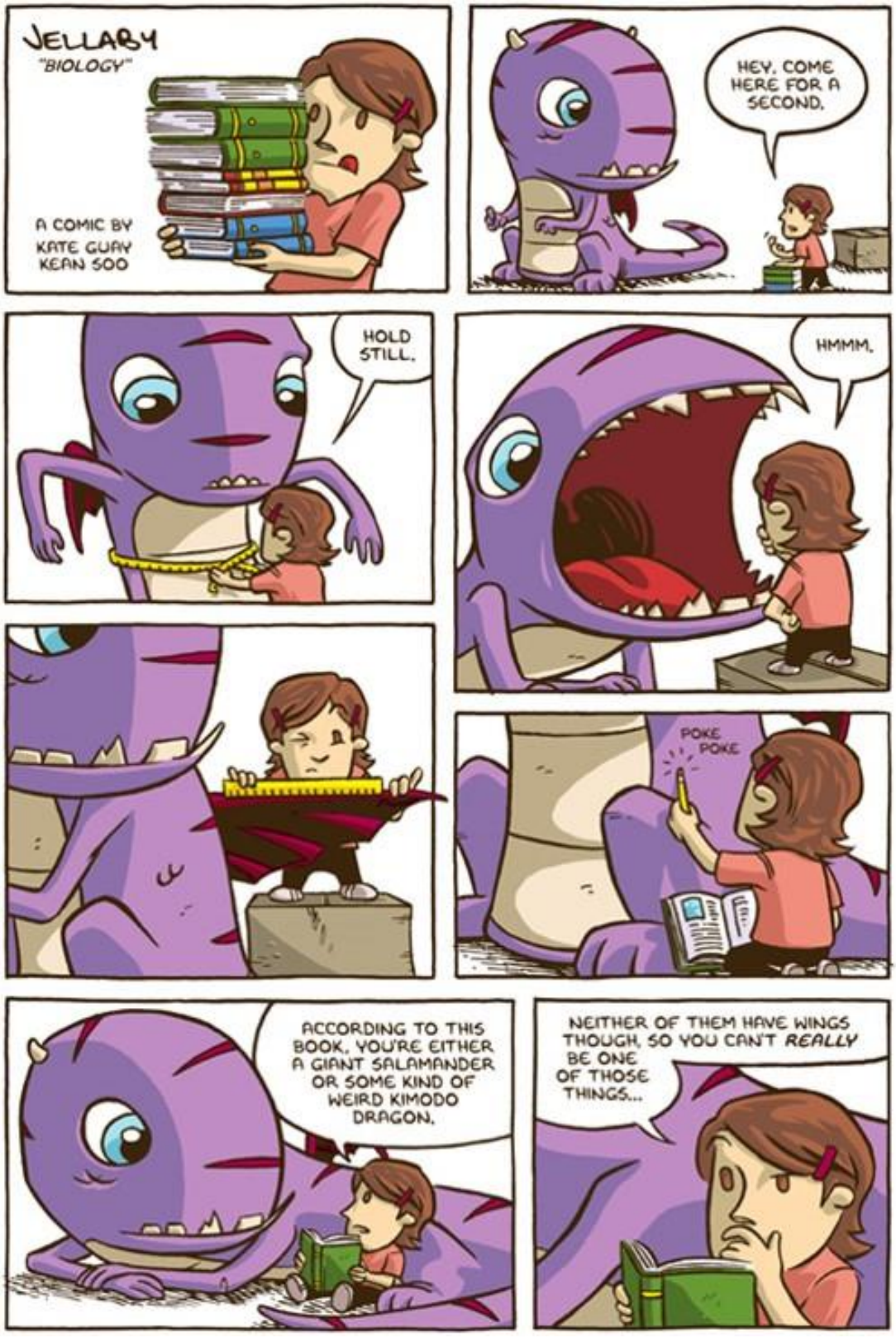
THE STUDY OF ANIMALS



HOW TO STUDY AN ANIMAL

When studying an animal there are certain things that are important to know.

1. Name of animal. Common name(s) and taxonomic (i.e. scientific, Latin) name.

2. Which continent and country is it from?

3. What kind of habitat does it live in? For example, ocean, temperate forest, savannah, swamp, rainforest, desert, arctic tundra? Where does it build its home? In a tree? Underground? How?

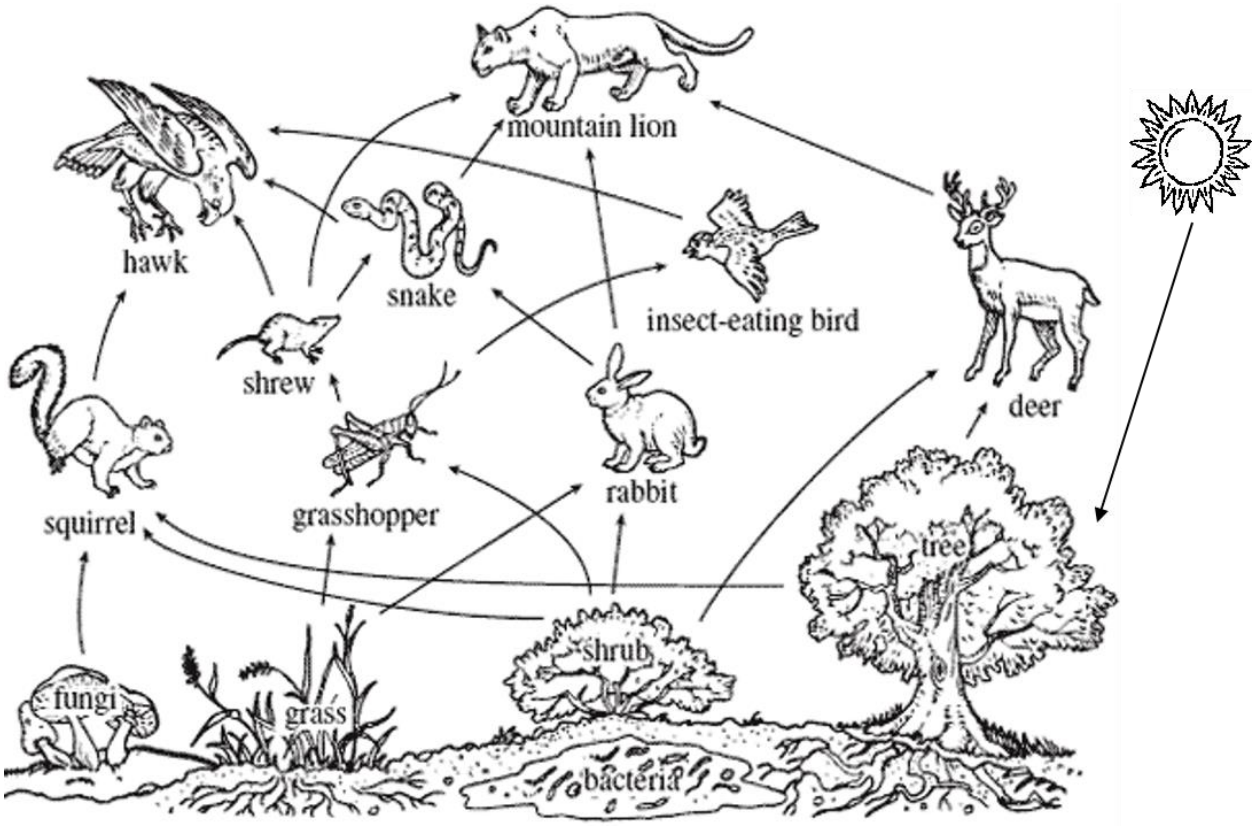
4. What does it eat? Is it an omnivore, carnivore, or herbivore? Grains? Insects? Mice?

