

PART ONE

SETTING THE SCENE

How did we get to where we are now? The backstory to the tale of humanity is a long one. There would be no human history without a physical place for it to unfold. So to truly understand ourselves, we have to understand how the universe came into being, how the stars and planets formed, and why our planet has the right conditions for life to have appeared. And we also need to understand how living things work, and how they evolved, and how we have ended up - with us.

13.8 billion years ago The Big Bang brings the universe into existence.

4.6 billion years ago Formation of our solar system.

4 billion years ago Possible appearance in the oceans of self-replicating molecules, such as DNA.

3.7 billion years ago Earliest indirect evidence of life on earth, presumed to be bacteria-like organisms feeding on organic molecules.

2.4 billion years ago So much oxygen has accumulated from photosynthesis in the earth's atmosphere that there is a mass extinction of those many microorganisms for whom oxygen is toxic.

600 million years ago The emergence of the first multicellular organisms.

542–488 million years ago Cambrian period. Evolution of external skeletons leads to a great diversity of animal body plans.

488–444 million years ago Ordovician period. Great diversification of trilobites, lamp shells, gastropods and graptolites. Emergence of sea urchins, starfish and ammonites. The end of the period sees the first evidence of land plants, and a mass extinction of many species.

444–416 million years ago Silurian period. The first invertebrates, scorpions and wingless insects appear on land.

416–359 million years ago Devonian period. Emergence of primitive amphibians, the first four-legged animals, which begin to colonize land.

359–299 million years ago Carboniferous period. Emergence of first flying insects and first reptiles. Great proliferation of land plants, including conifers, which over time form extensive coal deposits.

299–251 million years ago Permian period. Diversification of reptiles. Period ends with mass extinction of many groups of marine animals, including trilobites. Many terrestrial groups also wiped out, making way for the dinosaurs.

251–200 million years ago Triassic period. Emergence of the dinosaurs on land. The first small mammals also appeared.

200–145 million years ago Jurassic period. Great diversification of the dinosaurs, turtles and crocodiles. Tropical forests and the first bird fossil (Archaeopteryx) appear towards the end of the period.

145–66 million years ago Cretaceous period. Flowering plants emerge and begin to dominate on land, with grasses appearing towards the end of the period, which also witnesses the sudden mass extinction of the dinosaurs. Birds and mammals survive.

66–56 million years ago Palaeocene epoch. Many new groups of mammals appear, including the first primates.

56–34 million years ago Eocene epoch. Spread of mammals, including elephants, whales, rodents, carnivores and hoofed mammals.

34–23 million years ago Oligocene epoch. Spread of grasslands, and first appearance of monkeys.

23–5.3 million years ago Miocene epoch. Spread of horses, first appearance of apes. Many animals, such as frogs, snakes and rats, are very similar to those of today.

7 million years ago Split between our ancestors and the ancestors of chimps and bonobos.

6 million years ago Early humans begin to walk some of the time on their hind legs.

5.3–2.6 million years ago Pliocene epoch. Origin of mammoths. Walking on two feet becomes the norm for early humans.

2.6 million years ago Earliest evidence of human tool use.

2.6 million–11,700 years ago Pleistocene epoch. Period of ice ages and warmer interglacial periods.

2.4 million years ago Appearance of *Homo habilis*.

1.9 million–143,000 years ago Dominance of *Homo erectus*.

200,000 years ago Emergence of *Homo sapiens* (modern humans) in Africa, where they remain for another 100,000 or more years.

11,700 years ago–present Holocene epoch. After the end of the last Ice Age, many large land animals such as mammoths become extinct. Humans come to dominate the planet.

IN THE BEGINNING

Before the advent of modern science, there were a range of beliefs about the age of the earth, and of the universe. Christians believed that God created both a mere 6,000 years ago. Ancient Hindu texts, in contrast, talk of an infinite cycle of creation and destruction, each lasting over 300 trillion years.

Towards the end of the eighteenth century, geologists began to realize that the earth was much more ancient than had previously been thought – perhaps millions if not billions of years old. However, into the twentieth century the scientific consensus was that the universe itself was eternal, and in a ‘steady state’. Although stars might be born and die, the dimensions of the universe were fixed and unchanging.

A chink in this theory came in the 1920s when the American astronomer Edwin Hubble studied observations made some years earlier. It was known that the light from stars moving away from the earth have their light moved towards the red end of the spectrum (a phenomenon called red shift), in a similar way that the pitch of the sound from a vehicle changes as it moves past us (the Döppler effect). Hubble studied the red shifts of various galaxies, and realized that the further away a galaxy is from us, the faster it is receding. The conclusion was that the universe is expanding, and that this expansion started in a single great explosion. This explosion that gave birth to the universe became known as the 'Big Bang'.

For some decades there were arguments between the proponents of the steady state and the big bang. Then in 1964 two radio astronomers working in New Jersey, Arno Penzias and Robert Wilson, noticed that their sensitive microwave receiver was suffering from constant interference, the same in all directions, with a wavelength representing a temperature of 2.7 degrees above absolute zero. At first they thought it might be because of the proximity of New York City. Then they thought it might be caused by pigeons defecating on their instrument. But even after a thorough cleaning, the interference persisted. Eventually they realized that what their receiver was picking up was an echo of the Big Bang. If you retune your radio, part of the 'white noise' you hear between stations is this very same echo – an echo from the beginning of time.

Cosmologists have now come up with a timetable for the Big Bang, which they believe took place about 13.8 billion years ago.

Why does the universe go to all the bother of existing?

Stephen Hawking, *A Brief History of Time* (1988)

In the beginning there was a single point, a singularity, whose density and temperature were infinite. Once expansion started, it occurred with unimaginable rapidity. Between 10^{-36} and 10^{-32} seconds, the volume of the universe expanded by a factor of at least 10^{78} . At this stage the only matter was elementary particles such as quarks and gluons. At about 10^{-6} seconds, as expansion slowed down and temperatures fell, quarks and gluons came together to form protons and neutrons.

A few minutes later the temperature had cooled further, to about 1 billion degrees, and protons and neutrons combined to form the nuclei of deuterium and helium, though most protons remained unattached as hydrogen nuclei. After 379,000 years, the positively charged nuclei had attracted negatively charged electrons to create the first atoms. This was the beginning of matter as we know it. These simple atoms were to become the building blocks of the stars.