Where Nature Meets Learning

WILD THINGS IN WILD PLACES

Unit 2:
Wild Things in Wild Places

Produced by: Whitehawk Birding & Conservation

Content by: Jenn Sinasac & Marta Curti, with additional text by Edwin Campbell

Graphic Design:
Marta Curti & Jenn Sinasac

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by Jenn Sinasac, Marta Curti & Edwin Campbell

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Table of Contents

Unit 2: Wild Things in Wild Places 6

CLASSIFICATION, ADAPTATION, and BEHAVIOR 7

Animals Among Us 7

What's in a Name 10

Vertebrates 12

- Fish 13
- A Special Look at Sharks 14
- Amphibians 16
- A Special Look at Salamanders 18
- Reptlies 19
- A Special Look at Basilisks 21
- Birds 23
- Mammals 24
  - Monotremes 24
  - Marsupials 26
  - Placentals 27
- A Special Look at Sloths 28
- Vertebrates at a Glance 30

Invertebrates 31

- Poriferans 32
- Cnidarians 33
- Echinoderms 34
- Mollusks 35
- Arthropods 36
- Worms 38
  - Platyhelminthes 38
  - Nemotodes 38
  - Annelids 39
- Protozoans 40

Food Chains 42

- Producers 43
- Primary Consumers 44
- Secondary Consumers 44

A Special Look at Scavengers....44
Tertiary Consumers....45
Top Predators....45
Decomposers....46
Food Webs....46
Animal Interactions....47
Mutualism....47
Parasitism....49
Competition....49
Communication....50
Seasonal Adaptations....51
Hibernation....52
Estivation....52
Migration....52
Read & Reflect....53
Glossary....55
Photo/Art Credits....57
References....60

CHAPTER 2

WILD THINGS IN WILD PLACES

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe" - John Muir

The **harpy eagle** feels the rush of air against its wings as it flies just below the forest canopy. With talons outstretched, it aims for the three-toed sloth slowly making its way up the branch of a Cecropia tree. The eagle's aim is true. Minutes later, the large and powerful eagle clutches its prey in its talons and carries it to a large branch. As the eagle uses its powerful beak to feed, tiny bits of the sloth's fur and flesh fall to the ground a hundred feet below. But nothing goes to waste in nature. The damp forest floor is a bustle with activity. A swarm of army ants moves almost as one over leaves, twigs, and low-growing plants. They will take advantage of the tidbits the eagle drops as they scour the forest for arthropods and other things to eat. Several species of antbirds are attracted to this swarm. They are on the hunt for the spiders, crickets, worms, and other critters fleeing the marauding ants. Underneath the leaves, out of sight, lies a **rainbow boa**. It, too, is looking for a meal. But not everything is about eating or being eaten. Just a few feet above, a female **blue-crowned manakin** finds a downy feather the eagle has dropped. She will use it to line the nest she is building. In a few days' time she will lay a few small eggs that she will raise and care for.

Classification, Adaptation and Behavior

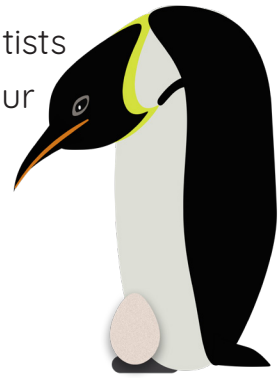
Animals Among Us

If you could be any kind of animal for a day, which would it be and why? Would you soar through the skies as an **Andean condor**? Or would you prefer to explore the deep, dark depths of the ocean with your octopus tentacles? Would you be a gazelle and run like the wind? Or perhaps you would like to experience life from a turtle's perspective, slowly watching the world go by? Does a **platypus** sound appealing? What about a frog or a snake or maybe even a dragonfly?

Scientists estimate there are approximately 8.7 million different **organisms** that share our planet with us, but we have only identified about one-fifth of them! In fact, recent studies that include **microorganisms**, such as bacteria, tell us that the number of species on Earth is now estimated at one trillion! It is fun to imagine what sorts of creatures we have yet to discover. Some might be large, others could be small, and most will definitely be microscopic! Surely some will be **predators**, an animal that has to hunt for its food, while others will be **prey**.

Our imaginations can run wild thinking about all the organisms we haven't yet discovered! But what is even more amazing is that there is still so much to learn about all the animals we have known about all our lives. If asked, I bet you could easily name one species of mammal, one species of fish, and one species of bird without giving it too much thought. But what if you had to explain what makes a mammal a mammal, a fish a fish, and a bird a bird? Would that be easy or hard? While it is often simple to tell the difference between these three types of organisms, defining what makes them what they are isn't always as straightforward as it may seem. After all, some fish fly while some birds don't, some mammals live mostly underwater, while some fish breathe air. Some mammals even lay eggs, and birds, some fish and even octopuses have beaks. The truth is, nature is marvelous and extremely complex. This can make it hard to place different components of our natural world into neat, well-defined categories. This is where science comes in. Science can help us better understand all of nature's complexities and how all living things are connected.

One of the ways scientists work to understand our natural world is through the study of **taxonomy**. Taxonomy has nothing to do with taxes!



Taxonomy is the science of defining and classifying all of Earth's organisms based on characteristics or traits that they have in common. The classification of living things has kept scientists busy for probably almost as long as humans have been around. Though the official birth year of modern taxonomy is said to be in 1758, humans before then had to be able to identify plants and animals easily and quickly - often for safety reasons. Recognizing the characteristics of poisonous snakes and plants was literally a matter of life or death. Taxonomy is always changing, and as genetic technology advances, we are learning more about the relationships animals have with each other, often with surprising discoveries. For example, there are many widespread species that are now, through genetic testing and other detailed observations, considered several separate species. This is the case with birds, frogs, mammals, and just about all major **taxa** on Earth. In the **Neotropics**, the well-known **blue-crowned motmot** has recently been split into six different species! Even these "new" species to science have their own subspecies, each with unique characteristics.

Today, all living things are divided by **Domain**, **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus**, and **Species**.

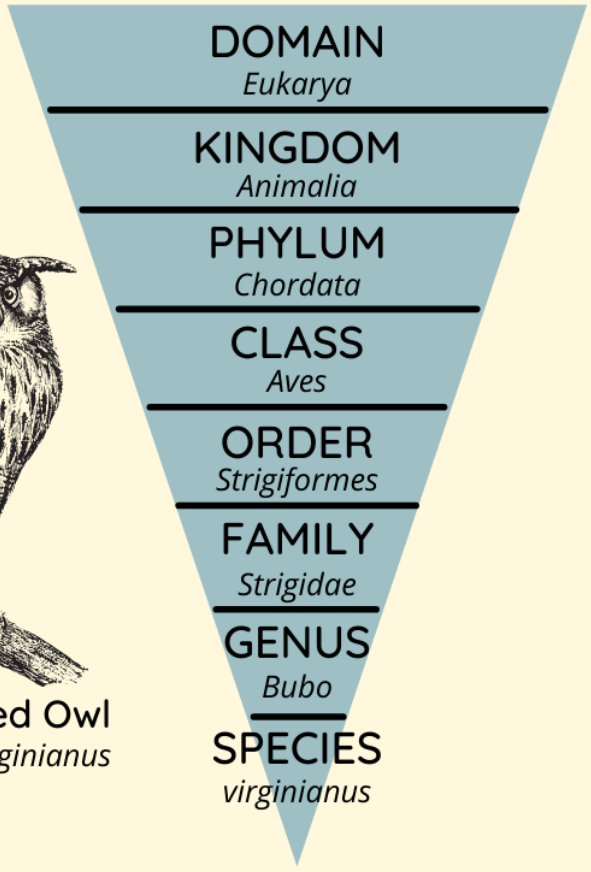
Animal, Vegetable, or Mineral?

The Classification of Living Things

The modern classification system of species was developed by Swedish biologist and physician Carl Linneaus in the early 1700s. This system ranks organisms based on shared characteristics in a hierarchy of groupings. This classification, known as **binomial nomenclature**, assigns each organism a scientific name composed of two parts, the **genus** and **species**. For example, **Homo sapiens** refers to us - humans. Homo is the genus and sapiens is the species name. Since then, taxonomy has come a long way (whales and manatees were originally classified as fish!) but, the basic principles remain the same.

Linneaus identified three kingdoms: **Animale** (animals), **Vegetabile** (plants), and **Lapideum** (minerals). Now, six kingdoms are recognized.

Great Horned Owl
Bubo virginianus



What's in a name?

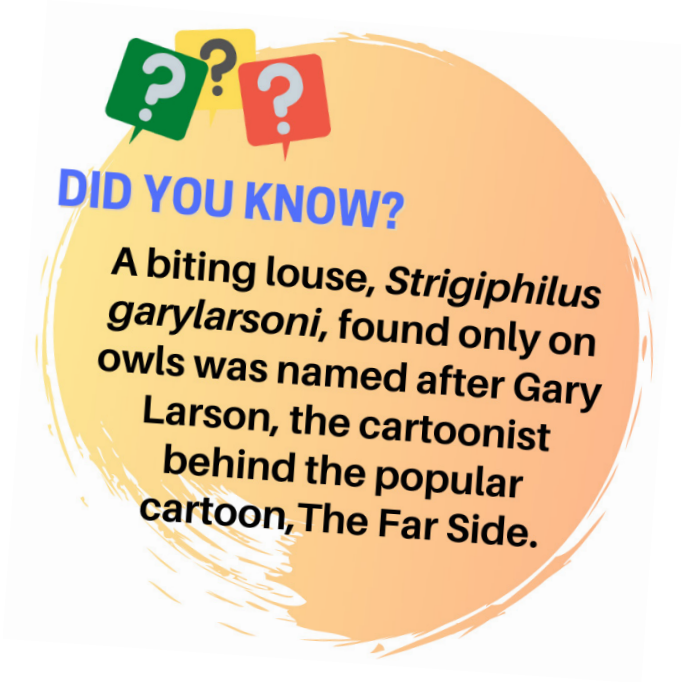
Imagine if living things didn't have names. It would be very confusing and difficult to get someone's attention, identify who or what we are talking about, or even introduce ourselves. Having names helps us do all those things and more. In general, most people are given first and last names. However, depending on one's culture and tradition, some people may also have one or more middle names, several last names, only one name, or even a nickname. In 1993 the artist Prince even changed his name to a symbol!

But, of course, naming things goes beyond just the names we give each other. Naming organisms helps identify and classify them. It also greatly helps with communication. Around the world, many organisms have two different types of names: common names and scientific names. Common names are the names most people use. But, sometimes one species can have many different common names depending on who is doing the talking, what language they are speaking, or what region of the world they live in.

For example, the **osprey**, a large raptor that feeds mainly on fish, is found around the world. In many Spanish-speaking countries, this bird is known as **águila pescadora**, which translates to "fishing eagle," even though the osprey does not belong in the eagle family, and there are many other fishing eagles in the world.. It is also known as "guincho" in a few other Spanish-speaking countries or regions such as Dominican Republic and the

Canary Islands of Spain. These are just some of the common names people have for this bird. Its scientific name is *Pandion haliaetus*., and this is recognized in every language.

Scientific names are usually derived from Latin or Greek and help create a universal name for all species, so that no matter where a person lives or what language they speak, they can ensure they are talking about a specific species. Many scientific names have meanings that often describe a species' appearance or characteristics. Sometimes, they are named after a person who has made a significant contribution to science.



If you could give yourself a scientific name, what would it be?

Take a look at some of the commonly used Greek/Latin words and their meanings. Do any of these words resonate with you? Do they describe you in any way? Pick one, two, or three of these words and make up your own scientific name! Have fun and be creative! If none of these words fit your personality, see what other words in Greek or Latin you can find that do.

Greek/Latin	Meaning	Greek/Latin	Meaning	Greek/Latin	Meaning
alatus	winged	**cursor**	runner, racer	**sapiens**	wise
elegans	elegant	**magnus**	great	**timidus**	shy
ambiguus	uncertain	**maritima**	of the sea	**verus**	true, genuine
aquaticus	found near water	**nitidus**	shining	**volans**	flying
garrulus	talkative	**natans**	floating	**velox**	swift
canorus	melodious	**paradoxus**	contrary to expectations	**laetus**	pleasant, bright
chrysos	gold	**regalis**	royal	**gregarius**	sociable

Vertebrates

Simply put, vertebrates are those animals that have a spinal cord, just like you and me. Humans, of course, are vertebrates. So are dogs and deer, mice and mongoose, sharks and sheep, and frogs and flamingos! Close to 70,000 species of vertebrate animals live on Earth. They can be found in just about every type of ecosystem on the planet. They come in all shapes, sizes, and colors, too.

Do you know what the largest vertebrate to have ever lived is? Hint - this animal is still alive today. It is larger than any dinosaur that ever roamed the planet and it lives deep in the ocean. If you guessed the **blue whale**, you are correct. This massive vertebrate can weigh over 170 tons and reach lengths of almost 30 meters (m). Blue whales can also live to be around 90 years old. The smallest vertebrate in the world is a tiny frog that was only discovered in 2010. Found in the rainforests of Papua New Guinea, this frog is only around 7.7 mm long.

The fastest animal on Earth is the **peregrine falcon**, which can stoop (dive) at speeds over 400 km/h. This falcon can be found on every continent of the world except Antarctica. The slowest animals are sloths, moving at speeds that top only 4 meters per minute! Sloths are found in the **rainforests** of Central and South America. They have extremely slow metabolisms. It can take them up to two weeks to digest a meal! As a result, they must limit their activity, so they spend most of their time lounging in the treetops.

There are five major classifications of vertebrates: **fish**, **reptiles**, **amphibians**, **birds**, and **mammals**. Read on to learn more about some of the most interesting vertebrates we share our planet with.

