OUR LEGACY of Caring, Scholarship, and Scientific Discovery

Duke Lemur Center

The Duke Lemur Center

An extraordinary place exists in the heart of Duke Forest: an 80-acre campus of buildings and forested animal enclosures bustling with students, scientists, and visitors from around the world. They are drawn to this place to see, learn about, and explore the animals that call this place home: a colony of more than 200 of the most endangered mammals on Earth—lemurs.

A world leader in the study, care, and protection of lemurs, the Duke Lemur Center (DLC) was established in 1966 on the campus of Duke University in Durham, NC. For over 50 years, the DLC has brought together scientists, conservation biologists, and educators to understand and protect these extraordinary primates and make new and exciting discoveries through interdisciplinary non-invasive research.

The DLC works tirelessly not just in Durham but also in in Madagascar, the only place on Earth where lemurs exist in the wild. We're proud to work with the organizations and people of Madagascar to create opportunities for positive change, and to play a leading role in preventing the island's legendary population of endemic and endangered national treasures from being lost forever.



"To look at the Duke Lemur Center today, you would never know it was once an unknown part of the Duke University campus. Today it's a thriving hub of learning where Duke students and alumni, scientists, and animal lovers of all ages from around the world explore the importance of lemurs, scientific discovery, and conservation. No other university has anything like it!"

-SALLY KORNBLUTH, PH.D., DUKE UNIVERSITY PROVOST

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COULD THIS SIX-OUNCE HIBERNATING PRIMATE HOLD THE KEY TO DEEP SPACE TRAVEL?

The Duke Lemur Center is home to more than 20 fat-tailed dwarf lemurs the world's only hibernating primates. By mimicking the environmental factors that trigger hibernation in these ancient cousins of ours, Duke researchers are gaining significant insight into how this incredible survival technique works.

Once understood, primate hibernation may help the US military lessen the effects of sleep deprivation in soldiers on long combat missions; extend the lives of people awaiting organ transplants until suitable donors can be found; and, because hibernating lemurs live up to ten years longer than their non-hibernating cousins, identify "anti-aging" genes in humans. By helping us learn how to induce a hibernation-like condition in astronauts, these little lemurs may even help us leave the galaxy!

IMPERCEPTIBLE BRAIN ACTIVITY

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

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

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

Interdisciplinary Research: The Power of Scientific Discovery

An internationally renowned center for scientific research, the DLC is a hub of scientific discovery on the Duke University campus. Here you will find some of the most innovative and collaborative research taking place at Duke, including exciting new projects with real-world applications and major implications for human health and technology.

Aging: Like humans, mouse lemurs can develop amyloid brain plaques and other Alzheimer's-like symptoms as they age. Our non-invasive research with mouse lemurs could help explain the initial stages of Alzheimer's and other neurodegenerative diseases, helping doctors identify people at risk sooner or pointing to new ways to delay onset or slow progression of the disease.

Diet and health: Lemurs' gut microbiomes affect their digestion, immune system function, and brain health. Our gut microbiome research could have a huge positive impact on lemurs' health, from improved diets for captive lemurs to the prevention of potentially deadly diseases.

Hibernation: Could humans be sent into a deep hibernation that would carry them hundreds of years into the future? Our research seeks answers to that question and more (see facing page).

From 2014-2019 alone, the DLC's research program has facilitated 343 research projects representing 104 different institutions from six different countries. These projects have spanned a remarkable array of disciplines, including, but not limited to:

Aging | Behavioral ecology| Biomechanics| Cognition | Epigenetics | Metabolomics | Metagenomics| Molecular evolution | Neurophysiology| Phylogeography | Phylogenomics | Population genetics | Reproductive biology | Sensory communication | Speciation | Virology | Energetics

Such variety yields a large and diverse research program, but all DLC research projects have one thing in common: a non-invasive approach. **We do not allow research that will harm our animals in any way.**

The DLC's Division of Fossil Primates provides access to physical specimens and digital paleontological data to researchers around the world who are unraveling the evolutionary journey of primates.

