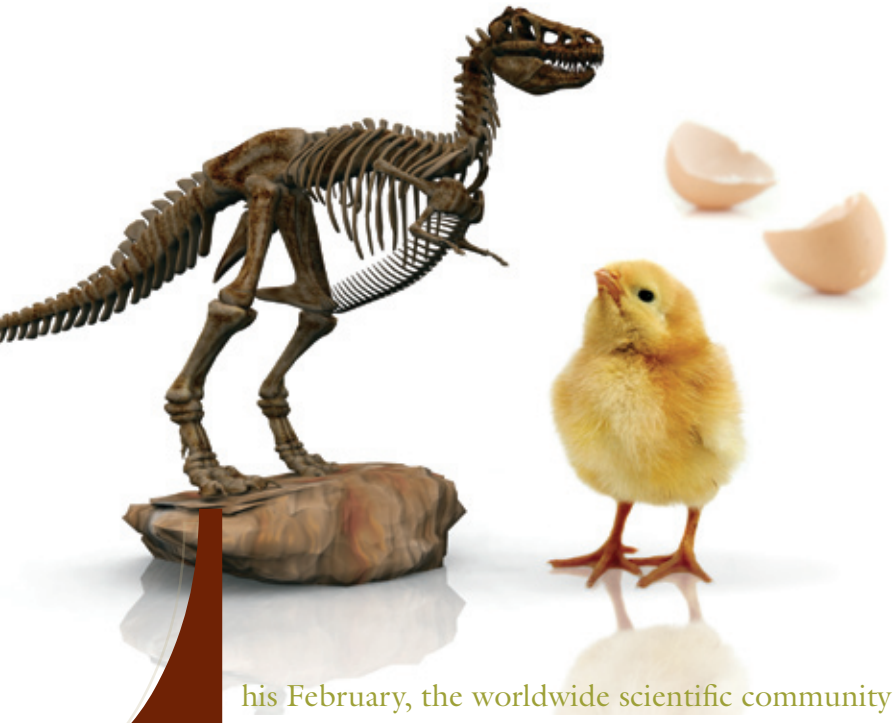
story by ANDREA GIBSON

THE EVOLUTION OF DISC

150 years after the publication of Darwin's *On the Origin of Species*, Ohio University scientists reflect on what they've discovered — and what they're still learning — about the evolution of life on Earth

Discovery



"Darwin truly deserves the credit he gets in science. If you make a list of the 10 most influential people, he should be there."

Willem Roosenburg
Associate Professor of Biological Sciences

This February, the worldwide scientific community will celebrate Charles Darwin's 200th birthday. Scholars will honor one of their most influential icons — the father of evolution — and his long legacy.

It's not hard to find examples of that legacy at Ohio University. In the Life Sciences building alone, evolutionary scientists study everything from how lumbering dinosaurs transformed into petite feathered birds to how modern creatures such as monkeys, lizards, and alpacas evolved to outrun predators, meet the best mates, and nosh on the most nutritious food. Ohio University's Ohio Center for Evolutionary and Ecological Sciences (OCEES) serves as a nexus for these scientists to connect with colleagues in related disciplines who study the oldest plant and animal fossils, as well as the DNA embedded in living organisms, to unlock the mysteries of life on this planet.

To have such a critical mass of evolutionary scientists and paleontologists on one campus is unusual. Ohio University faculty count themselves lucky to be in daily contact with so many kindred spirits.

"It's tremendous. I can't imagine being in a place where I have colleagues who don't understand why I ask what I do. They push you to think about things — they're great people to bounce ideas off of," said Susan Williams, an assistant professor of biomedical sciences. She notes that only a few other universities — Brown, Harvard, Berkeley, Arizona State, and SUNY Stonybrook — have as many active researchers who study the interconnections between evolution and ecology. And a number of faculty members here receive funding from the National Science Foundation, she adds.