Fish

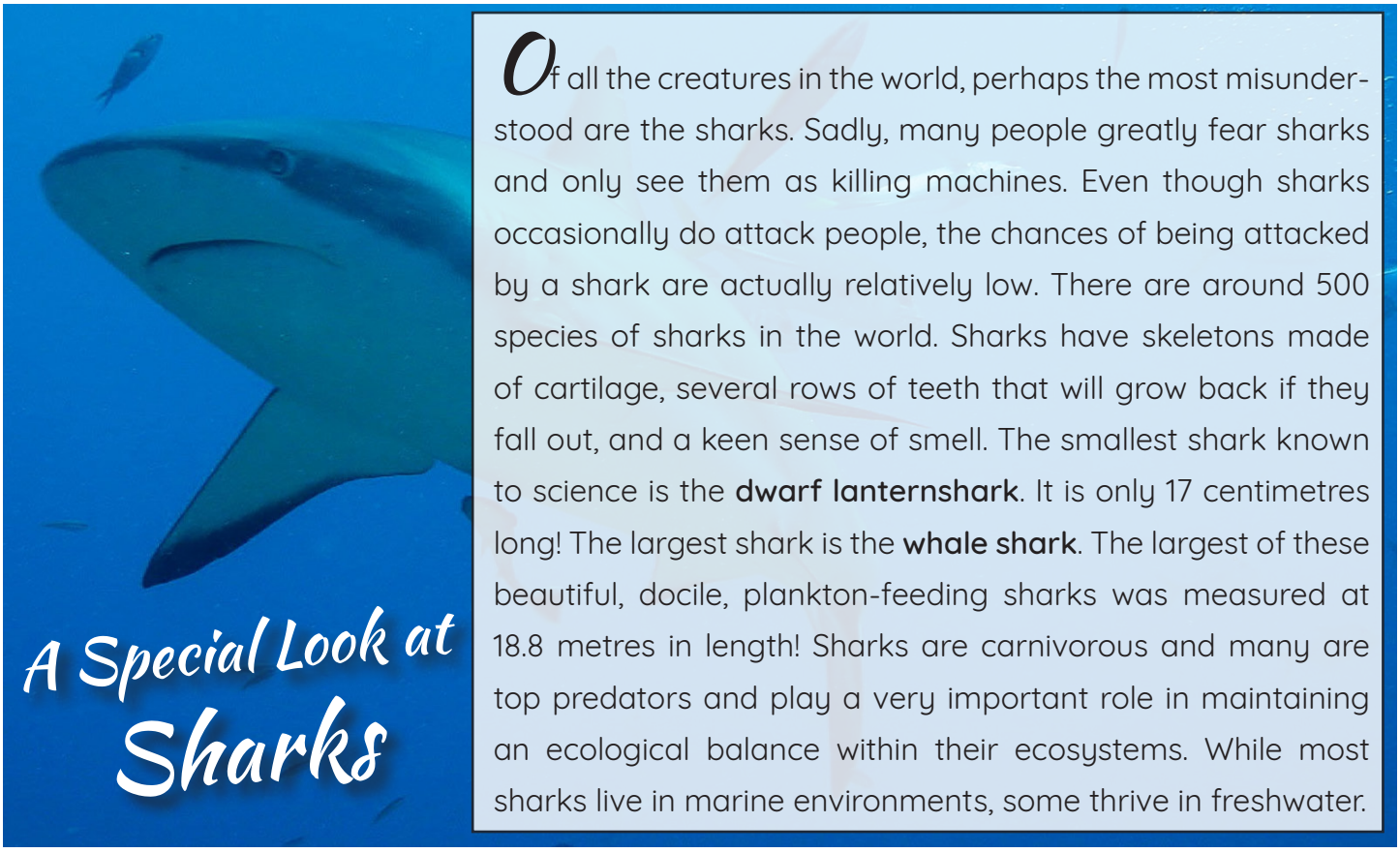
Fish live in waters all over the planet. Many are covered in scales, propel through the water with their fins, and use gills to breathe. Some fish are adapted to live in saltwater, while others require freshwater, and there are even some species that can live in both. There are roughly 32,000 species of fish on Earth. Fish range in size from 7.9 mm long to the enormous **whale shark**, which can measure over 12.5 meters in length!

While there are many different types of fish in the world's oceans, rivers, streams, ponds, and lakes, and each has its own unique characteristics, there are a few things that nearly all fish have in common. First, all fish are **ectothermic** - meaning their body temperature is influenced by the outside environment. But even so, this hasn't stopped some species from surviving in extreme temperatures. One adaptation for surviving in chilly water is to become lethargic or dormant during periods of extreme cold. While everyone knows that fish live in water, there are several species of mudskippers that actually spend a lot of time "skipping" or walking on mudflats. Mudskippers have forward-facing fins which they use to propel them forward on the ground. Some have even been known to climb onto low branches of trees using their fins. And speaking of fins, that is another characteristic all fish have. **Fins** help fish swim, of course, but they also help provide them with balance and agility. Just like fish themselves, fins can come in all different shapes

and sizes. Most fish have a dorsal (on the back) fin, side fins, anal fin, and a tail fin.

Finally, fish have special organs, called **gills**, which they use to breathe. Fish take in oxygen through their mouths in the form of oxygen-rich water. This is how a fish inhales. Then, the water is pumped over the gills and this helps the oxygen reach the fish's bloodstream. Then, the water that now has had the oxygen removed, exits the fish's body through the gills. Even though gills work extremely well, some fish species have developed lungs, and other fish species, such as the mudskippers which you read about above, can also breathe somewhat through their skin - like amphibians can.

Another important characteristic that most fish have is what is known as a **swim bladder**. If you have ever been underwater, you probably noticed that your body naturally tends to float to the surface. You might have had to kick your legs and work really hard to stay underwater. So, what about fish? It wouldn't make sense for them to continually be exerting extra energy just to stay below the surface of the water or at deeper depths. So what is a fish to do? This is where the swim bladder comes in. This is an organ that most bony fish have. Another name for it is an air bladder. This bladder in fact holds gas (oxygen) or oil and helps keep the fish from drifting up to the water's surface or sinking to the bottom of the sea.



A Special Look at Sharks

Of all the creatures in the world, perhaps the most misunderstood are the sharks. Sadly, many people greatly fear sharks and only see them as killing machines. Even though sharks occasionally do attack people, the chances of being attacked by a shark are actually relatively low. There are around 500 species of sharks in the world. Sharks have skeletons made of cartilage, several rows of teeth that will grow back if they fall out, and a keen sense of smell. The smallest shark known to science is the **dwarf lanternshark**. It is only 17 centimetres long! The largest shark is the **whale shark**. The largest of these beautiful, docile, plankton-feeding sharks was measured at 18.8 metres in length! Sharks are carnivorous and many are top predators and play a very important role in maintaining an ecological balance within their ecosystems. While most sharks live in marine environments, some thrive in freshwater.

Have you heard of an animal called a sea robin? Do you think it is a bird or a fish? A sea robin is a type of fish that perhaps got its name because it is said to resemble a bird when it swims, opening and closing its fins the way a bird might open and close its wings when it flies. You learned in Unit 1 a little bit about the fastest fish, the sailfish. But do you know which animals are the only ones in the world where the male gets pregnant and carries the eggs? The answer is seahorses, a type of fish. The female produces the eggs, but the males carry them until they hatch, 40 to 50 days later!

Some fish, like the **angler fish**, can glow through a process called **bioluminescence**. Some fish are venomous, some with venom strong enough to kill a person. There are even fish that can generate electricity! Electric eels emit strong electrical currents into the water to stun prey. Other fish can puff up to intimidate predators and some, like flying fish, "fly" over the water to escape predators. Though they don't fly like birds do, they can glide through the air at distances of up to 200 meters, though most "flights" are generally much shorter.

Amphibians

Amphibians, at different stages of their lives, live in both water and on land. They are ectothermic vertebrates with permeable skin. They are known for having primitive lungs and external egg fertilization. Most adult amphibians are **carnivores**. There are over 5,600 amphibians on Earth, including frogs, toads, and salamanders.

Amphibians (Class Amphibia) have the best of both worlds. The word '**amphibian**' comes from Greek *amphi* + *bios* which means "double life." This makes sense because, in a way, amphibians do lead a double life. Upon hatching, they live underwater and breathe through gills, like fish. But as they grow, they develop lungs which allows them to live on land and breathe air. The first known amphibian was ***Elginerpeton***. The fossils of this now extinct creature have been found in Scotland. Scientists believe it lived approximately 368 million years ago. Over the subsequent 300 million years or so, amphibians have continued to diversify and evolve, taking on a wide variety of unique and even bizarre forms.

For example, like fish, amphibians are ectotherms. As you learned in the section above, this means they cannot regulate their body temperature internally. Rather, their body temperature reflects the temperature of the environment around them. However, unlike many other ectotherms, such as reptiles, that are mostly adapted to living in hot environments, amphibians have unique adaptations for survival in cold temperatures. One frog, the **wood frog** of North America, is the most northerly occurring amphibian. It can even

be found living in the Arctic Circle. But how does it do it? When a wood frog begins to hibernate (which many amphibians do), it increases the amount of urea and glucose in its tissues. These work to limit the amount of ice that forms in the frog's body. During **hibernation**, the wood frog goes through cycles of freezing and thawing until the spring arrives. As long as no more than 65% of the frog's body water freezes, it will survive.

One of the most interesting of all the amphibian adaptations has to do with the ways in which they breathe. As you now know, amphibian larvae (young) breathe through gills when living and developing in water. As the young develop, they lose their gills and begin to grow lungs. By the time adult amphibians are fully developed, they have a fully working set of lungs. But, they actually use another organ to breathe with as well - their skin! Amphibian skin tends to be very thin and moist. Because their skin is so thin, amphibians can actually breathe through it.

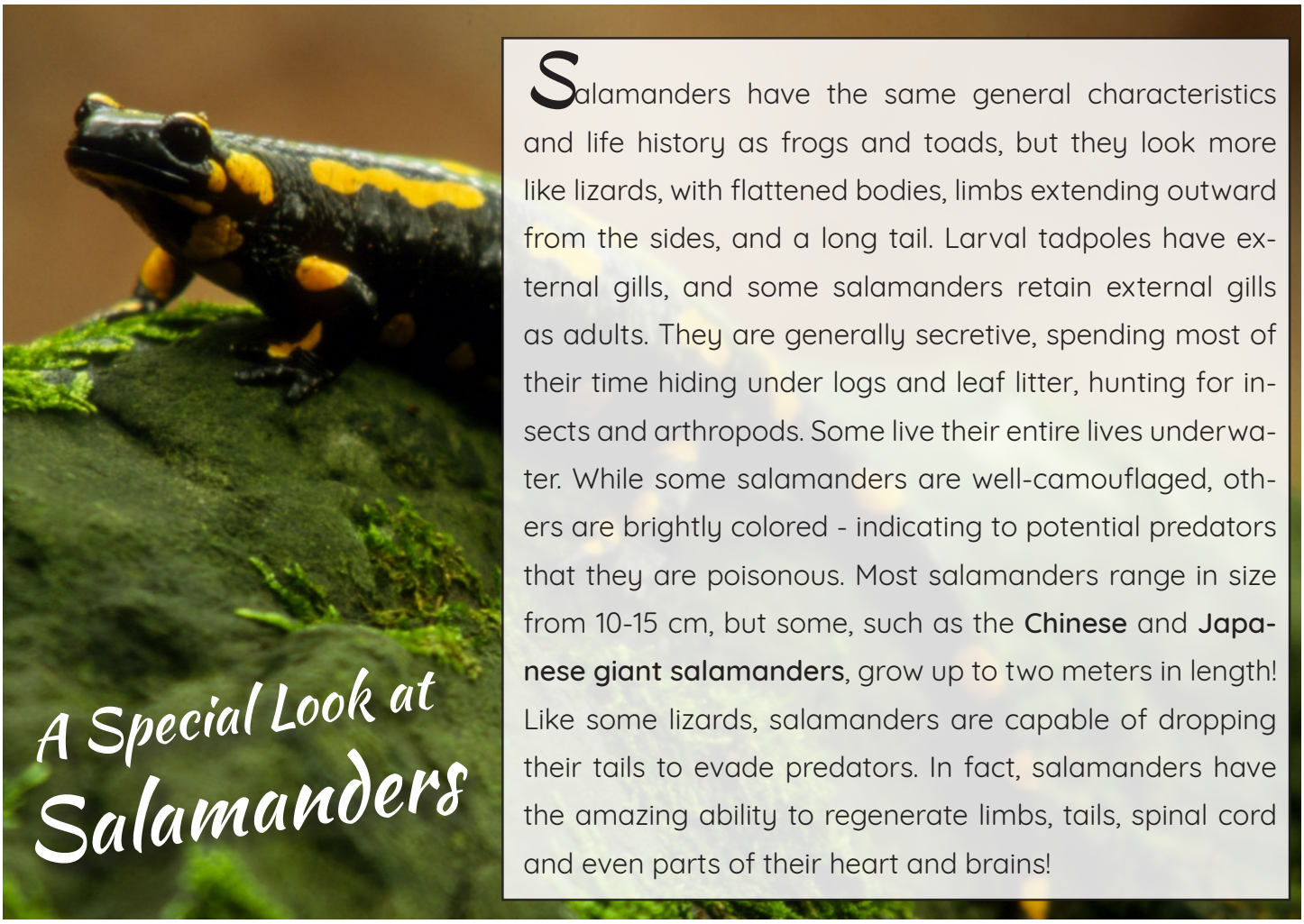
But, there is more to learn about amphibian skin! Many amphibians secrete substances from their skin that help in their survival in other ways. Some frogs and toads secrete waxy oils from their glands. This helps them live in more arid environments without having to worry about drying out (**desiccation**). Others, like poison dart frogs and marine toads, secrete toxins (that they get from eating ants!) from glands in their skin. This toxin is a great way to deter would-be predators who prefer to dine on animals not covered in poison!

When it comes to reproduction, amphibians have some unique adaptations. They engage in a variety of courtship rituals that can involve singing and some complex dance moves! Surely you have heard frog choruses on warm summer nights. These are male frogs calling to females. Some frogs, called gladiator tree frogs, will aggressively fight for females. They have a spike (called a spur) on their forelimbs which they use as a weapon!

After the singing, dancing, and fighting is over, it is time for the frogs to mate. Once they have done so, the females look for a place in or near water to lay their eggs. Unlike bird eggs, amphibian eggs do not have shells. Instead, they are laid with a protective layer of jelly-like substance. This helps the eggs to stay moist and avoid drying up. Many amphibians lay their eggs directly in water, in either clusters, along strings, or individually. Others opt to lay their eggs out of water in very humid environments, on leaves that hang over ponds or puddles, or directly in the mud. The larvae, called tadpoles, hatch from the eggs, are limbless and have a tail to move around in the water. As the larva grows, it will go through **metamorphosis**, or a change. First, it will slowly start to grow four legs, and at the same time, its tail will

shorten until it disappears. Its gills will shrink and disappear, and it will emerge from the water as an adult. As we know, there are exceptions to every rule in nature. Some species of frogs actually lay eggs on dry land and the larvae undergo metamorphosis in the egg stage and hatch as froglets with already formed legs and a reduced tail, ready for life on land.

Perhaps the most well-known amphibians are the frogs, toads, and salamanders. But, there is probably at least one group of amphibians you might not have heard of - the caecilians. These meat-eating amphibians look like a cross between an earthworm and a snake. They spend much of their life underground, although some species remain aquatic as adults and look a bit like eels. Many caecilians are nearly blind, while others have no eyes at all. They get around by using sensory tentacles located on the sides of their heads. These creatures are found on the continents of Africa, Asia, and Central and South America, but are rarely seen by humans.



