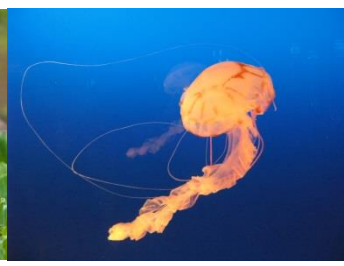
Classification & Variation Student Pack

This pack is aimed at people who require in depth information for course work, homework and may also be of general interest to anyone. It can also support learning during a visit to Colchester Zoo.

COLCHESTER ZOO
Action for the Wild

Contents



Classification

There are around 8.7 million known organisms on earth; 7.7 million are animals, 611,000 are fungi, 63,000 are Protoctista, 300,000 are plants and the number of bacteria is unknown.

With all of these forms of life, a way to deal with this vast array of life in a logical and useful manner is important. By having a way to group and categorise life, it allows scientists to discover where life has come from and how one species fits in with another in an attempt to encode the evolutionary history of life.

This is what is called binomial classification. There are a number of ways life can be classified and a variety of methods to classify it.

Biological classification is used to group living organisms, but even with this system only 1 million of the 7.7 million animals and only 43,000 of the 611,000 fungi have been classified.




Methods of Classification

Classical taxonomy: Looks at descent from a common ancestor, i.e. fossil evidence. It also looks at embryonic development, as well as physical characteristics.

Cladistics: Can use data from DNA or RNA sequences. It can be used to emphasise the evolutionary relationships between different species.

Evidence used in Classification

Embryology: looks at the development of embryos and foetuses.

DNA: looks at the genetics of species.

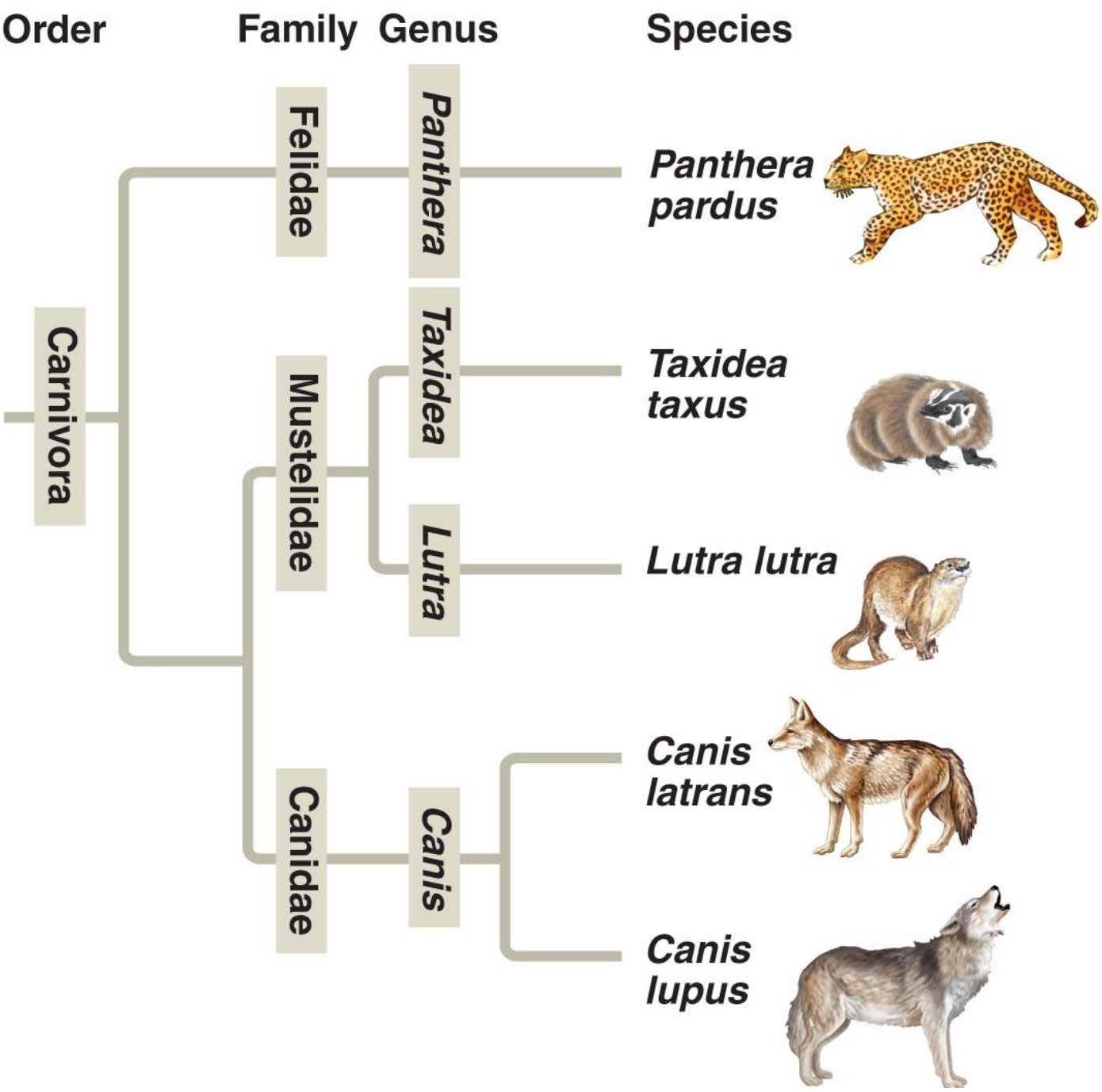
Biochemistry: looks at similar structures between proteins and nucleic acids.

