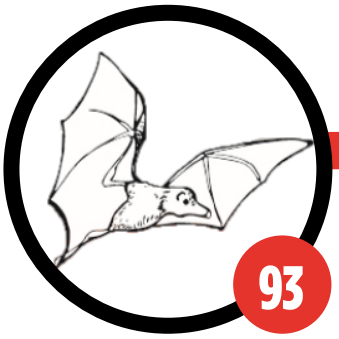
Bat and Banana



93

Musonycteris harrisoni

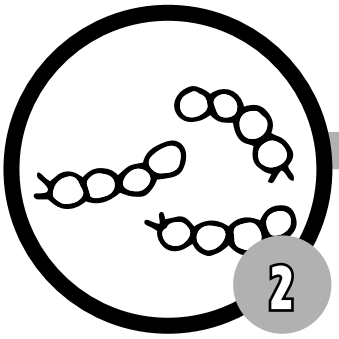
211

Musa paradisiaca

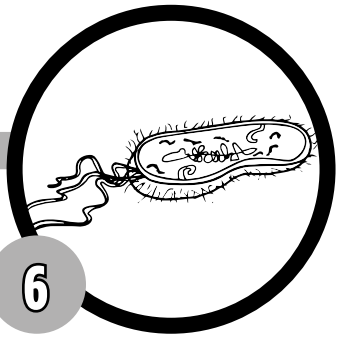
The wild banana has white flowers growing in rows down a long stalk. Each horizontal row is covered by a bract. Every night, the topmost bract lifts up exposing the flowers which emit a perfume attracting bats, who coming to sip the nectar, transfer pollen stuck to their fur. The flowers are pollinated and the next morning the petals and bract fall off. The following night the next bract below lifts up. Eventually all the female flowers have been pollinated. Further down the stem the flowers are male. The ritual is repeated but this time the visiting bats collect pollen. Efficient or what?

Refrence: *The Private Life of Plants*: David Attenborough

Bacteria



Streptococcus sp.



Pyrolobus fumarii

Bacteria are Prokaryotes, having no membrane–bound nucleus.

They were one of the first forms of life on earth, about 3.5 billion years ago and they are usually unicellular. There are good bacteria (for example those in your gut, which aid digestion) and bad bacteria which cause diseases.
There are 3 main types of shape: spheres, rods and spirals.

Some are immobile, but some of the rod shaped and spiral types have flagella, which are long thin whip-like appendages that lash to and fro and propel the bacteria along.

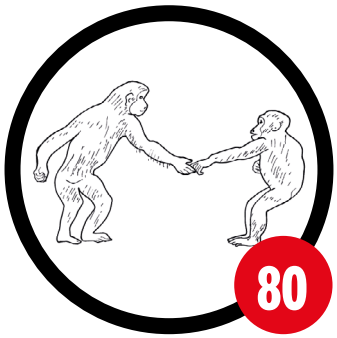
Flagellated bacteria come in 4 designs:
Monotrichous =single polar flagellum,
Amphitrichous = single flagellum at both ends,
Lophotrichous= tuft of flagella at one or both ends,
Petritrichous = flagella surrounding the cell.

CYANOBACTERIA known as blue-greens changed the world forever. They are rod/spherical shaped and contain chlorophyll, the green pigment that is necessary in order for photosynthesis to convert carbon dioxide and water, using sunlight, into oxygen and glucose. Over vast periods of time the oxygen they produced formed an oxygen rich atmosphere on which all animal life depends.

The oxygen also produced the ozone layer which protects the earth from the UV rays of the sun.

Reference: *Life on Earth:* David Attenborough Flagellated bacteria: microbeonline.com

Chimps



Pan troglodytes

Chimpanzees are our closest animal relative, we share 98% of their DNA. They live in troops from 12 to 100 and work as a team when sharing information and hunting.

They are intelligent and use tools.

Chimps fish for termites by poking sticks down holes in termite hills and extract water from tree holes with folded leaves. They look for a suitable stone to act as an anvil to crack nuts on. Clever!

Reference: *The Life of Mammals*: David Attenborough

Corals

Lithophyllia lacera

Stony corals, look like plants but are actually animals! They form hard calcium carbonate skeletons.

Reefs are built from coral polyps, which are translucent animals containing tiny algae which give them their colour. Reefs are home to thousands of sea creatures, fish, molluscs, sponges and worms supporting about 25% of all marine animals. They also protect coastlines from tsunamis.

Climate change and pollution have damaged coral reefs, which are now considered important carbon sinks, and there is an urgent drive to protect them.

References: Corals: nationalgeographic.com, Corals: nhm.ac.uk, *The Living Planet*: David Attenborough

Darwin's Abominable Mystery

Pediastrum lunatum

Pyrolobus fumarii

Still unsolved till this day!

There was a sudden explosion of flowering plants in the Cretaceous period. But, why?

This puzzled, and indeed troubled, Darwin, who couldn't explain such a sudden change, when evolution is usually a slow and gradual process. In fact, to his dismay, Creationists seized on this to try and discredit his theory of evolution.

There have been a number of attempts at an explanation including

1) There was a period of global warming during the Cretaceous (>10 degrees C higher than today)

2) There was an increase in pollinating insects then, so was this a case of co-evolution?

3) Recently a team of scientists have suggested that in fact flowering plants existed undetected, much earlier than thought, possibly since the Jurassic.

The jury is still out.

References: New Light Shed on Darwin's Abominable Mystery, www.bbc.co.uk
The Evolution of Plants: K.J. Willis J.C. McElwain
New Study unravels Darwin's Abominable Mystery: www. sciencedaily.com 28/01/21

Darwin's Moth and Orchid

Xanthopan morganii praedicta

Angraecum sesquipedale

A famous example of co-evolution.

When Darwin was sent an orchid Angraecum sesquipedale (meaning a foot and a half) from Madagascar, back in 1862, he couldn't believe what a long spur it had.

He predicted that there must be a moth with a probiscus 35cm long to reach the nectar at the tip.

Everyone laughed and said it wouldn't be able to fly!

But 20 years after he died, they found it, a rare hawk moth, the orchid's only pollinator. Its tongue is normally kept coiled up under its head. They called it Xanthopan morgani praedicta, in honour of his prediction.

References: *Life in The Undergrowth*: David Attenborough
The Private Life of Plants: David Attenborough

Gingko

Ginkgo biloba

Indestructible! A 'living fossil' Ginkgo is almost unchanged for 200 million years, from the age of the dinosaurs.

