



BioNews

Keeping you updated on
what's happening in the
Department of Biology
Spring 2018



Photo by Sue Anne Zollinger

How do birds, like this urban Great Tit (*Parus major*), cope with the dramatically altered environment of a city? Sue Anne Zollinger (this issue's alum profile) and her colleagues study the impacts of chronic traffic noise on vocal behavior, learning, stress physiology, metabolism, and aging in birds.

Editor's note

During this spring's annual Student Awards Ceremony, IU Biology Chair Greg Demas expressed his admiration at how involved our students are—not only with their classes and research, but with volunteer and outreach activities. Madeline Danforth, who graduated with a B.S. in microbiology and a B.A. in Spanish, is no exception. Danforth is the focus of the student profile in this issue of *BioNews*.

Our alum profile covers Sue Anne Zollinger (Ph.D. '07) who maintains a zeal for her work and activities. Read about how Zollinger developed her passion for science and how her artistic and scientific sides complement each other.

In this issue, we share with you some awards our faculty members have received during the past months—highlighting Julia van Kessel's study on quorum sensing in bacterial pathogens for which she received a \$1.89 million Maximizing Investigators' Research Award. van Kessel's work holds promise in unlocking a new method to fight diseases that are becoming increasingly resistant to antibiotics.

We also introduce you to John Patton, IU Biology's new Blatt Chair of Virology. And, speaking of new, be sure to read about the discovery of a plant species that until recently was not thought to be in Indiana.

Terri Greene, *BioNews* editor

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BioNews is published by the IU Department of Biology—with support from the IU College of Arts and Sciences—for alumni and friends to encourage their interest in and support for Indiana University, the College of Arts and Sciences, and our department.

Editor: Terri Greene

Editorial correspondence

Email: bionews@indiana.edu
Letters: 1001 East Third Street,
Bloomington, IN 47405-7005 USA

Department of Biology

<https://biology.indiana.edu>
Chair: Greg Demas
Associate Chair for Research and Facilities:
Scott Michaels
Associate Chair for Teaching: Rich Hardy
Development Officer: Kathy Wyss

College of Arts and Sciences

<https://college.indiana.edu>
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News in brief



Photo by Anna Powell Teeter

Laboratory courses allow students to develop skills critical to careers in academic, clinical, and pharmaceutical sciences. Learn more at <https://mls.indiana.edu>.

New degree in molecular life sciences

Starting in the fall semester, we're offering an interdisciplinary Bachelor of Science degree in Molecular Life Sciences jointly with the IU Bloomington Department of Molecular and Cellular Biochemistry.

"The MLS degree program was created with the pre-professional in mind," said Justin Kumar, professor of biology and GCDB section associate chair who helped design the new program. "The MLS degree will prepare students for graduate work—whether they choose to pursue medical school or a Ph.D. in the life sciences."

For the first two years, students will focus on a selection of interdisciplinary courses in Biology, Chemistry, Physics, and Math. In their junior year, they'll select a preferred concentration: Molecular and Structural Biology or Developmental and Cellular Biology. We've designed several 400-level Molecular Life Sciences courses that provide in-depth understanding of important cellular processes. These courses are open to all eligible students, not just MLS majors.

Academic advisor receives prestigious award

Undergraduate advisor Libby Tilghman's service to our students has been recognized by IU's Bloomington Academic Advisors Council. The BAAC presented Tilghman with its 2018 Terri Nation Outstanding Academic Advisor Award. The award is given to advisors who have made exceptional achievements.

Tilghman has been advising Biology, Microbiology, and Animal Behavior undergraduates for five years. She loves facilitating a clear understanding of the "nuts and bolts" of degree requirements, so that the students are free to focus on their courses and to ultimately discover and follow their passions. She also credits her colleagues for making her job so rewarding. "They're a joy to work with," says Libby. "They're dedicated to the students as well as supportive of each other."



