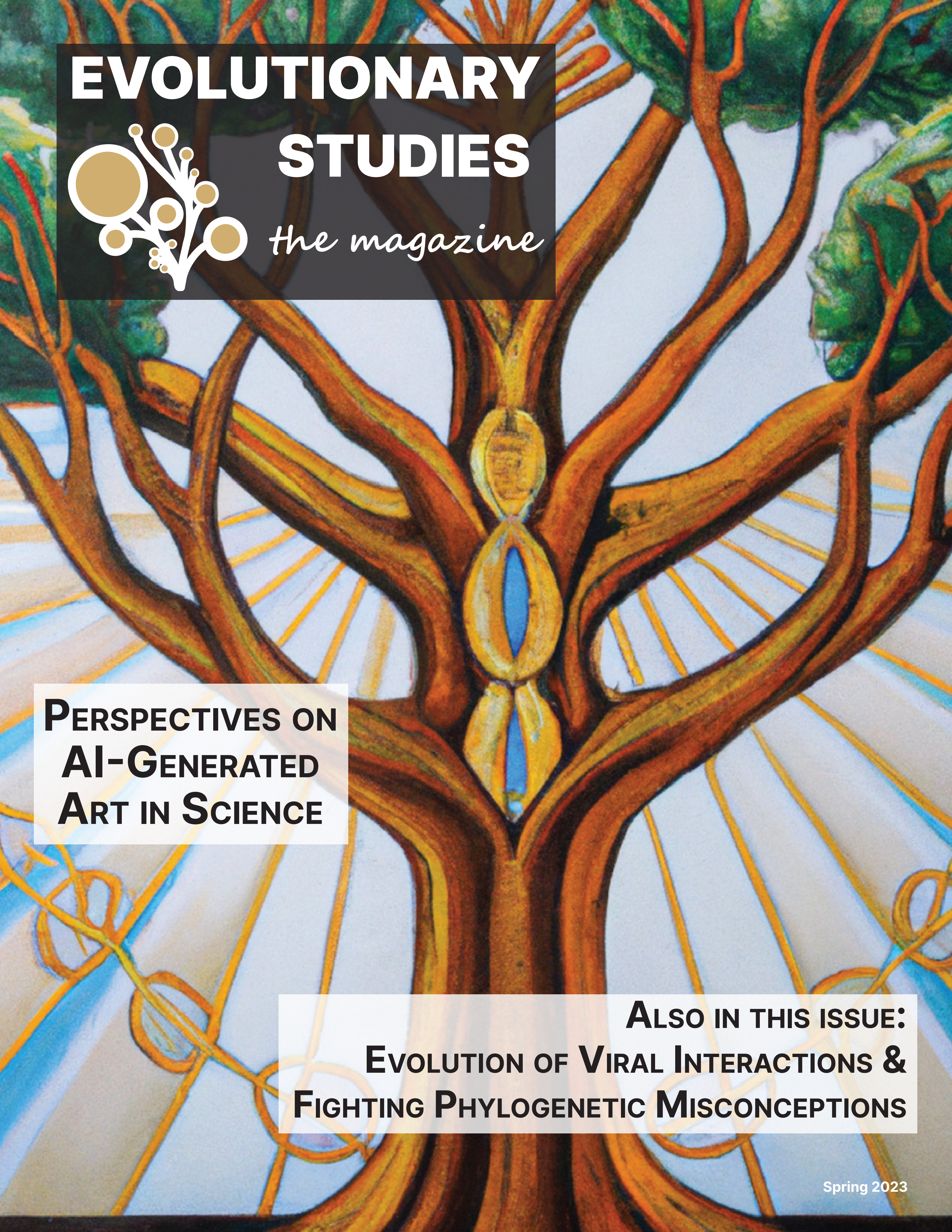
EVOLUTIONARY STUDIES

the magazine



Perspectives on AI-Generated Art in Science

Also in this issue:
Evolution of Viral Interactions & Fighting Phylogenetic Misconceptions

Spring 2023

IN THIS ISSUE

* The cover art was created in DALL-E-2 by Assistant Professor Megan Behringer using the art-deco style for a tree of life.

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VANDERBILT ESI

Greetings Alumni and Friends,

Following last year's sabbatical at the Heidelberg Institute for Theoretical Studies in Germany and Oxford's Merton College in the UK, I am back on campus and more excited than ever as I work with our amazing trainees and colleagues to further the mission of Evolutionary Studies.

On the grants front, we received a competitive score and invaluable feedback on our application to the National Institutes of Health to build our graduate program on computational evolutionary approaches for the study of disease. We also recently partnered with Northeastern University's Institute for Experiential Artificial Intelligence and Vanderbilt's Quantitative and Chemical Biology Program on a National Science Foundation proposal to create a $15M Biology Integration Institute focused on mechanisms of predictability in evolution.

Over this past year, our scientists traveled around the world spreading the excitement of evolutionary studies at Vanderbilt. For example, Amanda Lea, assistant professor of biological sciences, co-organized a three-day workshop in Berlin, Germany about developmental plasticity and early life adversity. Simon Darroch, associate professor of Earth and Environmental Sciences, hosted an evolution of ecosystem engineers workshop at Vanderbilt, bringing in researchers from Germany, England, and across the US. You can read about both workshops on page 33 of this magazine!

We have also been developing our outreach programming. Kyle David, a postdoctoral researcher in my lab, recently began a collaboration with the Dismas House, a residential reentry group that helps former TN inmates adjust to life outside of prison. He is especially keen to reach groups that historically have little access to science programming.

As part of the "150 Years of Vanderbilt" celebrations, our undergraduate researchers have been reconstructing our university's history of evolution and evolutionists through a project with the Library Buchanan Fellowships (pages 26-32). Consider Elsie Quarterman, a leader of conservation biology in Tennessee, who became the first female chair of a department at Vanderbilt. She co-directed a plant evolution seminar to train college teachers in evolution.

We are really proud of the progress we have made and excited for our future. In the pages of our magazine, you can learn all about the latest amazing discoveries from our stellar scientists. This edition contains research from Biological Sciences, Medicine, Anthropology, Psychology, and Earth and Environmental Sciences. I thank you for your support of our efforts and look forward to sharing our progress with you in the future. If you have questions or ideas, please do not hesitate to reach out.

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


Credit Dr. Ester Gaya

Dr. Antonis Rokas at the Fungarium collection of the Kew Gardens, which holds over 1.25 million specimens of fungi and is one of the oldest and most scientifically important in the world.

EVOLUTIONARY STUDIES the magazine

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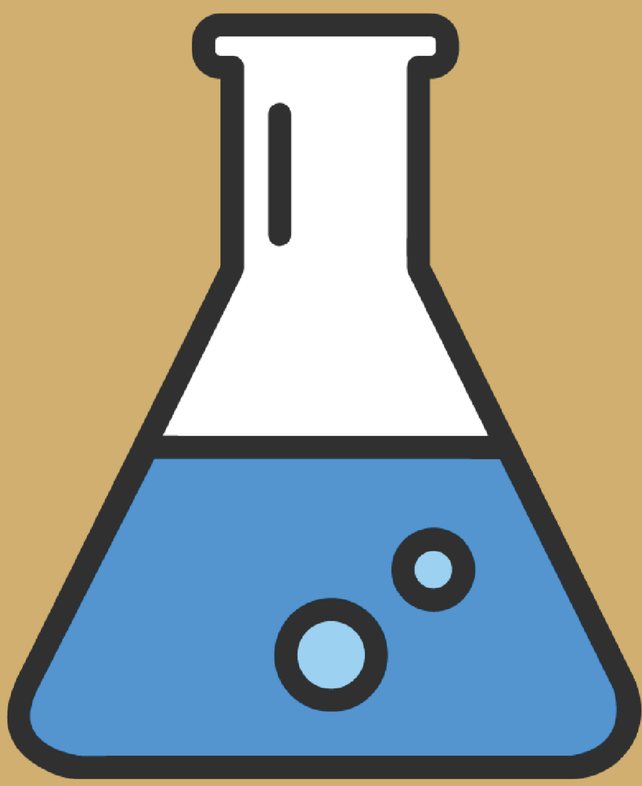
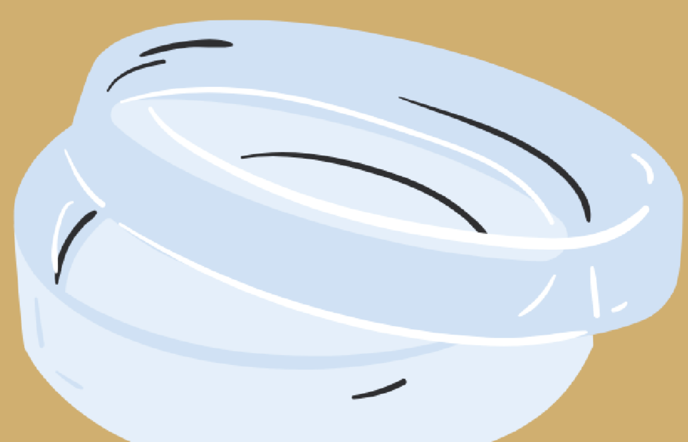
RESEARCH FEATURES





Darroch Lab

The Lessons of Vase-shaped Microfossils

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Kelly Tingle, graduate student in Simon Darroch's lab (Earth and Environmental Sciences), published a new first-author article outlining some exciting discoveries related to microfossils found in the Grand Canyon. Vase-shaped microfossils were amoebae that exist worldwide and can provide some insight into early life on Earth. The new work, "Organic preservation of vase-shaped microfossils from the late Tonian Chuar Group, Grand Canyon, Arizona, USA" was published in the journal *Geobiology*. These microfossils were single-celled amoebae less than one millimeter in size.

The rock formation that the fossils came from dates back to the Tonian Period of the Neoproterozoic era roughly 750 million years ago. The team, including Tingle's former M.S. advisor, Susannah Porter of the University of California in Santa Barbara, set out to test if the material in and around these microfossils was original to the fossils or from a later date and how the organisms were fossilized.

Submitted by Kelly Tingle

Kelly Tingle at the Nankoweap Butte in April 2022, where her field site is located on the west side of the Colorado river in the Grand Canyon

According to Tingle, these results may help in the search for the very earliest of soft bodied animals; "VSMs were very small and made from organic material that may be quite difficult to preserve under normal circumstances. Understanding what conditions can promote such preservation can help narrow 'search windows' when looking at rocks in search for new microfossils. This is especially important when considering the search for the earliest animals, which were likely small and made of decay-prone, soft, organic material."

Read more >>

Credit Tatum Lyles Flick

Kelly Tingle finds fossils in the creek at Coon Creek Science Center.

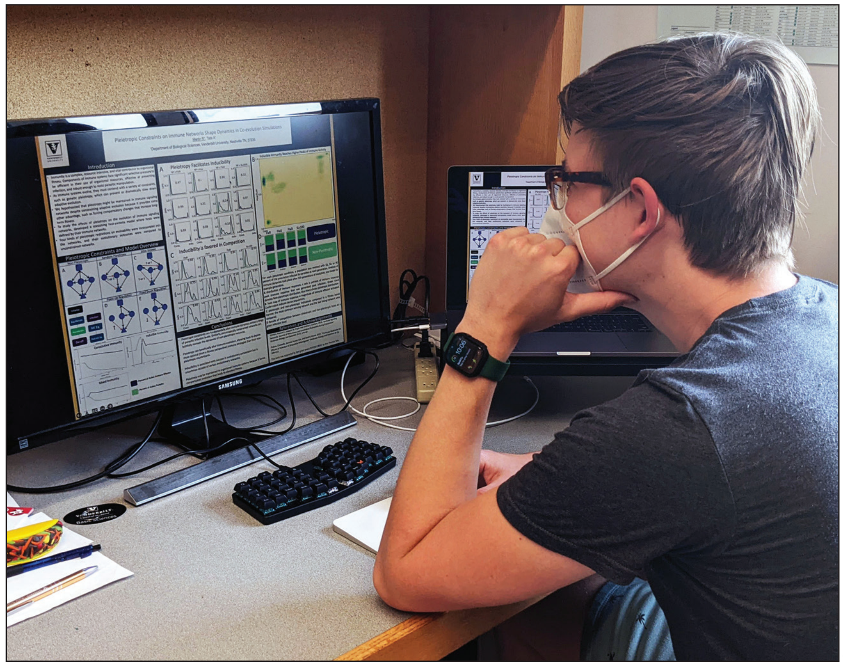
Tate Lab

Evolution, Disease, and Pleiotropy: A Model

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Graduate student Reese Martin and his doctoral advisor, Ann Tate, assistant professor of biological sciences, used theoretical modeling to identify a potential relationship between genetic pleiotropy and the evolution of immune responses. The pair authored a paper titled, "Pleiotropy promotes the evolution of inducible immune responses in a model of host-pathogen coevolution," in the journal *PLOS Computational Biology*.

Martin used a metaphor to explain pleiotropy and inducible versus constitutive defenses. "Imagine you always want to have the lights on as soon as you enter a room. One solution would be to leave the lights on all the time, wasting energy when you aren't in the room, another would be to set up a sensor that turns on the lights when you enter the room, saving energy but potentially leaving you in darkness as the lights come on," explained Martin. "The first solution here is akin to constitutive immunity – always investing energy in fending off parasites even when there are no parasites present. The second is akin to inducible immunity, where an investment in immunity only occurs when a sensor is triggered but the response may take time to ramp up, giving invaders time to prosper before your immune system can remove them," he continued.



Credit Dr. Andy Flick

Reese Martin creating a poster with simulation output

He then explained that pleiotropy, the phenomenon where one gene affects multiple traits, would be like using a single switch to turn on both the lights and a blender. In the metaphor, he imagined that it would be helpful if you wanted a smoothie every time you turned the lights on, but that otherwise this setup was wasteful at best.

