A PUBLICATION OF **THE DUKE LEMUR CENTER**

LEMURS

The "Why" Issue

Duke LEMUR CENTER

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Duke LEMUR CENTER

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Special thanks to everyone who has helped make this magazine better: Megan McGrath and Glenna Rowe for their editorial feedback, students Talia Felgenhauer and Natalie Peoples for their endless enthusiasm and creativity, Matt Borths for fact-checking far more articles than he wrote, and designer Regina Barnhill for her patience and skill. Any mistakes are my own.

Comments, feedback, or something you'd like to see in our next edition? Email **sara.sorraia@duke.edu**. We'd love to hear from you!

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ON THE COVER:
Agrippa, a golden-crowned sifaka (*Propithecus tattersali*). *Photo by David Haring.*

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LETTER FROM THE DIRECTOR

OF ALL THE ISLANDS in the ocean, why is Madagascar remarkable—and so worthy of our conservation attention?

Of all the animals on Earth, why are we so passionate about lemurs?

In this issue, you'll find out.

Our "why" is the thread that ties together the seemingly disparate stories in the pages that follow. Of course, it was impossible to include everything that gives our work meaning; we had only 56 pages to work with, after all. But I hope these stories convey, in even a small way, why the Duke Lemur Center is steadfastly and uncompromisingly committed to studying and protecting lemurs and their island home.

For us, the motivation to see our mission succeed and the "why we do what we do" isn't just academic; it also has a strong emotional connection to the animals we care for every day. Extinction isn't an abstract consequence. It's personal, and its victims have the same faces we know and love here at the DLC.

An equally important part of our "why" is to inspire and train the next generation of environmental stewards, researchers, conservation scientists, animal care and welfare professionals, educators, and veterinarians. You'll see the work of one of these incredibly talented young people inside. Talia Felgenhauer, a gifted storyteller and artist and DLC Undergraduate Fellow in Communications, created a 12-page showpiece with dozens of hand-drawn illustrations that beautifully tells the story of Madagascar. Talia, like so many other students we've had the privilege of working alongside, gives me hope that the conservation problems we struggle with today can and will be solved by their generation.

GREG DYE
Executive Director, Duke Lemur Center

ABOUT THE DLC

PROTECTING AND CARING FOR EARTH'S MOST ENDANGERED MAMMALS

Founded in 1966 on the campus of Duke University in Durham, NC, the Duke Lemur Center is a world leader in the study, care, and protection of lemurs—Earth's most threatened group of mammals.

LEMUR CARE

What began as a small primate menagerie 58 years ago, has grown to become one of the most precious collections of endangered primates anywhere in the world.

Throughout its history, the Duke Lemur Center has cared for nearly 4,000 animals, including lemurs, lorises, bushbabies, and tarsiers. Today, it houses more than 200 lemurs across a dozen different species—**the most diverse population of lemurs on Earth**, outside their native Madagascar.

The DLC works within a network of other AZA-accredited institutions worldwide to develop and adhere to Species Survival Plans (SSPs). These cooperatively-managed conservation breeding programs are critical to lemur conservation, and the DLC maintains the world's largest **genetic safety net** for lemurs. We're proud to have celebrated over **3,405 births** since our founding in 1966.

Our signature Natural Habitat Enclosures enable our lemurs to **roam freely in multi-acre tracts of forest** and live in natural social groups, fostering the same behaviors and social structures seen in the wilds of Madagascar.

The DLC's daily enrichment program promotes lemurs' **curiosity, exploration, and mental stimulation** and is a critical component of our animals' care and welfare.

Positive reinforcement training is used to teach lemurs to enter a kennel, sit on a scale, and other behaviors that may seem like play to the lemurs but enable us to provide the best care with minimal handling or stress to the animals.

RESEARCH

By studying the variables that most affect lemurs' health, reproduction, and social dynamics, we learn how to better care for them in captivity and how to most effectively focus our conservation efforts in Madagascar.

The DLC is an internationally acclaimed hub of scientific discovery, conducting and facilitating research that spans a remarkable array of disciplines, from behavior and genomics to conservation biology and paleontology. The Center is also recognized as a global authority on lemur veterinary medicine.

All of the DLC's research, both in Durham and with wild lemurs in Madagascar, is non-invasive. **We do not allow any research that will harm the lemurs.**

The DLC also houses **35,000+ fossils** and subfossils at the DLC Museum of Natural History, enabling students and researchers to study the evolution of primates and the species that lived alongside them for millions of years.

Because lemurs are our primate relatives, we share many of the same diseases, susceptibilities, and health concerns. Thus, studying lemurs can help us find solutions to combat serious problems facing humans.

CONSERVATION

Lemurs are found in the wild only in Madagascar. At least 17 species of lemur have gone extinct, and the existing lemurs are the most threatened group of mammals on Earth. In fact, **98% of lemur species are endangered**, and 31% of species are critically endangered.

For over 35 years, the DLC has worked on-the-ground in Madagascar to **protect lemurs and their natural habitat**. Most of these activities are community-based, encouraging biodiversity conservation in northeastern Madagascar by supporting the livelihoods of rural people in forest-bordering communities.

Many of the DLC's community-based conservation projects involve partnerships with students and faculty at Duke and at the Centre Universitaire Regional de la SAVA (CURSA) in Madagascar, **educating and inspiring the next generation** of conservation leaders and environmental stewards.

At the invitation of the Government of Madagascar, the DLC is **assisting Madagascar's zoos and wildlife parks** in developing a conservation breeding program and establishing best practices in lemur care. In doing so, the DLC is improving the care and welfare of over 600 lemurs representing 20 endangered species housed in 14 licensed zoos across the island.

PUBLIC OUTREACH AND EDUCATION

Our Student Projects Program connects students with **volunteer, work-study, research, and internship opportunities** at the DLC. Our goal is to provide hands-on experiential learning opportunities that allow students to take part in the DLC's research, education, animal husbandry, and conservation programs here on Duke's campus and in Madagascar.

Through a variety of onsite tours and programs, the DLC's Education Department hosts tens of thousands of visitors annually. Online, we connect anyone, anywhere in the world to science, conservation, and lemurs through our full-length virtual tour, presentations and videos, and other educational resources—available free at **lemur.duke.edu**.

Camilla, a four-month-old Coquerel's sifaka. *Photo by Sara Nicholson.*

"I DO SCIENCE."

HOW NON-INVASIVE RESEARCH BENEFITS LEMUR CARE AND CONSERVATION

"By learning what most affects lemurs' survival and reproduction, we can better focus our conservation efforts in Madagascar. And for our lemurs living here in Durham, we can focus our husbandry practices in ways that best accommodate lemurs' dietary, social, and other needs."

ERIN EHMKE, Ph.D., DLC DIRECTOR OF RESEARCH

Written and photographed by **NATALIE PEOPLES**,
2023 Undergraduate Communications Assistant

Through non-invasive research, staff at the Duke Lemur Center learn how to better care for lemurs onsite and aid conservation efforts for wild lemurs in Madagascar.

Non-invasive research is research that does not involve harming or stressing the lemurs. Lemurs voluntarily participate in studies at the DLC, receiving food rewards and enrichment in return for helping researchers gain valuable data.

"It's important to know what variables most affect lemurs' reproductive health, social dynamics, food acquisition, and other things of that nature," says the DLC's Director of Research, Erin Ehmke, Ph.D. "By learning what most affects lemurs' survival and reproduction, we can better focus our conservation efforts in Madagascar. And for our lemurs living here in Durham, we can focus our husbandry practices in ways that best accommodate lemurs' dietary, social, and other needs."

What does non-invasive research look like? The answer is as varied as the projects themselves. Some projects explore lemur behaviors through observational studies in the forest, while others study lemurs' mental and physical capabilities by exploring lemur cognition and biomechanics.

"The lemurs' care and well-being is our utmost priority," says Erin. "We don't allow projects that will harm our animals in any way."

Opposite page: Maddie, a critically endangered mongoose lemur (*Eulemur mongoz*), free-ranges in Duke Forest. *Photo by Sara Nicholson.*

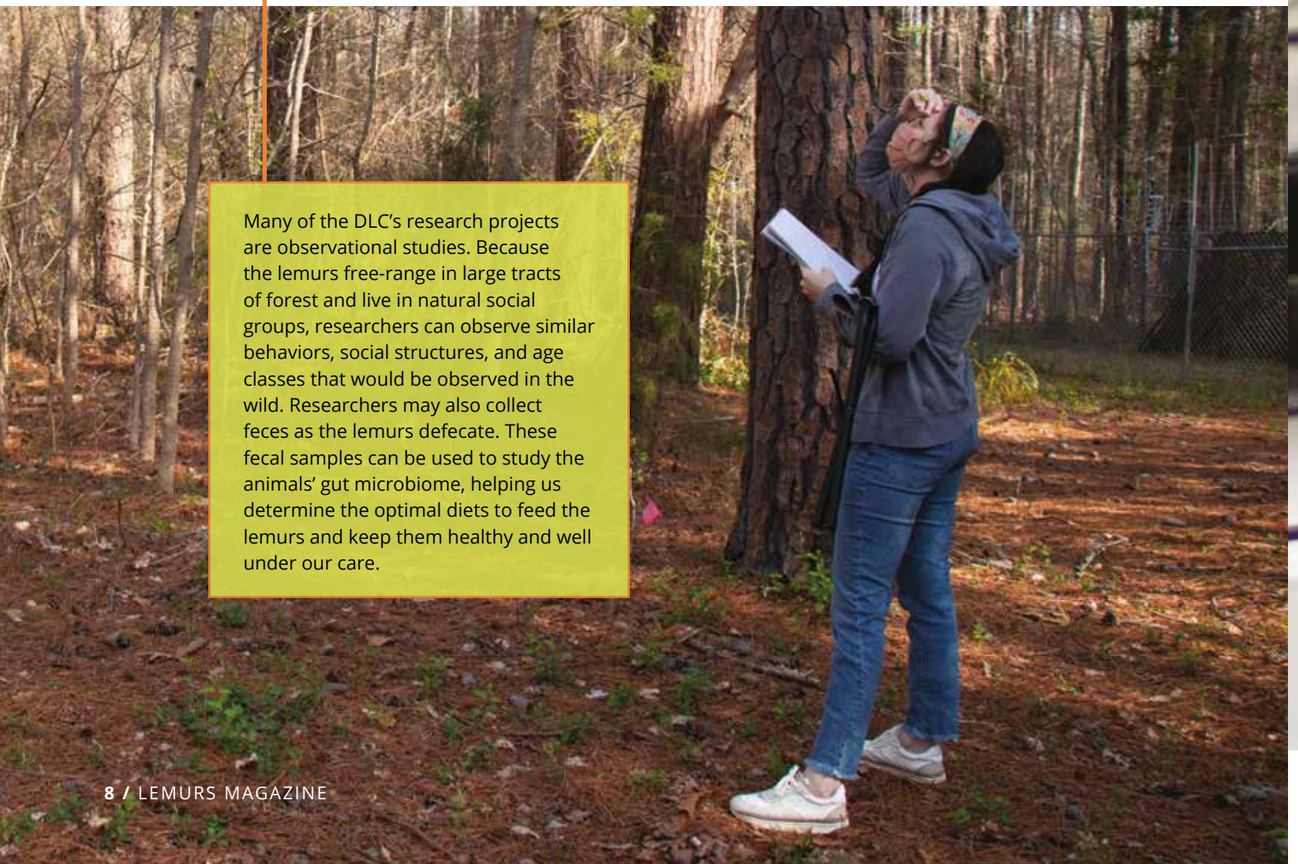
APPROVAL PROCESS

Researchers come from both within and outside of the DLC, but all projects undergo a multi-step approval process.

Duke University's Institutional Animal Care and Use Committee (IACUC), which is responsible for all animal-based research studies, must approve every research proposal. Additionally, the Duke Lemur Center Research Committee reviews each proposal through an even more comprehensive lens.

"When we review protocols, we assess the merit of the study to make sure there is scientific merit—a strong basis for doing the study—and that there will be high-quality data that result from it," explains Erin. "We also ensure that it falls within our non-invasive policies."

All research projects are then facilitated by the DLC's research department for the duration of the study, which can range from short-term to long-term. DLC research technicians observe the lemurs' behavior throughout the research trials and reserve the right to end a trial if a lemur shows signs of stress or chooses to no longer participate.



Many of the DLC's research projects are observational studies. Because the lemurs free-range in large tracts of forest and live in natural social groups, researchers can observe similar behaviors, social structures, and age classes that would be observed in the wild. Researchers may also collect feces as the lemurs defecate. These fecal samples can be used to study the animals' gut microbiome, helping us determine the optimal diets to feed the lemurs and keep them healthy and well under our care.

Herschel, a 10-year-old black and white ruffed lemur, pulls on a string contraption, bringing the grape-skin "treat" closer to him. Researchers use food rewards to encourage lemurs' voluntary participation in research trials. In this cognition trial, Herschel understands that pulling on the orange string dish will result in a reward. "They enjoy the enrichment that they get from participating in the studies, and they're eager to participate, especially if there are snacks involved," says Alexis Sharp, Research Manager at the DLC.

