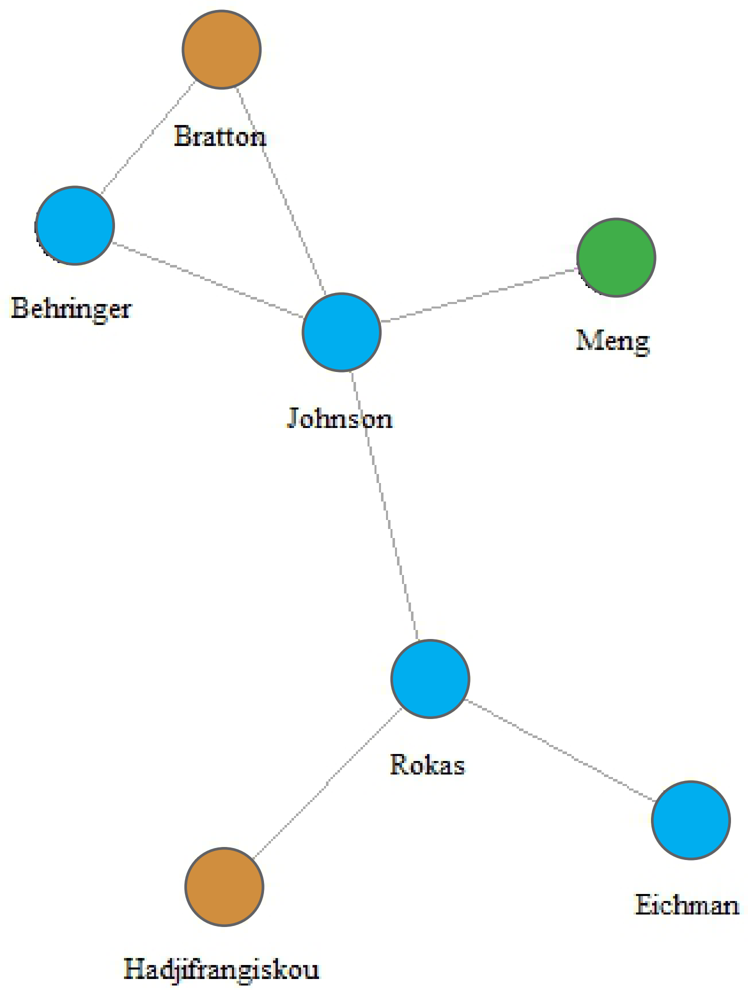
From the VU story: Taboada was among the 2024 Packard Fellows for Science and Engineering. The fellowships provide the nation's most promising early-career scientists and engineers with flexible funding to take risks and explore new frontiers in their fields of study. Packard Fellows have gone on to receive Nobel Prizes, Fields Medals, Breakthrough Prizes and been elected to the national academies of science, engineering and medicine.

"Professor Taboada's work beautifully demonstrates what is possible when passion and curiosity drive inquiry across the boundaries that separate disciplines," Chancellor Daniel Diermeier said. "Professor Taboada's achievements are a testament to the enduring power and value of wonder—and to the kind of discovery that is a university's unique stock-in-trade. I'm proud to congratulate him on behalf of Vanderbilt."

Quick Facts

The Evolutionary Studies Initiative was founded in 2019 by Antonis Rokas with the help of the Advisory Board (Jada Benn Torres, Larisa DeSantis, Suzana Herculano-Houzel, Owen Jones, Houra Merrikh, and Betsey Robinson).

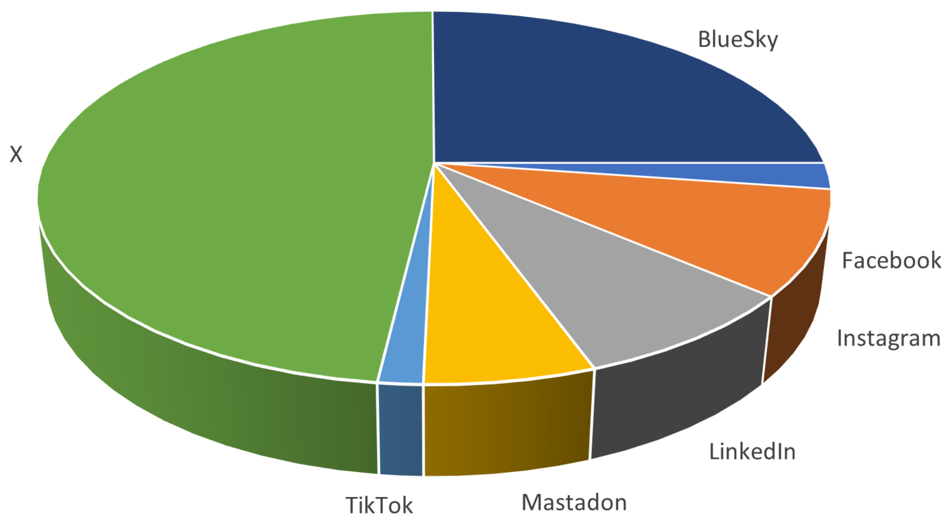
In 2021, ESI began a Pilot Grant Program with the aim of funding collaborative research projects across not just labs, but also departments. To date, we have given out 33 grants to fund research in Biological Sciences (BSCI), Earth and Environmental Science (EES), Anthropology, Communication of Science and Technology (CSET) and Medicine (MED). We have started new collaborations between BSCI and EES as well as BSCI and Medicine. The figure to the right shows one of the research networks inspired by our pilot grant program. The blue dots are BSCI labs, the orange dots are MED labs, and the green dot is an EES lab.