Submitted by Reese Martin

Reese Martin enjoying a hike

The work was inspired by a perceived conflict between the rapid evolution of immunity, the usually slow evolution of pleiotropic genes, and the abundance of pleiotropic genes involved in immunity. Martin and Tate designed an evolutionary model where hosts were required to fend off parasites and the hosts that successfully fended off parasites created the next generation of hosts, with the potential to pass along a mutation to a child. Some hosts were also saddled with a trait in their immunity that could not be changed, corresponding to the slowly evolving nature of pleiotropic genes.

The pair tested several populations of hosts, one without pleiotropic genes and others with varying implementations of pleiotropic genes. In the first population, constitutive responses were common with some populations evolving inducible immune responses as the chance of being infected increased. Two of the pleiotropic populations were identical to the non-pleiotropic population, but two others expressed more constitutive immune responses or more inducible immune responses than the non-pleiotropic population. Despite being less common than constitutive hosts, inducible hosts were highly fit suggesting that the evolution of inducible immunity was challenging.

According to Tate, "Reese is an awesome computational biologist who is bringing theoretical teeth to many of the concepts, including the evolution of life-history trade-offs, we are investigating in the lab. His work is complementing experimental work in the lab by forming new testable hypotheses, helping us see holes in our logic, and connecting the dots across different processes at evolutionary levels."

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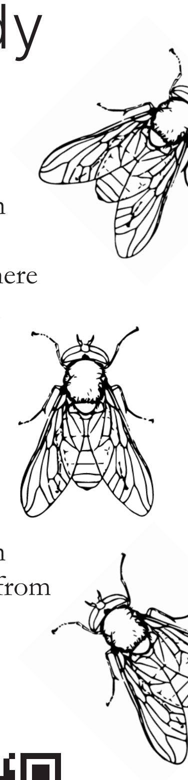
Tate Lab

Evolution, Disease, and Pleiotropy: A Case-study

By Dr. Andy Flick, Evolutionary Studies scientific coordinator



A new study led by members of Ann Tate's (Assistant Professor of Biological Sciences) lab found evidence that pleiotropy may slow down evolution of genes involved in immunity. Alissa Williams, postdoctoral researcher, and Thi Ngo, lab alumna, equally contributed to the new paper studying the evolution of immunity in *Drosophila* species. The paper, titled "The effect of developmental pleiotropy on the evolution of insect immune genes," was published in *Genome Biology and Evolution*.

Pleiotropic genes are genes involved in two distinct functions. Working with these fruit flies, the group learned that genes with immune-developmental pleiotropy are quite common. They classified genes into three groups: 1) non-pleiotropic immune genes (genes involved in immunity and not development), 2) pleiotropic immune genes (genes involved in both), and 3) non-pleiotropic developmental genes (genes involved in development and not immunity). They found that non-pleiotropic immune genes evolve more quickly than pleiotropic immune genes; further, this latter group evolves in a similar way as development-only genes.

Genes involved in development often are under purifying selection – that is, evolution is acting to keep things the same, which is common for important genes. If a developmental gene changes, the organism will likely not survive. In contrast, when co-evolution is occurring between a pathogen and its host, genes regulating immunity must be able to evolve or the pathogen could overwhelm the organism. When the genes involved in immunity also regulate development, it makes for an interesting tug of war between remaining the same in order to aid in development and changing in order to aid in immunity.

According to Williams, "pleiotropy is a phenomenon found in essentially all organisms, both in immune systems and other biological functions. Our results show that immune genes evolve with more constraint when they're pleiotropic, which has implications for how hosts fight off pathogens, how hosts and pathogens coevolve, etc. More broadly, these results show that there can be evolutionary constraints acting on dual function genes."

Tate added, "this study provides evidence that pleiotropic immune genes are under stronger purifying selection than non-pleiotropic ones, which might help provide extra context for Ph.D. candidate Reese Martin's study [story on left]."

Williams added, "there could be variation in pleiotropy even within the genus, and that would be something really interesting to investigate—we'd love to have more expression and functional data from other species."

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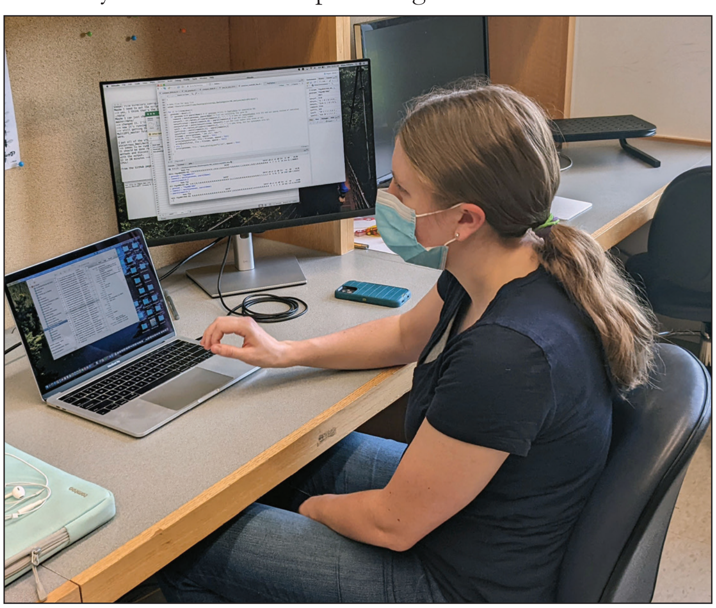
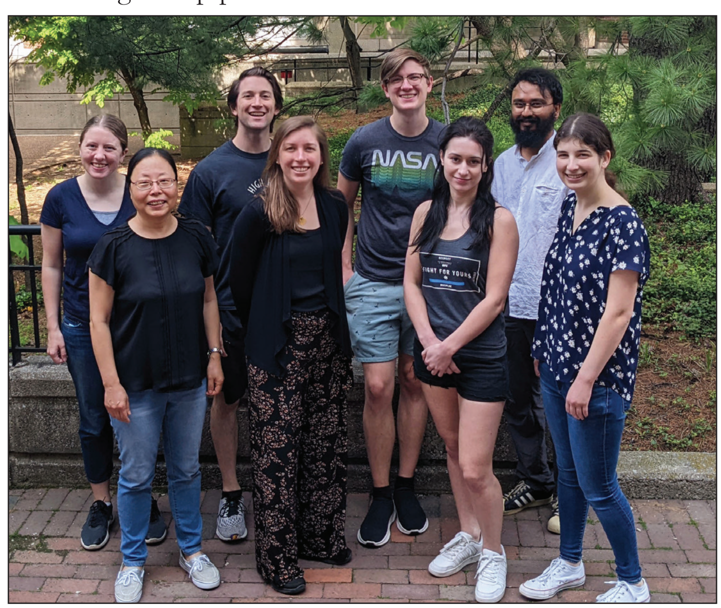


Credit Dr. Andy Flick

Dr. Alissa Williams analyzes data of immunity and development genes



Credit Dr. Andy Flick

The Tate lab in Spring 2022. From left, Dr. Alissa Williams, Thi Ngo, Justin Critchlow, Assistant Professor Ann Tate, Reese Martin, Louise Perrier, Dr. Arun Prakash, Carly Stewart

Rokas Lab

Examining *Aspergillus* Genus Virulence

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Graduate student Annie Hatmaker, along with a team of researchers including her adviser, Cornelius Vanderbilt Professor of Biological Sciences Antonis Rokas, recently published a study identifying the differences in virulence among *Aspergillus* species. *Aspergillus* is a common human-pathogenic genus of fungi that includes *A. flavus*, which can cause aspergillosis and fungal keratitis infections, a type of eye infection.

Credit Dr. Andy Flick

Annie Hatmaker stands in front of the evolutionary studies props.

Hatmaker and the team found that secondary metabolites – compounds produced that are not necessary for survival but can be advantageous in specific environments – differed among species at room temperature. Ramping the temperature up to 98 degrees Fahrenheit, the team found that the production rate of secondary metabolites increased considerably, likely because human body temperature is not the preferred environment for these fungi. They may be creating these secondary compounds to help cope with the relatively increased temperature.

Hatmaker's work pushes the boundaries of our knowledge of the species complex beyond *A. flavus*, which is better studied in clinical settings than its sibling species. In fact, when fungal keratitis is diagnosed in a medical lab, the conclusion is often just *Aspergillus*, which can be useful for medical doctors but leave something to be desired for researchers seeking to have a better understanding of the evolution of *Aspergillus* and how it might be treated, or even predict which strains may become pathogenic in the future.

"If every clinical laboratory had money and equipment to sequence the genomes of all their fungal strains isolated from patients, we would see a lot finer resolution in which species are regularly infecting humans and more diversity in rare infections," Hatmaker said. "The genus *Aspergillus* is incredibly diverse in a multitude of traits, so it ultimately would benefit the scientific community to have the genomes of species causing each infection available for further study."

One important trait of these fungi species is the interaction between environment and pathogenicity. The natural environment they can be found in includes soil, which is subject to climate change – particularly, to global warming.

"In general, *Aspergillus* species produced more secondary metabolites at the higher temperature," Hatmaker said. "Global warming could absolutely drive differences in virulence."

The project was a collaborative effort among many scientists across several universities. Hatmaker worked with chemists at the University of North Carolina at Greensboro, microbiologists at the University of Sao Paolo in Brazil, and immunologists from the University of Oklahoma Health Science Center.

Read more >>

Rokas Lab
Comparing Nuclear and Mitochondrial Genomic Evolution

By Kelly Tingle, Evolutionary Studies communications assistant

Former Vanderbilt University undergraduate student Miya Hugaboom provides insight into fungal mitochondrial genomic evolution in a paper she published recently as lead author, along with Biological Sciences graduate student Annie Hatmaker and Professor Antonis Rokas.

The study focused on the mitochondrial genomes of 20 different *Aspergillus* species, a type of fungi, to examine the relationships within section *Flavi*, a group of closely related species within the genus *Aspergillus*. The team found that while the genomic content of *Flavi* nuclei is approximately 1,000 times larger than that of the mitochondria, phylogenies (the relationships between organisms and their common ancestor) produced by mitochondrial genomes are consistent with those produced by nuclear genomes. This is significant because it shows that mitochondrial genomes may be underutilized in constructing phylogenies, as most previous studies have focused only on nuclear genomes.

Hatmaker explained that mitochondria have separate genomes from the nucleus of the same cell. They are also inherited in cell reproduction in a different way than nuclei; therefore, they have a distinct evolutionary history.

"[Mitochondrial genomes] offer a unique phylogenetic perspective when compared to their nuclear counterparts," described Hugaboom.

> "mitochondrial genomes may be underutilized in constructing phylogenies"

"Fungal mitochondria have been linked to diverse processes including energy metabolism, cell differentiation, drug resistance, biofilm and hyphal growth regulation, and virulence, among others, so an understanding of these organellar genomes is important to grasping the complete genomic profile of section *Flavi*," explained Hugaboom. "There is a dearth of genomic analyses of section *Flavi* that are mitochondrial in focus, with most focusing exclusively on nuclear genomes."

Hatmaker explained that she helped Hugaboom with assembling and annotating mitochondrial genomes and constructing phylogenetic trees.

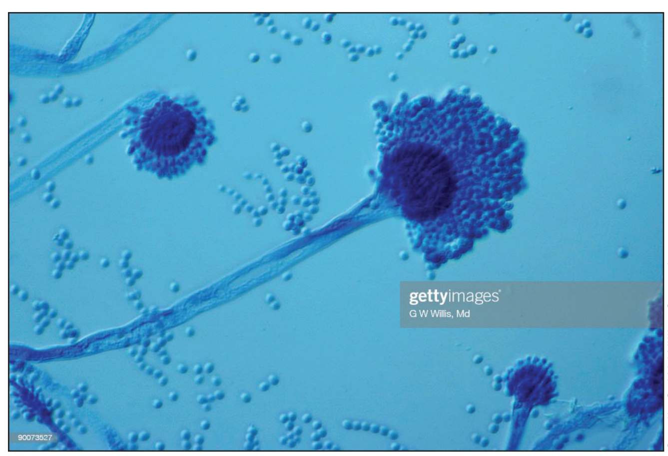
"I also constructed a phylogeny using nuclear genes, whereas Miya constructed a phylogeny from the mitochondrial genes. She was then able to compare the two phylogenies," added Hatmaker.

"[Results from this study suggest that] the two datasets, nuclear and mitochondrial, had overall similar evolutionary histories," said Hatmaker. "We now have a comparison point for other fungal species, allowing us to contrast this group of species with others."

Hugaboom joined the Rokas Lab after completing an independent study course taught by Hatmaker and started this research as an undergraduate honors thesis project. Hatmaker served as Hugaboom's mentor for the project. "Miya is wonderful to work with – she was transparent about her progress and any challenges, and she was extremely hardworking, motivated, and interested in the project," described Hatmaker.

Hugaboom graduated from Vanderbilt in 2022 and is now a postgraduate associate at the Yale School of Medicine.

This study was funded by Vanderbilt Data Science Institute Summer Research Program, the National Institutes of Health/National Eye Institute (F31 EY033235), the National Science Foundation (DEB-2110404), the National Institutes of Health/National Institute of Allergy and Infectious Diseases (R56 AI146096 and R01 AI153356), and the Burroughs Wellcome Fund.



Credit G. W. Willis; Getty Images

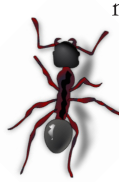
Aspergillus flavus, a species of fungus within *Aspergillus* section *Flavi*, can produce toxins that are harmful to mammals. VU alumna Miya Hugaboom studied the nuclear and mitochondrial genomes of 20 different *Aspergillus* species within section *Flavi*.

