For Ted, Rose and Robyn. Never stop being curious! – C.A.

For all the teachers and tutors who have ever inspired and encouraged me, and for all those who inspire the children of today. – F.F.

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MARVOLUTION

A guide to the EVOLUTIONARY MARVELS *of the future*

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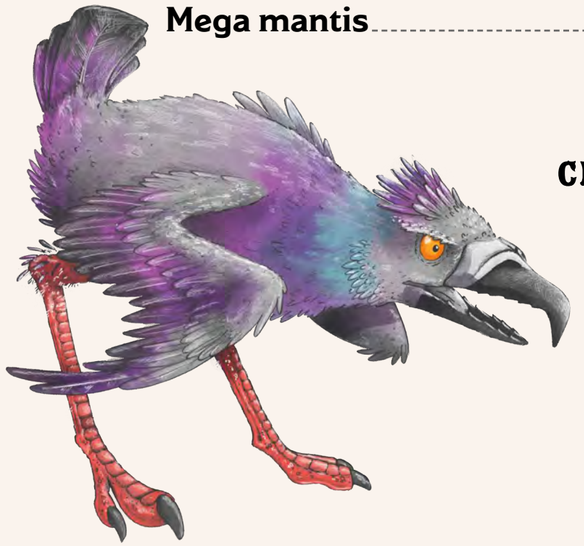
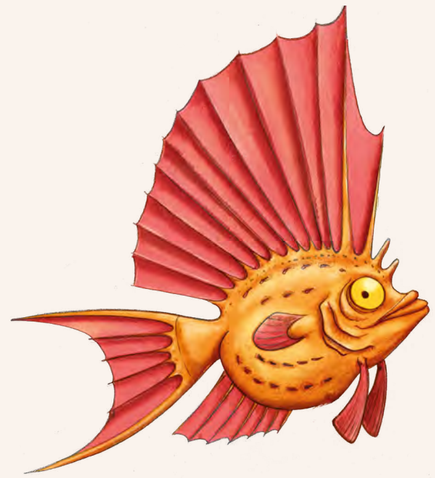




Note on family trees

At the beginning of each chapter, I have included a family tree which shows how the animals of the future came to exist. I hope that this helps you develop a deeper understanding of how these animals came to be and realise that they are not so different from the animals of today, which I refer to in the book as 'modern-day' animals. These incredible creatures are not to be feared or mocked, but rather marvelled at for their incredible evolutionary feats!

Dear Reader,

It is with immense caution that I write this book, for what I have discovered is not something I share lightly. But, as a scientist, it is my duty to report my findings to the world – however strange and unsettling they might be – so that we can all learn more about the wonders that exist within it.

What you are about to read is the result of many years of hard work and planning. I have finally mastered the skills of 'Time Walking' – the art of harnessing the past and future to travel through time. I wasn't sure I would ever make it work, but once I did, what I experienced was further from anything I could ever have imagined.

My first trip to the future was a bizarre experience that threw me into an unknown cavern of confusion, spitting me out millions of years from now. I cautiously opened my eyes and peered at this new land I found myself in. I was surrounded by weird and wonderful creatures I had never seen before. The sounds, the smells ... this place was familiar, yet at the same time, completely new. My mission to travel into the future had worked! But where, and when, was I?

I don't know what caused the extinction of the human race, but humans were nowhere to be found in this strange and fantastic world. However, there was plenty of evidence that they had once been here: decaying buildings, rusted machines and most of all – waste. Rubbish piled high and buried deep underground.

I spent many years exploring this future world, documenting the creatures that call it home. Then, I returned to the modern day to write this book and tell you all about the amazing species I had discovered.

In 1859, Charles Darwin published his revolutionary book, *On the Origin of Species*, which explained how all the different forms of life had come to be, through a process he called 'natural selection'. Natural selection shapes the species that live on the Earth, by favouring the individuals that are best suited to the environment around them. You'll surely have noticed that different individuals of the same species have slightly different characteristics. Some are short, some are tall, some have black fur and some have brown. This variation is fuel for natural selection. In each generation, individuals with characteristics that help them survive and reproduce get to pass those characteristics on to the next generation. And so, slowly, the creatures we see around us change and adapt to their local conditions. This is 'evolution'.