Physiology: looks at the structure of body parts.

Phylogeny: looks at the evolutionary history and common ancestry.

Phylogenetic Trees

With evidence, scientists can create a phylogenetic tree. These classification trees are used to display the evolutionary relationship between two or more organisms. The tree starts with one node - the common ancestor. This common ancestor than diverges (splits) into two which are now also nodes. Each of these then diverge and so on until all the relationships are displayed. The diagram below displays the phylogenetic tree for a selection of animals.



Classification Hierarchy

All life forms are classified using a hierarchical system. Animals are generally classified into specific groups using derived features or traits, be it physical, genetic or evolutionary. Animals are first assigned a domain then into a kingdom; this kingdom is further broken down into several groups which are called phyla. This phyla group is further divided into class and so on until we reach the level of species .

One way of looking at this system is to imagine that you were trying to classify all the people on earth on the basis of where they lived. You would begin by dividing them by the continent they are found in i.e. Asia, Europe Africa etc. This is still a very large group so you would subdivide it further; by country, by county, by town, by street till getting down to the persons first name.

Biological	Postal
Domain	Continent
Kingdom	Country
Phylum	County
Class	City
Order	Street
Family	House number
Genus	Surname
Species	First Name

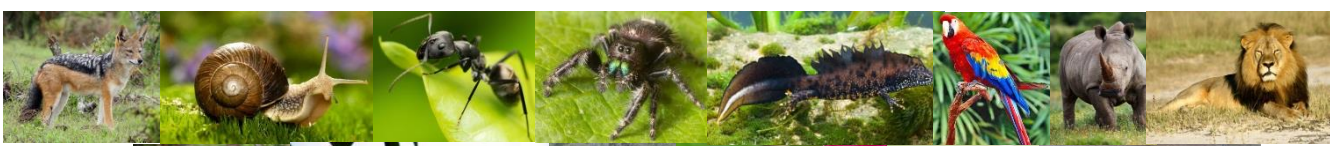
There are many ways to remember the order of the hierarchy. One common way is:

D—Dear
K—King
P—Phillip
C—Came
O—Over
F—For
G—Great
S—Soup

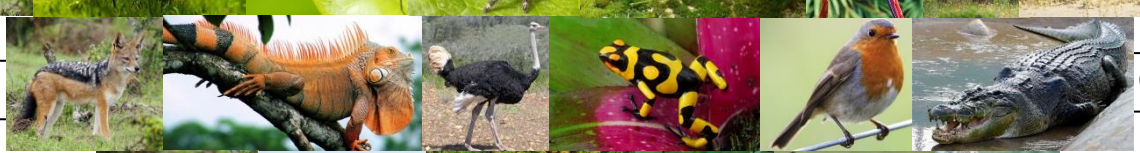
Classification Hierarchy of the Black-Backed Jackal

Domain Eukarya

Kingdom Animalia



Phylum Chordata



Class Mammalia

Order Carnivora

Family Canidae

Genus Canis

Species Mesomelas

The Domains

There are currently 3 domains. These domains are:

Bacteria
Uni-cellular
microscopic organisms.

Unknown number of species

Kingdom: Eubacteria

Archaea
Uni-cellular
microscopic organisms.
Able to survive extreme conditions, such as volcanic events.

Unknown number of species

Kingdom: Archaebacterial

Eukarya
The Domain for every other living organism.
Contains 4 different Kingdoms.

The Kingdoms

Living organisms are grouped into 4 different kingdoms within the domain Eukarya

Animal
Multi-cellular organisms that can move spontaneously and independently at some point in their life.

7.7 million known species.

Fungi
Uni-cellular microorganisms as well as multi-cellular fungi that produce familiar fruiting forms known as.

611,000 known species

Prototista
A diverse group of usually multi-cellular organisms, which are not animals, fungi nor plants.

I.e. amoeba, diatoms and plasmodium

63,000 known species.

Plants
Multi-cellular, photosynthetic organisms ranging from simple mosses to complex angiosperms (flowering plants)

300,000 known species

The following pages will go through the classification hierarchy, showing members of the extant (living) animal kingdom.

