WORDS THAT CHANGED THE WORLD

Charles Darwin's

ON THE ORIGIN OF SPECIES



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WHO WAS CHARLES DARWIN?

Charles Darwin is considered to be one of the greatest scientists who ever lived. In 1859, he published his world-famous book, *On the Origin of Species by Means of Natural Selection*, which opened people's eyes to the incredible diversity of life on Earth. Contained within its pages was a detailed account of Darwin's theory of evolution by natural selection, which remains the best evidence-based explanation for how species develop and change over time. The publication of his theory changed our entire understanding of the natural world and was one of the most significant events in scientific history. Darwin's impact on science continues to be celebrated over 150 years later.

"There is grandeur in this view of life... whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."

EARLY LIFE

Darwin's father was a very successful doctor, but his mother passed away while he was still young, leaving him to be raised by his sisters at their home in Shrewsbury, England. Darwin didn't enjoy school, but he was fascinated by nature from a very young age.

In his spare time, he loved nothing more than exploring the outdoors around his home, collecting plants and dead animals, or pouring over books about the natural world.

Though he wasn't a fan of school, Darwin made up for his lack of study in other ways. In a shed in his back garden, he had a makeshift chemistry laboratory, where he carried out scientific experiments with his brother, Erasmus. They dabbled with chemicals and minerals, following popular 'recipes' from books, and Darwin would later look back on those days as a useful first step into the world of scientific experiments.

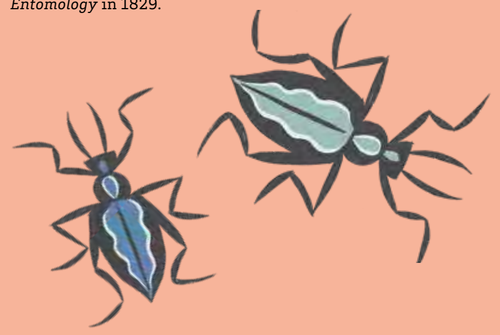
UNIVERSITY LIFE

When Darwin was older, he started studying medicine at the University of Edinburgh, Scotland, following in the footsteps of his father. But medical procedures were carried out without anaesthetic in the 19th century, and when Darwin witnessed a surgery being performed on a young child, he realised he didn't have the stomach for medicine. After just two years, he moved on to study theology at Cambridge University, England, with the aim of becoming a priest – but soon found he lost interest in that, too. Not all hope was lost, though, as Darwin became friends with two professors at the time, geologist Adam Sedgwick and botanist John Henslow, who helped Darwin develop his interest in nature and collecting.

Henslow soon became a mentor of Darwin's, and would eventually play a major role in encouraging him to take the journey of a lifetime around the world...

BEETLING

Darwin's friend and cousin, William Fox, introduced Darwin to the world of 'beetling' while at Cambridge University, and the two spent much of their time out in the countryside collecting beetles instead of going to lectures. Darwin built up an impressive collection of beetles over the years, and was proud to see his name appear in *Illustrations of British Entomology* in 1829.



INTRODUCTIONS TO EVOLUTION

Around the time Darwin was studying medicine, scientists had already begun to play with the idea of 'evolution'. Even his own grandfather had written a medical book called *Zoonomia*, which touched on early ideas of evolution, but it provided very little evidence or method for the process.

While at Edinburgh, Darwin met a lecturer named Robert Grant. He took him to meetings with other students and faculty members, where they discussed scientific methods and papers.

Grant often talked with Darwin about the idea that all living things were related in some way, but nobody could quite pinpoint how they could be. The idea of evolution at the time simply seemed vague and perplexing.

IDEAS OF THE TIME

The revolutionary ideas about evolution and natural selection that Darwin would eventually release into the world went against the belief that humans had a special, God-given place in existence. Yet at a time when most biological ideas seemed absurd to the average person, he somehow managed to completely alter the way we view every living thing around us and even our own place in the world. It could be said that no biologist in history has managed to change the average person's world view more than Charles Darwin...

A COMMON MINDSET

Early in the 19th century, most people of England believed that all life stood unchanged since its moment of creation. They thought each species on Earth had been created by a 'designer', as written in the biblical texts of Genesis, and that humans had the role of protecting all created things.

What's more, the common view of the people was that the planet was only about 6,000 years old at most – which didn't provide much time for anything to progress or change. Even Darwin himself accepted this idea, until the discoveries of his life's work provided him with facts that he could no longer ignore.