A Special Look at Salamanders

Salamanders have the same general characteristics and life history as frogs and toads, but they look more like lizards, with flattened bodies, limbs extending outward from the sides, and a long tail. Larval tadpoles have external gills, and some salamanders retain external gills as adults. They are generally secretive, spending most of their time hiding under logs and leaf litter, hunting for insects and arthropods. Some live their entire lives underwater. While some salamanders are well-camouflaged, others are brightly colored - indicating to potential predators that they are poisonous. Most salamanders range in size from 10-15 cm, but some, such as the **Chinese** and **Japanese giant salamanders**, grow up to two meters in length! Like some lizards, salamanders are capable of dropping their tails to evade predators. In fact, salamanders have the amazing ability to regenerate limbs, tails, spinal cord and even parts of their heart and brains!

Reptiles

Reptiles, another major class of animals, are characterized by being covered in scales. They are ectothermic, which means they can't regulate their internal body temperature, but depend on external sources to stay warm. Because of this, reptiles are a little more limited on where they can live and are not found in environments of extreme cold. They are often seen sitting in open places to let the sun warm them, a behavior called **thermoregulation**. There are over 10,000 species of reptiles around the world, including snakes, lizards, turtles, and crocodiles.

Reptiles come in all shapes and sizes, and have some amazing adaptations for survival. Some are venomous, some are not. Some eat mainly plants while others are carnivorous. Some run, some slither, and some can swim. Most snakes can dislocate their jaw in order to swallow prey that is much larger than they are. While there are many venomous snakes found all around the world, only a few venomous lizards exist. The **Gila monster**, found in the southwestern United States and northwestern Mexico, uses venom to kill its prey. This lizard does not inject venom from fangs like a snake does. When it bites down on its victim, the venom pours into the wound from grooves in its teeth. Their bite is generally not fatal to humans. These lizards also store fat in their tails!

However, most other lizards use their tails for a different purpose. Since most lizards are not venomous, they have developed other means of self-defense against predators. Many have the ability to “drop” or release their tail when grabbed and then they can grow a new one. This will effectively startle the predator and give the lizard a chance to escape. The **horned lizard** of

North America has developed an even stranger method of escape. This lizard can shoot a thin spray of blood out of its eyes when it is scared or threatened, often startling the animal chasing it. This gives the lizard a few extra seconds to escape. Many lizards, such as chameleons and anoles, can change their color quickly to **camouflage** with their environment.

Snakes are unique reptiles that often get a bad reputation. Many people fear snakes because some are venomous, or their movements are seen as unpredictable. But the truth is, snakes are amazing predators essential for the health of the ecosystems where they live. They do not have legs, but they can move with great ease and efficiency in almost about every habitat imaginable. They are perfectly designed to live on land, in the treetops, and even in water.

Snakes are masters of movement. Despite being limbless (they have no arms or legs), their simplified bodies have various adaptations for locomotion. Their bodies are composed of strong muscles that contract as they move and many more vertebrae than most other vertebrates. This allows them to travel quickly on the ground, to agiley climb trees, to wind around branches, and even to hold their head and upper body absolutely still when waiting to strike at prey. They use one of two methods to kill their prey - venom or constriction.

Venomous snakes, such as pit vipers, cobras and coral snakes, strike their prey with their mouths and, biting down on their quarry, they inject a strong, lethal venom through their fangs. The majority of snakes lack venom. Most non-venomous snakes have adapted another hunting strategy. They grab their prey and wrap their bodies around the animal, tightening their muscles and strangling their prey. Once the animal is dead then they will start to eat. They have a specialized jaw that they can dislocate to open very wide and swallow prey whole. Many can even swallow prey much larger than they are! Despite a full mouth of teeth, they don't chew their food.

Snakes eat a wide variety of animals, including rodents, birds, frogs, insects, snails, earthworms, eggs and even other snakes! The largest snakes - **anacondas**, **pythons**, and **boa constrictors** - are capable of killing and eating rather large animals such as capybaras and pigs. There are over 3,000 species of snakes on Earth, found on every continent except Antarctica (and some large island countries).

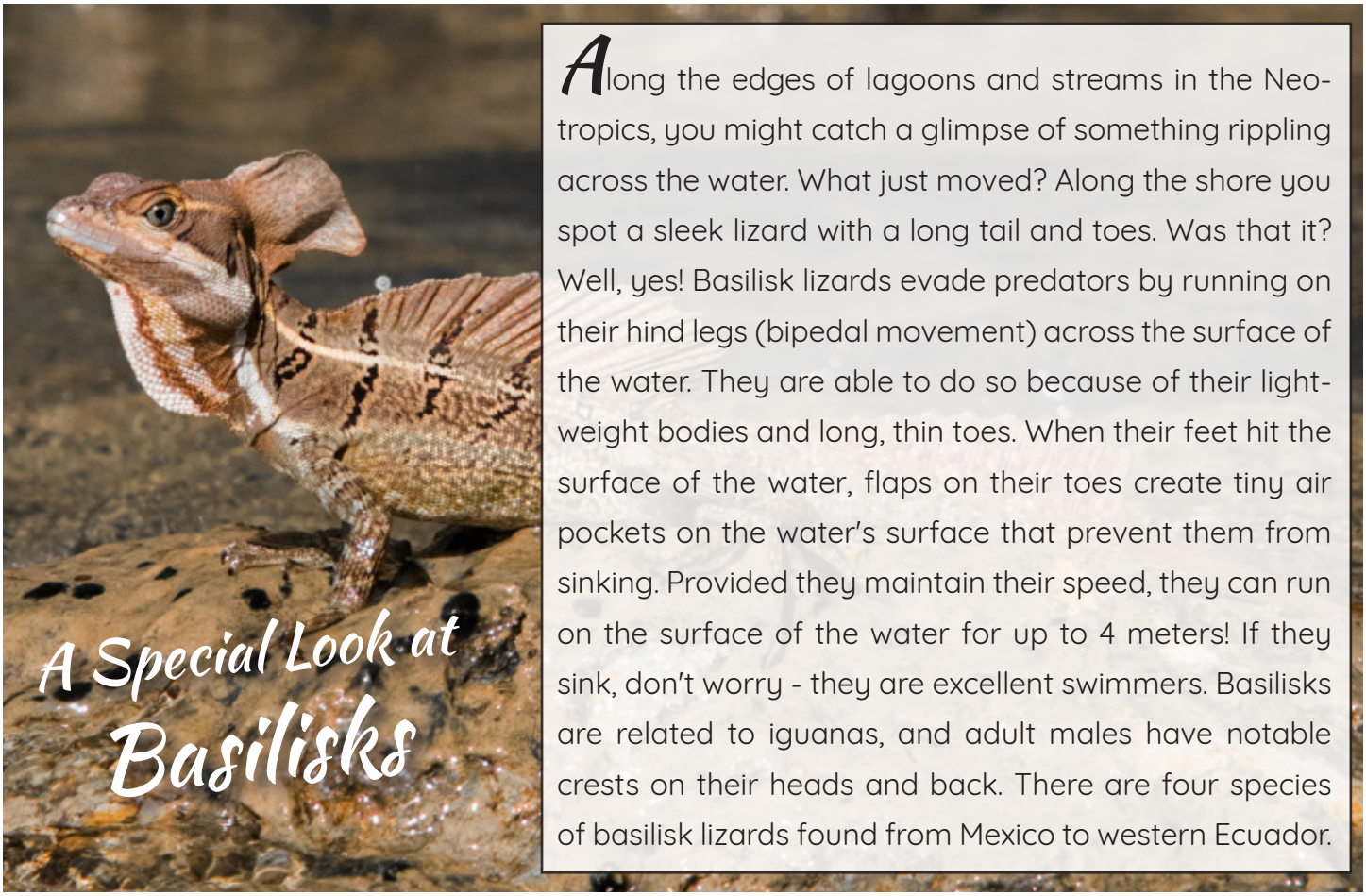
Turtles and tortoises are reptiles that are characterized by having a round shell (made out of keratin or cartilage) covering the upperparts and underparts of their body. The upper shell is called a **carapace** and the undershell is called a **plastron**. Together, they act as a shield to protect them from predators. Some land species can even fully tuck their head, legs and tail into their shell for additional protection. However, sea turtles do not have this ability.

Turtles and tortoises generally all have a similar, distinctive appearance, but there are some species with unique adaptations for acquiring food,

living semi-aquatic lives, and avoiding predation. Turtles and tortoises are generally slow-moving on land, but many are excellent swimmers, and some only come to land to lay eggs. Sea turtles have special adaptations for keeping themselves warm in cold water. They can adjust their swimming style and many have a thick layer of fat to help keep them insulated. Sea turtles have also been known to migrate for thousands of kilometers in their lifetimes. Like other migratory animals, they travel between nesting and feeding grounds, or to move to warmer waters.

Among the largest reptiles are the crocodilians. They are semi aquatic predators found in warm fresh and salt waters around the world. There are 27 species of crocodilians, classified into three families, which include crocodiles, alligators, caimans, and gharials.

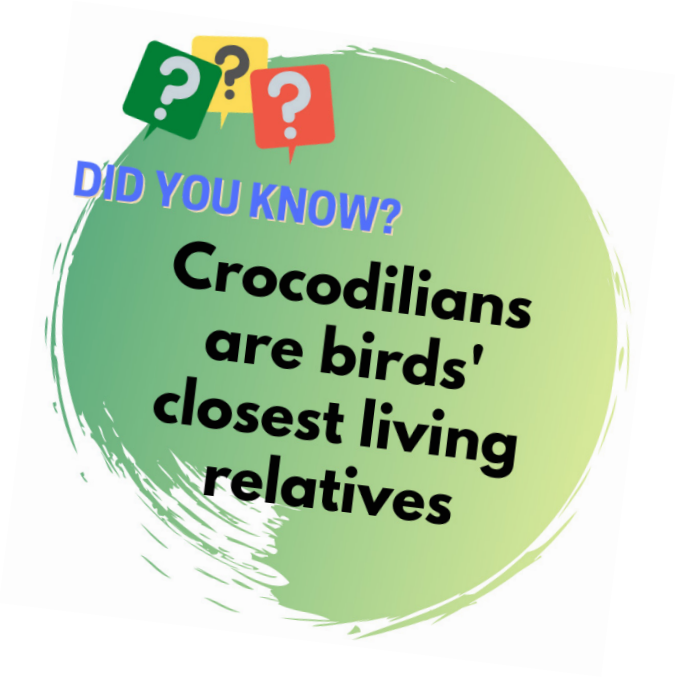
Crocodilians share some similar traits that help them survive in the water and on land. If you look at a crocodilian, many of these traits are easily identified.They have elongated, flat snouts (or noses), tails that are “laterally compressed” which means they are taller than they are wide, and, their ears, eyes, and nostrils are on the top of their heads which allows them to be almost fully submerged in water but still hear, smell, and see what is happening above the surface. They have thick, scaled skin and relatively short legs. But don’t let those short legs fool you. They are actually quite agile on land and can walk quite quickly. Some species are even known to gallop!



A Special Look at Basilisks

Along the edges of lagoons and streams in the Neotropics, you might catch a glimpse of something rippling across the water. What just moved? Along the shore you spot a sleek lizard with a long tail and toes. Was that it? Well, yes! Basilisk lizards evade predators by running on their hind legs (bipedal movement) across the surface of the water. They are able to do so because of their lightweight bodies and long, thin toes. When their feet hit the surface of the water, flaps on their toes create tiny air pockets on the water's surface that prevent them from sinking. Provided they maintain their speed, they can run on the surface of the water for up to 4 meters! If they sink, don't worry - they are excellent swimmers. Basilisks are related to iguanas, and adult males have notable crests on their heads and back. There are four species of basilisk lizards found from Mexico to western Ecuador.

As you would expect, crocodilians are great swimmers and they use their sharp, conical teeth and powerful jaws to trap both aquatic and terrestrial prey. These large reptiles will eat a wide variety of animals including fish, birds, mammals both large and small, crustaceans, and more. They often lie in wait, as still as logs, readying themselves for an attack when an un-suspecting animal comes to the water's edge to drink or swims by.



Think about all the amazing adaptations reptiles have. Many different reptiles have a number of adaptations in common. Some have unique ones all their own. Can you match the reptile on the right with its specific adaptation on the left?

Migrate

Change colors quickly

Squirt blood from its eyes

Lots of muscles and extra vertebrae

Retract head and limbs into shell

Ears, eyes and nostrils on top of head

Birds

Birds are the only living animals with feathers. They have perfected flight, even though not all birds can fly. As of today, just over 10,000 species of birds are recognized by science. The smallest bird in the world is the **bee hummingbird**, which is barely over 5 cm in length. The tallest, heaviest birds are the ostriches. They are 2.8 m tall and weigh over 130 kg! That is taller than most adult humans will ever grow.

Birds are perhaps the group of animals most often and most easily observed. This is because birds are found on every continent of the world and can be seen flying over land and sea, from the wildest habitats to the busiest cities. Whether in a desert, in a lush forest, in mangroves, on a high mountain peak, along a beach, in a high-rise building, on the open ocean, and even right in your own neighborhood, chances are, it won't be long before you notice a bird flying overhead or perched nearby.

Birds are feathered animals which hatch from eggs laid by the female. Like the other animals we are learning about, birds, too, come in all different shapes and sizes. They also have achieved some amazing adaptations for survival - from long-distance migrations, to parents and young learning each other's calls while the young is still in the egg, to incredible speed, strength, and agility. There is so much to learn about birds, we have dedicated a whole unit to them. You are going to learn more about birds in Unit 3.

Mammals

Mammals, like you and me, are found on all continents and in just about every habitat across the globe. From the waters of Antarctica to the deserts of Mongolia, and from the high peaks of the Himalayas to the lush forests of Madagascar, mammals are everywhere. But what exactly makes a mammal a mammal? Generally speaking, mammals are animals with hair or fur on their bodies. When they are babies, mammals suckle or drink milk from their mothers. While most mammals give birth to live young, a special group, called monotremes, hatch from eggs. All mammals are **endothermic**, which means their internal body temperature is constant regardless of outside environmental conditions. There are over 6,000 species of mammals on Earth. Rodents, bats, ungulates, felines, cetaceans, and primates are all types of mammals. They are highly diverse in form and have complex behaviors. There are mammals that walk, run, climb, swim, tunnel underground, and even fly!

Monotremes

One of the first things that we learn about mammals is that they give birth to live young! However, as you have also learned, nature is complex and there are exceptions to almost every rule. The monotremes fall into both of those categories.