The university formally recognized OCEES with center status in 2006, and that provided the group with more funding to support graduate student researchers, develop an undergraduate research track, and launch a Darwin lecture series that was kicked off earlier this year with a talk from renowned bird evolution expert Ken Dial.

This school year, OCEES joins other universities in recognizing Darwin and his pioneering book *On the Origin of Species*, which also marks an anniversary — 150 years of publication — in 2009. In the past decade in the United States, Darwin's theory of evolution has become a critical lightning rod for those who have argued that a religious view of Earth's history should be taught in the nation's public schools, either alongside or instead of evolution. That debate, evolutionary scientists are quick to point out, isn't new. Darwin feared — and in fact faced — a religious backlash to *On the Origin of Species* when he published it in 1859. His own wife even reportedly rejected the theory. "However, 150 years of scientific research, from anatomy to behavior to genetics, DNA sequencing, and disease resistance, has illustrated patterns of evolution in life on this planet," says Steve Reilly, director of the OCEES.

Faculty in the OCEES are solidly aligned with Darwin. They agree that evolution is the single most important concept in biological science, and the backbone to everything they do. You can't talk about modern biology or paleontology, they note, without talking about evolution.

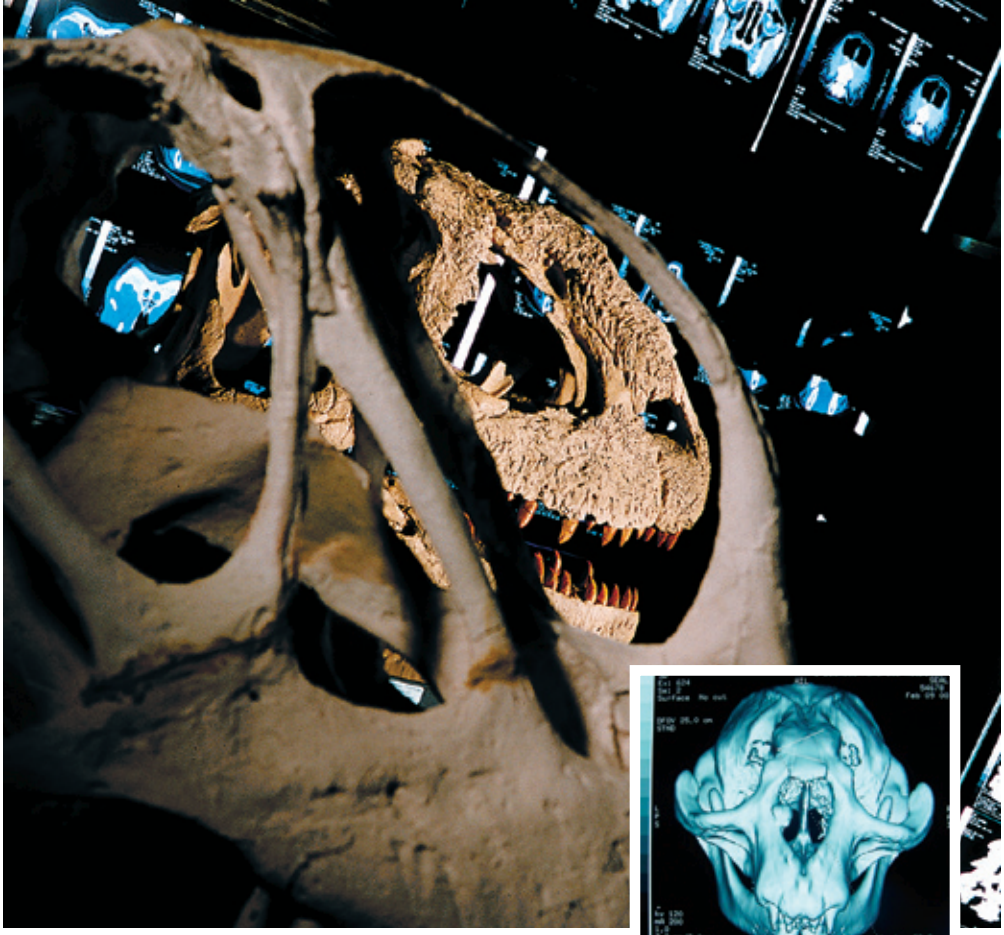
"Darwin truly deserves the credit he gets in science. If you make a list of the 10 most influential people, he should be there," says Willem Roosenburg, an associate professor of biological sciences.

