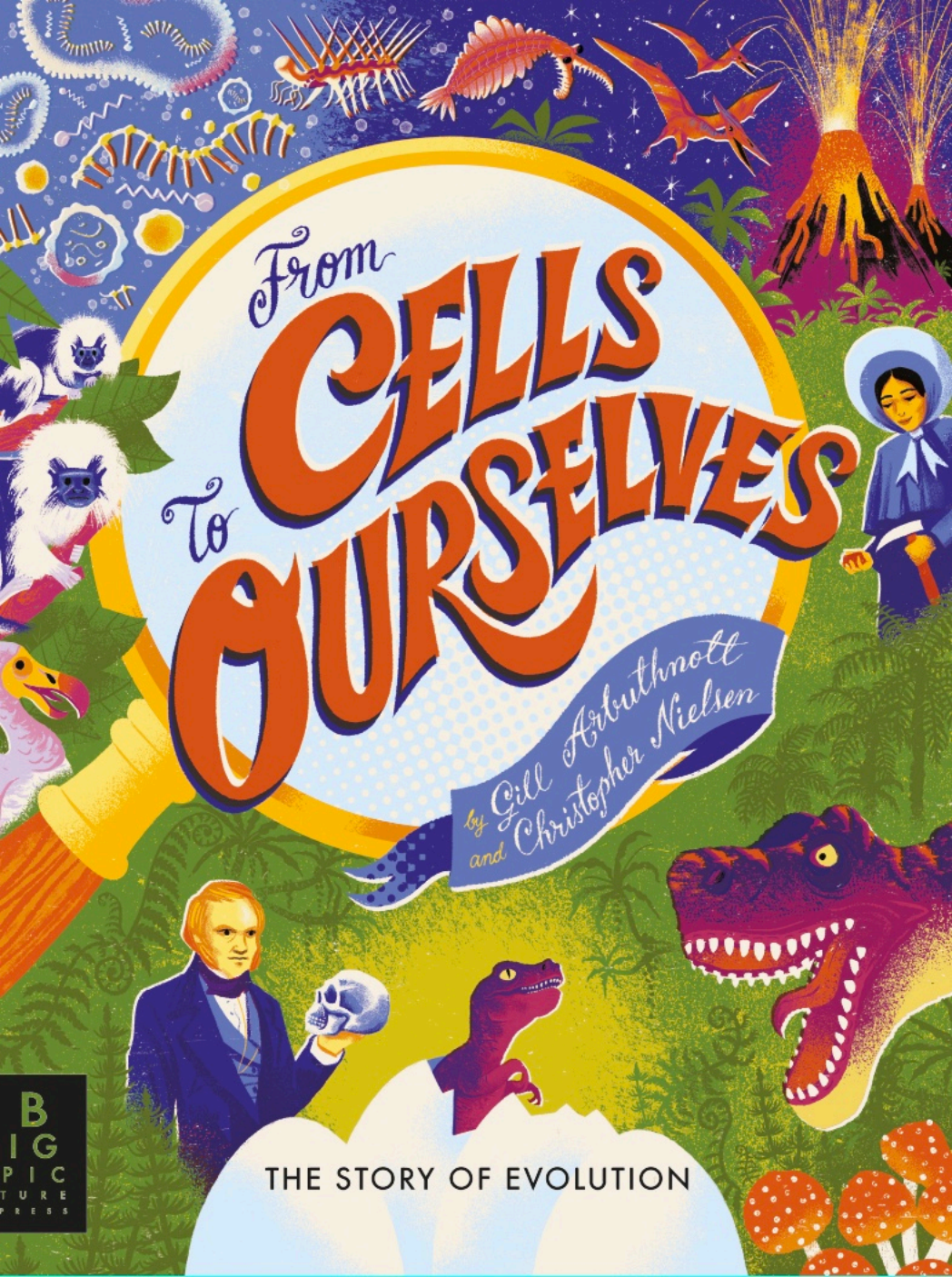
From
CELLS
to
OURSELVES
by Gill Arbuthnott and Christopher Nielsen
THE STORY OF EVOLUTION
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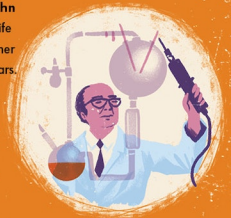
HOW DID LIFE BEGIN?