POPULAR GEOLOGY

In the first half of the 19th century, the science of geology had captivated public interest. Thousands of books about geology were sold and people enjoyed following the latest stories about discoveries and the new theories that sprung from them. Many of these suggested that Earth had transformed over time and that the land beneath their feet was still shifting and changing day-by-day. A famous Scottish naturalist of the time, James Hutton, had observed how some of the layers of rocks at Siccar Point in Scotland were lying vertically and some were lying horizontally, and suggested that it must mean the rocks had been altered. He recognised how rocks undergo profound changes in their lifetime and was the first to describe Earth as a living system – even touching on the idea that similar changes may take place in the animal kingdom. His work planted a seed of thought in Darwin's head about how plant and animal species may too have changed over millions of years...

EARLY THEORIES

Many scientists proposed their own ideas about evolution in the 18th and 19th centuries, before Darwin came up with his own theory.

ERASMUS DARWIN

In his book *Zoonomia*, published in 1794, Darwin's grandfather suggested that warm-blooded animals may have a common origin and that living creatures have progressed over time, beginning with plants and then animals. Although Darwin read his grandfather's book while at university, he thought it was full of speculation and very few solid facts.

ROBERT EDMOND GRANT AND CHARLES LYELL

In the late 1820s, British scientists Grant and Lyell suggested that all life forms can change into other species and that plants and animals had a common origin. Studying the geological record, they noted how it seemed to show the progression of life forms, but they were unable to explain the way this happened.

JEAN-BAPTISTE LAMARCK

Lamarck was the first to publish a fully-formed theory of evolution in 1809, though we now know it to be incorrect. He suggested that creatures could change during their lifetime and that offspring could then inherit those changes, or characteristics. He also suggested that all life was being continuously created from dead matter – he didn't believe in a common ancestor.

Though each of these scientists, and others, had suggested that evolution of creatures occurred; nobody had pinpointed a mechanism for *how* it actually happened.

This, it seems, was left to Charles Darwin to answer.

VOYAGE OF DISCOVERY

When Darwin was recommended by his university professor to be a naturalist onboard the *HMS Beagle* on its mapping expedition to South America, he jumped at the opportunity. The ship set sail at the very end of 1831 and, under the command of Captain Robert FitzRoy, began a five-year journey around the world. The huge range of plants, animals and habitats Darwin saw during this time would form the basis of his life's work. He was amazed at how living things were so well-suited to their environments and kept detailed notes and specimens to take home with him.

"The voyage of the Beagle has been by far the most important event of my life."

THE ROLE OF A NATURALIST

A naturalist is someone who studies living species and the environments in which they live.

During Darwin's time, Europeans were exploring parts of the world their ancestors had never been to and coming across animals they didn't know existed. A naturalist usually had a scientific background and had to record everything they saw, so that they could inform scientists back home about them. Darwin didn't have any specific jobs to do on the ship, so he was completely free to explore the land when the ship was moored, or when it was mapping shorelines.

THE GALÁPAGOS ISLANDS

Darwin saw many sights on his journey, but he was most inspired by the Galápagos Islands. This group of islands, around 1,000 kilometres off the coast of Ecuador in South America, supported a huge variety of wildlife.

What was interesting was that the animals on the islands seemed to resemble those Darwin had seen on the mainland, but they had certain characteristics that also made them look very different.

As well as this, the differences between each animal seemed to change from island to island. The Governor of the islands told Darwin he could tell exactly which island each giant tortoise came from by looking at the shape and markings on its shell.

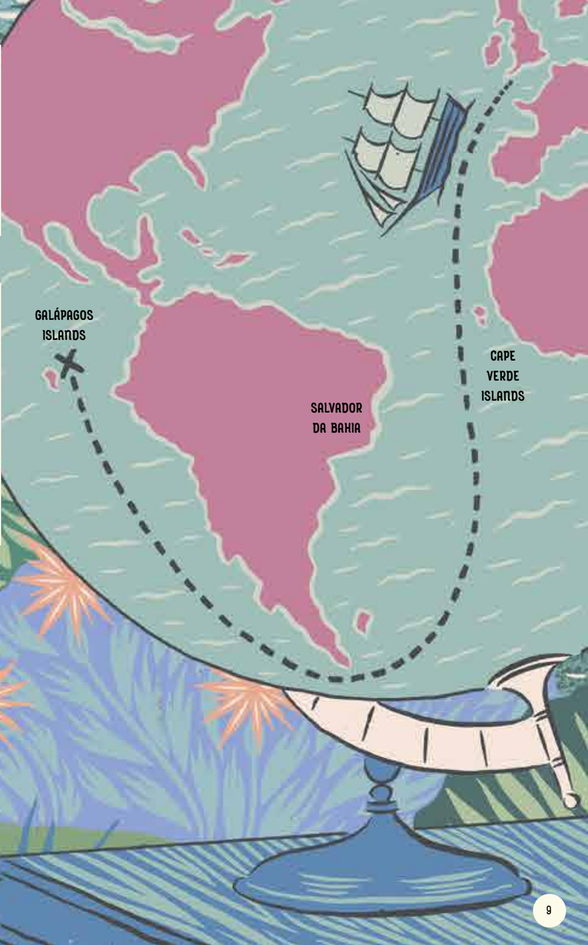
Darwin began to wonder whether animals from mainland South America had somehow reached the Galápagos Islands and then changed as they adapted to life on the islands.

