

# RIVER DRAGONS: NILE CROCODILES

A SCIENCE 3D ADVENTURE

MIDDLE SCHOOL



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symbioeducation™

# KEY WORDS

BALANCED FORCE

BODY SYSTEM

CIRCULATORY SYSTEM

COURTSHIP

DELTA

DIGESTIVE SYSTEM

DOMINANCE

ECTOTHERM

ENERGY

EVAPORATION

EXCRETORY SYSTEM

IMMUNE SYSTEM

KINETIC ENERGY

MOLECULE

MUSCULAR SYSTEM

NERVOUS SYSTEM

ORGAN

POTENTIAL ENERGY

RESPIRATORY SYSTEM

SKELETAL SYSTEM

TISSUE

TRANSPIRATION

UNBALANCED FORCE

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# MASTERS OF FRESHWATER

Crocodiles and their extinct relatives have been at the top of the food chain in tropical lakes, rivers, and wetlands for millions of years. Today, crocodiles, along with alligators, caimans, and gharials – members of a group called the “crocodilians” – are the undisputed masters of the freshwater habitats where they are found.

With some species, like the Nile crocodile (*Crocodylus niloticus*), growing to enormous size, being equipped with incredible strength and speed, and having the most powerful jaws on the planet, even big animals have to be careful coming to the water for a drink! Crocodilians seem like they are river dragons!

Because crocodilians can be dangerous and people have used them for food and other products, populations of many species have been hunted to near extinction. But people have helped most crocodilians begin to recover and take back their place in ecosystems. People need to find ways to protect the growing populations of these incredible animals as well as their pets, livestock, and themselves. We are going on a mission to help find a way for Nile crocodiles and people to live together. But first, let’s explore crocodiles and their worlds!



# CROC, GATOR, CAIMAN, OR GHARIAL

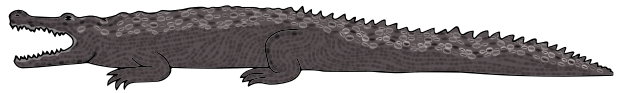
Crocodiles are reptiles. They are **ectotherms**, or “cold-blooded.” They have skin covered with dry scales. They lay eggs on land that are covered with leathery shells to keep them from drying out.

The first relatives of crocodiles appeared around 225 million years ago in the late Triassic period. These early crocodiles varied in size from fairly small to huge. Unlike today’s crocodiles, which are almost exclusively carnivores, some ancient species were omnivores and others were herbivores. But there were also super-predators. Around 120 million years ago, a super croc named *Sarcosuchus* grew to around 9.5 meters (31 feet) and 4,300 kilograms (9,500 pounds)! An even bigger croc, *Deinosuchus*, lived around 75 million years ago. It grew to more than 10 meters (33 feet) and 5,000 kilograms (11,000 pounds)! Both of these species were incredible predators and would have snacked on dinosaurs!

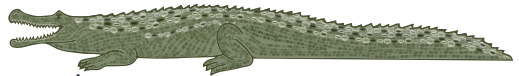
*Purussaurus brasiliensis*  
10.3 meters 20.4 - 5.3 mya



*Deinosuchus riograndensis*  
10 meters 82 - 73 mya



*Sarcosuchus imperator*  
9.5 meters 133 - 112 mya



*Crocodylus niloticus*  
6 meters Present day



*Alligator mississippiensis*  
4.6 meters Present day



Triassic Period



Cretaceous Period



Jurassic Period



Present Day

Crocodiles and their relatives have been around for more than 200 million years. The world has changed a lot over that time because the continents have been in motion. Many ancient crocodylians would have crossed paths with dinosaurs.

Crocodylian  
Ancestor

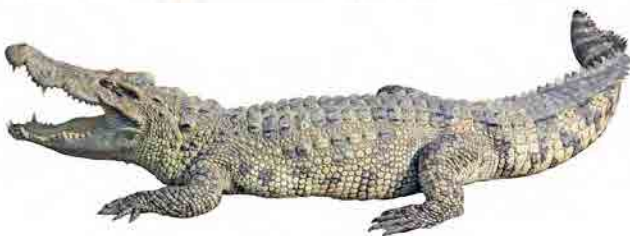
Caimans



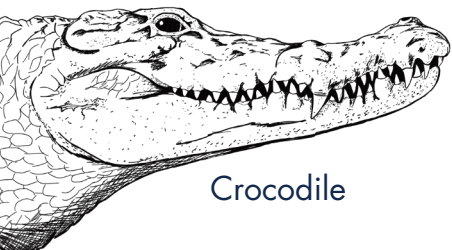
Alligators



Crocodiles



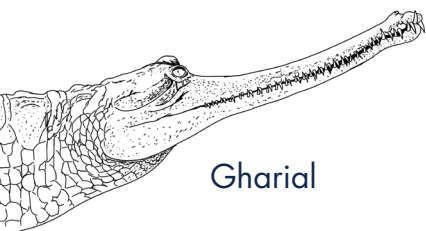
Gharials



Crocodile



Alligator



Gharial

Today, there are 27 living species in the order Crocodylia. They are sorted into three families, the true crocodiles (17 species), alligators and caimans (8 species), and the gharials (2 species). The easiest way to tell the three groups of living crocodylians apart is by looking at their snouts. Alligators and caimans tend to have more rounded snouts. And, the teeth in their lower jaw aren't visible when their mouths are closed. That is because the teeth of their lower jaws fit into holes in their upper jaws. That means the teeth can only be seen from the upper jaws. Crocodiles have more narrow and triangular snouts. When their mouths are closed their teeth can be seen from both upper and lower jaws. Gharials have very long and narrow jaws with a lot of very pointy teeth. They have perfect snouts for grabbing slippery fish!

Today's crocodylians range in size from dwarf crocodiles that are less than 2 meters (6.2 feet) and 32 kilograms (70 pounds) to the saltwater crocodile that can grow to 7 meters (23 feet) and over 1,000 kilograms (2,200 pounds).