Phylum

There are 35 phyla in the animal kingdom. At least 34 phyla are for the invertebrates (there are many invertebrates yet to be classified) and 1 phyla which contains all the vertebrates.

Despite the large number of different types of animals, typically only 9 phyla are focused on.

The table below names the 9 phyla and some species you may recognise.

Porifera	Sponges
Cnidaria	Jellyfish, sea anemones, corals
Platyhelminthes	Flat worms
Mollusca	Clams, snails, squids
Annelida	Segmented worms
Nematoda	Round worms
Arthropoda	Insects, crustaceans, arachnids
Echinodermata	Sea stars, sea urchins
Chordata	Fish, mammals, birds

Orange = invertebrates
Yellow = vertebrates

The difference between the vertebrates and invertebrates, is that vertebrates have a back bone or similar structure, whereas invertebrates do not.

The following pages will look at the 8 invertebrate phyla in more detail.

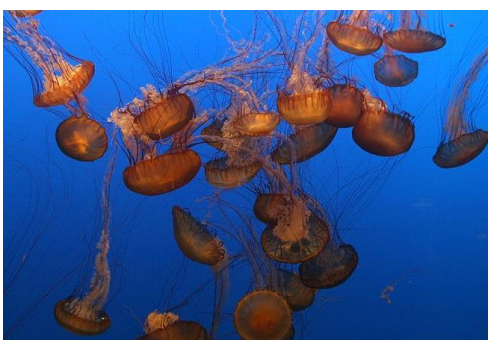
Invertebrate Phyla

Porifera

Porifera (sponges) are actually a closely knit group of tiny animals. Sponges have no nerves or muscles, but individual cells can sense and react to environmental changes. The sponge body resembles a sac perforated with holes. Water is drawn into a central cavity and expelled via a large opening at the top of the sponge.
The lining of the central cavity is covered in tiny suspension feeding cells; these cells filter the water of nutrients as the water passes through.

Cnidarians

Cnidarians include jelly fish, sea anemones and coral. They are carnivores and use their stinging tentacles to capture prey. The body plan of a cnidarian is basic and consists of only one opening, which acts as both the mouth and anus.



Platyhelminthes

Platyhelminthes are flatworms and live in the oceans, freshwater or are actually parasites living in another animal. Marine living flatworms can be very colorful. These invertebrates are called flatworms because their body is extremely thin. Some can grow up to 20metres long.

Mollusca

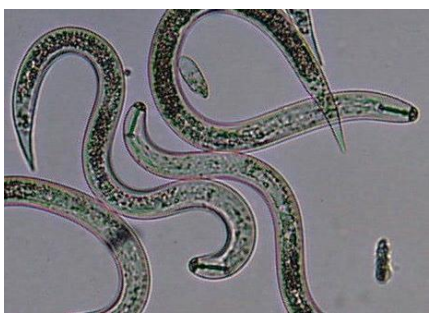
Snails, slugs, octopus, squid, oysters and clams are all examples of molluscs. Most molluscs are marine although a few do live on land. All molluscs have a body plan made up of three parts: a muscular foot used for movement, a visceral mass which contains the internal organs and a mantle which is a fold of tissue that drapes over the visceral mass and secretes a shell. Some molluscs have a reduced shell, or internal shell; such molluscs include octopus, squid and slugs.

Annelida

These have segmented body structures and live in the sea, freshwater or in damp soil. Their internal body structure tends to be repeated segment by segment down the body. Earthworms and leeches are examples of annelids.

Nematoda

Nematodes are roundworms and are not segmented. Roundworms can be as small as 1mm and as long as 1metre in length. A nematode's body is covered in a tough cuticle so as it grows, it sheds its old skin.
They live anywhere where it is moist and can be parasitic.