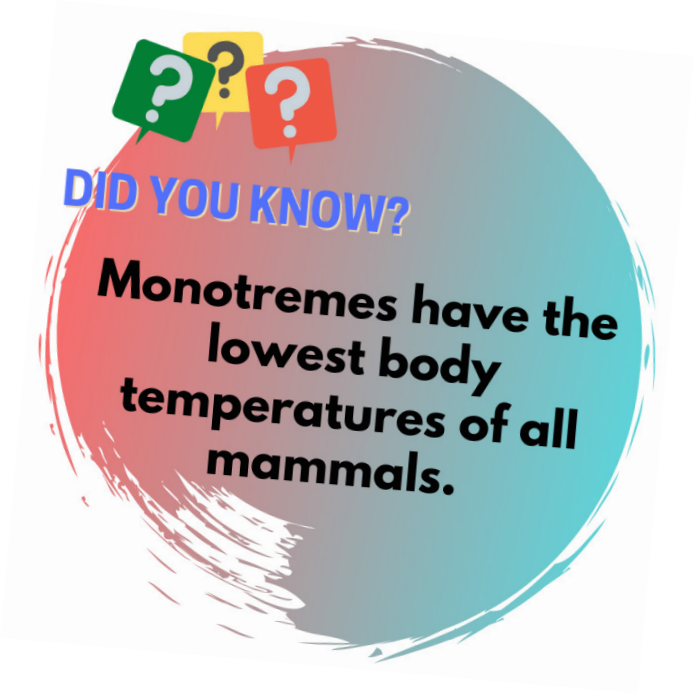
Even though they are mammals, monotremes don't give birth to live young at all. They, in fact, lay eggs! The eggs stay inside the mother for a relatively long time, and normally hatch less than two weeks after being laid. Even though the young hatch from eggs, they still feed on their mother's milk as they develop, which is one of the most important characteristics that makes a mammal a mammal.

Monotremes are predatory animals, meaning they hunt other organisms for food. If we break down the word "monotreme" we can understand a bit more about these fascinating creatures. "Mono" means one, and "treme" means opening. Just like birds, monotremes have one posterior opening that serves as its digestive, reproductive,

and urinary tract! Though it might sound like we are describing a species that belongs in a science fiction story, the truth is you have probably heard of the most well-known monotreme - the **platypus**.

There are only five species of monotremes in the world and they are all found in Australia and New Guinea. These include the platypus and the **echidnas**. The platypus, also sometimes called the duck-billed platypus, is the only living member of its family. It is semi-aquatic and can be found in quiet streams and rivers where it senses its prey through electrolocation using receptors in its fleshy bill. It is an excellent swimmer and has highly developed webbed feet. It is one of the only venomous mammals in the world. Males have a spur on the hind foot which delivers a venom, which can be quite painful to humans.

Echidnas, also known as spiny anteaters (although they are not related to anteaters at all), are medium-sized mammals with a narrow snout. They are covered in thick hair and spines. Like the platypus, their snouts are equipped with electroreceptors to detect their prey, which includes earthworms, ants, termites, and other insects.



Marsupials

Marsupials are also known as “pouched mammals.” This is because female marsupials have a pouch where the young stay and develop for a period after birth. When born, marsupials are very underdeveloped, many don’t even have fully-developed limbs at birth! They exit the birth canal and climb into their mother’s pouch where they attach to a teat and suckle milk for up to several months, depending on the species. You have probably seen a young kangaroo, called a joey, sticking its head out of its mother’s pouch. Well, that is how marsupials start their lives. Once they are big enough, they exit the pouch and are able to find food on their own.

Marsupials are found only in Australia and the Americas. Kangaroos, wallabies, wombats, **Tasmanian devils**, koalas, sugar gliders, and opossums are all marsupials. There are more than 250 species of marsupials, ranging in size from tiny mouse-opossums weighing under 5 grams to 200-lb kangaroos, the largest marsupials. They inhabit a wide variety of habitats and occupy different ecological niches. Marsupials first evolved in South America about 100 million years ago, but now reach their greatest diversity in Australasia, where nearly three-quarters of all marsupials are found.

Placentals

The majority of mammals are placentals. This means the females have a placenta - an organ that develops inside the female's uterus during pregnancy. The placenta makes it possible for the mother and fetus to exchange nutrients while the fetus is in the womb.

Placental mammals give birth to live young that feed on their mother's milk during the early stages of their lives. Some have a relatively short **gestation period** - the time that the fetus needs to develop in its mother's womb - while others are extremely long. For example, an **African elephant** develops for almost two years before it is born! Compare that to a **meadow mouse**, which only needs 21 days in the womb before birth. Of course, a fetus' development is just the beginning.

Once young mammals are born, life truly becomes difficult. Some remain with their parents for a long time and take months or years before they can fend for themselves. This is true of humans, of course, and of apes in general. For example, young gorillas

A Special Look at Sloths

Sloths live in the rainforests of Central and South America and are known for their slow-moving, upside-down, treetop style of living. Because their metabolisms are very slow, and because they feed on the leaves, flowers and fruits of rainforest plants, most of their days are spent eating and digesting. Long claws help them to grab onto branches and are used in defense. Sloths have long fur with grooves that hold algae, giving them a greenish appearance and helps them camouflage. Furthermore, sloths themselves are an entire ecosystem! They have special moths that live in their fur, eat the algae and lay their eggs in sloth poop. There are two families and six species of sloth alive today. But living sloths have several extinct relatives, and not all sloths lived in trees. The giant ground sloths were nearly the size of elephants!

and orangutans will stay with their mothers for several years until they become independent. Others, like many ungulates, are up and running (literally) only a few hours after being born, even though they still rely on their mother's care for food and protection. Some mammals are born blind and helpless, including mice and other rodents. The elephant shrew, found throughout parts of Africa, develops very quickly. It is completely independent of its parents' care just two weeks after it is born. Compare this to a wolf pup, that doesn't even open its eyes until two weeks after birth. Then, it still needs time to learn to hunt and avoid danger!

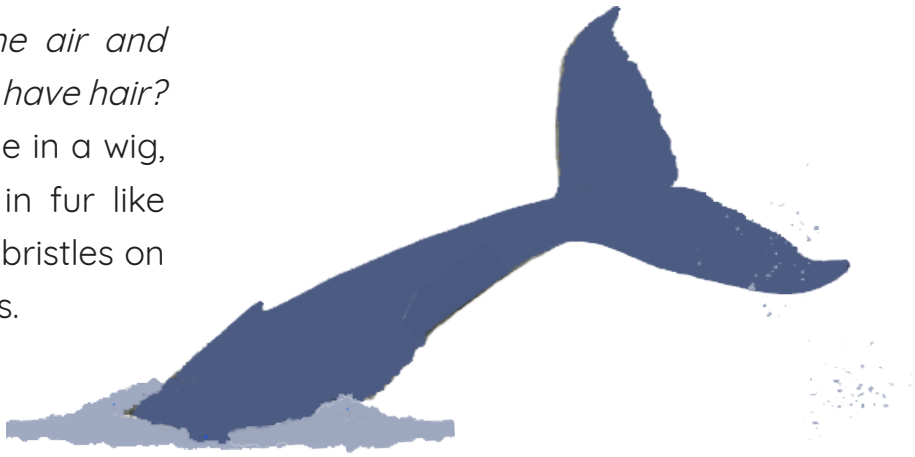
The largest order of mammals (the one with the most species), is the rodents. The **capybara** is the largest rodent in the world. This rodent is native to South America and measures over 1 meter in length and can weigh over 100 lbs! One of the smallest rodents in the world is the **pygmy jerboa**. It is believed to be endemic to Pakistan. It is only 5 cm long (not including the tail, which adds about 8 cm to its length), and weighs only 3 grams.

The second largest order is that of the bats, which is split generally into the insect-eating Microchiroptera and the larger fruit-eating bats and flying foxes, the Megachiroptera. There are 1,400 species of bats, found on every continent except for Antarctica. Like other groups of animals, bats reach their greatest diversity and number of species in the tropical regions around the world.

Primates, including humans (yes, we're mammals), are a highly diverse group of placental mammals. This varied group includes lemurs, bushbabies, gibbons, and apes. Primates are highly social, with complex behaviors and high levels of intelligence.

Sometimes, we forget that mammals don't necessarily have to live on land. Many live in water, for example, whales. Now, you might be thinking to yourself, *I know that baby whales suckle, they breathe air and are warm-blooded, but do whales have hair?* Well, you have never seen a whale in a wig, have you? Though not covered in fur like many mammals, whales do have bristles on their bodies, usually on their heads.

Other ocean-dwelling mammals, called **cetaceans**, include dolphins and porpoises. And, of course, we can't forget the **manatee** (also known as the sea cow) and the **dugong**. Marine mammals that spend quite a bit of time in the ocean and land include the pinnipeds (seals, sea lions and **walruses**), **polar bears**, and **sea otters**.



You have now learned a little bit about some of the amazing mammals found on planet Earth. How do they vary? How are they similar? Take a look at the words in the left hand column of the chart. Using what you learned, think about some descriptions you can put into each column to explain a bit about the different adaptations of the three main types of mammals. Can any words apply to more than one? How about all three?

	Monotremes	Marsupials	Placentals
Birth of young			
Development			
Distribution			
Size			
Diet			

A CLOSER LOOK

Vertebrates at a Glance

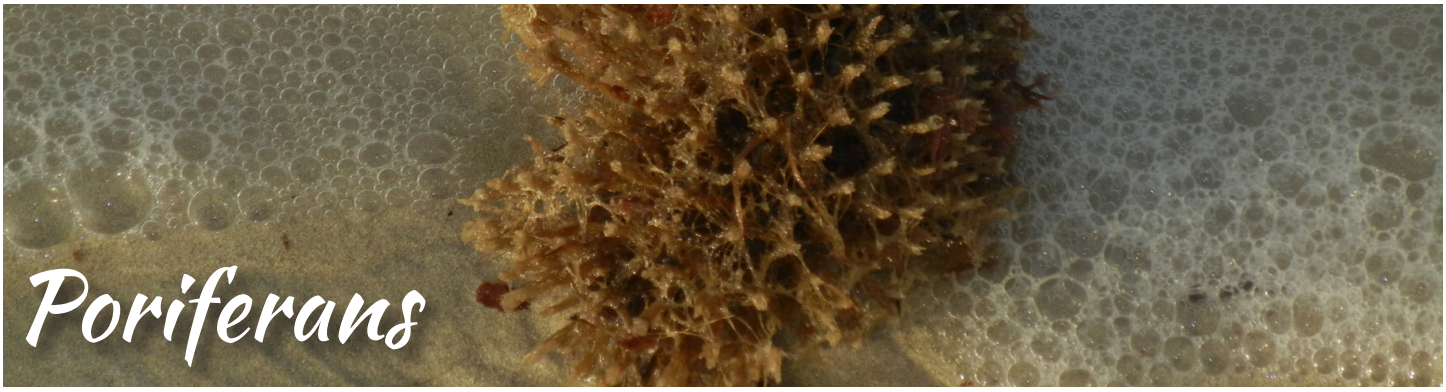
	 Body Cover	 Temperature	 Young	 Dentition	 Breathing	 Defense
Fish	Modified scales, fins, some have spines	Ectothermic (cold blooded)	Most hatch from eggs Some live birth	Highly variable teeth designed for chewing, crushing, tearing, and grabbing prey	Primarily internal and external gills, swim bladders, few species with lungs	Sharp teeth, mimicry, safety in numbers, camouflage, venomous spines
Amphibians	Smooth, thin and breathable	Ectothermic (cold blooded)	Born from eggs, some live birth Long period of development, metamorphosis	Teeth, but not for chewing, used to hold prey in place	Breathe through skin, gills, and lungs	Camouflage, poison, speed, evasion
Reptiles	Overlapping scales, sometimes hard shells, some with spines	Ectothermic (cold blooded)	Most hatch from soft-shelled eggs Some live birth	Conical, sharp teeth, ability to regrow them	Well-developed lungs	Venom, camouflage, speed, hard shells, tail-dropping
Birds	Covered in feathers with some bare skin patches	Endothermic (warm blooded)	Hatch from hard-shelled eggs laid by female	Toothless beaks of many sizes and shapes	Lungs and air sacs	Camouflage, some have spurs or sharp talons, stooping, distraction display
Mammals	Fur covering at least part of body	Endothermic (warm blooded)	Mostly live born (except monotremes) Young suckle their mother's milk	Varied teeth including canines, molars, and incisors, conical teeth or baleen in Cetaceans	Well-developed lungs	Camouflage, teeth, claws, spines, spurs, armor, odor, speed, venom

Invertebrates

Of all the animals on Earth, the invertebrates are the most abundant and the most diverse. Though they often go unnoticed, they are actually some of the more fascinating creatures we share our planet with. As you know, vertebrates are animals with a spinal column. **Invertebrates**, therefore, are those organisms that lack one.

As you may have guessed, they vary quite a bit in size, shape, form, and function, though they are all ectothermic. The smallest invertebrates are the rotifers, otherwise known as "wheel animals" that measure 0.1-0.5 millimeters long. The largest invertebrate is possibly the **Colossal Squid** which can measure about 10 meters long! That is about the length of 6 averaged-size humans put together. It is estimated that 97% of all animals on Earth are invertebrates, somewhere around 1,300,000 species. Of all the invertebrates, the insects are the most abundant, with around 1,000,000 different species! How many different insects can you name?

Generally, invertebrates are classified into several main groups, which can sometimes be broken down even further into smaller categories. The major groups of invertebrates are **poriferans**, **cnidarians**, **echinoderms**, **mollusks**, **annelids**, and **arthropods**.



Poriferans

When you think of the word "sponge" perhaps the first thing that comes to mind is the soft, man-made object one might use to wash dishes or wipe down a table. But sponges are, in fact, living, mouthless, sometimes carnivorous multi-celled animals. They live mainly in marine environments, though some will live in brackish water and, more rarely, freshwater.

At first glance, most people would probably guess that sponges are plants. After all, they are stationary and colorful creatures that look a bit like tall clumps of moss. But rest assured, these organisms are indeed animals. In fact, they are part of the most ancient lineage of all animals.

As you learn more about sponges, some questions might come to mind. For instance, how can sponges eat if they don't have mouths? Well, they also don't have nervous, digestive or circulatory systems either! So what is a sponge to do? Sponges eat, get oxygen, and pass waste through their pores. The flow of water over these openings helps direct nutrients to their bodies, which they filter from the water, and flush out waste.

Sponges are found the world over and live in many different ocean habitats from warm tropical waters to frigid Arctic oceans. However, they are more abundant in clear, calm parts of the ocean. You can imagine how difficult it would be to be covered in large pores and live in turbulent water that was always kicking up sand and other sediments.

Sponges provide habitat for many other sea creatures - providing them with shelter, and even access to food!

Cnidarians

If you've ever been stung by a jellyfish, touched the sticky "mouth" of a sea anemone, or seen a coral reef, you have been in contact with a cnidarian. There are between 9,000 and 11,000 species of cnidarian (belonging to the Phylum Cnidaria) on Earth. They are found mainly in marine environments, but a few also make their homes in freshwater ecosystems.