Courtesy photo

Libby Tilghman.

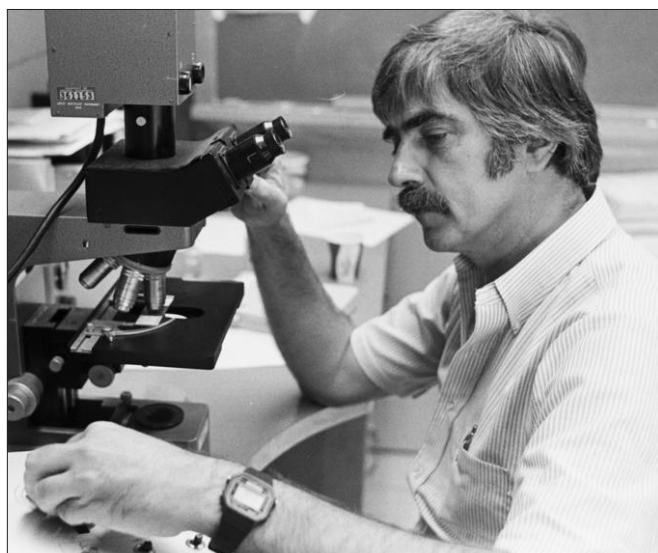


Photo courtesy of IU Archives, #P0067135

Don Whitehead tests for acid rain, July 1982.

Celebration of Don Whitehead's life

A celebration of life will be held for Professor Emeritus Donald R. Whitehead on the weekend of September 29, 2018, in Bloomington, Indiana. Whitehead died earlier this year on February 6.

His family and Bloomington friends and colleagues hope that the long advanced notice will allow time for distant friends and former colleagues to make plans to join them in honoring Whitehead and providing a proper send-off party.

A dedication of the local Sycamore Land Trust's new Don & Betsy Whitehead Nature Trail will be followed by a celebration of life party. "And it will be a party," declared Whitehead's daughter.

Check the CaringBridge site (<https://www.caringbridge.org/visit/donbetsywhitehead>) for details and updates.

Student profile: Madeline Danforth

"We live in a microbial world, and it's pretty awesome," Madeline Danforth told those attending Biology's 2018 undergraduate graduation ceremony on May 5. Madeline—the featured student speaker—graduated with a B.S. in microbiology with departmental honors, a B.A. in Spanish with a concentration in Spanish literature, and a minor in chemistry. She is recipient of IU's 2018 Herman B Wells Senior Recognition Award.

Madeline remembers from childhood being wonderstruck by pictures of bacteria, infections, and diseases in her mother's microbiology book from nursing school. Madeline admits she initially chose to study microbiology because she "wanted to be a doctor, doctors cure disease, and disease is caused by microbes." But, Madeline realized quickly that this was an all too simplistic view of microbiology. The microbial world we live in is much more complex and much more remarkable than that. Her fascination with microorganisms, or microbes, blossomed during her undergraduate studies at IU.

During her freshman year, Madeline joined the laboratory of Professor Malcolm Winkler as an undergraduate researcher. "This was a lucky event," she notes, "because my four years of research experience in Dr. Winkler's lab shaped my undergraduate career."

Madeline completed two research projects that involved genetics and high-resolution microscopy of essential cell division proteins (FtsA and FtsX) in the major bacterial respiratory pathogen, *Streptococcus pneumoniae*," said Winkler. "Both of these studies, containing Madeline's beautiful micrographs and conclusive results, were published with Madeline as co-author, which is a major accomplishment for an undergraduate student."

Madeline's education has changed her perspective in many ways. She has learned that gaining knowledge

is not meant to be simple, nor is it meant to be accomplished quickly. Scientific inquiry requires creativity, dedication, and an immense appreciation for the complexity of the processes studied. Her education has also impacted her lifestyle.