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The skeleton of *Paleopropithecus*, a sloth-like lemur that went extinct in Madagascar only a few centuries ago

Fossils: Learning from the Past to Improve the Future

Fossils hold a treasure-trove of information and stories about the history of life on Earth. Physical fossil specimens, and now highly detailed threedimensional digital images of fossils, help researchers gain deeper insights into a long list of questions they seek to answer about the history of primates.

The Duke Lemur Center is proud to have the most diverse collection of primate fossils in North America. Its Division of Fossil Primates (DFP) is steadily building awareness, interest, and access to its impressive collection of more than 35,000 fossil and subfossil specimens from Egypt, Madagascar, Colombia, and the western United States.

The collection's specimens of primates, as well as other animals and plants that impacted primate evolution, can provide valuable clues to researchers who are studying primates and their evolution from lemur-like primates 60 million years ago to the data-gathering humans of today.

The fossils also aid researchers in their studies of other topics. For instance:

Environmental and climatic changes that affected our primate ancestors: One research group is examining the PETM (Paleocene–Eocene Thermal Maximum), a time period 55 million years ago when global temperatures rose rapidly, triggering mammals to adapt to a greenhouse world.

Ecosystems: One research group is exploring how the ecosystem in Madagascar changed when humans first arrived on the island and the largest Malagasy animals, like the gorilla-sized lemur *Megaladapis*, went extinct.

As DLC researchers learn about the biological connections between lemurs and humans, DFP researchers can learn where, when, and how our ancient connection was shaped by adaptation, diversification, and extinction. At the invitation of the Government of Madagascar, the DLC's newest conservation initiative is to develop a conservation breeding program to help the island's zoos and wildlife parks establish best practices in lemur care. In doing so, the DLC has the opportunity to improve the care and welfare of over **600 lemurs** representing **20 endangered species** housed in **14 licensed zoos** in Madagascar. This initiative may protect these species from extinction by maintaining a population of lemurs that one day may be the best candidates for reintroduction to Madagascar's forests, to reinforce or re-establish wild populations.

Madagascar Conservation: A Race Against Time

Lemurs are among the most endangered mammals on Earth. Protecting them and their only natural habitat of Madagascar—an island famous for its endemic plants and animals, and one of the world's most threatened biodiversity hotspots—is a race against time.

For more than 35 years, the Duke Lemur Center has developed and implemented programs, working side-by-side with the people of Madagascar, to create positive change to protect lemurs and their natural habitat. Our key projects, which instill and inspire understanding and respect for the island's natural resources and promote environmental sustainability, include:

Environmental education | Reforestation | Fish farming | Distribution of fuel-efficient stoves | Family planning | Sustainable agriculture | Scientific research | Conservation action

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 involve partnerships with Duke students and faculty, inspiring the next generation of conservation leaders and environmental stewards.

The sustained efforts of the DLC's staff and partners on the island of Madagascar are making a positive impact and real progress that will help not only lemurs, but also the people and other natural riches of Madagascar.

> FOR MORE THAN **35 YEARS**, THE DLC HAS WORKED ON-THE-GROUND IN MADAGASCAR TO PROTECT LEMURS AND THEIR NATURAL HABITAT.



By actively engaging students, we inspire future generations to continue the legacy of the DLC through discovery and conservation of the world's most endangered mammals. Former DLC volunteers and interns have gone on to study primates in the most remote parts of the world; to become veterinarians and zookeepers; to serve in the Peace Corps; to attend graduate school; to teach environmental education; and so much more.



Education and Outreach: Interaction that Inspires Environmental Action

The DLC's 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. Hundreds of students from across the US and around the world have been involved in the work of the DLC through these opportunities.