5. What adaptations does it have for getting food? A long tongue? Nighttime vision? Claws?

6. How does it protect itself? Quills? Armor? Venom? Plays dead? Camouflage? Odors?

7. How does it fit into its environmental niche? Top predator? Lives in groups? Territorial?

8. Does this animal cause conflicts with humans? How? What can we do? Does the animal need protection due to low population numbers in the wild? If so, why is it rare? What can we do?



TAXONOMY

Taxonomy is the identification and classification of living organisms into groups based on their similarities and evolutionary relationships. Taxonomy helps scientists organize species by defining the characteristics of each species and the relatedness between species.

Binomial Nomenclature = Carl Linnaeus' system of taxonomy assigns each species a two-part Latin name called a "binomial**"**. This name minimizes confusion created by animals having more than one common name and provides an international system for naming species in only one language.

1. The first word is the **Genus** to which the species belongs. A genus includes similar species.
2. The second word is the **species.** In rare cases there is a third word called **subspecies**.

Example: Tigers are within the Genus *Panthera* and the species *tigris*.
There are several types of tigers; so subspecies names are used. Bengal tigers are *Panthera tigris tigris,* Sumatran tigers are *Panthera tigris sumatrae*, Siberian/Amur tigers are *Panthera tigris altaica*, Indochinese tigers are *Panthera tigris corbetti*, and Malayan tigers are *Panthera tigris jacksoni*.

Linnaeus created a system for filing animals into a hierarchy of increasingly general categories.

1. The first step is built into binomial nomenclature. Animals who have the exact same genetics and geographic range are put in the same species. Species that are similar are then placed in the same Genus. For example, we group species of cats that purr into one genus - *Felis*, to distinguish them from cats that roar instead - Genus *Panthera.*
2. The categories or **taxa** (singular **taxon**) then become progressively broader as we group upward from there. The levels of classification above Genus are: Family, Order, Class, Phylum, and Kingdom.
   Example: All genera of cats are grouped together inside the Family *Felidae*. Felids are grouped together with other animals that have meat-eating teeth inside the Order *Carnivora*. Carnivores are grouped together with other milk-producing backboned animals inside the Class called *Mammalia*. Mammals are grouped together with other backboned, spinal cord possessing animals inside the Phylum called *Chordata*. Chordates and all multi-celled animals are within the Kingdom *Animalia*, to set them apart from fungi, plants, bacteria, and protozoans. Therefore, an Amur tiger is classified as: Animalia > Cordata > Mammalia > Carnivora > Felidae > Panthera > tigris > altaica

There are several mnemonic devices to help you remember the levels of taxonomy.

KINGDOM	**PHYLUM**	**CLASS**	**ORDER**	**FAMILY**	**GENUS**	**SPECIES**
King	**P**hilip	**C**ame	**O**ver	**F**rom	**G**reat	**S**pain
Kings	**P**lay	**C**hess	**O**n	**F**at	**G**reen	**S**tools
Kevin's	**P**oor	**C**ow	**O**nly	**F**eels	**G**ood	**S**ometimes

If those mnemonics don't work for you, then make up one of your own to help you remember

ANIMALIA – KINGDOM OF ANIMALS

All creatures inside the Kingdom Animalia have certain characteristics in common including:

- Multicellular – They have more than one cell
- Heterotrophic – They must ingest other organism or their products to obtain their nourishment
- Eukaryotic – Their cells contain a nucleus and organelles within membranes
- Cell wall – Their cells lack a rigid cell wall
- Mobile – They can move spontaneously or independently at some point in their lives.
- Reproduction – most animals reproduce through sexual combination, not necessarily via intercourse, with gamete cells (eggs & sperm) from each parent. Some animals are capable of asexual reproduction without mating. At some embryonic stage of their development, most animals are a hollow sphere of cells surrounding a fluid-filled cavity.

Animalia is divided into about 35 different phyla. The two we will focus on are Phylum *Arthropoda* and Phylum *Chordata*. All arthropods are invertebrates. Most chordates are vertebrates, but there are some chordate invertebrates.

INVERTEBRATES = ANIMALS WITHOUT BACKBONES

A majority of animals in existence are considered invertebrates, including all within the Phylum *Arthropoda*. Animals without backbones make up about 97% of all known animal species. Invertebrates come in many shapes and sizes, from grasshoppers to clams to jellyfish. Invertebrates have nerve fibers that carry signals to control body movement. Some invertebrates have groups of nerve cells called ganglia and a brain. ALL of the invertebrates in our care have a brain. Most invertebrates digest food using enzymes secreted into a gut. A few soft-bodied invertebrates have only one opening to accomplish this. Most invertebrates, including all the ones in our care, have a tube system for digestion instead (like vertebrates do), where food travels from mouth to esophagus to crop/gizzard to intestines to anus.

PHYLUM ARTHROPODA
JOINTED LEGGED ANIMALS

About 80% of all animal species are arthropods, making this the largest phylum. There are more unique species of arthropods than any other animal on the planet! There are over a million different species already known and new ones are discovered, and go extinct before discovery, every day. A few examples of arthropods include insects, spiders, lobsters, shrimp, barnacles, millipedes, and centipedes.

Characteristics of Arthropods

1. **Exoskeletons** – A protective and supportive hard outer shell made of chitin. This takes the place of an internal skeleton. Because an exoskeleton is hard, arthropods must molt to grow larger. Molting involves secreting a new exoskeleton beneath the existing hard shell. The old shell is then shed off. Then the arthropod typically pumps up its body (for example, with air or water) to allow the brand new exoskeleton to expand to a larger size before it hardens. For this reason, newly molted arthropods typically appear pale but darken in color as their new shell hardens.
2. **Jointed appendages -** The name arthropod means "jointed leg" due to the bendable arms and legs they have. Inside their joints and exoskeletons are muscles that help them move.
3. **Segments –** Arthropod bodies can be visually divided into sections. All arthropods have a head. You will work only with insects and arachnids. Insects have a separate thorax and abdomen. Arachnids have a combined head/thorax called a cephalothorax but have a separate abdomen.
4. **Advanced sense organs, brain and head**. A brain and sense organs allow arthropods to gather information from the environment and respond to it. A couple well known examples are antennae and compound eyes.

