LIFE IN THE TREES

A SCIENCE 3D ADVENTURE

MIDDLE SCHOOL

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symbio education™

KEY WORDS

ADAPTATION

CANOPY

COMMENSALISM

DIGESTIVE SYSTEM

DISPERSAL

EPIPHYTE

EXOSKELETON

MUTUALISM

NOCTURNAL

PARASITE

POLLINATION

SENSORY CELL

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ON TOP OF THE WORLD

What comes to mind when you imagine the rainforest? A dark jungle? Wet leaves, mud, and dense vegetation that make it hard to walk? Yes, but these characteristics of the rainforest floor are only part of this amazing ecosystem - the parts people can see! The tops of the tall rainforest trees form the **canopy**, an incredible habitat 20 to 30 meters (60 to 100 feet) above the ground. An entire ecosystem thrives among the high branches of the canopy.

Some organisms that live here, including both plants and animals, never touch the ground during their lives. But, these organisms are important parts of the rainforest ecosystem. They have amazing internal and external **adaptations** that help them thrive under challenging conditions. Scientists are just starting to learn about some of the most secretive animals of the canopy.

We are on a mission to study kinkajous and other canopy-dwelling nocturnal mammals in the Costa Rican rainforest. But first, we need to learn more about the canopy and the other species that live there.

North America

Kinkajou

Central America

Costa Rica

South America

Canopy

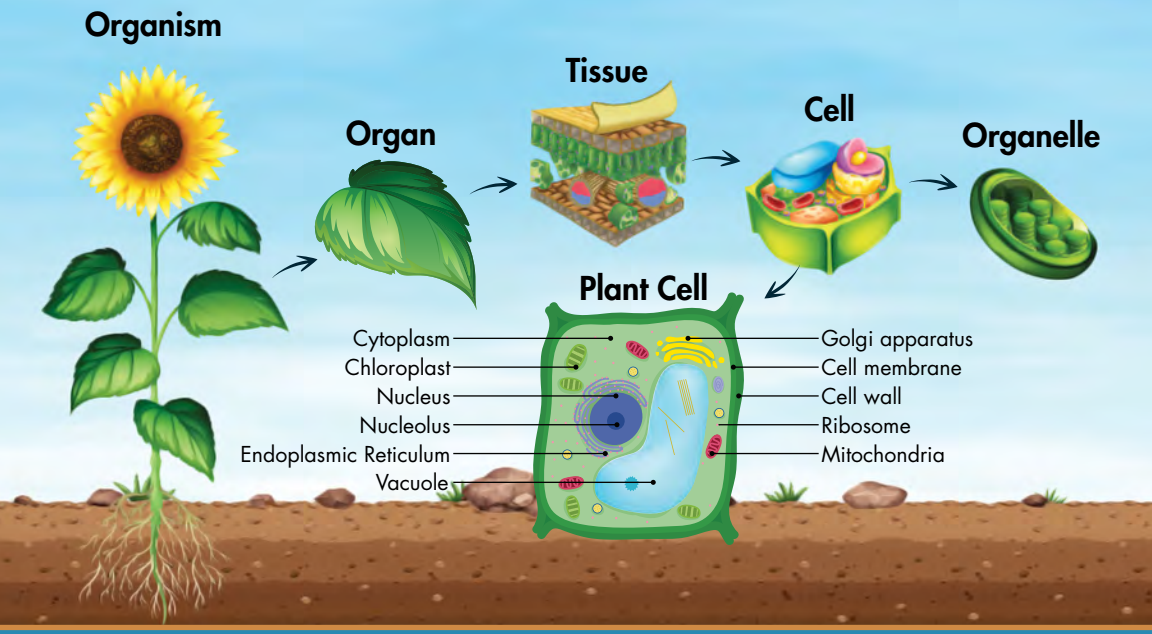
Forest floor

PLANT BUILDING BLOCKS

Without plants there wouldn't be a canopy at all. The trees that grow tall enough to form the canopy are adapted to harness the bright sunlight that hits their leaves and get enough nutrients and water to build their bodies. But the success of canopy trees, and every other plant the rainforest, starts at a much smaller level. Like all organisms, plant bodies are made of cells.

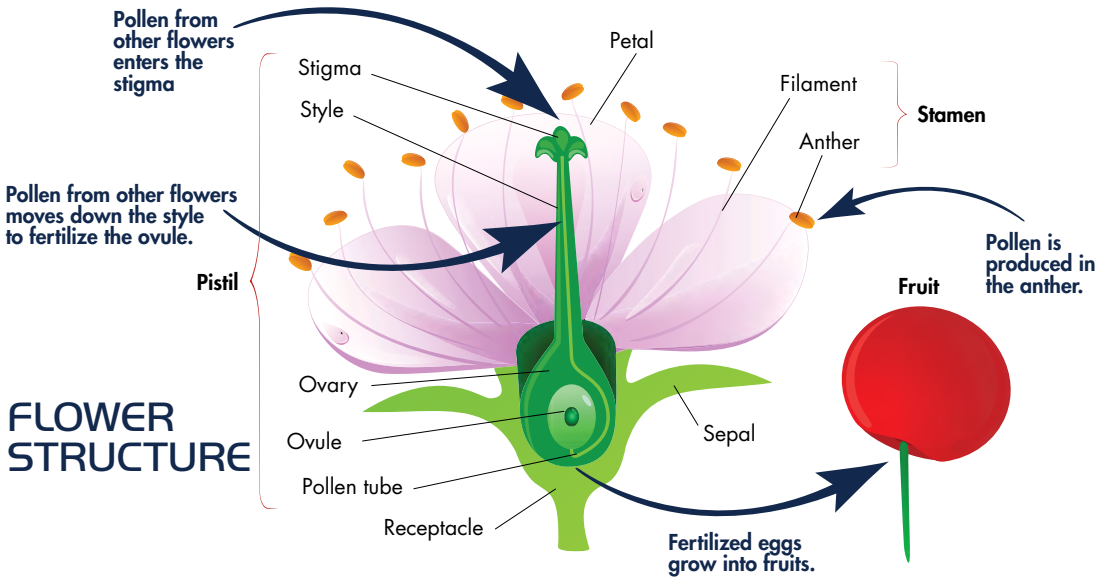
Growing tall isn't easy! Soils in the rainforest are poor, so roots can't grow deep. Buttress roots spread out to the side and help support tall trees.

PLANT BODY LEVELS



Plant bodies are made up of many levels. Organelles and molecules make up cells. Cells are the building blocks for tissues. Tissues that work together are organs, like leaves, the stem, or roots. Groups of organs together make up the whole organism.

FLOWER STRUCTURE



Flowers are a system of organs that work together to help plants reproduce. **Pollination** is the transfer of pollen from the male to the female parts of a plant, enabling fertilization.

LIFE WITHOUT TOUCHING THE GROUND!

Epiphytes, like bromeliads, are plants that live on other plants. They get nutrients and water from the air, animal droppings, and other organisms living on the plants that host them. Strangler figs are **parasites**. They get their nutrients from the host tree they grow on and can eventually smother and kill it.