"I think he's underappreciated — or perhaps we take him for granted," Williams says. "He was able to describe a process so creatively, and he was working at a time when he didn't have access to tools and techniques we have today."

"He's rightly credited — he's a genius on the scale of millennia," agrees Glenn Matlack, an assistant professor of environmental and plant biology. "Though there have been many important discoveries in biology since then, they're just working out the mechanism of how evolution can be understood. It's an incredibly robust theory, a helpful one."

In honor of Darwin's birthday, we take a look at a sampling of the evolutionary science research at Ohio University that wouldn't have happened without the work of this pioneering British naturalist.

The OCEES will sponsor talks by nationally renowned evolutionary scientists in conjunction with the 2009 "Year of Darwin" celebration. Nina Jablonski, professor and chair of anthropology at Penn State University, will deliver the February 12 Darwin Lecture on the evolution of human skin and skin color. Kevin Padian, a University of California at Berkeley professor, will deliver the inaugural Kitzmiller Lecture in April on the *Kitzmiller vs. Dover* trial that ruled against teaching intelligent design in public schools. Watch the Ohio University web site for details, or contact Steve Reilly at *reilly@ohio.edu*.



FLESHING OUT THE BONES

How can scientists use dusty dinosaur bones to flesh out the anatomy of these ancient beasts? For Larry Witmer, the answer required a trip to the hospital. The paleontologist and anatomist uses the CT scanner at O'Bleness Memorial Hospital in Athens to capture highly detailed images of the small marks left by soft tissue on hundreds of dinosaur fossils. By comparing the remains to modern ancestors such as crocodiles and birds, Witmer has shed new light on the anatomy of dinosaurs and reptiles, from the nasal cavities of sauropods to the inner ears of flying pterosaurs, and has helped explain how these creatures chewed, tracked prey, kept cool, and communicated.

High-tech hospital scans reveal the anatomy of dinosaurs.

Photos: (above) Jo McCulty; (inset) Christina Ullman

PRIMARY PLANTS

Earth wasn't always so green. It wasn't until 400 million years ago that plants began taking root on the land. Paleobotanist Gar Rothwell and colleagues have found fossil evidence of the earliest land plants, and have discovered how conifers — the most dominant trees for 250 million years — dispersed and conserved their seeds. Rothwell says that searching for patterns in the fossil record has led scientists to understand how plants have evolved over time and why certain traits were perpetuated by natural selection.

Evidence of early land plants.

Photo: (right) Jo McCulty

BIRD BREATH

The sparrow and robin evolved from ancient dinosaurs, and scientists are still finding evidence in the fossil record of a family resemblance. Paleontologist Pat O'Connor has reported that predatory dinosaurs had a complex pulmonary system of air sacs that invaded the bones of the neck, chest, and hips — a system similar to that found in modern birds. In addition to conducting paleontological field work in Tanzania to find new specimens of dinosaurs and ancient mammals, O'Connor continues to study the anatomy of modern birds to learn more about their unique way of breathing.

TERRAPIN TURMOIL

Maryland's Chesapeake Bay has long been home to the diamondback terrapin, but development and fishing practices have changed the turtle's environment. Studies by biologist Willem Roosenburg suggest that the terrapin may be adapting by changing where and how it lays its eggs to control the temperature and incubation of its nests. That, in turn, assures that the ratio of male and female births stays at an even level for the terrapin population, as nest temperature can impact the sex of the hatchlings.

Biologists keep track of Maryland's terrapins.