## Dwarf crocodile

Freshwaters of Western Africa  
1.5 - 1.9 m long, 18 - 32 kg



Southeastern United States  
2.6 - 4.6 m long  
91 - 360 kg



**American alligator**

Southern United States, Central  
America and the Caribbean,  
and Northern South America  
3 - 4.8 m long  
172 - 500 kg



**American crocodile**

## Saltwater crocodile

Salt and brackish waters from  
Southeast Asia to Northern  
Australia, and  
Papua New Guinea  
2.25 - 7 m long  
81 - 997 kg



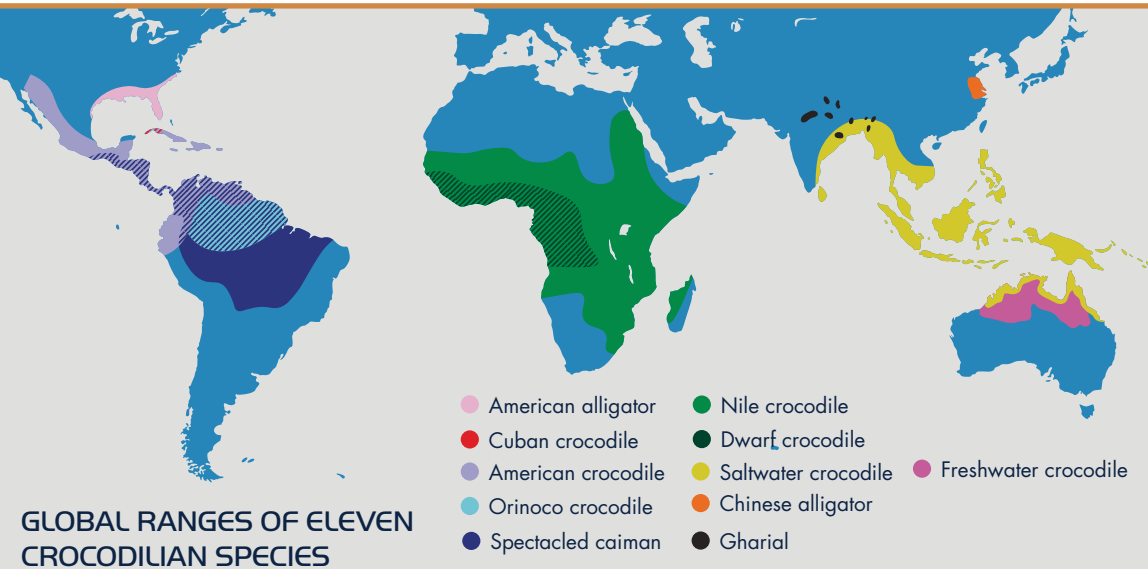
## Gharial

Freshwaters of South Asia  
2.7 - 4.9 m long  
158 - 250 kg



# MORE THAN FRESHWATER

Crocodiles and their relatives are mainly found in the tropics, where the temperatures are above freezing. Because they are ectotherms, their bodies are the same temperature as the air or water around them. If they stayed cold too long, they would die. But American and Chinese alligators can live in some temperate areas. These are places where the air temperature gets below freezing in the winter. Alligators don't have to eat much when they are cold, and they will stay in the water with their snouts above the surface to get a breath. They will actually keep a hole in the ice to breathe through if the water starts to freeze. People have found alligators with their snouts sticking out of ice frozen around them and their bodies in the water below. They may be very cold, but are still alive!



Crocodiles change their behavior to warm up and cool down. When they want to warm their bodies, they climb out of the water and bask in the sun. To stay cool in the tropical heat, crocodiles find shade, take a dip in the cool water, or open their mouths. The **evaporation** of water from inside their mouths cools them down!



All species of crocodylians spend time in freshwater. Alligators, caimans, and gharials live almost exclusively in freshwater. Recently, scientists learned that some alligators travel to saltwater habitats to feed. But they can't stay long, because it is too salty. Their bodies can't get rid of the extra salt, so they have to return to freshwater. Crocodylians are found in many different kinds of freshwater habitats. Some are in rivers with clear water and fast currents. Others are found in huge slow-moving rivers, ponds, backwaters, or lakes. Large, shallow wetlands are home to a variety of crocodylians around the world. The most famous is probably the American alligator of The Everglades in southern Florida. Some crocodylians can live in areas where their watery homes dry up seasonally. They can dig burrows where they sleep through the dry season!



**Nile crocodile**



**American alligator**



**Nile crocodile**

An American crocodile  
cruises the shallow ocean.



No species of crocodile lives only in saltwater, but some species are at home in the oceans. American crocodiles can be found in shallow ocean waters. The saltwater crocodile of Northern Australia and Asia is usually found in large rivers and estuaries. Sometimes they are found far out to sea. Scientists have tracked them moving hundreds of kilometers in the ocean by riding ocean currents! Their ability to ride the currents and survive in saltwater is a major reason saltwater crocodiles are found in so many places, including remote oceanic islands.

In Africa, dwarf crocodiles are semi-terrestrial. They spend much of their time hunting on land in forests next to their wetland habitats. Recently, scientists found a population of dwarf crocodiles that live mostly in caves! They spend so much time among the droppings of the bats that live in the caves, that their skins are stained orange!



Dwarf crocodiles in Africa are commonly found in dense forests (top). Recently, biologists discovered a population of dwarf crocodiles living deep inside caves. The skin of these crocodiles is stained orange because they spend so much time sitting in bat poop on the cave floor (bottom).

# BUILT FOR SUCCESS

Crocodiles are an incredibly successful group of animals. With ancestors that looked quite similar to modern forms appearing more than 100 million years ago, there is no doubt that crocodiles have bodies that are built for success. Like all other animals, crocodilians are living systems! It starts with the building blocks of the material and organelles that make up cells. Next, groups of similar cells work together as **tissues**. Groups of tissues form **organs**, and groups of organs that work together form **body systems**. Body systems work together to make the whole body run.



## GETTING AROUND

The **skeletal system** and the **muscular system** work together closely. The skeletal system provides support for the body. It also provides the attachment points for muscles. Getting around is not a problem for crocodilians. In the water, their tails provide propulsion. They can explode at tremendous speed over short distances. They can grab prey drinking from the shore and can even leap almost entirely out of the water! They can also be pretty fast on land. If they need to find a new place to live they can walk for long distances. They can even throw their bodies side to side in a “belly run” that can reach 10 kilometers per hour (6 miles per hour). The freshwater crocodile of Australia can gallop at up to 17 kilometers per hour (11 miles per hour)!