This was just one of Darwin's many observations on the voyage.

STOPPING POINTS

The *HMS Beagle* set sail from Plymouth, England, on the 27th December 1831. It sailed past Madeira and the first stop was the Cape Verde Islands. After making it across the Atlantic Ocean they stopped at Salvador Da Bahia in Brazil and were amazed by the diversity of life in the tropical rainforests.

The next two and a half years were spent hugging the coast of South America before reaching the Galápagos Islands in September 1835. From there, they sailed to Tahiti, New Zealand, Australia, the Cocos Islands, Mauritius, South Africa, Saint Helena and Ascension Island, with a brief stop back in Brazil, before heading on to the Azores... and home to Falmouth, England on the 2nd October 1836. By the end of the voyage, Darwin had sailed 65,000 kilometres, explored over 3,200 kilometres of land and collected more than 5,000 specimens!



Darwin described **EVOLUTION** as 'descent with modification'. This was based on the idea that members of a species share a common ancestor and that a species can change over time, potentially leading to the creation of an entirely new species.

NATURAL SELECTION is the idea that the individuals best adapted to their environment are more likely to survive and produce more offspring. All sorts of variations can exist within a species, but nature 'selects' the most desirable variations to be passed down through generations – the variations that make a parent more likely to survive and reproduce.

An **ADAPTATION** is the way a living creature has adapted to suit an environment.

A **SPECIES** is a group of individuals who share characteristics and are able to breed with one another to produce offspring that can go on to breed again.

VARIATIONS are the differences between living creatures.

DARWIN'S GREAT IDEA

Back home, with his feet on solid ground, Darwin began to write about his travels and discoveries in his notebooks. He shared his ideas with other scientists and the Zoological Society of London, while he continued to observe the natural world around him. As he did, a powerful theory began to take shape in his mind...

DARWIN'S MAIN THEORY

Darwin saw that there were always small differences – or variations – between the individuals of a species of animal, and that these variations could be passed on from parent to child. Some of these variations might be useful traits that make an individual better adapted to survive in their environment – for example, by helping them get food or helping them escape a predator. These animals were more likely to survive for longer and have more offspring, and then pass these useful traits on to that offspring. So, over long periods of time, these useful traits would become more common in a population.

Essentially, nature was 'selecting' those with traits that made them better adapted to their environment to go on to survive and produce more offspring. This was the basis of Darwin's theory of evolution by natural selection.

THOMAS MALTHUS

While coming up with his theory, Darwin was inspired by the work of economist Thomas Malthus. In his research papers, Malthus suggested that food production rates could never keep up with human population rates, so unless population numbers were controlled in some way, there would always be competition between humans for food and other resources.

Darwin reasoned that the natural world worked in a similar way: Just like humans, all living things produce more offspring than can possibly survive and reproduce – so they all face a 'struggle for existence' with one another.

That is, individuals face constant competition for survival.

TROUBLESOME TIMES

Darwin was careful to gather as much evidence as he could before going public with his theory. He knew his ideas went against Christian ideas of Creation at the time and especially the religious beliefs of his wife, Emma.

The idea of humans being a result of evolution and natural selection, and not fate and purpose, was going to be difficult to push.

He was so worried about the backlash against his theory that he often suffered from ill health.

DECIDING TO PUBLISH

In June 1858, after years of deliberating over his theory and gathering evidence to support it, Darwin was encouraged to move forward with publishing his ideas. Another naturalist, Alfred Russel Wallace, had written to Darwin and outlined his own theories about how a new species might come about, and his main points were very similar to Darwin's. To avoid any doubt about whose ideas were whose, the two scientists' theories were presented together at a meeting of the Linnean Society of London on 1 July 1858. This led to the publication of Darwin's book, *On the Origin of Species*, in 1859.

Finally, Darwin's ideas were let loose into the world...

IMPACT OF DARWIN'S IDEAS



The reaction to Darwin's ideas from religious Victorians of the time was largely what he had expected, so Darwin was well-prepared. But the reaction from fellow scientists was more difficult to deal with.

It took decades, but Darwin's argument that species could gradually change over time was eventually widely accepted by the scientific community – especially as other scientists had suggested other theories of evolution at the time. Yet the hardest thing for them to grasp was the idea of natural selection – that individuals could change because nature had 'selected' certain variations to be passed on. It was only later in the 20th century, with the discovery of genes, that the scientific community really took note.

Ever since then, Darwin's work has been considered one of the greatest achievements of humankind.