TRAINING AND PREPARATION

While many of the DLC's research projects are observational studies in which scientists observe lemurs' natural behaviors in the surrounding forest, some studies require preparatory positive-reinforcement training with the lemurs.

For example, training is used in locomotion trials. In these trials, research technicians cue lemurs to jump from one elevated branch to another in various ways. When the lemurs execute the cue, they receive a reward. Training helps lemurs understand the goal of the research and know that they will receive a food reward. Additionally, training introduces them to the environment and equipment beforehand, minimizing stress and the risk of distraction during trials.

"Training is teaching," says Meg Dye, M.Sc., Curator of Behavioral Management and Welfare. "Animals are similar to us; they learn in different ways. And so as a teacher, we come up with an individualized plan that works for each animal."

Meg ensures the lemurs are prepared for trials even if it takes a few different training techniques. Once the trained behavior is repeated in multiple nonconsecutive sessions, the lemur is ready for the trial. Training is also enrichment for the lemurs, an added benefit.

Meg Dye, M.Sc., the DLC's Curator of Behavioral Management and Welfare, leads a training session with Sputnik, a three-year-old black and white ruffed lemur. Sputnik will participate in a research study that compares the force exerted during vertical leaps between two diurnal lemurs (lemurs that are active during the day), one of which is a natural vertical leaper and the other is not. Sputnik is not a natural vertical leaper; therefore, he must learn the behavior before the trial. "He's a go-getter," Meg says. "I can keep increasing the height and he gives it his best to get up there as high as he can."

Nine-year-old ring-tailed lemur Lulu jumps from one elevated bar to another during locomotion trials, prompted by research technician Julie McKinney. "Lemurs are arboreal, meaning they hang out in the trees," says Alexis. "They're known to leap great distances from tree to tree in the wild." During locomotion trials, a DLC Research Technician uses a plastic "lollipop target" to cue the lemur to jump across three elevated bars, varying in distance. "It's really important for those animals to be able to safely move among the trees and be able to calculate distance and understand the force that they need to leap and jump with and to avoid things like falls," Alexis explains. By recording the locomotion trials, researchers at the DLC analyze the physical adaptations that allow lemurs to leap from one surface to another.

DLC researchers set up equipment and cameras ahead of locomotion trials with bush babies. Red light must be used during research trials with nocturnal animals. Because bush babies perceive red light similar to moonlight, it does not influence their behavior or hurt their eyes during trials. The locomotion trials examine the force exerted by a bush baby when she jumps vertically from the force plate to a horizontal branch.

DLC Research Technician Gabbi Hirschkorn oversees cognition trials with Camilla, a two-year-old Coquerel's sifaka. The trials evaluate lemurs' problem-solving ability, rewarding actions with grape-skin treats. Studying lemur cognition gives insight into the development of mental abilities in lemurs and the evolution of complex brains in our primate ancestors. "We learn a lot about how lemurs think, how they learn in the process, and how intelligent they are," says Erin Ehmke, Ph.D., Director of Research at the DLC.

APPLICATIONS BEYOND LEMURS

Non-invasive research conducted at the DLC is essential to keeping lemur populations healthy and thriving both in the wild and at the Lemur Center. But lemurs aren't the only ones who benefit from these projects: Data from certain studies may even be applicable to human health research.

"The gray mouse lemur, for example, is a great model for Alzheimer's disease," says Research Manager Alexis Sharp. "Mouse lemurs show evidence of cognitive decline as they get older, and their brains shrink as they age—similar to the aging brains of humans." Notably, there is early evidence that some mouse lemurs develop plaques and tangles in the brain, a symptom common to Alzheimer's disease.

Because lemurs have an accelerated lifespan compared to humans, researchers can gather data through their lifespan to study how their brains work and potentially apply the research to study Alzheimer's disease in humans.

Similarly, promoting successful hibernation in the DLC's colony of fat-tailed dwarf lemurs—the only primates in the world that hibernate—not only improves the lemurs' care and health, but could also inform biomedicine in the treatment of diabetes and other metabolic disorders, or even understanding mechanisms that defy aging.

"It's really cool to see how all this different research can be applied beyond lemurs to improve human health as well," says Alexis.

From their evolutionary relationship to humans to their diverse and unique biology, lemurs are a fascinating study system. The DLC's "do no harm" research program is dedicated to learning about these critically endangered species, and is proud to prioritize the welfare of each individual and the conservation of species while also facilitating scientific advancement.

WHY DOES THE DLC STUDY LEMURS?

Lemurs have fascinated scientists for centuries. There are many reasons to study lemurs—indeed, too many to list here—but here are some of our favorites:

Because of lemurs' history and diversity: When the ancestors of today's lemurs serendipitously rafted from mainland Africa to Madagascar tens of millions of years ago, they became isolated from the rest of the world. Thus launched one of the greatest natural experiments in primate evolution. Since then, 125 species of lemur (and counting) evolved from these early pioneers in Madagascar, where they developed diverse strategies to cope with challenges and take advantage of opportunities. Studying lemurs, and their unique history in Madagascar, allows us to study the evolutionary, ecological, and anthropogenic processes that can shape biodiversity itself.

Because lemurs are endangered: Although lemurs have thrived for millions of years, human activity has now rendered them among the most endangered vertebrates on Earth. The threats facing lemurs include habitat loss and fragmentation, increasingly frequent and extreme weather events, changing landscapes and climate, and poaching and hunting. As lemur researchers, we cannot ignore the omnipresent conservation concerns facing the animals we study. Rather, we can use research-based initiatives to develop sustainable solutions that are firmly grounded in team-based and integrative approaches.

Because lemurs are part of our family: As primates, lemurs are our most distant living relatives within our own family tree. Studying lemurs within a comparative context across primates allows us to understand ourselves, and the traits and processes that make us both primate and human. Moreover, we share with lemurs the vast majority of our genetic code and many of the same diseases, susceptibilities, and health concerns. Studying lemurs could potentially help us find solutions to combat serious problems facing modern society.

A ring-tailed lemur mother and infant. *Photo by Bob Karp.*

DURING HIBERNATION...

IMPERCEPTIBLE BRAIN ACTIVITY

RESPIRATORY RATE DROPS FROM
60
BREATHS PER MINUTE TO LESS THAN
1
BREATH PER MINUTE

CORE TEMPERATURE DROPS FROM
98° F TO JUST
2° F ABOVE AMBIENT TEMPERATURE

HEART RATE DROPS FROM
300
BEATS PER MINUTE TO
8
BEATS PER MINUTE

LEMUR *Dreams* (excerpt)

By **PETER KLOPFER, Ph.D.**, Co-founder of the Duke Lemur Center and Professor Emeritus of Biology at Duke University

Photos by **DAVID HARING**

When fat-tailed dwarf lemurs enter hibernation at temperatures below 25°C, they show little or no brain activity other than occasional muscle movement. However, at intervals of three to 10 days (depending on the temperature), they raise their body temperature to around 30°C for a few hours. During this time, they sleep. These periods of sleep include frequent and lengthy bouts of REM sleep, which in humans are associated with dreams. And these bouts were more frequent and lengthy than at other times, as if the animals had a pent up need to make up for lost opportunities to sleep.

While the act of producing REM waves is not likely to be costly calorically, the rise in body temperature that precedes it *is* costly—and we can measure that cost precisely by monitoring oxygen uptake. It appears that the arousals from torpor account for most of the energy expended during hibernation. Evidently, sleep, from an evolutionary viewpoint, is indeed vitally important.

Do lemurs dream? We still don't know, although the presence of REM suggests that they do. And since the bulk of the energy expended during hibernation is used to warm up so as to allow these arousal intervals, sleep must indeed have been vital in evolutionary history, as it is today.

We still don't know why we sleep, but what these lemurs have taught us reinforces the belief that coming to understand the function of sleep is not of trivial significance. Nor is this all there is to this tale of lemur hibernation. *Cheirogaleus medius* is about squirrel size, 150–250 grams in weight. Mammals of that size generally have a short life span, only two or three years. The European dormouse, which is of similar size and also hibernates for half of each year, is exceptional in that it can live three to four times that long. Associated with this longevity is the observation by a group of Austrian biologists that they regenerate their telomeres after each hibernation season. Telomeres are the codons that serve as the bookends on the DNA strands that comprise the chromosomes. Normally, they shorten with age or trauma and serve as indicators of lifespan.

Since our little dwarf lemurs can live for well over 20 years, we decided to duplicate the dormouse study. This work is still in a preliminary stage, but our early data do suggest that for dwarf lemurs as for dormice (*Glis glis*), hibernation may be an elixir of life in more than one respect. And since researchers at the Duke Lemur Center have also established that the major genes activated for hibernation are shared by humans, a tantalizing prospect emerges: Can we hope to induce torpor in humans? What inestimable benefits for medical practices, or perhaps even for space travel! Certainly a rich prospect for science fiction. Dwarf lemurs are for real, however, and studying them an ever-growing adventure.

Is hibernation an elixir of life? Jonas, the world's oldest known fat-tailed dwarf lemur, lived at the DLC and died just months shy of his 30th birthday. Non-hibernating mammals of similar size have much shorter life spans of just two to three years.

DIGGING INTO PRIMATE HISTORY

EXPLORING THE PAST TO PROTECT LEMURS' FUTURE

By **MATT BORTHS, Ph.D.**, Curator of the DLC Museum of Natural History

There is never a good time to have a flat tire.

But if I could choose, I'd have a blowout on a level, well-paved street within walking distance of an auto shop. But I don't get to choose. The tire exploded on what the mapmaker called an "unimproved road" and I call a rut designed to accumulate pointy rocks.

It had been a long day of coaxing the vehicle along the remote road/rut, winding through the cliffs, badlands, and buttes near Bryce Canyon in southern Utah. Every few turns, we found a spot to perch the truck, hop out, and crawl the ground, hunting for the glint of enamel or the texture of fractured bone.

As I rolled under the Jeep's sideboard to brace the jack in the dust, the question bubbled up: Why? Why haul six perfectly comfortable researchers into the scrub for a few bits of extinct critter? This question has flitted through the minds of dozens of DLC-affiliated paleontologists over the decades as tires blow, maps lie, camps wash away, and the heat catches up.

When the new tire finally gripped the dirt and we bounced toward dinner, the answer surfaced, as it always does: Because we need to know where we came from. We need to figure out where we're headed.

"We need to know where we came from. We need to figure out where we're headed."

Cavernous Time Capsule: 2023 Madagascar field team members Julien Anselme (Madagascar National Parks), Faniry Rabenaivo, and Joeline Rasoamaminirina (University of Antananarivo) search Soarano Cave in Tsimanampetsotsa National Park for the fossils of horned crocodiles and giant lemurs, species that went extinct within the last 1,000 years. The field team is piecing together why these species disappeared, and the effect these extinctions had on surviving ecosystems.

Ancient Climate Change: Duke Evolutionary Anthropology graduate student Julia Stone and DLC Museum Curator Matt Borths search for fossils near Bryce Canyon National Park in Utah. The 34 million year old rocks record the catastrophic climate change that drove North America's primates to extinction.

A Giant Lemur's Last View: Looking out of a skylight cave in Tsimanampetsotsa National Park. The floor of the cave preserves layers of fossils, a seasonal record of adaptation and extinction.

BIG QUESTIONS IN THE DIRT

For 58 years, the Lemur Center's researchers have been driven by our origins. The fossil collection became an official part of the DLC's mission in 1977, and since then, research with the living lemur colony has been in dialogue with the primate fossil record.

Lemurs, both living species and their extinct relatives, are a crucial part of the human story. Despite millions of years separating lemurs and humans, we still share genes, complex social lives, opposable thumbs, and many of the same susceptibilities to disease. When and where did our core primate adaptations emerge? How are we shaped by shifting continents, rising mountains, and changing climates? What do lemur diets, health, physiology, and behavior tell us about being a primate or being a human? What can we learn from our common history to conserve our primate relatives for the future?

Over the past five decades, the DLC has led dozens of fossil expeditions around the world, each with a different driving question. In that dusty rut in Utah, we were on the trail of the last American lemurs.

Today, most primate diversity is concentrated in more tropical parts of the world, but our primate story really begins 66 million years ago in North America and Eurasia. After a peak northern diversity 40 million years ago, primates slowly diminished in North America. When Rocky Mountain volcanoes were making the rocks in southern Utah, global temperatures were dropping and forests were shrinking. Our team was crawling Utah's buttes and cliffs to collect data on a world suddenly hostile to lemur-like primates—one of shrinking forests and changing climates eerily similar to the world faced by lemurs today.

In Madagascar, the recent fossil record is preserved in caves. The caves act as rocky time capsules, documenting the changing climate and the rapid extinction of Malagasy giants like elephant birds and sloth lemurs over the last 1,000 years.

A few weeks after the flat tire, as I was crouched in a cave on a sliver of rock over a stagnant pool of bat poop, the "Why?" bubbled up again. This collaborative project in Madagascar requires repelling rope, powerful flashlights, and cave divers—plus a hefty dose of risk and luck. Why do we do it?