Conservation Issues

Conservation threats faced by arthropods include loss of habitat, introduced exotic species, pollution, pesticides, public persecution, and a lack of public education/research. Despite being the largest group of living creatures in the world, arthropods do not often get conservation attention. This is mostly due to poor public perception caused by a lack of education and pre-conceived ideas about them. The situation is made worse by a lack of funding. As of 2012, the IUCN Red List only had 3844 insect species listed so far with 700 marked as vulnerable, endangered, or critically endangered, and 33 species of arachnids listed with 19 marked as vulnerable, endangered, or critically endangered. A significant portion of the species listed need to be updated or are reported to have a deficient amount of data. Arthropods play an incredibly important role in the ecosystem. E. O. Wilson states that if invertebrates as a whole group were to go extinct he "doubt(s) that the human species could last more than a few months."

Arachnophobia - An irrational fear of spiders is called arachnophobia. Only a few spider species have venom that is dangerous to people, and spider bites are actually pretty rare. Most spiders have such small, weak fangs that they can't break through human skin. The fear is mostly spread through horror movies and children learning to be fearful by watching scared adults.

CLASS INSECTA

80% of all known animal species are insects. Insects live everywhere - on land, in freshwater, and at the edges of the sea. Many insects are beneficial to the planet. Most flowering plants depend on insects to pollinate them. They also have a vital role in the food chain and are even eaten purposefully by humans!

Insect Body Basics

The Latin word "insectum" means "with a divided body". Insects have 3 body sections (Head, Thorax, and Abdomen) and 6 legs.

- **Head** houses the brain and beginning of nerve cord
  - **Mandibles =** chewing mouth parts. Insects also have salivary glands producing saliva.
  - **Compound eyes** have a series of facets, each one acts like a little eye with its own parts.
  - **Antennae** are primarily olfactory (smelling organs). Are segmented and incredibly sensitive.

- **Thorax** is divided into 3 sections – Prothorax, Mesothorax, and Metathorax
  - 1 pair of jointed legs attach to each segment to form 6 legs total on each insect
  - If present, forewings attach to the Mesothorax and hindwings attach to the Metathorax. Insects were the first organisms to fly! Several species developed wings of transparent chitin and flight muscles which contract quickly. Flying was a big advantage allowing insects to spread where other organisms could not. Because insect wings are extensions of the exoskeleton, insects can fly without sacrificing any legs. In contrast, flying vertebrates (like birds and bats) have their upper legs modified into wings instead and as a result are clumsier on the ground.

- **Abdomen** is divided into up to 11 sections. Contains digestive, respiratory, and reproductive organs.
  - **Respiration:** Insects do not have lungs. Instead, a system of internal tubes and sacs deliver oxygen directly to the tissues in need via the trachea. This is the biggest factor that limits insects to being small. Gas exchange (taking in oxygen and releasing carbon dioxide) can happen many different ways in insects and differ during their life cycle.
  - **Circulatory:** Since insects lack lungs, their circulatory system is simplified and lacks veins or arteries. They have a heart that pumps plasma and blood cells into direct contact with organs.

Metamorphosis is the way that all insects develop and grow. The word means "to change form". The majority of insects hatch from eggs which are drought resistant and have adaptations to withstand cold.

- **Incomplete Metamorphosis –** These are insects which change gradually through a series of molts. Wingless nymphs or naiads hatch from eggs, looking similar to their adult version, and molt several times until they finally reach adult size and body shape with wings. About 12% of all insects go through incomplete metamorphosis.

- **Complete Metamorphosis -** About 88% of all insects go through complete metamorphosis and have 4 very easy to see life stages. Larvae hatch out of eggs looking nothing like the adults and are usually worm-like. A larva grows until it becomes a pupa. At that point it seals itself within a cocoon and stops eating. The pupa stage can last anywhere from 4 days up to several months. As a pupa, the insect changes dramatically in shape before emerging from its cocoon as an adult.

CLASS ARACHNIDA

Arachnids include spiders, scorpions, mites, ticks and harvestmen. Almost all arachnids live on land, but a few are in freshwater and on the edges of the ocean. There are estimated to be over 100,000 species.

Arachnid Body Basics

Two body sections (cephalothorax & abdomen), 8 legs, and 2 extra appendages (cheliceraa & pedipalps)

- **Cephalothorax** = fused head and thorax
  - **8 legs**, each of the 4 pairs is attached to the cephalothorax
  - **Pedipalps** = pair of feelers or grasping organs on either side of the mouth.
  - **Chelicerae** = special mouth parts that look like pincers or fangs to bite with.
  - **Simple eyes –** Arachnids have either six or eight eyes for sight.
- **Abdomen** - contains the digestive, respiratory, and reproductive organs

All arachnids lack both wings and antennae. Both spiders and scorpions are opportunistic predators, feeding on other live arthropods, mostly insects. A few have been seen eating small lizards, minnows, and mice. Both scorpions and spiders feed through external digestion – their food must be liquefied before they can swallow it. Both exude digestive juices which turn their meals into protein juice smoothies that are sucked dry, but the mechanics differ.

Order Scorpiones (Scorpions)

Scorpions are nocturnal arachnids found around the world and numbering about 1,750 species. Only 25 species have venom dangerous to humans. Scorpions avoid light as much as possible and are susceptible to damage from UV rays. Scorpions have modified pedipalps called claws or pincers and a narrow, segmented tail ending in a **telson**, often called the stinger. Their pedipalps are covered in extremely sensitive hairs. They catch their food with their pincers and then either crush it to death or paralyze it with venom from their tail. They have a very unique way of eating. They use a pre-oral cavity below their chelicerae to hold food while it is being liquefied. Their sharp, claw-like chelicerae move small amounts of food into the pre-oral cavity. Any solid, indigestible matter like exoskeletons are spit back out later after the liquid food is sucked inside. They are very efficient at storing food within their body and excrete very little waste. One of the most fascinating body features to look for underneath a scorpion is their **pectines**, which are comb-looking structures forming an inverted V shape which help them sense chemical and tactile information.

Order Araneae (Spiders)

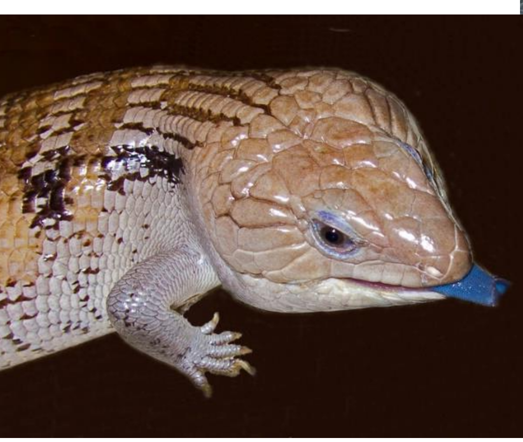
There are over 40,000 different species of spiders worldwide. Baby spiders are so light they can put out a line of silk and float away on a breeze. In this way, they spread around the globe. Spiders that live in peoples' houses often get transported by accident when people move. Unlike scorpions, spiders have no muscles and instead move their limbs through hydraulic pressure. They bite their prey with venomous fangs that causes paralysis and inject digestive enzymes to liquefy their food. Their pedipalps are modified to help grind the food, since they have no jaws. Spiders have **spinnerets,** nipple-like structures that spin silk from glands on the back underside of the abdomen. Spider silk is a protein produced as a liquid spun into fibers that solidify upon contact with air. Spiders use these fibers in a variety of ways: as drop lines for rapid escape, as cocoons for eggs, as balloon-like parachutes for travel, as gift wrap for food that certain male spiders offer to females during courtship, and, of course, to make webs. Not all spiders make webs, however. Some are wandering predators who pounce instead of using silk to catch prey. For those that create webs, each spider engineers a style characteristic of its species and constructs it perfectly on the first try. Apparently, this complex behavior is inherited.