The skeletal and muscular systems also combine to create an incredible bite force! In fact, the Nile crocodile has the highest bite force measured for any living animal! The extinct *Deinosuchus* had a bite force that was probably two times stronger than that of *Tyrannosaurus rex*! Crocodile jaws and teeth are not built for chewing. If they want to eat big prey, they have to hold on to a piece and spin. Eventually, they will tear a piece off that they can swallow.

Considering the force that crocodiles use to bite down, the muscles that open a crocodile's jaws are quite weak. This helps scientists working with crocs. If they can wrap tape around a croc's jaws when they are closed, the croc can't open them!

## BITE FORCE!



**Human**

162 pounds per square inch



**Tiger**

1,050 pounds per square inch



**Great white shark**

4,000 pounds per square inch



**Hippopotamus**

1,800 pounds per square inch



**Nile crocodile**

5,000 pounds per square inch



**Polar bear**

1,200 pounds per square inch



**Hyena**

1,100 pounds per square inch

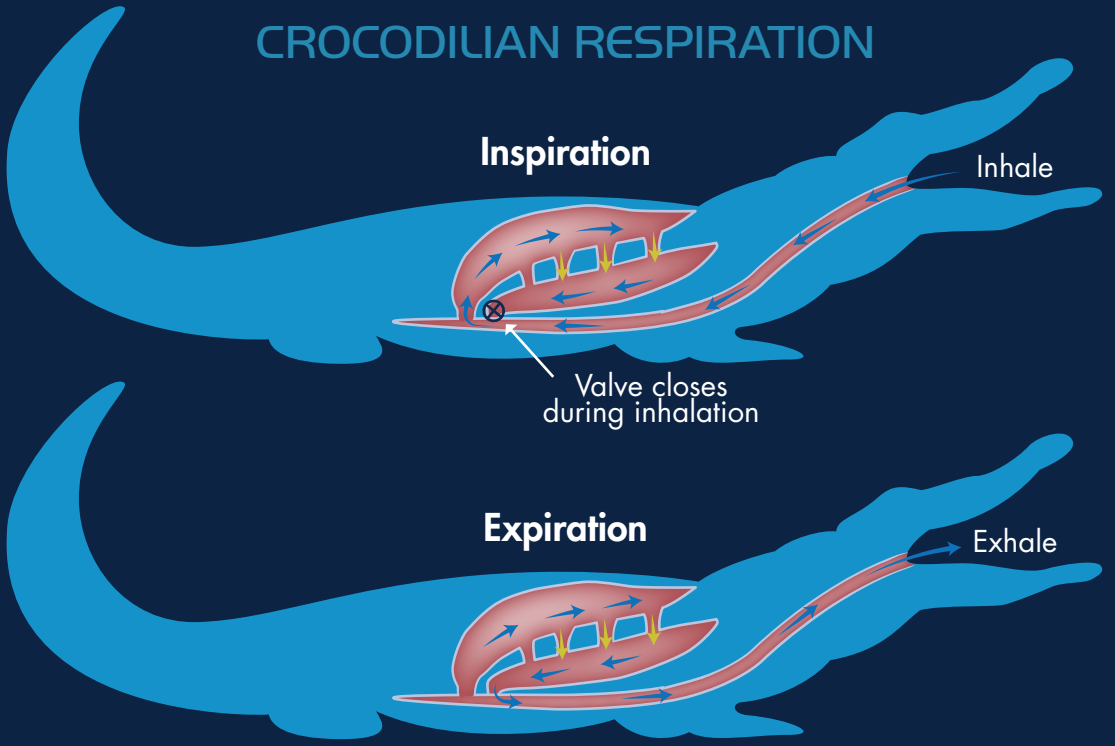
## WHAT A BODY NEEDS

Once the muscular and skeletal systems have worked together to catch a meal, the **digestive system** takes over. The food passes into the stomach, where it is digested. Crocodile stomachs are filled with more acidic fluid than any vertebrate. Bones, turtle shells, and hooves are all broken down! And, crocodiles sometimes get some extra help grinding down a meal by swallowing stones. The stones roll around in their stomachs and help break up food. Digested food passes from the stomach into the intestines where nutrients are extracted from the food. The **excretory system** gets rid of the parts of the food that the crocodile's body doesn't use. It also removes waste from the blood. The digestive system also works with the **circulatory system** to get nutrients distributed throughout the body.

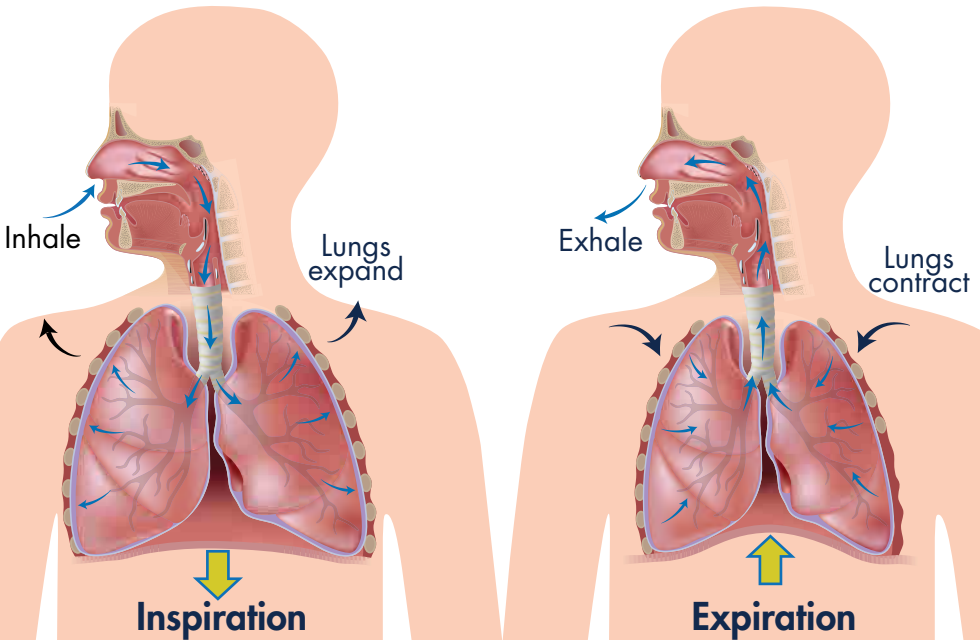
A body also needs oxygen! The **respiratory system** gathers oxygen and gets rid of carbon dioxide. The circulatory system carries oxygen from the lungs to the body through blood vessels and brings the carbon dioxide from the body back to the lungs to be released. One interesting aspect of crocodiles is that air only moves in one direction through their lungs. When people breathe, the air moves in and then out through the same chambers. Crocodiles use their lungs for more than just exchanging gases. They can control whether they float or sink based on how much air they keep in their lungs. Like humans, crocodiles have a four chambered heart. This is more efficient than the three chambered heart of other reptiles!