Zwiebel Lab

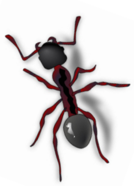
Ant Olfaction and the Evidence for Soldiers

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Stephen Ferguson, first-author of a new paper with his postdoctoral advisor, Laurence Zwiebel, Cornelius Vanderbilt Chair in Biological Sciences, and two undergraduates associated with the lab, Isaac Bakis (alumnus) and Nicholas Edwards, confirmed the existence of a specialized soldier caste within an ant species in a paper titled, "Olfactory sensitivity differentiates morphologically distinct worker castes in *Camponotus floridanus*," in the journal *BMC Biology*. By exposing different members of the ant society to olfactory chemicals and quantifying their reactions, the team parsed out differences between smaller (minor caste) and larger (major caste) ants. Previous experiments have shown that minors performed most of the colony maintenance tasks, such as foraging and brood care. The role of majors was unclear, and majors infrequently, if ever, engaged in routine colony maintenance tasks.



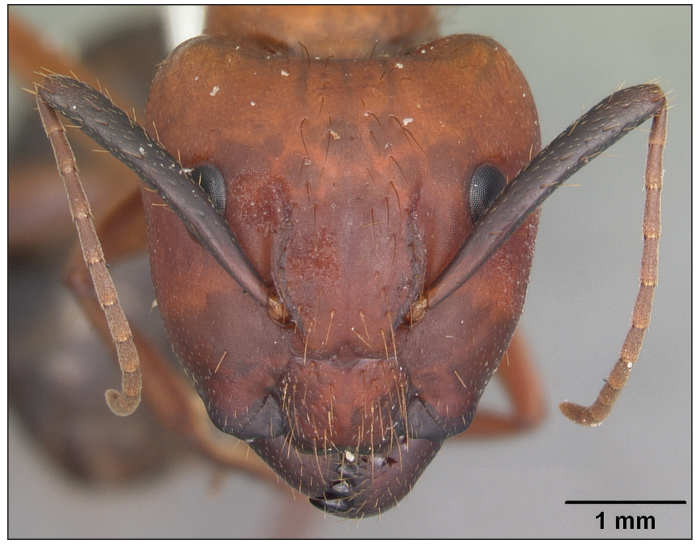
According to the article, previous studies have shown that ants sense odorants in their environment using neurons that are distributed along their antennae as well as other sensory areas of their bodies. These neurons help ants detect chemical pheromones and cuticular hydrocarbons used for communication. The team exposed ants of each caste to around 400 odorants making up 36 odor blends, including a compound closely related to a pheromone secreted by the ants to create an odor trail for nestmates to follow to resources like food.



The results of the chemo-sensing experiment suggest that minors can detect a broad range of odors and pheromones and are jacks-of-all trades responsible for many necessary activities in the nest, while majors are fine-tuned to detect chemical cues associated with enemy intruders and are primarily soldiers. When encountering non-nestmate chemical signals, majors were more aggressive and more likely to subdue and kill potential enemies than minors. On the other hand, the team found that while minors detected and followed a trail pheromone, majors treated it no differently than any other chemical odor.

According to Ferguson, "the evolution of different castes within the colony enhances their ability to perform specialized tasks, such as defending the colony as large, heavily armored, and deadly soldiers."

Moreover, the group found significant differences in the



A headshot of *Camponotus floridanus*. Photo by April Nobile with no endorsements of this work. Available through a CC BY-SA 3.0 license on AntWiki

physiology of minors and majors. While minor workers could smell many general odorants and pheromones, majors were seemingly nose blind. As the concentration of the odors increased, the responses of minors also increased. However, majors had a greatly diminished sensitivity to odors with the exception of those found on enemy non-nestmates.

"Ants are fascinating because of the immense complexity of their social behavior. At first glance, a single ant might seem lost, aimlessly wandering about the pavement, but as a collective, the workers are able to cooperate with one another to build incredible societies. Ants achieve impressive feats because of their highly evolved olfactory system, which allows them to exchange information with one another through the use of chemical signals," Ferguson said.

"Looking forward, we want to better understand how aggression is regulated between enemy non-nestmate ants by identifying the precise molecular components in the antennae and brain which are responsible for detecting and processing olfactory signals, respectively," he continued.

Read more >>

Castiglione Lab

Low-light Vision of Antarctic Icefish

By Tatum Lyles Flick, Evolutionary Studies communications volunteer consultant

Though many researchers have considered how fish survive in extreme cold, using everything from antifreeze glycoproteins that protect cells to not producing hemoglobin, few have taken a molecular approach to evaluate how they are able to see in such conditions.

In "Adaptation of Antarctic Icefish Vision to Extreme Environments," published by assistant professor of biological sciences and ophthalmology Gianni Castiglione and others in *Molecular Biology and Evolution*, Castiglione and his colleagues delve into how Cryonotothenioidea, or Antarctic icefishes, see in very cold, low-light environments.

"These fishes live in temperatures near the freezing point of saltwater (-1.9°C)," Castiglione said, adding that in the Antarctic, snow and ice shift light to redder wavelengths, while also reducing the amount of light that enters the ocean, leading to darker, relatively redder surroundings.

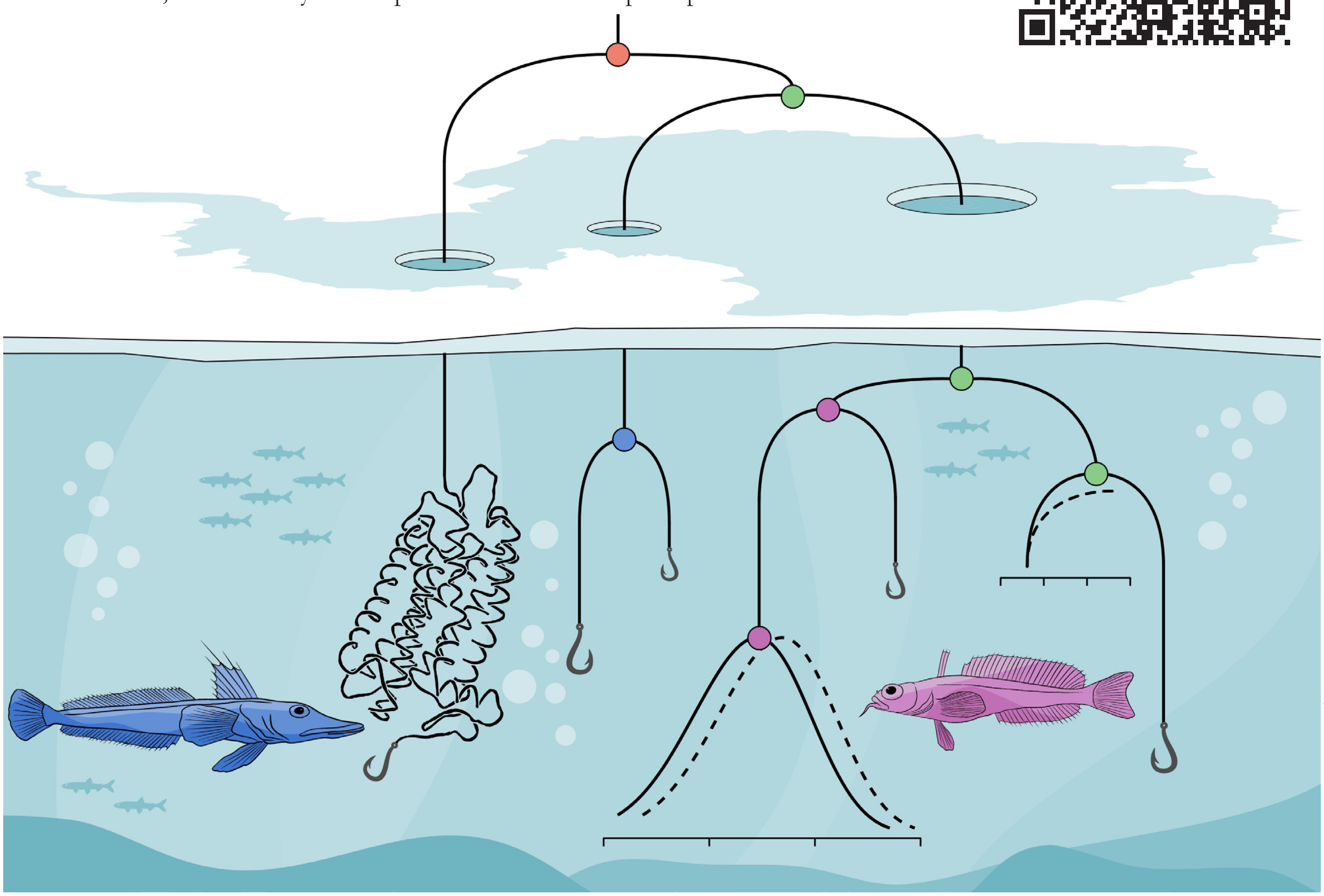
Using likelihood models and ancestral reconstruction, Castiglione and the research team found that, over evolutionary time, Crynotothenioidea experienced genetic mutations, leading to an adjustment in amino acids incorporated into rhodopsin, a protein in the eye's rod photoreceptors that mediates low-light vision.

"Cryonotothenioidea are so well adapted to subzero temperatures that they dominate 95 percent of biomass surrounding the Antarctic content," Castiglione said. "They live across a broad depth spectrum (0-3000 meters) uncommon in other deep-sea fauna assemblages."

In general, fish that can see in low-light Antarctic waters are able to do so only up to about 60 meters. In addition to the mutations which increase their ability to see, Cryonotothenioidea also have specialized retina that are better able to sense available light.

"These mutations also lower the activation energy associated with retinal release of the light-activated RH1, and accelerate its return to the dark-state likely compensating for a cold-induced decrease in kinetic rates," Castiglione said.

Read more >>



Submitted by Assistant Prof Gianni Castiglione

Behringer Lab

Methods in Experimental Evolution

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Sarah Worthan, a postdoctoral researcher, led a new effort with undergraduate researcher Robert McCarthy and their advisor, assistant professor of biological sciences Megan Behringer, to understand the effects of the environment on the outcome of experimental evolution fitness evaluations. The article, "Case Studies in the Assessment of Microbial Fitness: Seemingly Subtle Changes Can Have Major Effects on Phenotypic Outcomes," was just published in the *Journal of Molecular Evolution*.

Experimental evolution, especially studies using microbes like E. coli, often use fitness evaluations to report the results of evolution. A typical adaptive laboratory evolution setup might be to start with one strain of E. coli, which we will name the ancestor, and add a selective pressure to the population for a given period of time, resulting in an evolved mutant population. Often following evolution, the researchers compare the initial ancestral strain and the evolved strain in a pair of common fitness evaluations. First, the ancestral and evolved strains may be grown in isolation as a common approach to reveal the differences in growth rates between the strains. In a second approach, the researchers grow both populations in the same growth vessel, starting with equal proportions of the ancestor and evolved populations. Then, after a period of growth, they assess the composition of each population. The differences in the proportions of each strain before and after growth will help identify the effects of the selective pressure over time.

Credit Dr. Andy Flick

Assistant professor Megan Behringer (front) and Dr. Sarah Worthan identify *E. coli* populations on a petri dish

In this study, the team tested small but important changes in the execution of these fitness tests to see how those changes might affect the results. What they discovered was that the environment that the experimental population was subjected to during the adaptive laboratory evolution is critical in accurately determining the outcome of the fitness tests. For example, if the fitness evaluations are performed in an environment that differs from the initial evolved environment, the results may not actually reflect the fitness of the mutants when grown in the evolved environment.

According to Worthan, "the main takeaway from the paper is that fitness is totally relative to the environment. When evaluating the fitness of an evolved population or a derived mutation, the most important thing is that the original evolved environment must be considered. Any slight deviation from the original evolved environment can have drastic effects on a microbe's physiology and alter the outcome of the fitness experiment. With that said, fitness evaluations in environments that differ from the evolved environment can also be useful as well, as they may provide insight into the mechanisms of adaptation and any potential associated trade-offs."

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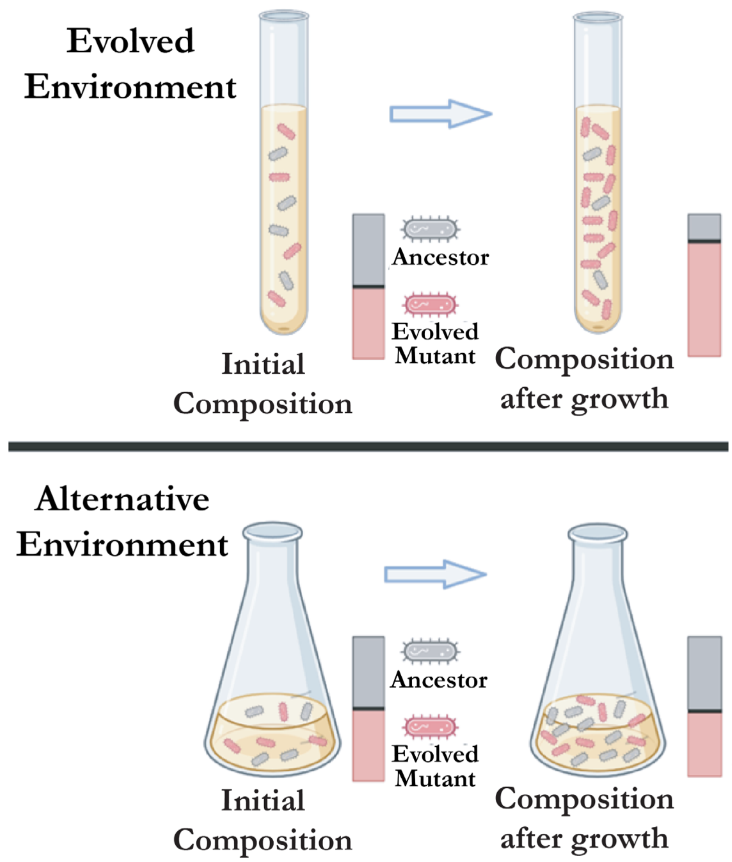

Submitted by Sarah Worthan

Top panel:Two strains of E. coli growing in the original evolved environment (culture tube). The red evolved strain is more abundant than the gray ancestral strain after growth and may have higher fitness in that environment. Bottom Panel: The same strains of E. coli growing in an alternative environment (flasks). This time, the composition of each strain remains stable after growth which implies both strains have equal fitness. Figure created in BioRender.com

Creanza Lab

Specialization and Cultural Evolution

By Kelly Tingle, Evolutionary Studies communications assistant

The cultural evolution of a population depends, not only on size but also on the degree of specialization within a population, according to a new study published last month by a team of scientists including biological sciences assistant professor Nicole Creanza.