Though cnidarians are extremely diverse, there is one thing that they all have in common. This characteristic separates them from all other animals on the planet. It is something called cnidocytes. A **cnidocyte** is basically a stinging structure that they use to stun and catch prey, sometimes for defense, and less often to anchor themselves. While you might be thinking that a porcupine also has stinging quills, you would be right of course. But a porcupine loses its quills when they are used for defense. The cnidocytes are connected to the cnidarian's body, thus the difference!

Another interesting thing about cnidarians is that they use the same opening on their body for eating and discarding waste (pooping)! And speaking of eating, different cnidarians get their food in different ways. Some are predators, feeding on small prey such as plankton. Some feed on prey even larger than they are. Some cnidarians are parasitic.

Cnidarians are divided into several groups including anemones, stony corals, soft corals, hydrozoans, box jellyfish, true jellyfish and stalked jellyfish. There are tiny obligate parasite cnidarians (Myxozoa), containing some of the smallest animals ever known.

Cnidarians are generally found in shallow waters, in order to uptake nutrients efficiently. However, there are some deep sea corals, as well. Cnidarians can be found worldwide, but different groups have different ecological preferences. Coral form complex ecosystems throughout warm tropical waters, but others, such as some sea anemones can even be found in cold Arctic waters.

Echinoderms

Echinoderms are animals only found in marine environments. Though they are varied, they do share some common traits. They are usually symmetrical, and often have five (or multiples of five) arms. which gives them their round or star-like appearance. They have skin-covered shells made up of **calcium carbonate**. The name "echinoderm" comes from the Greek meaning "spiny skin," a great way to describe some of these unique creatures!

There are around 7,000 different species of echinoderms (and even more extinct species) including starfish, sea urchins, brittle stars, sand dollars, sea lilies, feather stars, and more! Also within this group are the sea cucumbers. They are typically **benthic**, meaning they live on the ocean floor.

When it comes to feeding, echinoderms have simple digestive systems and most are generally herbivores or **detritivores,** scraping up plant and animal matter with specialized mouthparts designed for grinding. Some, such as starfish, are carnivorous, and are key predators of corals and other marine animals. Others, such as the crinoids, catch plankton with their extended arms as it floats in the water.

Instead of having blood vessels, echinoderms have a water **vascular system** that moves oxygen throughout their bodies. When it comes to walking, starfish need the help of water to get moving! Starfish have hundreds of tiny "tube feet" or "podia" on their underside, which fill with sea water. Little spaces in the vascular system pump water through the tube feet to extend them and have special muscles to retract them. By expanding and retracting the tube feet, they can "walk" across surfaces. Many echinoderms have amazing regenerative powers, and if they lose limbs or spines they will be able to grow them back over time.

As you can imagine, the echinoderms are prey for many other sea creatures. But don't worry, many are equipped with strong deterents. For example, sea urchins and starfish are well-protected with spiny covering over a majority of their bodies.

Mollusks

If you've ever come across a snail or a slug in your backyard, you have met a mollusk. Mollusks are the second largest group of invertebrates after the arthropods, and contain around 85,000 living species. However, this number is a broad estimate, and there could be as many as 120,000 species of mollusks on Earth.

Right about now, you may be wondering what makes a mollusk a mollusk? Mollusks are generally soft-bodied invertebrates that are either partially or fully enclosed in a hard shell. The shells of mollusks are made up of calcium carbonate (which we see in the echinoderms and some cindarians, like coral, too).

The three major groups of mollusks are the **gastropods** (snails and slugs), **bivalves** (clams, mussels, scallops, and oysters), and **cephalopods** (octopus, squid, and cuttlefish). Chitons, tooth shells (a burrowing mollusk) and other minor groups are also mollusks. You're probably familiar with snails, clams and octopuses, but you're probably thinking, wow, they all look so different from each other, how can they all be related?

To understand their shared characteristics, we need to look at a few special body features. They all have a mantle, or body wall, which has a chamber and is used for breathing and excreting wastes. Most mollusks (except the bivalves) have a radula, a scraping mouthpart used for feeding. Finally, their nervous systems all share the same structure. Another main characteristic of many mollusks, especially notable in gastropods and bivalves, is a muscular foot. This fleshy part is used in many ways - for moving, secreting mucus, burrowing, balance, as a sucker, and for jet propulsion!

Mollusks can be found in marine environments, in freshwater, and on land. As you know they come in many, many forms and are very diverse. Approximately 80% of all mollusks are gastropods. Mollusks range in size from tiny snails less than a millimeter in shell length, to the **giant** and **colossal squids**, which reach 10 meters long and weigh over 1000 lbs. These large squids are rarely seen because they live deep in the oceans.

Arthropods

Another major classification of animals is the arthropods. The word "arthropod" means "jointed limbs," and includes any critter with four or more jointed legs. When we talk about arthropods, we are talking about advanced invertebrates including insects, spiders, scorpions, centipedes, crabs, lobsters, and any other animal that has a hard exoskeleton, a segmented body, and paired jointed legs. They can be found on land and in the sea. Scientists believe that there are between 6 and 9 million arthropod species in tropical forests alone and that up to 10 million species exist on the planet! There are surely some arthropods that scientists haven't even discovered yet.

When you see an insect, such as a beetle, or a crustacean, such as a crab, what is the first thing you notice? Well perhaps it is the hard outer covering all over its body. This is called an **exoskeleton**. This external skeleton acts as an armor, is used for feeding (think about a crab or lobster claw), produces secretions, and provides protection from water loss and drying out (**desiccation**). It is also a solid surface for muscles to attach.

Compared to other invertebrates, arthropods are the most advanced group in terms of their more complex internal organs and systems. Many arthropods, notably the insects, have even developed wings and taken to the air. While many are solitary, there are notable groups of arthropods, such as wasps and ants, that are highly social.

Speaking of wasps, there is one group that has a particularly interesting way of feeding its young. The tarantula hawks (which are actually wasps) are found around the world and specialize in parasitizing spiders. When they find an unsuspecting large spider, they will attack it and sting it, injecting them with venom. But the venom doesn't kill the spider - it only paralyzes it. The wasp then drags the spider to its underground den. There, it lays its eggs on top of the spider. When the wasp larvae hatch, they have a fresh meal (the spider) waiting for them!

As you may know, some arthropods use camouflage to evade predators or to hide in wait for prey. Some nocturnal scorpions have taken that one step further. They actually glow under UV light - a trait which sci-

entists have yet to fully understand. Some believe it is to help the scorpions detect UV light so they can avoid it and stay hidden in the darkness. Others theorize that this helps them find other members of their species, protect them from the sun's rays, or even trick their prey.

While some arthropods might not be on the top of the your list of favorite animals, there are some that are quite beautiful. Take a look at the photos below. Notice their bright colors, intricate patterns, and flashy decorations. Can you think about the benefits of having these attractive characteristics? Would their be any disadvantages?

Of course, we could write a book on arthropods alone, as there is much to say about this amazing group of invertebrates.

Worms

Do you like to dig through the dirt, or spend time working in your garden? If you do, have you ever come across an earthworm? The earth's soils are home to many burrowing animals, and one of the most abundant groups of organisms that we can find underground are worms. But that's not the only place that worms can live! Worms lack limbs, but despite that, they can lead very interesting lives. Worms are quite diverse, and they are generally divided into three major groups: **flatworms**, **roundworms**, and **segmented worms.** You will find out some of the wild and wonderful things about worms in this section.

Platyhelminthes

As you may have guessed, flatworms, also known as platyhelminthes, look flat which is how they got their name! This group, which includes true flatworms, tapeworms, and flukes, often resemble leaves or ribbons and have simple eyes at one end. If you are having trouble picturing them, it might help to imagine a flattened slug. They can be found in marine and freshwater habitats, as well as soils around the globe. They truly are very simple: they do not have any internal organs, and lack specialized respiratory and circulatory systems. They simply pass oxygen and nutrients through their skin, and intake food and excrete wastes from their main digestive cavity through only one opening. While most are free-living, many are parasites, found only in the bodies of other animals. Those we find in leaf litter and aquatic environments are primarily predators.

Nematodes

Nematodes - the roundworms - are very abundant on our planet. Like flatworms, there are both parasitic roundworms and free-living roundworms. They can be found in a wide variety of habitats, from leaf litter and soils, freshwater and marine environments, from the frigid poles to the hot and humid tropics, and even in deep, water-filled cracks in the Earth's crust. There are two species found in the deepest ocean trenches. They are the deepest living multicellular organisms known on our planet. As their name suggests, these worms are round, slender, and smooth, and tapered on both ends. Their

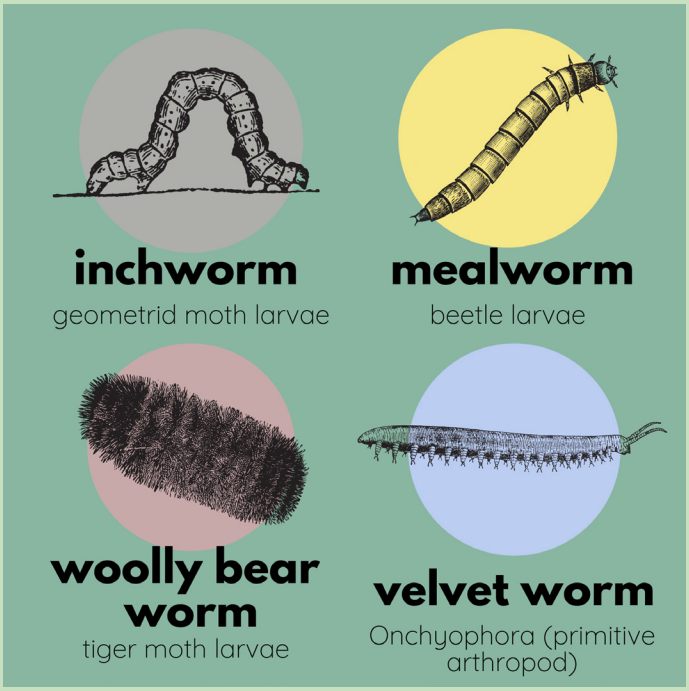
skin is covered in a thick cuticle, which is shed on occasion. Unlike flatworms, their digestive system is tubular with an opening on each end of their bodies. They range in size from microscopic to up to 7 meters long! The longest roundworms are found in the intestines of whales. Nematodes are well known parasites of animals and plants, and can cause a number of diseases. Scientists aren't sure just how many species of roundworms there are on Earth. However, they estimate that there are between 20,000-40,000 but with good evidence that there may be more than 1 million species. Considering they are found in great numbers in many different habitats, nematodes are among the most abundant animals on our planet.

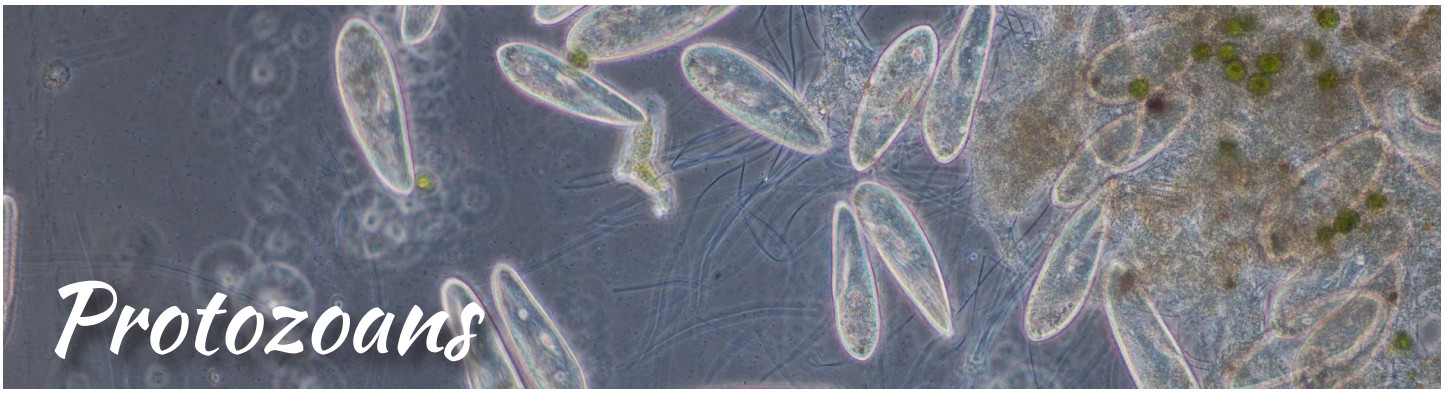
Annelids

Otherwise known as the ringed or segmented worms, there are over 22,000 species wriggling around our planet. Perhaps the most well-known annelid is the earthworm - denizen of backyard gardens and compost piles. This group of worms includes earthworms, polychaete worms, and leeches. All annelids have body segments, which often look like rings around the worm. With the exception of leeches, all annelids have tiny hairs called setae that grow off their cuticles that cover their skin. Some annelids, such as the aquatic and semi-aquatic polychaete worms, have leg-like appendages called parapodia. Compared to flatworms and roundworms, annelids have well-developed internal organs. They can be found in marine, freshwater and terrestrial ecosystems. Some are filter feeders, while others are quite predatory.

A worm or not a worm?

There are many critters on our planet with the word "worm" in their names, but in reality, many are not really worms at all! Have you heard of a glowworm? It is actually a beetle larva. How about a silkworm? It is the larva of a family of moths. And ringworm? It is a type of skin fungus! So we need to be a little careful when we hear the word "worm," and maybe investigate a little more into what it really is! Here is a list of some other "worms" that are not true worms!





Protozoans

Protozoans are single-celled organisms that can only be seen with the help of a microscope. For centuries, no one even knew these organisms existed and scientists had to work really hard to prove their existence, even to other scientists! The invention of the microscope helped us to study and discover so much more about these incredible organisms!

Have you ever heard of an amoeba? It is just one type of protozoa. Even though we may not know it, protozoans are all around us and we interact with them on a daily basis. Some are free-living, and others are parasitic. In fact, many major diseases are caused by protozoans. Malaria is caused by a protozoan called ***Plasmodium*** and is transmitted by mosquitoes.

While we may worry about protozoans that cause diseases, many are harmless or can even be beneficial to their hosts, aiding in digestion or other processes. ***Amoeba***, ***Euglena***, ***Paramecium***, and ***Trypanosoma*** are just a few examples of some common protozoans.