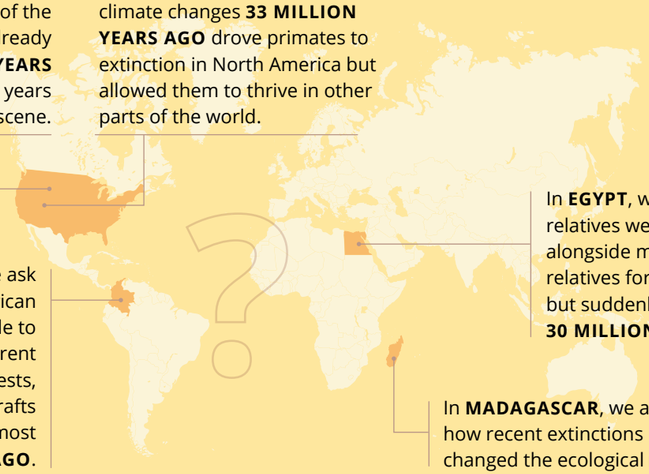
Because the fossils we find within the caves document extinction on a decade-by-decade scale. They reveal that today's highly endangered and geographically isolated lemur species, such as indris and greater bamboo lemurs, were once widespread on the island and lived alongside pig-sized hippos and gorilla-sized lemurs. The fossils help us understand the distribution and behavior of living lemur species, the survivors of an ongoing extinction and reorganization of Madagascar's climate and ecosystem.

Fresh Fossils: Remains of the extinct giant ruffed lemur (*Pachylemur*) and small sloth lemur (*Mesopropithecus*) from Vintany Cave in Tsimanampetsotsa National Park. The specimens are collected from submerged chambers by cave divers.

EACH FOSSIL EXPEDITION IS DRIVEN BY **QUESTIONS**

In the badlands of **WYOMING**, we ask how much of the primate blueprint was already in place **50 MILLION YEARS AGO**, only a few million years after dinosaurs left the scene.

In **UTAH**, we ask how massive climate changes **33 MILLION YEARS AGO** drove primates to extinction in North America but allowed them to thrive in other parts of the world.



In **EGYPT**, we ask why lemur relatives were able to flourish alongside monkey and ape relatives for millions of years, but suddenly crashed in diversity **30 MILLION YEARS AGO**.

In **COLOMBIA**, we ask how monkeys with African ancestors were able to thrive in wildly different South American forests, after drifting on natural rafts across the Atlantic almost **40 MILLION YEARS AGO**.

In **MADAGASCAR**, we ask how recent extinctions changed the ecological rules.

FROM THE FIELD TO THE MUSEUM

Fieldwork is the most photogenic part of paleontology, but real exploration takes place in the museum. There, fossils are extracted from rock, in-depth research takes place, and collaborators with different perspectives and expertise evaluate new discoveries.

Fossil preparation is the science of stabilizing fossils for research and display. The DLC Museum of Natural History is one of two fossil preparation labs in North Carolina. The fossil preparator—Karie Whitman—trains undergraduate students, interns, and volunteers to help clean, repair, and cast specimens. Karie is also a graphic designer (she is responsible for the museum exhibit materials) and researcher who studies rice agriculture in Madagascar (she learned Malagasy along the way).

Tracking specimens in the collection, ensuring researchers have all the materials they need, and coordinating loans and research exchanges is the job of the Collections Manager, Cat Riddle. Cat trains volunteers and students to support dozens of projects including transcribing field notes from an expedition to western Madagascar, picking through sieved sediments from Peru for miniscule primate teeth, and recharging silicon beads to maintain constant dry conditions around the specimens. Digital Collections Manager Kate Neely follows the specimens beyond the physical collection and into the networked database that allows researchers and educators around the world to explore the collection and download 3D scans of ancient monkeys, modern lemurs, and extinct elephants (to name a few options).

In the field and in the museum, we continue to ask "Why?" and we find new answers. Sometimes it's because we want to help a researcher understand the origins of a dental disease in primates. Sometimes it's because it's awe-inspiring to stabilize some of our oldest ancestors. And sometimes it's because we need to share the story of our adaptable lineage with third graders, telling them how our relatives survived rhino-sized carnivores and wild climatic swings. We are a clever, curious, socially complicated group of primates that occasionally get trucks stuck in the dirt and occasionally discover a remarkable way to more sustainably survive on this planet. That's why.

2023 Madagascar Field Team: The crew includes researchers from the American Museum of Natural History, the University of Antananarivo, the Ministry of Culture, and the Duke Lemur Center.

***Megaladapis* Mandible:** The jaw of the gorilla-sized extinct lemur *Megaladapis*, excavated by the 2023 Madagascar field team. The bone can be radiocarbon dated, and we may even be able to extract genetic material from this beautifully preserved specimen.

DID YOU KNOW?

The DLC Museum of Natural History houses the largest and most diverse collection of fossil primates in North America—and you can come and meet your distant kin! Visit our website to schedule a visit, contact us for a virtual tour, or keep an eye out for weekend open house events.

LEARN MORE AT
LEMUR.DUKE.EDU/FOSSILS

STAFF PROFILE

Meet ALANNA!

By **ALANNA MARRON,** DLC Lead Educator

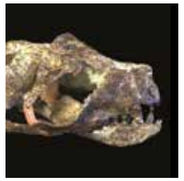
I'VE ALWAYS loved a good mystery—following along as pieces are discovered and assembled to reveal their hidden truth. I see fossils as the ultimate mystery. What creature did they belong to? Where did that creature live? What did it eat? And how in the world can scientists learn so much from a bone-shaped rock!?

For most of my life, I associated fossils only with dinosaurs. It wasn't until I visited the DLC Museum of Natural History as a full-time staff member that I connected fossils with primates! As lead educator at the DLC, my natural curiosity about the mysteries of nature drives me to seek out answers to share with visitors and students. Fossil lemurs presented a new challenge. And a mysterious one, as Madagascar has an extremely limited mammalian fossil record.

As I worked with Museum staff to design a new exhibit space and public tour that would share the stories and mysteries of the DLC's fossil collection with a broader audience, I fell hard for fossils. Over the course of three years, I read more than 1,000 scientific articles. I relished learning everything I could about each species in the exhibit space, reading theories about the adaptations and habits of extinct lemurs and following the trails of researchers as new claims were made or disputed. I even read up on different methodologies and how paleontologists can identify a species from a single, tiny tooth.

In July 2023, I joined the Museum's field team for a week fossil hunting in Utah and Wyoming. We were up every day before the sun rose, filling water bottles and packing our field bags with lunch, snacks, electrolytes, specimen bags, rolls of toilet paper (for wrapping fossils, in addition to their other obvious role), rock hammers, and ice picks. Then we spent 10 hours foraging and prospecting sites. We scarfed lunch in what small patches of shade we could find. Small fossils were gingerly coaxed from rock with fingertips and ice picks. Larger ones required delicate excavation with rock hammers. It was very different work than I was used to, and I loved every second.

At day's end, we returned to our tents, swapped clothes dusted with rock powder and dirt for marginally cleaner ones, and rehydrated 'round the campfire. After dinner and dishes, fossils were catalogued and every specimen, from the larger turtle shells to the tiniest tooth fragments, was numbered and wrapped protectively in toilet paper and tape.



My favorite fossil in the Museum collection is of *Northarctus*. It's ~50 million years old and was found by our field team in Wyoming in 2022. *Northarctus* was one of the first leaf-eating primates. Leaves are tough to slice and digest. This adaptation unlocked a whole new menu for primates!

Our trip yielded 144 fossil specimens. The smallest 134 specimens flew with us back to North Carolina; the remaining 10 were packaged in boxes, cushioned with layers of sleeping bags and jackets, and mailed to the Museum via FedEx. They arrived two days later, boxes intact, fossils as fragmented as they were when we found them, escorted by a confused delivery driver.

No, I didn't make any groundbreaking discoveries during my time in the field (though most discoveries take place in the comfort of the museum where there's time to really study the haul). But I did expand my knowledge base, and I gained a new perspective on what searching for fossils really looks like. Of the 144 specimens we collected, only two of them belonged to primates. Turns out primates are rare both in the wild and in the fossil record. But I did get to experience the thrill of discovery: Every fossil contains clues to the story of our ancient primate relatives and the creatures that lived alongside them. And that's a story I can't wait to share!

FOSSIL PLAYLIST

Hunting massive dinosaur fossils means parking in a quarry to chip out a few huge specimens. Hunting for extinct small primates, on the other hand, was more like looking for a dropped contact lens—head down, tracking the ground for tiny teeth and bone fragments.

At the end of each day, we shared the songs that got stuck in our heads during our fossil-hunting treks and built the Utah-Wyoming 2023 playlist. Some make sense if you squint: "Winds o' Wyoming" by Yonder Mountain String Band and "Beast of Burden" by the Rolling Stones. Others suggested we needed to drink a little more water: the Reading Rainbow theme song, "Don't Cry for Me Argentina" (the Glee version), and the disco song "The Hustle."

Our new exhibit space, developed with funding from the NC Science Museums Grant Program, is chock-full of display cabinets with fascinating fossils and educational graphics. Here, I'm taking visitors on a guided journey through tens of millions of years of lemur evolution. If you're interested in early primates, you won't find a collection or a tour experience like this anywhere else in the world! *Photo by Megan McGrath.*

NURTURING *the* EXTRAORDINARY

HELPING RISING CONSERVATIONISTS KICK-START THEIR CAREERS

By **ERIN HECHT**, Student and Volunteer Program Coordinator

"An important part of the Lemur Center's mission, our 'why,' is to inspire and train the next generation of environmental stewards," says the DLC's executive director, Greg Dye. "To do that, we offer as many opportunities as possible for students to work side-by-side with the Lemur Center's researchers, science educators, animal care and veterinary staff, and conservationists."

"The emotional connections these experiences create are incredibly powerful," says Erin Hecht, who coordinates the DLC's internships and student programs. "They can provide clarity to students who want to make a positive impact on the natural world. Often, these positions are students' first steps toward conservation- and animal-focused careers."

> **"An important part of the Lemur Center's mission, our 'why,' is to inspire and train the next generation of environmental stewards."**
>
> **GREG DYE, EXECUTIVE DIRECTOR**

STUDENT VOICES

AARON SANDEL, Ph.D.
Student Researcher, Student Volunteer

"I applied to one college and for one reason: I wanted to study primates, and Duke University had the Lemur Center... It's wild to think that I am who I am today because of the DLC."

PRARTHANA MINASANDRAM, Pharm.D.
Field Research Intern, Student Researcher

"I often reflect on my time spent at the DLC and know that my experiences there gave me the confidence to become a strong female leader in science."

DANIELLE MOU
Education Intern

"I didn't think there was a place for me in the animal science field until participating in this internship. The staff immediately welcomed me and took me under their wing, and through their mentorship, my world expanded exponentially."

TSIKY RAJAONARIVELO, D.V.M.
Veterinary Intern

"Since there are so many lemurs in captivity [in Madagascar], it's very important to consider their welfare and how to improve their lives... I can now provide better care for those lemurs and share my knowledge with others."

BEN BERRIMAN, D.V.M.
Field Research Intern, Student Volunteer

"Working at the DLC really solidified my interest in conservation medicine. I also learned about the wide variety of career paths that involve working with animals and conservation of wildlife."

LAILA BARNES
Animal Welfare Intern

"After working on my [intern research] project, I want to go into behavioral medicine. I would never have gotten to this point without this internship, and I am so happy I participated!"

BRANDON SEMEL, Ph.D.
Work-study Student, Student Researcher

"Ever since taking a tour of the DLC, I knew that I wanted to go to Duke, work at the Lemur Center, and study lemurs. 10 years later, that dream became reality as I stepped on campus as a freshman and secured a work-study position at the DLC... Another 10 years and [I was in] Madagascar [studying] the effects of climate change on golden-crowned sifakas for my Ph.D. I couldn't be more grateful for all I learned and experienced at the DLC, and I hope to continue their mission in Madagascar for years to come!"

YOU CAN HELP

Supporting students as they find their place in the conservation movement

In 2021, the DLC launched a new opportunity for donors to give a targeted impact gift that goes directly toward student support for summer internships. A gift of $8,000 fully covers one student for the 10-week internship at a living wage, opening the door to candidates who might otherwise be unable to consider the internship experience because of cost and the need to earn a summer income to support themselves or their families.

"My hope is that with donors' help, this scholarship can expand exponentially," says former intern Lisa McCullough. "To support the next generation of scientists in this decade of climate action, we need to nurture young people in an inclusive and diverse setting. The DLC's supportive, intern-centered, open-door atmosphere directly inspired and empowered me to pursue a research career focused on the environment. We need to make this experience accessible to all students, not just those of independent means. Funding need-based scholarships is a game-changer."

To learn more about this giving opportunity, please visit the Targeted Impact Gifts page on the DLC website: **LEMUR.DUKE.EDU/TIGIFTS**

NYU graduate students
Mel Dashdorj, Rachel Waitt,
Gina Pol, and Kojo Dadzie.
Photo courtesy of Rachel Waitt.

