The Ascent of NESCent

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The National Evolutionary Synthesis Center (NESCent), in Durham, North Carolina, was established in December 2004 to foster synthetic, collaborative, cross-disciplinary studies in evolutionary biology. The center sponsors scientific catalysis meetings to stimulate new approaches to research and working groups for in-depth investigations of particular topics. NESCent also offers faculty sabbaticals and postdoctoral fellowships, as well as education and outreach opportunities.

The old Erwin Cotton Mills building in Durham, North Carolina, was once the most prominent landmark of a bustling factory town. Today, the brick structure that remains houses office space and blends into an eclectic university community bordering the Duke University campus.

Inside a south entrance and up a flight of stairs, carpets cover former factory floors. Computers and conference rooms have displaced spindles and looms. Only a few nicks and knocks in the woodwork betray the building's early rough use. Today's occupants—the faculty and staff of the National Evolutionary Synthesis Center (NESCent)—labor to weave research remnants into a new fabric of understanding.

The programmers and biologists who attended a five-day "phyloinformatics hackathon" stand outside the old Erwin Cotton Mills building, now home to NESCent. Photograph: Courtesy of NESCent.

Encouraging "a grand synthesis"

Just over two years ago, the National Science Foundation (NSF) established NESCent, granting $15 million over five years to foster and encourage what it termed "a grand synthesis of the biological disciplines through the unifying principle of descent with modification." The intent: Do for evolutionary biology what on another coast has been accomplished for ecology by the National Center for Ecological Analysis and Synthesis (NCEAS), widely regarded as a successful model for fostering synthesis research. The NSF renewed funding for NCEAS in September 2006.

Like NCEAS, which is located at the University of California–Santa Barbara, NESCent represents a collaborative effort, drawing on the interdisciplinary expertise of more than 90 faculty members from the three universities that make up the Research Triangle: Duke, North Carolina State, and the University of North Carolina–Chapel Hill (UNC). And, as with NCEAS, the "synthesis" in NESCent's name goes beyond simple

collaboration. The center sponsors two kinds of collaborative meetings: scientific "catalysis" meetings intended to stimulate ideas for new research areas and methodologies—a sort of brainstorming session—and "working groups," which offer multiday opportunities for more in-depth investigation of a particular area. NESCent also offers faculty sabbaticals and postdoctoral fellowships.

The center is open to other approaches, as well. In December, NESCent hosted a five-day "phyloinformatics hackathon," challenging a group of more than 20 programmers and biologists to collaborate to write new phylogenetic analysis software. The results will be made freely available to the evolutionary biology community.

The scientific community may not at first have been entirely sure what NESCent was about, but it greeted the new center enthusiastically, says Joel Kingsolver, associate director of Science and Synthesis at NESCent. "We were amazed that we got 65 proposals in the first month for all kinds of activities, way more than we could fund." Since then, proposals have become more refined as NESCent has established its purpose. "So far we've been really impressed at the things we've seen that people have sent us."

Faculty members are currently tackling topics ranging from introducing evolution to elementary students to finding new and meaningful ways to graphically represent previously collected genetic data—using GIS (geographic information system) technology originally used to map city water mains. "The diversity of topics that come to NESCent is tremendous," says NESCent director Kathleen Smith. "It's not a surprise but, I think, a real affirmation of the vision."

Establishing communications

In a front conference room, sun streaming through orange leaves lends a dappled, autumn light to a conversation that might otherwise easily leave newcomers in the dark. The working group, "Towards an Integrated Database for Fish Evolution," will have this room for three days, during which the dozen or so participants will mostly discuss how to best define the term "homologous to" as it relates to the database they envision. For anyone just dropping in, it's dense stuff.

Kathleen Smith (top), director of NESCent, divides her time between NESCent and her duties as a professor in the departments of biology and biological anthropology and anatomy at Duke University. Her lab maintains a breeding colony of gray short-tailed opossums. Joel Kingsolver (bottom) is a biology professor at the University of North Carolina–Chapel Hill and associate director of NESCent. Photographs: Sonya Senkowsky.

Actually, even for a roomful of evolutionary and developmental biologists, the topic is a challenge, say working group leaders Monte Westerfield and Paula Mabee. Their entire first session at NESCent involved what Mabee calls an "ontology boot camp," learning the importance of finding a shared language to help two different disciplines combine and make sense of one another's data. "The first goal Monte and I had was to just simply establish communication between the zebrafish people—model organism people—and the ichthyological group of us," says Mabee.

The two researchers joined forces at NESCent because they believe evolutionary biologists will benefit from the same information developmental biologists are collecting, and vice versa. The group proposes to join databases to combine the genetic information collected from developmental biology research—particularly information on mutations—with the morphological data from evolutionary biology.