Photo: Andrea Gibson

STRANGE INVADERS

In Ohio's forests, native wildflowers fight for space with invasive species such as Japanese honeysuckle. Who will win the battle? The answer, says plant biologist Glenn Matlack, depends on rates of ecological and evolutionary change. Over thousands of years, natural selection allowed Ohio wildflowers to disperse to suitable sites in natural forests. But the arrival of humans — who disturbed the natural habitat and tracked in non-native species — threw a wrench into the ecological works. Though wildflowers can evolve their dispersal systems to adapt to new environments, the human pace and scale of impact on forests might overwhelm that natural process, says Matlack, who studies the dispersal methods of plant species. "Evolution is a powerful process," he says, "but evolution is not magic." And yet, Matlack notes, invasive species have already evolved for rapid dispersal, which suits them very well in forests shaped by human activity.

FISH FAMILIES

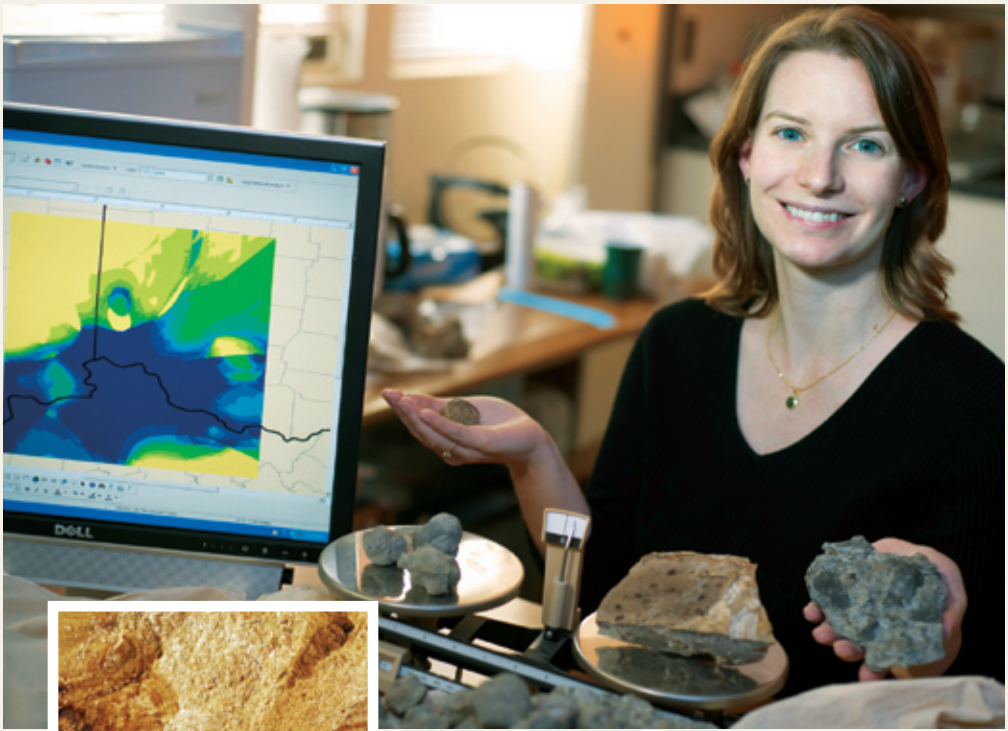
All freshwater fish were not created equal. Population genetic studies by biologist Matt White suggest that some fish species, such as madtom catfish and non-parasitic lampreys, can actually be multiple species of fishes. In other cases, DNA testing shows that fish can be surprisingly homogenous. How did these freshwater animals become so biologically diverse? How did the movement of glaciers and other changes to habitats in streams, lakes, and rivers impact the genetic viability and distribution of fish? White's research aims to solve this basic research riddle, but state fisheries agencies have also made use of his findings to determine the best way to manage popular sport fish, such as walleye and sauger, in Ohio, West Virginia, and Kentucky.

A NEED FOR SPEED?