"I remember the day in my introductory microbiology class," Madeline recalls, "when Dr. Winkler (my professor) explained the antibiotic crisis—how many bacteria have become resistant to drugs commonly used to treat infections. Although there are multiple reasons for this serious crisis, one stood out to me: use of antibiotics in livestock food. I was upset about the consequences of our misuse of antibiotics. Because of this and other reasons, I largely cut meat from my diet and became aware of antimicrobials in everyday items."

Although microbes are mostly known as foes, many are friends. "Microbes are necessary members of ecosystems and symbiotic relationships," Madeline explains. In one of her favorite classes at IU, Environmental Microbiology with Assistant Professor Irene Newton, Madeline read the book *I Contain Multitudes* by Ed Yong. Madeline says, "This book narrates the wonders of the microbial world we live in and is a great read for someone who wants to learn about the role microbes play in our world. After Dr. Newton's class, I shared this book with my parents, siblings, and friends."

Madeline has also been passionate about improving and practicing her Spanish in order to eventually serve the U.S. Spanish-speaking population as a physician. Through the IES Summer Health Studies Program, she spent a summer in Santiago, Chile—studying the country's healthcare system and observing clinical operations.

Her experiences in Chile motivated her to become involved with the international community in Bloomington. Through VITAL



Madeline Danforth. Courtesy photo

(Volunteers in Tutoring Adult Learners) at the local library, Madeline served as an ENL (English as a New Language) conversation group leader and an ENL tutor for Spanish speakers. She recently co-taught an English class for Spanish speakers at Bloomington's free clinic, Volunteers in Medicine.

Madeline has experienced firsthand how questions about immigration and citizenship manifest themselves in someone's life. Through VITAL, she had the opportunity to tutor one Spanish-speaker for the U.S. Citizenship exam, who passed her citizenship test in March. Madeline was able to attend her friend and new citizen's naturalization ceremony in April—in the same building where Madeline saw her mother become a naturalized citizen when she was a child.

Madeline is grateful for opportunities she had to engage with people from many different backgrounds. "I have met fascinating and delightful people whom I believe make our community the wonderful community that it is."

Madeline will spend next year in Mexico as a Fulbright scholar, where she will partake in cultural and educational exchange as an English teaching assistant. While in Mexico, she hopes to gain a deeper understanding of Mexican culture and the Spanish language. Afterwards, Madeline will attend Washington University School of Medicine in St. Louis to pursue her M.D.

NIH funds research to open door to a new way of fighting infection

Drug-resistant bacteria are a growing public health crisis. When antibiotics no longer work to treat an infection, what do you do? Julia van Kessel, assistant professor of biology, may have the answer.



Photo by Sandee Milhouse

Julia van Kessel.

“Most antibiotics that are currently used to treat disease work by preventing bacterial cell growth,” van Kessel said. “They are quite effective, but they also have a high potential to generate antibiotic resistance.”

Members of the van Kessel lab are taking a different approach. They study **quorum sensing** in bacterial pathogens. Quorum sensing is the regulation of gene expression in response to fluctuations in cell-population density. A few tiny bacterial cells generally cannot cause disease in a huge human host; however, when their numbers have multiplied, it’s a different story.

Once the bacteria reach a threshold—or “quorum”—where their numbers are great enough to enable them to work together, they

change their **gene expression** (cell’s ability to convert information stored in its DNA into instructions for making proteins or other molecules for communication) to perform group behaviors. Group behaviors include actions as benign as emitting a faint bioluminescent glow or as dangerous as secreting toxins and making biofilms* and antibiotic-resistant genes. Bacteria launch their action at high numbers when billions of cells are present to make the action effective. Infection by bacteria is a nutritional strategy—it is the way that bacteria live off the nutrients provided by the host.

van Kessel wants to know when, why, and how much bacterial pathogens change gene expression. She wants to know why the timing of gene expression is important during infections.

To answer these questions, van Kessel lab members study the timing of gene expression of genes required for causing disease, such as those responsible for toxin secretion and cell motility (movement).