Because all of our research is non-invasive, the DLC is also open to the public. More than 32,000 people visit every year to learn about lemurs, science, and conservation. The DLC's education team utilizes a variety of tours and special learning venues to create a powerful learning experience. Programs include:

Tours | Summer camps | Wild Workshops | Special events | Community engagement

A large team of volunteers, too, makes a huge difference at the DLC! Volunteer animal care assistants, educators, junior docents, mentors, administrative professionals, gardeners, and photographers contribute to all areas of our operations and are a vital component of the DLC's success.

> MORE THAN **32,000** PEOPLE VISIT THE DLC EVERY YEAR TO LEARN ABOUT LEMURS, SCIENCE, AND CONSERVATION.



Protecting and Caring for Lemurs [the most endangered mammal group on earth]

CARING FOR OUR COLONY

For over 50 years, the Duke Lemur Center has cared for more than 4,315 lemurs, lorises, and bushbabies; welcomed more than 3,285 infants; and shared our lemur care expertise with zoos and conservation organizations worldwide. As active participants in the Species Survival Plans developed by the Association of Zoos and Aquariums (AZA), we take seriously our commitment to develop and adhere to breeding recommendations, ensuring optimal genetic outcomes for the irreplaceable endangered animals in our care.

DLC HAS CARED FOR MORE THAN 4,315 LEMURS, LORISES, AND BUSHBABIES AND HAS WELCOMED MORE THAN 3,285 INFANTS.



PROMOTING CURIOSITY, EXPLORATION, AND MENTAL STIMULATION

To achieve the highest standard of animal well-being, the DLC is committed to providing for both the physical and psychological needs of each individual lemur. Enrichment is provided by introducing novel items, including puzzle boxes and feeders; modifying the lemurs' environments in interesting ways, such as adding new branches to explore; housing the lemurs in natural social groups like those found in the wild; and empowering the animals to make choices within their environments.

Expert Care

SHARING KNOWLEDGE

The DLC veterinary team hosts and trains veterinarians, students, and zookeepers from around the world and fields more than 100 calls annually from outside professionals seeking their expertise in lemur care. Our extensive database of lemur health information, downloadable free online, is also an invaluable resource for animal care and research professionals.

By making its expertise available to the world, the DLC hopes that the information will help institutions better care for lemurs in captivity, and help researchers and conservationists understand these animals in order to better protect them in the wild. "In the last decade I've been on staff, it's been incredibly rewarding to see and be a part of the transformation and growth here at the DLC. The vet team's practices and standards of care get better every day because we are always seeking answers to the questions we have. Every day, we provide top quality care for our colony and we appreciate the many opportunities we have to share what we know with others."

 BOBBY SCHOPLER, D.V.M., PH.D.



Dr. Schopler mentors Malagasy veterinarian Tsiky Rajaonarivelo, who traveled to the DLC in 2019 for three months' intensive training in lemur veterinary medicine.



EMPOWERING LEMURS AND HUMANS WITH SKILLS THAT HELP BOTH

In 2006, the DLC established an animal training program to complement the center's husbandry and research programs. Utilizing positive reinforcement, the animal care staff began teaching the lemurs how to participate in their own health care and in non-invasive research. Today, husbandry behaviors such as voluntarily entering a carrier kennel, taking medication from a syringe, or allowing a pregnancy check by a DLC veterinarian have become positive interactions with the animal care staff and help us provide the lemurs with the highest quality of care.

Additionally, choosing to participate in research, such as learning to touch a red square for a color discrimination project, allows the lemurs to be relaxed and confident while simultaneously allowing researchers to collect data in a time efficient manner. Both the husbandry and research training sessions double as a stimulating form of enrichment for the lemurs as they become engaged students who eagerly participate in the opportunity to learn something new.



In 1987, the DLC established the first aye-aye conservation breeding program in North America.