Arthropoda

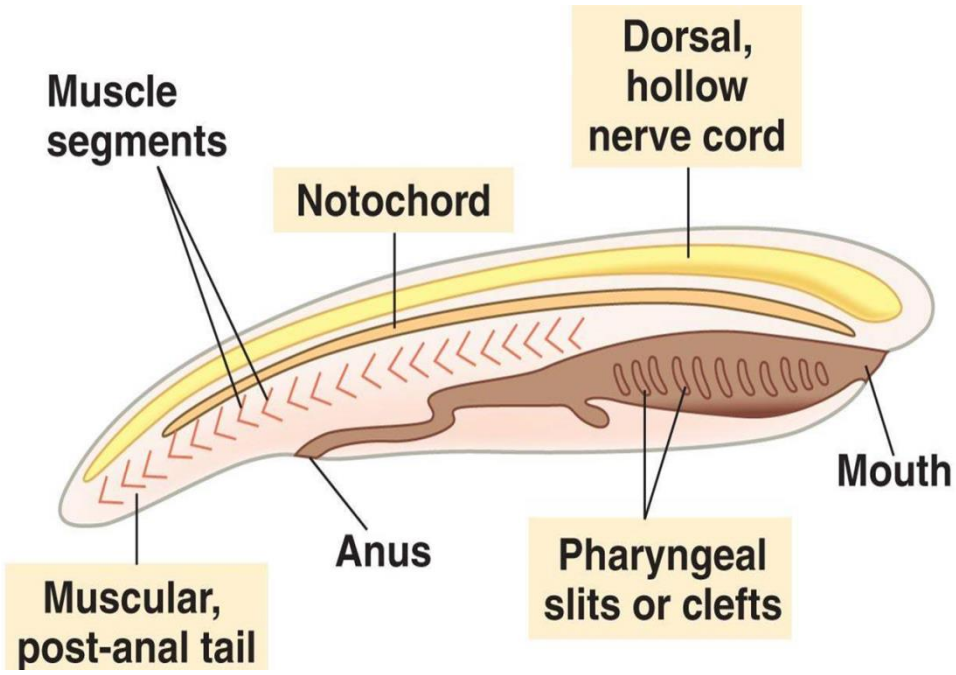
Arthropods are segmented and tend to be characterised by having jointed appendages and a hard exoskeleton which moults as the animal grows. Arthropods are one of the most numerous phyla of the animal kingdom. This phylum include insects, crustaceans and arachnids.

Echinodermata

Echinoderms are slow-moving marine animals. They move with the use of tube feet that also function in feeding and gas exchange. Most echinoderms have a hard calcareous endoskeleton and are prickly or spiky. Sea –stars, brittle stars, sea urchins and sea cucumbers are all echinoderms.

Chordata

Animals in this phyla are classed as chordates if they have the four specific anatomical structures (the ones in the yellow boxes) found at some point during their lifecycle.



Notochord
Theprovides skeletal support, and develops into the columnin vertebrates. It is from this the name Chordata comes from.

Dorsal, hollow nerve cord
The hollow cord into the system, the brain and spine.

Pharyngeal gill slits
Pharyngeal slitsare openings in the pharynx that develop into in bony fish and into the jaw and inner ear in terrestrial animals.

Post-anal tail
The post-anal tail is a skeletal extension of the posterior end of the body, being absent in humans and the other apes, however it is present during their embryonic development.

The chordates are divided into seven major classes:
- Jawless fish
- Cartilaginous fish
- Bony fish
- Amphibians
- Reptiles
- Birds
- Mammals

Chordata Sub-phyla

Within the Chordata phylum , there are three sub-phyla.

Cephalochordata– Lancets
30 known species.

Tunicata- Thaliacea, salps, seas squirts and appendicularia larvaceans
3,000 known species

Vertebrata– mammals, birds, reptiles, fish and amphibians
45,000 known species

Classes

The following will look at the classes within the sub-phyla vertebrata.

Myxini

- Cartilage skeleton
- Ectothermic (cold blooded)
- No jaws

Hagfish are the only living member of this class.

Petromyzontida

- Cartilage skeleton
- Ectothermic
- Sucker teeth

Lampreys are the only living member of this class.

Chondrichthyes—Cartilaginous Fish

- Cartilage skeleton
- Bone jaws
- Rough skin

Sharks and rays are members of this class.

Sarcopterygii—Lobed-fin Fish

- Scales
- Bone skeleton
- Swim bladder
- Fleshy lobe fins

Coelacanths and lung fish are part of this class.

Actubioterygii—Ray-finned fish

- Scales
- Swim bladder
- Bone skeleton
- Thin fins

This class includes the most well known and common fish.

Amphibia—Amphibians

- Jelly eggs laid in water
- Ectothermic (cold blooded)
- Breathe through skin

Frogs, toads, newts, salamanders, caecilians and axolotls are part of this class.

Reptilia—Reptiles

- Scales
- Ectothermic
- Leathery eggs laid on land

Members of this class include snakes, lizards, Turtles, tortoises, and crocodiles.

Aves—Birds

Feathers
Endothermic (warm blooded)
Wings and beaks
Hard shelled eggs

Includes flying, swimming and flightless birds

Mammalia—Mammals

Turn the page to look into this class in more detail

Mammals

Mammalia—Mammals

Fur
Endothermic (warm blooded)
Females produce milk

Humans are part of this class, as well as whales and dolphins.

The mammal class is the most diverse of all of the vertebrate classes. Mammals are characterised by having mammary glands which produce milk. They are also endotherms producing and regulating their own body heat; hair is also present on some parts or all of the body. Teeth have differentiated to specialise on different food sources so that mammals cannot only exploit a large range of foods, but also exploit a range of habitats.