Their research will focus on bacteria in the *Vibrio* genus—*V. cholerae*, *V. vulnificus*, and *V. parahaemolyticus*. *V. cholerae* is the causative agent of the diarrheal disease cholera. Cholera is rare in the U.S. but common in developing areas of the world. Approximately 3 million cases of cholera occur each year, causing over 100,000 deaths. *V. vulnificus* and *V. parahaemolyticus* are responsible for the disease vibriosis in humans, which produces vomiting and fevers in some cases and skin infections in others. There are about 80,000 cases in the U.S. every year, with around 100 deaths. *V. vulnificus* and *V. parahaemolyticus* are also pathogens of shellfish and fish and are of great concern to the aquaculture industries.

Most of van Kessel’s research into quorum sensing will occur in the less infectious, bioluminescent bacterium *V. harveyi*. Its cellular mechanisms behave similarly to the more pathogenic vibrios. Although it is a pathogen to shellfish and

fish, *V. harveyi* poses no risk to the lab members. It is also the vibrio for which the most is known about quorum sensing.

It has been established that the bioluminescent vibrios such as *V. harveyi* and *V. fischeri* produce light only when the cells reach high densities. The enzyme required to produce light is made in a “burst” when the cells start growing quickly. Researchers learned that the burst is controlled by bacterial proteins that produce and sense small molecules used for cell-cell communication.

Because of similarities, knowledge gained from studying *V. harveyi* can be extrapolated to the other pathogens to investigate how quorum sensing impacts bacterial physiology, infection, and toxicity.

The van Kessel lab has pinpointed the LuxR/HapR proteins as key targets for developing inhibitors of quorum sensing in pathogenic vibrios. These proteins are at the center of the quorum sensing pathway in vibrios. They control the expression of hundreds of genes which allow the bacteria to behave as groups and work together. LuxR/HapR proteins are the ones directly changing the expression of the genes for such things as toxin secretion, biofilm formation, and bioluminescence. If van Kessel can learn enough about how LuxR/HapR proteins function, drugs that target these proteins to block their activity can be developed. van Kessel notes that if the cells cannot change their gene expression, they cannot launch their attack of toxins and biofilms.

The van Kessel lab is also studying quorum sensing in a second type of bacteria called mycobacteria. Tuberculosis, which is estimated to infect about one-third of the world’s population and cause about 2 million deaths each year, is caused by species of mycobacteria. Other species of the bacteria cause diseases such as leprosy, skin infections, and lung diseases. The van Kessel lab members aim to use

*Biofilm is a thick layer (or colony) of microorganisms (e.g., bacteria) that excretes a sticky substance to encompass and protect the microbes as well as channel oxygen and nutrients. The secretion allows the colony to attach to a surface. Biofilm promotes growth and survival of the microorganisms.

the field's collective knowledge about quorum sensing in other bacteria to uncover cell-density regulation in mycobacteria. They will study gene expression of motility and biofilm genes as part of their research.

The goal of our research is to understand how cell-cell communication controls pathogenesis in bacteria," said van Kessel. "We are working toward the larger goal of developing drugs that target the quorum sensing pathway. When bacteria cannot use quorum sensing to count their numbers, they do not know when to launch their 'attack' and cannot cause disease. If we use drugs that block quorum sensing, we would stop expression of virulence genes but not kill the bacteria. This would minimize the rate of antibiotic resistance, and the host's immune system could clear the infection. It's like taking the weapons away from the army but not killing the soldiers. It's an effective strategy to stop the war with much less damage."



Photo courtesy of van Kessel lab

"Painting" with bioluminescent *Vibrio harveyi*, the model organism for quorum sensing studies in *Vibrio* species. Quorum sensing controls expression of the genes in the bacteria, which enables the cells to "glow in the dark" after reaching high numbers.