In the 1920s, biochemist **Alexander Oparin** in the Soviet Union and scientist **John Burdon-Sanderson Haldane** in the UK had similar ideas about the origins of life – that simple chemicals in the hot oceans of early Earth had reacted with each other to produce compounds like amino acids (the building blocks of proteins) and sugars. These compounds, called coacervates, were the ancestors of cells.



However, there was no evidence for this. In 1953, American chemist **Stanley Miller** mixed boiling water, hydrogen, ammonia and methane, all of which were thought to be present 3,800 million years ago, and passed electricity through the mixture, to simulate lightning strikes. After a few days, amino acids had formed. This was hugely exciting: could the origins of life really be that simple?

Well, no. Even the simplest cell is enormously complicated compared to coacervates. We can't say yet how the first cells formed, but many scientists think we will understand how life began in the next few years.

...AND WHERE DID LIFE BEGIN?

The Oparin-Haldane hypothesis suggested something a bit like Darwin's 'warm little pond': an ocean so full of chemicals that it became known as 'primordial soup'.

1980s

Geologist **Mike Russell** found evidence that vents for water at less than 150°C had existed. At these lower temperatures, there was much more chance for chemicals to form and survive. But for Russell's idea to work, the water would need to be alkaline.

The problem with the theories of life developing near deep sea vents is that the molecules can't form in water by simple reactions. Recent work has suggested that shallow, geothermal ponds near volcanoes might be where life began. They have the right temperatures, minerals and UV radiation from sunlight – which research suggests is crucial to lots of the necessary reactions.

1977

A team led by geologist **Jack Corliss** discovered hydrothermal vents on the deep sea floor. These are areas where acidic, chemically rich water up to 400°C wells up into the ocean. They are home to shellfish, worms, crabs and bacteria. Corliss thought similar vents might have existed billions of years ago and be where life began. However, many scientists thought the water was too hot for the necessary chemicals to survive.

2000

Deborah Kelley and her colleagues found the first alkaline vents in what she called 'The Lost City' on the Mid-Atlantic Ridge. The water was much cooler too, only 40–75°C, and huge numbers of microbes lived there.

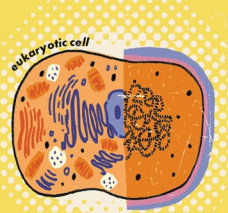
LIFE ON MARS?

A few scientists have suggested that life travelled here from another planet, carried on meteorites or comets. This idea is called 'panspermia'. It was first suggested by the Swedish Nobel Prize-winning chemist **Svants Arrhenius** in the early 20th century. The idea was quickly dismissed on the assumption that nothing living could survive a long journey through space, but bacteria are known to have survived on the outside of the International Space Station for over three years.
Recent exploration of Mars has suggested microbial life could have developed there and NASA is designing equipment to look for signs of DNA, or the closely related molecule RNA, on Mars which would confirm that there was once life there.

But even if evidence of panspermia was found, it doesn't explain how life began, it just moves the question to another planet...

THE FIRST CELLS

The first organisms were simple, single cells called 'prokaryotes'. For about 1.5 billion years, they were the only cell type, but about 2.7 billion years ago a more complex type of cell evolved. These eukaryotic cells are the ancestors of all other living things. Eukaryotic cells contain many specialised organelles – tiny structures surrounded by membranes – which are not found in prokaryotes. It is thought that these organelles were originally independent bacteria, which evolved to live permanently inside large cells.



The first eukaryotes were single-celled organisms, but over 1.7 billion years ago they began to form multicellular organisms. The first ones were probably mats of cells similar to modern algae.

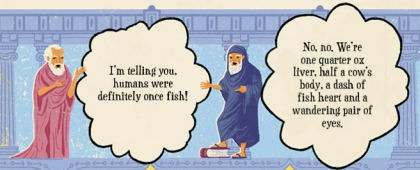
The first recognisable animals were sponges, forming at least 700 million years ago. Next came mysterious organisms called Ediacarans, which lived on the seabed. These were thought to be algae, bacteria or fungi, but researchers now think that some were early animals with guts and the ability to move.