Mammals can be further divided into three groups:

Monotremes

These are the only egg laying mammals; offspring develop by gaining nutrients from the yolk and hatch at an early stage of development and then gain nutrients from the mother's milk. The milk is secreted through certain parts of the mother's skin. Echidnas and the duck-billed platypus are part of this group.

Marsupials

These mammals give birth at a very early stage of the offspring's development. The offspring crawls up into the mother's pouch and latches onto a teat. The offspring develops by gaining nutrients directly from the mother's milk. Marsupials include kangaroos, koalas, wombats and possums.

Eutherian

The mammals of this group give birth to live, fully developed young. They are also known as placental mammals, due to the development of a placenta during pregnancy. The foetus develops in the uterus and is joined to the mother by this placenta. Once born, young gain nutrients from the mother's milk.

Mammalian Orders

Below are the 21 orders of eutherian mammals:

Order	Example	Estimated Number of Species
Soricomorpha	Shrews and moles	433
Erinaceomorpha	Hedgehogs	43
Scandentia	Tree shrews	20
Afrosoricida	Tenrecs	43
Macroscelidea	Elephant shrews	16
Hydracoidea	Hyraxes	4
Rodentia	Rodents	2277
Lagomorpha	Hares, rabbits and pikas	80
Tubulidentata	Aardvarks	1
Pilosa	Sloths and anteaters	10
Dermoptera	Flying lemurs	2
Chiroptera	Bats	1240
Cigulata	Armadillos	21
Pholidota	Pangolins	8
Sirenia	Sea cows and manatees	6
Cetacea	Whales and dolphins	90
Carnivora	Cats, dogs, seals,etc.	280
Proboscidea	Elephants	3
Perissodactyla	Odd-toed ungulates	17
Artiodactyla	Even-toed ungulates	220
Primates	Monkeys and apes	496