Six trees survived the blast centre of the Hiroshima atom bomb, one beside the Hosenji Temple within half a mile of the epicentre. The new temple built round it celebrates the hope of renewal.

It is resistant to air pollution, pests and disease.

It is called the Maidenhair tree and it has distinctive fan-shaped leaves sometimes used in jewellery design.

The leaf extract Ginkgo biloba is a popular herbal medicine to improve memory.

Reference: *Ginkgo*: Peter Crane

Honeybees

Apis mellifera

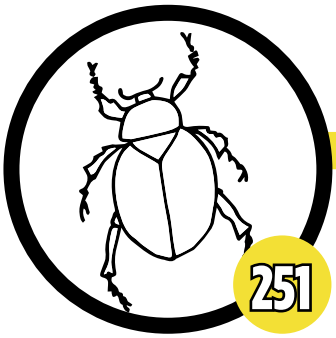
'If the bee disappeared off the face of the earth, man would only have 4 years left to live' - 75% of the world's food crops rely on insect pollination.

A hive can contain 50,000 honey bees. The worker bee performs a dance outside the hive to indicate where food is. When a bee sucks nectar from a flower, pollen sticks to it and so it pollinates the next flower it visits. It takes 12 worker bees to produce a teaspoon of honey.

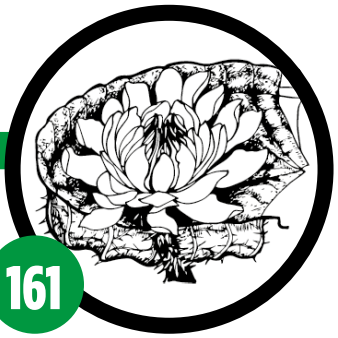
Bees in danger – UK and US numbers have dropped around 50% in the last 25 years, largely due to pesticides.

References: Honey bee; Geographical Magazine, Jan 2019
AA Book of The British Countryside
Honey bee drbeekeeper.com
Honey bee wildlifetrust.org
Beguiling History of Bees: Scientific American, Dave Goulson 25/4/14

Honeytrap



Cyclocephala hardyi



Victoria amazonica

The perfume of the white Amazon waterlily, attracts a specific nocturnal beetle.

It's party central! Word gets round and 6 or 8 fly in and get drunk in the nectary.

BUT, then the flower starts to close trapping them inside, as it slowly turns deep pink.

The next night it opens. The escaping beetles, coated with sugary juice, brush past pollen on their way out, which sticks to them.

They go to the next white lily, pollinating it on their way in.

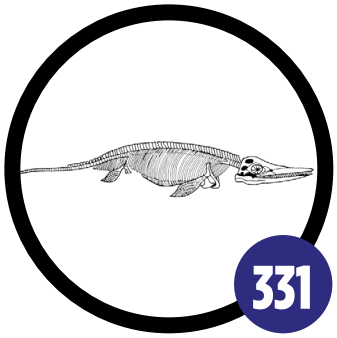
And history is repeated.

White flowers shows up at night, so the cunning trick of changing colour is very efficient as it prevents a lily being pollinated twice.

The underside of the leaf structure inspired Paxton for his design of the Crystal Palace.

References: *A Passion for Plants - The Life of Ghillean Prance:* Clive Langmead

Ichthyosaur



Ichthyosaurus communis

The Ichthyosaur lived 200 million years ago, during the age of the dinosaurs.

It was a huge marine reptile, with enormous eyes, was protected by bony plates, grew up to 25m long, and looked a bit like a modern shark. It breathed air and gave birth to live young. It was a transitional animal, see Coelacanth 42 and Tiktaalik 43

It was probably descended from land animals and evolved to return to the sea. Its paddles and tail drove it through the water, where it was the top predator for 150my.

It was first discovered by Mary Anning at Lyme Regis on the Jurassic coast in 1811 and it caused a sensation. She sold the fossils she discovered to scientists but as a young girl of 12, from a poor family, she was given no credit. At first it was thought to be a crocodile, but Mary was sure it was a new creature.

Ichthyosaur means fish lizard in Ancient Greek.

References: Mary Anning - A fossil hunter's story: https://www.ase.org.uk/mary-anning-fossil-hunters-story
Mary Anning: the unsung hero of fossil discovery: https://www.nhm.ac.uk/discover/mary-anning-unsung-hero.html
Attenborough and The Sea Dragon: BBC1
Britain's largest ever ichthyosaur discovered in Rutland: https://www.nhm.ac.uk/discover/news/2022/january/britains-largest-ever-ichthyosaur-is-discovered-rutland-water.html

Living Fossil

Latimeria menadoensis

The extraordinary story of the Coelacanth, a 'living fossil', is as amazing as the creature itself. This large fish was thought to go extinct 400 million years ago. So when one was caught in 1938 off the South African coast, it caused a scientific sensation.

It was spotted in a local fisherman's catch by Margaret Latymer who realised its importance. It is a deep sea dweller. Rewards were offered for live specimens, but it was 14 years until another was discovered in the Comoros.

It has paired lobed fins, which move alternately, strong enough to propel it along the sea bed. The start of the movement onto land?

Reference: *A Fish Caught in Time*: Samantha Weinberg

Man's Best Friend

Canis lupus

Canis lupus

Dogs diverged from grey wolves 32,000 years ago. Man has domesticated and bred numerous breeds, selecting certain wolf attributes for working dogs.

They are highly intelligent and are trained as Guide dogs, search and rescue, hunting, racing, and guard and police sniffer dogs.

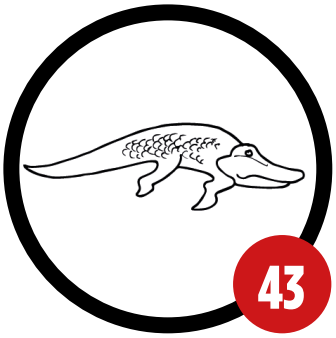
Their amazing sense of smell can detect a teaspoon of sugar diluted in two Olympic –sized swimming pools of water!

Their super-sensitive noses can find drugs, explosives, firearms, cash and forensic evidence. They are even being trained to sniff out mobiles, laptops and SIM cards in the fight against cybercrime, 'collaring cyber crooks'.