COMING MAY 2024!

Empowering Education:

NYU Graduate Students Partner with the DLC to Bring Lemur Learning to Middle Schools

By **RACHEL WAITT**, **KOJO DADZIE**, **GINA POL**, and **MEL DASHDORJ**

THIS ACADEMIC YEAR, the Duke Lemur Center has partnered with four enthusiastic graduate students from NYU's Robert F. Wagner School of Public Service: Rachel Waitt, Kojo Dadzie, Mel Dashdorj, and Gina Pol. Their joint mission is to address the current gaps in lemur-focused education by developing comprehensive, downloadable, and user-friendly curriculum modules for middle school teachers and students to help bridge the gap in lemur learning.

Lemurs, as the most endangered mammals on Earth, play a crucial role in raising awareness of conservation issues necessary for environmental stewardship. Lemurs also provide rich educational opportunities, as Madagascar's diverse lemur species (more than 100) exemplify speciation in response to environmental niches and challenges. The island itself is home to 5% of all known species on Earth, with levels of endemism at the species, genus, and family levels that are unmatched by any other country (International Union for the Conservation of Nature, 2013). In the words of one reviewer, if islands are playgrounds for evolution, Madagascar makes Galapagos look like Little League.

Yet available educational resources about Madagascar and its lemurs, specifically tailored to the middle school age group, are curiously absent—most existing materials are designed either for very young students or cater to academic and professional audiences.

To bridge this gap, Rachel, Kojo, Mel, and Gina plan to provide three no-cost "plug and play" lesson plans in May 2024 as part of their year-long Capstone project. Highlights of the project include:

- **Three complete curriculum modules**, bringing the expertise of the DLC's tours and other educational programs—currently available only onsite in Durham, NC—to classrooms across the United States
- **Downloadable free via a brand-new Educators' Portal on the DLC website**, ensuring widespread availability and use
- **Minimal preparation and no specialized knowledge or equipment required**, making it easier for educators to incorporate lemur-related content into their curriculum or to provide single-class-period options for substitute teachers

Follow the DLC's blog and social media channels for updates on the lesson plans' release in May 2024, or email **sara.sorraia@duke.edu** to be notified directly. We're very excited about this partnership and its contribution to the DLC's education and conservation missions!

FREQUENTLY ASKED QUESTION:

WHY ARE THERE LEMURS AT DUKE?

MANY PEOPLE ask why and how the DLC's first lemurs came to North Carolina, but few expect the response: through a civil rights protest and a legal journey that ended in the Supreme Court of the United States.

Our story begins in 1963, when Peter Klopfer, a Duke University professor of biology, was charged with criminal trespass while participating in a civil rights demonstration at a restaurant. As his case worked its way through to the Supreme Court, friends and colleagues donated money for his legal defense.

Here, Peter describes what happened next:

> "When my case began to cost money, my friends and colleagues set up a defense fund and contacted my former teachers and friends at Yale for contributions.
>
> One of those who contributed was John Buettner-Janusch. John was on the faculty at Yale, and although we'd never met and he didn't know me, he was committed to civil rights.
>
> When he came down [to Durham] to give a lecture—and, although I didn't know it at the time, to be considered for an appointment at Duke—I went to the lecture and introduced myself, so I could thank him personally. He expressed an interest in my work, so I brought him to the site of my Duke zoology behavior station where I had my animals. I had a herd of deer, goats, turkeys, and all kinds of different animals within a 40-acre enclosure.
>
> John was impressed by what he saw. He told me that one of the reasons he couldn't stay at Yale was because they wouldn't give him space for his lemurs. He would much rather have the animals outdoors in facilities such as mine. Would I consider letting him bring the lemurs out to the behavior station if he, in turn, allowed me to use the lemurs for my behavioral work?
>
> I said, 'By all means, come, and we'll form a partnership.' And that's how we met, and that's how the Lemur Center got started."

Bill Anlyan, then dean of the Duke University School of Medicine, granted a large swath of Duke Forest to the project, and the National Science Foundation provided the funds to build a "living laboratory" where lemurs and their close relatives could be studied non-invasively.

In 1966, the nascent DLC—then called the Duke University Primate Center—was founded on 80 wooded acres (later expanded to 100 acres), two miles from the main Duke campus. John's colony of lemurs was relocated from Connecticut to North Carolina, and the DLC began assembling the largest living collection of endangered primates in the world.

The DLC was established over 50 years ago as an opportunistic collaboration between two researchers: John Buettner-Janusch of Yale University, who was studying biochemical genetics in lemurs; and Peter Klopfer, a Duke University biologist studying maternal behavior in mammals. Together, the two biologists conceived the idea of establishing a primate facility in Duke Forest that would combine their research perspectives in order to explore the genetic foundations of primate behavior. *Undated image of John Buettner-Janusch courtesy of the Duke University Archives.*

Peter Klopfer at the Duke Lemur Center's 50th Anniversary Scientific Symposium in 2016. Peter was a member of the search committee that hired John Buettner-Janusch onto faculty at Duke. John accepted the position, on the condition that the University provide accommodations for his lemurs and other primates. *Photo by David Haring.*

Madagascar Periwinkle

Madame Berthe's Mouse Lemur

Panther Chameleon

Fossa

Madagascar Leaf-nosed Snake

Giraffe Weevil

Mousetrap Tree

Madagascar Lace Plant

Leaf-tailed Gecko

Ring-tailed Lemur

Tomato Frog

Darwin's Orchid

Lantern Bug

Flying Fox

Traveler's Palm

Silky Sifaka

ISLAND of EVOLUTION

THE ONE AND ONLY MADAGASCAR

Written and illustrated by **TALIA FELGENHAUER**, 2023-24 Undergraduate Fellow in Communications

Madagascar is an island like no other. Located hundreds of miles off the southeastern coast of Africa, Madagascar has been isolated for more than 80 million years, changing and evolving independently from the rest of the world. Today, the island is famed for its extraordinary biodiversity and distinctive flora and fauna, with more than 85% of its species found nowhere else on Earth.

Blue Coua

Madagascar Pitcher Plant

Aloe Helenae

Madagascar Hissing Cockroach

Radiated Tortoise

Lowland Streaked Tenrec

The island of Madagascar is a natural laboratory for evolutionary experiments. Through isolation and ecological opportunity, Madagascar has shaped the unique evolution of thousands of species. "While smaller islands tend to have more uniform ecosystems, Madagascar is big enough that it has variation," explains Matt Borths, Ph.D., a paleontologist and Curator of the DLC's Museum of Natural History.

The fourth largest island in the world, Madagascar stretches the length of the entire western coast of the United States. Its sheer size, plus its varied topography and four regional climates, creates such a vast array of habitats for animals and plants that Madagascar is often called the "Eighth Continent."

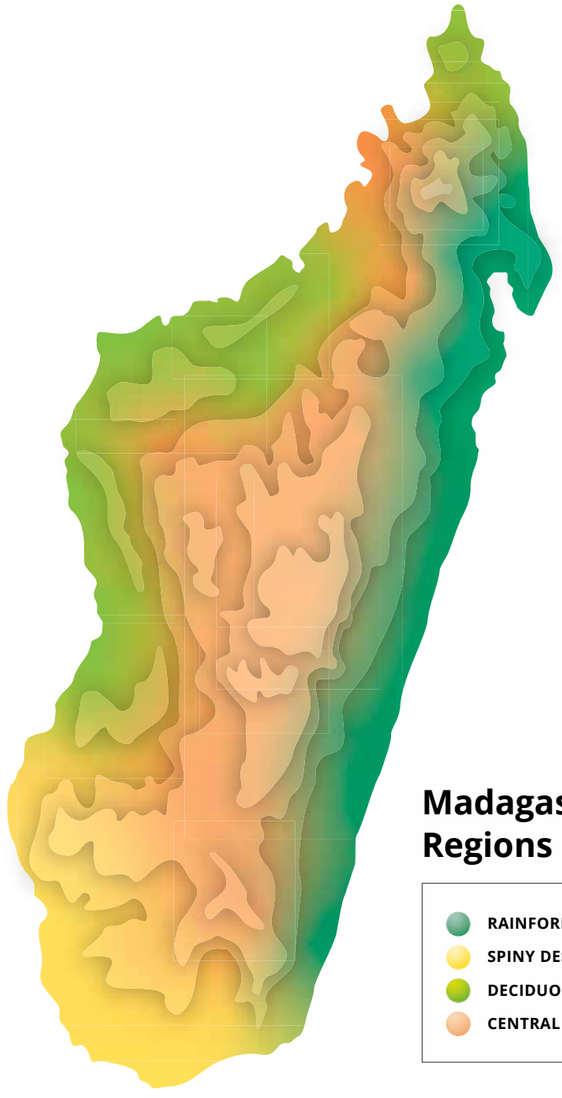
"Every region of the island is different," says Charlie Welch, who oversees the DLC's conservation programs on the island. "You run the gamut from the spiny desert in the south, which of course is very dry, to the rainforest in the east, which gets nearly three meters of rain annually." Because each region has its own ecological opportunities and niches to fill, species spread out and adapt to fit their very different surroundings.

"What really makes Madagascar unique is that it's been an isolated island for so many millions of years," says Charlie. Madagascar broke from Africa 165 million years ago and India 80 million years ago and has stood alone ever since.

Over the course of its long isolation, a small number of species made it to the island, most flying, swimming, or rafting across the Mozambique Channel from mainland Africa. For those that survived the trip, Madagascar was a whole new world. With less competition for resources, new niches to fill, and almost no genetic influx from the rest of the world, species diversified and life evolved in new directions.

It was as difficult to leave the island as it was to arrive. Species were marooned there, spending millions of years evolving their own unique characteristics. Today, more than 85% of the mammals, reptiles, amphibians, and plants of Madagascar are found nowhere else on Earth.

In addition to this extreme endemism, Madagascar has one of the highest numbers of endangered species in any country, making this biodiversity hotspot a top priority for conservation.



Madagascar Regions

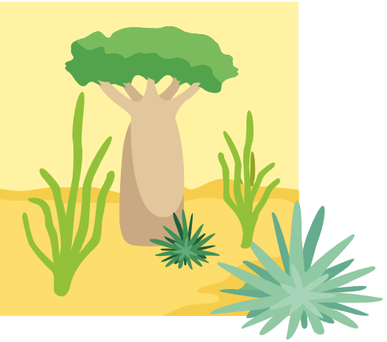
- RAINFOREST
- SPINY DESERT
- DECIDUOUS FOREST
- CENTRAL HIGHLANDS

TROPICAL RAINFOREST

Lush rainforests stretch along Madagascar's eastern coast, bordering mountains to the west and the Indian Ocean to the east. As storms blow in from the ocean, the mountains stop the warm air and rain from moving further inland, creating this warm, wet ecoregion.

SPINY DESERT

The spiny desert's mix of spiky and succulent plants used to cover much of the island, but as Madagascar drifted north out of the Arid Belt, this ecoregion became confined to its southern tip.



DRY DECIDUOUS FOREST

Madagascar's western deciduous forests range from high altitude to nearly sea level. The ground is often made of limestone, which in some areas is eroded into spike-like formations called tsingy.

CENTRAL HIGHLANDS

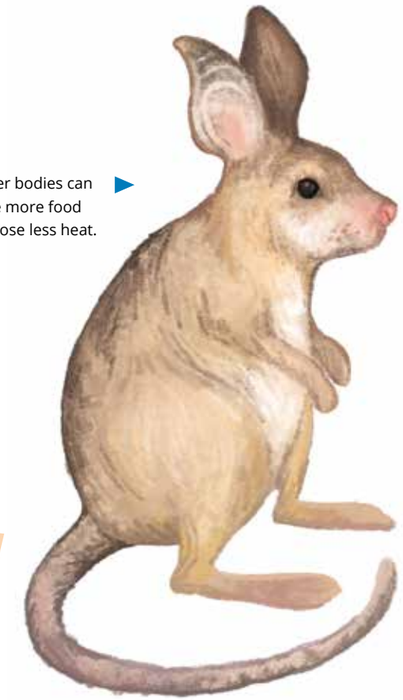
The central highlands are a mosaic of grasslands and wooded areas. This region is characterized by valleys and mountain peaks, some more than 6000 feet above sea level.

Because constraints on an island can be different from those of a continent, islands can push and pull evolution in new directions. "In most ecosystems you would say 'here are the rules, here is what this animal is capable of evolving into,'" says Matt. "But on islands, animals can really break the mold." Size is one way island animals may differ from their mainland relatives. Over time, islands may shrink a big animal lineage, or enlarge a small one.

GIANT JUMPING RAT

Critically Endangered | *Hypogeomys antimena*

Giant jumping rats are the largest **endemic** rodents on Madagascar. With long ears and powerful back legs, they have adaptations like a rabbit's, an animal that was absent from Madagascar before humans introduced them to the island. Jumping rats' swiveling ears allow them to hear approaching predators, and if threatened, they can hop over three feet to evade danger.



Larger bodies can store more food and lose less heat.