What I discovered in the future was the product of millions of years of evolution by natural selection, acting in conditions different to those that we see today. In the future, the climate is warmer, the oceans are deeper and the deserts are larger. These changes, along with the relics we humans had left behind, shaped the species that survived and populated the world.

It is my hope that, by learning about the amazing animals that I discovered on my life-changing journey to the future, we can better understand the natural world around us and appreciate our own place within it. Perhaps we can even learn to forge a different path forwards, so that our own species and many others can extend their legacy further into the future.

Sincerely,

Beatrice Russel

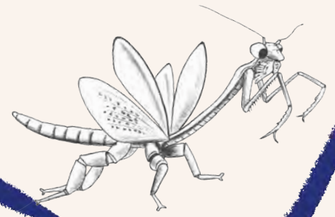
Professor Beatrice Russel
Time Walker

CHAPTER ONE
INVERTEBRATES

Invertebrates are a diverse collection of creatures that are ectothermic (cold-blooded) and have no spine. The group includes insects like bees, which have six legs and a hard outer shell called an exoskeleton; crustaceans like crabs, which have an exoskeleton and many legs; and molluscs such as snails, which have a soft muscular body and a rasping, scraping tongue.

The theory

All living things on Earth are the descendants of an ancient life form that lived many millions of years ago. So, we can think of each species as a branch on the 'tree of life', whose trunk stretches back to the very first life on Earth. It's a bit like a family tree, except instead of individual people, each branch is a whole species. Scientists sometimes draw out these evolutionary trees to make it easier to understand how different species are related to each other.



Asian shore crab

Bee crab

Dungeness crab *(extinct)*

Extinct due to climate change

California spiny lobster *(extinct)*

Southern monarch butterfly

Vampire butterfly

Seven-spot ladybird *(extinct)*

Hairy reef beetle

Large black water beetle

Western honey bee *(extinct)*

Hairy-headed leafcutter ant

Large brown mantis

Mega mantis

Ten legs

Six legs

Moroccan bullia

Cement snail

Leopard slug

Giant cuttlefish *(extinct)*

Hawaiian bobtail squid

Common octopus

Australian golden orb-weaver

Zebra jumping spider

Emperor scorpion

Eight legs

Half of the body is a mirror image of the other

Arms and/or tentacles

Soft, muscular body

Black coral

Giant green anemone

Brain coral *(extinct)*

Purple-striped jellyfish

INVERTEBRATE FAMILY TREE

Evolutionary history

Climate change drove many ocean-dwelling crustaceans to extinction, which left unfilled roles for beetles to move into. Large black water beetles that were washed out of rivers and into the sea during heavy storms began to adapt to life in salt water. Too much salt is very damaging, so hairy reef beetles have glands that pump out salt through gaps in their outer shell.

Large black water beetle

Feathery antennae to detect the scent of females

Specialised glands pump out excess salt

Fine hairs to trap air so they can breathe underwater

Did you know?

Male hairy reef beetles use their antennae to detect the scent of females, so they can find a mate even in the dark!

HAIRY REEF BEETLE

Hydrophilus marinus

Small and brown with feathery tufts on their antennae, hairy reef beetles are the only beetles that live in the ocean. They are covered in fine hairs, which trap bubbles of air around their body, so that they can breathe underwater. Every few hours, they return to the surface to trap more air. Females lay their eggs on delicate black coral fronds, and the eggs later hatch into tiny swimming babies called 'larvae'.

Diet

Hairy reef beetle larvae are small but fierce predators, hunting tiny ocean creatures called 'zooplankton'. But as adults, these beetles prefer a diet of plants and algae. This means they play an important cleaning role in their habitat, by preventing the black coral forest from being overrun with algae. Black corals feed by filtering tiny particles of food from the water, so if their filters get clogged with algae, they might die!

Habitat

These cute, charismatic beetles live in the black coral forests that now carpet tropical coastlines around Australia, Indonesia and the Philippines. This habitat replaced modern-day coral reefs that went extinct in the warmer and more acidic oceans caused by climate change. Black corals have an outer shell made of a material called 'chitin', which doesn't dissolve as easily in acidic water and gives them their dark colour.