The study found that populations can increase their cultural repertoire by subdividing knowledge into smaller groups, but the total group must be sufficiently large for specialization to be advantageous. Specialization in smaller communities may create vulnerability to loss of cultural knowledge if dynamic events like environmental change or illness occur.

The authors reached these conclusions by developing a model in which tools, which symbolized cultural traits, were divided amongst populations with varying degrees of specialization. As time increases, new tools are invented, and the rate of invention is linearly related to population size. New tools can be lost before assimilation and established tools can be lost by chance. In addition, the more tools sustained collectively within a group the higher the degree of tool loss, due to knowledge capacity limits.

"The idea is that it might be a double-edged sword for an organism to specialize, particularly if the population is too small," explained Creanza of the main findings from the study. "We have tried, through this model and a couple of others, to think about why you can't always predict the repertoire size of a population. One idea is specialization."

"If there is a divide-and-conquer strategy where small groups of people do apprenticeships and you have a situation where there is specialization, you can get a larger overall cultural repertoire in the population, but a lot of the knowledge is sequestered in small groups of people. It might be less resilient to disruption or susceptible to loss," said Creanza.

Creanza described that while community size is relevant, it is important to consider other more nuanced factors in cultural evolution and the development of tool complexity, such as tool structure, cultural repertoire, and interconnectedness with other populations.

This study builds on previous studies from Creanza and co-author Dr. Oren Kolodny of the Hebrew University of Jerusalem, who met while the pair were postdoctoral researchers at Stanford University, on cultural evolution and the appearance of multiple punctuated bursts of human innovation in the archaeological record. Creanza explained that previous cultural evolution models are traditionally based on population genetic models, but unlike genetic mutations, novel ideas may happen not just by chance but also by building upon and combining with other existing innovations.

Submitted by Assistant Prof Nicole Creanza

Assistant Professor Nicole Creanza (left) with former lab member Dr. Emily Hudson

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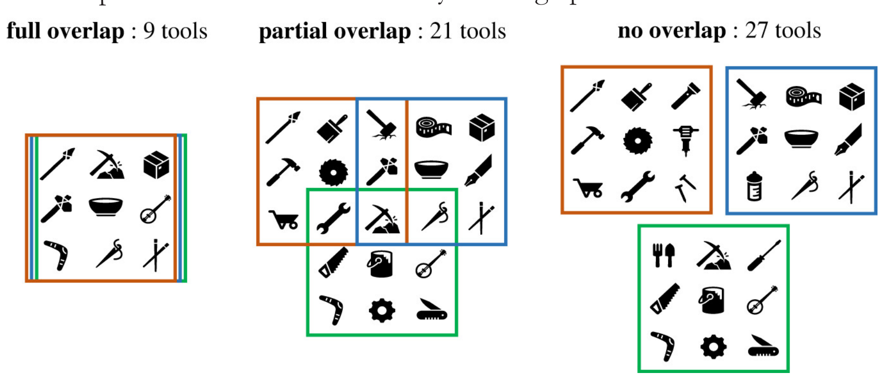


Submitted by Assistant Prof Nicole Creanza

The smaller the overlap between individual toolkits (in this case, three individuals each with a toolkit of nine tools), the bigger the population's overall cultural repertoire can be. At the same time, smaller overlap also means fewer people know each tool, which can increase its chances to be lost.

Lea Lab

Modes of Natural Selection in Human Populations

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Credit Dr. Andy Flick

The Lea lab with homonid "Lucy" and human skeleton casts. From left, Dr. Rachel Petersen, Assistant Professor Amanda Lea, Audrey Arner

Amanda Lea, assistant professor of biology, along with a global team of experts, have discovered new pathways of natural selection in humans.

The group, led by Tsimane Health and Life History Project Co-Director Michael Gurven of the University of California, Santa Barbara, studied two populations of Bolivians that live in the lowlands northeast of the Andes mountains, the Tsimane and the Moseten. Previous work revealed that these tropical populations are exposed to high burdens of pathogens and parasites, while showing minimal cardiovascular disease or dementia. Results from this study suggest that the Tsimane population's genome has undergone selection on traits associated with both immunity and metabolism, and that these selected regions are associated with health in the population today.

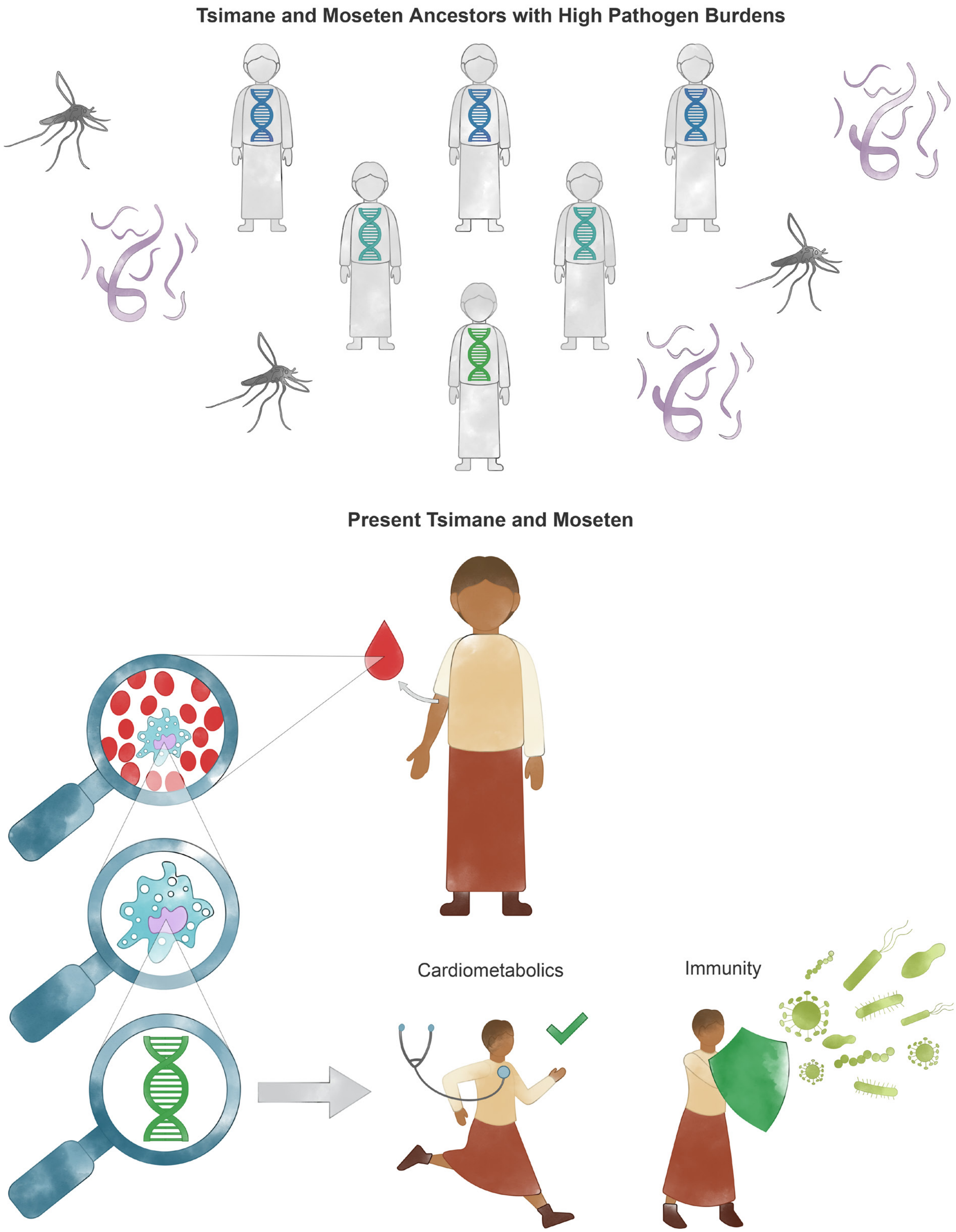
This research builds context into the evolution and specialization of humans across the globe. A few well-known examples of evolved human-specialization already exist. For example, some European, African, and Middle Eastern descendants can digest lactose, which allows for milk consumption well past puberty in those populations.

According to Lea, "despite great interest in understanding the DNA variants that differ between populations in beneficial or adaptive ways, they remain very hard to identify and characterize. Nevertheless, doing so has the potential to uncover previously undescribed loci involved in evolutionarily and biomedically relevant traits."

One especially unique piece of this project is that the study stems from a long-term partnership between the Tsimane Health and Life History Project and the Tsimane and Moseten communities. Over the past 20 years, the project has included collaborations between anthropologists, physicians, indigenous leadership, community members and local institutions to build a comprehensive picture of health and to improve it. Such trusting collaborations are vital for navigating the ethical landscape surrounding the study of indigenous DNA.

On the importance of working with Bolivian Amerindians, Gurven said, "most studies so far that have linked DNA mutations to health have focused on Europeans or Americans. Groups like the Tsimane have a distinct history living in a distinct environment. It is likely that there are genetic signatures in the Tsimane genome that do not exist in most populations typically studied. Exploring novel genes and their relation to a wide range of health outcomes is something we are currently doing and are very excited about."

Read more >>



Top panel: The Tsimane and Moseten populations have experienced a diverse pathogen burden over many generations. Findings suggest that this burden has selected for genetic variants involved in immune defense, and metabolism. Bottom panel: Regions that have been under selection over evolutionary time are associated with variation in health-related traits. Credit: This image was created by Caitlyn Skelton at Designs That Cell, with input from Amanda Lea and Michael Gurven. It is being used to communicate the results of our study with Tsimane and Moseten communities.

Das Lab

Evolutionary History of Respiratory Virus

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Stephanie Goya, who did a rotation with the lab of Suman Das, recently published a paper with the lab about the evolution of respiratory syncytial virus in a population of humans in Buenos Aires, Argentina. The paper, "Evolutionary dynamics of respiratory syncytial virus in Buenos Aires: Viral diversity, migration, and subgroup replacement," was published in the journal *Viral Evolution*.

Their sequencing project, expanding on a paucity of genome samples for RSV, revealed that two variants of RSV were common in different years; the study analyzed data from 2014 through 2017. From 2014-2016, RSV-B was dominant in samples but in 2017, 90% of samples were from RSV-A genomes. The group suspects that a relatively low-diversity subset of RSV-B infections led to the ability for the RSV-A subgroup to take over.

According to the paper, RSV is a globally-distributed virus and one of the main causes of lower respiratory infections in children. Goya hoped that the results of this study would lend support and awareness for the use of vaccines. With the evolution of this virus, reinfection is possible, and elderly and youth populations are at higher risk for serious symptoms. Getting a vaccine against RSV may help prevent this virus from infecting those at-risk populations.

Meghan Shilts, a senior research specialist in the Das lab, explained a bit about the differences between RSV-A and RSV-B.

According to Shilts, "two of the proteins on the outside of RSV (called F for fusion and G for glycoprotein) help RSV enter host cells and replicate and can make you sick. Your immune system tries to protect you from this by recognizing these two proteins, to target and destroy RSV. RSV-A and RSV-B have pretty different G proteins, a strategy that helps RSV survive as our immune system needs to be able to recognize both of them in order to protect us."

The authors found multiple introduction events for RSV in Buenos Aires. That is to say, new strains of RSV entered Buenos Aires through infection in other locations. The team also found that virus samples collected in other countries originated in Buenos Aires.

According to Goya, mitigation measures to prevent the spread of SARS-CoV-2 in 2020 also affected RSV viral dynamics.

"In some regions there were no RSV hospitalizations at all and no RSV detections in outpatients with mild respiratory disease. When the mitigation measures relaxed, RSV circulation reemerged with an unexpected seasonality. In this context, the mitigation measures against the SARS-CoV-2 transmission acted as a bottleneck for the RSV transmission and evolution and now we are closely monitoring what is happening in each region," Goya noted.

Goya was excited to study host-pathogen co-evolution and said, "it is a continuous fight between virus and host that, for those of us who study this field, offers us constant surprises, allows us to understand vulnerability to disease and also allows us to develop vaccines and antivirals helping our immune system fight pathogens."

Goya was thankful for her time at Vanderbilt and commented, "I needed to improve my skills and Suman opened his laboratory for me to work together in the Argentine RSV genomes sequencing. We built a synergistic collaboration that led to a recently published article in the journal *Virus Evolution*."

Learn More >>

Submitted by Meghan Shilts

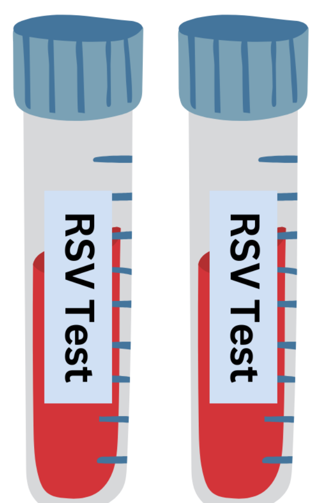
Meghan Shilts

Submitted by Dr. Stephanie Goya

Dr. Stephanie Goya

Submitted by Associate Prof Suman Das

Associate Professor Suman Das



Ogden Lab

New Interactions between Viruses

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Kristen Ogden, an assistant professor in the Pediatrics and Pathology, Microbiology and Immunology departments, studies what happens when two viruses attack the same cell – also known as coinfection. In a recent study led by an alumnus of her lab, Tim Thoner, the team discovered that the time between the first virus infecting a cell and the arrival of a second virus may drive the ability for the two viruses to reshuffle their genomes, creating hybrids.