SMALL TO BIG: *Insular Gigantism*

On continents, small animals use their size to hide from predators. But on islands, which are difficult for most species to reach, there may be fewer predators on the prowl. With less predation and less competition for resources, the benefits of having a larger body may outweigh the benefits of a smaller one. Over time, small species isolated on islands may evolve to be much larger than their mainland counterparts.

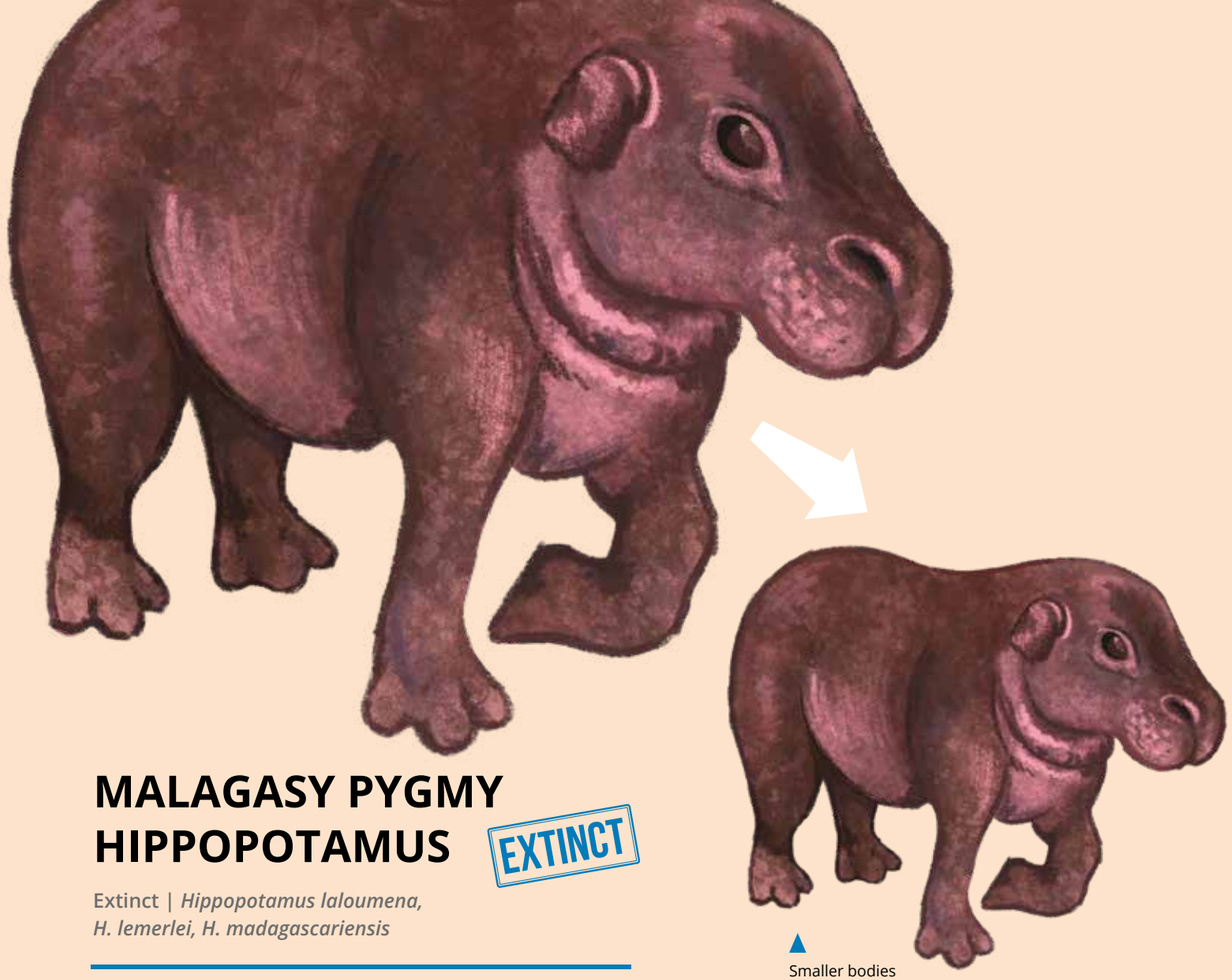
WHAT IS A SUBFOSSIL?

Pygmy hippo jaw

SUBFOSSILS ARE animal remains that are less than 10,000 years old. This means they often represent species that went extinct very recently. There are even subfossils of species that are still around today. In Madagascar, much of what we know about the biodiversity of the island is represented by subfossils. Older fossils (remains of life over 10,000 years old) are mostly from much more ancient time periods.

Subfossils are often found in caves. "Caves act as time capsules, and even though they contain only relatively recent material, we find some really spectacular animals," Matt says. "We find everything from giant lemurs to pygmy hippos."

Because the animals found went extinct so recently, they are especially interesting for conservation reasons. "The factors that led to extinction in Madagascar are acting all over the world. With subfossils, we can learn about extinctions of the past to prevent extinctions of the future," says Matt.



MALAGASY PYGMY HIPPOPOTAMUS

EXTINCT

Extinct | *Hippopotamus laloumena, H. lemerlei, H. madagascariensis*

The Malagasy pygmy hippopotamus was far smaller than its mainland African cousin, the common hippo (*Hippopotamus amphibius*). Whereas the common hippo can weigh 9,000 pounds and is one of Earth's largest living mammals, the Malagasy pygmy hippo was approximately the size of a large pig. Even so, it still weighed hundreds of pounds and was one of the larger animals on the island.

Unlike common hippos that graze on open grass, Madagascar's pygmy hippos preferred browsing on sedges and leaves in the island's wet, forested landscapes.

Like other large animals on Madagascar, pygmy hippos went extinct within the last 1,000 years. In the **subsistence shift hypothesis**, paleontologist Laurie Godfrey, Ph.D., and an international team of colleagues suggest that the island's "megafaunal crash" between 700–1,000 CE was due to people's transition from hunting/gathering to forming permanent communities and raising domestic animals and crops. Clearing the forest to plant rice and create grazing land for herds of cattle severely modified or destroyed the animals' habitats, and their populations crashed and never recovered.

Smaller bodies need less space and fewer resources.

BIG TO SMALL: *Insular Dwarfism*

By definition, islands are smaller than continents and thus have fewer resources. A large animal needs a large amount of resources to sustain a healthy population, and islands are not always big enough to provide that. When a large species is marooned on a smaller land mass, it can be beneficial to evolve a smaller body size that better fits the constraints of the island's resources.

LUCKY LEMURS

Between 55 and 25 million years ago, the ancestor of aye-ayes and the ancestor of all other lemurs were blown out to sea, likely in two distinct colonization events, drifting across the Mozambique Channel from mainland Africa and eventually landing on the island of Madagascar. When these ancestors arrived, Madagascar had no other tree-dwelling mammals.

"Very few mammal species initially made it to Madagascar, so there was more time for the lucky few that did arrive to fill ecological roles that wouldn't ordinarily belong to them," says Matt.

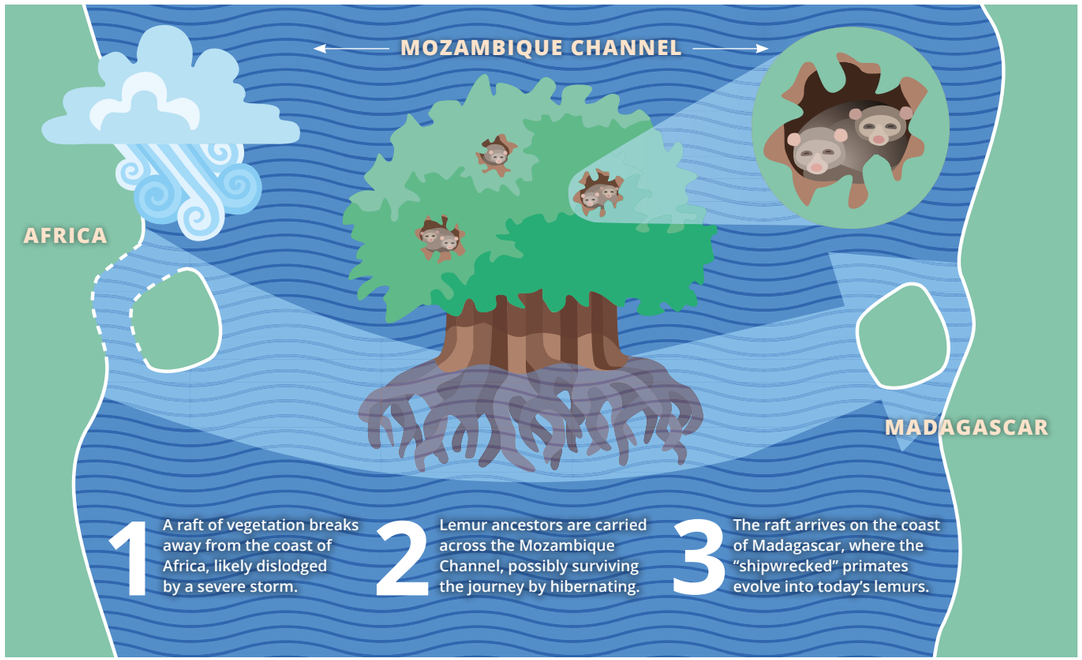
Lemurs were part of this "lucky few." As some of the first mammals to arrive on the island, these early primates had few predators and little competition for resources. They diversified and spread across Madagascar, developing different strategies for survival based on geographic region, available resources, and competition.

"Because of the pressures and opportunities of the island, the primates that managed to get to Madagascar are completely different than those left on the African continent," says Charlie. "This teaches us what evolution is capable of."

"Ancestral lemurs had an extremely basic body plan, and from that plan you can get all sorts of creatures," Matt adds.

From the gorilla-sized *Megaladapis* to the 1.2-ounce Madame Berthe's mouse lemur, species evolved to fill a staggering variety of ecological niches. Currently there are more than 100 different species of lemur, in addition to at least 17 species that have already gone extinct.

Today, lemurs are the most endangered group of mammals on Earth. They also constitute one-fifth of the world's primate species, giving Madagascar the highest primate diversity in the world for its size. These factors make Madagascar and its lemurs urgent priorities for research and conservation.



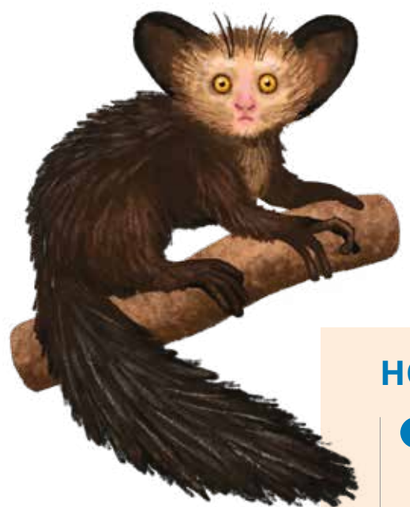
GOLDEN BAMBOO LEMUR

Critically Endangered | *Hapalemur aureus*

Golden bamboo lemurs are specially adapted to eat the cyanide-rich shoots of giant bamboo (*Cathariostachys madagascariensis*), which comprises as much as 90% of their diet. By evolving to eat toxic bamboo that few other animals can eat, these lemurs reduced competition and gained an abundant food source.

Lemurs did not stop specializing there: Even amongst the bamboo lemurs, different species eat different parts of the bamboo plant. The greater bamboo lemur (*Hapalemur simus*) uses its powerful bite to rip through the woody husks of mature bamboo stalks, whereas the golden bamboo lemur eats the tender shoots, which have a higher concentration of cyanide than mature stalks do.

While these extremely specialized diets help bamboo lemurs avoid competition, they are also limiting. Bamboo lemurs occupy such specialized niches that it is difficult for them to survive in a changing environment, making them one of the more critically endangered genera of lemurs.



AYE-AYE

Endangered | *Daubentonia madagascariensis*
Extinct | *Daubentonia robusta* EXTINCT

There are no woodpeckers on Madagascar; instead, the aye-aye exploits this grub-eating niche. This bizarre-looking nocturnal primate has developed a series of adaptations, unique among lemurs, that makes it a gold medal-worthy percussive forager.

HOW DOES THE AYE-AYE HUNT?

1. The aye-aye, with the largest ear-to-body-size ratio of any primate, cups its ears downward toward a tree branch or rotting log.
2. The aye-aye drums its skinny "tapping finger" rapidly against the wood, listening for hollow spots that may indicate the presence of insect tunnels below.
3. Once a hollow spot is located, the aye-aye uses its rodent-like front teeth to gnaw a small hole into the wood.
4. The aye-aye inserts its hyper-mobile tapping finger into the hole, searching for insect larvae.
5. The aye-aye hooks a larva with its claw, extracts it from the hole, and enjoys a juicy snack!

GIANTS OF MADAGASCAR

MEGALADAPIS

EXTINCT

Extinct | *Megaladapis edwardsi, M. grandidieri, M. madagascariensis*

Megaladapis was a gigantic, gorilla-sized lemur that specialized in eating leaves. Folivores (animals that feed on leaves) are able to exploit one of the most abundant resources in the forest. With the help of their specialized teeth and digestive systems, these lemurs unlock nutrients that are difficult for other animals to access.

