@NESCent

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Newsletter of the National Evolutionary Synthesis Center, an NSF-funded collaborative research center operated by Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University.

IN THIS ISSUE:

NEXT PROPOSAL DEADLINES:

NESCent has hosted nearly 5000 scientists from more than 50 countries. You could be one of them. We are now welcoming applications for the following:

April 1: short-term visitors

For more information, turn to page 6 or visit nescent.org/science/proposals.php

JORY WEINTRAUB WINS NORTH CAROLINA EDUCATOR AWARD

NESCent's Jory Weintraub has been recognized for his work coordinating NESCent outreach activities.

See page 6 for details.

RESEARCH HIGHLIGHTS

A NESCent working group has found that many plants acquired characteristics that helped them thrive in colder weather long before they first encountered freezing.

How plants evolved to cope with cold

Many were equipped for icy climates before cold conditions hit

Researchers have found new clues to how plants evolved to withstand wintry weather. In a study that appeared in the journal Nature, members of the NESCent working group 'Tempo and Mode of Plant Trait Evolution' constructed an evolutionary tree of more than 32,000 species of flowering plants—the largest time-scaled evolutionary tree to date. By combining their tree with freezing exposure records and leaf and stem data for thousands of species, the researchers were able to reconstruct how plants evolved to cope with cold as they spread across the globe. The results suggest that many plants acquired characteristics that helped them thrive in colder climates—such as dying back to the roots in winter—long before they first encountered freezing.

Fossil evidence and reconstructions of past climatic conditions suggest that early flowering plants lived in warm tropical environments, explained co-author Jeremy Beaulieu at the National Institute for Mathematical & Biological Synthesis (NIMBioS) at the University of Tennessee.

As plants spread to higher latitudes and elevations, they evolved in ways that helped them deal with cold conditions. Plants that live in the tundra, such as Arctic cinquefoil and three-toothed saxifrage, can withstand winter temperatures below minus 15 degrees Celsius.

Unlike animals, most plants can't move to es-

see COLD PLANTS, p 8

ABOUT NESCENT:

NESCent is a scientific research center dedicated to cross-disciplinary research in evolution. The center's mission is to promote the synthesis of information, concepts and knowledge to address significant, emerging, or novel questions in evolutionary science and its applications. NESCent achieves this by supporting research and education across disciplinary, institutional, geographic, and demographic boundaries.

NESCent is a collaborative partnership between Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University, and is funded by the National Science Foundation (award #EF-0905606). For more information about research and training opportunities at NESCent, visit **www.nescent.org.**

SENIOR LEADERSHIP:

Allen Rodrigo, Director

Susan Alberts
Associate Director
of Science and Synthesis

Todd Vision
Associate Director of
Informatics

Brian Wiegmann
Associate Director
of Education and Outreach

STAY INFORMED

Subscribe to the NESCent quarterly newsletter to receive news about the Center, research and training opportunities, and upcoming events. Comments, story ideas and photo contributions are welcome. Please send corrections and suggestions for future newsletters to Robin Smith at rsmith@nescent.org

To unsubscribe fill out our online form at bit.ly/qIuEWu. You can also visit NESCent on Twitter, Facebook, and YouTube.

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COMING SOON

Register for NESCent Academy 2014

If you are a grad student, postdoctoral fellow or junior faculty member, watch the NESCent website and Twitter feed as well as your favorite evolutionary biology news sources for information about registering for our next round of short courses through the NESCent Academy program. Each course is 1-2 weeks long, taught by experts in their fields, and includes lectures balanced by hands-on activities.