Fall colors are evident outside the window as the working group, "Towards an Integrated Database for Fish Evolution," meets inside one of NESCent's conference rooms (top). From the left are Chris Mungall, Melissa Haendel, and Erik Hilton. Working group coleaders (bottom) Paula Mabee, professor of biology at the University of South Dakota, and John Lundberg, of the Academy of Natural Sciences in Philadelphia, enjoy a session of the working group. Photographs: Sonya Senkowsky.

Evolutionary biologist Mabee, a biology professor at the University of South Dakota, studies zebrafish, prehistoric-looking paddlefish, and their relatives. Neurobiologist Westerfield, a biology professor at the University of Oregon In-

Duke University bioinformatician Hilmar Lapp (standing) gives a presentation to the fish working group, including leaders Monte Westerfield, behind Lapp, and Paula Mabee, at far left. From the back of the conference table, left to right, are participants Rick Mayden, Gloria Arratia, Miles Coburn, Nelson Rios, and Brian Sidlauskas. Partially obscured, at the back of the room, is education and outreach program manager Kristin Jenkins. Photograph: Sonya Senkowsky.

stitute of Neuroscience, also studies zebrafish, but with a different purpose. While Mabee seeks to answer evolutionary questions such as how joints in fish fins came to be, Westerfield, director of the Zebrafish Information Network (ZFIN) database, is interested in zebrafish as "model organisms" to help him understand the genetic mechanisms affecting normal development and disease in humans.

"Getting at that kind of information is just extremely hard," explains Mabee. "The amount that's being learned using these models is tremendous, but it's not been accessible to the evolutionary community. By using ontologies and developing an evolutionary database and connecting it to a zebrafish database, which is very well developed, we'll be able to make those kinds of connections." But the process is neither simple nor fast. Before data from the different disciplines may be combined, both sides must agree not only on the kinds of information they need to collect, but on how to best standardize data so that the database will be accurate as well as useful.

NESCent director Kathleen Smith points to the working group as a model for future projects. "Any kind of database that's going to do evolutionary phylogenetic questions has to get to grips with things like ontologies—with complex descriptions of anatomically very variable data and issues of homology."

They're helped on their journey by informatics professionals, such as Chris Mungall of ZFIN. "Ontologies are vital to data integration," says Mungall. "Now, in biology and biomedicine, we have this huge quantity of data being generated. Really, this all relates to the sphere of evolutionary biology, and we want to integrate this data somehow, but it's all a complete nightmare."

This working group brought its own informatics experts, but NESCent also has a three-person informatics staff available to support large-scale collaboration. Such support is an element that is entwined with the center's scientific endeavors, according to Todd Vision, associate director of informatics, from UNC's Carolina Center for Genome Sciences, who has a background in comparative genomics and computational biology. "We're not sitting on top of a supercomputing facility ourselves," explains Vision. Instead, the informatics group specializes in helping working group postdocs and fellows identify problems that need to be addressed before creating the appropriate database solutions. In addition to supporting NESCent's in-house scientific program, the informatics team considers itself a resource for the wider evolutionary biology community. "We partner with various groups to meet needs they spot."

Contrary to early notions that NESCent's main role would be to provide a computing infrastructure, Smith says, the informatics group is now finding it is most flexible and useful as a human resource. "I think the model or the notion that a megadatabase could be constructed by some entity, even if we had an order of magnitude larger staff than we have, is really a false one, because it wouldn't be scientifically useful," she says. What's more useful is to make informatics know-how and staff available for initiatives involving developing ontologies, data sharing, and working with metadata repositories.

Smith envisions NESCent will ultimately host 400 to 500 scientists per year, putting itself in a position to influence the culture of evolutionary biology data submittal, sharing, and storage. She also plans to invite reviewers and editors from evolutionary biology journals located in the Research Triangle area to join in that conversation. "If we have a culture where we've established ways that people can submit their data, and it would end up being an accepted part of evolutionary biology that when you publish a paper, you make this data accessible to the community, I think that would be a pretty important contribution," says Smith.

Postdocs and fellows: Enriching the experience

A NESCent postdoctoral fellowship is more self-directed than the usual postdoc experience, says Jory Weintraub, one of NESCent's two education and outreach program managers. "The key to being successful here is being really self-motivated," Weintraub says. "You're not working directly for an adviser, you're not in a lab." The experience may not be for everybody, he says, but "I fully expect to see our postdocs go on to be as successful as the NCEAS postdocs."

