1

Ancient cosmologies

The day of Brahma

The following ideas are found in ancient Indian mythological work, like the *Bhagavatam*:

The day or night of Brahma the Creator of the Universe is equivalent to 4 320 000 000 human years. This period is characteristic of the lifetime of one cycle of the universe, which is alternatively created and destroyed. Brahma plays the role of creator and Shiva the role of destroyer. In between Vishnu plays the role of preserver, who maintains the functions of the universe in each cycle.

This time scale is built out progressively in terms of cycles of *yugas*, which are very long periods. There are four yugas, with progressively diminishing states of the rule of the law or the truth: the *Satyayuga* having four out of four parts of truth, followed by the *Tretayuga*, having three parts truth and one part untruth, then *Dwaparayuga* with two parts of truth and two parts untruth, the last being *Kaliyuga* containing only one part truth against three parts untruth. Currently, according to these beliefs, the universe is passing through the Kaliyuga.

We will not go into details of how these time scales were arrived at but would like to emphasize that *they exist* in old literature, suggesting that the thinkers and philosophers of the day did think of time scales far in excess of the normal human lifespan. Moreover, they also had ideas on how these time scales were perceived to flow at different rates by different observers, as the following anecdote from the *Bhagavatam* shows.

A king called Kukudmi had a beautiful daughter Revati who had attracted several suitors for her hand. Anxious to choose the right Prince Charming, Kukudmi decided to take advice from no less an authority than Brahma himself. So he called on Brahma with his daughter. Brahma happened to be

busy when Kukudmi arrived at his abode and so asked the visitors to wait a while. Shortly, after he finished his chores, Brahma called in his visitors and asked for the reason of their visit. When Kukudmi explained his mission, Brahma laughed and said: 'While you waited here a few minutes, several thousand years have elapsed on the Earth and the young men you had in mind for your daughter, exist no more. So let me suggest another name, of a prince who will be around when you get back to your kingdom.' So saying, Brahma suggested the name of Balarama.

This anecdote tells us that the *flow of time* was at a much slower rate at Brahma's location compared to that on the Earth.

The ancient ideas of space in these mythologies also make interesting reading. The Sanskrit word for the universe is *Brahmanda*, the *egg of Brahma*. This cosmic egg is supposed to include *all of the universe*, observed or otherwise. The stars and planets in the sky, the animate, vegetable and mineral world on the Earth and the unseen but imagined part *underground* were all supposed to be included in this cosmic egg.

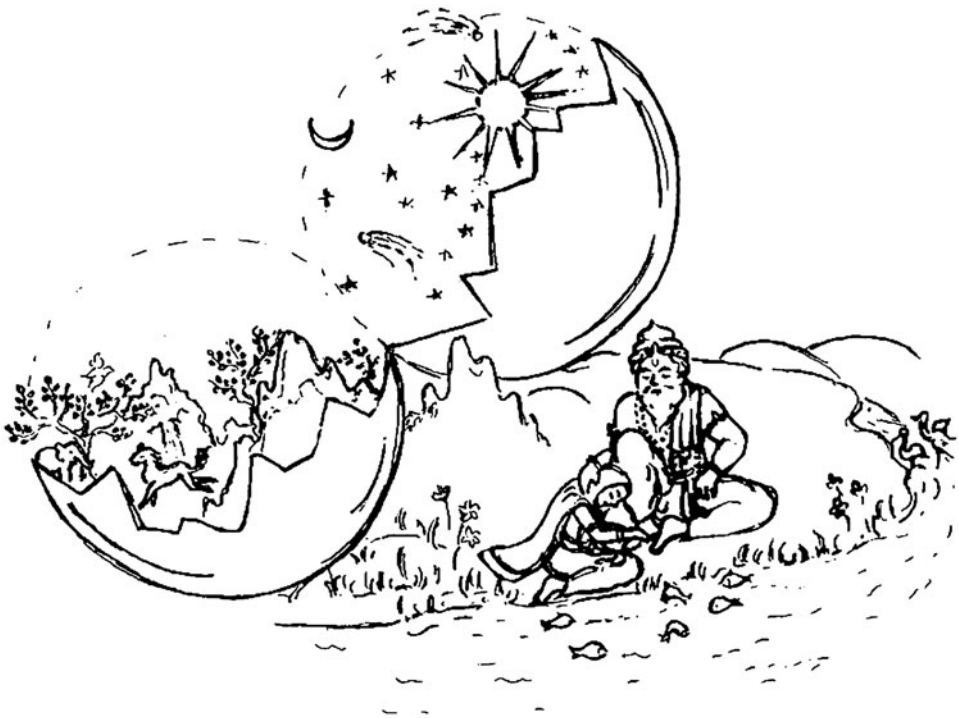

Fig. 1.1. An artist's impression of the concept of the universe as conceived in Indian mythology. The entire creation is supposed to come out of a 'cosmic egg' or the 'Brahmanda'.