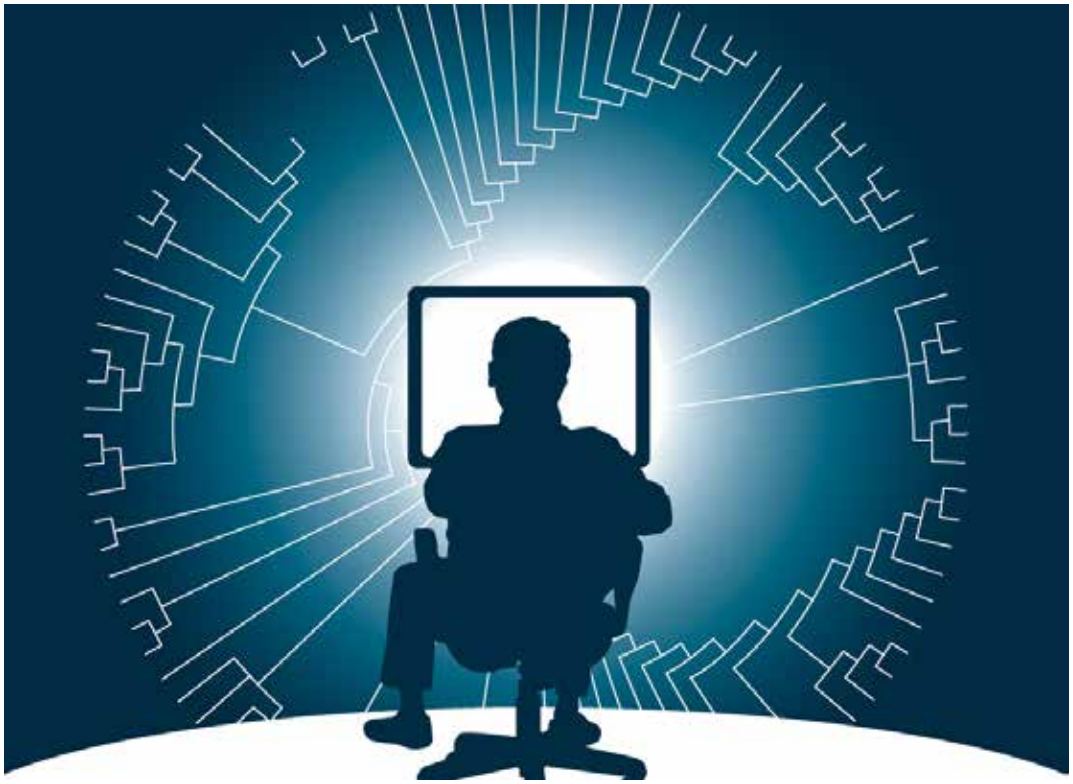
We are excited to announce the following short courses for 2014:

- Next-generation sequencing data for phylogenetics and phylogeography, July 14-19
- Paleobiological and phylogenetic approaches to macroevolution, July 22-29
- Phylogenetic analysis using RevBayes, August 25-31

For more information about instructors, dates, and how to apply, visit academy.nescent.org/wiki/Main_Page or contact Dr. Karen Cranston at karen.cranston@nescent.org.

RESEARCH HIGHLIGHTS

Participate in the 2014 Phyloinformatics Summer of Code program



Last summer for the seventh year in a row, NESCent offered a number of internships aimed at introducing students to open-source software development. Six interns from the 2013 Google Summer of Code™ program, and one from the GNOME Outreach Program for Women worked remotely under the guidance of an experienced mentor on an evoinformatics project of their own choosing.

Their projects ranged from machine learning for ecological genomics to phylogenetics in BioPython to visualization of evolutionary trees.

This summer you could be one of them. Learn how to participate in the 2014 Phyloinformatics Summer of Code program at informatics.nescent.org/wiki/Phyloinformatics_Summer_of_Code_2014.

Letter from the director

Registration opens in February for Evolution 2014! We hope to see you June 20-24 at the Raleigh Convention Center in the heart of North Carolina's capital city for five days of the latest developments in evolution research.

ALLEN RODRIGO

Join more than 1,400 of your friends and colleagues for a full slate of symposia, oral presentations, workshops, poster sessions and social events, including an opening reception, mixers with each evening poster session, and a "Super Social" at the North Carolina Museum of Natural Sciences on our last night.

Special symposia and addresses will include:

- Modern approaches to local adaptation (ASN Vice Presidential Symposium; organized by Michael Whitlock)
- Beyond reproductive isolation: micro-evolutionary controls on macroevolutionary speciation dynamics (ASN Solicited Symposium; organized by Daniel Rabosky & Daniel Matute)
- The "dark side" of phylogenetic comparative methods (SSB Symposium; organized by Natalie Cooper)
- Phylogenomics, transcriptomics, and the evolution of gene expression (SSB Symposium; organized by J. Chris Pires & Casey Dunn)
- The role of sexual selection in speciation: an integration of theoretical and empirical perspectives (SSE Symposium; organized by Rebecca Safran & Maria Servedio)
- Reuniting fossil and extant approaches to macroevolution (SSE Symposium; organized by Graham Slater, Samantha Price and Lars Schmitz)
- Seeing the forest for the trees: the contributions of synthesis to evolutionary science (SSE Symposium; organized by Todd Vision & Maria Servedio)
- Those interested in the intersection of biology, software and mathematics will also be able to participate in the 5th annual iEvoBio conference on evolutionary informatics.