WHAT A PLANT NEEDS

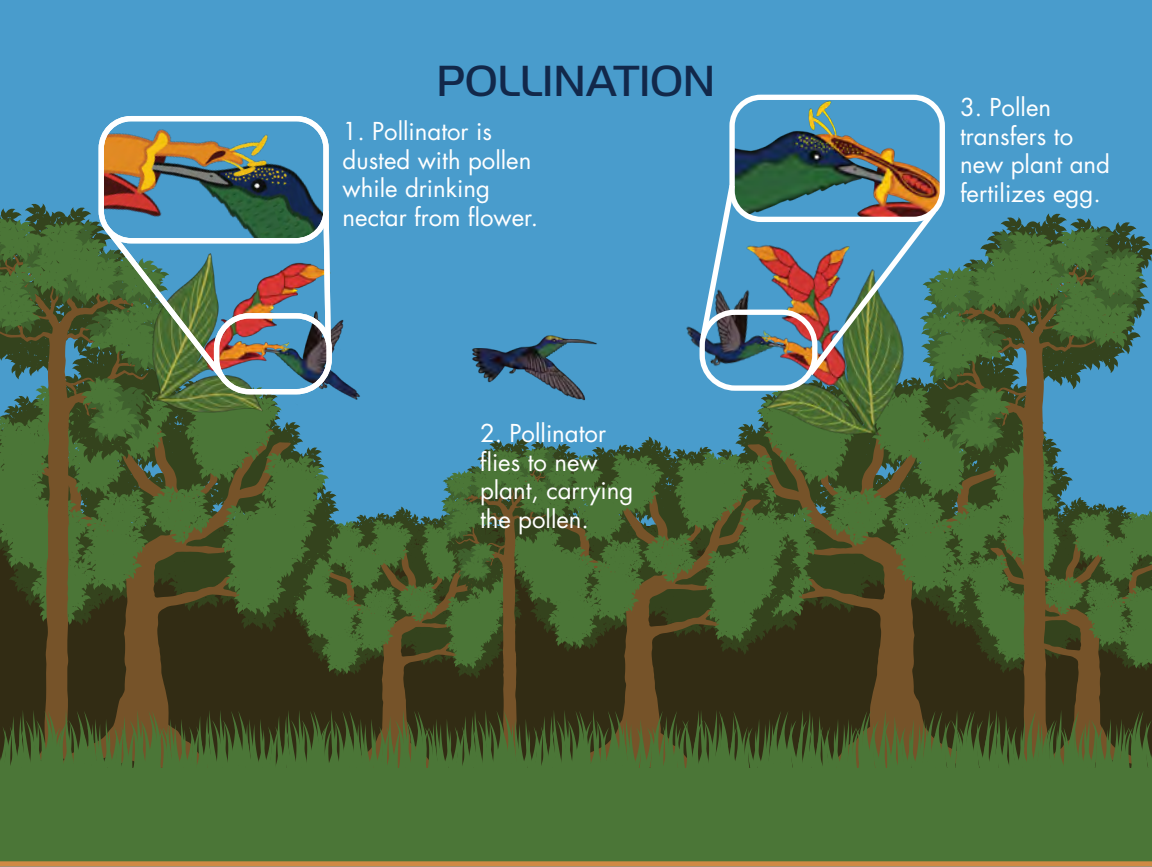
Whether are a tree, an epiphyte, or a vine, there is more to life than just growing and surviving. These plants need to reproduce! Getting to the right spot is critical for a seed. Many of its traits and how it grows are determined by its genes. The seed's parents each contributed one set of genes, and that combination of genes determines a lot about the plant that grows from the seed. The genes determine the basic leaf shape, size, if it has flowers, if it has a trunk or a stem, and many other traits. But, life isn't all about genetics. It turns out that even organisms with identical or similar genes may grow differently and have different traits based on their environments. Both genes and environment are important for determining the final traits of an individual.

Imagine the seed of a tree species lands right under its parent. It might have trouble growing. The shade from its parent's leaves may make it hard to get enough sunlight. Also, it will have to compete with its parent for nutrients. Now imagine if that seed is carried away from the parent and lands in an open area where an old tree just fell. There is plenty of light. There is no competition for nutrients. Even if the genes are exactly the same, do you think the two seeds will grow in the same way? Which do you think will grow better?

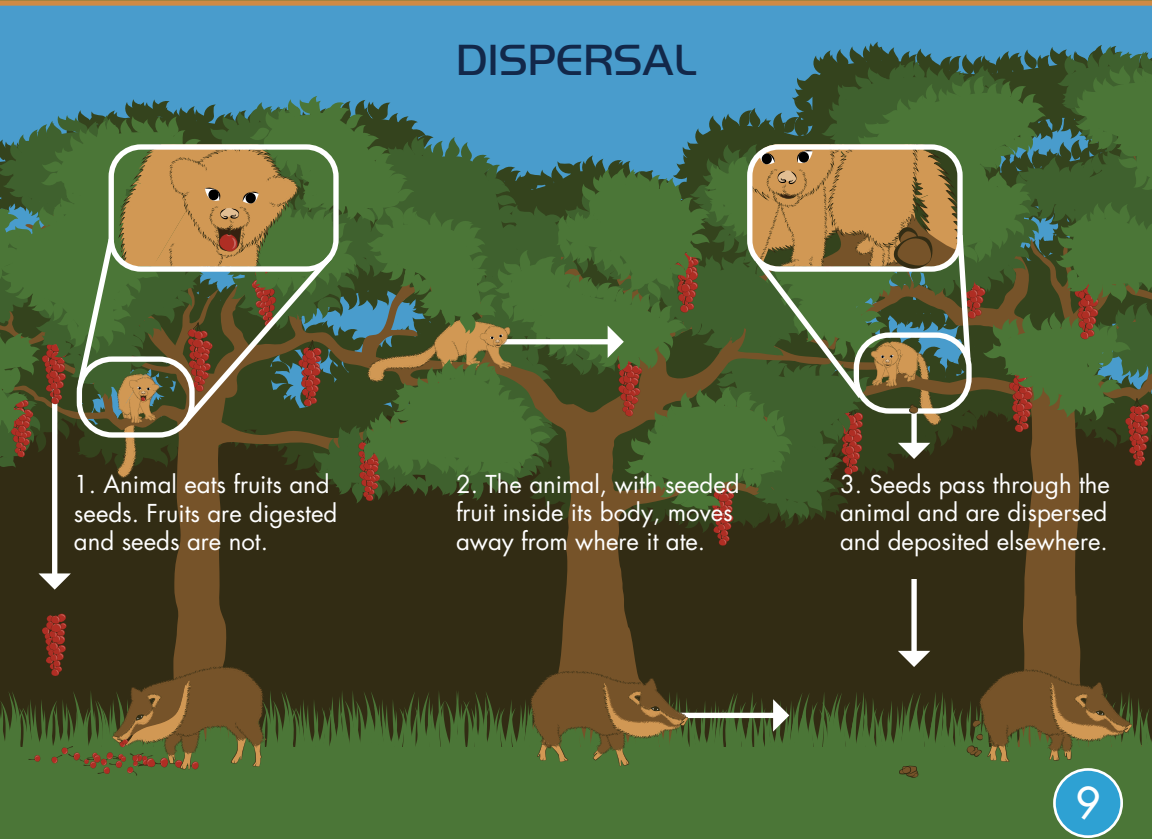
Seeds on the move! Seeds can disperse by the wind, in the water, or by animals! The seeds stuck to the dog have structures that help them hitch a ride!

If you said the seed in the open area, you are right! Seed **dispersal** is very important for plants. Seeds need to get away from their parents. It's even better if they can get a head start in some fertilizer! Many animals that eat fruit pass the seeds through their **digestive systems** and eventually poop them out. The seed survives and is surrounded by nutrients when they get started! Not all seeds are dispersed by animals eating them. Some plants release their seeds in the wind to be blown to other places. Other seeds stick to animals passing by and eventually drop off in a different location.