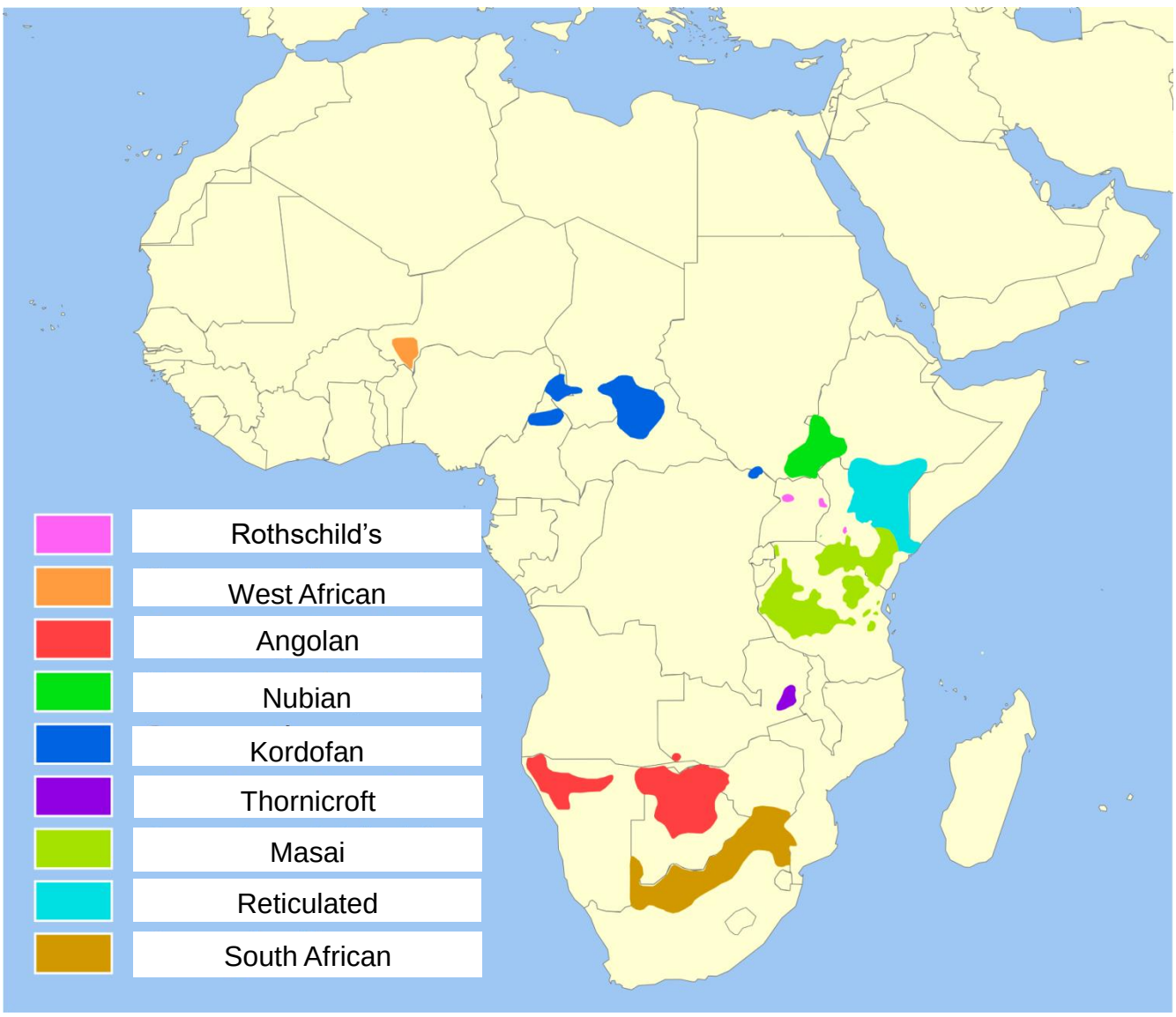

Species

A species is defined as being a group of related individuals that resemble one another and are able to breed amongst themselves.

In some cases, the species can be divided further into sub-species. Sub-species are usually geographically separate, which allows changes or variations to occur. The key part, however, is they still have enough genetic similarities to look similar and are still capable of producing fertile offspring.

An example of a species that has nine sub-species is the giraffe, which inhabits different areas of Africa.

The map below shows the areas where the different sub-species of giraffe are found within Africa.



Naming Species

Living organisms have two names, the common name and the scientific name (also know as the Latin name or the taxonomic name).

The common name varies amongst languages, dialects and regions, whereas the scientific name is the same regardless. This method of identification is called **binomial nomenclature**.

Binomial nomenclature was introduced by Carl Linnaeus when first identifying plants. This method of naming uses the genus the organism belongs too along with the species' name. When writing the scientific name it should be in italics, but if written by hand it can be underlined. The second word should not start with a capital, but the first word does.

For example, the scientific name for a lion is *Panthera leo* as they are part of the genus panthera and the species is leo.

Using scientific names to universally identify organisms makes identifying them much easier as there is no language barrier. This comes into use if an organism has more than one common name such as the mountain lion. The mountain lion has over 100 common names across the English, French and Spanish languages and that doesn't include the names it has in any other languages. However the mountain lion only has one scientific name *Puma concolor.*

<u>Naming Sub-Species</u>

When naming a sub-species, the scientific name is made up of the species' scientific name plus a third name.

For example there is one tiger species *Panthera tigris* however there are six living sub-species and if the extinct sub-species are included that number goes up to nine.

Two examples of the six living sub-species of tiger are the Amur tiger and the Sumatran tiger.

The scientific name for the Amur tiger is *Panthera tigris altaica* and the scientific name for the Sumatran tiger is *Panthera tigris sumatrae.*

Panthera tigris altaica

Panthera tigris sumatrae

Hybrids

Hybrids are a result of two organisms that are not part of the same species or sub-species breeding. Hybrids can occur in several ways.

Two different sub-species of the same species can reproduce and give birth to hybrid offspring, a mixture of the two. If this occurs they are able to produce fertile offspring. These are called **intra-specific hybrids**.

However, in some cases, two separate species who share the same genus can also breed and produce offspring. These offspring are infertile and are called **inter-specific hybrids**.

Offspring that are produced from two different species from two different genus but have the same family are called **inter-generic hybrids**. These rarely occur.

In all cases, the offspring will share characteristics from the two species. These hybrid offspring are only given a common name, as they are not classed as a true species so do not get a scientific name.

Their common name gives an indication as to what two species have hybridised – the first half of the name comes from the male species, the second half from the female.

An example of an intra-specific hybrid is produced by an Amur tiger breeding with a Sumatran tiger.

An example of an inter-specific hybrid is the zeedonk, which is produced by the mating of a male zebra with a female donkey. A liger is another example, produced by a male lion and female tiger.

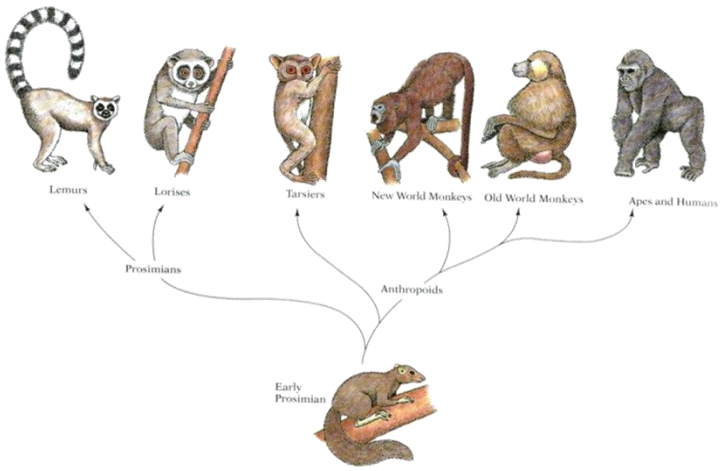
An example of inter-generic hybrid have been know from the breeding between a goat and a sheep.