Projects led by graduate students have already had a massive return on investment. Of the 33 grants given out, 19 have been to graduate students. Those students have received four NSF GRFPs, two NSF DDIGs, one DoD NDSEG, one SSE Rosemary Grant Graduate Research Excellence Award, a Wenner Gren Dissertation Grant, and four internal Vanderbilt grants in recognition of excellence.

We engage in several outreach activities, with our two major projects consisting of teaching high school students about evolution while digging for fossils at Coon Creek Science Center and working with the Dismas House residential re-entry program to produce hands-on labs the residents can do during a campus tour.

We also engage with the community on many social media platforms. We have a total of 1759 followers across all platforms, up by 75% over last year's numbers at this time. Our pie chart to the left breaks down our followers by social media type. We have been on X (formerly Twitter) since 2019 and have the biggest following there - though the numbers are decreasing. Recently, we joined BlueSky and have seen rapid growth with it now being our second biggest platform. Find us on X, TikTok, Instagram, BlueSky, and Mastadon as EvolutionVU while on LinkedIn and Facebook as Evolutionary Studies at Vanderbilt.



RECRUITING NOW

Brian O. Bachmann (Biochem)
Biosynthesis, Secondary Metabolites, Directed Evolution, Drug Discovery
Megan Behringer (BSCI)
Population genetics, genomics, microbiology, *E. coli*
Rachel Bonami (PMI)
B cell evolution, *T* cell, autoimmunity, type 1 diabetes, arthritis, microbiome
Benjamin Bratton (PMI)
Bacterial evolution, microscopy, cell shape, quantitative biology
Walter Chazin (Biochem)
DNA Replication, cell biology, proteomics, cancer
Gianni Castiglione (BSCI)
Molecular evolution, vision, oxidative stress, evolutionary medicine
Larisa DeSantis (BSCI)
Vertebrate paleontology, paleoecology, paleoclimates
Monica Keith (Anthro)
Bayesian modeling, health disparities, bio-anthropology, cardiometabolomics
Amanda Lea (BSCI)
Gene regulation, biological anthropology, genotype x environment interactions, early life effects
Lin Meng (EES)
Climate change, plant ecology, remote sensing, light pollution
Antonis Rokas (BSCI)
Evolutionary genomics, molecular evolution, phylogenomics, fungi, mammals, fungal diversity
Eric Skaar (PMI)
Bacteria, host-pathogen interactions, biochemistry, molecular biology, cell biology
Carlos Taboada (BSCI)
Treefrogs, camouflage, biochemistry, protein evolution, animal fluorescence, visual ecology, optics
Ann Tate (BSCI)
Immune system, virulence, systems biology, coinfection, host-parasite coevolution, life history evolution
Allison Walker (Chem/BSCI)
Natural product discovery, machine learning, chemical biology

UNIVERSITY POSITIONS

Professor of the Practice:
Computer Science

Senior Lecturer:
Philosophy
Psychology
Sociology

Assistant Professor:
Computational Systems Biology
Computer Science
Mathematics
Medicine, Health & Society
Molecular and Cellular Biophysics
Social Science Approaches to Health

Support our mission to **create a world-class center for evolutionary studies** at Vanderbilt! Our researchers conduct groundbreaking evolutionary research across the disciplines, while offering the highest quality education to our trainees. Your donation supports cross-disciplinary research, student travel grants, and helps us bring in the world's best speakers to our seminar series.

Donate today at tinyurl.com/29tycx3p or

https://vanderbilt.alumniq.com/giving/to/GrandChallengeEvolutionaryStudies?appealcode=CFE12

EVOLUTIONARY STUDIES

VANDERBILT UNIVERSITY