The Earth itself was believed to rest in a hierarchical structure on the heads of four elephants (in the four directions), which in turn rested on the back of a giant turtle, which rested on the head of a divine cobra.

As mentioned above, this large-scale structure was subject to periodic destruction and recreation. The cyclic idea also enters in the concept of *reincarnation* of living beings. The soul is indestructible, but the body is not. After death, the soul seeks another body to get into. In case you are worried how this reconciles with the increasing world population, the answer is that the bodies that the soul gets into need not be all human: the soul may enter into *any* being on the Earth . . . an insect or a bird or a fish or an animal. So, if one wants to check this hypothesis, one must keep track of the total number of living beings on the Earth!

Ra in ancient Egypt

The mythologies of ancient Egypt were different and equally colourful. Take the case of the Sun God Ra, who was supposed to travel through the sky in

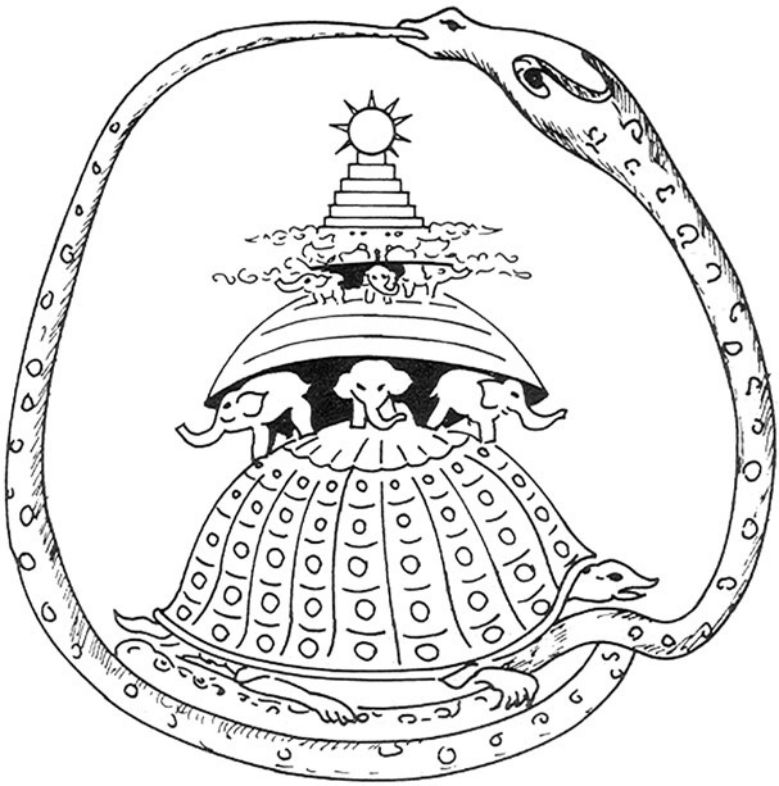

Fig. 1.2. Another concept from ancient Hindu mythology depicting the Earth as part of a cosmic hierarchy.

a boat called *Manjet*, or a *barque of a million years*. Many gods were supposed to join him on this journey. The Manjet-boat sailed through twelve provinces, representing twelve hours of daylight. At the end of the day Ra died and became a corpse and sailed in another boat called the *Mesektet-boat*, meaning a *night-barque* that sailed for twelve hours on water and appeared in the east in the morning with a rejuvenated Ra.

One sees this idea described pictorially in ancient relics such as those in the National Museum in Cairo. The Sun God is shown with a head like that of a hawk with the solar disc on top, encircled by a cobra. Legends do not always