POLLINATION



DISPERSAL



ANIMALS OF THE CANOPY

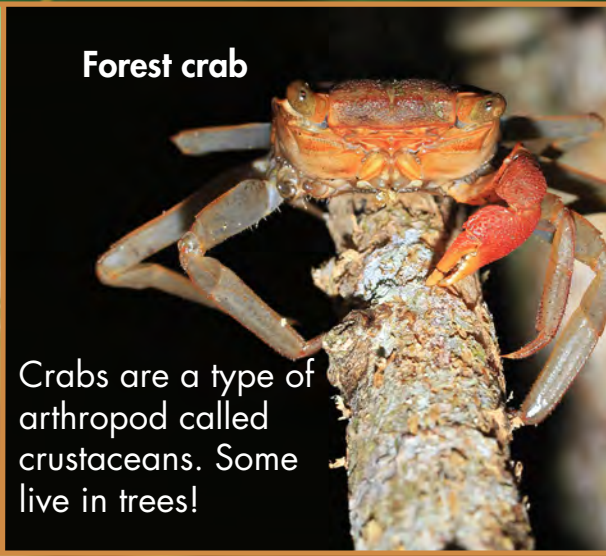
Most of the major animal groups can be found in rainforest canopies. Let's check some of them out!

Zebra longwing butterfly

INVERTEBRATES: LIFE WITHOUT A BACKBONE

Animals like insects, spiders, crabs and millipedes are arthropods. Arthropods have **exoskeletons**, jointed legs, and segmented bodies.

Jumping spider

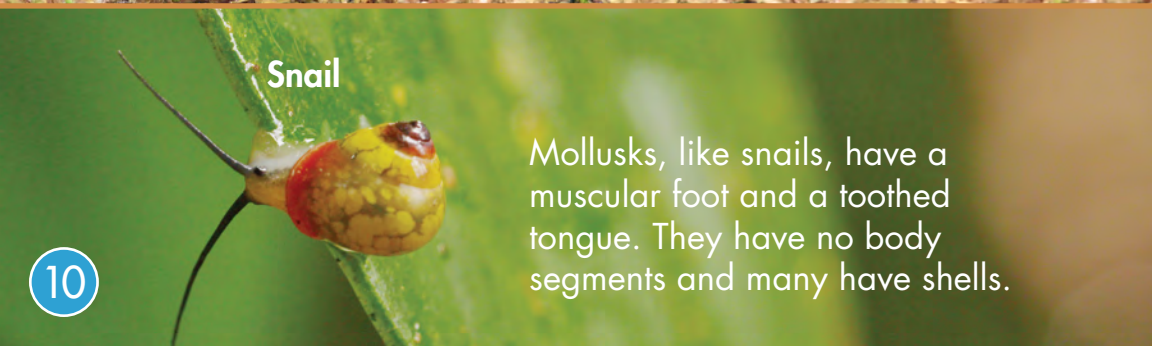


Forest crab

Crabs are a type of arthropod called crustaceans. Some live in trees!

Millipede

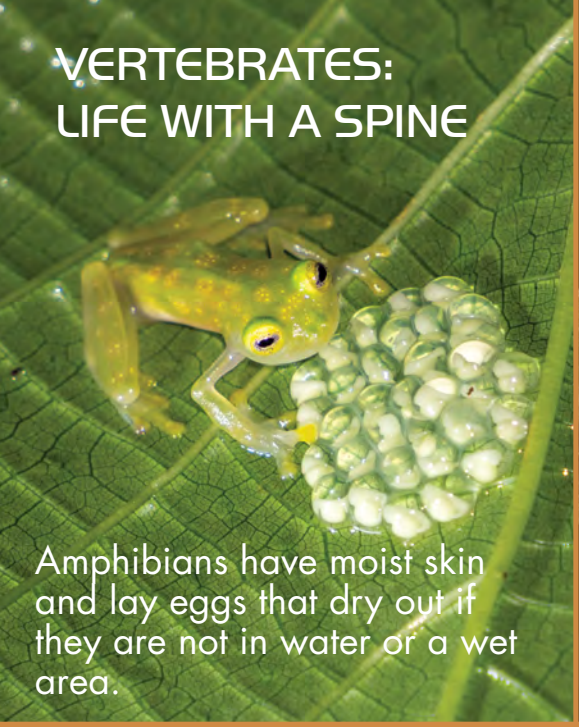
Millipedes and centipedes are myriapods, a type of arthropod with many legs!



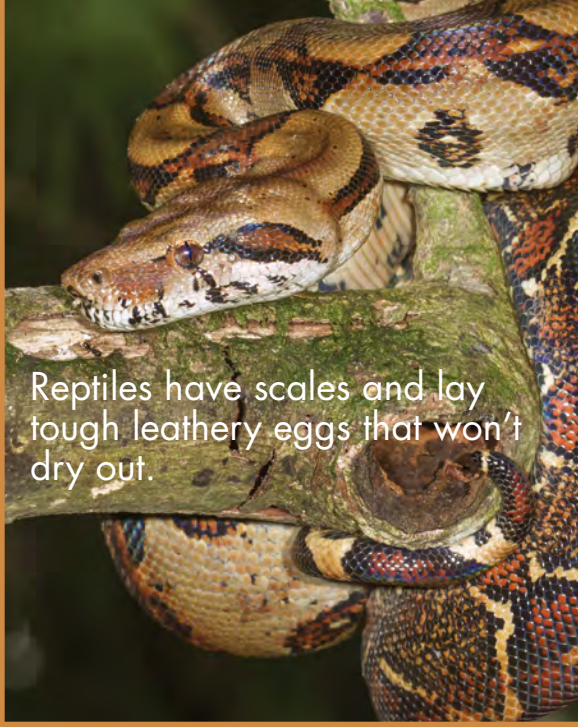
Snail

Mollusks, like snails, have a muscular foot and a toothed tongue. They have no body segments and many have shells.

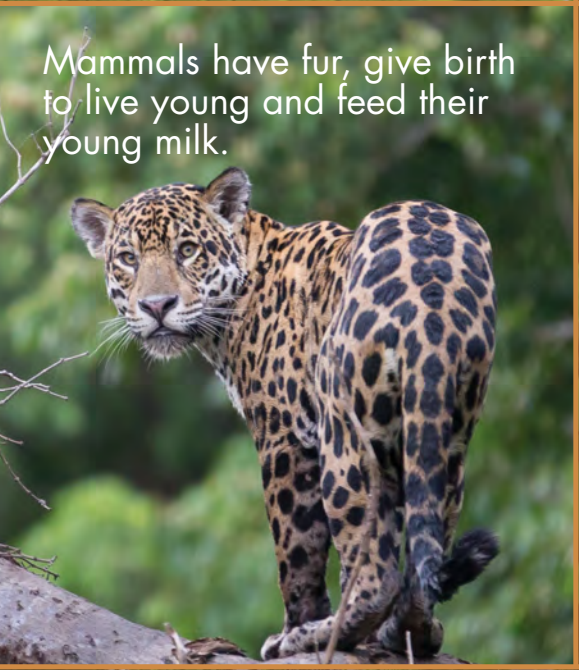
VERTEBRATES: LIFE WITH A SPINE



Amphibians have moist skin and lay eggs that dry out if they are not in water or a wet area.



Reptiles have scales and lay tough leathery eggs that won't dry out.



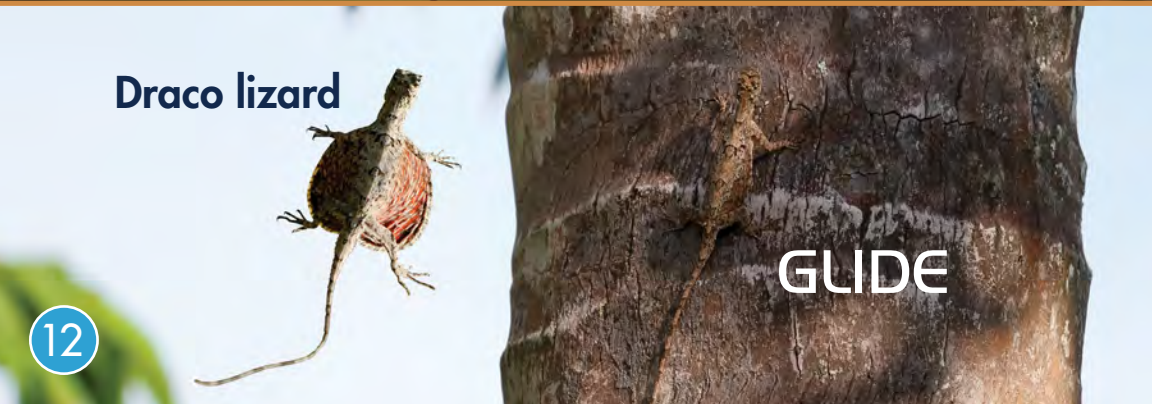
Mammals have fur, give birth to live young and feed their young milk.