Megaladapis and the other giant lemurs are extinct, but just barely. "As far as we can tell, *Megaladapis* only went extinct in the past 800 years," says Matt. "There were people building castles in Europe as *Megaladapis* stomped around Madagascar."

PALAEOPROPITHECUS

Extinct | *Palaeopropithecus ingens, P. maximus, P. kelyus*

EXTINCT

Palaeopropithecus, which survived until ~ 550 years ago and could weigh more than 100 pounds, was a lemur built for life upside down. With long limbs and hook-like hands, it was probably awkward on the forest floor and instead lived suspended in the trees. These adaptations and lifestyle are similar to those of arboreal sloths, earning them the nickname "sloth lemurs."

Madagascar's giants, including sloth lemurs, played a key role in seed dispersal. Plant seeds are often covered in sweet-tasting pulp, enticing lemurs and other seed dispersers to seek and gulp them down. As giant lemurs roamed through the forest, they passed the large seeds of their favorite fruits with their feces, germinating future generations of fruiting trees. Large burs (prickly seed pods) also embedded in their fur.

"Big animals can carry big seeds in their guts or on their fur and not be bothered by them," says Matt. "A small animal, on the other hand, will eat around large seeds and therefore not transport them very far from the parent plant. Or if a big bur latches on, a small creature will notice and brush it off quickly. So the extinct giants of Madagascar probably helped move seeds all over the landscape, diversifying the forest for other creatures."

INDRI

Critically Endangered | *Indri indri*

Today, the 20-pound indri is the largest surviving species of lemur. The indri is found in only a small sliver of eastern rainforest, where its unearthly, wailing song can be heard for over a mile. As primatologist Alison Jolly said, "Indri sing the song of the forest as whales sing the song of the sea."

Like many lemur species, the indri is unable to survive within human care. Once the indri is gone from Madagascar's forests, it is gone forever.

ELEPHANT BIRD

EXTINCT

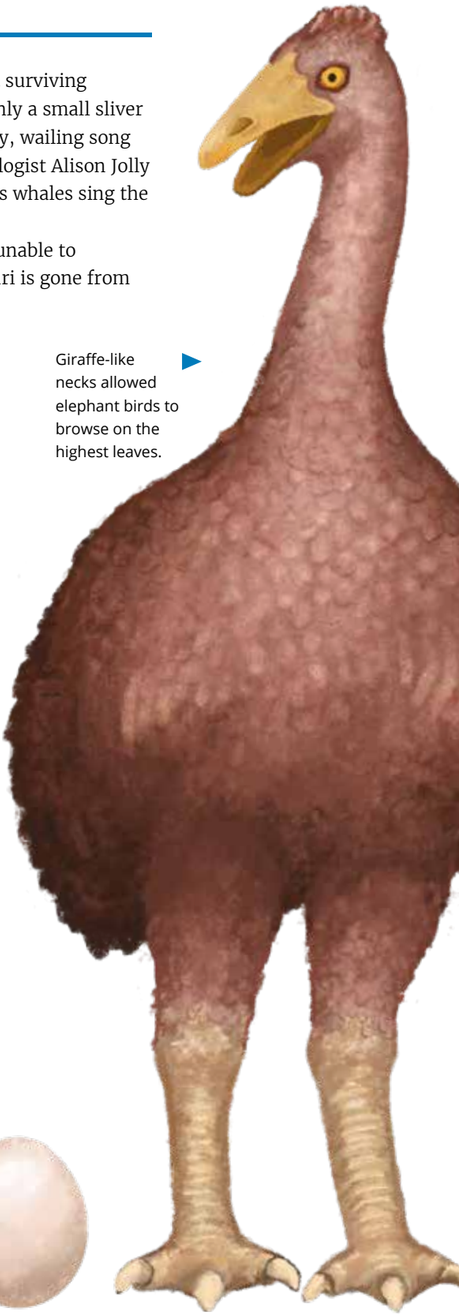
Extinct | *Aepyornis hildebrandti, A. maximus, Mullerornis modestus*

Madagascar was once home to the largest birds ever known. The island harbored several species of ratites called elephant birds until they became extinct around 1,000 years ago. The largest, *Aepyornis maximus*, stood 10 feet tall and weighed nearly a ton.

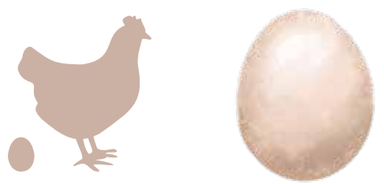
The name "elephant bird" was inspired by Marco Polo's stories of a bird so large it could prey on an elephant. The myth of the roc, the colossal bird that swooped up Sinbad the Sailor, may also have originated with elephant birds and their giant eggs.

Like other **ratites**, elephant birds were incapable of flight. "Lots of people wish they could fly like a bird, but, given the chance, birds love to lose their wings so they can just walk on the ground," says Matt. "This is probably because maintaining all that flying muscle and specialized feathers takes a lot of energy. If birds don't need to fly, natural selection reduces those structures."

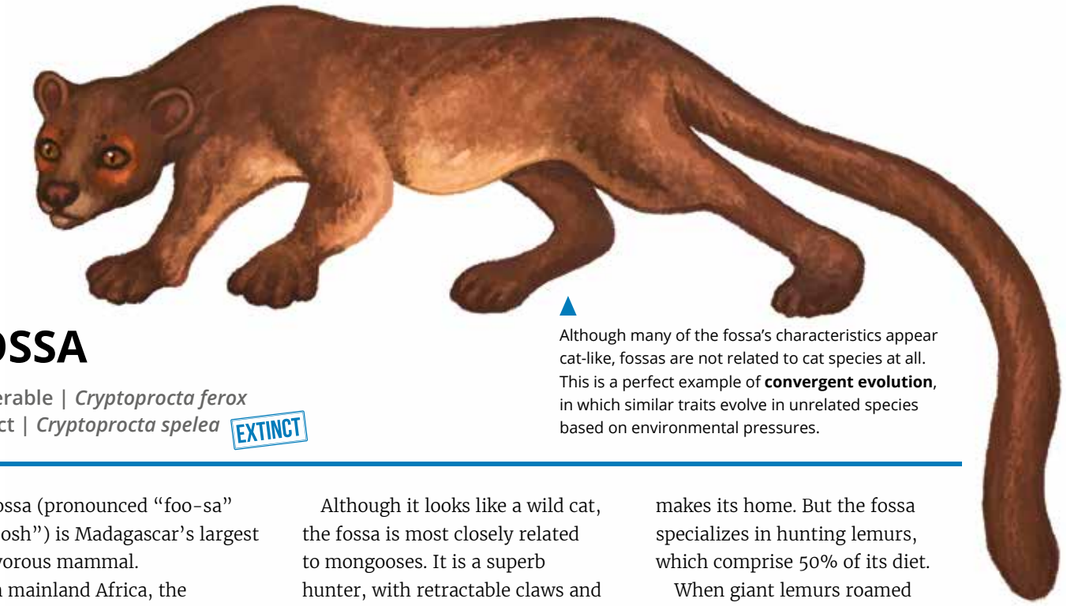
On islands, plenty of food and a relative lack of predators can eliminate a bird's need for flight. "Flightlessness is especially common on islands where there are fewer creatures raiding nests," Matt explains. "Dodos were giant flightless pigeons. Hawaii once had a giant flightless duck. And Madagascar had its elephant birds."



Giraffe-like necks allowed elephant birds to browse on the highest leaves.



One elephant bird egg could contain two gallons of liquid, the equivalent of 160 chicken eggs! Unlike chickens, however, an elephant bird probably laid only one or two eggs per year.



FOSSA

Vulnerable | *Cryptoprocta ferox*
Extinct | *Cryptoprocta spelea* EXTINCT

Although many of the fossa's characteristics appear cat-like, fossas are not related to cat species at all. This is a perfect example of **convergent evolution**, in which similar traits evolve in unrelated species based on environmental pressures.

The fossa (pronounced "foo-sa" or "foosh") is Madagascar's largest carnivorous mammal.

"On mainland Africa, the ancestors of the fossa would have been mid-tier carnivores," says Matt. "They would've been outranked by, or competing with, hyaenodonts and the ancient relatives of modern dogs, cats, and hyenas." But when the fossa's ancestors arrived on Madagascar 20 million years ago, there were no other large carnivores on the island; so fossas evolved to become the island's apex predators.

Although it looks like a wild cat, the fossa is most closely related to mongooses. It is a superb hunter, with retractable claws and swiveling ankle joints that enable it to run and leap nimbly through branches—even race down tree trunks headfirst! Meanwhile, the fossa's three-foot-long tail acts as a counterweight, keeping the animal balanced even in the most precarious positions.

Fossas are opportunistic hunters, and their diet consists of 500+ vertebrate species found in the humid forests where the fossa makes its home. But the fossa specializes in hunting lemurs, which comprise 50% of its diet.

When giant lemurs roamed Madagascar, the giant fossa was there to prey on them. Although both fossa species looked nearly identical, *C. spelea* was larger and more powerful than *C. ferox* and may have weighed as much as 44 pounds. The giant fossa most likely went extinct due to habitat loss, and the decline of the giant lemurs it preyed on. The 11- to 22-pound *C. ferox* continues to face the same troubles today.

PATTERNS OF EXTINCTION

IT TAKES A LOT to sustain large animals. They need more food, water, and shelter. Because of the space needed to find enough food or meet mates, large animals also require more space and have larger home ranges than most small animals do.

Large animals often face the additional challenge of subsistence hunting. With big, slower-moving bodies, they make easier targets and can feed more people.

Many of Madagascar's giants have already gone extinct. The largest surviving lemur, the indri, is critically endangered due to the same pressures faced by its extinct or endangered kin: habitat loss due to deforestation and climate change, and hunting pressure from humans.

TENRECS

30+ species within the family *Tenrecidae*
Conservation status ranges from
Least Concern to Endangered

This is no hedgehog! Although both have spines and can roll into spiky balls, these animals evolved completely independently. In fact, hedgehog tenrecs are more closely related to elephants than to hedgehogs! So why do they look alike? Sharp spines are an effective defense against predators—so effective, in fact, that they have evolved multiple times on unrelated animals. This is called **convergent evolution**.

For some tenrecs, spines serve an additional purpose. The lowland streaked tenrec can rub its spines together to produce high-pitched squeaks used to communicate with other tenrecs. This is called **stridulation**, and tenrecs are the only mammals known to be capable of it.

When tenrecs made landfall on Madagascar between 42 and 25 million years ago, they left behind the packed ecosystems of Africa. In their new world of reduced competition and predation, they diversified into more than 30 species.

Like lemurs, tenrecs are a superb example of adaptive radiation. "It's probably the most classic **adaptive radiation** I've seen in my life," says tenrec researcher PJ Stephenson, Ph.D., quoted in David Quammen's *The Song of the Dodo*. "You've got ancestral stock, it arrives on the island, finds all the niches available. Evolution takes its course. And it adapts to fill all the niches… You've got shrews, you've got hedgehogs, you've got moles. You've got things you can't possibly describe. It's unbelievable."

Lowland Streaked Tenrec

Lesser Hedgehog Tenrec

"THE PREDICTED ONE"

IN 1862, Charles Darwin received a specimen from a colleague. It was a white, star-shaped flower from Madagascar that would later be named "Darwin's orchid" (*Angraecum sesquipedale*). The orchid had an unusual adaptation: a nectar tube measuring almost 12 inches long. Darwin exclaimed to a friend, "Good heavens, what insect can suck this!" He then hypothesized the existence of a moth with a tongue so long that it could suck nectar from the very bottom of the tube.

Fellow naturalist Alfred Russel Wallace agreed. He was so sure of the moth's existence that he wrote, "Naturalists who visit that island (Madagascar) should search for it with as much confidence as astronomers searched for the planet Neptune—and they will be equally successful."

Darwin and Wallace were proven right with the discovery of Wallace's sphinx moth, christened *Xanthopan praedicta* ("the predicted one"). At nearly one foot in length, the proboscis of Wallace's sphinx moth is the longest of any insect.

Darwin, although he did not live to see the moth discovered, believed that the moth and the orchid had evolved together over time in a process now known as **escalatory coevolution**. As generations of the orchid evolved longer nectar tubes, the moths would evolve longer tongues. The moth had less competition for food as no other pollinators could reach the orchid's nectar, and the orchid had a higher chance of pollination because the moth was likely to visit more of the same species.

WHY MADAGASCAR MATTERS

By **CHARLIE WELCH**, DLC Conservation Coordinator

Why do we do what we do at the Duke Lemur Center? Why lemurs? Why do we feel so strongly about the importance of our research, education, and conservation missions?

It was a stroke of luck that in the 1960s, an anthropology professor with an interest in Madagascar and lemurs landed at Duke University, met colleagues with similar scientific questions, and laid the groundwork for what we know today as the Duke Lemur Center. But that was just the beginning! How and why did it all grow, evolve, and expand from that point forward?