In addition, there will be presidential addresses by Mohamed Noor of Duke University (SSE), Lacey Knowles of the University of Michigan (SSB) and Trevor Price of the University of Chicago (ASN).

As you plan your trip to North Carolina, consider signing up for one or more of the following field trips:

- Green Swamp/Lake Waccamaw/ Singletary Lake (Fri, June 20 - whole day): Explore three unique spots in the Southeastern Coastal Plain—an unexpected hotspot of biodiversity that is home to 6,170 native plant species and 1,133 vertebrates, including Venus flytraps, Hessel's hairstreak butterflies, mimic glass lizards, red-cockaded woodpeckers and more.
- Sylvan Heights Bird Park (Fri, June 20 - whole day): Visit the world's largest collection of captive waterfowl, with more than 2,000 ducks, geese, swans and other rare and endangered birds from around the world.
- Weymouth Woods (Wed, June 25 - half-day): Learn about the natural and cultural history of the longleaf pine forest, including plants and animals, the use of prescribed fires to maintain the forest, and past uses of longleaf pines as sources of tar, pitch and rosin for sailing vessels.
- Walking with Lemurs (Wed, June 25 - half-day): Go behind the scenes at the Duke Lemur Center, home to the largest collection of lemurs outside of Madagascar. Walk into parts of the Duke Forest where lemurs run free with no barriers between you and the animals. Watch ring-tailed lemurs run past your feet while Coquerel's sifaka lemurs—several of them with new infants on their tummies—leap from branch to branch overhead. It's an experience you can't have anywhere else in the U.S.

Also, for the fourth year in a row, attendees will also be able to view and vote on their favorite three-minute videos at the NESCent Evolution Film Festival. You don't need to attend the conference to enter. All videos submitted by May 31 are eligible to win. For more information visit filmfestival.nescent.org/.

Register by April 16, 2014 to take advantage of early bird rates. Hotel arrangements and campus housing reservations can be booked through the conference website at evolution2014.org/accommodations/.

Undergraduates, graduate students, postdocs and faculty are invited to apply for travel awards to attend the meeting. For eligibility and deadline info please visit evolution2014.org/travel-information/travel-awards/.

NESCent is pleased to coordinate this year's conference, in collaboration with scientists from Duke University, East Carolina University, North Carolina State University, the University of North Carolina at Chapel Hill, the University of North Carolina at Greensboro, and the North Carolina Museum of Natural Sciences.

Stay up-to-date on program details as they unfold by visiting evolution2014.org/, or by using the Twitter hashtag #Evol2014 for meeting-related tweets.

We look forward to meeting you at Raleigh, and learning about your research!

Dr. Allen Rodrigo
Director of NESCent

COMING SOON

Faculty at minority-serving institutions and undergrads are invited to apply for travel awards to attend Evolution 2014

Evolution 2014 to be held June 20-24 in Raleigh, NC

Faculty at minority-serving institutions (MSIs) are invited to apply for travel awards to attend Evolution 2014

Faculty from historically black colleges and universities or other institutions with significant enrollment of under-represented minority students are encouraged to apply. Funds are available to cover conference registration, travel, food and lodging for up to three individuals.

Sponsored by the National Evolutionary Synthesis Center (NESCent) and the Society for the Study of Evolution, the awards are intended to provide MSI faculty with an opportunity to present original research in evolution, systematic biology, evolutionary genomics/informatics, evolution education/outreach or other disciplines typically represented at the Evolution meeting. As such, your application must include a talk/poster title and abstract. In addition, you will be asked to provide a brief (1 page) statement describing how this award will contribute to your professional/scientific development, as well as provide benefit to your students and institution.

To apply, please fill out the online form at nescent.org/Evo2014facultyapp.

Deadline March 31, 2014. Awards will be announced by April 4, 2014.

For more information, please contact Dr. Jory Weintraub at jory@nescent.org.

Current and recently-graduated undergraduates from throughout the US and Puerto Rico are invited to apply for travel awards to attend Evolution 2014

For the twelfth year in a row, the Undergraduate Diversity at Evolution program will send a talented and diverse group of students to the meeting to present posters of their own research, interact with mentors, and attend a career-development panel and discussion.