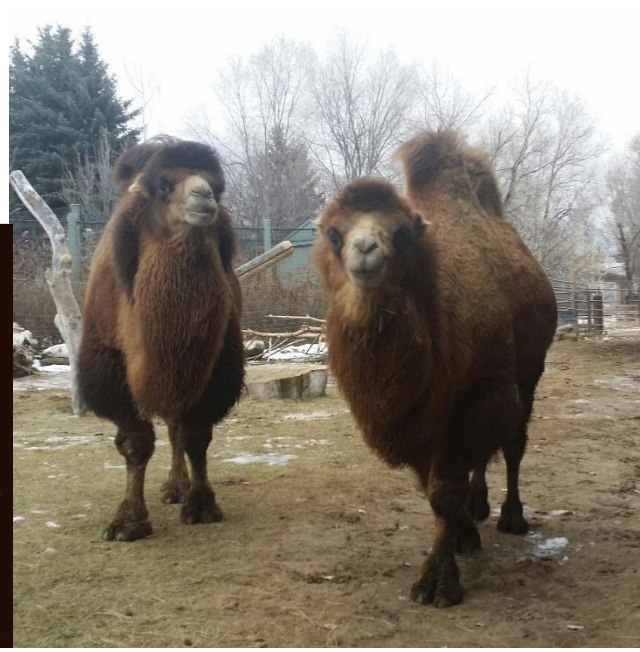
PHYLUM CHORDATA

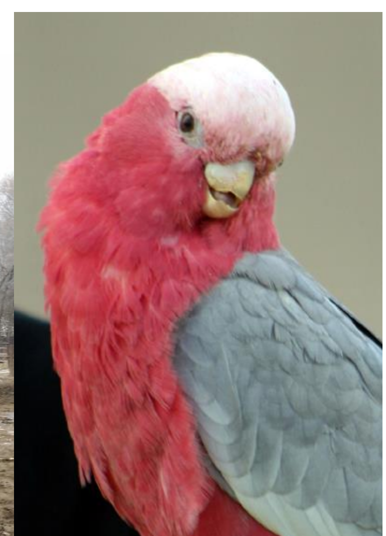
Most members of the Phylum *Chordata* are vertebrates. At some stage in life, all chordates have a stiff rod of cartilage running along their back. In vertebrates, this turns into the spinal backbone as the embryo grows. At some stage of development, all chordates also have a bundle of nerve fibers running down their back connecting their brain to the rest of their nervous system. In vertebrates, this turns into the spinal cord as the embryo develops. Chordates all have a muscular tail that extends backward from the anus. However, in some vertebrates, such as humans, this has evolved to be re-absorbed during embryonic development because it is no longer needed. Chordate embryos also all have a series of slits in the area of the throat just behind their mouth. In fish, these develop into gills. In humans they develop into our eustachian tubes, tonsils, middle ear, and other nearby organs. Because humans and other vertebrates have these slits while developing as embryos, they were one of the sources of the infamous "ontogeny recapitulates phylogeny" theory that animals go through stages as embryos that represent their evolutionary past.

VERTEBRATES = ANIMALS WITH A BACKBONE

Vertebrates are animals with backbones. Over 64,000 species of vertebrates have been described and include fish, amphibians, reptiles, birds, and mammals. The backbone is a series of bones articulated end-to-end. It provides attachment for the muscles and appendages such as arms, legs, and wings. All vertebrates have a nerve cord, also called a spinal cord, on their back side. The backbone column surrounds and protects this spinal cord. Vertebrates have a closed circulatory system with oxygen and nutrients carried within closed vessels. The body wall of a vertebrate consists of skin, muscle, bone, and connective tissues. In between the body wall and the gut is a body cavity containing organs.







CLASS AMPHIBIA (AMPHIBIANS)

Amphibians are found throughout the world except in areas of extreme cold or aridity. Areas directly alongside water are common habitats such as ponds, streams, or swamps, but they can also be found living high up in trees, underground, and deep within the rainforest. All amphibians use their skin as either secondary or primary respiratory surfaces. This is why it is soft and permeable, and thus why they need to keep it moist to avoid losing too much water. A few species of frogs and salamanders have no lungs and rely entirely on their skin to breathe! The word “amphibian” meant "double life" in ancient Greek. Most amphibians start life in water breathing through gills, metamorph into adults living on land breathing with lungs, and require water again to lay their eggs in. Their eggs have no protective shell and are susceptible to drying out. A few species have found ways to avoid needing water by surrounding their eggs with a foam instead or by carrying their eggs inside their mouths! On the other hand, some species never leave the water and are entirely aquatic. Amphibians are ecological indicator species because they are often the first organisms to suffer from the effects of pollution and climate change, providing an early warning of environmental degradation. Their permeable skin is very susceptible to man-made toxins and pollutants.

Other Characteristics of Amphibians

1. **Ectothermic** = “Cold blooded”. They cannot produce their own body heat and thus their body temperature is the same as the environment surrounding them.
2. **Three-chambered heart** – right and left atria, and a single ventricle
3. **Toes without claws**
4. **Tear ducts and moveable eyelids**
5. **Muscular tongues** that are usually very long in most species
6. **Eardrum on or near surface of head** – They can detect both airborne and ground vibrations. The order of amphibians which are frogs can switch between two frequency ranges; a low frequency for detecting predators and a high frequency during mating season.
7. **Reproductive** fertilization is external in most species. Some species must lay vast numbers of eggs because mortality is so high. Either males or females defend the eggs.

Metamorphosis is a process of change in form, structure, or function as a result of development. Not all amphibians go through metamorphosis. The larval stage is hatched out of the jelly-like egg. It is usually aquatic with gills and a long, finned tail. During metamorphosis, the gills are reabsorbed and walking legs develop. The young tetrapod crawls onto shore and begins its second life as a terrestrial hunter. Larval salamanders are carnivorous, larval frogs are herbivorous, and larval caecilians are usually born in an egg with yolk for nutrition or in the mother’s womb feeding on skin cells.

Conservation

Amphibians are going extinct. The IUCN estimates that between 35-50% of all amphibian species are threatened with extinction. More than 100 species have gone extinct since 1980. Like all wildlife, amphibians are threatened by habitat destruction, climate change, and pollution. When an ecosystem is rapidly altered, amphibians, which are critical in all ecosystems as both predator and prey, are the first to be affected. That's why biologists refer to amphibians as "nature's indicators." Amphibians have a brand new threat as well – a devastating disease caused by a species of chytrid fungus. The fungus attacks the amphibian’s skin hindering their ability to respire or breathe through their skin. The fungus also damages the nervous system, affecting the animal's behavior. The risk of losing the world's amphibians represents a threat to losing entire ecosystems and damaging our planet beyond repair.