Submitted by Assistant Prof Kristen Ogden

Assistant Professor Kristen Ogden

When a virus invades a cell, it can create factory-like entities in the cell's cytoplasm that create new (or progeny) virus particles.

According to Thoner, "we found that increasing time between infections reduces the number of reassortment progeny generated during the secondary infection. The primary infecting virus had more time to replicate, generated more RNA, and as a result, most of the coinfection progeny packaged RNA from the primary infecting virus."

Another cool – and highly unexpected – result, is that viral factories are not loyal to a particular virus. The machinery can be used by either the primary or secondary infecting virus to create new viral progeny. Ogden and Thoner had imagined that each factory would serve only one virus, and this would be a barrier to viral hybridization. Realizing that was not the case, both were pretty excited.

Ogden said, "my favorite result from this study is that cytoplasmic factories from a primary virus infection fail to exclude RNA from a superinfecting virus. This was an exciting result because it was the opposite of what we expected to find!"

Thoner followed up, "this was really interesting from a virological perspective, as it suggests that either much more RNA is being synthesized in the cytoplasm than was previously thought, or that RNA readily traffics in and out of factories, or that factories are bringing together RNA through their established ability to fuse with one another."

While dual infections of a single cell by dissimilar viruses may be uncommon, Ogden added that this work is useful as dual infections of similar viruses may, in fact, be quite common.

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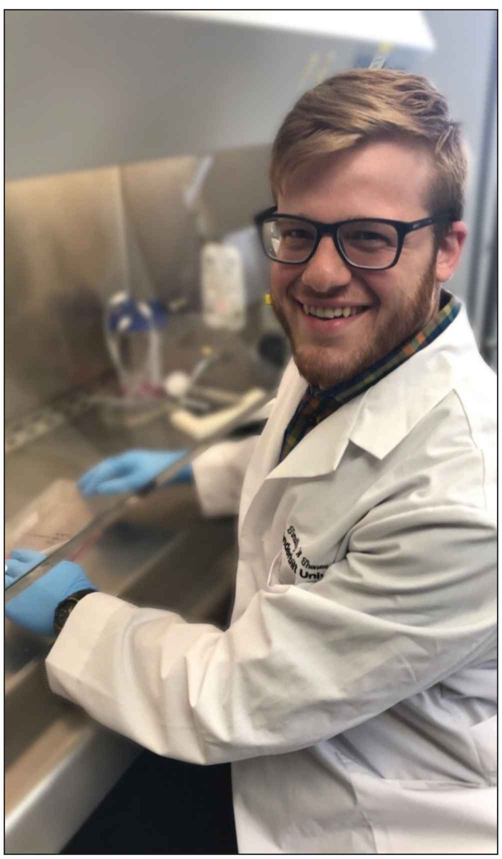
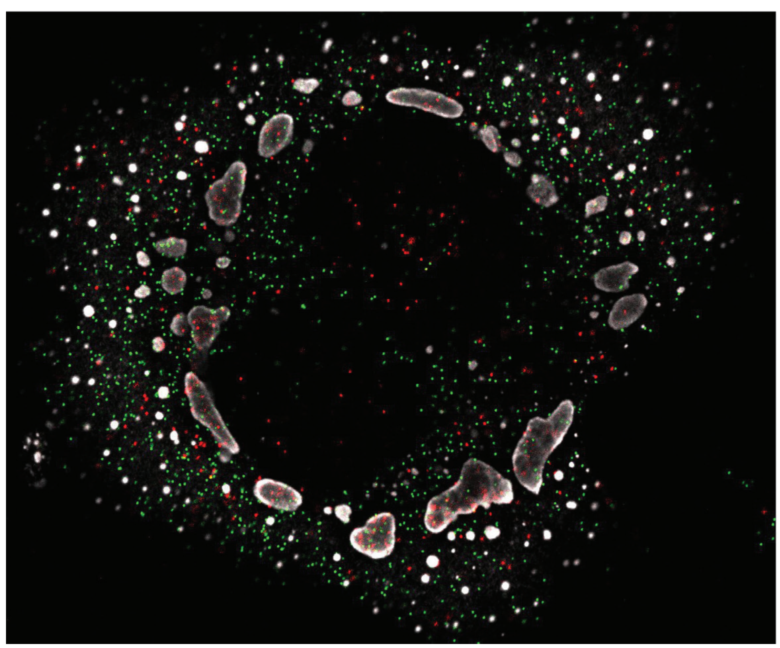


Submitted by Assistant Prof Kristen Ogden

Dr. Tim Thoner



Submitted by Assistant Prof Kristen Ogden

A cell coinfected with 2 viruses

Darroch Lab

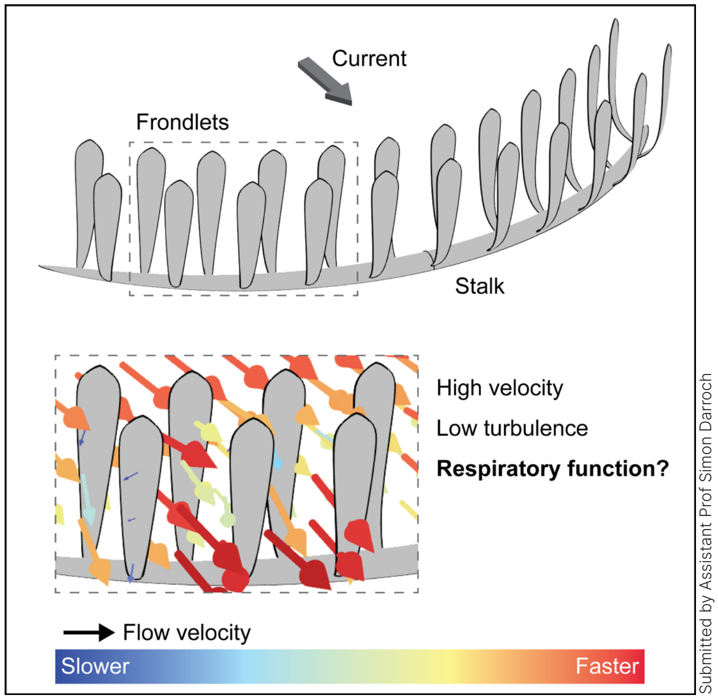
Divergent Function in Convergent Evolution

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

The classic idiom form fits function does not always mean that everything of the same form has the same function. That's what a group of paleontologists have discovered with the help of fluid physics and preserved fossils. Simon Darroch, assistant professor of Earth and Environmental Sciences, led a team that studied the function of the comb-shaped ancient rangeomorph organism, *Pectinifrons abyssalis*. The paper, titled, "The rangeomorph *Pectinifrons abyssalis*: hydrodynamic function at the dawn of animal life," was published in *iScience*.

Pectinifrons abyssalis lived deep below the sea, roughly 570 million years ago. The bottom of the organism laid on the sea floor and was worm-shaped with frondlets (imagine comb teeth) extending upward. The currently living harp sponges have a similar shape with the upward extending 'vanes' used for feeding. Using computational fluid dynamics (CFD), the team deduced that the ancient rangeomorph likely used its frondlets for gas exchange, rather than feeding.

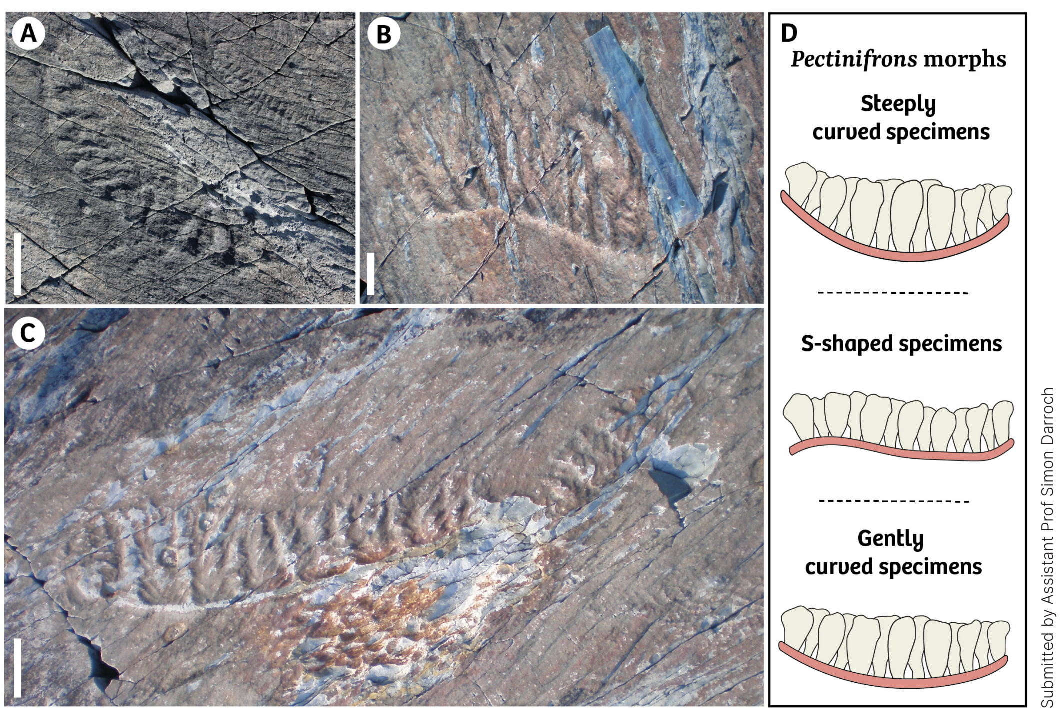
According to Darroch, "we think the upright frondlets were organs for breathing rather than feeding. If we're right, this requires us to re-imagine the oldest macroscopic animals as highly adapted to scavenging oxygen in an ocean that was only periodically oxygenated, rather than adapted for feeding. Not only does this bring us closer to understanding what these critters were, but also helps us understand the environment in which they evolved and the constraints on early animal evolution."



Top panel: close up of modeled frondlets coming off the stalk. Bottom panel: zoomed in to show fluid flow patterns through an example portion of frondlets. Red arrows indicate fastest flow while blue arrows indicate slower flow.

Digital models of *Pectinifrons* were created by postdoctoral researcher at the Natural History Museum in London, Susana Gutarra, and undergraduate researcher in the Darroch lab, Hale Masaki. CFD simulations were run by Imran Rahman, a principal researcher at the Natural History Museum. Rahman also visualized the results.

Current postdoctoral researcher and former Ph.D. student in the Darroch lab, Brandt Gibson, is keenly interested in uncovering the biology and ecology of these ancient rangeomorphs. He is excited to be studying the oldest macroscopic communities ever found and documenting the rapid evolution of organisms on ancient Earth. He noted that life changed very quickly in the Ediacaran



Pectinifrons abyssalis from Mistaken Point(A–C) Photographs of steep 'U'-shaped (A), 'S'-shaped (B), and gentle 'U'-shaped (C) morphotypes of Pectinifrons. Scale bars: 5 cm. (D) Schematic diagrams of *Pectinifrons* morphotypes.

Period, when rangeomorphs lived.

Focusing in on rangeomorph anatomy was Frances Dunn, a research fellow at the Oxford Museum of Natural History. While others on the team (like Darroch and Gibson) were interested in the paleoecology, Dunn provided insight into the best way to actually form the model of *P. abyssalis* for computational fluid dynamics. Understanding the anatomy is the first step to building a functional model.

Working at the community level, Emily Mitchell, an assistant professor at the University of Cambridge, provided insight from *Pectinifrons* specimens collected in various fossil surfaces and the communities they may have lived in. She also works in current ecosystems and was able to provide an appropriate modern sponge for computational fluid dynamics comparisons.

On connections to Evolution at Vanderbilt:

Darroch, the lead investigator in this group, is on the seminar series committee for the Evolutionary Studies Initiative at Vanderbilt University. He is interested in evolution of early life on Earth and has even written a grant to study geologic evidence for life that may be useful for searching for signs of ancient life on other planets. On this project, rangeomorphs provide a sort of proof of concept for studying evolutionary radiations.

Darroch said, "because rangeomorphs appear before just about everything else in the Ediacaran, and are thus perhaps the key to understanding the first major evolutionary radiation of complex eukaryotes, it was important that we took our methods for a test drive, trying to pick it apart. It is also key to understand the environment in which rangeomorphs lived and the general constraints on early animal evolution."

Gibson, having been trained in the Darroch lab, echoed that understanding these rangeomorphs will shed light on life in these early ecosystems. He also mentioned that Vanderbilt, in particular the Biology and Earth and Environmental Sciences departments, was a great place to study the evolution of life on early Earth.

Gibson noted, "as it's often easier to learn by doing, students should reach out to faculty conducting cool research. There are so many unknowns that are currently being investigated at VU, and there's only so much time to work on a given question. Most faculty love collaborating with junior scientists, and it's a great way to gain experience studying evolution and paleontology."

On working together:

Darroch expressed his overwhelming joy from working with this group as well. He commented that the group is able to get so much accomplished because they work well as a team. He is especially proud of the undergraduates on this project – Hale Masaki and Andrei Olaru – noting that they brought incredible enthusiasm to the project.

Read more >>

Credit Tatum Lyles Flick

Dr. Brandt Gibson (center, blue jeans) and Assistant Professor Simon Darroch (leaning over) at the Coon Creek Science Center hunting for fossils.