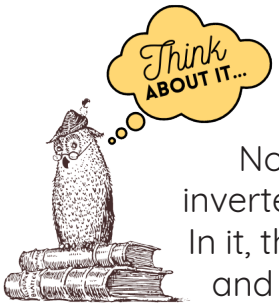
Like all the other organisms on Earth, protozoans are found in a wide variety of environments including marine, freshwater, and terrestrial. Deep in oceans, in shallow puddles, and in the soils beneath our feet when we walk through a forest are just some of the habitats where we can find these microscopic creatures. Some can even live in rather extreme environments, such as hot springs.

Protozoans can be thought of as simple animals and plants. In fact, the word “protozoa” actually means “first animal.” Despite being single-celled, they are actually complex and come in a wide variety of forms and sizes. The smallest ones measure 1 micrometer, but the largest deep-sea dwelling protozoans can have shells up to 20 cm! They feed by engulfing food into a “mouth cavity” or simply by absorption through their cell membranes.

Free-living protozoans may be predatory or herbivorous, feeding on algae, bacteria and microfungi. Many protozoans are food sources for some invertebrates. They move with the assistance of either cilia (tiny hairs covering their body that move in waves), fla-

gella (thin, whip-like structures), or through amoeboid movement, in which they extend a part of the cell called “pseudopodia” to move, kind of like growing a limb every time you want to walk!

So the next time you are playing in the dirt or swimming in a lake, think about all the microscopic protozoans in there that you cannot see, and remember, they all play an important role in the environments in which they live.

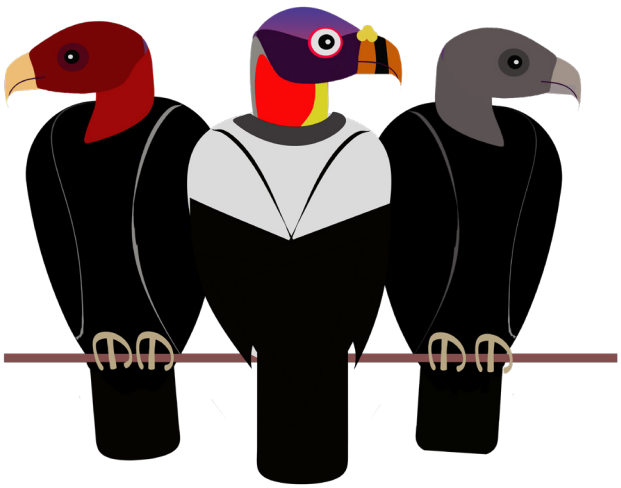


Now that you have learned more about some of the different groups of invertebrates, let's see what you remember. Take a look at the graphic below. In it, there are two echinoderms, one sponge, three mollusks, four arthropods, and one cnidarian and one worm represented here. Can you find them all?

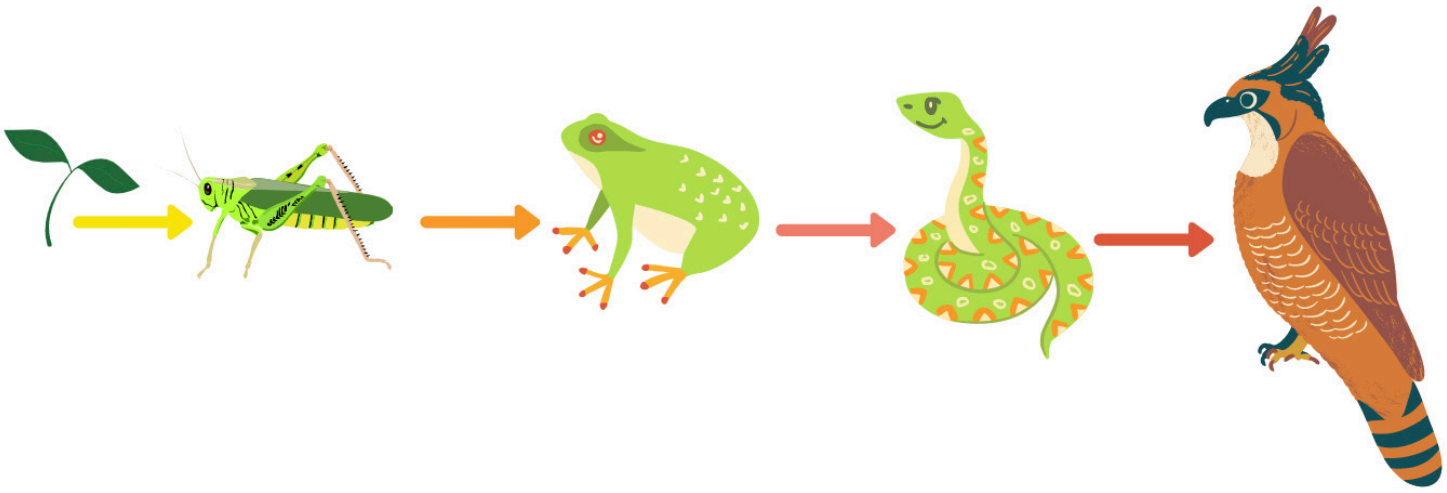
Food Chains

Did you have a meal today? What did you eat? Cereal? Porridge? Rice? Milk? Eggs? Bread? Fruit? Think about where your food comes from. Let's say, for example, you had an egg with breakfast. Where does this egg come from? Most likely, it came from a chicken. But what does a chicken need to eat in order to produce healthy eggs? A chicken eats small insects, such as grasshoppers, and other arthropods, as well as corn and some grains. What do the insects that the chicken eats feed on? They most likely eat plant matter. So, in order for you to have an egg for breakfast, there must be sunshine and rain to help plants grow. There must be enough plants to provide enough food for the insects. The insects have to eat the plants, and the chicken has to eat the insects. Then it lays the eggs which the farmer collects and sells, or which you collect right from your own backyard. Whew! That is some journey.

Do you see at least one reason why grasshoppers are important to humans? Humans and all living things are part of one or usually many food chains. **Food chains** are the sequence of plants and animals that eat each other in order to get food or their energy source. In a food chain, the plants are known as the **producers**. This is because they produce their energy from sunlight. Plants then serve as food (and energy) for other animals. The primary consumers are the herbivores, those that eat plants and the secondary and tertiary consumers are the omnivores and carnivores.



Here is a simple example of a food chain. Can you identify the **producer**, **primary**, **secondary,** and **tertiary consumers**? What would we call the hawk at the top of the food chain? Read on to learn more!



Producers

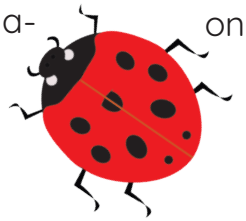
As you now know, the food chain cycle begins with green plants. The **chlorophyll** in their leaves is what makes them green, but it also gives them the amazing ability to produce their own energy - meaning they don't have to eat other living things in order to survive. How is this possible? These plants produce their own chemical energy through a process called **photosynthesis**. Photosynthesis takes place in the green parts of the plant. With the help of sunlight, plants create their own food from water and carbon dioxide (CO_2). This is actually key to the survival of all living things on the planet. Not only because plants form the base for most food chains, but because, as a byproduct of photosynthesis, oxygen is produced! As you know, we all need oxygen to breathe! Think about this next time you see a green plant.

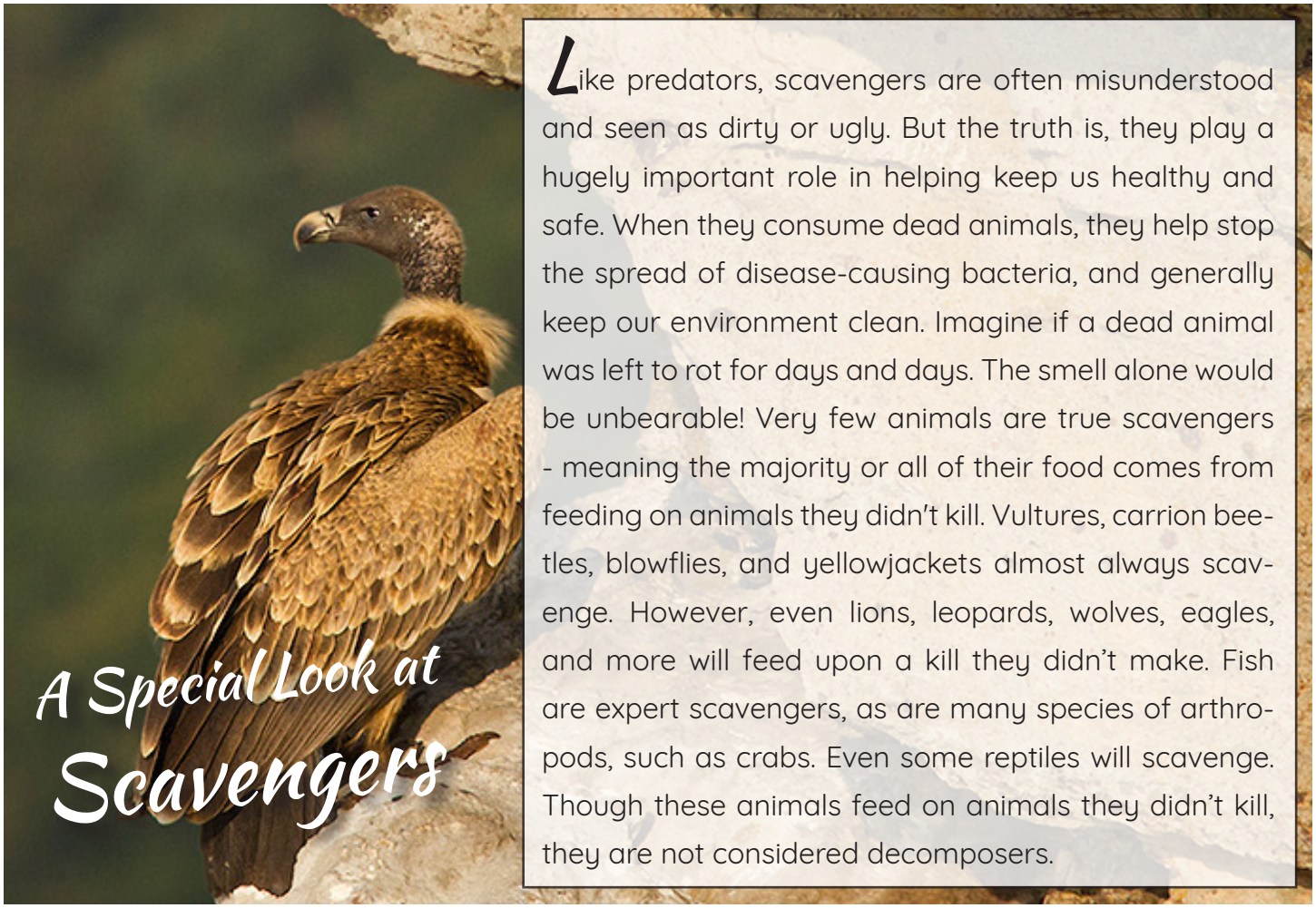
Primary Consumers

We have now learned a bit about the producers - or plants. Moving up the food chain, the next group of animals we find are the primary **consumers**. These animals are often strictly **herbivores**, meaning they eat only plants and plant matter. A primary consumer can be as large as a horse or a cow, or as small as a grasshopper, or even smaller. Elephants, gorillas, zebras, and butterflies are just some examples of primary consumers. What others can you think of?

Secondary Consumers

After the primary consumers, we find what are known as the secondary consumers. While secondary consumers might eat plants, they also hunt and feed on other animals as well. A good example of this is a songbird. Many songbirds eat fruits and nuts, but also capture insects and other arthropods. Generally speaking,. secondary consumers are **omnivores** or **carnivores**. Some examples of secondary consumers include lizards, frogs, songbirds, chickens, and ladybugs.





A Special Look at Scavengers

Like predators, scavengers are often misunderstood and seen as dirty or ugly. But the truth is, they play a hugely important role in helping keep us healthy and safe. When they consume dead animals, they help stop the spread of disease-causing bacteria, and generally keep our environment clean. Imagine if a dead animal was left to rot for days and days. The smell alone would be unbearable! Very few animals are true scavengers - meaning the majority or all of their food comes from feeding on animals they didn't kill. Vultures, carrion beetles, blowflies, and yellowjackets almost always scavenge. However, even lions, leopards, wolves, eagles, and more will feed upon a kill they didn't make. Fish are expert scavengers, as are many species of arthropods, such as crabs. Even some reptiles will scavenge. Though these animals feed on animals they didn't kill, they are not considered decomposers.

Tertiary Consumers

As we move up the food chain, we find ourselves side by side with the tertiary consumers. These, of course, are animals that feed upon the primary and secondary consumers. Tertiary consumers might be omnivorous, or they might be strictly carnivorous. Think about a seal catching fish, a raccoon eating crabs, or a fox snatching up eggs and birds from a nest. These are all examples of tertiary consumers.

Top Predators

As you know, predators are those animals that hunt other living animals for food. You also know that all of the secondary and tertiary consumers are considered predators. However, these animals aren't considered top predators. So, what is the difference between a predator and a **top predator**?

Top predators are those animals that prey on many other animals, but have few, or no, natural predators of their own. Wolves, lions, large sharks, crocodiles, tigers, eagles, cheetahs, and leopards are all top predators. Humans, of course, are also included in this category.

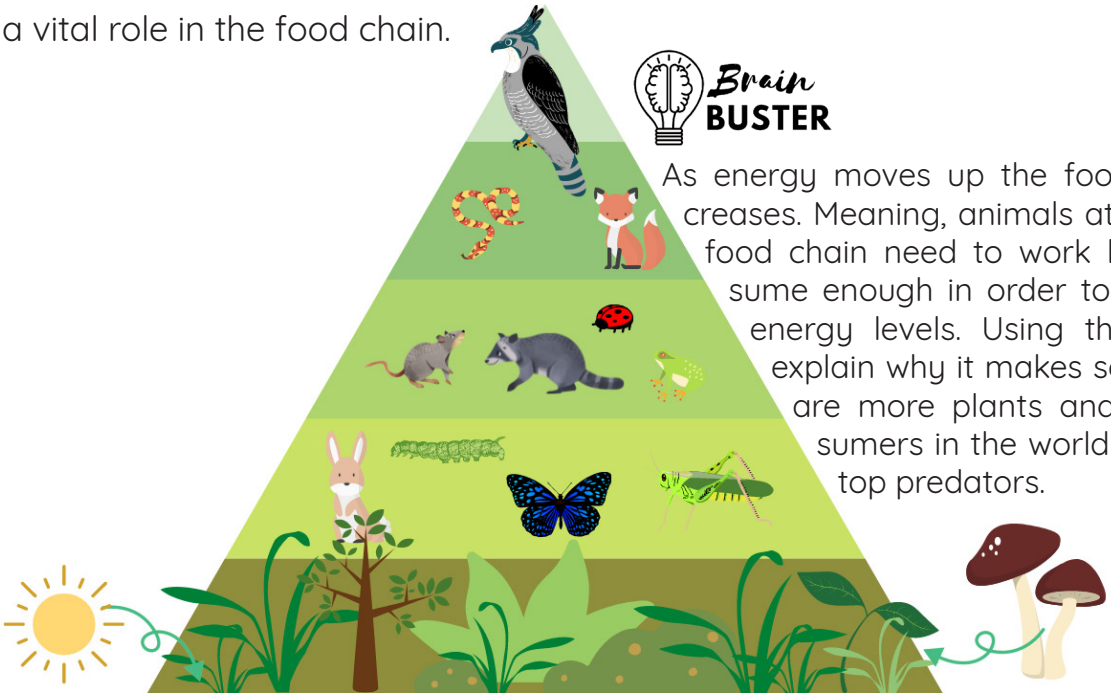
Sadly, many predators, especially wolves, are greatly misunderstood and feared. But the truth is, top predators are essential components of an ecosystem. They are the ones that help keep prey populations balanced (which helps maintain a balance throughout a food chain and even an entire ecosystem), prevent the spread of disease, and keep prey populations healthy by killing off old and sick individuals. While it might seem strange to think that deer need wolves, it is true. In some areas where wolves have been killed off, deer populations are exploding! This means that a lot of deer are competing for a limited amount of resources. This often leads to overgrazing, and a disruption in the ecosystem. When food runs out, some individuals might starve. Disease might spread more easily, and many might have to seek out poorer habitat in which to live. This can cause conflicts with humans, such as deer feeding on people's gardens, more vehicle collisions, and a host of other problems. This is just one example of why we should make sure top predators are protected and valued for the vital roles they play in the ecosystems in which they live.