ORDER ANURA (Frogs and Toads)

"The tail less ones"

Frogs and toads make up 90% of amphibians with an estimated total of 5,966 different species. They are highly adapted for life on land with strong leg muscles for jumping, well developed ears, and vocal cords for calling. They also have extendible sticky tongues attached to the front of their mouth so it can be quickly flipped out to catch prey. Some Anura have developed interesting ways to care for their young such as carrying the larvae on their backs, incubating their eggs in their stomachs (these frogs are now all extinct), or even carrying their eggs/babies in their mouths! Larval Anura are called tadpoles.

ORDER CAUDATA (Salamanders and Newts)

"The tailed ones"

There are over 600 known species of salamanders and newts. They are the most similar to prehistoric amphibians. They range in size from a few centimeters to 1.5 meters.

ORDER GYMNOPHIONA (Caecilians)

"The legless ones"

There are estimated to be 186 species of rare caecilians. They are aquatic or damp soil burrowing, wormlike amphibians, living in tropical areas of Asia, Africa, & South America. In appearance, caecilians look sort of similar to an eel.

CLASS REPTILIA (REPTILES)

Reptiles were the first animals to live completely away from bodies of water. Reptilian dinosaurs were once the largest land animals on earth, but today most reptiles are relatively small. The largest reptiles now are saltwater crocodiles reaching up to 30 feet. There are over 8,200 species of reptiles on earth. Reptiles are found everywhere, including mountain tops, deserts, caverns, rainforest, large urban cities, remote islands, in freshwater, and in saltwater oceans.

Characteristics of Reptiles:

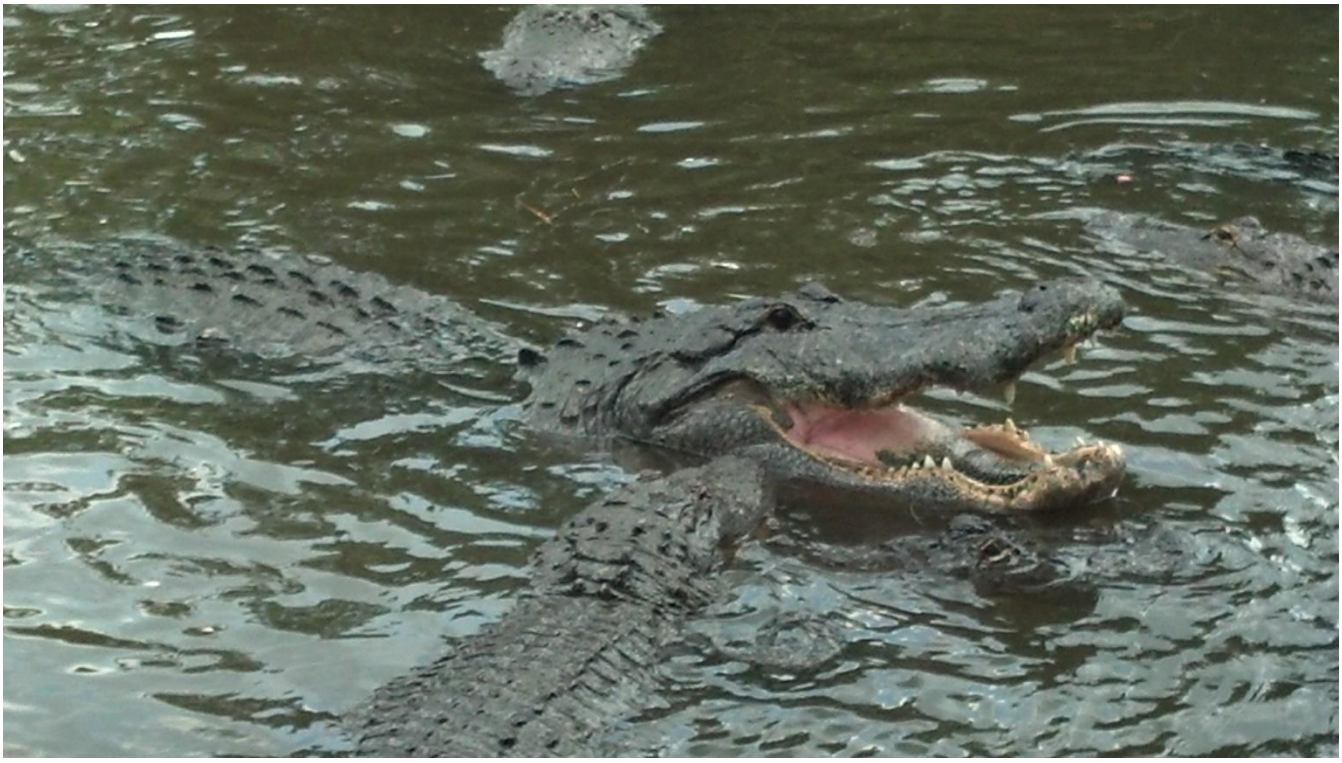
- **Ectothermic =** "Cold blooded". They cannot produce their own body heat and thus their body temperature is the same as the environment surrounding them.
- **Scales or scutes** containing the protein keratin cover their body. Scales develop from the outermost layer of skin; scutes develop from a much deeper dermal layer. This type of skin better absorbs heat from the sun, provides physical protection, and prevents reptiles from drying out.
- **Breathe through lungs only.**
- **Amniotic egg** = the embryo is protected by a membrane. Most reptiles lay eggs externally, but a few give live birth. Externally laid eggs have a shell that protects the embryonic amnion membrane from drying out. Reptile eggs usually have soft, leathery shells
- **Internal fertilization only.** This evolutionary adaptation is necessary for amniotic eggs to exist.
- **Multi-chambered hearts.** Crocodilians (alligators, caimans, etc.) have four-chambered hearts. All other reptiles have three-chambered hearts, but a few lizard and snakes species have hearts that can function as if four-chambered.
- **Most reptiles have claws on their toes. Most reptiles also have teeth**. They are homodonts - all their teeth are the same/similar shape.

Reproduction

Most reptiles lay external eggs that the embryos develop within (oviparous). Reptile nests are usually made in sand, leaf litter, topsoil, or rotting logs. Their nests vary in structure and construction depending on the species. For example, reptile nests can be scratched into the space between tree roots, dug into a deep urn-shaped cavity in the sand, or built into raised, mounded nests. Some reptiles, like crocodilians, provide care to their young, but most leave their hatchlings to fend completely for themselves. Some lizards and snakes bear live young by using a placenta (viviparous), and some reptiles retain shelled eggs inside the mother's body until hatching (ovoviviparous).