Keith Lab

Lasting Effects of Disasters

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Monica Keith, Assistant Professor of Anthropology, recently co-authored a paper addressing severe climate events in Bangladesh and their lasting effects on human health outcomes. Working with Shodagor fishing families in Matlab, the team found that body mass decreased following the flood of 2017 and did not recover by the end of the study period in 2019. This result was true for both children and adults. The data from these fishing communities before 2017 suggest that this group is at high risk of under-nutrition. The article, “Economic impacts and nutritional outcomes of the 2017 floods in Bangladeshi Shodagor fishing families,” was published in the *American Journal of Human Biology*.

According to Keith, “we’ve been working with this fishing community since 2014 and know from greater than 5 years of longitudinal data that Shodagor children are generally small according to WHO standards in height, weight, and BMI, and losses in body mass place Shodagor individuals at risk of under-nutrition.”

Environmental disasters impact family household economics in this subsistence-based group through both their fishing success and through market inflation that follows widespread crop losses. The Shodagor economy is strongly tied to income from fishing during the wet season. One discovery that lead author Katie Starkweather, of UI – Chicago, didn’t anticipate at the beginning of the study was that flooding would increase the volume of fish caught but decrease the value of the types of fish caught.

Credit Katie Starkweather

Matlab, Bangladesh in September 2017 just before the peak floodwaters

According to Starkweather, “we expected catch and income to mirror one another and for both to be lower during this period of time in 2017 than in the same time period in 2018, when flooding did not occur. However, fishers were actually catching a higher volume of fish during this time in 2017 than in the subsequent year, but also earning less money.”

Government assistance comes to the Shodagor community primarily in the form of rice. The team found that families that spent a larger proportion of their income on rice were the most negatively affected. Keith and Starkweather hope results from their study can push policy to come up with a new mechanism for assistance in times of need outside of increased access to rice.

According to Keith, “market inflation that follows crop losses and food shortages leads families to rely more on lower-nutrient foods that are less expensive, such as rice, to meet their basic caloric needs.”

Read more >>

Credit Dr. Andy Flick

Assistant Professor Monica Keith stands with the Evolutionary Studies props

Novick Lab

Fighting Misconceptions with Evolutionary Figures

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

Associate professor of psychology and human development, Laura Novick, and graduate student Joanna (Jingyi) Liu, published a paper highlighting the importance of intentionally and thoughtfully designed figures to explain evolutionary relationships and overcome preconceived misconceptions.

Credit Dr. Andy Flick

Associate Professor Laura Novick poses with the Evolutionary Studies props

The work was inspired, in part, by a common misconception that was rampant at the beginning of the COVID-19 pandemic. Many people assumed the SARS-CoV-2 virus was similar to the flu virus, as most of the symptoms overlapped. However, a phylogenetic tree showed that the two viruses are in fact only distantly related.

Liu and Novick hypothesized that changes to the layout or content of an evolutionary tree might be enough to help students reason based on evolutionary evidence, rather than their prior misconceptions. For example, it is not uncommon for people to think that whales are more closely related to manatees than to bison, when the opposite is true. The misconception is reasonable enough, given that manatees and whales both look similar and live in the same type of environment.

Novick explained, the human brain has a strong tendency to associate like items. Perceptual similarity is one basis for grouping items. The Gestalt principles of perceptual grouping describe a suite of criteria, including perceptual similarity, that the human brain uses to extrapolate relationships among objects.

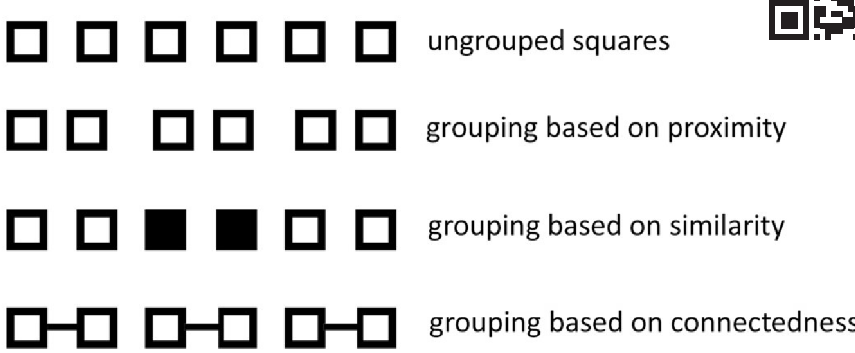
Novick explained, using the figure below, “the first line is an ungrouped set of six squares. We see six individual squares. But in the second row, because some squares are closer to each other than to other squares, we automatically see that row as consisting of three groups of two squares each. We don’t have to do any analyzing or reasoning, we just automatically see this grouping of the squares.”

Submitted by Associate Prof Laura Novick and Joanna Liu

Graduate student Joanna Liu

Liu and Novick showed Vanderbilt undergraduates cladograms that used two different branching structures for depicting relationships among types of living things. These cladograms were called either weakly contradictory (easier to form the misconception) or strongly contradictory (harder to form the misconception), for the way in which they depicted relationships between species that are commonly misconceived as close relatives. They found that students were less likely to make an inappropriate scientific inference (e.g., that whales have the same type of placenta as manatees) when the cladogram strongly contradicted their misconception. This can mean the designers of the cladogram should use one or two different species to create automatic perceptual groupings that reinforce the correct interpretation. Understanding when a cladogram contains a common evolutionary misconception and actively creating a diagram to correct that misconception can help students reason the correct information more easily or more often.

See some cladograms and read more >>



Diffrent types of grouping patterns. Credit Associate Prof Laura Novick

Coon Creek Outreach

Local High Schoolers Find Fossils

By Kelly Tingle, Evolutionary Studies communications assistant

Credit Tatum Lyles Flick

High school teacher, Jessica Seifert, talks about food webs featuring organisms found at Coon Creek Science Center

Local students from Stratford and Overton high schools got to excavate 70-million-year-old oysters, clams, and shrimp at the ESI Fossil Search, a field trip sponsored in November by Evolutionary Studies and a regional outreach grant from the Society for the Study of Evolution, to the Coon Creek Science Center in Adamsville, TN. The fossil search had two main goals: to teach students about food webs and to connect students with Evolutionary Studies (ES) grad students, postdocs, and faculty to talk about college, science, and evolution.

Dr. Angela Eeds, the interim director of the Collaborative for STEM Education and Outreach (CSEO), was instrumental in connecting ESI and the high school groups.

According to Eeds, “the student participants from Overton and Stratford are a part of the Interdisciplinary Science and Research program (ISR) that is a collaboration between MNPS and VU, housed under our group’s umbrella – the Collaborative for STEM Education and Outreach.”

The ISR sets up scientists to work directly with teachers. For example, Dr. Kiara Vann, a postdoctoral researcher studying neuroscience and education, pictured below, attended the trip and works closely with teacher Jessica Seifert at Stratford HS.

“The high schoolers and our folks talked about what it means to study evolution in college and the college experience more generally. The students got to meet anthropologists, fungal biologists, and microbiologists,” said ESI Scientific Coordinator Dr. Andy Flick. “Our group had a blast getting to know the students. In the end, it was a great experience for everyone with just an amazing backdrop that is Coon Creek.”

Credit Dr. Andy Flick

Evolutionary Studies graduate student Sam Schaffner finds a pair of fossils

Upon arriving, students were greeted by Dr. Michael Gibson, director of the Coon Creek Science Center, who explained the geological and palaeoecological background of the fossil site. The students were then taken down to the fossil site within the creek bed and taught how to remove specimens from the exposed mud, which Gibson explained was once an ancient seafloor.

Because the animals are so old, excavation can be challenging, and care must be taken.

“There was an initial period of not understanding just how fragile the fossils are. It took some trial and error to be able to remove the fossils correctly, or at least in good pieces,” said Mr. Jaredd Wilson, a biology teacher at Overton who accompanied students on the trip.

Once the students got the hang of good techniques, they were keen to keep exploring.

“My students really liked physically digging up the fossils. They really started to get into the mud and hunt for things. They continuously went back to the riverbanks to find more,” said Wilson.

Digging for fossils and discussion with the ES community helped the high schoolers better understand how science is done and how it might be a career choice for them going forward.

Read more >>

Dismas House Outreach

New Partnership with Residential Reentry Group

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

This spring, a new partnership formed between Evolutionary Studies at Vanderbilt and Dismas House, a residential reentry program for men leaving Tennessee state prisons and jails. Dr. Kyle David, a postdoctoral researcher in the Rokas lab, founded this partnership with coordination from Natalie McMillan, program coordinator for Dismas House. He and other ES members are currently planning the first set of programming to be available for men of the Dismas House at Vanderbilt.

Evolutionary Studies has been increasing community outreach, which David has been a part of, and he serves as the co-chair for outreach.

According to David, "I've really been enjoying the work ES is doing, I think giving the students the chance to collect their own data and form their own inferences is a great way to demonstrate how science creates new information. Our teaching module also demonstrates how evolutionary relationships are estimated and that the resulting phylogenetic trees themselves can be used to make evolutionary inferences. However, I also think it's important to make sure our outreach efforts are directed toward groups that have been historically excluded from science. Formerly-incarcerated people represent the intersection of several marginalized identities disproportionally targeted by the American carceral system, which is why I'm very excited to collaborate with Dismas House."

The Dismas House has two phases to their program. The first is a period of 30 days where the men must remain on the grounds or be escorted by a staff member. During this time, the men engage with programming to help manage finances and job readiness along with things like required yoga and meditation classes.

According to the Dismas House website, "in Tennessee, 70% of those released from prison will re-offend within three years, and roughly 50% will return to prison within three years. The Dismas House residential reentry program, a comprehensive program that extends beyond housing and employment, has proven to help stop the revolving door of recidivism. By using evidence-based practices that focus on the holistic needs of each resident, our program fosters lasting change from the inside-out."

The idea, spearheaded by David, is to add an opportunity for men to learn about and interact with science, particularly evolution, at Vanderbilt.

According to McMillan, "Dismas is trying to incorporate more sober fun because a significant portion of our residents have struggled with substance use in the past. We've been trying to incorporate more visits to the free museums in Nashville, but there aren't many."

Read More >>

Submitted by Jessica Seifert & Elijah Ammen

Dr. Kyle David teaching local high school students about differences in skulls of different species

Cover Story
Perspectives on AI Art in Science

Perspectives by
Andy Flick, Ph.D.
Evolutionary Studies
scientific cooridnator

The prevalence of artificial intelligence is likely to grow as platforms like ChatGPT and DALL-E-2 break into the mainstream. The benefits and drawbacks of such platforms must be properly addressed before the scientific community can begin using these types of services.

Megan Behringer, an assistant professor of Biological Sciences at Vanderbilt University, has become interested in using AI to generate art inspired by her research. She used DALL-E-2 to create a few "tree of life" renderings included here and on the cover of this magazine.

This tree of life was created in the realism art style by Behringer in DALL-E-2

In addition to Behringer, Jacob Steenwyk, a recent Ph.D. graduate of the Rokas lab, also has a keen interest in AI generated art. Steenwyk comes from a family full of artists and grew up in the art-influenced city of Los Angeles. Among other things, he created the logo for the Evolutionary Studies Initiative and created art for the Rokas lab. At Vanderbilt, he sat on a panel about science and art and was featured in a Vanderbilt story as well.

"It felt natural that my scientific career path would occasionally cross paths with my interest in art," Steenwyk said. "To this end, I've done numerous art projects, such as created portraits of endangered species to raise awareness about their endangered status and, in some sense, immortalize them in their portrait."

Behringer and Steenwyk had some great insights about the use of AI in creating art for scientific purposes. They identified some of the potential benefits and drawbacks. One benefit may include creating engaging imagery for organisms that are less charismatic and often go overlooked. For example, Behringer studies *E. coli*, best known for its involvement in food-borne illness. While this is one facet of some strains of *E. coli*, many are harmless and some can even be beneficial by aiding digestion and inhibiting other pathogens. Along with the bad rap *E. coli* has gotten over the years, it is also a microbe that is hard to illustrate in an attractive way that people might enjoy. Using a variety of styles including realism, cubist, and art-deco, Behringer is able to create some interesting graphics not otherwise available to her.

Steenwyk, too, has experience with platforms like ChatGPT but has also developed his own software that uses artificial intelligence and machine learning. He added that using AI can help brainstorm ideas.

That leads into a potential drawback; these AI generators may be reducing the jobs available for artists, especially those interested in illustrating science. Scientists can create graphics in a variety of artistic styles for a fraction of the price and virtually no wait time.

Steenwyk suggested that AI can be used to augment human creativity, rather than stifle it. He also added that AI should be used as a means to an end, rather than the end itself.

Behringer described this drawback as a potential starting point for a conversation between scientists and artists. In the past, scientists may come into a conversation with an artist with limited common ground. The scientist might have no knowledge of the field of art, while the artist may have a limited understanding of the science. After playing around in DALL-E-2, Behringer learned that she liked magic realism, more than some of the other styles of art.

"Using the AI generator forced me to read more about what distinguishes the different styles of art, I have a greater appreciation now," she explained. "When beginning a collaboration, communication barriers are a common early roadblock. I might lack the terminology needed to describe some ideas to an artist, or a scientist in another discipline."

She also was able to create images that could serve as a starting point for an artist to build off of. AI-generated art helped to illustrate her initial ideas when she may otherwise lack the correct terminology to convey them, contributing to a foundation for future conversations with artists.

One current technique for artists to create imagery for scientists is known as the artist-in-residency program. Artists spend months in a lab observing and learning about the types of work, the organisms, and the people involved. While using AI-generated art as a building block may drastically reduce the time artists need to stay in residency, it may also potentially inhibit the artist's knowledge of the science from which the art is created and inhibit creativity.

Another potential problem with AI-generated imagery would come from academic misconduct. In 2022, Evolutionary Studies hosted Elisabeth Bik, scientific dishonesty sleuth. Arguably, she has become the world's best investigator of academic fraud. She has found manipulations of scientific imagery that predominantly include reproduced sections within or between images. AI generated scientific images could forego the dishonesty of manual reproductions and create incredibly realistic images without replication – or scientific basis. This fraud would be much harder to detect. One potential way around this problem is to make AI art generators embed an identifier into each creation so that a trained eye could always identify the source of the generator.