The charity Medical Detection Dogs trains dogs to detect some cancers, malaria and Parkinson's disease. There is a current research project training Labradors and cocker spaniels to detect Covid-19 in people who have yet to develop symptoms.

References: Domestic dog livescience.com
nationalgeographic.com
Evening Standard 8/11/19 Collaring Cyber Crooks
bbc.co.uk Coronavirus: Trial begins to see if dogs can sniff out virus 16/05/20

Onto the Land



Tiktaalik roseae

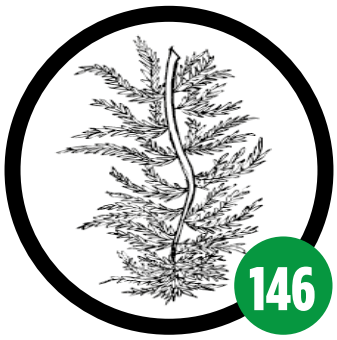
A glance at the map will show you that just as the first animals were emerging out of the water onto the land, the land plants were also taking off. And coincidentally, so were the insects – literally!

In 2004 a fossil of Tiktaalik was found in the Canadian Arctic. It had a skull, neck and ribs like an animal, with the jaws, gills and scales of a fish, and crucially long hind fins which could have helped it to walk on mudflats.

It was hailed as the Missing Link between fish and amphibians.

References: The Guardian 2/08/14

Sphagnum Moss



Sphagnum cuspidatum

Sphagnum moss is an ancient plant which forms peat. Peat bogs were drained after WW2 to improve agriculture.

BUT we now know that they are the UK's most significant carbon stores and they are being restored, which will also reduce flooding.

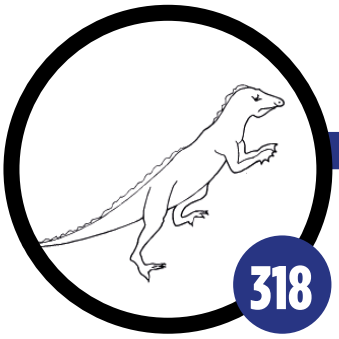
The world's peat lands store 415 gigatonnes of Carbon equivalent to 46 years of current global CO2 emissions. The concern is that half of the lands are frozen and are at risk of thawing, due to global warming, releasing carbon into the atmosphere.

Moss can absorb 20 times its weight in water (forget micro fibre cloths which can absorb only 7 times). Together with its antibacterial properties, it was ideal for wound dressing in WW1.

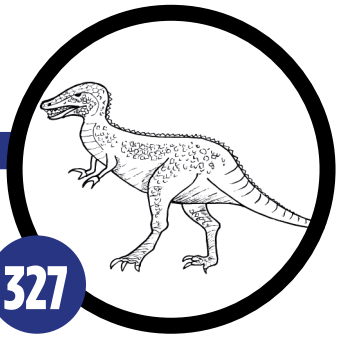
It is used in hanging baskets as the moss retains moisture.

References: The Geographical Magazine, *Land Use UK Peatlands: For Peat's Sake* Laura Cole 2018
BBC, *Science and the Environment: Climate Change - Frozen Peatlands,* Matt McGrath 10/8/20

Death of the Dinosaurs



Ornithosuchus woodwardii



Tyrannasaurus rex

Luis Alvarez and his son discovered a worldwide layer of rare iridium associated with extra-terrestrial collisions, supporting their theory that earth was hit by a huge asteroid 66mya.

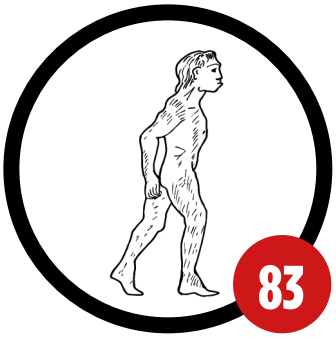
The crater it caused at Chicxulub in Mexico is 150 km wide. The pollution altered the climate and partially blocked out sunlight, affecting plant growth, which impacted on herbivores and the carnivores who preyed on them.

Three quarters of animals, including the dinosaurs, died. Only a few groups of birds and small creatures less than 25kg survived.

There was a lot of volcanic activity about then too, a double whammy!

References: *What killed the dinosaurs?*: nhm.ac.uk
K-T Extinction: National Geographic.com

The Neanderthals



Homo neanderthalensis

The Neanderthals have a bad press, but they were actually very intelligent, sociable and compassionate.

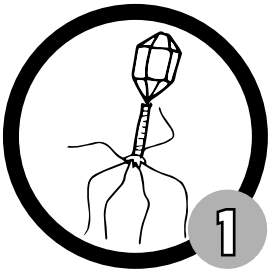
They are our closest ancient human relative and they lived alongside early modern humans for at least part of their existence.

Some of us have inherited around 2% of their DNA. They were skilled toolmakers, making flint tools and weapons and also jewellery and cave paintings.

Most importantly, about 200,000 years ago, they discovered how to make fire.

Reference: *Who Were the Neanderthals*: nhm.ac.uk

Viruses



Bacteriophage T4

Forget nuclear weapons. A simple but deadly virus has stopped the world. Countries have closed their borders, cities and streets are empty, and people are on lock-down. The arms race is on with scientists everywhere working together in an unprecedented collaboration to beat it.

Viruses were the first living things on earth 3.5 billion years ago. They are prokaryotes, having no nucleus or membrane. They are single-celled with a protein shell, the simplest contain RNA, others DNA. When a virus infects someone these genetic instructions tell the virus how to replicate once it enters a cell.

Coronaviruses are a modern group, which normally cause mild illnesses like a cold, but also SARS and COVID-19! They have an amazingly long single stranded RNA and are spherical with a 'crown' of club-shaped spikes – hence the name. The virus uses these spikes to hook onto a 'docking point' on the surface of human cells and inject its RNA, which then hijacks the machinery of the host cells' nucleus to make multiple copies. These burst out of the cell destroying it and they then go on to infect neighbouring cells. A huge invasion.

Covid-19 was thought to have originated with bats and recently jumped species to humans - zoonotic. (Bats first occurred in the Eocene 50 million years ago).