The National Institutes of Health has awarded van Kessel \$1.89 million from its MIRA program for her quorum sensing research. MIRA—Maximizing Investigators' Research Award—grants are part of the National Institute of General Medical Sciences' Outstanding Investigator Award Program. The awards are granted to investigators with outstanding records of productivity and innovation.

Faculty awards

Distinguished Professor and Clyde Culbertson Professor **Yves Brun** was awarded a \$4 million NIH MIRA to advance research on bacterial cell biology.



Brun



Bush

International Society of Chemotherapy for Infection and Cancer presented Professor **Karen Bush** with its highest award, the Hamao Umezawa Memorial Award. Bush is the first woman ever to receive the award.



Demas

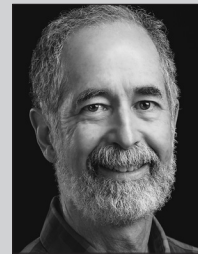


Hahn

Professor and Chair **Greg Demas** was honored with a Daniel J. Ziegler Award from Villanova University Department of Psychological and Brain Sciences.

Professor **Matt Hahn** was named 2018 fellow of the American Association for the Advancement of Science.

NSF-USDA joint program on plant biotic interactions funded Professor **Roger Innes**'s work to facilitate development of disease-resistant crops.



Innes



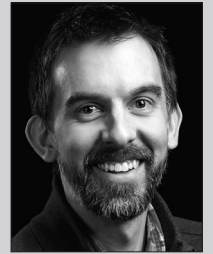
Kearns

Professor **Daniel Kearns** was elected as a 2018 fellow of the American Academy of Microbiology.

International Animal Behavior Society named Distinguished Professor **Ellen Ketterson** its 2018 recipient of the Distinguished Animal Behaviorist Award.



Ketterson



McKinlay

Assistant Professor **Jake McKinlay** will use a \$1.15 million NSF CAREER Award to advance research and teaching on bacterial nutrient exchange.

Professor **Armin Moczek** was awarded a Fulbright grant to conduct research on developmental biology in Australia as a Fulbright Distinguished Chair in Science, Technology, and Innovation.



Moczek



Pikaard

Professor **Craig Pikaard** was elected as a 2017 member of the National Academy of Sciences.

Associate Professor **Heather Reynolds** was awarded a SARE Sustainable Agriculture Grant for her project to improve methods for small organic tomato growers.



Reynolds

Bush and Demas are courtesy photos; all other photos are by Sandee Milhouse.

New Blatt Chair of Virology

John T. Patton joined our faculty last August as an associate professor and will serve as the department's first Lawrence M. Blatt Chair of Virology.

John's seminal contributions to the field of rotaviruses and RNA viruses, as well as the general virology community, have been outstanding. We're excited to have someone with John's experience and expertise to step into this role of further developing virology research and education within our department," said Greg Demas, chair and professor of biology.

Patton obtained his Ph.D. in microbiology from Virginia Tech and was a postdoctoral fellow in virology at University of North Carolina at Chapel Hill. Before joining IU Biology, he was an associate professor at the University of Maryland. He is a fellow of the American Academy of Microbiology.

Patton's research involves the molecular biology of rotaviruses—important pathogens causing gastroenteritis in infants and young children. His focus is on the mechanisms used by these viruses to replicate their segmented RNA genomes and to suppress innate immune responses.

The Lawrence M. Blatt Chair of Virology is funded by a \$2 million endowment from alumnus Larry Blatt. Blatt received a Bachelor of Science in microbiology from IU in 1983. He is a pioneering virologist and founder of Alios BioPharma Inc. (a clinical-stage biopharmaceutical company that developed therapeutics for a range of viral infections).



Courtesy photo

▶ John T. Patton

Roots

Born in California; grew up in Virginia

What you might not know about him

He likes to ride bicycles, hike in the woods, and hang out with his big dog Savannah. He played cymbals in his high school's marching band.



Photo by Alexandra Yepes

Sue Anne Zollinger.