Steenwyk noted, "The ethics of AI are being played out in real-time. I think if anyone suspects that what they are doing is in the 'gray' zone, they shouldn't do it or they should fully disclose what they've done."

By talking about these and other issues, we can more readily identify and comprehend the ethical implications for the use of AI-generated art in science.

The cover art was created in DALL-E-2 by Behringer using the art-deco style for a tree of life.

This This tree of life was created in the cubist art style by Behringer in DALL-E-2

History of Evolution at Vanderbilt

Submitted by Sheila Chau

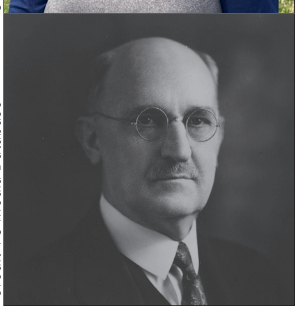
Sheila Chau

Credit wm.edu News Archive

Mary M. Voigt

Submitted by Kaitlyn Russell

Kaitlyn Russell



Credit VU Media Database

Leonidas C. Glenn

These stories are being updated this semester as the students learn more. To read the most up to date versions, follow this QR code:

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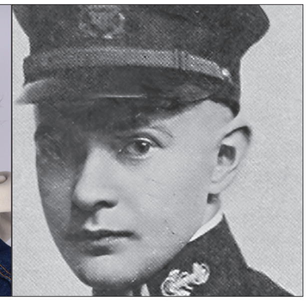
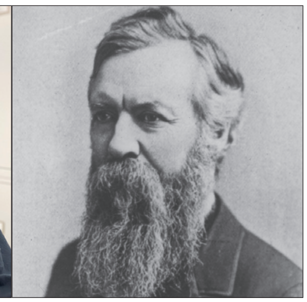
Submitted by Dante Hernandez



George R. Gage

Dante Hernandez

Credit Associate Prof Larisa DeSantis

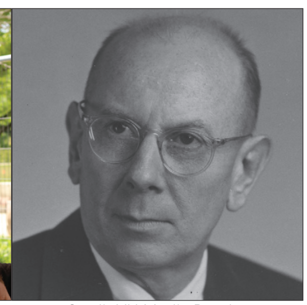


Alexander Winchell

Credit VU Media Database

Ashley Rogers

Credit Tatum Lyles Flick



Willard B. Jewell

Credit VU Media Database

Bill Xu

Submitted by Olivia Quiroga

Elsie Quarterman

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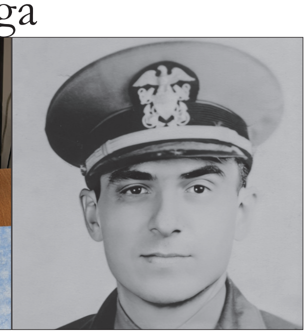


Claude S. Chadwick

Credit VU Media Database

Carly Stewart

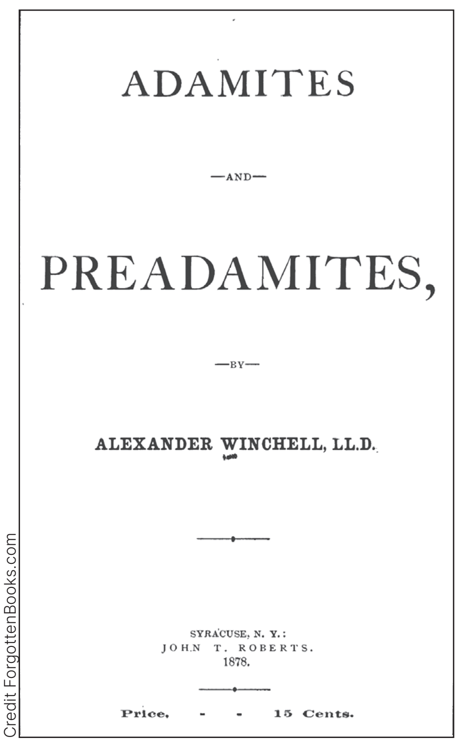
History of Evolution at Vanderbilt

Alexander Winchell

By Ashley Rogers, Evolutionary Studies research assistant

Alexander Winchell, also commonly referred to as the “Great American Geologist,” was a well renowned geologist in the late 19th century. Winchell was born on December 31, 1824 in North East, New York. He attended Wesleyan University and graduated in 1847. Also, in 1850, he earned a M.A. degree. He taught at various universities including in Selma, Alabama, at the University of Michigan-Ann Arbor, Syracuse University, and Vanderbilt University. At the University of Michigan, he was initially a professor of Physics and Civil Engineering. He later switched to teaching Geology, Zoology, Botany and Paleontology and continued to teach these subjects at Syracuse and Vanderbilt.

Winchell was a Geology professor at Vanderbilt University from 1875 to 1878. He was heavily sought after by Bishop Holland McTyiere who was very familiar with Winchell’s reputation at other universities. After finally agreeing to teach at Vanderbilt, Winchell obtained the position of the Chair of Natural History and Geology alongside James M. Safford. Many of Winchell’s teachings were influenced by evolutionary thought and theories. Though his work was heavily influenced by evolutionary principles, he opposed Darwin’s theory of evolution by the means of natural selection. He believed that natural selection could only work as a mechanism to refine and make species better adapt to their environment as opposed to having the ability to create new species.


ADAMITES

—AND—

PREADAMITES,

—BY—

ALEXANDER WINCHELL, LL.D.

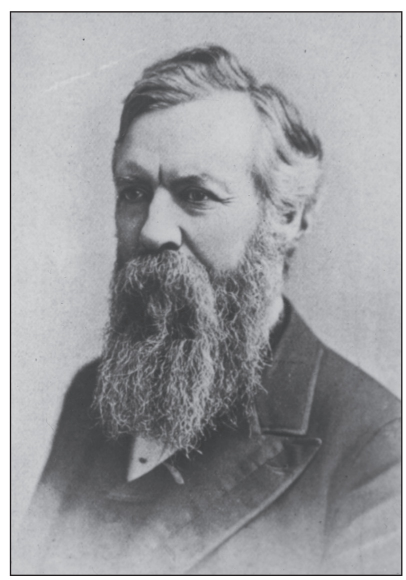
SYRACUSE, N. Y.:
JOHN T. ROBERTS.
1878.

Price, - - 15 Cents.

Credit ForgottenBooks.com

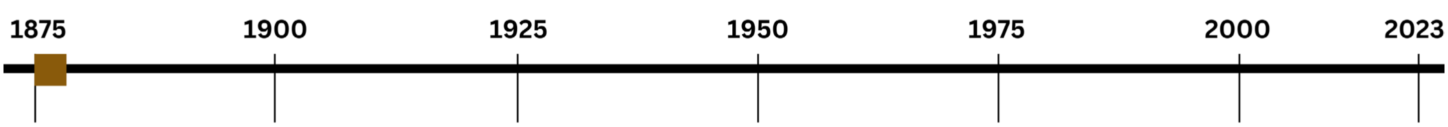
The “Adamites and Preadamites,” booklet cover

Theories of evolution at the time opposed those of the Southern Methodists; however, written records indicate Winchell was allowed to speak on the subject in his courses. It was not until Winchell wrote a booklet titled “Adamites and Pre-Adamites” that Winchell’s relationship with Southern Methodists at the time became tense. This booklet implied that Black people were the first on this Earth, the Pre-Adamites, and the white majority evolved after the Pre-Adamites were already established on Earth. At the time that this was written, Black people were viewed as inferior humans who were stripped of their humanity by the white majority. As a result, this booklet received a lot of backlash, as it implied that Black people paved the way for the white majority and were the first to establish life on Earth. It was also viewed in a negative light because it conflicted with the Biblical story and identity of Adam and Eve in the Bible, as argued by the Southern Methodist majority. Consequently, after writing this booklet, Winchell was dismissed from Vanderbilt and his full responsibilities were transferred to his co-chair James Safford. Though Winchell created this booklet and was beloved by a lot of different universities at the time, he was not absent of racist beliefs and teachings. He commonly referred to Black people as people who “could not be held to the same standard as the white man” and described the ways in which Black people were “phenotypically inferior” to the white man. These views were accepted at Vanderbilt as they aligned with many of the ideals that the Southern Methodists of the time preached and were heavily ingrained in societal norms of the time. However, as soon as Winchell implied that Black people in some way were superior to the white majority (like, by evolving first), he was no longer in alignment with the Southern Methodists’ thought, and his science as well as reputation at Vanderbilt were at stake.



Credit VU Media Database

Alexander Winchell c. 1875



History of Evolution at Vanderbilt

Leonidas C. Glenn

By Kaitlyn Russell, Buchanan Library Fellow

Dr. Leonidas "L.C." Chalmers Glenn was born in North Carolina on September 9, 1871.

He earned his B.S. degree at the University of South Carolina in 1989 and he went on to be the superintendent of grade schools in South Carolina while earning his Ph.D. in geology at Johns Hopkins University. He joined Vanderbilt as an assistant professor in geology in 1900 and became chair of the department in 1903.

He was a founder of the Tennessee Academy of Science and served as its president on three occasions. He also served a short time as the Tennessee state geologist. He retired from Vanderbilt in 1942 and died in January of 1951.

He did field work in geology for the states of Kentucky, North Carolina, and Tennessee, along with the United States Geological Survey and the United States Forest Service, including working on coal steams. One place that he investigated was the Appalachian Mountains which showed great erosion.

In 1912, Tennessee was one of the first states to maintain any considerable geological survey due to Glenn's work. He went on to publish numerous papers including "The Growth of Our Knowledge of Tennessee Geology" in 1912. It was the first comprehensive work of its time for geology in Tennessee. The paper gives the history of all the geology work that has been conducted in Tennessee up to 1910.

In 1910, Glenn also conducted and wrote a paper on the deconstruction of South Carolina forests.

Glenn was also a part of many organizations such as being the chairman of the boys work department for the Y.M.C.A.

Credit VU Media Database

Dr. L.C. Glenn circa 1932

Willard B. Jewell

By Bill Xu, Buchanan Library Fellow

Willard Brownell Jewell was born in Little Compton, Rhode Island on April 4, 1899.

He graduated from Mount Harmon School for Boys in 1918. He served as a seaman in U.S. Navy from September to December in 1918 and Ships Carpenter in U.S. Merchant Marine from February to August in 1919.

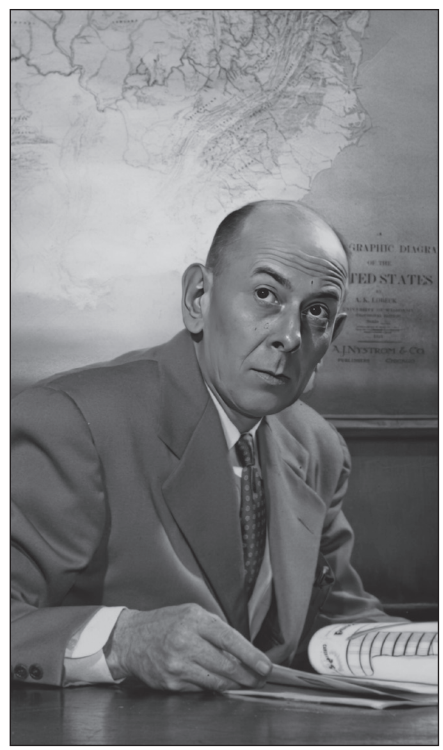
He finished his degree at Brown University in 1923. A few days before his graduation from Brown, he was told about an opening in the geological field, so he went to Canada and became a geologist. Jewell finished his Ph.D. at Princeton University in 1925.

After his graduation, he moved to Vanderbilt to become an assistant professor. He was promoted to associate professor in 1938. He also worked as a visiting professor of geology at Colorado College in the summer of 1935, and director of the Vanderbilt Summer Field Trip in Geology in 1929, 1930, and 1936.

He remained at Vanderbilt, where he was promoted to full professor and chairman of the Department of Geology in 1942. He eventually became dean of the Geology department.

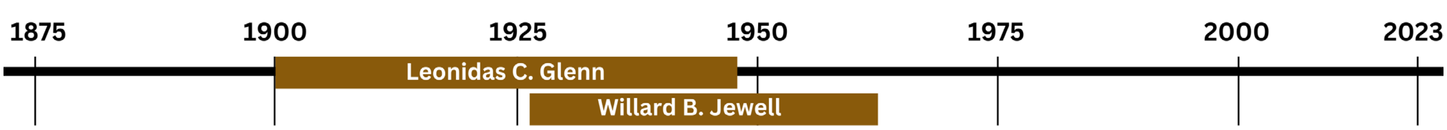
Jewell focused his research on the mineral deposits and geology of Alaska, British Columbia, Tennessee, and Newfoundland.

During World War II, he volunteered to learn meteorology so that he could teach the subject to cadets in the Army, according to Professor Emeritus Leonard Alberstadt. Jewell died in 1969.



Credit VU Media Database

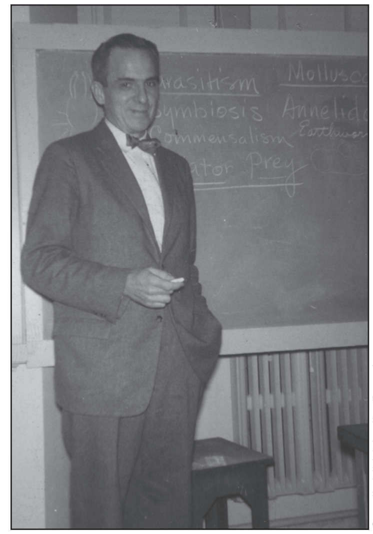
Dr. Willard Jewell circa 1949



History of Evolution at Vanderbilt

Claude S. Chadwick

By Carly Stewart, Buchanan Library Fellow



Credit VU Media Database

Dr. Chadwick circa 1959

Dr. Claude S. Chadwick was born in 1907 and is originally from Carthage, Texas. He received a B.S. degree from Centenary College in Louisiana, and an M.S. degree at Vanderbilt University. After graduating, he spent some time working at the University of Michigan, before joining the Vanderbilt biology department in 1927 as a teaching fellow and instructor while he worked toward his Ph.D. under Dr. Edward Reinke. He became an assistant professor in 1939. He was subsequently sworn in as a lieutenant in the US Naval Reserve in 1944, serving on the SS Thomas during World War II. Upon his return to Vanderbilt in 1946, he became an associate professor, and a full professor at Peabody College in 1951. In 1963, he left for Emory and Henry College.