The fastest lizard doesn't always win, says biologist Donald Miles. Take the ornate tree lizard of Arizona. When a drought hit the area and diminished the food supply, the inactive "sneaker" males conserved energy and survived. The faster, dominant males used too much energy darting around their habitat and, by attracting attention, were more susceptible to predators, Miles explains. On the Galapagos Islands, however, Miles observed that speed has a survival advantage. In areas where vegetation is so sparse that lizards can't hide from hunting herons and egrets, he and his colleagues found that natural selection favors speedy hatchlings. Their neighbors on the greener side of the island don't need to be — and aren't — as fast.

SPECIES STRUGGLE

Don't call them clams, says Alycia Stigall as she lays down a series of small, fossilized marine animals that she's been collecting since her youth in Cincinnati — which turns out to be an excellent hunting ground for these critters called brachiopods. Common and plentiful millions of years ago (and still thriving in some cold, deep water spots today), brachiopods serve as an excellent model for studying how species either adapted to changes in the environment or died during several historic waves of invasive species. Using computer mapping techniques such as Geographic Information Systems and Ecological Niche Modeling to track the size and location of populations of brachiopods and other animals over time, Stigall has learned how invasive species can prompt extinctions by wiping out the variety of organisms in an environment. The work has implications for understanding modern invasive species and how — and if — we can save endangered animals.

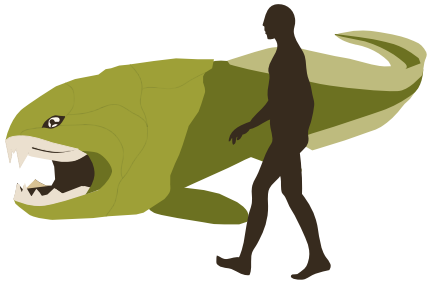


Alycia Stigall, assistant professor of geological sciences, uses computer mapping techniques to track how various creatures, from marine animals to horses, adapted to environmental change and invasive species — or died.

Photos: (above) Rick Fatica; (inset) Courtesy of Alycia Stigall

KILLER FISH

If Steven Spielberg had lived in the Devonian era, "Jaws" would have been set in Cleveland. That's because northeast Ohio was home to a terrifying, 20-foot-long giant fish called *Dunkleosteus* that was part of an early branch of aquatic animals that didn't pass the natural selection test some 360 million years ago. Biologist Bob Carr is the only American expert on these long-lost placoderms, which were the first animals to evolve jaws. He hunts for fossils of these armored fishes in Ohio and Michigan to learn more about their anatomy and why they may have gone extinct. Interest in placoderms is on the rise, he says, as other scientists attempt to shed light on the development of modern relatives such as bony fish and sharks.

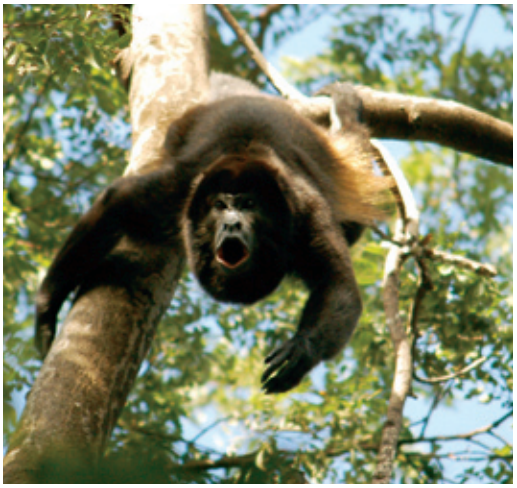


Approximately 11.5 feet from jaw to tail

One of the fiercest marine predators, *Dunkleosteus* had a bite as powerful as *T. Rex*.
Photo: Cleveland Museum of Natural History. Reproduced with permission.