The awards cover the costs of travel, registration, food and accommodation at the meeting. Funds are available to offer awards to up to 25 students.

Applications are welcomed from all undergraduates – the goal is to create a diverse pool of students. For more eligibility information, and to apply, please visit www.nescent.org/eog/undergraddiversity

Deadline Monday April 14, 2014. Awards will be announced by April 21, 2014.

For more information please contact one of the organizers:

Jory Weintraub (jory@nescent.org)

Scott V. Edwards (sedwards@fas.harvard.edu)

Richard Kliman (rmkliman@cedarcrest.edu)

Ensuring access to digital data over the long term

Growing numbers of researchers are making the data associated with their publications available for research and educational use—and receiving credit for it—with help from digital repositories like Dryad, a curated general-purpose repository for scientific and medical data.

Developing the Dryad Digital Repository has been a major focus of NESCent's informatics program since 2009, and usage has continued to grow each year since then. Twelve new journals integrated article submission with Dryad data submission in 2013. As of January 2014, the repository contained more than 4,600 data packages associated with articles in over 290 different journals.

Now, two new developments will help make sure that this content will be accessed and put to good use for many years to come:

First, Dryad has agreed to share data, infrastructure, and expertise with a digital data network called the Data Observation Network for Earth, or DataONE.

Supported by NSF, DataONE provides long-term access to environmental and Earth science data from many different sources, including long-term ecological research stations, remote sensing observatories at government labs, citizen science projects, as well as from a variety of institutional and disciplinary data repositories like Dryad.

While individual data centers contribute the expertise and infrastructure to build and manage their own holdings, DataONE enables scientists around the world to easily discover the data wherever it resides, and to preserve it for the long-term by replication among nodes in the network.

Dryad joining DataONE means that anyone who browses the DataONE interface will be able to find a replica of Dryad's data holdings as well. Should Dryad cease operations at some point in the future, all existing content would still be available.

As additional assurance of long-term availability, the Dryad Digital Repository has also joined the CLOCKSS network (clocks.org), a not-for-profit organization that manages a long-term, distributed dark archive for web-based scholarly publications. Should content no longer be available from Dryad or one of its other member publishers, CLOCKSS provides insurance that the content will continue to be freely and legally available for reuse.

Submit your best evolution-themed video for screening at this year's Evolution meeting

Scientists of all stripes—graduate students, postdoctoral fellows and faculty—are invited to enter the fourth annual NESCent Evolution Video Competition. To enter, please submit a video that explains a fun fact, key concept, compelling question, or exciting area of evolution research in THREE MINUTES OR LESS.

Entries may be related or unrelated to your own research, and should be suitable for use in a classroom (K-12, undergraduate, graduate... your choice). Videos should be both informative and entertaining. (In other words, no taped lectures or narrated Powerpoint presentations!) Animations, music videos, and mini documentaries are all fair game.

The finalists will be screened at the Evolution 2014 conference in Raleigh, NC.

To enter your video, please visit filmfestival.nescent.org/.

A winner from the 2013 Evolution Video Competition.

PUBLICATIONS

Recent publications by NESCent authors

Barber, P., et al. (2014). "Advancing biodiversity research in developing countries: the need for changing paradigms." *Bulletin of Marine Science* 90.

Beger, M., et al. (2014). "Evolving coral reef conservation with genetic information." *Bulletin of Marine Science* 90.

Botero, C., et al. (2013). "Environmental harshness is positively correlated with intraspecific divergence in mammals and birds." *Molecular Ecology*.

Bowen, B., et al. (2014). "Phylogeography unplugged: comparative surveys in the genomic era." *Bulletin of Marine Science* 90.

Cornwell, W., et al. (2014). "Functional distinctiveness of major plant lineages." *Journal of Ecology*.

Govindaraju, D., et al. (2013). "A systems analysis of age-related changes in some cardiac aging traits." *Biogerontology*.

Groover, A. and Q. Cronk (2013). "From Nehemiah Grew to genomics: the emerging field of evo-devo research for woody plants." *International Journal of Plant Sciences* 174(7): 959-963.

Keyse, J., et al. (2014). "The scope of published population genetic data for Indo-Pacific marine fauna and future research opportunities in the region." *Bulletin of Marine Science* 90.