> Why are lemurs so special? In addition to their beauty, rareness, and importance to their native ecosystems, lemurs resemble our earliest primate ancestors. Because the lineage that includes lemurs split from the monkey, ape, and human line millions of years ago, lemurs retain traits that are truly unique among today's primatesand these are fascinating for research! By studying lemurs, we gain tremendous insight into primate evolution and human health and behavior. We also learn the variables that most affect lemurs' health and reproduction, which helps us focus our conservation efforts in Madagascar most effectively.

Protecting and Caring for Earth's Most Endangered Mammals

The DLC is one-of-a-kind in its expert care of lemurs. No other zoo or research center—except us—is accredited by both research and animal welfare organizations, including the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) and the Association of Zoos and Aquariums (AZA). These accreditations testify that the Duke Lemur Center meets the highest standards of animal care.

- With more than 200 animals across 16 species, the DLC cares for the world's largest and most diverse population of lemurs outside their native Madagascar.
- The DLC works within a network of other AZA-accredited institutions nationwide to develop and adhere to Species Survival Plans (SSPs), using carefully planned conservation breeding programs to create a **genetic safety net** for rare and endangered lemurs.
- We're proud to have celebrated over 3,285 births since our founding in 1966.
- The DLC's 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.
- Our daily enrichment program promotes curiosity, exploration, and mental stimulation. Positive reinforcement training is used to teach lemurs to sit on a scale, enter a kennel, 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.

DLC Student Stories

"I could not have gotten where I am today without the DLC!"

My most formative primate experience came from the four years in undergrad that I worked at the Duke Lemur Center, caring for and participating in research with the lemurs and lorises. Under the effective mentorship of the DLC's management team, I gained skills in animal husbandry, training, and data collection.

Through my four years, I realized that primate welfare and research are extremely important to me. Having up-close experience with the lemurs at Duke drove me to pursue a doctorate degree in primatology and earned me a graduate research position at the Ape Cognition & Conservation Initiative and as a student in the Jane Goodall Research Center. I am currently in my second year as a primatology doctoral student and am so happy with my choice! I could not have gotten to where I am today without the DLC!

-KATIE BEACHEM, CLASS OF 2016

INSPIRING STUDENTS TOWARD PROMISING FUTURES



I was fortunate to spend almost four years working alongside outstanding staff, administrators, veterinarians, and researchers at the Duke Lemur Center. My first introduction to the DLC was through former director Dr. Anne Yoder, who led my freshman seminar course on conservation of biodiversity. As a Technician Assistant, I woke up at dawn once a week to chop fruits and vegetables, clean enclosures, and construct *enrichment items for the DLC's furry* inhabitants. Interacting with lemurs was nothing short of a thrill: they never ceased to captivate me with their inquisitiveness, intelligence, and distinct charm.

In my time with the dedicated, compassionate people of the DLC, I learned invaluable lessons in lemur husbandry and management and was further inspired to continue my quest towards zoological medicine. The DLC continues to set the standard for lemur conservation in captivity as well as for those still surviving in Madagascar, but these extraordinary species need all the help they can get. I hope I can continue to support this institution and its cause, now as a veterinarian, in the coming years.

-JORDAN COLE, D.V.M., CLASS OF 2014

DLC Student Stories

"My experiences [at the DLC] gave me the confidence to become a strong female leader in science."

As a freshman at Duke, I took a course with Dr. Anne Yoder, then director of the DLC, and was fascinated by the prospect of doing research with lemurs. This interest sprouted into a field research internship at the DLC followed by independent, hypothesis-driven research for my senior thesis. Mentoring me throughout the process, DLC staff taught me valuable and transferable life skills: I learned the importance of collaboration and teamwork required in research, developed my critical thinking skills, and maximized my ability to be flexible, yet organized. Now that I've graduated Duke, 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.

-PRARTHANA MINASANDRAM, CLASS OF 2018

I applied to one college and for one reason: I wanted to study primates, and Duke University had the Lemur Center.