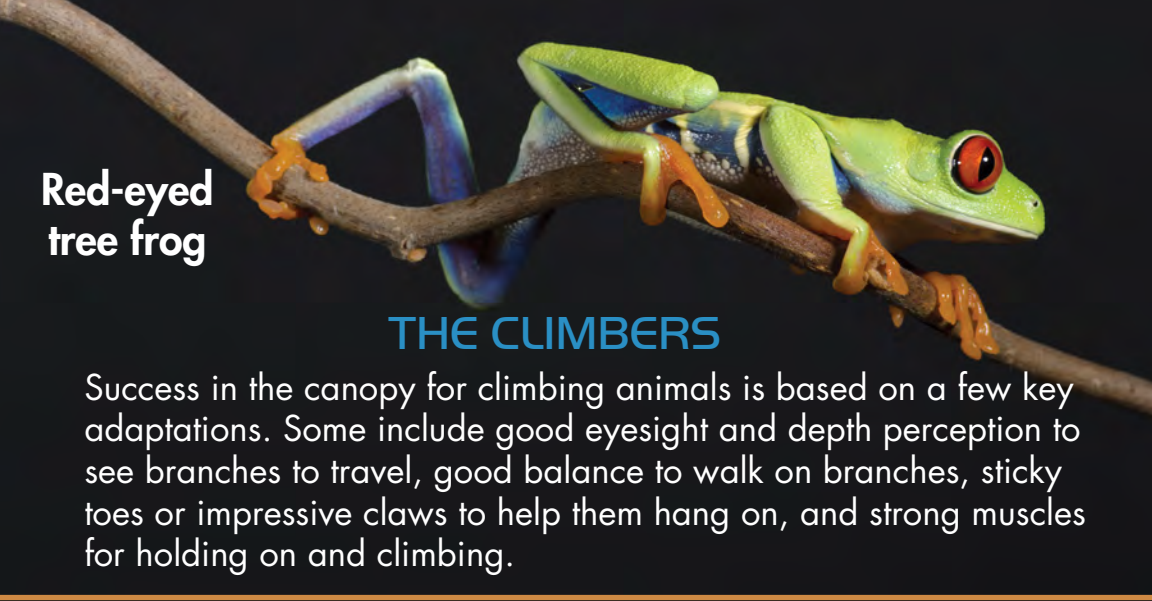
Birds have feathers and wings. They lay hard eggs.

Fish in the forest?!

In some rainforests the floods can be so high that fish swim through parts of the forest. Canopy critters have to climb higher!

All animals that make the canopy their home have to be well adapted to their environment. Some of their adaptations are external and are pretty obvious. There are two basic ways for animals to thrive in the canopy – by climbing or flying. A few species have another ability to help them get around – climbing and then gliding! Gliding is not really flying. It's more like controlled falling, but it's a great way to avoid predators and travel between trees without having to touch the ground.





Red-eyed tree frog

THE CLIMBERS

Success in the canopy for climbing animals is based on a few key adaptations. Some include good eyesight and depth perception to see branches to travel, good balance to walk on branches, sticky toes or impressive claws to help them hang on, and strong muscles for holding on and climbing.

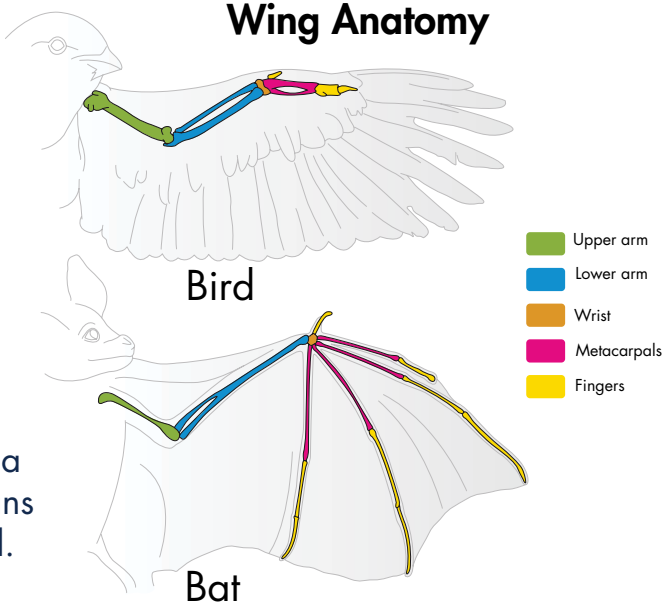
Three-toed sloth

Tamandua

THE FLYERS

Animals that can fly through the canopy all share a similar trait – wings. But that doesn't mean all flying animals are related. A close look at wings will show both internal and external differences. Flying takes a lot of energy, which means fliers need plenty of food.

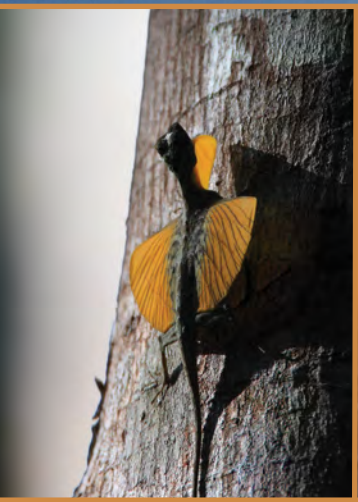
Wing Anatomy



Paradise flying snake

THE GLIDERS

Gliders can't fly, but they can still travel a long way through the air. They are able to stretch their bodies in various ways to trap air, which lets them control their descent instead of falling down quickly. They have to have incredible vision and muscle control to land safely!



Draco lizards

Colugo

WATCH OUT!

Whether they fly, climb, or glide, canopy-dwelling animals need to be excellent at sensing and responding to their environment and moving through the trees. One wrong move and they could fall to their death or break a wing. If they don't hear, see, or feel danger, they could become meals for predators.

Finding enough food is another challenge in the canopy. Predators have to be able to detect prey and track them down in an obstacle-filled environment. Even finding fruit can be tough because trees with ripe fruit may be few and far between! Having a good memory, a keen sense of smell, and the ability to cover a lot of area without touching the ground are critical!

Animals have special **sensory cells**, or receptors, that detect conditions in the environment. Then, these cells send signals to the brain through neurons. The brain interprets the signals, makes memories, and sends signals to the body to respond appropriately.

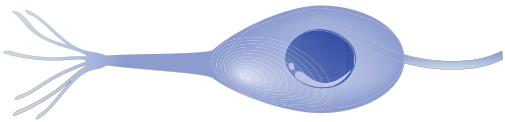
There are different types of receptors. Electromagnetic sensors detect electromagnetic radiation, like light. Light-sensitive cells in the eye, called rods and cones, are an example. Mechanical sensors detect pressure, tension, and movement. A good sense of touch is needed to choose the right branch to grab onto or to manipulate food. Mechanical sensors in the ear that can detect sound waves can help detect predators, find prey, and interact with other animals. Chemical receptors detect chemical signals. A keen sense of smell allows animals to follow the trail of chemicals released from ripe fruit, detect the scents that mark the boundaries of rival territory, and warn of approaching predators. Is this fruit ripe enough to eat? Better have a good sense of taste! Some canopy creatures, like snakes, can taste the air to find prey using chemical receptors.