Lundgrin, E., et al. (2013). "Plasma hepcidin of Ethiopian highlanders with steady-state hypoxia." *Blood* 122(11): 1989-1991

Martin, J., et al. (2013). "Removing the entropy from the definition of entropy: clarifying the relationship between evolution, entropy and the 2nd law of thermodynamics." *Evolution: Education and Outreach* 6(30).

Midford, P., et al. (2013). "The Vertebrate Taxonomy Ontology: A framework for reasoning across model organism and species phenotypes." *Journal of Biomedical Semantics* 4(34).

Murren, C., et al. (20). "Evolutionary change in continuous reaction norms." *American Naturalist* In press.

Panahiazar, M., et al. (2013). "Advancing data reuse in phyloinformatics using an ontology-driven Semantic Web approach." *BMC Medical Genomics* 6(S5).

Perez, K., et al. (2013). "The EvoDevoCI: A concept inventory for gauging students' understanding of evolutionary developmental biology." *CBE—Life Sciences Education* 12: 665-675.

Piwowar, H. and T. Vision (2013). "Data reuse and the open data citation advantage." *PeerJ* 1(e175).

Shifman, A., et al. (2013). "Phylo SI: a new genome-wide approach for prokaryotic phylogeny." *Nucleic Acids Research*.

Smith, N. A. and J. A. Clarke (2013). "Osteological histology of the Pan-Alcidae (Aves, Charadriiformes): correlates of wing-propelled diving and flightlessness." *The Anatomical Record*.

Van Cleve, J. and L. Lehmann (2013). "Stochastic stability and the evolution of coordination in spatially structured populations." *Theoretical Population Biology*.

von der Heyden, S., et al. (2014). "The application of genetics to marine management and conservation: examples from the Indo-Pacific." *Bulletin of Marine Science* 90.

Wagner, A., et al. (2013). "Computational evaluation of cellular metabolic costs successfully predicts genes whose expression is deleterious." *PNAS* 110(47): 19166-19171.

Willette, D., et al. (2014). "So, you want to use next-generation sequencing in marine systems? Insight from the Pan-Pacific Advanced Studies Institute." *Bulletin of Marine Science* 90.

Zanne, A., et al. (2013). "Three keys to the radiation of angiosperms into freezing environments." *Nature*.

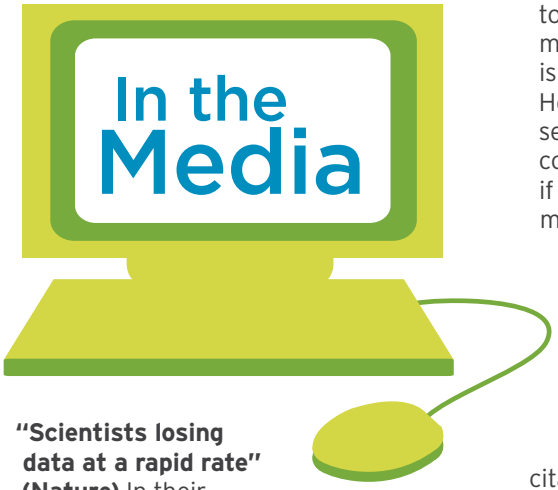
Jory Weintraub wins NC Educator Award

Please join us in congratulating Jory Weintraub for being selected as the Outstanding NC Informal Educator in Science, Mathematics, and Technology Education!

This award recognizes a North Carolina informal educator who excels in engaging young people in science, mathematics, and technology activities and experiences and is presented by the N.C. Science, Mathematics, and Technology Education Center's (NC SMT) Board of Directors.

This is certainly a distinguished and well-deserved honor for Jory and is in recognition of his success in coordinating our NESCent Education and Outreach activities.

Way to go, Jory!!



"Scientists losing data at a rapid rate" (Nature) In their parents' attic, in boxes in the garage, or stored on now-defunct floppy disks—these are just some of the inaccessible places in which scientists have admitted to keeping their old research data. Such practices mean that data are being lost to science at a rapid rate—so much so that 80% of data are unavailable after 20 years, finds a new study in Current Biology. Read the full story at bit.ly/1frMXOR, or find out what digital data repositories like Dryad are doing to ensure data access over the long term on page 4.