The origin of viruses is a mystery, the jury is still out on this one:

- Virus first- illustrated here for simplicity
- Reduction hypothesis: small cells paratised larger cells
- Escape hypothesis: Viruses evolved from bits of DNA and RNA that escaped from the genes of larger organisms.
- Co-evolution
- Chimeric origins

References: *The Plant Kingdom*: Ian Tribe
National Geographic Magazine Feb 2020
Newscientist.com 27/03/20
NPR.org: *Research looking at how coronavirus is mutating* 25/3/20
Viral Evolution: Wikipedia

Insects

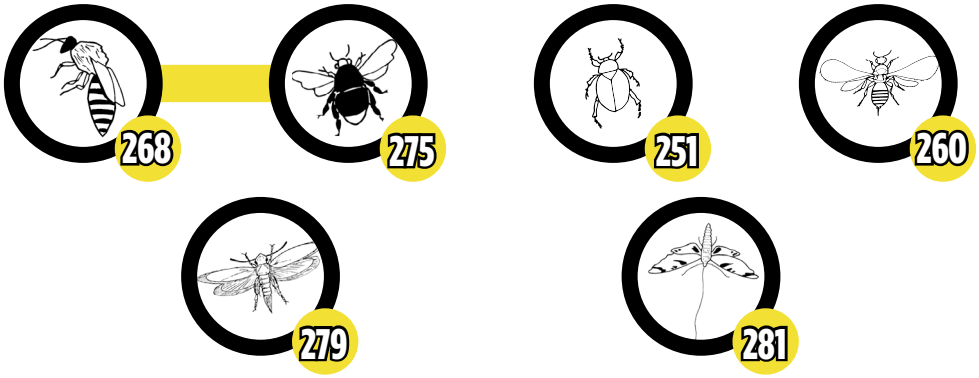
'If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago. If insects were to vanish, the environment would collapse into chaos.'

- E.O.Wilson

An insect's body is in 3 parts: Head, thorax with 3 pairs of legs, and abdomen.

UNSUNG HEROES

It is estimated that insects make up nearly 90% of all species of animals, there are 1.4billion insects for every person on earth, and they are essential to the health of the planet.

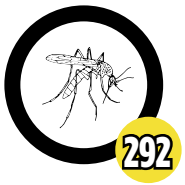


75% of all flowering plants and most fruit rely on insects for pollination, not just bees, but beetles, wasps and moths.

Insects are waste disposal experts, they are crucial for decomposing dead organic matter keeping the planet clean.

Insects

Blowfly maggots can consume 60% of a human corpse in a week.



Insects also provide food for fish, birds, reptiles and insectivore animals. You could ask 'what's the point of mosquitoes'? Well, they provide food for dragonflies and damsel flies.

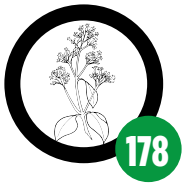
References: Royal Entomological Society: royensoc.co.uk
Oxford Uni Museum Natural History: royensoc.co.uk
Where Have All the Insects Gon?: National Geographic Elizabeth Colbert May 2020
Where did mosquitoes originate?: mosquitocontrol.net

Herbs and Medicines

Plants have been used for centuries to treat ailments and diseases. Many plants' 'virtues' were handed done over the generations, and more recently written down in herbals, which were often illustrated to help with identification.

Homeopathy and aromatherapy are popular today as alternative medicines. Modern research is being done on the effectiveness of traditional medicines derived from plants, and is also carried out looking into new cures for diseases including cancers.

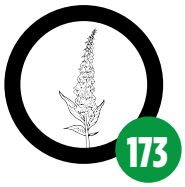
The Ginkgo leaf extract, Ginkgo Biloba is a popular herbal medicine to improve memory.



Quinine used to treat malaria, is derived from the bark of Cinchona. It was first discovered in Peru by a Jesuit priest in 1631. Malaria killed 300 million people in the 20th century.

Aspirin is derived from Salicyn found in willow bark.

Herbs and Medicines

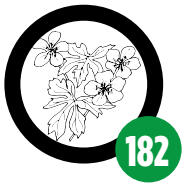


In 1775, Dr William Withering learned of the foxglove's medicinal properties from a local herbalist which he reported to the medical profession. Foxglove is commercially grown for Digitalis used for treating heart failure.

The Eucalyptus, is a very aromatic tree. Oil derived from the leaves has been used in indigenous Australian medicine for centuries and is used as an antiseptic and an antifungal. It is a decongestant and it also acts as an insect repellent. It is used in India's Ayurvedic medicine.

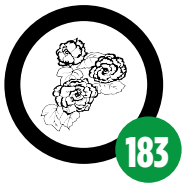
It was used to disinfect hospitals in England during the 17th century.

The peony is regarded as an anti-aging herb. The roots are used as a tonic and for a skin treatment.



The geranium has many medicinal properties, which include antiseptic and antibacterial and can reduce inflammation.

Herbs and Medicines



Juice extracted from the root of Begonia is used to treat conjunctivitis.

References
Into The Wild: Plant Drug discovery Kew 2/9/2020
Leaves from Gerard's Herbal arranged by Marcus Woodward
Ginkgo: Crane, 2013
The tree that changed the world map: bbc.com 26/520 Vittoria Traverso
Plants from Roots to Riches Kathy Willis
Culpepper's colour Herbal edited by David Potterton
Eucalyptus woodlandtrust.org
7 remarkable Facts about Eucalyptus Trees www.ambientbp.com
Flowers of Love a Kew Colouring Book Sue Mason
12 Amazing Facts of Geranium organicfacts.net
Begonia medicinal herbs naturalmedicinalherbs.net

The Cambrian Explosion

Initially, very primitive, simple life forms existed in the seas.

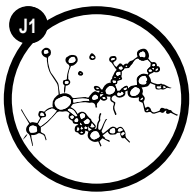
Viewed under a microscope they exhibit all the basic symmetries. The blueprints of life. Then came soft bodied sponges, jellyfish, corals & flatworms.

Suddenly, there was a major expansion of animals, the hard bodied arthropods (crustaceans, arachnids, insects), molluscs and echinoderms.

Sea levels had risen, newly created continents had flooded & temperatures rose. Resulting continental rock erosion lead to nutrients washing into the oceans, calcium & phosphorous needed to build skeletons & shells. Oxygen levels increased.

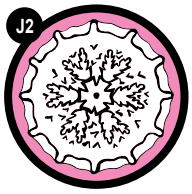
References
The Cambrian Explosion was far shorter than thought nhm.ac.uk Feb 2019
What Sparked the Cambrian Explosion, D Fox 2016 Nature.com
The Evolution of Plants Kathy Willis
A Journey Through Time Since the PreCambian Britannica.com

Junctions



MONERA JUNCTION

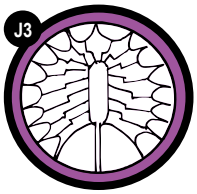
The Monera Kingdom consists of Prokarote (no nuclear membrane) unicellular organisms, such as Bacteria.