Alum profile: Sue Anne Zollinger

A nexus of art and science . . . with a slice of pie

Sue Anne Zollinger, who completed her Ph.D. in biology from Indiana University in 2007, is excited about an investigation she and colleagues have recently begun in collaboration with an avian sleep expert. They will measure if and to what degree noise pollution interferes with sleep quality in urban birds.

"It is a two-part thing," Zollinger explains, "where we have cameras in nest boxes of urban Great Tits (songbirds common in cities here, related to chickadees) with recorders that track noise and temperature and light pollution along with nocturnal behaviour of the birds (whether they 'wake up' more often in noisy places). The second part is in the lab, where we will put small wireless EEG electrodes and heart rate monitors on birds and record sleep state in the brain and heart rate during the night with traffic noise exposure."

The group hopes to learn more about the relationship between poor sleep quality and the observed effects attributed to noise pollution as a stressor. Many correlations exist between noise-disrupted sleep in humans and numerous health problems often found in people chronically exposed to noise.

Zollinger is a research scientist at The Max Planck Institute for Ornithology in Germany. Much of her research focuses on how birds and other animals cope with urban noise pollution. Conservationists and human health experts alike are increasingly concerned about physiological stress responses caused by chronic exposure to loud noise. High levels of noise pollution have been linked with decreased breeding success and species richness as well as changes in vocal behavior in bird, mammal, and amphibian species. In humans, chronic noise can result in high blood pressure, hyperglycemia, and elevated cholesterol levels as

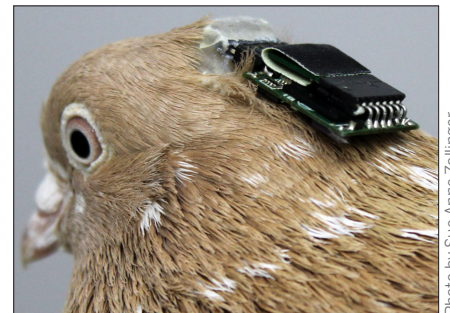


Photo by Sue Anne Zollinger

Wireless EEG electrodes and microphones are attached to pigeons' heads. The birds can fly free and return to their sleeping roosts at night, where their sleep quality and neural behavior can be tracked remotely.

well as delays in brain development, impaired cognitive function, and deficits in learning and memory.



Photo by © Axel Griesch

Zollinger records vocalizations of a male Great Tit (*Parus major*), a songbird widespread in both forests and cities across Europe and Asia. Zollinger and her group at The Max Planck Institute for Ornithology are interested in vocal and physiological changes that birds make in order to survive and even thrive in urban environments.

Zollinger, however, did not start out in life to become a scientist. While growing up in the Washington, D.C., area, she had aspirations of procuring a career as a visual artist. She attended a special magnet high school for the arts in Maryland and then started a B.F.A. program at the School of the Art Institute of Chicago. During that time, Zollinger landed an internship in the anthropology department at the Field Museum of Natural History in Chicago. She worked in the “Africa” collections, cataloging holdings for an upcoming exhibit. Her proximity to the museum’s birds department allowed her to interact with avian scientists and preparators.

After taking a few years off from school to earn and save money for tuition, Zollinger transferred to University of Illinois at Chicago to complete her bachelor’s degree. Influenced by her experiences at the Field Museum, she added some biology courses to her schedule to inspire her art. She quickly realized, however, a new passion: SCIENCE! Zollinger transferred to the University of Maryland where she completed a B.S. (cum laude) in biological sciences.

Rod Suthers’ innovative work in vocal production and communication in birds as well as the multi-departmental community of animal behavior researchers in the Center for Integrative Study in Animal Behavior drew Zollinger to Indiana University to pursue her doctoral studies.