ORDER CROCODILIA (Alligators, Crocodiles, Caimans, and Gharials)

Crocodilians appeared 83.5 million years ago during the Late Cretaceous period and are the closest living relatives to bird. They have remained virtually unchanged for the past 65 million years. There are 23 living crocodilian species found in over 90 countries and islands. Only 8 species have ever been known to attack humans. Crocodilians are generally found in the lowland areas of tropical regions, being unable to survive and reproduce successfully in cold climates. North American and Chinese species are the most cold-tolerant. Crocodilians are carnivorous, semi-aquatic reptiles with muscular tails for swimming and defense, and short legs with multiple toes on each foot (usually 5 non-webbed toes on front feet, and 4 webbed toes on back feet). They are excellent swimmers and are well adapted predators with their nostrils, eyes, and ears located at the same level on top of their head. This allows them to remain less detectable while cruising the water looking for prey. They have a well-developed olfactory system and tactile system for detecting vibrations. They have ear slits on their heads that lead to highly sensitive inner ears. Flaps over their ears close when they dive to keep water out. They also have keen eyesight with nictitating membrane-protected eyes. They can probably see some color, and they have good nighttime vision because of a reflective tapetum lucidum and vertical pupils that can open wide to let in more light. Crocodilians tend to have sexual dimorphism, with males being much larger than females. Crocodilians have shown more advanced ability to learn than other reptiles, and have the unique ability to carry their tail and belly off the ground when walking. Unfortunately, crocodilians suffer greatly declining populations due to overharvesting (for skin), conflicts with humans, and habitat destruction. Some species have been hunted almost to extinction. Thankfully, farmed crocodilians have significantly reduced the demand for illegal poaching. However continued egg collection and hunting along with habitat loss has caused the number of gharial to reduce by 98% since 1946 to less than 230 individuals currently. Similarly, due to habitat loss along the Yangtze River, the Chinese alligator only exists in fragmented ponds. Thousands have been bred in captivity, but there is very little habitat left in the wild to reintroduce them into. In 1998, only 11 individuals were left in the wild. However, the most critically endangered crocodilian in the world is the Philippine crocodile. Due to habitat loss and hunting, it has been extirpated in most of the country. Very little is known about the species, it has almost no public or government support to conserve its survival, and only 100 individuals remain.



ORDER SQUAMATA (Snakes and Lizards)

This is the largest order of terrestrial vertebrates, with over 9,000 species. They are found throughout all continents except Antarctica. All squamates have horny scales and a moveable bone at the back of their skull. This allows the lower jaw to be loosely connected and allows them to swallow large prey. Male squamates are the only vertebrates with a hemipenis for reproduction. This is also the only reptile group with viviparous and ovoviviparous species. Modern squamates can vary in size from 0.6 inches long (dwarf gecko) up to 17 feet long (green anaconda)!

Snakes - are skilled predators despite having no arms or legs. They evolved from lizards and can be most quickly distinguished from legless lizards due to not having eyelids. Most snakes also have more joints in their skull than lizards do. Most snake species reach an adult length of about 3 feet long. The smallest measured species still in existence was an adult Barbados threadsnake measuring 3 inches long, and the longest snake ever measured was a 23 foot long reticulated python. Because of their elongated bodies, their paired organs (like kidneys) are arranged one in front of the other instead of side-by-side. Snakes are strictly carnivorous and kill by either swallowing prey alive, constricting it to death through suffocation, or using venomous saliva to kill it. Venomous snakes tend to have prey-specific venom. Thus the purpose of their venom is for hunting, and self-defense is only a secondary benefit. Trying to overcome prey can be a great risk to a snake. Snake teeth are designed for holding instead of deep punctures. Struggling prey can bite, claw, tear tender tissues, and rip teeth out of a snake's mouth.

Lizards – are a loose collection of squamates, with the term mostly being defined as not being a snake. Lizards often have legs, a detachable tail, well developed color vision, and external ear openings. Many lizards have moveable eyelids. Due to their well-developed sight, most lizards rely on body language to communicate and some use bright body colors that can be hidden or revealed at will. Since most lizards can see UV light, some species have patterns only visible in that spectrum. Many lizards also have a differently colored tail in order to entice predators to strike there first. Many are capable of regeneration of lost limbs or tails. Most lizards are insectivores, but lizard species can feed on a wide variety of other foods including fruits, vegetation, small vertebrates, carrion, and up to even human-sized prey. Lizard bites are rare among humans. However, lizards are eaten in large numbers by humans in Africa, Central America, and South America. Lizards range from chameleons only a few centimeters long up to Komodo dragons 11 feet long!

Conservation of squamates - Even though they have survived since the mid Jurassic period and endured some of the most dramatic changes in Earth's history, today a lot of Squamata species are in danger of extinction due to humans. Threats include habitat loss, hunting, the pet trade, pollution, and introduced species which outcompete or eat them. Many have recently gone extinct, with Africa having the highest rate of extinction. Lizards and snakes have played an important role in the tribal cultures of humans worldwide. They appear in several legends, have been used as status symbols by royalty, and have been worshipped as gods. Lizards and snakes feature heavily in artwork and entertainment. In some cultures, snakes are considered an edible delicacy or to flavor alcoholic beverages. Their extinction is a heavy blow to religions worldwide as well as to biodiversity. Captive breeding programs, zoos, wildlife parks, and private hobbyists are actively trying to save squamates from extinction.

ORDER TESTUDINES/CHELONII (Turtles, Tortoises, and Terapins)

This group of reptiles have been on the earth for about 200 million years. They evolved before mammals, birds, snakes, and even crocodiles. There are 327 known species alive today, but about 65 are critically endangered. They all breathe air, have four legs, a tail, and a beaked head without any teeth. The largest member is the leatherback sea turtle reaching almost 7 feet long and weighing over 2,000 pounds. The smallest member is the speckled padloper tortoise measuring 3 inches long and weighing

only 5 ounces. “Chelonian” is popular as a catch-all term to describe any member of this Order and comes from a Greek word. “Testudines”, on the other hand, comes from a Latin word. Some languages, such as Spanish, have only one base word to refer to all members of this order, but other languages such as English have a lot more confusion in terminology. The English term “tortoise” usually refers to land-dwelling, non-swimming member of the Order. The Native American word “terrapin” denotes small, edible members of the Order living in brackish waters. The word “turtle” in North America can refer to any and all species of the Order, but in the United Kingdom is reserved only for the sea-dwelling members with flippers. Regardless of terminology, all members have tough shells joined together on the sides by bony structures called bridges. The inner layer of the shell consists of about 60 bones, including portions of the backbone and ribs. The outer layer of the shell is usually covered in scutes that are part of the outer skin epidermis. The upper shell is called the **carapace**, and the lower shell is called the **plastron**. Most members can retract their limbs and head into their shell for protection, and can be grouped into either the Cryptodira group who contract their necks backwards underneath their spines or the Pleurodira group who contract their necks to the side instead. Their diets vary greatly depending on habitat and can range from carnivorous to herbivorous to scavenging on carrion. All members of the Order lay their eggs in nests on land, regardless of their primary habitat. There are no known species in which the mother cares for her young. About 200 species are listed by the IUCN with 60% either endangered or vulnerable. Asian species are the most endangered due to unsustainable harvesting as a food and medicine source. However, since hunting turtles is legal in most of the U.S., many Americans make a living supplying the Asian demand for turtle meat. Exportation of U.S.-caught turtles was recorded as high as 3,000 pounds of turtles exported per week from just one Florida airport to Asia!