PROTISTA JUNCTION

The Protist Kingdom contains Eukaryotic (have a membrane bound nucleus) protists, which are neither animals nor plants nor fungi.

They are very simple and consist of a cell which contains DNA, a genetic material, inside a defined nucleus. They are usually uni-cellular but some are multicellular. Protists were named by Ernst Haeckel, a German zoologist who supported Darwin. He produced the beautiful illustrated book Art Forms in Nature.



CHROMISTA JUNCTION

The Chromista Kingdom (Chromista means coloured). It contains eukaryotic species, both single and multi-celled and most are photosynthetic.

PLANTAE JUNCTION

All Life Depends on Plants

The Plant Kingdom contains all the world's plants. Green plants get most of their energy from sunlight using photosynthesis. This process converts energy from sun light into chemical energy. The plant absorbs carbon dioxide which is synthesised with water and stored as sugar in the plant, while oxygen is released.

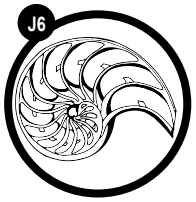
Oxygen is fundamental to life on earth which is why it is so important to conserve the rain forests.

Junctions

ANIMALIA KINGDOM

The Animal Kingdom gets its name from the Latin word 'animalis' meaning 'having breath'. Animals are multi-cellular eukaryotes.

Most of them breathe oxygen, are mobile and reproduce sexually. They are generally bi-laterally symmetrical.

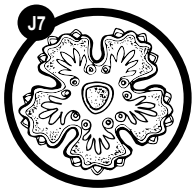


MOLLUSCA JUNCTION

From Scallops to Squid

Molluscs arrived during the Cambrian Explosion due to nutrients like calcium and phosphorous becoming available.

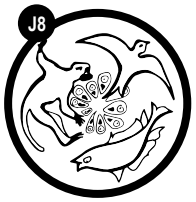
They are invertebrates, with a mantle, and some have a shell. They are unsegmented and bi-laterally symmetrical.



ECHINODERMATA JUNCTION

Sea Stars and More

The name comes from the Greek and means spiny skin. They are marine creatures which are radially symmetrical.

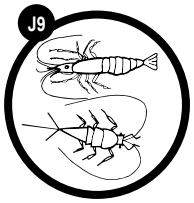


CHORDATA JUNCTION

The Central Line From Cambrian to Holocene

This phylum contains all the vertebrates and also the invertebrates: tunicates and lancelets. They have a notochord, dorsal nerve chord, pharyngeal slits, an endostyle and a post-anal tail at some stage of their development. They are bi-laterally symmetrical.

Junctions



ARTHROPODA JUNCTION

Boneless

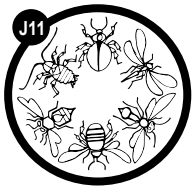
Arthropods are invertebrates, animals which do not have a backbone or bony skeleton. Instead they have an exoskeleton, segmented bodies and paired jointed appendages. They form an amazing 84% of the Animal Kingdom and consist of crustaceans, arachnids, myriapods and insects.

VERTEBRATE JUNCTION

Backbone

Vertebrates have a spinal cord (backbone) and are bilaterally symmetrical.

They include amphibians, fish, birds, amphibians, reptiles and, of course, mammals. More than 90% of all animals are actually invertebrates!



INSECT JUNCTION

Six legs

An insect is an arthropod. It's easily identified as it has 6 legs. It's body is in three parts: head, abdomen and thorax, with 2 antennae on its head. 75% of all flowering plants rely on insects for pollination. Insects provide food for fish, birds, and insectivore animals. Waste disposal experts, they are crucial for decomposing dead organic matter.

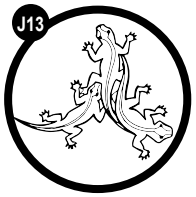
'If insects were to vanish, the environment would collapse into chaos'. - E.O.Wilson

Junctions

VASCULAR PLANTS

Plumbing

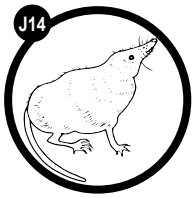
They contain plant tissues (xylem and phloem) which conduct water, sap and nutrients like veins and arteries convey blood around the body in mammals.



REPTILE JUNCTION

Onto the Land

A reptile is a cold blooded vertebrate with a dry scaly skin and typically lays soft-shelled eggs on land. Reptiles include crocodiles, dinosaurs, turtles and tortoises, lizards and snakes.



MAMMAL JUNCTION

Fur and Milk

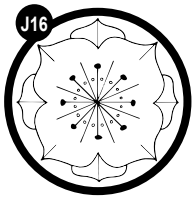
A mammal is a warm–blooded vertebrate, with hair or fur, and the mother feeds her young on milk she produces herself. Initially mammals were small and kept a low profile, but they underwent a massive expansion after the K-T extinction of the dinosaurs. They made the most of the new opportunities! The Age of the Mammals had arrived.

BIRD JUNCTION

Feathers for Scales

A bird is a warm blooded egg-laying vertebrate, with feathers, wings and a beak. All orders of birds had appeared by the Eocene except for perching birds. Archaeopteryx is the earliest known bird. Flowering plants had started to appear together with their pollinating insects. Then wow, we have birds!

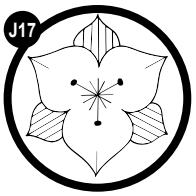
Junctions



FLOWER JUNCTION

A burst of colour

Darwin referred to the explosion of flowering plants as an 'An abominable mystery'. They produce seed within an ovary, usually a fruit, unlike gymnosperms which have unenclosed seeds, eg pinecones. The main line divides into Early Diverging Eudicots, Asterids and Rosids .They have 2 seed leaves and petals in multiples of 4/5.



MONOCOT JUNCTION

The Branch Line

There is a branch line to the Monocots, which have only one seed leaf (the clue is in the name) & multiples of 3 petals. The large leaf veins run parallel to each other.