Crocodile bodies also need protection. Viruses, bacteria, and parasitic organisms can make a crocodile sick or even die. It turns out crocodilians have incredible **immune systems**! Germ-killing **molecules** in their blood are so good at attacking and killing viruses and bacteria that scientists are studying them to see if they can help cure human diseases!

# CROCODILIAN RESPIRATION



# HUMAN RESPIRATION



## DETECT, INTEGRATE, RESPOND

The **nervous system** includes the brain, spinal cord, neurons, and sensory systems. The first job of the nervous system is to get information from the environment. This starts with special sensory cells that detect different things like physical contact, temperature, chemicals (smell and taste), sound waves (hearing), and light waves (vision).

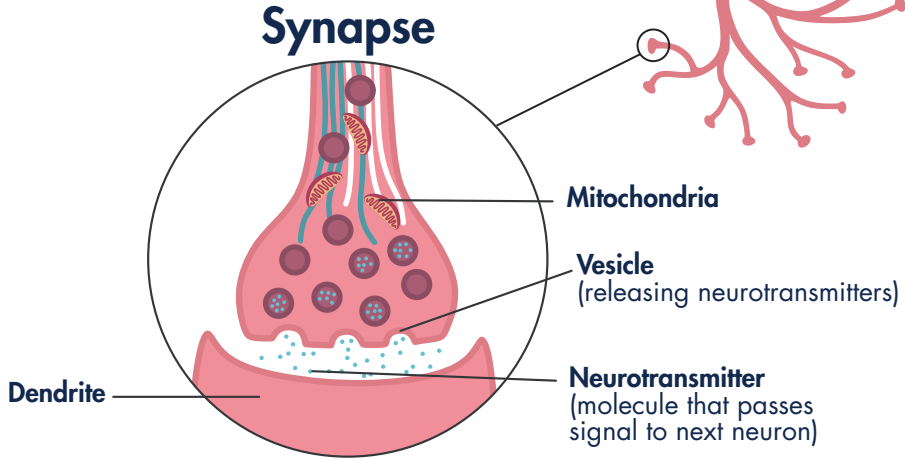
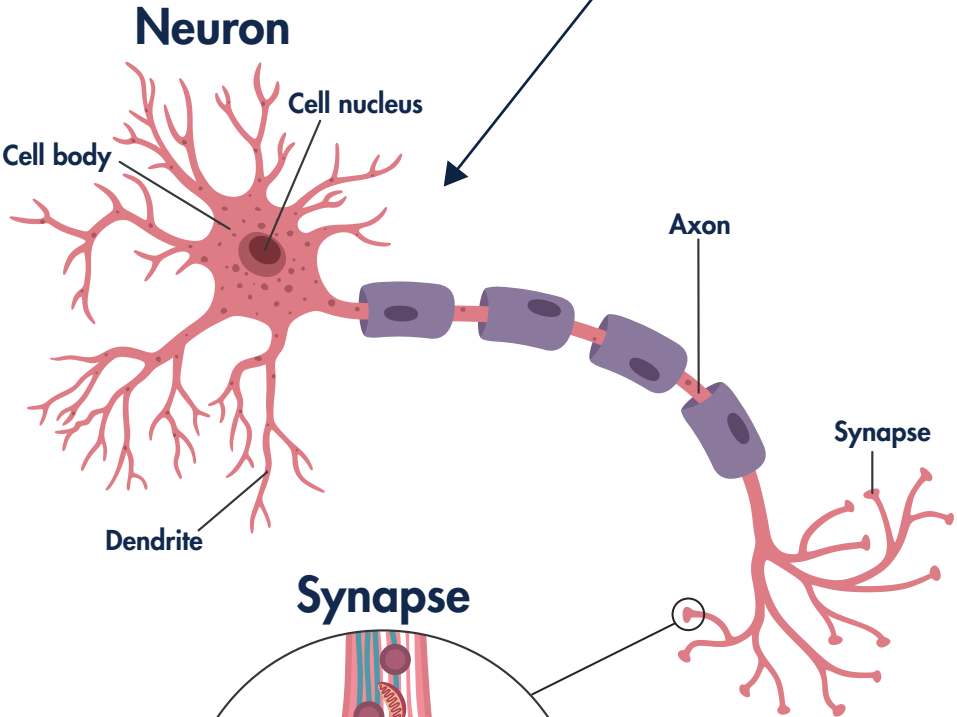
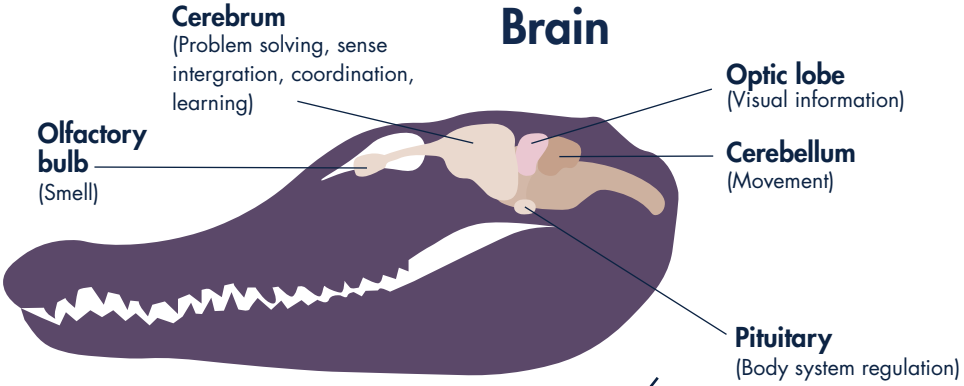
Crocodylians have a good sense of hearing and smell in air and in water. Their vision is also good. They can see colors and have a special lining in their eyes that helps collect light and gives them very good night vision. Crocodiles have an especially sensitive sense of touch. The “dome pressure receptors” on their skin can detect tiny vibrations in the water. This helps them lunge at prey that get close to their mouths. The receptors can detect more than touch. They also detect temperature and chemicals! No other vertebrate has individual sensory cells that can do so much!