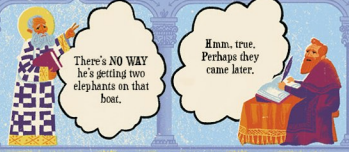
But the big explosion in life forms was just around the corner...

EARLY IDEAS ABOUT EVOLUTION

How long is a million seconds? Have you been alive for one billion seconds? What was happening a million days ago? We find it very difficult to comprehend these huge numbers. If we don't have a feel for how long a million seconds is, how can we possibly comprehend time spans of millions or billions of years? This is one reason why some people have a problem with evolution. The idea that single, primitive cells evolved into all the species that have ever lived seems incredible, unless you get to grips with the timespans involved.

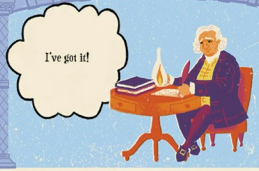
In ancient Greece, philosopher **Anaximander** suggested that one type of animal could change into another, while **Empedocles** thought that new types of living things could be made from a range of parts that already existed.





Theologians **Gregory of Nazianus** and **Augustine** both thought that although God had created all the original animals and plants, new types had developed from them. Their idea was in response to the practical problems that would have arisen from trying to get two of everything into the Ark.

The naturalist **George-Louis Leclerc** proposed a way for the Earth to have formed from debris in space. Although he believed in spontaneous generation, he thought that animals could change as they migrated to different conditions. This let him explain the discovery of elephant fossils in North America, and mammoth fossils in Siberia, although living elephants are today only found in Africa and South Asia. He suggested the American ones had become extinct, while the mammoths had changed as they migrated south.



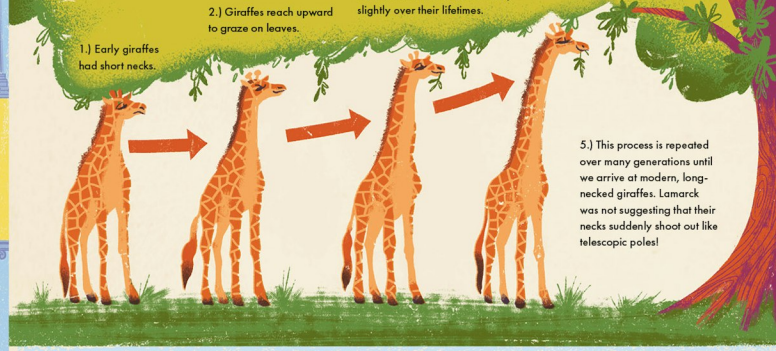
Erasmus Darwin was Charles Darwin's grandfather. He was a doctor, poet and naturalist, and in his book *Zoonomia*, or, '*The Laws of Organic Life*', he was one of the first people to propose a theory of evolution. He never hit on the idea of natural selection, but did recognise the importance of sexual selection (see page 59) and realised it could cause changes in species.

Answers: 1,000,000 seconds = 11 days, 13 hours, 46 minutes and 40 seconds.
You will have your billion (1,000,000) second birthday when you are 31 years, 251 days, 1 hour, 46 minutes and 40 seconds old!
1,000,000 days ago Rome was colonising areas around the Mediterranean about 180 BCE.

GRADUAL CHANGES

In the early 1800s **Jean-Baptiste Lamarck**, inventor of the terms 'invertebrate' and 'biology', was the first person to develop a coherent theory of the development of life on Earth and its evolution. He believed that life had originated by spontaneous generation, rather than creation by a deity, and had then become more complex and varied over many generations. Lamarck suggested how this could happen. His idea is often called the 'Theory of Evolution by Acquired Characteristics'. In simple terms, he thought that the more an animal used an organ during its lifetime, the more well-developed it would become and that these changes could be inherited by offspring if both parents had the same developments.