As a means to not get too removed from art while working on her Ph.D., Zollinger resurrected the pie club. The Pie of the Month Club—postcards Zollinger designed with an interesting pie recipe on one side and an original illustration on the other side—was a novel way she conceived during her years in Chicago to stay connected with friends as well as to regularly create a new piece

of artwork. It grew into a website during her IU years. “The POTMC was always mostly about cultural history, art, and folklore more than actually about pie baking,” Zollinger explains.

After receiving her Ph.D., Zollinger was offered a postdoc position at University of St Andrews in Scotland, where she worked with one of the fathers of birdsong research, Peter Slater, in collaboration with Henrik Brumm (The Max Planck Institute for Ornithology in Germany). The project examined effects of urban noise on birdsong learning and vocal behavior. For logistical reasons, the project and Zollinger relocated to The Max Planck Institute for Ornithology in Germany in 2010. It was there she became a research scientist and began a long-term collaboration with Henrik Brumm in the institute’s Communication and Social Behaviour Group.

The nexus of art and science continues to be an important part of Zollinger’s life and work (although keeping the POTMC going became impractical after her move to Europe).

“I find many aspects of art and science are essentially the same,” says Zollinger. “Both artists and scientists seek ways to better understand and interpret the world around them. The creative part of me finds the same challenge and satisfaction in planning and conducting experiments as it does in creating visual art, and my training in art gives me an important advantage in designing innovative ways to test hypotheses in my research.”

Outside of the lab, Zollinger is developing projects that satisfy both her science and art backgrounds. She’s creating a series of paintings and drawings of birds from A-Z for a children’s book about bird diversity and behavior. She regularly organizes tours of local biological and zoological sites for the public. And, she is photographically and historically documenting medical “moulages” (wax models of pathologies and diseases) from the end of the 18th century through the mid-20th century. From an artist’s viewpoint, Zollinger finds the “moulages” fascinating. She notes, “They were created by very talented and highly skilled sculptors entirely for pedagogical use by doctors—never for public display.”

Although Zollinger no longer spends time uncovering bizarre or old-time pie recipes for the POTMC, it seems ironic that she now lives in a country where its language doesn’t have a word for pie. Germans call everything Kuchen (cake). Zollinger jokingly muses, “If we don’t get the next grant, maybe I’ll end up opening a pie shop here and try to teach Germans the difference between a pie and a cake.”



Preliminary sketch by Zollinger of a Slavonian Grebe for her birds from A-Z children’s book.



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INDIANA UNIVERSITY
College of Arts and Sciences
Bloomington

1001 East Third Street
Bloomington, IN 47405
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Visit <https://biology.indiana.edu/news-events/newsletters> to access the current issue with class notes and a few extras as well as past issues of IU Biology newsletters.

Contact information changed? Notify Kathy Wyss at kwyss@indiana.edu or 812-855-6195.

Update your record with the IU Alumni Association at <https://myiu.org/my-profile/alumni-directory>.

Indiana's newest plant species

A new entry has been added to the list of plant species known to occur in Indiana: *Caulophyllum giganteum*, commonly known as giant blue cohosh.

Spring wildflower enthusiasts throughout Indiana are familiar with its smaller and later blooming relative the common blue cohosh, *C. thalictroides*. Giant blue cohosh was previously thought to be restricted to the northeastern states and southeastern Canada.

Two hikers found a plant they were unable to identify last spring in Steuben County in northern Indiana. Photos and measurements taken suggested it was *C. giganteum*, but no specimen was collected for documentation.

On April 6, 2018, IU botanist Daniel Layton discovered the plant blooming in Martin County in southern Indiana. Having the proper permit, Layton collected a specimen. Paul Rothrock, IU Herbarium associate curator, confirmed the identification.

This discovery highlights the need for continuous monitoring of natural resources. As changing climate and other factors affect species distribution, both citizen and professional scientists are critical to keeping track of native flora and fauna.



Giant blue cohosh as encountered by Daniel Layton in Martin State Forest, Ind.

Photo by Daniel Layton