Reaching way back will give a bit of clarifying background—and I mean *way* back! 165 million years ago, the piece of land that we now know as Madagascar was attached to the African continental land mass. Via tectonic drifting, Madagascar separated from Africa, with what today is India attached along its eastern side. India then split from Madagascar and went merrily sailing across the Indian Ocean, leaving Madagascar a completely isolated island for the past 80 million years. Because of that isolation, evolution of Madagascar's flora and fauna followed a different path there than in nearby Africa or anywhere else in the world.

But what about lemurs? How did they come to exist on Madagascar and only on Madagascar? The ancestral lemur was an African creature that did not exist until roughly only 60 million years ago—but how did that lemur ancestor get across the Mozambique Channel, water deep enough that it never provided a land bridge over millions of years of oceanic level fluctuations?

The silky sifaka (*Propithecus candidus*) is one of the rarest primates on Earth, with as few as 250 individuals remaining in the wild. They are found only in the SAVA region, where the DLC's conservation programs are based. *Photo by Martin Braun.*

DLC-SAVA Conservation encourages biodiversity conservation in the SAVA region of northeastern Madagascar by supporting the livelihoods of rural people in forest-bordering communities, and through collaborations with local environmental organizations and governmental institutions to promote environmental education, reforestation, freshwater fish farms, family planning, fuel-efficient cook stoves, and conservation-oriented lemur research projects. *Photo by Charlie Welch.*

The critically endangered diademed sifaka *(Propithecus diadema)* is one of the largest living lemurs. *Photo by David Haring.*

Approximately 40% of Madagascar's bird species, including this blue vanga (*Cyanolanius madagascarinus*), are unique to the island—the highest percentage of endemic bird species of any major country in the world. *Photo by David Haring.*

Madagascar is home to two-thirds of the world's chameleon species. *Photo by Sara Sorraia.*

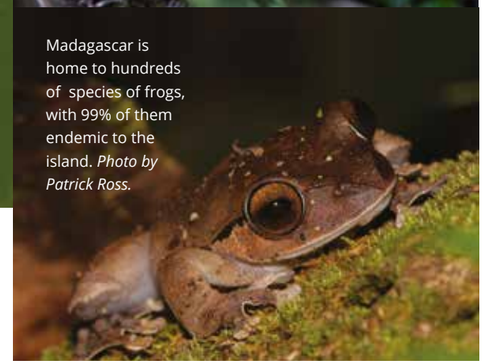
The hairy-eared dwarf lemur (*Allocebus trichotis*) is exceptionally rare. For many lemur scientists and enthusiasts, merely seeing this small nocturnal lemur is a lifetime goal. *Photo by Edgar Rabevao.*

The critically endangered indri (*Indri indri*) is known for its eerie, wailing song. The dark coloration of this mother and infant is found only in the northern part of the species' range. *Photo by Patrick Ross, taken during a research expedition funded by the Lemur Conservation Foundation.*

Red-bellied lemurs (*Eulemur rubriventer*) range through the higher elevations of Madagascar's eastern rainforests, including in the SAVA region. *Photo by Martin Braun.*

This is where things really get interesting: Science's most probable theory suggests that the first wave of ancestral lemurs made their way to Madagascar via giant mats of vegetation that floated from Africa to Madagascar. Imagine a major catastrophic event such as an enormous tsunami, kicked up by nearby volcanic activity or earthquakes. The towering waves would have crashed into the coastal forests of eastern Africa, washing copious amounts of forest debris out into the ocean. Or, imagine a strong tropical cyclone that caused African rivers to flood and disgorge into the ocean huge pieces of forest that had sloughed off of the river banks. In either case, the forest vegetation that washed out to sea would have almost certainly contained some very wet and frightened ancestral lemurs of African origin.

The Malagasy civet *(Fossa fossana)* is Madagascar's second largest carnivore, after the fossa *(Cryptoprocta ferox). Photo by Sara Sorraia.*



Madagascar is home to hundreds of species of frogs, with 99% of them endemic to the island. *Photo by Patrick Ross.*

"All of this makes lemurs a stunningly unique taxonomic group. They have become a supreme example of the power of evolution."

Now, things become even more interesting and improbable: With the good luck of prevailing winds and ocean currents pushing the floating island(s) of vegetation eastward to the island of Madagascar, at least some of the ancestral lemurs survived the journey and successfully made their new home in the exotic (to them) forests of Madagascar. Surprisingly, their new home was depauperate of mammalian competitors and predators, so the newcomers thrived in their new island home and over time evolved into the 100+ lemur species that we know today.

Among the many points that make this story truly astounding are: (1) that the floating islands delivered surviving lemurs across miles of open ocean to the Madagascar shore over what must have taken, at the very least, weeks of time; (2) that there were numerous enough individuals to provide sufficient genetic diversity to survive as a species into the long term; and (3) that the forests of Madagascar offered the appropriate resources for survival, with very little competition. And few predators! The arrival and survival of those early primates was an exceptionally remarkable and random act of nature.

At that arrival moment, tens of millions of years ago, the pre-lemurs of Madagascar were the exact same creatures as their brothers and sisters in Africa. From that point forward, however, it all changed as their evolutionary paths diverged dramatically due to different resources, competition, and predator pressures. Lemurs evolved to fill a wide array of available niches in a brand-new habitat, whereas the others back in Africa evolved into the less-diverse bush babies and lorises.

All of this makes lemurs a stunningly unique taxonomic group of primates that very easily might not exist at all without the alignment of the right set of geologic and climactic circumstances. They have become a supreme example of the power of evolution.

Back to the present: How could we at Duke Lemur Center *not* be filled with awe and scientific curiosity about how these unique mammals live and function? And about how their primate line relates to us as humans. And even about evolutionary processes in general! There is so much to learn and understand, but our quest as an institution does not stop there. We have always felt a need to share our enthusiasm for lemurs and Madagascar, and that need gave rise to our tour and education programs, which have been in place for decades and are now expanding into virtual and long-distance outreach options. That is a rare activity for a "research center." Pre-COVID, the Lemur Center was receiving over 30,000 visitors annually, many of which are school classes and other youth groups.

Finally, to the third component of the DLC's mission: conservation. For nearly 40 years, the DLC has carried out and participated in conservation initiatives in Madagascar. In part, that beginning, too, was serendipitous: In the early 1980s, Madagascar began to open up as a country after years of political isolation. Once the doors were open, the DLC immediately identified a serious need and opportunity for conservation efforts in a country riven with crushing poverty, where many rural Malagasy had no choice but to turn to the forests to feed their families. The naturally forested areas were fast disappearing, falling to subsistence agricultural techniques.

Because the DLC was home to so many lemurs outside of their native island country, we felt a responsibility to do what we could to protect them in their place of origin and to secure their future there. We couldn't just sit by and not join a broader conservation effort to protect not just lemurs, but also the other unique creatures and plant life that compose Madagascar's natural heritage.

Our precious blue and green gem of a planet is currently under human pressures as never before, and the biodiversity hotspot that is Madagascar is a microcosm of that struggle. The time for scientific discovery, education, and conservation is now. We have a responsibility and not a moment to lose.

The ring-tailed vontsira *(Galidia elegans)*, named for its striped red and black tail, is one of Madagascar's most widespread carnivores. *Photo by Patrick Ross.*

"Most people in the SAVA region have never visited the national parks that are all around them," says Evrard Benasoavina (far right). "It is important for people to see these natural spaces themselves and experience them to understand more about the value of the environment. That is why I began bringing groups of school children to the national park for field trips. We do lesson plans about lemurs and the importance of the forest. At the end, all students are so grateful to have the experience and ask for more ways they can help."

IT TAKES A VILLAGE

The importance of community-based conservation programs in the SAVA

By **LANTO ANDRIANANDRASANA**, DLC-SAVA Project Coordinator
and **EVRARD BENASOAVINA**, DLC-SAVA Education Specialist

The DLC's conservation programs in the SAVA (northeastern) region of Madagascar are important because they are building strong relationships with communities and other stakeholders. These relationships make our conservation efforts sustainable, such that communities can work independently to preserve biodiversity and to help each other based on what they've learned. For example, people who received agroecology training can help train others, and students who received training from environmental education can tell their parents how important it is to protect lemurs for the regeneration of local forests.

Our work in the SAVA continues to spread, and the number of communities involved is increasing. We share our conservation accomplishments and objectives with other organizations, so that we can all learn from our experiences working to make conservation work more efficient.

Many people have become environmental protectors after participating in DLC conservation activities. There is the creation of numerous protected areas and reforestation sites, such as New Generation School Garden (NGSG), Ambanitaza reforestation site, and others. Food sources are increasing, such as the creation of fish ponds in the Andapa high school and NGSG agroecological gardens. There is also an increase in the number of districts involved within the SAVA region, including Antalaha and Vohémar.

Through environmental education, many students and villagers have received training about the importance of the environment and how to sustainably use forest resources. There are many students who can visit protected areas like Marojejy National Park during trips that are organized by DLC-SAVA.

If the DLC weren't working in the SAVA, many people would not be aware of the region's environmental degradation, and why that is so important.

STAFF PROFILE

Meet GRAYSON!

By **GRAYSON PELLERITO**

Hi! I'm a Conservation Technician at the DLC, which means I work both in the United States and in Madagascar. I care for animals at the Lemur Center for part of the year, and spend the rest of my time working with the keepers and animals at Parc Ivoloina (eev'-uh-lah-ween) in Tamatave, on Madagascar's eastern coast.

Photo by Sara Sorraia.

Why she loves working with lemurs

Lemurs are so unique, not just because they're only found in Madagascar, but because they've evolved to truly thrive on this island. With the diversity of species, each lemur is so different for specific reasons that allowed them to be successful.

I love to observe the specific characteristics a species portrays and better understand how and why they are the way they are. Then, I love to create enrichment and other opportunities that really help bring out those natural behaviors, encouraging lemurs to act and behave as they would in the wild.

Why Madagascar is important

Lemurs are only found in one place on the planet, and their populations are drastically dwindling. I want to be part of the positive change to help these animals. Parc Ivoloina is not just a zoo, but also a center for environmental education. While working there, I'm helping care for the animals as well as assisting with educating the local community on how important lemur conservation is.

"Being an intern at the Duke Lemur Center allowed me to get a taste of what the DLC had to offer. This internship changed the course of my career by inspiring me to work hard to get to where I am today." *Photo by Bob Karp*.

Her favorite thing about Madagascar

The people! I'm so lucky to have developed close friendships with the Parc Ivoloina team and members of the community. I often eat in the village for lunch and dinner and spend time with my friends practicing Malagasy and English and learning the tips and tricks about what is around!

Her favorite lemur at the DLC

I'm a big aye-aye fan because they are truly the epitome of evolution...

and Agatha is the epitome of chaos, which is my favorite! Agatha loves to train and is so curious about enrichment, so as a keeper, I really enjoy observing her personality in different situations.

Hardest thing about her job

Not feeling like there's enough time in a day. I got into this field to give these animals the best life possible, and if I'm an hour short of finishing a project, sometimes that is tough to walk away from! This challenge always pushes me to work harder and do the most I can for each animal.

Advice to someone who wants to enter this field

Be willing to take risks and try new things! Without the different routes I've taken in my career, I would not have ended up here. This field can be challenging emotionally, physically, and financially, but the joy that your day brings makes all of that feel like nothing!

PARC IVOLOINA

Parc Ivoloina is a zoo, environmental education center, and forestry station managed by the **Madagascar Fauna and Flora Group**, of which the DLC is a founding and managing member. It houses wildlife endemic to Madagascar, including 12 lemur species, and serves as a government-authorized site to house animals confiscated by the authorities and illegally held pets surrendered by private individuals. Here, a female crowned lemur engages with an enrichment feeder designed to promote natural foraging behavior.

"On an island of lemurs, I could not help but become obsessed with chameleons! They were hidden in plain sight, and that was so impressive and mesmerizing!" *Image courtesy of Grayson Pellerito.*

Artwork by Natasha Mutch
for the Duke Lemur Center.

NEVER LET GO.

We can't think of a better message to epitomize the Duke Lemur Center's passionate commitment to our mission, which guides our decisions every day.

For 58 years, the Duke Lemur Center has held strong to its extraordinary purpose: to learn everything we can about lemurs, so we can better care for them in captivity and protect them in the wild.

We've expanded our mission to encompass non-invasive research, Madagascar conservation, and public outreach and education. We've broadened our scope to teach and inspire the next generation of environmental stewards, and to be world leaders in the care and conservation of lemurs, Earth's most endangered mammals.

Throughout our long history, the Lemur Center has been sustained through your support—and your donations continue to make a meaningful impact on our work, now and in the future.

We hope that you share the pride we have in our accomplishments. Likewise, we hope you **never let go** of the Duke Lemur Center as an important way you can make a difference in the world.

Warmest regards,

GREG DYE, Executive Director

WE INVITE YOU TO MAKE A DONATION TODAY.

Please visit **LEMUR.DUKE.EDU/DONATE,** scan the **QR code**, or call our development officer, Mary Paisley, at **919.401.7252**.