My time at Duke was defined by my time at the DLC. By my second semester I was volunteering as a tour guide. That summer, I stayed for a semester of summer school to take "Primate Field Biology" at the DLC — a unique chance for students to learn how to study wild primates in a nearly wild setting.

The summer after my sophomore year, I spent five days a week at the DLC, studying self-control in five species of lemurs. No other university provides the chance for a student to become engaged so deeply and independently in primate behavior and cognition research. I truly felt like a scientist. My junior year I continued conducting cognitive studies. My senior year I developed an honors thesis. Even after graduating, I spent the summer collecting more data, which provided the basis for a manuscript entitled, "Evidence from four lemur species that ring-tailed lemur social cognition converges with that of haplorrhine primates," a notable discovery published in the journal Animal Behavior in 2011. It turned out lemurs were more intelligent than previously thought.

Now I am an assistant professor at the University of Texas at Austin. I got the job offer immediately after finishing my Ph.D. at the University of Michigan and have no doubt that I got this position because of the Lemur Center. Usually in our field people spend at least two years as a post-doctoral researcher before being competitive for a faculty position. But, based on my research at the DLC as an undergrad, I had built a CV that was extremely competitive. I had 11 publications, five of which were based on my lemur research. Importantly, the Lemur Center provided me with a strong research foundation, inspiring me to pursue other projects and publish my findings.

Now, as an assistant professor, I appreciate all the more the unique and profound value of the DLC. For example, next semester I am teaching a class, "Methods of Primate Behavior," but will have to send students to a far-flung zoo or in search of campus squirrels to get hands-on experience.

... It is wild to think that I am who I am today because of the Duke Lemur Center. But it is, after all, a wild place.

-AARON SANDEL, PH.D., CLASS OF 2010

DLC Student Stories

"I hope to continue their mission in Madagascar for many years to come!"

Ever since taking a tour of the Duke Lemur Center at a young age, I knew that I wanted to go to Duke, work at the Lemur Center, and study lemurs. Ten years later that dream became reality as I stepped on campus as a freshman and secured a work-study position at the DLC. It was an incredible four years at Duke, with weekly jaunts to the DLC providing much-needed stress relief from classes; and I learned so much from the amazing staff and researchers whose passion for the center and its mission is evident on a daily basis. Thanks to connections at the center, I even had the opportunity to study critically endangered silky sifakas while studying abroad in Madagascar.

Another ten years later and I am now writing this message from Madagascar, where I continue to collaborate with many of the people I met through the Lemur Center as I study the effects of climate change on golden-crowned sifakas for my Ph.D. I couldn't be more grateful for all that I learned and experienced at the DLC, and I hope to continue their mission in Madagascar for many years to come!

-BRANDON SEMEL, CLASS OF 2013

The Duke Lemur Center has been part of my life since my first days at Duke University as a freshman undergraduate in 2007. Having failed somewhat spectacularly as a professional ballerina, I came to college eager for a new path forward: I signed up as a DLC work-study tour guide my first week. By

junior year, my enthusiasm for lemur husbandry and research had overtaken my former passion for ballet. I joined a research lab working at the DLC, declared myself an anthropology major, launched my first independent project on scent-marking in sifakas, and decided that pursuing lemur research and conservation in graduate school was my future after college.



Now, having received a Ph.D. here at Duke, I am thrilled to be joining the DLC's research department next year as a postdoctoral fellow. Through my research on the gut

microbiomes of captive and wild lemurs, I will continue to probe how microbes contribute to lemur nutrition and health, with implications for husbandry strategies at the DLC and conservation in Madagascar.

Looking back, the growth at the DLC and in myself over the past decade is staggering. The DLC has transformed from a place few had even heard of, into one of the most famous facilities for research, education, and conservation worldwide. I transformed from a kid scared that the world had no place for me, into a confident scientist with passion, optimism, and drive for my work. I made lifelong professional and personal relationships, and I even married another DLC researcher on the new tour path last year!