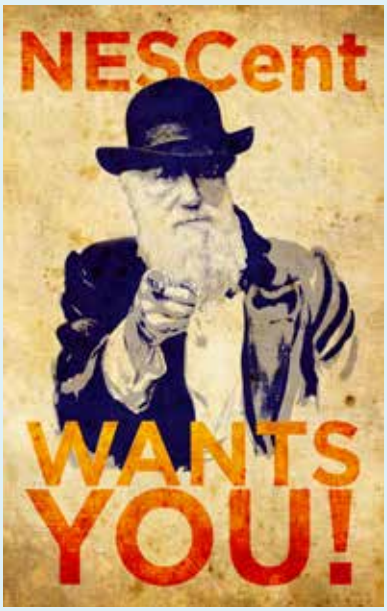
"A safety net for scientific data" (American Scientist) Online data archives like Dryad bolster confidence in science and provide a springboard for future scientists. Whose responsibility is it to curate aging data sets? Read more at bit.ly/1e3PgG3.

"Data-sharing: Everything on display" (Nature) A number of early-career researchers are enthusiastically posting their work online. Although exhortations to share data often concentrate on the moral advantages of sharing, the practice is not purely altruistic. NESCent scientist Heather Piwowar has found that researchers can get visibility and connections by putting their data online—if they go about it in the right way. Learn more about the latest trends in data-sharing at bit.ly/L3sPbd.

"Scientists who share data publicly receive more citations" (Eurekalert) A new study finds that papers with data shared in public gene expression archives received increased numbers of citations for at least five years. The large size of the study allowed the researchers to exclude confounding factors that have plagued prior studies of the effect and to spot a trend of increasing dataset reuse over time. The findings will be important in persuading scientists that they can benefit directly from publicly sharing their data, says author and recent NESCent postdoc Heather Piwowar. Learn more at bit.ly/15I8RqH.

"Should we ditch journal impact factor?" (Science Magazine) The journal impact factor was designed to help librarians decide which journals to subscribe to and was never intended as a measuring stick for the value of a scientist's research, as it is sometimes used today. Now, there has been a push to reexamine the importance that tenure committees and journal reviewers assign to journal impact factors. NESCent's Heather Piwowar, an expert in bibliometric factors and credit attribution, participated in this live chat about the impact factor and possible alternatives. Watch a video of their discussion at bit.ly/1fi9qyE.

COMING SOON



Apply to be a short-term visitor at NESCent

Deadline April 1

We are currently accepting proposals from short-term visitors to work on a project of their own choosing for 2 weeks to 3 months. The next deadline for short-term visitors is April 1.

Please note that we have suspended calls for applications for our other fellowship programs—graduate fellowships, postdoctoral and sabbatical fellowships, and working groups and catalysis meetings—until we know what our financial future is beyond December 2014, when our core funding from the National Science Foundation comes to an end. In the meantime, we have been working with funding agencies, foundations and corporations, and our partner institutions to figure out how we can keep our activities going. We also expect a lively continuation of ongoing and recently-awarded projects.

For more information and examples of recently-funded short-term visitor projects, please visit nescent.org/science/short_term_visitors.php , or contact Dr. Allen Rodrigo (a.rodrigo@nescent.org).

AWARDS

Congratulations to the newest award recipients for 2014

SHORT-TERM VISITORS

Yaniv Brandvain (University of California, Davis) *Does mother-fetus coevolution lead to coadaptation?*

Sarah Rolfes (TiHo Hannover, ITZ) *Evolution of the p53-network in Placozoa*

Erica Tennenhouse (University of Toronto) *Heritability of body mass in sexually monomorphic animals*

Francisco Ubeda (University of London) *Does mother-fetus coevolution lead to coadaptation?*

SABBATICAL SCHOLARS

Susan Kalisz (University of Pittsburgh) *Shedding new light on Baker's law through synthesis*

Alexander Weiss (University of Edinburgh) *The personalities and life histories of the Gombe chimpanzees*

CATALYSIS MEETINGS

Sally Archibald (University of the Witwatersrand) *The co-evolution of plants and fire and consequences for the Earth system*

Caren Cooper (Cornell University) *Anthropogenic sensory stimuli as drivers of evolution: a conceptual synthesis and roadmap for the integrated citizen-science research network*

Benjamin Dainat (Swiss Bee Research Centre) *BeeBiome: Omic approaches for understanding bee-microbe relationships*

Marymegan Daly (Ohio State University) *Integrating organismal and applied perspectives on animal venom diversity*

Michael Whitlock (University of British Columbia) *SimBank: Planning population genetic simulations to test statistical genetics software*

For more information about these scholars and their research projects, please visit **nescent.org/science/awards.php**.