SENSORY CELLS

Taste

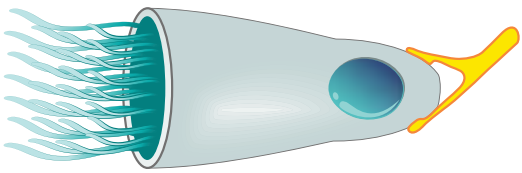
Chemical sensor

Smell



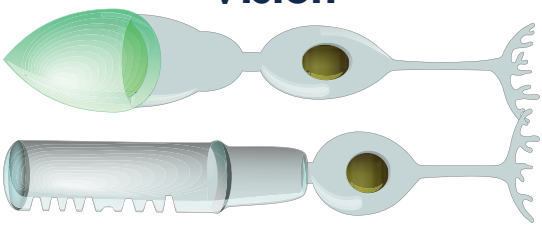
Chemical sensor

Hearing



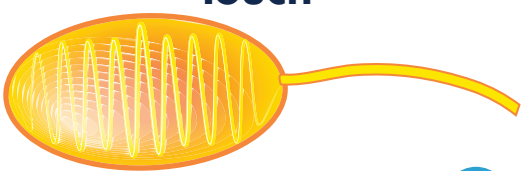
Mechanical sensor

Vision



Electromagnetic sensor

Touch

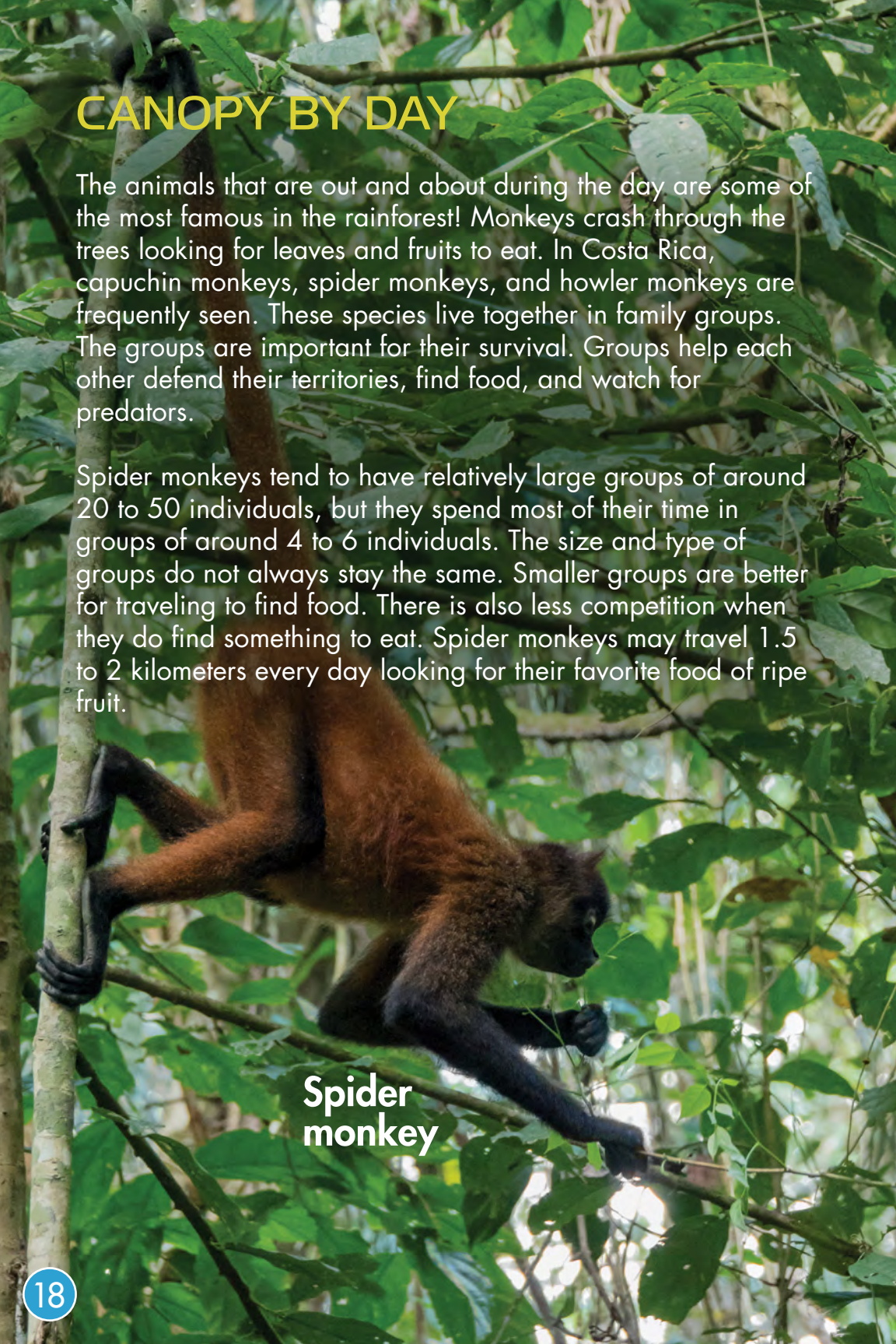


Mechanical sensor

CANOPY BY DAY

The animals that are out and about during the day are some of the most famous in the rainforest! Monkeys crash through the trees looking for leaves and fruits to eat. In Costa Rica, capuchin monkeys, spider monkeys, and howler monkeys are frequently seen. These species live together in family groups. The groups are important for their survival. Groups help each other defend their territories, find food, and watch for predators.

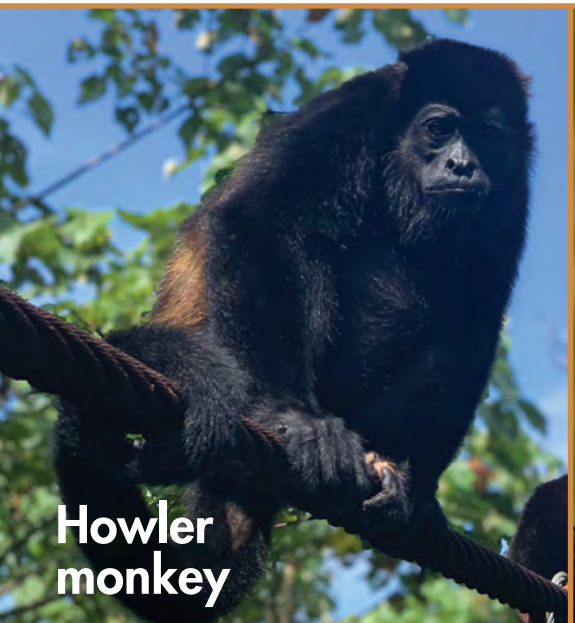
Spider monkeys tend to have relatively large groups of around 20 to 50 individuals, but they spend most of their time in groups of around 4 to 6 individuals. The size and type of groups do not always stay the same. Smaller groups are better for traveling to find food. There is also less competition when they do find something to eat. Spider monkeys may travel 1.5 to 2 kilometers every day looking for their favorite food of ripe fruit.