ORDER RHYNCHOCEPHALIA (tuatara)

Tuatara are endemic to New Zealand. The term comes from the tribal Maori language and means “peaks on the back”. They are greenish brown and gray reptiles, with a spiny crest along the back. The crest is especially pronounced in males. They can grow up to slightly under 3 feet long and weigh up to 3 pounds. Tuatara flourished about 200 million years ago and have the nickname “living fossils”, but now only 2 species remain on Earth. They have unique dentition in their mouth, with two rows of teeth in the upper jaw overlapping one row of teeth in the lower jaw. They also have several unique skeletal features, including the ability to hear well despite having no eardrums nor external ears. Similar to some lizards, their tail can break off to escape predation and they will regenerate a new one. Tuatara have evolved the ability to tolerate cold temperatures much lower than most reptiles and will hibernate during the winter. Tuatara have a third eye on top of the head with its own retina, cornea, lens, and nerve connection to the brain. However, this parietal eye is only visible in hatchlings and becomes covered by scales by 6 months of age. Its function is unknown but appears to be photoreceptive and might help with producing vitamin D and/or with circadian or seasonal body cycles. Internal body parts are similar to fish, birds, turtles, and crocodilians, but the outward appearance is most similar in shape to lizards. Their molecular evolution has been shown as the fastest of any animal yet examined. However, tuatara reproduce very slowly having babies at only 2 to 5 year intervals. It takes about 15 years before they reach sexual maturity! Their average lifespan is about 60 years but they have been documented to live over 100 years old and are believed capable of living as long as 200 years! They are highly territorial, carnivorous, and tend to be nocturnal. Tuatara used to be widespread throughout New Zealand, but now number less than 100,000 left. The introduction of Polynesian rats has been the largest threat to their survival. As a result of habitat loss and introduced predators such as the rats, remaining tuatara have been confined to a few offshore islands. However, in recent years captive breeding and reintroduction efforts have attempted to re-establish them to the mainland of New Zealand. As a result, in 2008, the first wild tuatara nest in 200 years was discovered in a nature reserve on the mainland!

CLASS AVES (BIRDS)

The 9,000 living species of birds have adapted to ecosystems across the globe, from the Arctic to the Antarctic. Birds first appeared on earth about 150 million years ago and are descendants of dinosaurs. Most birds fly. Even flightless birds, like the ostrich or penguin, are descended from flighted ancestors. Consequently, bird adaptations for flight dominate their form and function.

Characteristics of Birds

- **Endothermic**
- **Feathers** – Unique to birds – all birds have feathers, anything with feathers is a bird.
- **Forelimbs modified as wings**
- **Bipedal –** walk, run or waddle on two legs
- **Beak with no teeth**
- **Internal fertilization**
- **Hard-shelled amniotic eggs**
- **High metabolic rate**
- **Four-chambered heart**

Adaptations for Flight

Wings – A bird's wing is very similar in structure to our arm and hand. We have 29 bones in our hand and arm, while most birds only have 11 much longer, simpler, and fused bones. Fewer bones = fewer joints = increased rigidity. This makes the wing very strong. It is the 'hand' section of the wing that produces the power to propel the bird through the air. The shape of a bird's wings is related to the kind of flying it does. Short, rounded wings allow for tight maneuvering in small spaces like you find in forests. Short, pointed wings combined with rapid wingbeats make for high speeds (peregrine falcon fastest speed at 165-180 mph). Wings that are far longer than wide are for slower flying and gliding long distances. Broad wings with slots in the primaries are used by soaring birds reaching great heights on little energy (Bearded vulture flies the highest at 25,000 feet).

Wing feathers

- **Primary feathers** – on "hand", power for flight
- **Secondary feathers** – forearm, smooth surface for lift
- **Tertiary feathers** – near body, smooth connection with body to reduce drag
- **Covert feathers** – front edge, give curved edge to front of wing, also reduces drag

Feathers – Feathers are one of the strongest by weight structures ever found in nature. Feathers facilitate flight, provide insulation for thermoregulation, and are used in display, camouflage, and signaling. Feathers consist of a shaft with rows of fine filaments (barbs) on each side. The barbs themselves have finer filaments with hooks (barbules) branching from them. The interlocking rows of the barbules give feathers their shape and strength. In the down feathers, the barbs and barbules are loose and fluffy. They trap an insulating layer of air close to the body and so reduce heat losses.

Types of Feathers

- **Flight** - wing and tail feathers; used for flight; long, stiff with rigid shaft
- **Contour** - body feathers give bird shape and color; shorter than flight feathers
- **Down** - soft, fluffy under-feathers; provide insulation

Preening – Birds take good care of their feathers by constantly grooming, oiling and arranging their feathers to reduce wear. A preen gland located at the base of the tail secretes an oil that birds rub onto their feathers to keep them cleaner and water repellent.

Molting (shedding) – Birds renew their feathers at least once a year, often twice. Molting usually follows a regular pattern of feather loss. Plumage changes drastically in appearance from newly hatched chick to adult or may vary with the season in some adult birds for courtship or camouflage.

Lightweight but strong skeleton - Bones are hollow with internal cross supports reducing weight and adding strength. Bird skeletons are compact and reduced by fused bones. The backbone, ribcage and hip bones are rigid while the tail remains flexible. Birds that fly have a keeled breastbone for attachment of powerful flight muscles. Ratite birds have a flat breastbone.

Air sac respiratory system – Special organs spread throughout their body increase the amount of oxygen a bird takes in and allows air to flow in one direction through the lungs. Wingbeats are coordinated with breathing to draw air flow through this system. Similarly, birds have very high heart rate due to increased gas exchange (hummingbird's 1000 beats/min).

Absence of structures to reduce weight. E.g. females have only one ovary; all birds have no teeth.

Weight and balance are centralized – Heaviest organs are located in the center of the body. Muscles for flight are not actually in the wings. Most of the muscle mass is along the central keel and function via long tendons.

Large eyes provide the keenest vision of any group of living creatures. Excellent eyesight allows them to avoid objects while flying and spot food from long distances.

Very high metabolism – Flying requires more energy than any other form of locomotion. Because weight is a factor, flying birds tend to eat frequently on high fat, high protein diets. Birds have small digestive tracts with food going from the mouth to the **crop**, where it stored before moving into the gizzard. The **gizzard** often contains small stones that help grind up the food.

Reproduction

Nests - Most birds build some type of **nest**, but construction and materials used is widely varied. Most nests are shaped like a large bowl - the right shape for oval eggs to rest without rolling out. Birds that don't build elaborate nests, like penguins, have elongated eggs to prevent them from rolling away and breaking.

Eggs - Coloration is laid upon a bird's eggshell by glands as it passes down the oviduct. Eggs laid in open nests are speckled, spotted, blotched or lined. Birds lay hard shelled eggs that are remarkably well-designed. Bird eggs are very strong – they are engineered to withstand a lot of weight. Birds **brood** their eggs: they sit on the eggs using their body heat to keep the eggs warm until they hatch. Some species share brooding duties among males and females. Some birds, like cuckoos and cowbirds, lay their eggs in the nests of other species leaving brooding and rearing to foster parents. Birds may be born altricial (weak and helpless at birth) or precocial (fully active, ready to eat on own). The largest egg is from the ostrich (weighs 3 lbs., 6" to 8" long). The smallest egg is from the bee hummingbird (weighs 5/1000 of an ounce, the size of a pea).