Zeedonk

Liger

Primate Classification Example

The following pages will look at the primates, which are a diverse group of species with a complex classification.



There are two sub-orders of the primate order:

•Prosimians: Lemurs and lorises

There are 6 families of prosimians

Family	Common name examples
Lemuridae (true lemurs)	ring tailed and ruffed lemur
Lepilemuridae	sportive lemur
Cheirogaleidae (dwarf lemurs)	dwarf and mouse lemur
Indriidae	indris, sifakas
Daubentoniidae	aye-aye
Loridae	loris, potto
Galagonidae	Galagos (or bush babies)

•Anthropoids: Tarsiers, monkeys and apes

There are 6 families of anthropoids

	Family	Common name
	Tarsiidae	tarsier
New World - platyrrhini	Callitricidae	marmoset and tamarin
	Cebidae	squirrel monkey, capuchin, howler and spider monkey
Old World - catarrhini	Cercopithecidae	vervet, baboon, macaque, colobus and proboscis monkey
	Hylobatidae	gibbon
	Hominidae	orangutan, gorilla, chimpanzee, bonobo, human

Within the sub-order anthropoids, new world and old monkeys are grouped together depending on the characteristics they have. Below is a comparison of the characteristics of new and old world monkeys.

New World Monkeys	Old World Monkeys
Infra-order: Platyrrhini	Infra-order: Catarrhini
- Come from the Americas - Have a flat nose with side facing nostrils - Some have a prehensile tail - Do not have ischial callosities (bottom pads) - Have little sexual dimorphism	- Come from Africa and Asia - No prehensile tail - Have a narrow nose with downward facing nostrils - Have ischial callosities (bottom pads) - More sexual dimorphism

Humans are grouped in the Hominidae family. This family consists of the lesser and the great apes.

- Lesser Apes: Gibbons

- Great Apes: Orangutan
  Gorilla
  Chimpanzee
  Bonobo
  Humans

Below is a summary of the grouping for the primate order:

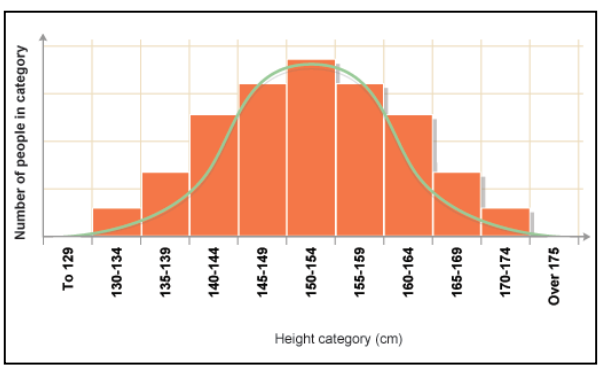
Suborder	Infraorder	Superfamily	Family	Subfamily	Common Names
	Lemuriformes	Lemuroidea	Lemuridae		Ring-tailed and ruffed lemurs
			Lepilemuridae		Sportive lemurs
			Cheirogaleidae		Dwarf and mouse lemurs
			Indriidae		Indris, avahis, and sifakas
			Daubentoniidae		Aye-ayes
		Lorisoidea	Loridae		Lorises, pottos, and angwantibos
			Galagonidae		Galagos (or bush babies)
	Tarsiformes		Tarsiidae		Tarsiers
	Platyrrhini	Ceboidea	Callitricidae	Calitricinae	Marmosets and tamarins
			Cebidae	Cebinae	Squirrel and capuchin monkeys
				Aotinae	Night and titi monkeys
				Atelinae	Howler and spider monkeys
				Pithecinae	Uakaris and saki monkeys
	Catarrhini	Cercopithecoidea	Cercopithecidae	Cercopithecinae	Guenons, baboons, macaques
				Colobinae	Langurs, colobuses, proboscis monkeys
		Hominoidea	Hylobatidae		Gibbons and siamangs
			Hominidae	Ponginae	Orangutans
				Gorillinae	Gorillas
				Homininae	Chimpanzees
					Bonobos
					Humans

Variation

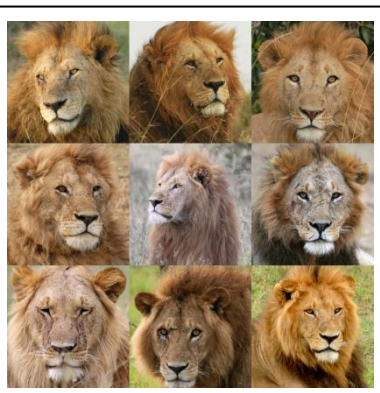
Variation simply means differences. All individuals show variation, which can be grouped as either continuous or discontinuous and these variations arise due to genetic or environmental differences.