NESCent currently has 15 postdoctoral fellows and 8 sabbatical faculty on site. As the postdoc population has increased, so has the quality of the interactions and program, says Smith. "A good

What Happens at NESCent

Catalysis meetings

These one-time meetings bring together about 30 scientists from diverse disciplines to focus on a major question or research area in evolutionary biology. These meetings are intended to identify avenues for scientific synthesis and classes of primary data that must be collected before grand-scale synthesis is possible. The goal: to increase the scale and ambition of the community's scientific vision. (Think of them as brainstorming sessions.)

Example: Historical perspectives on the distribution of biodiversity in Madagascar

For five days last June, Anne Yoder and Claire Kremen brought together a group of 34 scientists to address three questions related to biodiversity and conservation in Madagascar. The scientists shared information through presentations on their work and met in breakout sessions to design future projects based on the information gathered at the meeting. Questions included determining the sequence of arrival for various groups of organisms, and the impacts of geography and climate—as well as how answering evolutionary biology questions might help set the stage for establishing sound conservation priorities.

Working groups

Working groups involve small groups of about a dozen scientists collaborating intensively on the analysis or synthesis of data and models to address a major question in evolutionary biology. The working groups typically meet three to four times over two years, with each meeting lasting three to seven days. These are nuts-and-bolts meetings.

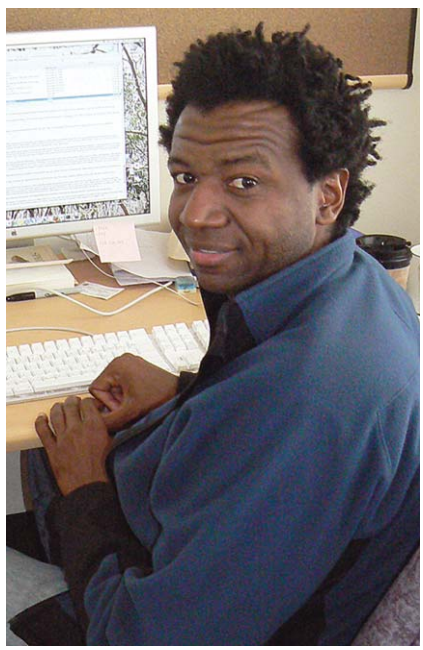
Example: Evolutionary ecology of primate life histories (awarded for 2007)

Researchers from the University of Wisconsin–Madison, Duke University, and State University of New York–Stony Brook will use unique, individual-based life history data collected from wild populations by nine working group participants over nearly 20 years. Their main purpose is to develop age-specific mortality and fertility schedules and create population projection matrices for each species. The immediate goal is to test current hypotheses about the evolution of life histories to advance understanding of primate evolution. The group's long-term goal is to move toward a collaborative, shared data bank allowing analyses of irreplaceable life history data on wild primates.

part of the problem is that evolutionary biology is so broad that you can have six people with very little overlap in terms of what they're doing on a day to day level. By the time you have 15 or 16, there's more overlap."

NESCent postdoctoral fellow Joe Hereford, who completed his PhD at Florida State University, has been at NESCent since September 2005, working on a multispecies meta-analysis to answer questions such as what types of traits might make organisms more or less locally adapted. The data set he's generated so far, collected from previous research conducted by others, includes plants, animals, fungi, and a couple of protists. In many ways, creating such synthesis research is like writing a review paper, he acknowledges. Or the tools, at least, are similar.

"All I need is a printer, a light, and a library," says Hereford. Beyond those basics, he adds, NESCent provides an atmosphere largely free of outside responsibilities or academic bureaucracy, "so you can just do research here, anytime you want." He appreciates having Duke faculty and facilities nearby, as well as the opportunity to drop in on working groups related to his study area.



NESCent postdoctoral fellow Joe Hereford is conducting a multispecies meta-analysis to quantify differences in local adaptations by different populations. He appreciates having Duke faculty and facilities nearby, as well as the option to drop in on working groups related to his study area. Photograph: Sonya Senkowsky.

David Kidd, another postdoctoral fellow, once worked mapping water mains in Scotland. He now applies the same technology to developing information system tools and databases for evolutionary science. But not all work here requires synthesis research or even computer databases.

As a triangle sabbatical scholar, Maria Servedio, one of eight sabbatical fellows currently at NESCent, benefits from discussing her work with peers in evolutionary biology and getting some time away from routine teaching duties. Servedio splits her time between NESCent and UNC for a welcome opportunity to set aside obligations, such as a spring evolution class she teaches, in favor of research into male mate choice in sexual selection evolutionary theory. (Although there is a well-established literature for female mate choice, male mate choice has been less explored.)