COMING SOON

Celebrate Darwin Day 2014 at the NC Museum of Natural Sciences

When: February 15, 9am-5pm, FREE
Where: North Carolina Museum of Natural Sciences, Raleigh

If you're in central North Carolina and you're interested in evolution, the place to be on Saturday, February 15th is the North Carolina Museum of Natural Sciences in downtown Raleigh. Once again, NESCent is partnering with the museum to co-organize a day-long celebration of Charles Darwin and evolution. From 9:00 AM to 5:00 PM, the museum will open its doors (free of charge) and feature hands-on activities, booths, tables and stations designed to engage and inform the public about what evolution is and how it is relevant to all of us, and the many contributions Darwin made to our understanding of the field.

That afternoon, the keynote speaker will be Dr. Ed Scholes, an evolutionary biologist and ornithologist with the Cornell University Laboratory of Ornithology. Ed is one of the key players in the Cornell Lab of Ornithology's Birds of Paradise project, and his participation in the Darwin Day event is timed to compliment the museum's temporary Birds of Paradise traveling exhibit, which runs through March of 2014. He will be sharing fascinating stories of his work in the rainforests of Papua, New Guinea studying the brilliant plumage and dazzling courtship displays of these incredible birds, and what they teach us about sexual selection and macroevolution.

The museum expects to attract more than 3,000 visitors to this year's event, which marks its fifth annual NESCent co-sponsored Darwin Day. So, if you're looking to celebrate Charles Darwin's 205th birthday on February 15th, 2014, come to the NC Museum of Natural Sciences and check out all the fun. For more information, visit naturalsciences.org.

COMING SOON

NESCent hits the road for Darwin Day 2014

What: Darwin Day Roadshow
When: February 2014
Where: Coming to a state near you

Every year on Feb. 12th, the world throws Charles Darwin a birthday party and celebrates the contributions he made to our understanding of evolution. NESCent celebrates by taking Darwin Day on the road and sending our scientists around the country to talk about their work in a program we call the "Darwin Day Roadshow."

The goal of the Darwin Day Roadshow is to promote an awareness of, and appreciation for, evolutionary science, by bringing NESCent scientists into classrooms and town halls all around the country. Our scientists talk to students about their own research, as well as the rewards and challenges of pursuing careers in science, and describe a typical day in the life of an evolutionary scientist. The focus is on smaller, more rural communities not typically served by universities, museums, or other institutions, as well as communities with high numbers of under-represented minority students.

This year, we received over 70 applications, from 23 different states (from California to Maine). We selected schools in Alabama, Arizona, Massachusetts, Michigan, North Carolina, Pennsylvania and Rhode Island. The educators at these schools will act as local hosts, helping us organize events in their classrooms and in the surrounding community. In return, they will receive a collection of books, videos, and other resources to enhance the teaching of evolution in their classrooms. Several of the Michigan visits will be led by Dr. Louise Mead, our friend and colleague at the Michigan State University-based BEACON Center for the Study of Evolution in Action. We are excited to be partnering with BEACON on the Roadshow for the first time this year.

To learn more about the Roadshow, and to see pictures and stories from last year, visit roadshow.nescent.org.

COLD PLANTS, continued

cape the cold or generate heat to keep them warm. It's not so much the cold but the ice that poses problems for plants. For instance, freezing and thawing cause air bubbles to form in the plant's internal water transport system.

"Think about the air bubbles you see suspended in the ice cubes," said co-author Amy Zanne of the George Washington University. "If enough of these air bubbles come together as water thaws they can block the flow of water from the roots to the leaves and kill the plant."

The researchers identified three traits that help plants get around these problems.