The second job of the nervous system is to integrate the information. Sensory information is converted to electrical impulses which are sent to the brain through neurons. The brain interprets the data, makes memories, creates thoughts, and determines the right response. The brain sends signals to the body through neurons. It triggers responses, like muscles contracting. This causes the body to move or an organ to change its actions.

The crocodylian brain is the most complex of the reptiles. They learn quickly and have a diverse set of behaviors. This can make them difficult for scientists to study! If they need to catch a crocodile, they need to succeed quickly or crocs will learn how to avoid capture.



# BRAIN STRUCTURE OF CROCODILIANS



# DINNER TIME!

As an ectotherm, the temperature of a crocodile's body is the same as the temperature of the environment around it. This means that a crocodile doesn't have to eat a lot. In fact, a big crocodile that has been eating well may be able to go a year without eating! But when given a chance, crocodiles will eat much more often.

Crocodiles and their relatives are almost all carnivores. They eat meat. Many species are generalists. That means they eat just about anything they can get their mouths on. Some species even eat the occasional fruit or plant matter! Could some crocodilians help disperse plant seeds? Scientists are trying to find out.

Crocodilians eat a lot of aquatic prey like fish, turtles, crabs, snails, amphibians, or even small sharks. How do they grab food underwater if they breathe air? They don't want a lung-full of water! Crocodiles have a special flap of skin at the back of their mouths that keeps water from flowing into their tracheas or esophaguses. So, they can open their mouths underwater and then bring prey to the surface to eat.





Most crocodiles also eat terrestrial prey like birds, raccoons, wild pigs, deer, wildebeest, zebra and many more. In fact, just about any animal that comes to drink in crocodile, alligator or caiman territory is at risk. Only the animals too big for them to handle are safe. Crocodiles also won't overlook a free meal. They will happily scavenge dead animals.

Most crocodylians are ambush hunters. With nostrils at the end of their snouts and eyes on the top of their heads, they can lie motionless while they wait for prey to approach. Then they burst at incredible speeds to grab their meals!



# CROCODILE SOCIAL LIVES

Crocodylians can be found together in very large numbers. Most species are not territorial. However, during the breeding season, they try to stake out some space of their own. There can also be **dominance** among crocodylians. The biggest individuals will often have access to better spots to bask in the sun. They may also get the most food when there is competition over large prey. And, larger males tend to be the most successful at mating.

Compared to other reptiles, crocodylians are very vocal. Some species make more than 20 different sounds. They can bellow, chirp, and hiss. Many calls are used in **courtship** displays. Males of some species bellow to attract females and engage in other displays like splashing their heads on the water. Other sounds are used to communicate with rivals during mating season. Babies make “alarm calls.” They produce high-pitched chirps when they are in trouble. If an adult hears a baby in distress, they will come to protect it!



During courtship, American alligators engage in bellowing and displays, like head-slapping. Their bellows cause the water surface around their backs to vibrate.

Mating seasons can last from a few weeks to a few months. Most crocodilian males try to defend areas and attract females with calls and other displays. Once the female has chosen to mate, mating occurs in the water.



### **Baby dwarf crocodile**



About a month after mating, female crocodilians will lay between seven and about 100 eggs. Some species lay them in a hole dug in the sand, while others build mounds of plant matter for nests. The eggs are a favorite food of predators like racoons and large lizards, so mothers are very protective of their nests. After about two to three months, the eggs hatch. When they do, the mother makes sure the babies make it to the water. Then, she will look after them for months or more! During this time, the babies eat small insects and fish. They have to look out for predators that might eat them including birds, mammals, and large fish. Mother crocodilians do their best to protect the babies, but many young don't survive to adulthood.

# CROC TROUBLE

Many types of crocodiles used to be in danger of disappearing. Their populations greatly decreased. They were hunted for food and their skins were used for leather and other products. They were killed because they were dangerous. Their eggs were harvested for food.

Luckily, most types of crocodilians are doing much better now. Protection from hunting has helped American alligator populations grow. In the 1960s they were protected because they were in danger of going extinct. That strong protection helped. They are now abundant again and are no longer an endangered species! Other species of crocodile populations have recovered too. People have created crocodile farms that prevent wild crocodiles from being hunted. People get the food and products they need to make a living. Nile crocodiles are one of the most farmed species.

Crocodilians aren't completely safe. When people destroy their habitats for agriculture or cities or pollute the waters where crocodiles live, crocodiles may need to move or they might die out. Changes in temperatures and climate can also be a problem for crocodiles because the sex of babies is determined by the temperature of the egg as it develops! At lower temperatures, mostly females are produced. When eggs incubate at warmer temperatures, males hatch out. What do you think would happen if average air temperatures increase?



Orinoco crocodiles



# NILE CROCODILE!

Nile crocodiles are native to Africa. They are found in rivers, lakes, and wetlands on the continent and in Western Madagascar. Nile crocodiles are the second largest species of crocodile in the world. The largest grow to be over 6 meters (20 feet) long and can weigh 1,000 kilograms (2,200 pounds)! But most are smaller and typically grow to 3.5 to 4 meters (12 feet). Like other crocodylians, male Nile crocodiles are bigger than females.