In addition to supporting the health and welfare of animals at the DLC, Cathy spent years working in Madagascar, both as a lecturer at the University of Antananarivo and as a researcher. In the field, she studied lemurs in their natural habitat and their responses to human disturbance. Here, she examines an indri in 2012. *Photo courtesy of Cathy Williams.*

One of the **World's Leading Lemur Doctors** Hangs up Her Stethoscope

DLC Veterinarian Cathy Williams Retires After 28 Years

By **ROBIN SMITH, Ph.D.**

"I've had the opportunity to expand the field of lemur medical care... more than anyone else before me. It's been an honor and a privilege."

CATHY WILLIAMS, DVM, DIPL. ACAW

It's quite possible that no one in the world has diagnosed, treated, and otherwise cared for more lemurs than veterinarian Dr. Cathy Williams.

Since joining the Duke Lemur Center in 1996, Cathy has been responsible for the health and well-being of thousands of these endangered primates, from Jovian, the much-loved Coquerel's sifaka who was the star of the PBS Kids show "Zoboomafoo," to Endora, an aye-aye who lived at the Duke Lemur Center for almost 30 years and became the oldest of her kind in human care.

Whether it was a pregnant sifaka in for an ultrasound, a ring-tailed lemur with a limp, or an elderly dwarf lemur with cataracts, it was all in a day's work for Cathy.

Now, after nearly three decades and retiring not once but twice—first in 2020 and again in 2023—Cathy is officially calling it a career.

Ask Cathy what it's been like to be a lemur veterinarian, and her answer is swift: "It's a lot of detective work."

Veterinarians can't ask their patients where it hurts. And unlike with more familiar animals such as dogs and cats, horses and cows, there isn't a lot of information on, say, proper nutrition for an aye-aye, or how to safely sedate a mouse lemur. Through her experiences, Cathy became the go-to person for all of these questions.

She co-authored the first research on the proper dose of anesthesia for a ring-tailed lemur, for example, and what to feed a baby sifaka that isn't gaining weight as it should.

One of the biggest misconceptions people have about lemur medicine, Cathy said, is that all of her patients are alike. They are all primate cousins of humans, but in many ways their similarities stop there.

Duke Lemur Center has more than a dozen different species of lemurs, and there are at least 100 lemur species in the wild, "and they're all different," Cathy said.

Her tiniest patients, grey mouse lemurs, weigh less than a deck of cards and fit in the palm of her hand. Whereas the largest species at the Duke Lemur Center, the Coquerel's sifaka, weighs as much as a house cat and stands two feet tall.

Some lemurs eat insects and grubs while others eat leaves, seeds or fruit. Some love sunshine; others are creatures of the night.

"To the general public, a lemur is a lemur," Cathy said. "But from a veterinary point of view, they have different diets, different blood parameters; they get different diseases and they respond differently to medications."

"Each species has its own very

Throughout her career, Cathy collaborated with veterinarians globally to increase our collective understanding of the diseases, treatments, and dietary needs of lemurs in human care. The treatment room in the DLC's state-of-the-art veterinary hospital, the Anna Borruel Codina Center for Lemur Medicine and Research, was named in her honor in 2023. *Photo courtesy of Cathy Williams*.

unique needs," Cathy said.

Raised in the San Francisco Bay Area, near giant redwoods and sequoias, Cathy once thought she might become a forest ranger, or a pilot.

"I love flying," Cathy said. "And I love hiking and backpacking in the woods. I have a special place in my heart for the Sierras."

But she also loved animals growing up. "I was always bringing home kittens and puppies that my mom wouldn't let me keep," Cathy said.

Her career plans took a turn when, as a senior in high school, she took an internship shadowing a veterinarian at a local clinic after school. Watching dogs and cats in for everything from routine checkups to surgeries, she thought, "this is so cool."

"I fell in love with the intellectual part; the problem-solving," Cathy said. "If you have an animal that has certain signs, how do you figure out what's wrong with it? What does the lab work and exam tell you?"

"From that point on it was like: this is what I'm going to do," Cathy said.

She earned a bachelor's degree in comparative nutrition from the University of California, Davis, in 1981, followed by a veterinary degree, also from UC Davis, in 1985.

After vet school she moved to North Carolina State University to do a small animal internship in internal medicine and surgery, then spent the next 10 years treating dogs and cats and other companion animals in clinical practices and emergency care.

Living in Durham, she had heard about the Duke University Primate Center—as it was then called—so she started volunteering there on her days off.

She liked how the work combined conservation and treating endangered species, so in 1996 she made the leap and joined the center full-time.

In 2017, Cathy escorted a breeding pair of blue-eyed black lemurs from Parc Ivoloina in Madagascar to their new home at the DLC. The transfer marked the first time lemurs had been imported from Madagascar to the USA in 24 years.
Photo by Peter Larsen, Ph.D.

"I didn't plan to work on lemurs," Cathy said. "In fact, lemurs weren't covered in my veterinary training at all. But I guess I was in the right place at the right time, and it turned out to be a good fit for me."

Cathy admits the first few years were tough. For a decade she was the only veterinarian on staff, taking care of 450-plus animals and up to 20 or more species. A lemur who wasn't eating or an infant needing round-the-clock care meant she could never just clock out.

"I was on call every weekend," Cathy said. "If there was a critical case, I was in all night working on the case, because we didn't have backup for that. There were some exhausting moments."

"It's a 24/7, 365-days-a-year job," said Dr. Bobby Schopler, who joined the center's veterinary team in 2005 and worked alongside Cathy for 16 years.

Add to that the fact that there were no how-to guides to refer to. "When I started doing lemur medicine, there were almost no publications on it," Cathy said. "There were certainly no textbooks on it."

So if a lemur came down with an upset stomach, for example, or a zoo called about an infant that was weak and having trouble nursing, she had to put her sleuthing skills to work.

To diagnose all but the most obvious ailments she had to rely on lab tests, X-rays, colleagues in other specialties, and what she could find on physical exam.

In one case, a Coquerel's sifaka had developed a terrible bout of diarrhea. The staff had been trying to figure it out for weeks. A slew of tests couldn't find the cause. He was screened for infectious diseases and parasites including *Giardia* and *Cryptosporidium*. Nothing.

"I tried ruling out everything I could think of," Cathy said.

Then a call to a colleague led to a diagnosis. Knowing that the GI tract of a sifaka is most similar to a horse's, she reached out to a friend in equine medicine and asked, "if you had a horse, and these were the symptoms and this was the bloodwork, what would you think of?"

It was *Clostridium difficile*, a bacterium that produces a toxin and can quickly become life-threatening if not treated properly. In future cases, Cathy and her colleagues found that taking stool from a healthy lemur and administering it to the patient to add back "good" gut microbes could help control such infections and keep them from coming back.

"A lot of it is trying to figure it out as you go and extrapolating from what works in other species," Cathy said.

Looking back on her career, Cathy said, what makes her most proud is being able to share the lessons she's learned.

Cathy has co-authored more than 30 scientific papers and six book chapters on lemur medicine, including some of the first studies of milk composition and safe anesthesia for different species of lemurs.

When newborn lemurs struggled to gain weight, Cathy's research revealed that the best infant formula recipe for a ruffed lemur doesn't work for an aye-aye, and vice versa.

Her research also led to non-invasive ways to screen lemurs for high iron levels—a problem thought to be common in captive lemurs but shown to be less worrisome than originally thought.

She lectured on lemur medicine in veterinary schools around the world and was an adjunct professor at the North Carolina School of Veterinary Medicine.

"I've had the opportunity to expand the field of lemur medical care and to learn more about how to treat the various different species than anyone else before me," Cathy said in a 2020 interview.

Cathy worked as a veterinarian at the Duke Lemur Center until 2017, and then as the center's colony curator for three years after that. She was set to retire in 2020, but she agreed to come back just five months after stepping down to help the center during a vet staffing shortage.

Now that she's going back into retirement for good, she's looking forward to taking more walks with her husband Fred and their dogs Kona and Lucy, and getting back to playing tennis.

"I'm trying to stay in shape to the extent that my knee will let me," Cathy said.

During her initial retirement, she also fulfilled a longtime dream of becoming a certified master gardener, and has been helping to raise funds for a community seed library.

"I'm also doing a bit of relief veterinary work," Cathy said. "And there are a few more papers I'd like to write on specific topics in lemur medicine."

Cathy said a friend once told her, about retirement, "don't commit to anything for the first year."

"Yeah, that didn't happen. It was a nice idea though."

"Cathy is recognized as one of the foremost experts in lemur medicine by the zoological veterinary communities in the United States and Europe," says DLC director Greg Dye. "Her contributions to the DLC helped establish Duke as the global standard-bearer for lemur care and conservation."
Pictured: Cathy treats an infant indri in Madagascar. Photo courtesy of Cathy Williams.

CREATE A LEMUR

Activity Designed by **FAYE GOODWIN**,
Lead Educator (2017-2023)

Illustrations by **TALIA FELGENHAUER**,
2023-24 Undergraduate Fellow in Communications

We'd love to see the new species you create! Email us your "field notes" (your lemur drawing and details) for the chance to win a finger-painting by one of the DLC's lemurs!
EMAIL primate@duke.edu

MADAGASCAR IS HOME to more than 15,000 species of mammals, birds, fish, reptiles, amphibians, invertebrates, and plants that are found nowhere else on Earth—an almost unparalleled level of endemism and species diversity.

Madagascar's most famous endemic species are its lemurs. Today, there are more than 100 different lemur species! The diversification of lemurs has resulted in some incredible adaptations, from the aye-aye's tapping finger to the fat-tailed dwarf lemur's remarkable tail.

OBJECTIVE:

In this exercise, we invite you to use what you know about Madagascar's habitats and real-life examples of lemurs' amazing adaptations, to create your own lemur species. Feeling extra creative? Create a home for your lemur that will provide the basic needs of a habitat: food, water, shelter, and space.

PROCEDURE:

Pretend you're a researcher studying lemurs in Madagascar and have stumbled upon a brand-new species of lemur! Now, you must do your best to document the new species. (It could happen: More than 40 mammal species have been discovered in Madagascar since 1999!)

REPORT YOUR FINDINGS

back to the Duke Lemur Center with the following information:

- Name the lemur—it's your discovery! Some lemurs, such as the sifaka (pronounced "shee-fauk"), are named after the sounds they make. Others, like the ring-tailed lemur, are named based on distinctive aspects of their appearance.
- Describe your lemur's appearance, including its color, size, and adaptations.
- Describe your lemur's diet. Many lemurs eat fruit, flowers, and leaves. Others eat insects. And some are opportunistic eaters—they'll eat anything they can catch, even small birds and chameleons!
- What is your lemur's social structure? Is it a nocturnal, solitary forager? Or does it live in a small or large family group?
- Describe your lemur's habitat. Does it live in Madagascar's central highlands, spiny desert, dry deciduous forest, or tropical rainforest?

NOW, HERE'S THE REALLY FUN PART:

Create a drawing of your new lemur! Your drawing should show at least one unique adaptation of the species. If your species is sexually dichromatic (males and females are different colors), a second drawing may be needed to show differences in sex.

AMAZING ADAPTATIONS

LOOKING FOR INSPIRATION for your new species? Check out these real-life lemur features!

Ruffed lemurs (*Varecia variegata* and *Varecia rubra*) are the largest pollinators in the world! Pollen sticks to the ruffed fur around their faces and gets transported from tree to tree as they feed.

Blue-eyed black lemurs (*Eulemur flavifrons*) are the most distinctively sexually dichromatic of all the lemurs: Males are black, whereas females are reddish brown.

Gray mouse lemurs (*Microcebus murinus*) are only three inches tall! Because they are so small and require fewer resources than other lemurs, they have adapted well to disturbed forests in Madagascar and are one of the most widespread and abundant lemur species.

Ring-tailed lemurs (*Lemur catta*) spend more time on the ground than other lemur species, and when traveling, they hold their tails high to keep the group together. Males also use their tails for "stink fighting."

Aye-ayes (*Daubentonia madagascariensis*) have continuously-growing incisors like a rodent's, bat-like ears to echolocate prey, and a middle finger that is skeletal in appearance and used as a primary sensory organ.

When food is plentiful, **fat-tailed dwarf lemurs** (*Cheirogaleus medius*) gorge on food and accumulate fat in their tails. When food is scarce, they enter a state of hibernation and live off the fat stored in their tails.

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We ♡ Our Supporters!

Explore the many ways you can make a lasting impact by investing in the Duke Lemur Center's work: learning from, caring for, and protecting lemurs and their natural habitat.

Visit **lemur.duke.edu/donate** to learn more, or scan the QR code to give now. We're so grateful for your support!

The Duke Lemur Center is a non-profit, tax-exempt organization operating under Duke University (EIN 56-0532129), and is accredited both by the Association of Zoos and Aquariums (AZA) and the American Association for Accreditation of Laboratory Animal Care (AAALAC).

Thank you to the following premier corporate sponsors and other organizations whose support provided a cornerstone to our success in 2023!