Also on sabbatical, Joseph Fail Jr., an associate professor with the department of natural sciences at historically black Johnson C. Smith University in Charlotte, North Carolina, came to NESCent

Triangle sabbatical scholar Maria Servedio, of the University of North Carolina, says one of the best things about NESCent is the opportunity get feedback from other sabbatical scholars. Her work at the center doesn't involve synthesis but is likely to lead to future collaboration, she says. Photograph: Sonya Senkowsky.

to build on his idea of creating an elementary school evolution curriculum. He has modified his approach and now wants to develop a primer that smoothly (and unthreateningly, he says) integrates evolution into the biology curriculum.

He has ventured into uncharted territory before. Though many historically black schools don't teach the subject, Fail designed an evolution class at Johnson C. Smith. His participation in NESCent is part of the Center's Evolution Education at Historically Minority Universities working group. "I don't want to make a big deal of evolution," says Fail. "I just want it to be part of the general curriculum, nothing special. Think of it. That's the way Darwin would want it: Nothing special. It is a part of biology and needs to be taught."

Fail has also used his time at NESCent, in part, to prod researchers to reconsider how they communicate their often arcane research. He believes scientists share blame for not communicating and teaching evolution well at the most basic levels. Explain it so a fourth grader could understand it, he tells his NESCent colleagues. Without such simplicity, he fears, the complex synthesis taking place here will be greeted unenthusiastically by a future public that can't understand it. "I'm surrounded by people who talk to themselves," he says. "I tell them, you can't use jargon with me; stop, go back. And they're happy to do it."

At the doorway of his sabbatical office at NESCent, Joseph Fail Jr. shows some examples of how young students he's worked with have interpreted concepts of evolution. Fail, an associate professor with the department of natural sciences at Johnson C. Smith University, wants to create an elementary school evolution primer or curriculum. His participation is part of the Evolution Education at Historically Minority Universities working group. Photograph: Sonya Senkowsky.

Education and outreach

At the back of the conference room, quietly watching and taking notes, sits Education and Outreach Program Manager Kristin Jenkins. At the end of each working group or catalysis meeting, she posts a summary to the Education and Outreach section of the NESCent Web site (*www.nescent.org/*). She is also available to consult on other ideas for education and outreach opportunities.

The main goal of the center's education and outreach program is to highlight specific research taking place within and to make it more visible, says Weintraub. That can be a tall order. "Because this is a really novel concept, this synthesis research, it is a challenge sharing what that means to the public," he says. "It is a challenge to explain, even to the scientific community, what synthesis research is."

However, good outreach is becoming increasingly important, says Jenkins. "It may be the difference between getting and not getting a grant if two really great [proposals] come through."

The NESCent outreach team assists groups and individuals working with NESCent with development of broader-impact activities and dissemination of research within the scientific community and to the general public, as well. The education and outreach program also provides a professional development series to assist postdoctoral students in developing and strengthening their own teaching and outreach skills.

This year, NESCent's education and outreach activities included providing support for a day-long evolution symposium at the National Association of Biology Teachers annual meeting, co-organized with the American Institute of Biological Sciences. They also created and distributed a CD of curriculum and video resources for teachers and have developed a Web site with teacher resources. There is a visiting lecturer series for classrooms. NESCent researchers may also take advantage of videoconferencing facilities or ask to have specific resources and curricula disseminated through the

NESCent site. Jenkins and Weintraub are building a broader-impacts database to help researchers find outreach opportunities that may save time by employing existing infrastructure and resources—leaving the researchers only the job of communicating their work.

One element notably missing is public advocacy for evolutionary theory. Though many people ask about whether the center will take such a role, or expect it to do so, a more appropriate outlet for the center's outreach, says Smith, is a focus on communicating applied science, such as the science of bird flu. "I think it's one very good strategy to take in terms of talking about evolution but not being as threatening in this current political environment," says Smith, "because you can be matter-of-fact about bird flu and agricultural pests, things like that, also evolutionary medicine....Whereas environmental policy is politically charged, it's not as politically charged as evolution."

As NESCent matures, it is itself likely to continue evolving, says Smith. "I'd like to feel more confident that the range of opportunities we're providing to the community is the right range," she says. "I don't know if rather than just having sabbatical scholars for 6 to 12 months, if we could figure out some way to have second or more short visits. Or maybe we should be finding ways that two to three people that really want to collaborate can come for a month and be there together." The catalysis and working group formats are also open to discussion. Smith welcomes feedback from community members.

Any good ideas from the biological sciences community that fit in with NESCent's mission could be the center's opportunity to expand and build on the foundation it has established: to create a program that will become a landmark for the evolutionary biological sciences community. "We have a nice space, a core informatics staff, a lot of scientists around," says Smith.

Just add the synthesis.

For more information, visit www.nescent.org.

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