Decomposers

Every living thing will eventually die. This is just part of the natural cycle of life, and death helps make room for new life to begin. When a plant or animal dies the very important **decomposers** jump into action. Bacteria, fungi, earthworms, protozoa, and other organisms feed on dead matter, breaking down (decomposing) the tissue, bones, skin, muscles and other parts. Thanks to a chemical process, these complex materials are broken down into simpler substances such as water, and simple compounds of calcium and nitrogen. These compounds return to the soil as nutrients. These nutrients are absorbed by plants, helping them grow. This gives the primary consumers lots of good food to eat, which in turn feeds the secondary consumers and so on and so on - thus ensuring the food chain cycle continues. So remember that even the tiniest organisms on Earth have a vital role in the food chain.

Food Webs

When we read about food chains, we might be tempted to imagine nice, straightforward connections between a select few species - the ones doing the eating and the ones getting eaten. While this can be true, especially for animals that have very specialized diets (for example, the **snail kite** feeds primarily on **apple snails**). In reality, most animals eat many different types of prey and they also fall prey themselves to numerous other predator species. So, if we were to draw an image of all the different food chains that might occur within a habitat, we would end up with something more along the lines of a food web - a complicated network of hundreds of plants and animals all dependent on each other for survival.



Brain BUSTER

As energy moves up the food chain, it decreases. Meaning, animals at the top of the food chain need to work harder to consume enough in order to maintain their energy levels. Using this information, explain why it makes sense that there are more plants and primary consumers in the world than there are top predators.

Animal Interactions

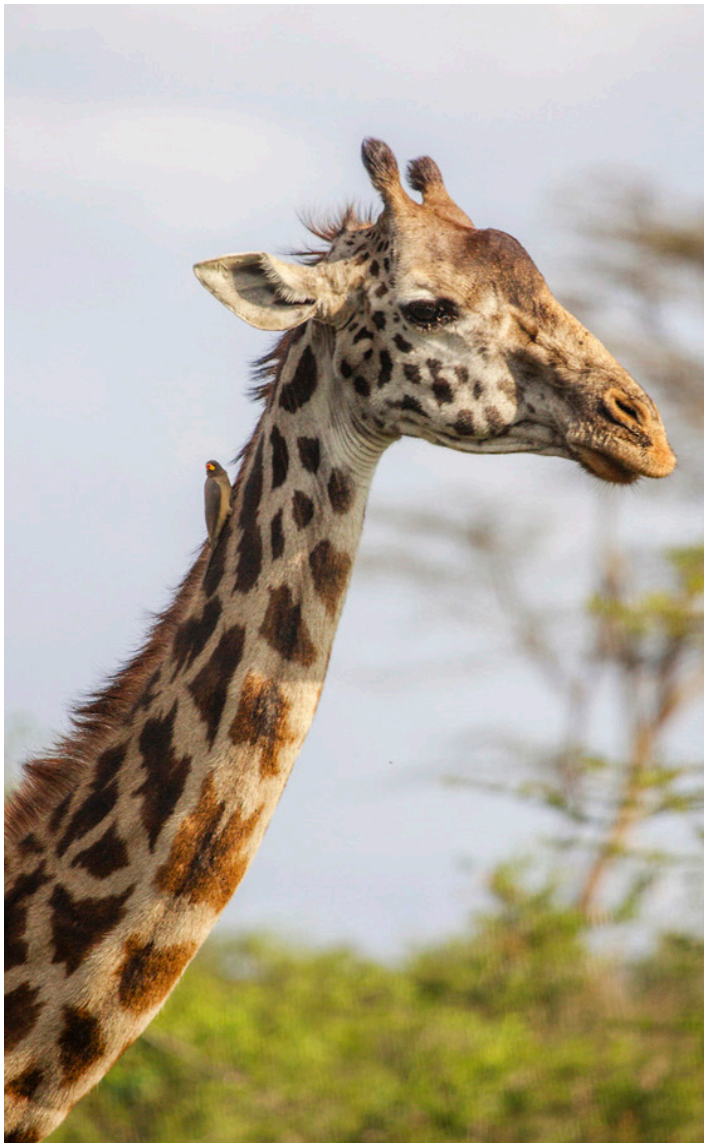
As you are now well aware, our planet is filled with a wide variety of life forms that each fill their own unique niche. All provide a service in nature and help keep our planet healthy. But how do all these animals relate? How does a badger help a coyote and vice versa? Why do ants protect a tree? How do grasshoppers help you? You are about to find out! However, keep in mind, animals interact with other living and nonliving elements in their environments in so many ways, one could fill volumes of books about all of these amazing behaviors. We have selected only a few to talk about here.

Mutualism

When two species both benefit from each other, this is called mutualism. After all, not all relationships that animals have with one another involve eating or being eaten. Take the case of ravens and wolves, for example. When ravens locate a dead animal, they often vocalize which, in turn, attracts other scavengers. **Common ravens** do not have beaks sharp enough to break into the tough hide, or skin, of many animals like deer or elk. Their calling attracts **wolves**, **coyotes**, and foxes, which are able to tear into the flesh more easily. This win-win situation helps the wolves locate food and, once they do, they begin feeding, making it easier for ravens to feed too. Badgers and coyotes also work together when hunting. Both these animals eat burrowing rodents. The coyote and ba-dger help each other flush the rodent from its hiding place. Working together, they can help each other catch their prey since they both hunt in different ways. Now, these were examples of animals helping other animals, but do animals help plants and vice versa?The answer is yes! Read on to learn more!

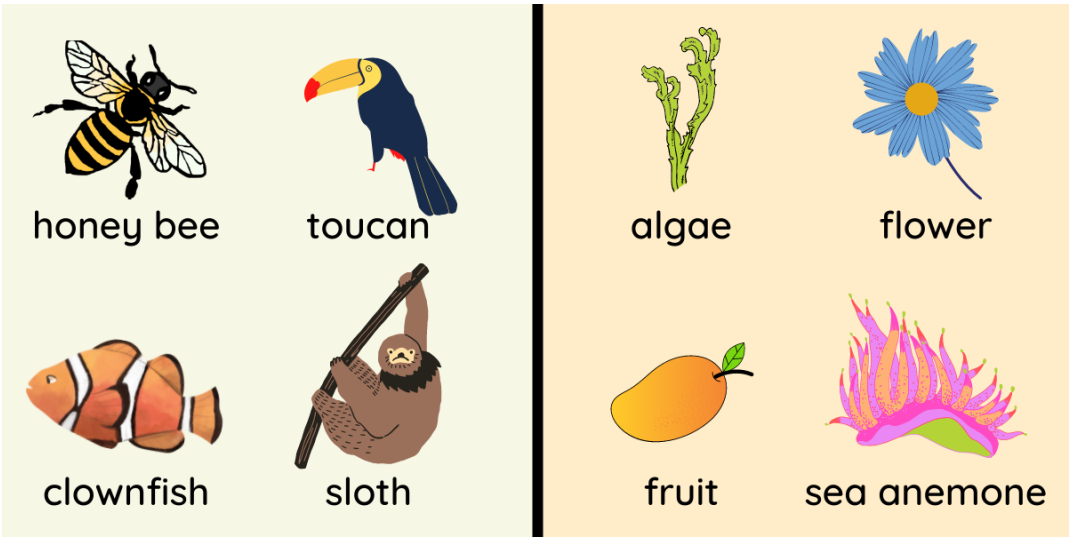
There is a plant known as a **bull's horn acacia** that is protected by ants! The ants benefit from this tree because it provides them

with food and a home. The tree benefits from the ants because if anything brushes up against its branches, the ants vigorously attack and bite the offending person or animal. These ants bite hard and are sure to chase away anything interested in feeding on this tree.In the picture to the right, you will see a small bird, called an **oxpecker** hanging out on a **giraffe's** neck. What's it doing there? This oxpecker is looking for ticks to feed on. Of course, this helps the giraffe too because nobody wants to be covered with ticks! The oxpecker feeds and the giraffe becomes tick free. Both animals highly benefit from this relationship. These are just a few of many examples of mutualism found in nature. Take a few moments each day to observe the animal life around you. How do the plants and animals in your neighborhood interact with each other? How are they dependent on each other? In what ways do you depend on plants and animals?



Brain BUSTER

Now that you have read about a few examples of mutualism, can you think of any others? Here are four more examples of organisms that benefit from each other directly. Can you identify the mutualistic pairs and the benefits that each organism receives?



Parasitism

Imagine a fly that lays its eggs on a mosquito. When the mosquito bites an animal, for example a **mantled howler monkey**, it unwittingly transfers the eggs to the monkey's skin. When the fly larvae hatch, they burrow into the monkey's skin, feeding on its tissue and muscle. Once the larvae have grown fat enough, they pop out of the monkey's flesh and form a pupae. The fly larvae are healthy and ready to develop into their adult stage. But what about the monkeys they fed on? Usually the monkeys are able to survive, but these **parasites** negatively affect their health and the health of the population. Either way, this is not a mutually beneficial relationship as the monkey doesn't gain anything at all from this behavior and actually even suffers a great deal.

A parasitic relationship occurs when one organism (the parasite) lives in or on the body of another organism (the host) causing it harm or death. Ticks, fleas, tapeworms, lice, and leeches are all examples of parasites.

Competition

When you hear the word "competition" what is the first thing that comes to mind? Do you think of sports, or something else? Does competition have a negative or positive meaning in your mind? The truth is, competition is a natural part of life for all living things. Organisms that share an environment naturally compete for things such as food, space, sunlight, water, or mates. Competition can occur between different species (interspecific), or between individuals of the same species (intraspecific). Even plants compete with each other, but we will talk more about plants in Unit 6!

Imagine two predators - such as cheetahs and lions. They live in the same habitat and hunt similar prey. These animals compete with each other for food. Many bird species, such as manakins, form **leks** where multiple males get together to perform wonderful displays to attract a mate. These males compete with each other for females and only the best dancers will be successful in mating. Woodpeckers might compete with squirrels, and other cavity nesters (including other woodpeckers) for nesting sites.

Competition is possible because there is enough food, shelter, space, water, and mates to go around. As habitats are destroyed, some animals might not be able to compete well enough to survive.

Communication

When we communicate, we can do so through speaking, sign language, reading, writing, music, facial expression, body languge and much more. Animals, of course, use many of these same methods to communicate with each other. They use vocalizations (e.g. howling, yapping, cawing, roaring), non-vocal sounds (such as wing snapping and tail thumping), body language (such as mating dances) and other behaviors to communicate with other individuals of the same species. But, what about communicating with animals totally different from themselves. How might a racoon communicate with a bird? Or a bird with a fish? Is it possible?

Though science still has a lot to learn about how animals communicate and what they are communicating, we do know it is possible. If you have ever owned a dog or a cat, you know that these animals have figured out a way to let you know when they are hungry, when they want to go outside, and maybe even when they are happy or feel afraid. The same is true of wild animals! For example, **poison dart frogs** have figured out at least one way to communicate with potential predators. They are easily recognizable by their small size and bright colors. Those **aposematic colors** - blues, greens, yellow, reds, and oranges - are warning signs to predators. Predators see these bright colors and immediately know that the frog is poisonous and not worth eating. Other organisms, such as butterflies, use this same technique.

Birds communicate with potential predators by mobbing them or diving down at them all while making really loud alarm calls. In fact even the smallest of birds have been seen chasing off large raptors and even mammals! There are so many ways that animals communicate with each other, it would be impossible to fit it all here. Take a few moments each day to observe the animal life around you. What can you discover about how animals around you communicate? You may even want to start a nature journal to record your findings.

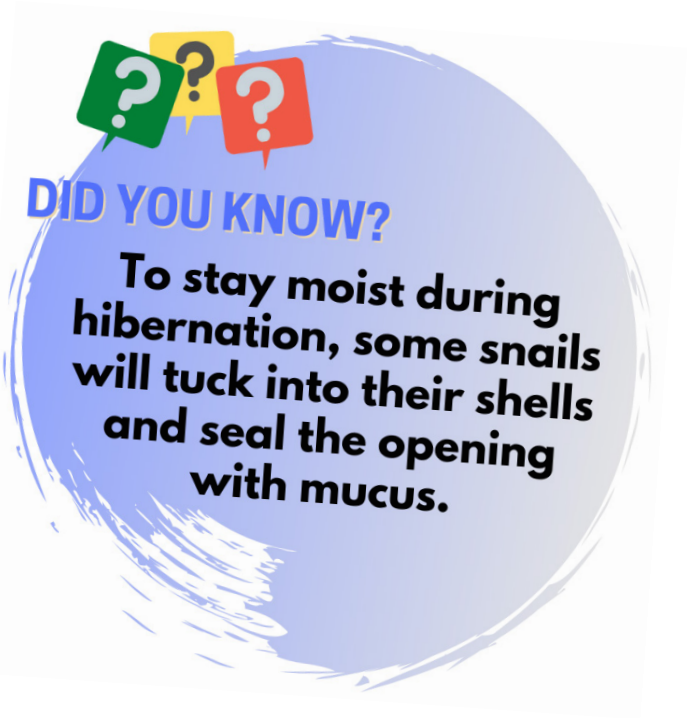
Seasonal Adaptations

Think about the changes of season where you live. Perhaps you have four very distinct seasons, or maybe you live in a region of the world where seasons are more easily distinguished by periods of heavy rain and no rain. Regardless, there are probably things you do differently depending on the seasons. You may need to change the types of clothes you wear, the foods you eat, how much time you spend outside, where you go, and maybe even your sleep schedule.