PRIMATE JUNCTION

From Loris to Man

'Primate' comes from 'primus' the Latin for 'first rank'. Primates have large brains compared to other mammals and rely on sight rather than smell. They have tails, apart from the more recent apes and humans. Most primates have opposable thumbs, which means the thumb can be moved round to touch the other fingers, giving them the ability to grasp things.

Natural Solutions

Sometimes natural solutions to problems can be found, they are sustainable, and eco-friendly.

FLOOD PREVENTION

Houses have been built on flood plains all across the country, adding to the problem of flooding.

Beavers are being reintroduced to the UK, having been hunted to extinction 400 years ago. The dams they build across streams have been proved to reduce flooding downstream, Not only this, but they also improve the quality of the water by removing phosphates.

They are nature's engineers!

TREE PROTECTION

Elephants are scared of bees! Although they have thick hides they can be stung around the eyes and ears and within the trunk.

A South African charity Elephants Alive have designed special hives, called Beepaks, to hang on Marula trees. This has proved extremely good at keeping elephants away from the trees, which they can destroy. Also the honey produced is collected and sold by local people in aid of the charity.

Natural Solutions

CROP PROTECTOR

A wasp has been named after Idris Elba (because of his character Heimdall in Marvel movies). It parasites the eggs of the stink bug species Bagrada hilaris which damages crops across the USA.

PEST CONTROL

Lizards, who were discovered by H.M. Customs and Excise as illegal imports, were given to the Royal Botanic Gardens Kew and they now patrol the Palm House to keep down the cockroaches.

Small Chinese water dragon lizards help control the cockroaches and other pests in the Princess of Wales Conservatory.

AVIAN PEST CONTROL

Hawk-eye. Traditional ‘green’ methods using Harris Hawks are being employed to control pests such as pigeons and seagulls in our cities. Pigeons collect where there is food lying around near

Natural Solutions

outdoor cafes. Pigeons can carry and spread three diseases fatal to humans. Hawking moves the pigeons on and the colony disperses.

References: *Beavers are to be released in plans to stop flooding* The Guardian 20/11/2019

Dam it!How beavers could save Britain from flooding. Patrick Barkham 8/8/17 The Guardian

Elephants, Bees and Marula trees, Journal of African elephants

'Protective wasp named after Elba', Evening Standard 18/11/2019

Thor actor Idris Elba becomes namesake of new wasp species: CNET 20/11/2019

The secrets of the Princess of Wales Conservatoy: Kew.org

Kew Gardens and the Temperate House: Rob Tomlinson.

www.spitfireapc.com

Camouflage

The Octopus is highly intelligent and knows how to disguise itself. It has 9 brains, one in each of its eight arms, and a central-control brain. Threatened with danger, it can instantly change colour and texture to merge with its background, be it rock or coloured seaweed.

One octopus is a master of disguise and can mimic other species, even walking away on two legs to escape a predator!

The most famous impersonator of all is the Chameleon. Changing colour to subtly blend into the background is his only means of defence. Cunningly disguised among leaves or branches, he is almost impossible to detect in the wild. This party trick has made him a popular pet!

The Peppered Moth is a superb example of evolution by natural selection. Usually white lightly speckled with black dots, it easily blends in on lichened covered trees. There is also a less common black form. But the pollution created by the Industrial Revolution in the 19th century, meant everything was blackened with soot. Then something amazing happened, in less than 50 years, the black moths became more prolific, especially in our towns and

Camouflage

cities. Now however, with cleaner air, the pale moths outnumber the black ones again.

The small chameleon prawn, Hippolyte varians, can change colour from red, brown,through green to almost transparent for camouflage during the day At night it becomes a transparent bluish-green.

The Glasswing butterfly, Greta oto, is transparent and invisible. This extraordinary butterfly lacks the scales which are characteristic of all other butterflies and moths, and which give them their colour. The toxic plants which the caterpillar eats render them poisonous.

References: *Octopuses Keep Surprising Us*: nhm.ac.uk

Life in Cold Blood, D. Attenborough

Chameleon's craziest colour changes: nationalgeographic.com

Hippolyte varians: Marlin.ac.uk

Glasswing butterfly: butterflyidentification.com

Glasswing butterfly: anywhere.com

Biomimicry

Many inventions are inspired by nature and this field is called Biomimicry. Nature has been in the design business forever and through evolution has perfected her designs over millions of years.

CATS EYES were invented by Percy Shaw, a road mender. He was driving home in fog one night in 1933, and couldn't see the road, but was saved by his headlights reflecting from a cat's eyes. He designed a simple unit consisting of 4 glass beads set in a rubber casing, placed in pairs facing in opposite directions. When a vehicle is driven over it the rubber is pressed down, at the same time rainwater captured in the cast iron base, automatically washes the beads.

VELCRO was invented by Swiss engineer George de Mestral, in 1941. One day, after walking his dog in the country, he was intrigued, rather than irritated, to find that they were both coated in burrs. He studied them under the microscope and discovered they were covered in tiny hooks which caught on anything which acted as a loop. (This is the cocklebur's way of dispersing seeds, epizoochory). He designed 2 strips of nylon fabric, one with hooks the other with loops, to make the familiar fastener we use today.

Biomimicry

THE JAPANESE BULLET TRAIN can travel at a phenomenal 300km/h. However there was a major problem when it came to tunnels. A pressure wave built up in front of the train and created a loud 'tunnel boom' as it exited.

Eiji Nakatsu an engineer and bird watcher, was inspired by the Kingfisher. It had similar problems with change in drag as it dived into water after fish. But its elongated beak allowed water to flow past it rather than being pushed in front of it. They streamlined the nose of the train, and it also now uses 15% less electricity and is 10% faster. Problem solved!

SPIDER SILK has the most amazing properties, strength combined with elasticity, inspiring scientists to copy it.

The silk is ultra-light (it is 1000 times thinner than human hair) and 5 times stronger than steel for the same diameter. It is very elastic, like a minuscule bungee cord, to help it catch insects that fly into it at speed. It's a superb shock absorber. Cambridge University has made artificial spider silk replicating these properties, which can dissipate 70% of the energy in impacts. The fibre could be used for armoured vests and even crash helmets.

Spider silk is also extremely sticky to stop insects escaping.

Biomimicry

Scientists at the University of Akron in Ohio have studied the glue. New adhesives inspired by spider glue could replace petroleum based ones. A solution to a sticky problem?

Millions of birds die by flying into glass and Ornilux Birdsafe Glass was inspired by the UV reflective properties of spiders' webs – which birds can see and so avoid flying into them. (Not good for the spider or the bird)!