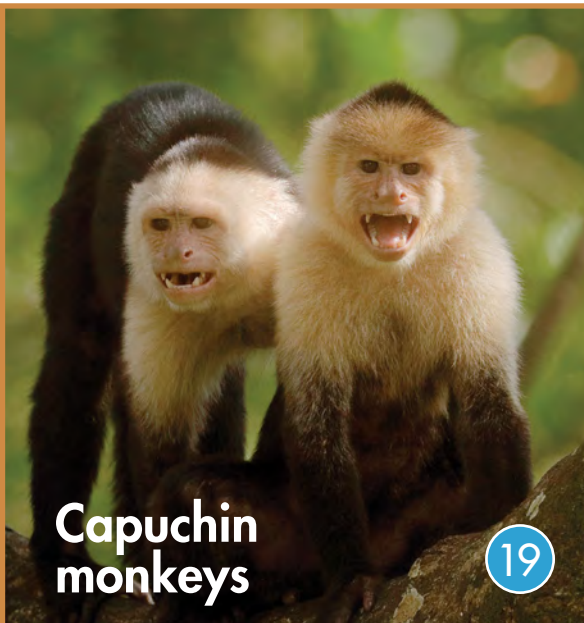
Spider monkey

Capuchin monkeys live in groups of around 10 to 35 individuals. Most group members are related females. There is usually one dominant male in the group. Sometimes there is a dominant female too. Capuchin monkeys eat a variety of foods. They love ripe fruits but will also eat leaves, arthropods, other invertebrates, small vertebrates and nuts. Capuchin monkeys can even use tools! They use rocks to smash open nuts or shellfish if they live near the water! Capuchin groups move over 1 to 3 kilometers every day in search of food. Their wide-ranging movements allow capuchin and spider monkeys to disperse seeds through the forest.

Howler monkeys don't eat as much fruit as other monkeys in Costa Rica. Most of their diets are made up of leaves. They prefer young leaves that are easier to digest than older leaves. Leaves may be easier to find than fruit, but they also don't provide as much energy. That is one reason howler monkeys don't move as far as capuchin and spider monkeys. They usually travel less than 750 meters in a day. Can you guess what howler monkeys do to let other groups know where they are and to stay out of their territories? They howl! It's common to hear howlers calling from several kilometers away, especially in the mornings and evenings! Howler monkey groups are usually between 10 to 20 individuals, including one to three adult males.



Howler monkey



Capuchin monkeys

Birds, like macaws and toucans, fly from tree to tree looking for fruits and nuts. There are actually 850 species of birds in Costa Rica. That is 10% of the total number found in the entire world and twice as many species as the United States and Canada have combined! Many species of birds live below the canopy. They fly among bushes looking for fruits, insects, and other tasty morsels near the ground. Other bird species spend most of their time high in the canopy, where they may eat fruits, nuts, or nectar from flowers.