HEALTHY BITE

Alpacas munch on grass; monkeys favor fresh fruit. Susan Williams studies how an animal's choice of chow has impacted the evolution of its jaw and jaw muscles. The scientist has implanted small sensors in the muscles and to the jaws of alpacas and other mammals, for example, to determine the force of their bite and the action of the muscles during chewing. She's also ventured into the jungles of Costa Rica to explore how the howler monkey — which some have called the "cow" of the primate world for its reported voracious love of grazing — chooses food in its environment. Williams is part of a new wave of scientists who are applying lab techniques to field work to get a more accurate view of how animals have evolved to behave in unique habitats.



Scientists study how howler monkeys chew their chow.
Photo: Courtesy of Susan Williams

NAME GAME

As scientists work to discover the evolutionary links between different plants and animals, tracing a wider and more complex family tree, they can encounter a major problem: names. In the traditional system of biological nomenclature, scientific names are based on hierarchical rank — categories such as genus, family, order — and type, which is an actual specimen representing the group of organisms. But naming a new group of species under this traditional system can cause a domino effect of having to rename the rest of the hierarchy, says plant biologist Phil Cantino. The system is so cumbersome that it's discouraged scientists from naming new taxonomic groups. That's why Cantino and Kevin de Queiroz of the Smithsonian Institution created the PhyloCode, a set of rules governing a new but somewhat controversial system called phylogenetic nomenclature that they hope the international scientific community will adopt. If so, proponents believe that scientists will be able to communicate more easily and clearly about the evolutionary tree of life.

Under the traditional system, at least eight scientific names have changed as a result of the discovery that termites are evolutionarily advanced cockroaches.

Photo: Dreamstime.com

WALK THIS WAY

Equipped with a treadmill, force plates, and high-speed video, biologists Steve Reilly and Audrone Biknevicius examine the evolution of walking, running, and trotting in animals such as crocodiles, salamanders, possums, rats, horses, and dogs. Studies have included the discovery that two unusual bones in the bellies of opossums could have aided in the original development of mammals' mobility. In 2007 the researchers traveled to Australia to study rare animals such as the echidna, a spiny, termite-eating critter that is the only mammal other than the platypus to lay eggs. The scientists compared the similar-looking hedgehog, which is unrelated, to the echidna to learn more about the gaits of these "living fossils" — and have observed some big differences. "Because they haven't changed much, the echidna can give us some insight into mammals that lived 60 million years ago," Biknevicius said.

The elusive Australian echidna (top) and the epipubic bones of the wombat (right) offer researchers such as Steve Reilly a window into the evolution of locomotion in mammals.

Photos: (above) Dreamstime.com; (right) Courtesy of Steve Reilly

OUT ON A LIMB

The lemurs of the Madagascar rain forest and the frogs, monkeys, and rodents that populated Africa millions of years ago might not seem to have much in common, at first. But evolutionary biologist Nancy Stevens points out that they provide a good snapshot of how animals have evolved to deal with changing habitats and immigrant species. Stevens has unearthed a number of new species of small animals from the Oligocene Epoch in the East African Rift — the only such site of that age below the African equator. Due to the unique arrangement of the Earth's continents after the extinction of the dinosaurs, small mammals such as elephant shrews and hyraxes evolved in virtual isolation in Africa. But when the land masses of Afro-Arabia and Eurasia merged, competition with animals from the north caused the resident animals to either diversify quickly or die out. Modern primates in areas such as Vietnam and Madagascar — where human disturbance and natural disasters have altered much of the habitat — face a more immediate danger. Stevens has studied these animals in the wild to examine how changes in their environment impact their locomotion and habitat use.

GARDEN VARIETY DNA

Though "evolution" is often defined as "changes over time," scientists such as Stefan Gleissberg point out that it might only take flipping one genetic switch on or off to create a big change in a plant or animal. Gleissberg has been able to alter the appearance of the California wild poppy, for example, by simply modifying one bit of genetic code in his lab. His work focuses on discovering the role of individual genes in a DNA family in the growth and development of flowering plants, which typically have 25,000 distinct genes. He notes that scientists have made some surprising finds — plants that don't look alike, such as a sycamore tree and the American lotus, are actually closely genetically related.

Photo: istockphoto.com