SHARKSKIN has flexible layers of tiny teeth (dermal denticles) which reduce drag by creating low pressure zones that 'pull' the shark forward through the water. Speedo designed fabric using this concept, which it used in its swimsuits in the 2008 Olympics. It was subsequently banned!

More significantly these minuscule 'teeth' also keep sharks clean and free from marine micro-organisms.

The US Navy funded Anthony Brennan at the University of Florida to develop a material to stop barnacles growing on ships. With a background in dental biomaterials, he had the extraordinary idea of mimicking sharkskin and he sent a dental impression kit to a fisherman friend who took an impression of sharkskin for him! He launched Sharklet Technologies in 2007 to develop an adhesive biofilm. It has a super rough relief micro-pattern of diamonds, which water slides off, deterring bacterial growth. Bacteria need water and can only flourish on smooth surfaces.

Biomimicry

Hospitals use the film to fight cross-contamination and it is in demand in the US during the Coronavirus pandemic. The Sharklet website states 'No antimicrobials, no chemicals – the first technology to inhibit bacterial growth through pattern alone'.

THE MANTA RAY'S elegant, minimalist shape inspired new graduate Mathis Cossons' revolutionary design for Lilium's all-electric jet aircraft. He said 'I believe biomimicry has a pivotal role to play in design'.

Rays glide through the water using their triangular wing-like pectoral fins which drive water backwards.

The Lilium Jet has no tail or rudder and only one moving part in each engine. Designed as an air taxi service, it's a 5 seater and flies at 300km/h. It had its maiden voyage over Germany in July '19. Meanwhile in February '20, Airbus unveiled its design for a plane based on the Ray, which cuts carbon emissions by 20%.

References:
History of Cats Eyes: trafficsignsandmeanings.co.uk
Velcro: sciencefocus.com
Lessons from Nature, Katie Burton, Geographical Magazine, April 2020
Shinkansen Train: asknature.org
Here's 7 of The Best Examples of Biomimicry and Nature: Digitaltrends.com
Biomimicry: 9 Ways Engineers Have Been Inspired by Nature, Interestingengineering.com
Spider Silk – Digital Trends: digitaltrends.com, 13 June 2017
8 Captivating Facts About Spider Silk: blog.adafruit.com
Researchgate.net A Review on Spider Silk Adhesion: Sahni, Blackledge, Dhinojurdla June'11
Biomimicry: 10 of The Best Examples of Biomimetic Design: Sciencefocus.com
Biomimicry Sharkskin Digitaltrends.com
Sharklet.com
How The Founder of Sharklet Technologies Fights Bacteria: www.USchamber.com
Lessons from Nature Geographical Magazine April '20 Katie Burton
Lilium.com The Inspiration Behind The Lilium Jet Design

Everything in nature is connected

WE ALL DEPEND ON EACH OTHER, EVERY CREATURE HAS ITS PLACE AND WORK TO DO.

Worms aerate the earth so plants can grow. Earthworms (29) are major ecosystem engineers, they plough the earth. 'It may be doubted whether there are many other animals which have played so important a part in the history of the world'. – Charles Darwin

Flies are nature's essential rubbish collectors, see Bluebottle (296). They are important scavengers and breed on decaying animal matter which helps nature's recycling.

https://www.aardvarkpest.co.uk/blue-green-bottle-fly/

Honeybees (270) 'If the bee disappeared off the face of the earth, man would only have 4 years to live'. (attributed to Einstein). *No more bees, no more pollination, no more plants, no more animals, no more man.*

https://www.resilience.org/stories/2015-05-21/albert-einstein-soil-honey-bees-and-biodiversity/

Australia's bees are in lockdown summer 2022 because of the varroa mite, which perfectly illustrates this quote. The honey industry could lose £40 million per year. Honeybees pollinate a third of the food crops, including apples and cherries, and the crops fed to livestock which affects the meat industry. This all leads to food shortages and rising prices.

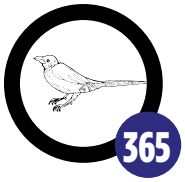
Sunday Times 10th July 2022 James Salmon

The ecosystem is like a house of cards, remove one card and the whole system becomes unstable.

Man's responsibility to the planet cannot be overstated.

Symbiotic Relationships

1. MUTUALISM (where everyone's a winner)

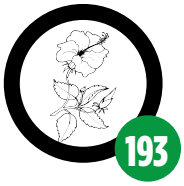


The Giraffe and the Oxpecker bird. The giraffe has his own personal groom. The tiny oxpecker bird is often seen riding on his back and eats the ticks and gets a free meal. He also chirps loudly to alert his host to danger.

Giraffa sp., Buphagus africanus: Livescience.com

The Yucca and the Yucca Moth. They are made for each other! The moth is the Yucca plant's only pollinator and the moth's larva depends on its seed for food.

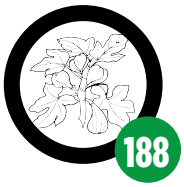
151 Yucca 233 Tegeticulla yuccasella
Blog.nature.org/science 2013/03/21 the yucca and its moth



The hibiscus flower is pollinated by a hummingbird.
It hovers in front of the flower to sup the nectar, coating itself with pollen as it flaps its wings an incredible 80 times a second. This makes the distinctive hum for which it's named.

Life on Earth: David Attenborough
The Life of Birds: David Attenborough
What are the adaptions of the Hibiscus Plant: sciencing.com

Symbiotic Relationships



Figs co-evolved with their minute wasp pollinators. The female wasp enters the fruit through a tiny hole and lays her egg. In doing so she gets covered in pollen, which she then transfers to the next fig she visits.

Co-evolution of a tree and a minute wasp: WP Armstrong www2.palomar.edu
Fig Wasps Pollinators: Deepa Padmanaban: 1/5/16, bbc.co.uk

2. COMMENSALISM (where one benefits at no cost to the other)

The Hermit crab is a squatter. Unlike other crabs, it lacks a hard outer protective shell and is therefore vulnerable. So, it cunningly finds an empty shell to live in.

Hermit crab: Encyclopedia Britannica

The Cocklebur seed comes in a hard bur covered in hooked spines, which stick to the fur of passing animals. A cunning method of seed dispersal. George de Mestral, a Swiss engineer took his dog for a walk in the country and they both came home covered in burs, which are very difficult to remove.
He examined the burs under a microscope and this inspired him to design Velcro.