Looking forward, I cannot wait for the next chapter of the DLC's renaissance. I am excited for our research team to launch new projects with truly transformative potential, particularly on hibernation in dwarf and mouse lemurs. I am eager to continue working with Malagasy colleagues and thereby create new bridges between the DLC community at home and the lemur community abroad. With the foundations put in place over the last decade, there is potential everywhere for new growth at the DLC. I could not be more excited for the future.

-LYDIA GREENE, PH.D., CLASS OF 2019

DLC Student Stories

"As a research center unparalleled by any other on the planet, it provided me with the confidence and experience that would take me to where I am now."

The Duke Lemur Center inspired my first campus visit as a rising senior in high school; before then, I knew little of lemurs and they knew nothing of me. It was the site of my first campus memories the summer before I matriculated, as I sweltered in the humidity while cleaning enclosures; anything to be close to the animals. It was, that same summer, where I first observed undergraduates conducting cognition research in order to understand lemur minds, and I aimed to be like them; months later, I would join their research group and eventually collaborate on several scientific papers during my undergraduate career.

The Duke Lemur Center was where I was trained to collect behavioral data, what inspired me to study abroad in Madagascar, and what led to my first job out of college. As a research center unparalleled by any other on the planet, it provided me with the confidence and experience that would take me to where I am now, in the homestretch of my dissertation. Finally, on a more personal level, it was also my favorite place on campus, a source of tranquility and a haven from the intensity and stress of campus life. And it all began in Natural Habitat Enclosure #4 with a family of mongoose lemurs named Pedro, Paco, and Guadalupe—where I was granted the opportunity to work with some of the world's most extraordinary creatures.

-JOEL BRAY, CLASS OF 2013

Financial Overview

"The Duke Lemur Center exercises great fiscal responsibility and works closely with the Provost's Office regarding strategic policy for growth. They have been successful in developing and enhancing revenue streams, including philanthropic giving, essential to maintaining their operations and furthering the impact of their mission."

-JENNIFER FRANCIS, PH.D., EXECUTIVE VICE PROVOST

WHERE OUR MONEY COMES FROM



WHERE OUR MONEY GOES



"These beautiful, innocent creatures face a progressive degradation and loss of their environment and well-being. It is our privilege to support the Duke Lemur Center and its conservation programs in Madagascar in their efforts to nurture lemurs and to preserve and mend their place in the world, which we share. They are a mirror to us, and by helping them we help ourselves."

-DRS. SARA MILLER AND DAVID HOWELL, T'76

Letter from the Director

What began as a small primate menagerie more than 50 years ago, has grown to become one of the most precious collections of endangered primates anywhere in the world. The Duke Lemur Center is recognized



today as a global center of innovative research, as well as a vital genetic safety net for lemurs—the planet's most endangered group of mammals. This irreplaceable biological treasure and cherished asset of Duke University provides one-of-a-kind research and learning opportunities to students, faculty, and the community. Its mission extends beyond scientific discovery

with broader impacts that include on-the-ground conservation efforts in Madagascar and educational programs designed to inspire the next generation of environmental stewards.

Thanks to a significant investment from a Duke alumnus and friend, the Duke Lemur Center is constructing a new state-of-the-art hospital and research complex that will enhance our animal care and research programs. This improved infrastructure will enable the DLC to secure more competitive research projects and funding while also securing its position as the world's leading non-invasive research facility for endangered primates.

All of us at the Duke Lemur Center are proud of our past accomplishments, but it is our future that truly drives us. As we prepare to enter a new decade, we have our sights set on achieving great things that will only be possible with support and partnerships from others who care deeply about Duke, the greater Durham community, scientific discovery, and protecting our planet.

Thank you for your support and friendship,

Greg Dye Executive Director Duke Lemur Center



RESEARCH | EDUCATION | CONSERVATION



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