A female Nile crocodile digs a nest into the sand near the water. Then, she lays between 25 to 80 eggs. Bigger females lay more eggs. The female guards her nests for 90 days before the eggs hatch. She has to protect them from predators, especially the Nile monitor lizard! When she hears her babies chirping as they try to break through their eggs, she starts digging them out of the sand. Once out of the nest, the mother carries the hatchlings to the water in her mouth! She may even use her mouth to help babies get out of their eggs!





Mothers protect their young for up to two years after they hatch! Sometimes, to keep them safe or move them away from danger, she scoops them up in her mouth. Large lizards, big fish, birds of prey, snakes, and mammals will all eat small crocodiles. When they are small, young Nile crocodiles seem to spend a lot of time on land. They eat a lot of terrestrial insects. Once they are about 1.2 meters (4 feet), they are ready to venture away from mom! We still don't know how long Nile crocodiles live, but it may be between 70 to 100 years!





**Large Nile crocodiles in Tanzania hunt wildebeests as they cross the Mara River during their annual migration. The crocodiles ambush wildebeests from below the water.**

As Nile crocodiles grow, they start eating more aquatic prey, like snails, crabs, frogs, turtles and fish. They also eat birds that come to the water's edge. Large juvenile and adult Nile crocodiles are capable of eating large terrestrial prey that come to drink or cross a waterway. Nile crocodiles are top predators! Usually, they sit with just their eyes and snouts at the surface and then explode from underwater to ambush their prey. Sometimes, however, Nile crocodiles chase their prey down outside of the water! Their most common prey are antelope, but they also hunt other hoofed animals like wildebeest and zebra. The biggest Nile crocodiles may also be able to kill giraffes and other large prey! Nile crocodiles also scavenge and even steal kills from land predators that feed close to the water! And, although it isn't very common, Nile crocodiles occasionally eat fruit and other plant matter.



# OKAVANGO!

Botswana is country in southern Africa. It's an amazing place to see wildlife, including Nile crocodiles! One of the best places to encounter them is the Okavango Delta.



The Okavango Delta is so impressive that it can be seen from space!

A **delta** is a landform that is created where the flow of a river slows and the sediment it carries is deposited. This usually happens where a river flows into a lake, estuary, or the ocean. Deltas often have many channels and winding river paths that may change as more sediment is deposited. The Okavango Delta is very different from most deltas. The water flowing into the delta never enters an ocean. It creates a huge wetland that covers up to 15,000 square kilometers (5,800 square miles)! Almost all of the water that enters the delta leaves through evaporation or is taken up by plants and eventually released into the atmosphere through **transpiration** (water lost from plant leaves).

The Okavango Delta is defined by periods of flooding and drying. Because the Okavango is flat (there is less than 2 meters of variation in elevation across the entire area) flood waters can cause the area of wetland to grow to three times its normal extent! The water flowing into the delta comes from far away, so the biggest floods actually occur during the winter months of June to August when there isn't a lot of rain on the delta.



The Okavango Delta changes drastically between the dry season (left) and the wet season (right).

The animals of the Okavango have adapted to these seasonal changes. In the wet season, predators and prey that normally don't swim have to swim, wade, or run through water. They have to do this to get to islands with food, chase their prey, or escape from predators. When these animals cross the waters, they may encounter a Nile crocodile!

In the Okavango and through a lot of their range, Nile crocodiles share their watery home with hippos. The hippopotamus is a large mammal that spends most of its time in the water. But to feed, hippos come ashore at night to graze. Hippos may look too big and ungainly to be dangerous, but looks can be deceiving! Hippos have huge teeth that they use in battles with other hippos. They can run and swim quickly. Entering a hippo's territory can be dangerous. Even Nile crocodiles won't tussle with hippos very often! Some scientists think that crocodiles avoid attacking small hippos because of the adult hippos that protect their young.

When the waters begin to recede, lagoons and water holes form across the drying landscape. The vegetation dries out. Life becomes more challenging for animals that have to concentrate into smaller areas. Nile crocodiles know that their prey will have to come to them!

**A hippo inspects a Nile crocodile.**



**Even lions take to the water in the wet season.**



# CROCS IN HUMAN COUNTRY

Because crocodiles are predators that can grow to a large size, they can be dangerous to people, pets and livestock. That means people need to find ways to stay safe from crocodiles. In some parts of the world, people post signs that warn not to swim or get close to the water in areas where crocodiles might be found. In other areas where people can't avoid the water, fences are built to keep crocodiles out of certain areas. Another method is catching crocodiles that come too close to where people live and relocating them far away to a new home.



Around the Okavango, people live in close proximity to wildlife in many areas. Many people's livelihoods are based on wildlife. Tourists come from all over the world to visit the Okavango. Many people also use the natural resources of the delta, like the fish, for food. They also rely on having clean water. People have to find ways to stay safe and allow wildlife to thrive! That means learning how to deal with the threat from Nile crocodiles when they are in the area.



**TOP TEN TIPS TO AVOID ATTACKS**

1. Never go to the river alone.
2. A big croc can stay underwater for 1 hour: don't assume it's not there if you can't see it.
3. A croc can jump almost its whole body-length, stay 3m from the water's edge, and don't camp near water.
4. Don't hang your legs or arms over the sides of boats or Mohoro.
5. If you have to get into the water, do it when it is cool and bring very quiet - make a crocodile think if your fishing line gets caught in the grass or reeds cut the line. Your life's worth more than your fishing gear.
6. Crocodiles often walk where cattle or goats come to drink. Avoid these areas.
7. In winter several of crocodiles from November to February.
8. Don't clean your fish or leave dead animals at the water's edge.
9. Don't touch baby crocs, their mother may be nearby.
10. Diwana ga tsa di ana le dingwaga le aqaeletl moang'eng, tshaba matlela a...