Continuous Variation

Characteristics show a gradual change; such as height, weight, length.

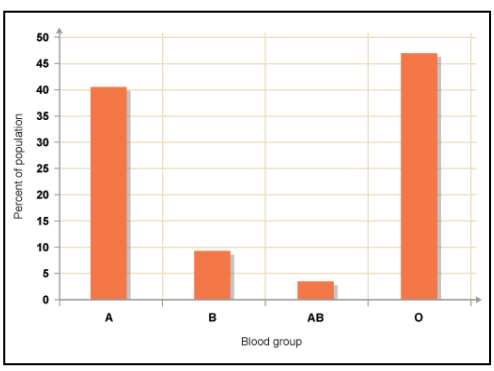


In male lions, continuous variation can be seen in mane colour. The higher the level of the hormone testosterone the males have, the darker their manes are.



Discontinuous Variation

Characteristics fall into categories; for example, eye colour, hair colour, blood type, gender.



An example of discontinuous variation is in elephants, where some elephants prefer to use their right tusk more than their left. This is the same with humans being left or right handed.

Genetic Variation

This form of variation is when characteristics are passed from parent to offspring. Half from the mother and half from the father, meaning characteristics from both parents are passed on.

Examples of this variation are eye colour and hair colour in humans and coat patterns and colour in other animals.

Recessive genes

In some cases, a recessive gene can be passed on from both the mother and the father who carry the gene. This can result in young from the litter expressing recessive characteristics. An example of this is seen in the black bear when an individual will gain the recessive gene for the white coat colour. This is a colour variation and not albinism.

Environmental Variation

This form of variation is when characteristics change due to the conditions the individual is brought up in.

Lifestyle, climate and diet, as well as pollution and exposure to disease, can all affect how an individual appears compared to others. This can be seen when one plant gets lot of natural light compared to the same species of plant that gets less light. These two different conditions result in the plants looking different from each other.

This can be seen in the pictures below. In each picture the species of plant is the same but the one on the left had little to no light.

Notice not only the different colour but also shape as the plant in no light grows towards the light, thus making its shape different.

Flamingos gain their colouring due to their diet. If an individual's diet has high levels of blue-green algae or brine shrimp, the deeper the colour of their feathers due to presence of carotenoids which get broken down in the liver with the pink and orange pigment molecules then deposited in the feathers, bill and legs.

Combination of the Two Variation

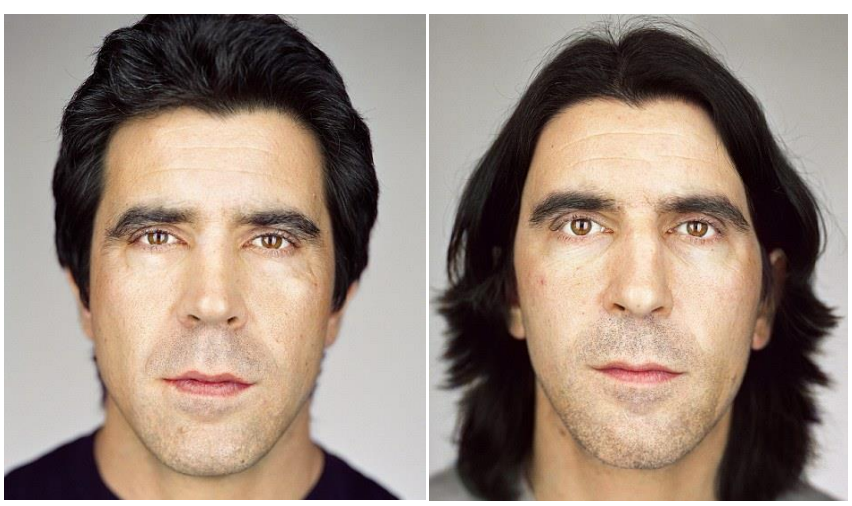
Differences may also be the result of both genetic and environmental variations. Examples of this can be seen in human twins.

Twins are genetically identical but if they grow up in different places and have different lifestyles, they will look different.

If the twins are separated at an early stage of growing up and raised by two different families in different environments, these twins may eventually look different, or they have different likes and dislikes resulting in different choices i.e. one may like their natural hair colour the other prefers to dye their hair a different colour. If one suffers an injury or survives a disease, along with lifestyle choices can all course variation between them.

This picture shows a pair of genetically identical twin sisters. The one on the left has never smoked cigarettes and the twin on the right has smoked cigarettes for 17 years. Notice the skin pigment difference along with degraded skin elasticity in the twin who smoked resulting in an older appearance.

This picture shows a pair of genetically identical brothers. Each has chosen a different hair style.



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