VARIATION WITHIN A SPECIES

During Darwin's voyage, he noticed a huge amount of variation within groups of animals that seemed to belong to the same species. It's easy to see that a sheep is different to a cow, and that a bird comes from a different family to a snake, but there are also lots of differences among individuals of the same species – just think about all the variation in domestic cats today, such as their eye colour, fur length, size and shape.

BORN WITH VARIETY

Before Darwin's time, people thought that any differences between members of the same species were caused by the environment they lived in. But Darwin noticed that differences – or what he called variations – still appeared even if the environment these individuals were living in had stayed the same over time.

He also realised that when a very rare variation appeared in a parent, and then again in its offspring, it was extremely unlikely to have been caused by the environment – particularly when others in the group were not affected.

Instead, he suggested, we are simply born with variations, and these can be passed on from parent to offspring.

DARWIN'S PIGEONS

Darwin spent many years breeding domestic pigeons to test his theory about variation being passed down from parent to offspring. He took notes about the huge differences that existed between pigeons' beak shapes, neck lengths, wing feathers and tail sizes. He said that, had he come across them randomly in the wild, he would have assumed they were all completely different species!

However, the fact that they still shared many similar features, and that he could breed any individual with any other to produce offspring that were still fertile, told him that they must all be the same species. After all, that is the definition of what a species is.

In fact, Darwin worked out that every single breed of domestic pigeon had descended from a single common ancestor – the rock pigeon.

All the visible differences Darwin was seeing were therefore simply variations within members of the same species.

CONSCIOUS SELECTION

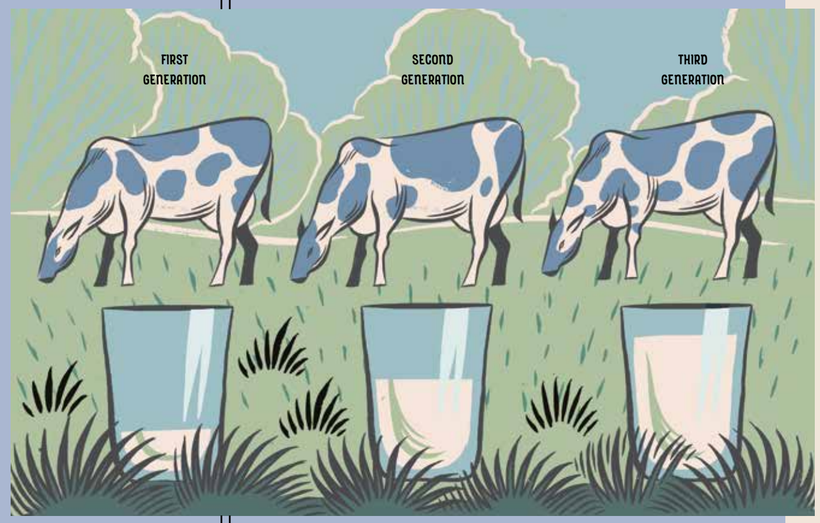
Darwin noticed that whenever a unique variation occurred in one of his pigeons, it could pass it on to its offspring. Over time, as those with the variation continued to breed, the variation would build up and up in the population.

Historically, humans have helped speed up this process when choosing to breed certain animals.

Breeders like Darwin would look out for the smallest variation and then breed those individuals with that variation again and again.

For centuries and centuries humans have owned livestock, like cattle. The owners would have preferred livestock which best matched up to their needs – like cows that produced a lot of milk. So, any time a variation appeared that produced more milk, the owner preferred it, and would try to continue this variation in the following generations by breeding the next generation of stock from this particular animal. Cows are bred over generations to produce more milk.

This idea of 'conscious selection' of variations acted as key inspiration for Darwin's theory of evolution.



SPECIES AND BREEDS

The word 'species' is a basic unit of classification for a living organism. Within a species, there might be multiple breeds with different characteristics. For example, the rock pigeon species groups together more than 800 different breeds. Darwin used the example of the domestic pigeon to explain his idea about variation within a species: there is huge variation in the look of these pigeons, but they are, in fact, all the same species.

This variation, Darwin would come to realise, is crucial for natural selection to be able to get to work.


TURBIT PIGEONS HAVE SMALL, SHORT BEAKS.


JACOBIN PIGEONS HAVE A HOOD OF FEATHERS AT THE BACK OF THEIR NECKS.


FANTAIL PIGEONS HAVE 30-40 TAIL FEATHERS RATHER THAN THE NORMAL 12-14.


FRILLBACK PIGEONS ARE NAMED AFTER THE FRILLY, CURLED FEATHERS ON THEIR BACKS.


ENGLISH POUTER PIGEONS HAVE A LARGE CROP – A POUCH BY THE THROAT THAT IS USED TO STORE FOOD.


ROCK PIGEONS ARE THE ORIGINAL ANCESTORS OF ALL THESE BREEDS.