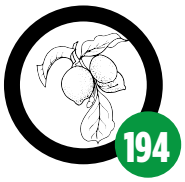
Velcro: sciencefocus.com

Symbiotic Relationships

3. PARASITISM (The parasite benefits but the host is harmed)

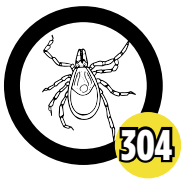
The Green oak roller moth lays its eggs so that they hatch just as the oak's new leaf buds are opening. They can defoliate a tree.

Oak defoliaters: forestresearch.gov.uk



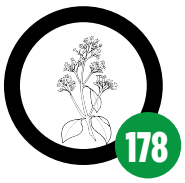
The Citrus mealybug is a serious threat to citrus orchards around the world.

Citrus mealybug: Britannica.com



Ticks are arachnids (not insects). They originally lived off lizards, but changed their diet when mammals and birds came along! They can be found on deer and, if they are infected with the bacteria Borrelia burgdorferi, they cause Lyme Disease in humans.

Comparison of hard and soft ticks: webapps.cap.org
Ticks a Living Fossil: journals.plos.org: B.J. Mans, 2011



Mosquitoes are one of nature's most hated insects due to their habit of snacking on human blood. They breed in stagnant water and infected mosquitoes can cause malaria, which killed

Symbiotic Relationships

300m people in the 20th century. Half the world lives in areas where the disease is transmitted. It is treated with quinine which is derived from the bark of Cinchona, sometimes called Jesuit's bark. It was discovered in 1631 by Jesuit priest in Peru.

The Tree that Changed the World Map: bbc.co.uk, 28/5/20, Vittoria Traverso

The Golden Spiral

Nautilus macromphalus

Nautilus is a 'living fossil'. A cross-section of the shell shows the inner chambers habe grown in a logarithmic spiral, which is derived from the Golden Rati - it is beautiful.

The growth spiral is found in natuure e.g. ammonites, unfurling ferns, sunflower centres and cacti.

Leaves grow up a twig in a spiral. This is clever, as each leaf is not overshadowed by the leaf above and gets the light it needs for photosynthesis.

You can construct the Golden Spiral from the Fibonnacci Sequence, using a ruler and a compass.

The Fibonnacci series of numbers is found by adding consecutive nubers to make the next one in the series e.g. 0,1,1,2,3,5,8,13,21,34...

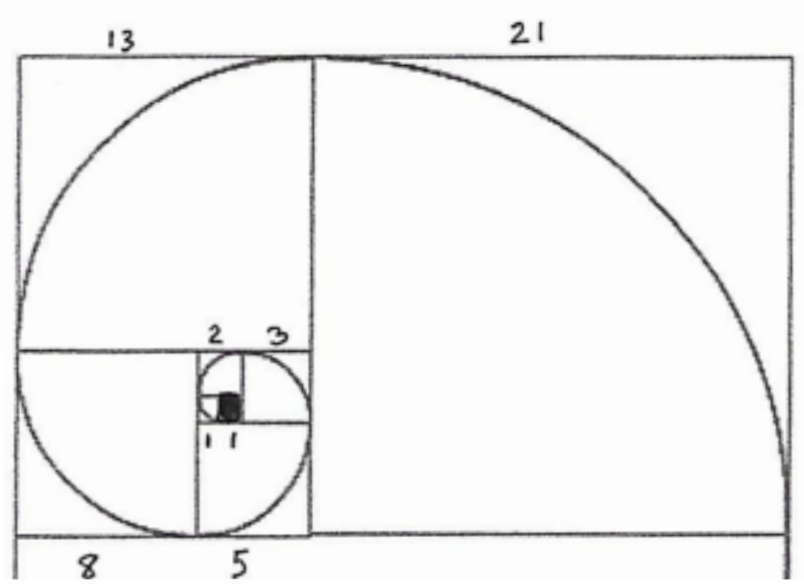
The Golden Ratio is roughly 1.618 and is approximated by taking a number from the sequence and dividing it by the previous number (excluding the first two in the series).

How to draw the Golden Spiral:

- Construct a square with a side 1cm in height
- Add another square, 1cm in height, on the left

The Golden Spiral

- Draw a square, 2cm in height, on top
- Add a square, 3cm in height, on the right
- Make a square, 5cm in height, below
- Add a square side, 8cm in height, on the left
- Draw a square, 13cm in height, on top
- Add a square with a 21cm side on the right
- Now take a compass and inscribe an arc, starting in the first square you drew - the radius of the compass should match the the height of the square you are drawing in.



The Mammal Exansion

The rapid expansion of the Mammals happened about 10my after the extinction of the dinosaurs (relatively quickly). They saw their chance and took it! It was also helped by global warming. The Paleocene- Eocene Thermal Maximum (PETM) occurred around 55mya, when the earth's temperature rose about 5 degrees and vegetation flourished.

PETM was found by geologists studying fossils of PLANKTON. This includes Phytoplankton (eg 5 Cyanobacteria, 126 single celled algae, 128 - 134 green algae) which make their own food releasing oxygen, producing an estimated 80% of earth's oxygen. They form the basis of the food chain. All other ocean living things depend on them.

Zooplankton (eg protists 8, comb jelly 21, jellyfish 23, krill 308) which eat them.

Plankton fossils from 55mya contain more of the oxygen isotope oxygen -18 in their shells indicating warmer water. A neat bit of detective work.

When global warming made our world super-hot: BBC.co.uk
Plankton: whoi.edu/science
Encyclopedia Britannica
The Evolution of Plants: K.J.Willis, J.C. McElwain

UNGULATES 95 - 111

Ungulates have hooves and are herbivores.

In the mid Eocene, temperatures were becoming cooler as continents drifted apart and the ice cap formed at the South Pole. Grasses began spreading, which is when the ungulates got going.

The Mammal Exansion

Heavy grazing crops everything to ground level, so only the grasses survive. By the Miocene huge tracts of dry grassland had appeared which stimulated a great expansion of large grazing animals.

Plants of the World Christenhusz, Fay, Chase

Life on Earth: David Attenborough

CARNIVORES 112 - 120

Meanwhile the Carnivores (meat eating animals) split into two main groups, Canids and Felids (cats and dogs). They underwent a fast expansion, food was plentiful as they preyed on the burgeoning groups of ungulates.