THE EVOLUTION OF THE GIRAFFE'S NECK, ACCORDING TO LAMARCK:



THE PROCESS ALSO WORKED THE OTHER WAY:

THE DINOSAUR DETECTIVES

In the 19th century, amateur scientists discovered, investigated and named many species of dinosaur. But just who were these dinosaur detectives?

MARY ANNING (1799–1847)

Anning was born into a very poor family in Lyme Regis, England. As a child, she helped her father collect and sell the fossils which were common in the nearby cliffs. He died when she was 11 years old and she continued fossil hunting to help support her family. In 1811, Anning uncovered a near complete skeleton – 5.2m long – of an animal never before seen. After years of study by scientists, it was named *Ichthyosaurus*, or 'fish-lizard'. She sold it for £23 – enough to feed her family for six months. Anning went on to find the first complete *plesiosaur* ('sea dragon') skeleton in 1823 and the first pterosaur ('flying dragon') in 1828.

Most scientists in the UK at that time were wealthy men, and the idea that an uneducated woman – even one who had taught herself geology and anatomy – could be their intellectual equal seemed ridiculous to many of them. As a result, Anning often got no credit in scientific papers discussing fossils she had found, and the importance of her work was undervalued during her lifetime. Only now is she being properly celebrated and has recently had an ichthyosaur named in her honour – *Ichthyosaurus anningae*.

WILLIAM BUCKLAND (1784–1856)

Buckland was a geologist and palaeontologist from the UK. In 1824, he found fossils of an unknown reptile which he named *Megalosaurus*. This was the first scientific description of a dinosaur. He also found fossil remains of hyenas, elephants and rhinoceros in Yorkshire and argued that these animals had once lived there, though most people at the time believed their bodies must have been washed there by the biblical flood. His argument was based on the presence of bones gnawed by hyenas. Buckland obtained a hyena and fed it ox bones to check the tooth marks matched. He even found fossilised hyena dung. This showed environmental conditions changed over time – modern hyenas are only found in hot climates.

RICHARD OWEN (1804–1892)

Owen was a leading Victorian anatomist and palaeontologist. During his training as a surgeon, he studied human anatomy by dissecting the bodies of executed criminals. In London, his skill in dissection led to him being sent any animal that died at London Zoo. Owen became fascinated by fossils and coined the word 'dinosaur' in 1841 to describe creatures whose fossil remains shared a number of features. He became convinced that the natural history collection of the British Museum deserved its own museum and, from the 1850s, he worked towards the establishment of the now world-famous Natural History Museum in London, which opened in 1881.

GIDEON MANTELL (1790–1852)

Mantell was a doctor, geologist and fossil collector. In 1822, he and his wife Mary found a huge tooth from a previously unknown animal. After finding more fossils of the creature, he named it *Iguanodon* in 1825. In 1833, he also found and named *Hylaeosaurus*. Mantell neglected his medical practice to study fossils and was constantly short of money. In 1841, his situation became even worse when he damaged his spine in a carriage accident leaving him partially paralysed and in constant pain.

THE GREAT COPE-MARSH RIVALRY

American palaeontologists Othniel Charles Marsh (1831–1899) and Edward Drinker Cope (1840–1897) began as friends excavating dinosaur fossils, but ended as bitter enemies. They fell out spectacularly when Marsh secretly arranged to buy the fossils found in a quarry that Cope had shown him. Cope was further humiliated when Marsh pointed out that he had reconstructed the skeleton of an *Elasmosaurus* with the head attached to the tail, instead of the neck! The two men spent the rest of their careers trying to outdo each other, rushing to name as many new dinosaurs as possible, sometimes identifying fossils as new species when they belonged to one that had already been discovered and named.

THE END OF THE DINOSAUR AGE

For a long time, theories abounded about the demise of the dinosaurs – apart from their only surviving group, birds. Some scientists argued that they were too big and unintelligent to survive, while others claimed their eggshells were too thin and broke before the embryos could fully develop. It wasn't until the 1980s that the so-called 'asteroid theory' became popular, and today this is what most scientists believe caused the catastrophic end for non-bird dinosaurs.