BEE CRAB
Hemigrapsus pollinis

Small and sociable, bee crabs are often seen scuttling along the beach, their claws oozing with sticky nectar. That's because they have a special relationship with the shorenut palm tree. When the palm is flowering, bee crabs climb up to feed on the sugary nectar. Their hairy forearms get coated in pollen, which they transfer to the flowers of the next palm they visit, pollinating the plant in the process.

Diet

With their long, slender, spoon-shaped front claws, bee crabs scoop up sugary nectar from the flowers of the shorenut palm to eat. They also forage for nuts, seeds and algae, as well as snails and shrimp on the beach or in rock pools.

Habitat

Bee crabs are found along tropical coastlines throughout Asia and Australia. They are most active at night and spend their days resting in the shorenut palm's branches, which they grip on to using spikes on their back legs. They live in groups of up to ten individuals, helping each other to find food and fend off predators, such as herons.

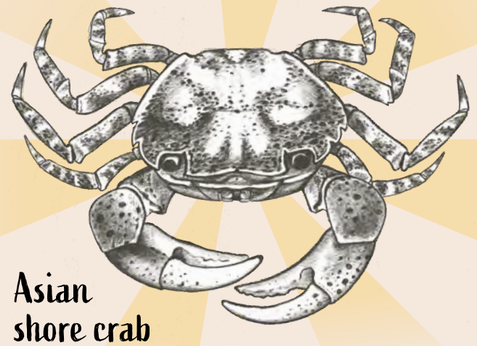
Spikey back legs to hold on to tree branches

Spoon-like claws to scoop up nectar

Hairy arms for transferring pollen

Evolutionary history

As climate change caused the world to grow hotter, palm trees spread across tropical and subtropical coastlines, and new palm species evolved. By then, many pollinating bees had gone extinct, creating an opportunity for the bee crab's ancestor, the Asian shore crab, to take advantage of the shorenut palm's delicious nectar. Over time, the crab's claws became longer and the palms' flowers got larger, helping bee crabs more easily access the nectar and pollen inside.



Asian shore crab

The theory

When two species interact frequently, each one can influence how the other evolves. This is called 'co-evolution', meaning that both species change so that their features match each other – for better or worse! Co-evolution often happens between predators and their prey, between parasites and their hosts and between plants and their pollinators.

Yellow patterned shells provide camouflage against old ruins

Conveyor belt of teeth to chew seaweed and algae

The theory

Creatures that change the environment around them to suit their needs are known as 'ecosystem engineers'. They can inadvertently create new habitats that other creatures can make use of.

CEMENT SNAIL

Dorsanum architectus

These sea snails are surprisingly industrious! Cement snails preserve abandoned buildings by spreading a thick, slimy chemical that's stronger than cement across the bricks. Several hundred snails live in each building, and together they can apply a coat of slime across the entire surface of the walls every few weeks. Their yellow colour helps them blend in with their surroundings, so they often go unnoticed by hungry predators.

Evolutionary history

After humans went extinct, the cement snail's ancestor – a sea snail called the Moroccan bullia – moved into the flooded cities. The underwater buildings provided a perfect habitat for them, but without humans around to maintain the buildings, their walls slowly crumbled. Cement snails evolved to produce slime that was stronger and more water-resistant than their namesake, so that they reinforced the buildings as they crawled over them.

Moroccan bullia

Diet

Like all snails, cement snails have a conveyor belt of tiny teeth called a 'radula' to chew up their food. They feed on marine algae and seaweeds that grow around flooded buildings. Bird poo from seabirds nesting in the roofs provides fertiliser for the new underwater urban forests where cement snails forage.

Habitat

Cement snails live in underwater buildings in the coastal cities of northern Africa that were flooded by sea-level rise. The abandoned buildings provide shelter from storm surges and tsunamis. Like modern-day beavers, the habitat they've created also provides a home for other creatures. Seabirds nest in the roofs of the buildings they preserve, while fish and crabs find shelter amongst the seaweed growing in these old human constructions.

VAMPIRE BUTTERFLY

Danaus vampyrus

These night-flying butterflies might look beautiful, but they have a dark secret – they're blood-sucking vampires! Feeding on blood gives them a protein-rich diet and helps warm them up, so they can stay active at night and catch their prey off-guard. They have surprisingly long lives compared to other butterflies and moths, living for up to five years.