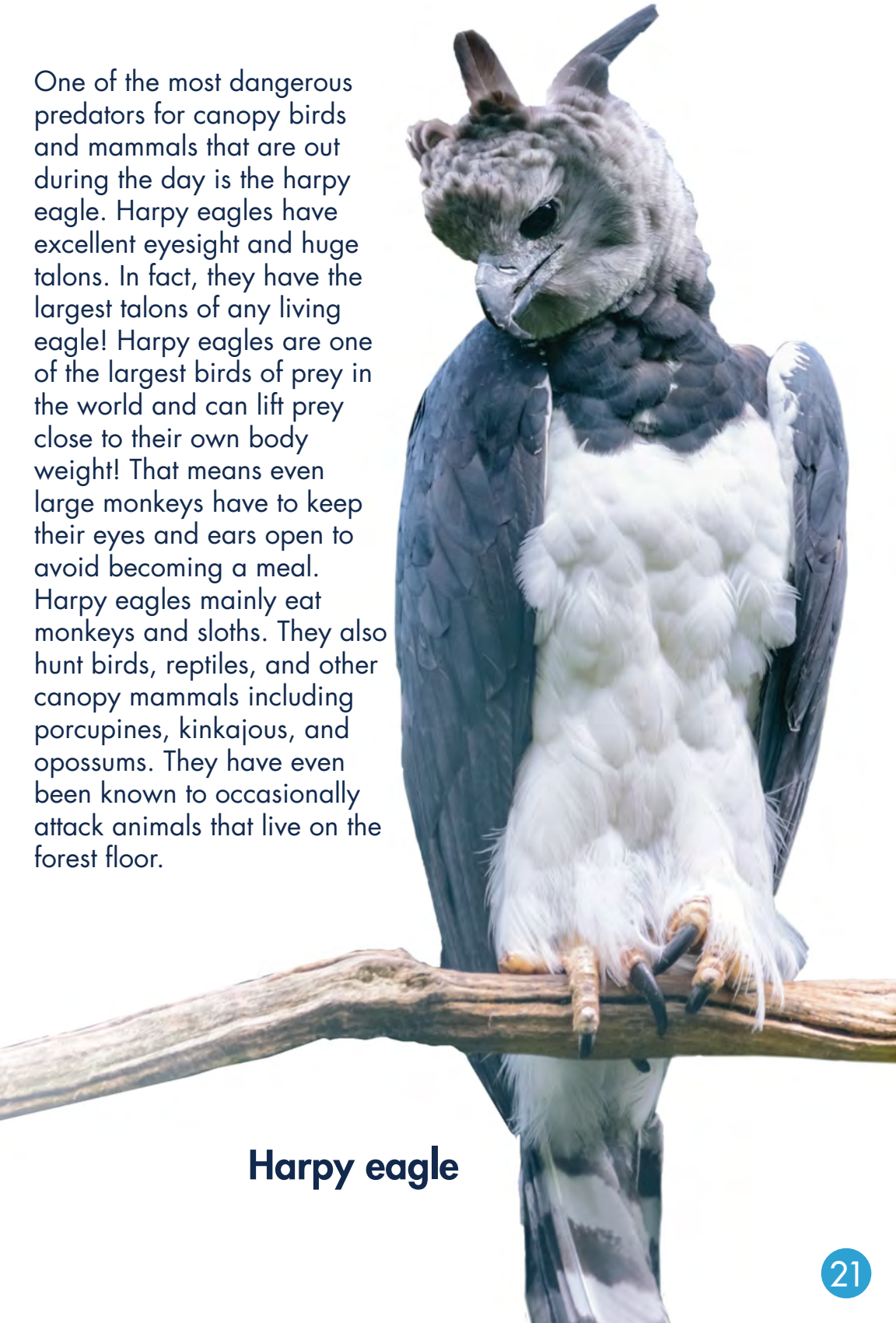
Chestnut-mandibled toucan

Hummingbird

Yellow-chevroned parakeet

Red-legged honeycreeper

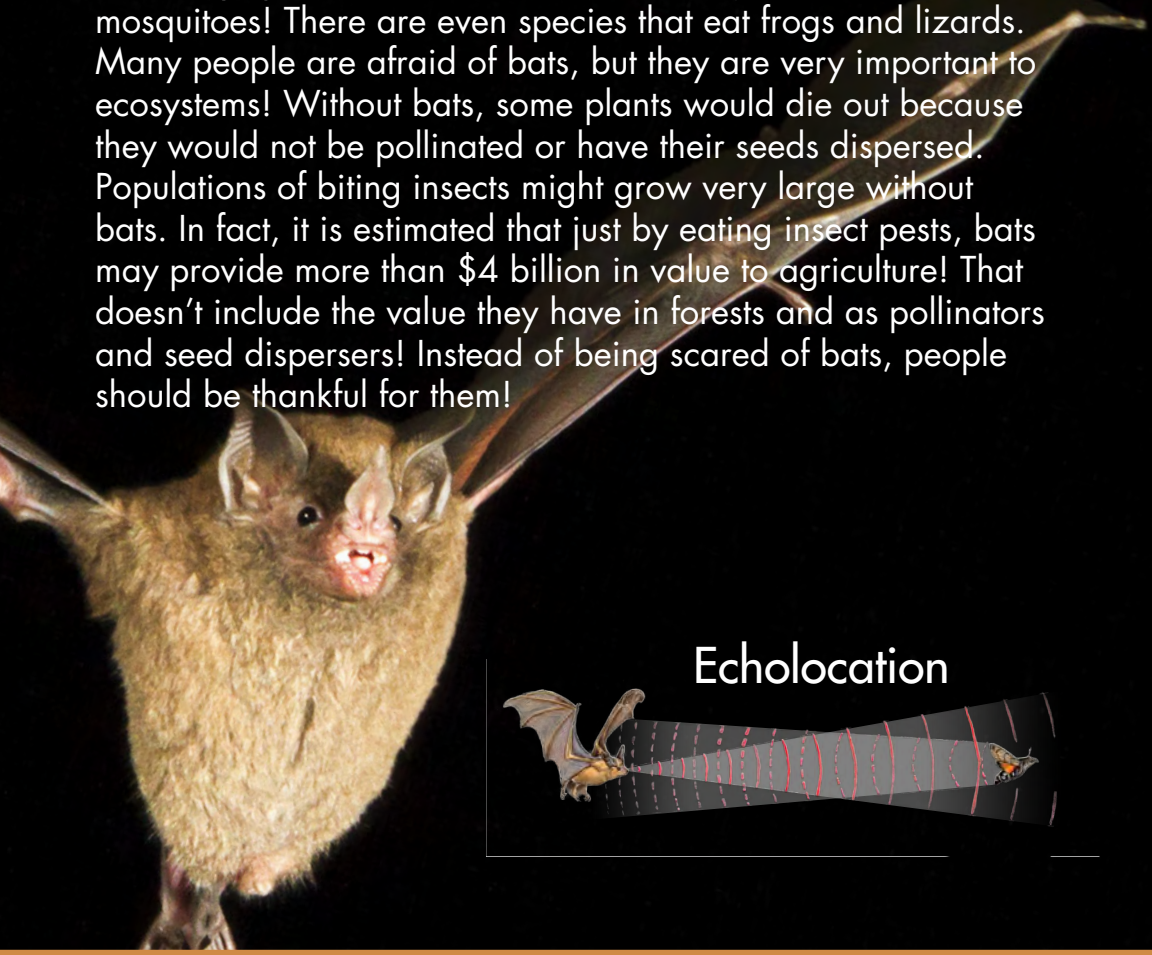
One of the most dangerous predators for canopy birds and mammals that are out during the day is the harpy eagle. Harpy eagles have excellent eyesight and huge talons. In fact, they have the largest talons of any living eagle! Harpy eagles are one of the largest birds of prey in the world and can lift prey close to their own body weight! That means even large monkeys have to keep their eyes and ears open to avoid becoming a meal. Harpy eagles mainly eat monkeys and sloths. They also hunt birds, reptiles, and other canopy mammals including porcupines, kinkajous, and opossums. They have even been known to occasionally attack animals that live on the forest floor.



Harpy eagle

CANOPY BY NIGHT

After the sun sets, a completely new set of animals wakes up from a day of sleeping and emerges into the night. Bats may be the most famous **nocturnal** animals in the rainforest. In Costa Rica, there are around 110 different species of bats. That is almost 10% of the world's total! Bats are most famous for feeding on blood, but there are only three species of blood-drinking vampire bats. Many species of bats drink nectar and are pollinators. Others eat fruits and disperse seeds. There are many species that eat insects, including moths and mosquitoes! There are even species that eat frogs and lizards. Many people are afraid of bats, but they are very important to ecosystems! Without bats, some plants would die out because they would not be pollinated or have their seeds dispersed. Populations of biting insects might grow very large without bats. In fact, it is estimated that just by eating insect pests, bats may provide more than $4 billion in value to agriculture! That doesn't include the value they have in forests and as pollinators and seed dispersers! Instead of being scared of bats, people should be thankful for them!



How does a bat get around at night? Echolocation! It produces clicks that travel into the environment. The clicks bounce off objects and reflect back. Sensory cells detect the echo and transmit the information to the bat's brain. The brain then forms an image of the environment.

Bats can be very social. In Costa Rica, there are several species of tent-making bats! They bite along the stems of large leaves, causing them to fold over into a tent. During the day, groups of these bats roost, or rest, under the tent they made! Other groups of bats roost in caves, under bridges, or in holes in trees. Grouping together can help bats stay warm. Vampire bats are actually one of the few species that help each other out. For instance, if a vampire bat misses a meal three days in a row, it will starve to death. But, a bat in a roost that has fed successfully will share some of its blood meal with one that needs a meal! Later, the bat that was given a meal can return the favor!

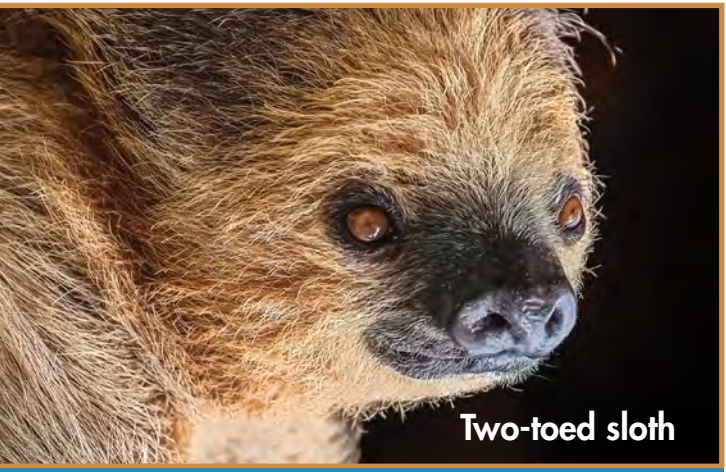
Living in groups isn't always a good thing for bats. In such close spaces, they can quickly pass diseases, like viruses. In fact, bats carry many different viruses including some that can infect humans. Even though bats have lots of viruses in their bodies, they rarely get sick. Why? Their immune systems have a special defense mechanism. In humans and other mammals, the immune system can go into overdrive when it encounters a virus. It is this immune overreaction that can make somebody very sick. Bats dampen this response. They have just enough defense without overdoing it. Their high body temperatures, caused partly by using so much energy to fly, might also help them suppress viruses.

Three-toed sloth

Ocelot

Ocelots are nocturnal predators. They eat reptiles, amphibians, small mammals, and birds.

Even though sloths don't move much at any time of day, they are more active at night. Three-toed sloths mostly eat leaves and stay in very small areas. Two-toed sloths have broader diets, move farther distances, and may be important in dispersing seeds and pollinating flowers. As slow as they are, you might think three-toed sloths would never risk coming down to the ground where they would be easy prey for predators like jaguars. But, once a week three-toed sloths take the risk and use a lot of energy to climb down to the ground…to poop! Why would they do that? That's where it gets really interesting. Moths that live in the sloth's fur lay eggs in the sloth poop when it climbs down to the ground. The moth eggs hatch and the larvae feed in the sloth poop until they climb into the sloth's fur when it passes by. The larvae bring nutrients from the sloth poop into the sloth's fur. The nutrients from the sloth poop that covers the larvae provides nutrients for the algae that grows on the sloth. And then, the sloth eats the algae and gets energy and important nutrients! It turns out that species of sloths that don't travel to the ground as often don't have as many moths or as much algae growing on them to eat! So, it looks like sloths use their bathroom breaks to help form algae on their fur. Yum!



Two-toed sloth

Scientists used to think the relationship between algae, moths, and sloths was a commensalism. The algae and moths benefited, but sloths were not affected. Now, it looks like a mutualism – sloths are cultivating the algae to eat and the moths help!