Singing

Singing is done primarily to establish territory by warning other males of its species to stay out. A secondary result is attraction of a female who desires a "man of property". Most birds hold territories in the spring at the start of the breeding season. "Calls" are used for communication, such as calling young, giving an alarm, and keeping a migrating flock together.

CLASS MAMMALIA (MAMMALS)

With about 4500 species, mammals are actually a small class of animals. About 200 million years ago, the first mammals appeared in the fossil record. These mammals were about the size of mice. Even early mammals were endotherms. Because they did not depend on their surroundings for heat, they could forage at night and avoid their dinosaur predators during the day. When dinosaurs became extinct, there was more land and food available for the mammals. Mammals began to diversify and live in many different environments. The blue whale, with a mass of more than 90,000 kg, is the largest animal – vertebrate or invertebrate – that has ever lived. You can find mammals in the coldest oceans, in the hottest deserts, and in every climate in between.

Characteristics of Mammals

- **Endothermic**
- **Mammary Glands -** secrete nutritious fluid called **milk**. Although only mature female mammals make milk, male mammals also have small inactive mammary glands. Milk is made of water, protein, fat, and sugar. But the milk from different animals has varying amounts of each nutrient. For example, human milk has half as much fat as cow's milk but twice as much sugar. The milk of seals may be more than one-half fat.
- **Hair -** All mammals, even dolphins, have hair somewhere at some point in their life.
- **Muscular Diaphragm -** a large muscle at the bottom of the rib cage helps bring air into lungs. All mammals including marine mammals breathe through lungs.
- **Heterodont teeth** - mammal teeth are specialized. They have different shapes and sizes for different functions.
- **External Ear and 3 middle ear bones –** not all mammals have outer ears, but only mammals have outer ears. Pinnae (outer ears) help collect sounds and direct them to ear canal. Position of the pinnae often indicates temperament of animal. Ears erect, directed forward often indicates alertness. Ears flat against head can indicate anger or fright. Ears lose a lot of heat so they get smaller as you increase latitude or altitude.
- **Large Brains** - mammals brains are much larger than the brain of other animals the same size. Mammals sense their environment well and learn, move, and think quickly.
- **Internal Fertilization**

Reproduction

Not all mammals were created equal. Mammals have 3 reproductive strategies:

1. **Monotremes – Egg-laying mammals** (duck-billed platypus, spiny anteater)
   Monotremes were the first mammals and are more closely related to reptiles than any other mammal. They have not yet evolved a way to have their babies live but rather continue to lay eggs in nests. Monotremes are only found in Australia, Tasmania, and New Guinea.
2. **Marsupials – Pouched mammals** (kangaroos, koalas, opossums, etc.)
   Marsupials are special mammals that give birth to their young live, but the babies mature in pouches. While they are in the pouch they suckle on the mother's milk for nourishment. Most marsupials are on the island continent of Australia. Because of its isolation, placental mammals didn't take hold in their ecosystems. Australia is like a mammalian time capsule.
3. **Placental – Live bearing mammals** (all the rest)
   Placental mammals deliver their young live and ready to drink mother's milk. Although the babies still need care, much of the basic development is done inside of the female's placenta. After a variable gestation (21 days for mice to 22 months for an elephant) mammalian mothers nourish their babies and teach them living strategies. Since there are no pouches, the baby must

walk or be carried. Placentals are the dominant form of mammal on the planet. Placental mammals are everywhere, even in the oceans. A group called cetaceans includes dolphins and whales. Their mammalian ancestors evolved on land but returned to the ocean. They still breathe air, feed their babies milk and even have tiny hairs like other mammals.

Clutch sizes (how many young per litter) and parental care- usually smaller mammals have larger numbers of young and invest less time teaching their young. Mice have up to 115 young per year. Larger mammals tend to bear fewer young and provide longer parental care. Elephants normally have one birth per four years. Generally, mammals take better care of their young for a longer time than any other type of animal.

Teeth

The kinds of teeth a mammal has reflect its diet. Dogs, cats, and other meat-eating mammals have large canines. Molars are better developed in herbivores. Unlike other vertebrates, mammals have two sets of teeth. A young mammal's first small teeth are called ***milk teeth.*** These teeth are replaced by a set of permanent adult teeth after the mammal begins eating solid food and its jaw grows larger. ***Tusks*** of elephants, hippopotamuses, and wild boars are modifications of incisors or canine teeth that protrude from the mouth when it is closed. They may be used in defense, territorial display or courtship.

- **Incisors** - front cutting teeth for biting, nipping or gnawing
- **Canines** - stabbing teeth help grab food and hold onto it
- **Molars** - flat back or cheek teeth that help grind up food. These are modified in cats: instead of flat molars, they have four "carnassials," which work like shears for cutting food.

Feet

Mammals have highly variable feet. Toenails may be modified into hooves or claws and be adapted to running, scratching, digging, climbing, or catching food. Reducing weight in the foot is one way to increase speed, so faster animals generally have smaller, lighter feet.

1. **Plantigrade** - walk on soles of foot (primates, bears, raccoons, rodents). Slower heavy foot, but very stable.
2. **Digitigrade** - walk on padded toes (cats, dogs). Small, lighter foot with pad; fast but quiet runners, often carnivores.
3. **Unguligrade** – walk on tip toes, usually a hoof (horses, antelope, giraffe) lightest strong foot for size, fast but less quiet, often herd herbivores
4. Modified into **flippers** (sea lions, whales) – aquatic mammals
5. Modified into **wings** (bats) – only true flying mammal

Hair

All mammals have hair. Mammals that live in cold climates usually have thick coats of hair. But large mammals that live in warm climates, like elephants, have less hair. Essentially, there are three types of hair:

1. **Guard hairs** – long, coarse outer hair protects animal from environment
2. **Under hair** – soft, dense, shorter inner hair insulates against temperature extremes
3. **Specialized hair** – usually sensory or protective, e.g. spines of hedgehog and porcupine, vibrissae (whiskers) of cats, bristles of hogs, or wool of sheep

Tails
Tails are extensions of the spine, highly modified in some, useless in others. Tails have a variety of uses:

- A **communication** device or signal - lemurs
- An **extra hand** - spider monkey
- Extra **insulation** while sleeping - chipmunk
- A **decoy** - squirrels
- A **fly swatter** - hoofed mammals
- To **sound warning** - beavers
- As a **chair** - kangaroos
- For **balance** - climbing mammals

Horns and Antlers
Imagine balancing heavy objects on your head and carrying them everywhere you go! Horns and antlers are physiologically different.

> **Horns** are a keratin cone developed from the outer skin layer which grows over permanent bony knobs on the skull. Horns are not shed, but can be knocked off by injury. The bone and cone continue to grow over the animal's lifetime.
>
> **Antlers** are an annual growth of soft bone covered by skin (velvet). Antlers are shed and new set grown each year. In some species such as moose and deer only males grow antlers whereas in caribou both males and females grow antlers each year.