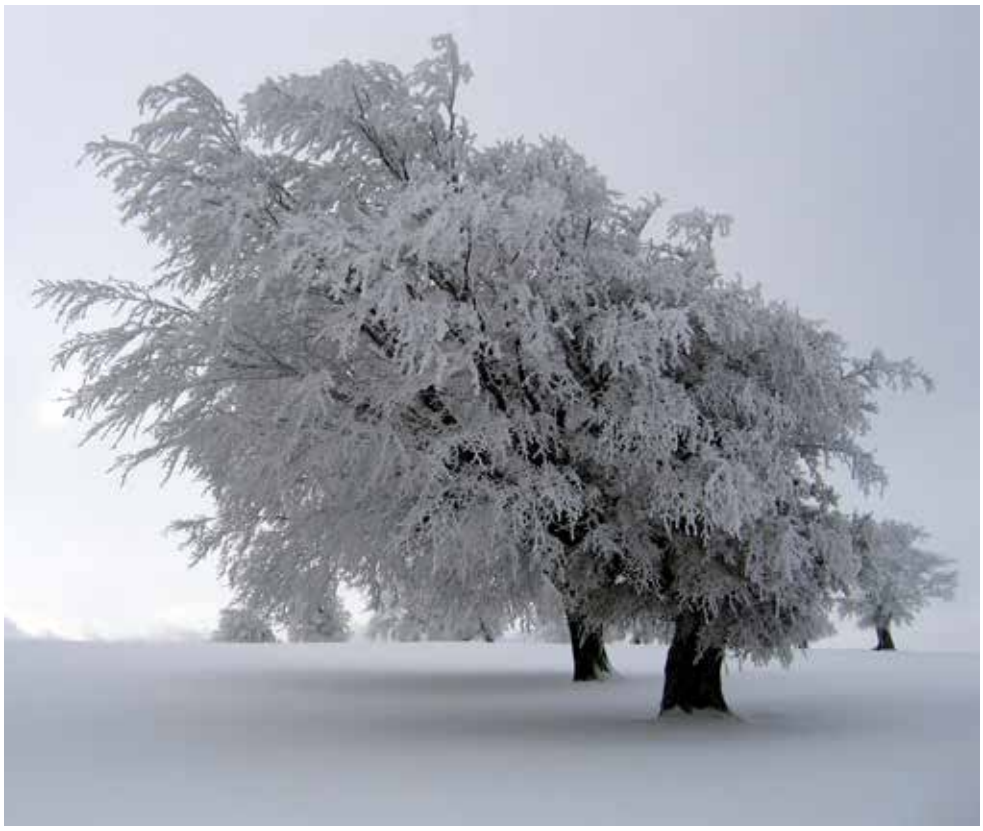
Some plants, such as hickories and oaks, avoid freezing damage by dropping their leaves before the winter chill sets in—effectively shutting off the flow of water between roots and leaves—and growing new leaves and water transport cells when warmer weather returns.

"The earliest angiosperms are believed to have been woody evergreen trees in warm tropical environments. As angiosperms radiated into freezing environments, a number of traits, including deciduous leaf phenologies, small vascular conduits and/or herbaceous habits, likely facilitated their success in the cold."

—Amy Zanne,
George Washington University"

Other plants, such as birches and poplars, also protect themselves by having narrower water transport cells, which makes the parts of the plant that deliver water less susceptible to blockage during freezing and thawing.

Still others die back to the ground in winter and re-sprout from their roots, or start growing as new plants from seeds when conditions are right.



Unlike animals, plants can't move to escape the cold, or generate heat to keep them warm. Plants evolved a variety of mechanisms to cope with the effects of freezing temperatures.

To compile the plant trait data for their study, the researchers spent hundreds of hours scouring and merging multiple large plant databases containing tens of thousands of species, largely with support from NESCent and Macquarie University in Australia.

When they mapped their collected leaf and stem data onto their evolutionary tree for flowering plants, they found that many plants were well equipped for icy climates even before cold conditions hit.

Plants that die back to the ground in winter, for example, acquired the ability to die and come back when conditions improve long before they first experienced freezing. Similarly, species with narrow water transport cells acquired a finer circulatory system well before they confronted cold climates.

"This suggests that some other environmental pressure—possibly drought—caused these plants to evolve this way, and it happened to work really well for freezing tolerance too," said Zanne.

The only exceptions were plants that shed and replace their leaves seasonally—these plant groups didn't gain the ability to drop their leaves during winter until after they encountered freezing, Beaulieu added.

As a next step, the researchers plan to use their evolutionary tree to find out how plants evolved to withstand other environmental stresses in addition to freezing, such as drought and heat.

The tree, data and source code are freely available online in the Dryad digital repository at http://dx.doi.org/10.5061/dryad.63q27 and in the TRY plant trait database at http://www.try-db.org. You can also view and explore the tree at www.onezoom.org/vascularplants_tank2013nature.htm. ●

CITATION: Zanne, A., et al. (2013). "Three keys to the radiation of angiosperms into freezing environments." *Nature*.