Mexican tree porcupine

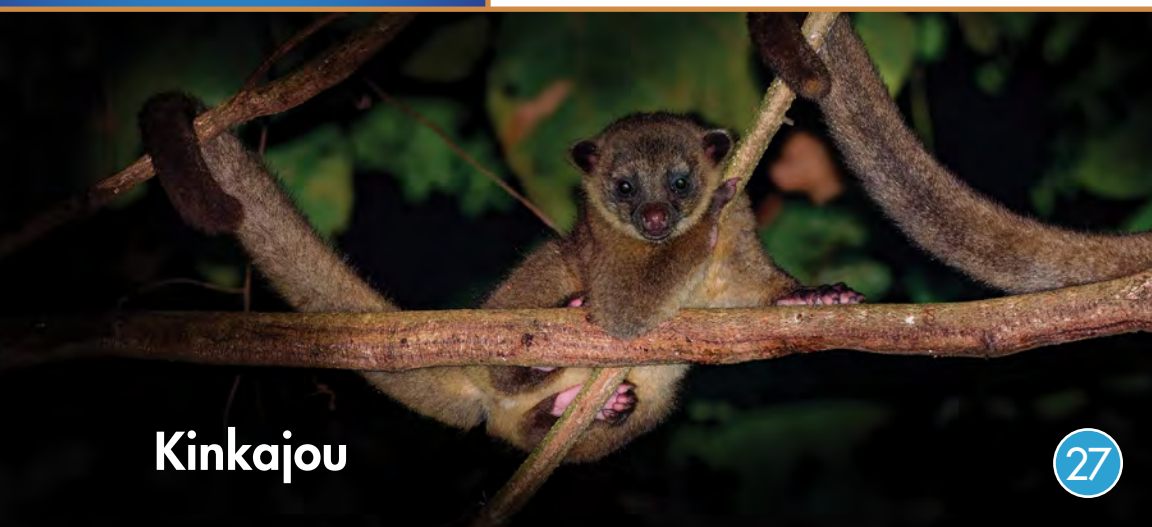
Mexican tree porcupines and woolly opossums are two other nocturnal climbers. The opossums eat fruit and occasionally nectar, while the porcupines prefer leaves and fruit. Unlike their relatives on the ground, Mexican tree porcupines have a prehensile tail. That means that they can use it like a fifth hand to hold onto tree branches!

Woolly opossum

KINKAJOU!

Kinkajous (*Potos flavus*) are another nocturnal mammal found in the rainforests of Central and South America. They look similar to monkeys, but are relatives of racoons. Kinkajous grow to be up to 60 centimeters (2 feet) long and weigh up to about 4.5 kilograms (10 pounds). Even though they are not related to the monkeys that live in the same forests, kinkajous also have a prehensile tail that helps them grab branches and move through trees. Their tails are so strong they can actually use them to hang from branches to reach meals. Their tails are also handy for curling up in a ball to sleep through the day.

Kinkajous also have paws that can rotate 180 degrees, allowing them to run backwards on branches! This adaptation also helps them walk down tree trunks headfirst. Their paws and tails make them incredibly nimble in the trees. And, at night their large eyes help them see well in low light.



Kinkajou

Kinkajous can be loud. Their barks and squeaks can be heard from long distances in the rainforest at night.

Kinkajous used to be thought of as solitary, or living alone. But recent studies show that their social behavior is more complex than once thought. Kinkajous usually look for food on their own. But during the day, they sleep together with members of their family in a tree hole or a dense clump of leaves. Family groups groom each other. In Panama, these groups include two males, one breeding female and two young kinkajous. The family groups mark their territory using scent glands to keep other kinkajous away. For most mammals, young males have to go look for a new place to live when they are old enough. But for kinkajous, it appears to be the females that disperse from their mother and father's home area. Breeding females are often found alone. Males may stay with their fathers to help defend an area from other male kinkajous.

After being pregnant for about 3.5 months, kinkajous give birth to a single baby. Sometimes they have twins. Babies are born with their eyes closed. After a month their eyes open, and after two months they are able to easily move around the trees! Only mothers provide care, but males will interact with young kinkajous in their social groups.

STUDYING CANOPY CRITTERS

Canopy mammals have many advantages. They have adaptations that help them move through the trees. They don't weigh too much so they can navigate even the smallest branches. People don't have those same advantages. That is one reason that for years people have had a hard time learning about these incredible animals. In the past, scientists spent days following diurnal species, like monkeys, through the rainforest, watching them with binoculars. Binoculars aren't very useful for observing kinkajous and other nocturnal creatures or plants that live high in the trees. But, rope and high-tech tools can help scientists learn a lot more about these rainforest species.

Studying canopy animals, like kinkajous, can be difficult work. Humans have several methods that enable them to work high up in the treetops.

Tirimbina Biological Reserve in Costa Rica is a great place to study canopy mammals at night! The reserve has 345 hectares of protected forest. Trails allow scientists and students to access the diverse habitats of the rainforest. Research teams are working throughout the rainforest to study it. They have stations where they can monitor the plants and animals of the forest. Two suspension bridges let scientists walk through and observe the canopy at eye level. The bridges also provide a highway for kinkajous and other canopy animals to get around. Dr. Bernal Rodriguez Herrera leads many studies in the reserve. His research teams spend much of their time studying nocturnal mammals like kinkajous, woolly possums, and bats.

Now, let's join the research teams to study canopy critters!

GLOSSARY

ADAPTATION
a trait of an organism that helps it survive in its environment

CANOPY
the uppermost layer of trees or branches in a forest

COMMENSALISM
a relationship in which one species benefits and the other is not affected

DIGESTIVE SYSTEM
the body system responsible for turning ingested food into absorbable nutrients

DISPERSAL
moving away from a parent

EPIPHYTE
a plant that grows on top of another plant

EXOSKELETON
a skeleton on the outside of the body

MUTUALISM
an interaction in which both species benefit

NOCTURNAL
active or occuring at night

PARASITE
an organism that lives off of and harms another host species

POLLINATION
the transfer of pollen from the male part of a plant to a female part of a plant enabling fertilization

SENSORY CELL
a cell that detects information through receptors on the body surface which is sent to the brain through nerves

PHOTO CREDITS

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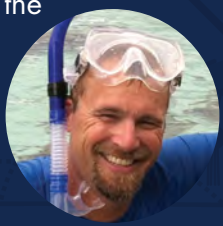
SCIENCE 3D

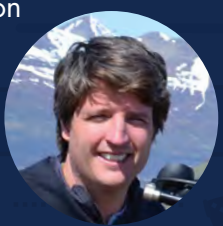
Thanks for exploring with us! Our science adventures take us around the world to uncover secrets of the most amazing animals and places. Our mission and passion is to share these scientific discoveries with you. There are so many cool things to see out there, even in your own backyard, so get outside and explore!

MIKE HEITHAUS PH.D.

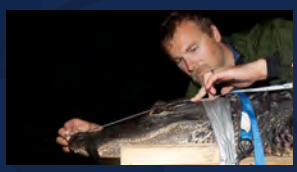


Dr. Mike Heithaus is a scientist, explorer, author, educator, and television host. He is a professor of biology and Dean of the College of Arts, Sciences & Education at Florida International University. Mike and his students study sharks, whales, sea turtles, and other large marine animals around the world. They also work with people to help protect these species. Mike loves sharing his work with others. He has written text books and helped create programs for students in elementary, middle, and high school. He has been on television programs including on PBS, National Geographic, and Discovery Channel's Shark Week.

PATRICK GREENE



As a wildlife filmmaker, Patrick has always had a passion for animals. He started to draw pictures of sharks and whales when he was just five years old. Later, he went to college to become a marine biologist and learned a lot about science. Then he got a job in television and learned how to make videos, too. Since then, he's gone all over the world studying and filming wild animals. He's made shows for National Geographic, PBS and ABC, and even won an Emmy Award. He loves making videos to teach students about science and about the many creatures that share our world.



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