**DON'T GET EATEN BY A CROC**

**DINTLHA TSE LESOMI TSEA BOTLOKONWA TSE O KA TLHANG GO TLHAKOLWA**

1. Go se neng o le nosi
2. Kwena wa leana e kgona go nka ka fa tšona ga metl e bakla na nwa e nka wa tšona gore ga e ya ka go e bone.
3. Kwena e kgona go tšela ešelašaya na hahalešaya mošale wa gona tšona šogale e šimolara ka tšona gona fa tšelašela le nka go e nka wa ka nka go kapa le metl.
4. Se tšona go e kgonašela dinoša le matšaga le šogale go neng e kgona mošara.
5. O nka wa kgobole dithaga kgotša wa togata dithagole tša di neng go kapa le tšelašela le nka. Se tšona bana-bakwena, mmotšana o kgona gore nka e le nagašimane.
6. Diwana ga tsa di ana le dingwaga le aqaeletl moang'eng, tshaba matlela a...
7. Diwanašona tšona mošara e kgonašela go ya ka šimolarašona go ya go go tšelašona.

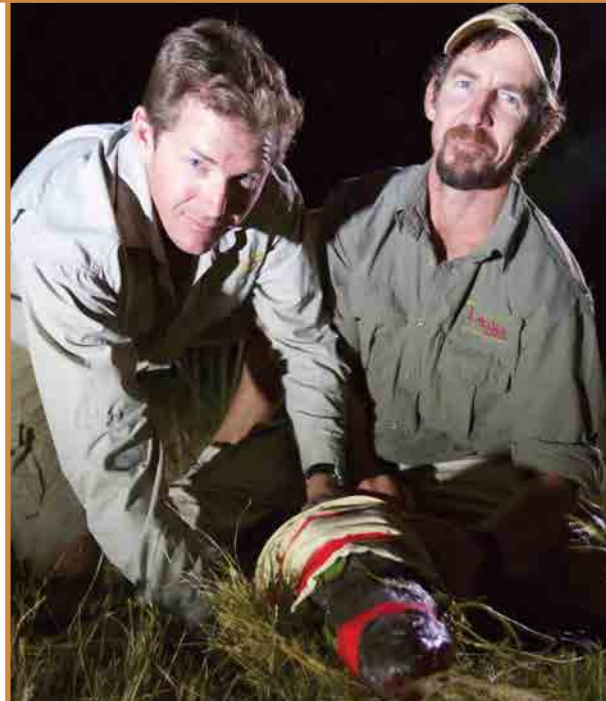
**ITLHOKOMELE, O SEKA WA JEWAKWENA**

Go e le gore o tšonašaga go tšona ome matšaga, se tšona go le mogale ka ošle gona o narašona tšonašona - mošona o tšona diwana. Go mošarašona o tšonašona dithaga ka ošo o tšonašona le šogale kapa tšonašona mošarašona, kgona o kgona. Diwanašona go gona le pele ga dithagolešona ka gona go tšonašona dithagole.

The town of Muan is in the Okavango Delta. Every autumn, its river systems fill with water. The water is a relief for the animals and farmers that depend on it. Farmers use the river for their livestock to drink. People swim and fish near the banks of the river. Pets come to the river to grab a drink. This puts all of them at risk of attack by a crocodile. So, when the waters bring Nile crocodiles to town, the community works together to remove them. They don't want to kill them.

Signs like these inform people how to stay safe in crocodile country.

Brent and Grant Reed are key members of the croc removal team. They are also safari guides and naturalists. They grew up in the Okavango. They, and the rest of the croc removal team, understand the behaviors of crocodiles and use that knowledge to figure out ways to catch the crocs. They also collect scientific data on the crocodiles they catch for the Okavango Crocodile Research team.





# ENGINEERING ANIMAL SOLUTIONS

People and animals have to find ways to live together. Often, people have to figure out how to reduce human impacts on ecosystems and species. Other times, people need to figure out how to protect themselves, their pets, and their crops and livestock from dangerous or destructive animals without killing them. More information about the animals themselves is usually needed to be able to design solutions. Solutions may be high-tech, low-tech, or use nature! Here are some examples:

**Problem:**  
Counting species in areas that are difficult to sample



**Solution:**  
Use remote camera systems to count. Artificial intelligence in computers helps sort millions of images.

**Problem:**  
Wildlife are killed for killing livestock.



**Solution:**  
Watch over flocks and use fenced "bomas."

**Problem:**  
People are illegally hunting and fishing.



**Solution:**  
Drones and satellites that watch for poachers.

**Problem:**  
Endangered wildlife are hit by cars.



**Solution:**  
Roadway overpasses and underpasses for wildlife.

# ENERGY AND FORCE

If you are going to catch a crocodile – for science or to relocate a dangerous animal – you need to make sure you design the right trap. That means you need to know about energy and force!

**Energy** is the ability to do work. There are two basic types of energy. One type is **kinetic energy**, or energy from motion. An example is a crocodile's tail moving to push the water while it swims. **Potential energy** is the energy in an object because of its position, its electric charge, stresses within itself, or in chemical bonds. For example, the door of a croc trap is held up by a string and isn't moving. It has potential energy because of its position. Gravity will pull it down when the string releases, changing its potential energy into kinetic energy.

A force is a push or a pull. Forces have both a direction and a magnitude. For example, the direction of the force of a crocodile jaw closing is down, and the magnitude is very large. The force of the jaw opening is up and weak. Anybody handling crocodiles needs to understand forces. Because the muscles in a crocodile's body and tail are so strong, the materials used to restrain one must be strong enough to not break. Another force that is strong enough to counter the croc's force might need to be applied.