Chadwick researched hormones using newts as a model organism, studying aspects such as their life cycle. He published at least four scientific articles while at Vanderbilt. One of his experiments, which determined that the pituitary gland is responsible for a newt's impulse to seek water, was featured in *Time Magazine* in 1940. Chadwick was a member of professional organizations including the American Association for the Advancement of Science, the Society for Experimental Biology and Medicine, the Association of Southeastern Biologists, and the Tennessee Academy of Science. He gave a variety of lectures, including "Man, the Becoming Species," "Time's Arrow and the Genes," and "In His Image," the latter of which was likely part of a church speaker series titled the *Lenten Forum Series*.

He also presented a lecture during the series "Great Human Issues of our Times" in 1953. The lecture series was reportedly the first integrated event at Peabody College. However, his beliefs on race were complicated, as he also made uncomfortable remarks about overpopulation in the Nashville Banner. In 1961, he wrote that while he believed the US could support a population up to one billion people, China and India were overcrowded. He also stated that birth control was not the answer, and that modern sanitation prevented the natural order of biology whereby certain conditions and mutations were not meant for survival. By 2026, he said, the world's population "will be approaching infinity" with too many people being "of the yellow race." Thus, though Chadwick was a supporter of integration at Peabody, it seems that his views were complicated and still reflected an uncomfortable view of other cultures.

Outside of his scientific career, Chadwick had a rich personal life. He was involved in campus life at Vanderbilt, heading the Camera Club unit of the Vanderbilt Outdoor Club as well as the Vanderbilt University square dance team. He even directed the Vanderbilt Pre-Med Club's square-dancing team and wrote an illustrated book called "Let's Square Dance." He also judged several science fairs in his spare time, belonged to the West End Methodist Church, and was president of the Brotherhood Bible Class.

Credit VU Media Database

Dr. Chadwick working with a student circa 1955

1875 1900 1925 1950 1975 2000 2023

History of Evolution at Vanderbilt

George R. Gage

By Dante Hernandez, Buchanan Library Fellow

Dr. George R. Gage was a professor of botany born on August 6, 1890, in Atlantic City, New Jersey.

He graduated Pennsylvania State College (now Pennsylvania State University) with a B.S. in 1914, an M.S. from Michigan State College (now Michigan State University) in 1915, and a Ph.D. from Cornell University in 1926, he served in the military during World War II in the Army Air Corps. After teaching at Michigan State College, Cornell University, and DePauw University, he joined Vanderbilt University in 1928. He died in his home of a heart attack on August 18, 1945.

Gage was a plant pathologist who worked on semi-loose smut disease of oats for a considerable part of his career with published papers by the Agricultural Experiment Station at Cornell University. While at Vanderbilt, he was one of the few people concerned about the danger that Dutch Elm disease posed to the North American elm tree populations. He warned colleagues of the looming threat in a presentation to the Tennessee Academy of Science in 1934. In this presentation he discussed how the problem could be mitigated but that it would require money that the USDA did not have. Eventually, the disease would go on to wipe out 40 million trees across the North American continent.

Gage also helped found the Vanderbilt University herbarium collection in 1935 with Dr. Harold Bold. The Vanderbilt University collection housed 20,000 specimens before being sent to the Botanical Research Institute of Texas in 1996 for preservation. Currently, the collection is being digitized for use in botanical research across the world.

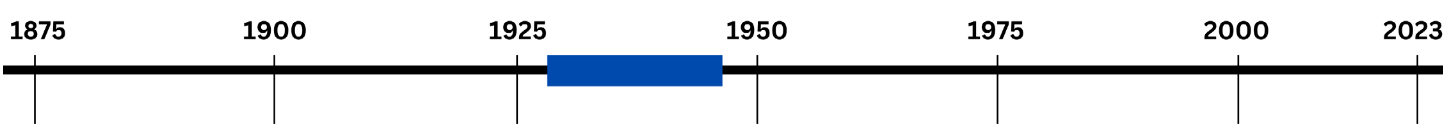
Gage was also an important advisor to the Vanderbilt Garden Club, students who were interested in learning more about plants and plant improvement. Before professional landscaping was done around the university, the garden club was in charge of all the plantings done on campus. He gave numerous talks to the members on a variety of topics, including the life cycle of pea plants and strategies for improving plant growth and yield.

Gage was also in charge of managing many of the trees during the summer. He spoke many times about how trees should be managed when they are damaged and when tree "surgery" is necessary. He was all around a supporter of ensuring trees are not cut down when possible.

Photos credit Nashville Banner Magazine

The wages of neglect is the death of a fine tree. Dr. Gage, professor of botany in the department of biology at Vanderbilt University, shows how a trunk can be destroyed when a branch is impropery cut. 6/20/1937

Photo accompanying Dr. Gage's obituary



History of Evolution at Vanderbilt

Elsie Quarterman

By Olivia Quiroga, Buchanan Library Fellow

Dr. Elsie Quarterman was a researcher, biologist, botanist, and professor at Vanderbilt University. She joined the Vanderbilt faculty in 1943, teaching during World War II. and eventually became the university's first female academic department chair.

Born November 28, 1910, in Valdosta Georgia, Quarterman attended Valdosta High School and earned the A.B. degree in English from Georgia State Women's College (now Valdosta State University). Quarterman earned her M.A. degree in botany at Duke University in 1941.

She completed her Ph.D. under Dr. Henry Oosting in Duke's botany department, where she focused on plant ecology and wrote her dissertation on the cedar glades of middle Tennessee. She remained close with her advisor throughout her years at Vanderbilt, often leaning on him for professional advice.

Oosting said of her in a letter of recommendation, "Dr. Quarterman is a dedicated and superior teacher. She speaks well under any circumstances, has given much thought to methods and objectives in modern beginning science courses, works conscientiously at improving her courses, and always has the student in mind. That she has attracted several graduate students to continue work with her is certainly indicative of her stimulating influence and the regard with which they hold her."

She taught systematic botany, plant anatomy, and the year-long series in general botany. She would go on to develop her own plant ecology class and teach evolution as well.

Credit VU Media Database

Dr. Elsie Quarterman in a greenhouse circa 1970

After WW2 ended, the university sought to end the teaching responsibilities of many newly employed women. The chair of the department, however, fought to keep Quarterman on the faculty due to her outstanding botany teaching capabilities.

Quarterman became the first woman to serve as an academic department chair at Vanderbilt University in General Biology in 1961.

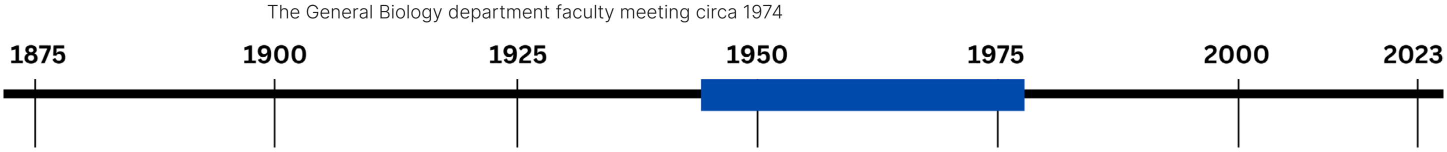
In a 1961 NSF application, she wrote, "the problem of evolution represents one of the great opportunities jointly facing taxonomy and ecology; accordingly, the program at Vanderbilt has been designed to utilize the appropriate concepts and methods of these two disciplines, and indeed any pertinent disciplines, as means of elucidating evolutionary problems.

Quarterman earned emeritus status in 1976 and died at the age of 103 on June 9, 2014.

The university featured her on vanderbilt.edu/150 as part of their sesquicentennial celebrations.

Credit VU Media Database

The General Biology department faculty meeting circa 1974



History of Evolution at Vanderbilt

Mary M. Voigt

By Sheila Chau, Buchanan Library Fellow

Dr. Mary Voigt was a professor in Vanderbilt's Anthropology department from 1971 to 1978. She was also a lecturer at University of Pennsylvania, Bryn Marw College, and College of William and Mary. She holds degrees from Marquette University (B.A. in History and English) and the University of Pennsylvania (Ph.D. in Anthropology).

At Vanderbilt, specifically, one of the main classes she taught was human evolution. Other interesting courses she taught at different institutions include human origins, the cells in archaeology and history, and seminars on problems in anthropological theory.

One of Voigt's accomplishments was finding the Neolithic vino, the oldest bottle of wine on record. Voigt has done some archaeological work in Iran, and during exactions at Haji Firuz Tepe (northern Zagros Mountains near the city of Urmia, six wine bottles were discovered in what was thought to be the kitchen of a neolithic home. The wine bottles that were found were found to be roughly 7,000 to 7,400 years old. Voigt analyzed a yellowish residue on the pottery, and she found that the material had calcium tartrate and terebinth, a resin, from a tree.

Tartaric acid is often found in grapes. Voigt and her team found that the tartaric acid was converted into the calcium salt by interacting with soil. The finding of ancient retsina made the origins of wine 2,000 years earlier.

Voigt was passionate about archaeology, and she thought archaeology as pertinent to unearthing stories from the past. Each artifact that is found is not an isolated instrument. Rather, she thought of each artifact as something that was a part of a larger story.

Credit wm.edu News Archive

The project's 1961 truck, project team (Voigt, seated), and restored garden at Gordion, 1988. Image credit wm.edu News Archive

Credit wm.edu News Archive

Voigt at the Gordion site's museum, 1991. Image credit wm.edu News Archive

Welcome Audrey!

EVOSt

Evolution at Vanderbilt Organization for Students

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Joyce Sanks
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Submitted Audrey Arner

Audrey Arner
Graduate Chair

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ES Sponsored Conferences

Developmental Plasticity and Early Life Adversity

By Amanda Lea, Assistant Professor of Biological Sciences

Drs. Amanda Lea (Vanderbilt University), James Higham (NYU), Sam Patterson (NYU), and Jenny Tung (Max Planck) co-organized a three-day workshop on the evolution of developmental plasticity. This workshop was hosted at NYU Berlin on December 15-17, 2022 and was co-sponsored by the Vanderbilt Evolutionary Studies Initiative, NYU Berlin, and the Max Planck Institute for Evolutionary Anthropology.

The workshop brought together more than a dozen experts from around the world in anthropology, evolutionary biology, biomedicine, and public policy to discuss theoretical frameworks, terminology, competing views on the adaptive value of developmental plasticity, and how to best conduct empirical tests moving forward. More generally, the workshop provided a much-needed synthesis on the definition of "adaptive" developmental plasticity and the evidence needed to demonstrate that developmental plasticity is adaptive.

Early life experiences can have profound and persistent effects on health, with major ramifications for Darwinian fitness. Early life adversity (e.g., inadequate nutrition, psychosocial stress, etc.) consistently predicts later life disease susceptibility and mortality rates, even if environmental conditions subsequently improve. However, despite robust research linking early life experiences to later life health, we still have a poor understanding of the mechanistic or evolutionary explanations for these so-called "early life effects."

E6 Meeting Hosted by Vanderbilt

By Dr. Andy Flick, Evolutionary Studies scientific coordinator

The appearance of new ecosystem engineers may have driven mass extinction events. On December 12-16, Simon Darroch, assistant professor of Earth and Environmental Science, hosted a conference about the history of life on Earth as it relates to ecosystem engineers. Darroch is a co-principal investigator on a grant from the NSF to study the ecological and evolutionary effects of extinction and ecosystem engineers – or E6 for short.

Ecosystem engineers are organisms that can profoundly impact the environment in which they live. A common example is the beaver, which builds dams and thus creates new niche spaces (like flooded grasslands) that other organisms can exploit. Ecosystem engineering also has a crucial deep-time component as well – over the last 3.8 billion years, major new ecosystem engineering behaviors have evolved, and exerted increasingly complex controls over Earth Systems that cumulatively create a habitable planet. Examples include the evolution of oxygenic photosynthesis (leading to the emergence of animals), and the colonization of land by plants (leading the formation of soils, and the foundation of terrestrial ecosystems).

The appearance of new ecosystem engineers may even have driven mass extinction events, and nowhere is this more apparent than the Anthropocene where human activities threaten approximately one million plant and animal species.

Submitted by Assistant Prof Amanda Lea

Developmental Plasticity and Early Life working group in Berlin, Germany

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Larisa DeSantis (BSCI)
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Monica Keith (Anthro)
Biological anthropology, data science, Bayesian modeling, maternal health disparities
Amanda Lea (BSCI)
Gene regulation, biological anthropology, genotype x environment interactions, early life effects
Lin Meng (EES)
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Maulik Patel (BSCI)
Mitochondria, adaptive evolution, genetic conflict, selfish DNA, female reproduction, disease inheritance
Antonis Rokas (BSCI)
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Carlos Taboada (BSCI)
Treefrogs, camouflage, biochemistry, protein evolution, animal fluorescence, visual ecology, optics
Ann Tate (BSCI)
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Credit Tatum Lyles Flick

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Credit Dr. Andy Flick

Credit Tatum Lyles Flick

Endless forms most beautiful and most wonderful have been, and are being

EVOLVED

-Charles Darwin