Diet

At night, vampire butterflies seek out sleeping animals, landing silently on them and piercing their skin with tube-shaped mouthparts. They will feed on pretty much any mammal, but their favourite meal is deer's blood, and they enthusiastically seek out their musty smell. The butterflies inject a special chemical that prevents the animal's blood from clotting while they feed. They can drink up to twice their body weight in blood in a single meal!

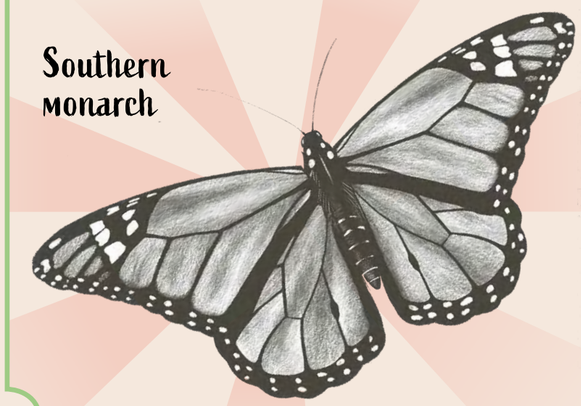
Habitat

Although most common in the former cattle-farming regions of southern Brazil and Argentina – where wild cattle and pigs now roam free – vampire butterflies are found throughout South America. They sleep hanging upside down under leaves, which uses less energy than standing upright. The butterflies lay their eggs on the leaves of milkweed plants, which are their caterpillars' favourite food.

Evolutionary history

Humans used lots of pesticides to kill crop-eating insects on their farms, but this also harmed helpful pollinating insects like bees. As a result, there were fewer flowering plants around to feed on, driving southern monarch butterflies to seek alternative food sources. They evolved into blood-suckers, just like modern-day mosquitoes, adapting their straw-like mouthparts to suck blood instead of nectar.

Southern monarch



Did you know?

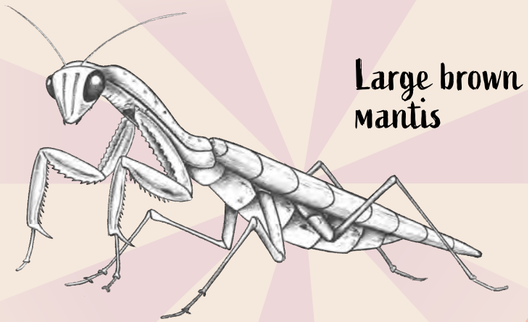
Vampire butterflies have special heat-sensitive vision, meaning that they can locate prey in the dark by sensing their body warmth!

Specialised glands release water to keep them cool

Orange-brown colour provides camouflage

Evolutionary history

Earth's future climate is warmer and there is more oxygen in the atmosphere, which has allowed some insects to become much larger than their ancestors. Climate change also drove several of Australia's predatory birds to extinction, creating an opportunity for the ancestor of the mega mantis, the large brown mantis, to evolve into the role of top predator.



Large brown mantis

The theory

Insects don't have a heart to pump oxygen round their body – instead, they have a network of tiny tubes. The bigger their body, the longer oxygen takes to reach their organs. So, very large insects are more likely to evolve when there is more oxygen in the air.

MEGA MANTIS
Archimantis immensa

One of Earth's fiercest future predators is the giant mega mantis. Their long, slender bodies can grow up to one metre in length – making them many times larger than any insect alive today! Their thick, sturdy back legs help them carry all that extra body weight, while their slender front legs allow them to strike their prey with precision. When startled, mega mantises unfold their colourful wings and take flight.

Diet

Mega mantises hunt birds, lizards, possums and even young kangaroos if they get the chance! Their reddish-orange colouration helps them blend in with their dusty surroundings in the Australian outback, making them nearly invisible to their unsuspecting prey, which they devour whole.

Habitat

Found in the grasslands of northern Australia, mega mantises hunt during the day and rest on tree branches at night. To stay cool in this hot, dry environment, they release water from glands at the base of their wings, which cools them as it evaporates. Females lays their eggs on a tree branch, covering them in a foamy casing to stop them drying out.