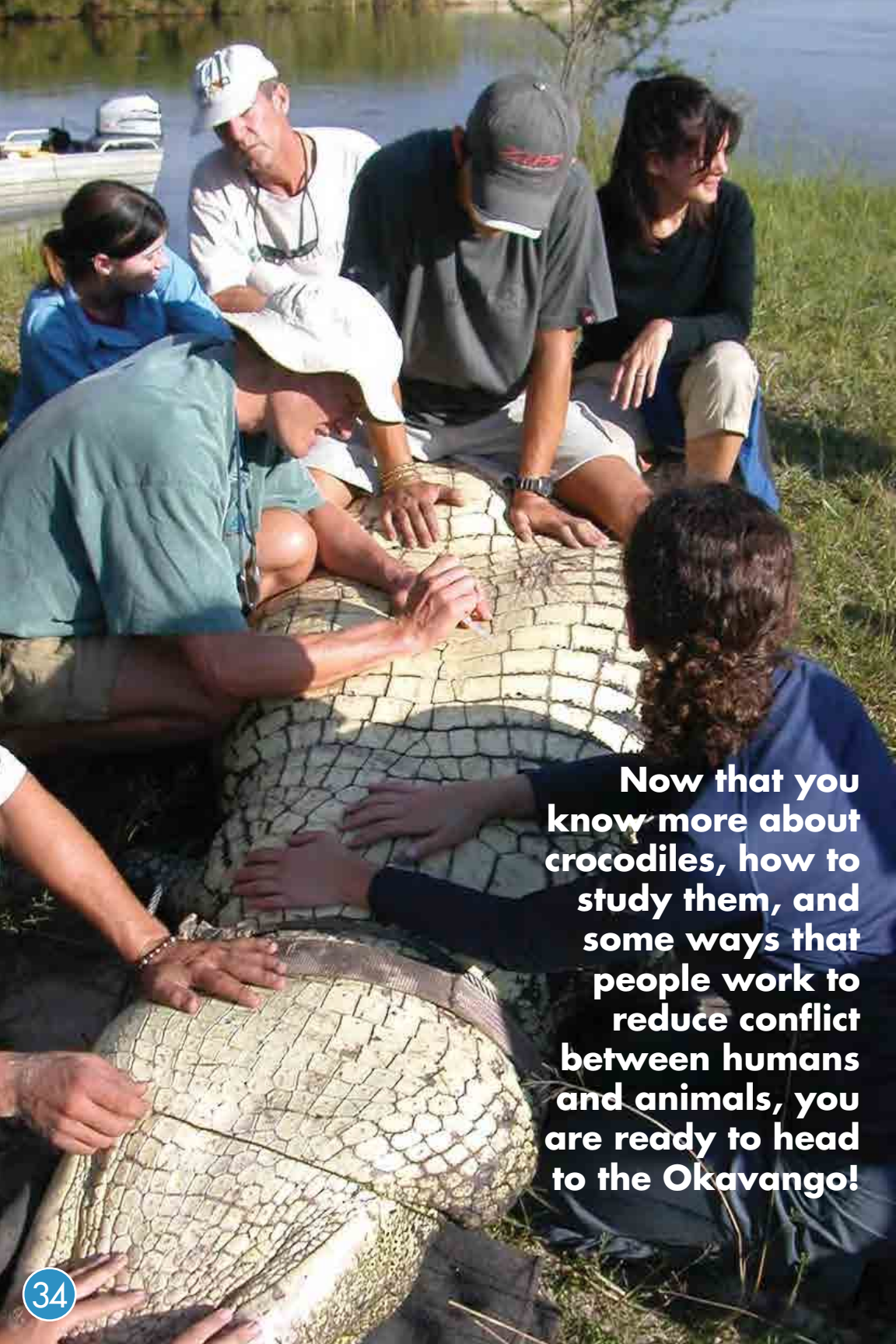
If there are two forces working on an object, they can be unbalanced or balanced. If one force is stronger than another force, then they are **unbalanced forces**. An object will move in the direction the stronger force pushes or pulls. If the forces are the same strength, then the object will not move. These are **balanced forces**. Gravity is one of the most important forces. It is the force that pulls objects, like the door of a crocodile trap, towards the Earth.

# STUDYING CROCODILES

Scientists around the world are racing to learn more about crocodilians. They want to know more about them so they can protect threatened species. They want to know about their habitats and how important they are to ecosystems. They want to know how far they can move. To do these studies, scientists use many methods. Some are low-tech. By going out at night, they can shine a spotlight to count crocodiles. Their eyes glow in the light, making counting easy. Want to see what crocs are eating? Sometimes, scientists just need to spend time watching them and recording what they do and what they eat. To see where crocs go, scientists use high-tech devices. They can catch the crocodiles and attach special tags to them. These tags send signals to satellites which send scientists emails with the animals' locations!



The Okavango Crocodile Research team studies all life stages of Nile Crocodiles. They use many different methods to study the crocs, from counting numbers at night to collecting blood and other samples to study their feeding behavior and health. The research team also works with the local community to help keep people safe from crocodiles.



**Now that you know more about crocodiles, how to study them, and some ways that people work to reduce conflict between humans and animals, you are ready to head to the Okavango!**

# GLOSSARY

## **BALANCED FORCE**

when two forces of the same strength act on an object

## **BODY SYSTEM**

a group of organs that work together to perform one or more body functions

## **CIRCULATORY SYSTEM**

the body system that circulates blood and transports nutrients, oxygen, and carbon dioxide to and from cells

## **COURTSHIP**

animal behavior aimed at attracting a mate

## **DELTA**

a broad area where sediment is deposited at the mouth of a river

## **DIGESTIVE SYSTEM**

the body system responsible for turning ingested food into absorbable nutrients

## **DOMINANCE**

an individual's preferential access to resources, like food or mates, over other individuals

## **ECTOTHERM**

an animal that gets its heat from the environment; cold-blooded

## **ENERGY**

the capacity of a physical system to perform work

## **EVAPORATION**

the process of liquid turning into gas

## **EXCRETORY SYSTEM**

the body system that removes waste from the body

## **IMMUNE SYSTEM**

the body system that helps fight off infection and diseases

## **KINETIC ENERGY**

energy in an object based on its movement

## **MOLECULE**

a group of atoms bonded together

## **MUSCULAR SYSTEM**

the body system that is responsible for movement

## **NERVOUS SYSTEM**

the body system that collects and interprets sensory information from the external and internal environment and responds to it

## **ORGAN**

a group of tissues that work together to perform a specific function

## **POTENTIAL ENERGY**

the energy of an object based on its position, electrical charge, internal stresses, or chemical bonds

## **RESPIRATORY SYSTEM**

the body system responsible for the uptake of oxygen and release of carbon dioxide

## **SKELETAL SYSTEM**

the body system that supports and protects the body; consists of bones, cartilage, and joints

## **TISSUE**

a group of cells that work together to perform a specific function

## **TRANSPIRATION**

the process of water being released into the atmosphere through plant leaves

## **UNBALANCED FORCE**

when one force stronger than another force acts on an object

# 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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