Of course, animals are no different. Some grow thicker fur in cold weather, or shed their fur when temperatures grow warmer. Sometimes an animal's fur color will even change completely to help it blend in with a snowy backdrop. Others change their diets, or move to areas with more access to food. During seasons of little rainfall, some animals travel for miles to gather at watering holes while others will spend long periods in a dormant state where they don't need to eat, move or poop. Read on to learn more about these incredible seasonal adaptations.

Hibernation

Temperatures start to drop, the days get shorter, plants have lost most of their leaves, and maybe the ground is even covered in snow. Due to these changes in weather, food availability for some species might start to decrease. Animals have to figure out a way to survive during those lean months. One option is to hibernate. To prepare for hibernation, many animals will eat as much as they can in the months prior, greatly increasing their body weight and sometimes even doubling it! When they are ready, they will find a safe place to make it thorugh the winter. Their body temperatures drop, their breathing and heart-rates begin to slow, and so does their metabolism. Some bears, bats, and rodents hibernate. So do some snails and bees! Even some reptiles will hibernate, this is sometimes referred to as brumation.



Estivation

While hibernation occurs during the cold, winter months, estivation usually happens during the hottest temperatures or driest conditions. Estivating animals find a safe, cool spot to hole up in and go into a state of torpor or dormancy until the weather cools or the rains begin. They conserve engery in this state of torpor by reducing their breathing, heart, and metabolic rates. Animals that go into estivation include some species of tortoises, salamanders, frogs, land snails, and even some insects. While there are very few mammals that estivate, the **fat-tailed dwarf lemur,** of Madagascar, avoids the drought of the hot, dry winter by entering into estivation in a tree cavity for up to several months.

Migration

Migration is the seasonal movement of certain animals from one area to another. Often, migrating animals change habitats completely from one season to another. Animals migrate primarily to find food, and for many species, especially birds, for breeding purposes. Many different types of animals migrate including butterflies, birds, and mammals. We are going to learn more about the when, what, who, why, and how of migration in Unit 5.

Read and reflect...

Wow! Give yourself a pat on the back! You just learned a lot about many of the different organisms we share our planet with! From tiny micro-organisms to the largest **blue whale**, from the slow-moving sloths to the very speedy **peregrine falcon**. Now, take a moment to let all that information sink and then read on to find out how to continue your journey of discovery!

In this unit we have learned about some of Earth's major animal groups. We have examined their characteristics, habits, diets, and behavioral adaptations But we only just touched the surface of all the fascinating organisms we share this planet with. Whether studying the makeup of an entire genus, or finding similarities between butterflies and sloths, or seeking to understand a jellyfish's **niche**, there is still so much for us to learn about the fascinating creatures that call this planet home.

While we hope this chapter helped answer some questions you might have had about our wonderful and fascinating natural world, we also hope it left you with a curiosity to learn more.

If so, we invite you to make a list of questions you would like the answers to in a journal or other place you can easily access your inquiries and make notes. Now, work on your own, with family members, friends, or your teacher to discover the answers to some of these questions. Using scientific resources, talking with an expert, and making your own observations are just some of the ways you can go about this.

Finally, take a moment to think about the quote at the beginning of this chapter. *"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."* What does this quote mean to you? Does it mean something different now that you have learned a little more about our natural world?

Can you give an example, using something you just learned, to illustrate what this quote might mean? Is the author speaking metaphorically? Is he being literal? What if you think of the quote from a mouse's perspective? Or a dragonfly's? Does the fact that everything in nature is connected mean something different to non-humans than to humans? Why or why not? Should it?

explorer's corner

my backyard

Do you live in a city, a desert, a forest, by the sea or in another type of habitat? No matter where you live, you should be able to find some vertebrates and invertebrates nearby! How many can you find in your own neighborhood, school or home?

Spend a week (or more!) exploring the areas you visit every day. Search the skies, look in the bushes, or even along the sidewalk. Keep a tally of how many different animals you can find. We have made a list of some of the more common ones to get you started. What others can you add to your list?

Vertebrates

(how many of each did you find?)

birds -
lizards -
rodents -
fish -
toads/frogs -

Invertebrates

(how many of each did you find?)

spiders -
crabs -
butterflies -
bees -
worms -

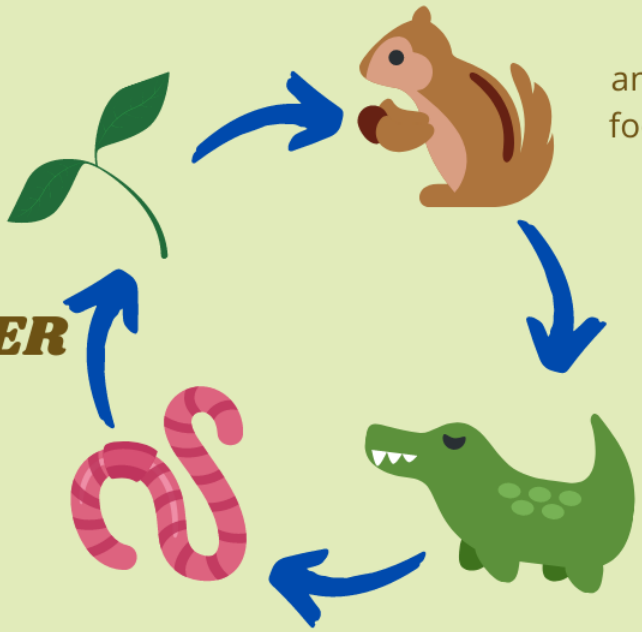
Before you go, be sure to review the components of a food chain below

PRODUCER

an organism that can make its own food

CONSUMER

an organism that gets its food by feeding on other organisms or organic matter

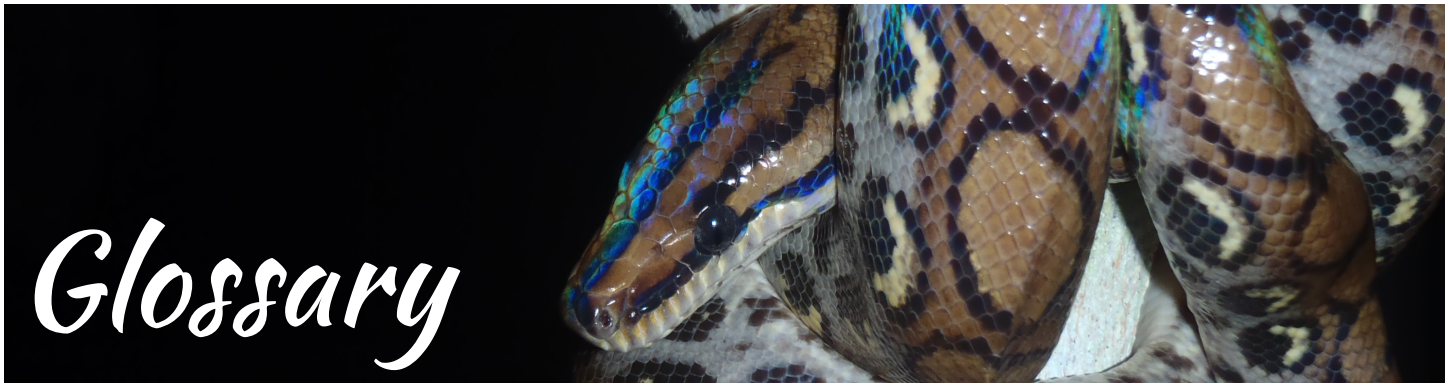


DECOMPOSER

an organism that helps break down organic matter and return associated nutrients back to the soil

TOP PREDATOR

an animal that has few or no other natural predators



Glossary

Adaptation - a change in structure, function or behavior of an organism which improves its chances of survival in a specific environment or condition

Aposematic colors - bright, warning colors that noxious animals have to advertise to potential predators that they are poisonous

Benthic - occuring on the bottom of a body of water (ie. ocean floor)

Bioluminescence - when a living organism produces and emits light

Camouflage - a physical or behavioral adaptation in which an animal or plant disguises itself to become less obvious and blend in with its surroundings

Carnivore - an animal that eats only meat

Consumer - an organism that gets its food by feeding on other organisms or organic matter

Decomposer - an organism that helps break down organic matter and return associated nutrients back to the soil

Desiccation - the process of removal of moisture or water, drying up

Detritivore - an animal that feeds on dead, organic matter

Ectotherm - an animal that regulates its body temperature through external sources of heat (i.e. sunlight)

Endotherm - an animal that is able to produce and regulate body temperature internally

Entomology - the scientific study of insects

Exoskeleton - a hard external body covering of some animals that provides protection and support

Food chain - the heirarchy of the transfer of energy in the form of food from organism to organism

Gestation Period - the time it takes for a fetus to develop from conception to birth

Habitat - A natural home or environment of an animal, plant or other organism.

Herbivore - an animal that eats only plant matter

Invertebrate - an animal that lacks a backbone or spinal column

Lek - an area where multiple males of a species gather to perform courtship displays

Metamorphosis - the transformation of an animal from an immature stage to adult

Microorganism - an organism that is microscopic and thus not visible to the naked eye, such as bacteria, viruses, and protozoans

Niche - The role that an animal, plant or organism plays in its environment

Omnivore - an animal that eats both plants and animals

Organism - an individual form of life composed of a single cell or a complex of cells in which organelles or organs work together to carry out the various processes of life. An organism is capable of growing, metabolizing nutrients and (normally) reproducing

Parasite - an organism that lives on or in a host organism and gets nutrients from and at the expense of its host

Photosynthesis - the process in which a plant uses sunlight, carbon dioxide, and water to produce its own food

Pollination - when pollen from the male part of a plant is transferred to the female part of a plant, which allows for seed production

Predator - an animal that catches, kills, and eats other animals

Prey - an animal or other organism that a predator kills for food

Producer - an organism that can make its own food

Rainforest - a forest with tall evergreen trees and continuous canopy that receives a high amount (over 200 centimeters) of rainfall every year

Species - a group of organisms that are able to interbreed in nature and produce fertile offspring

Taxa - taxonomic rankings of any group of organisms; ie. class, genus, species

Taxonomy - the science of classification, describing, and naming organisms

Thermoregulation - the process carried out by an animal to maintain or regulate its internal body temperature

Top predator - an animal that has few or no other natural predators

Vascular System - a network of vessels that transport different substances (i.e. blood, water, nutrients) through the body of an organism

Vertebrate - an animal with a backbone or spinal column

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PAGE 18 - A Special Look at Salamanders photo from Canva

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Top right: Western Diamondback Rattlesnake, Texas, USA © Marta Curti
Middle right: American Crocodile, Panama © Angel Muela
Bottom right: Cryptic Chameleon, Madagascar © Yeray Seminario

PAGE 21 - Striped Basilisk, Panama © Angel Muela

PAGE 22 - Did you Know graphic created wtih Canva
Compare and Contrast graphic created with Canva

PAGE 23 - Header: Crowned Sandgrouse, Morocco © Yeray Seminario

Right: African Golden-Weaver, Kenya © Marta Curti
Pelican drawing © Marta Curti

PAGE 24 - Header: Polar Bears, Manitoba, Canada © Marta Curti

PAGE 25 - Platypus, Australia © Jonathan Munro
Did you Know graphic created with Canva

PAGE 26 - Kangaroos, Australia © Jonathan Munro

PAGE 27 - Bottom left: Assam Macaque © Yeray Seminario
Top Right: Mantled Howler Monkey, Panama © Angel Muela
Bottom Right: Central American Agouti, Panama © Angel Muela

PAGE 28 - Two-toed Sloth, Panama. © Yeray Seminario

PAGE 29 - Whale tail drawing © Marta Curti
Compare and Contrast icon created in Canva

PAGE 30 - Vertebrates at a Glance created in Canva

PAGE 31 - Header: Giraffe Weevil, Madagascar © Yeray Seminario
Top right: Cicada, Panama © Angel Muela
Middle right: Blind Purplewing, Panama © Jenn SInasac
Bottom right: Sally Lightfoot Crab, Galapagos, Ecuador © Marta Curti

PAGE 32 - Header: Poriferans (sponge) image from Canva
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PAGE 33 - Header: Cnidarian image from Canva

PAGE 34 - Header: Starfish image from Canva

PAGE 35 - Header: Mollusks image from Canva

PAGE 36 - Header: Blue Soldier Crabs, Australia © Jonathan Munro

PAGE 37 - Dragonly drawing © Marta Curti
Top left: *Catacanthus punctus*, Australia, © Jonathan Munro
Bottom left: Hesperina-eyed Metalmark, Panama © Jenn Sinasac
Top right: Grasshopper nymphs, Panama © Jenn Sinasac
Bottom right: Flag-footed Bug, Panama © Jenn Sinasac

PAGE 38 - Header: Worms, earthworm photo from Canva

PAGE 40 - Header: Protozoans photo from Canva

PAGE 41 - Think About It graphic and activity created with Canva

PAGE 42 - Header: Tawny Eagle with prey, Kenya © Yeray Seminario

PAGE 43 - Food chain graphic created with Canva
Artichoke flower and honey bees, San Diego, California © Giorgio Curti

PAGE 44 - Ladybug drawing © Marta Curti
A Special Look at Scavengers image: Indian Vulture, India, © Yeray Seminario

PAGE 45 - Bengal Tiger, India © Yeray Seminario

PAGE 46 - Energy Pyramid and Brain Buster graphic created wtih Canva

PAGE 47 - Header: Jackal and vulture, Kenya © Yeray Seminario

PAGE 48 - Giraffe with oxpecker, Kenya © Yeray Seminario
Brain Buster graphic and activity created with Canva

PAGE 49 - Mantled Howler Monkey with botflies, Panama © Jenn Sinasac

PAGE 50 - Strawberry Poison Dart Frog, Bocas del Toro, Panama © Jenn Sinasac

PAGE 51 - Header: Trumpeter Finches, Morocco © Yeray Seminario
Top right: Barbary Macaque, Morocco © Yeray Seminario
Middle right: Snow Leopard, India © Yeray Seminario
Bottom right: Chukar, India © Yeray Seminario

PAGE 52 - Did you Know graphic created with Canva

PAGE 53 - Tropical plants, Belize © Yeray Seminario

PAGE 54 - Explorer's Corner and Food Chain graphics created with Canva

PAGE 55 - Rainbow Boa, Ecuador © Jenn Sinasac

PAGE 57 - Frill-necked Lizard, Australia © Jonathan Munro

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