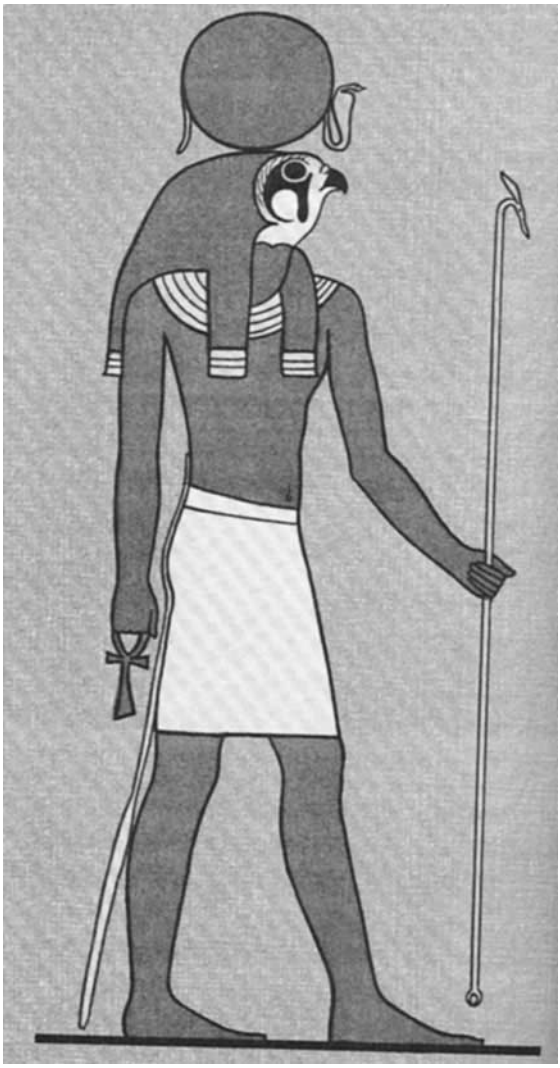

Fig. 1.3. Sun God Ra as given in ancient Egyptian findings.

depict a smooth sailing for Ra, in particular he has to frequently fight an enemy called *Apep*, in the form of a serpent. The god usually wins, except during solar eclipses when Apep swallows him.

Ra was believed to be the creator of light and other things found on Earth. He was supposed to have created the humankind from his tears and also the first couple, Shu and Tefnut, who were parents of the Earth and the sky. The solar disc itself was referred to as *Aten*, and Ra was supposed to reside in it.

The Norse world tree

In the Nordic civilization of northern Europe, the basic concept is of a world tree which carries the entire universe on its roots and branches. There are three levels in which nine 'worlds' reside.
At the upper level there are:

- Asgard (Æsir, the land of the gods)
- Alfheim (elves)
- Vanaheim (Vanir)

At the middle level we have:

- Midgard (men)
- Jotunheim (giants)
- Svartalfaheim (dark-elves)
- Nithavellir (dwarfs)

Finally the lower level houses:

- Muspelheim (fire, a bright, flaming, hot world in the southern region)
- Niflheim (the dead, the lowest level)

But the nine worlds and the world tree, Ygdrasil, were not there in the beginning. There are elaborate accounts of how they were created.

The Chinese mythology

The Chinese literature of the past is very rich and diverse. Here is a version of how it all began. First there was chaos everywhere and darkness. Then out of that emerged the cosmic egg (recall the Hindu notion of *Brahmanda*!). The egg harboured a sleeping giant of the name *Pangu* who was nurtured inside the egg for billions of years. When he grew and woke up, he stretched his body and came out breaking the egg. The lighter parts of the egg floated up to the sky

Fig. 1.4. The Norse 'world tree' was another hierarchical concept of the universe, as described in the text.

(Yang) while the heavier parts sank to become the Earth (Yin). The Yin–Yang duality comes in many aspects of Chinese thought.

Pangu liked this development, but he was afraid that some day the sky might fall on the Earth and so to prop it up, he grew and grew so that his feet were on the Earth and his head touched the sky. He grew at the rate of some 3 metres per day for 18 000 years and eventually increased the distance of the sky from the Earth to some 50 000 kilometres. Then he felt that they were reasonably stable and being very tired with his chore, he slept and never woke up.

When Pangu went into eternal sleep, his body was used to make the various parts of the universe. His eyes became the Sun and the Moon, his voice provided thunder and lightning, his breath led to the wind, his torso became the mountain while his arms and legs became the four directions. His flesh became soil, his blood the rivers while his veins became the roads. And so on and so forth, with the parasites on his body becoming the human beings of various races. Although he is no more, Pangu is still believed to control the weather according to his moods.

This story is ascribed to the Taoist writer Ko Hung who belonged to the fourth century AD, although its origin may be in South East Asia. It suggests the concept that the universe existed before man appeared in it.

From mythology to facts

Is there really a cosmic egg or a world tree housing the whole universe? Is there a Sun God as the Egyptians believed? What is Pangu up to now? These are mythologies that represent man's desire to 'know the final answer' about his origins, about the origins of what he observes and the extent of the universe around him. If he did not know for sure, he invented scenarios in which everything he saw fitted well, *given his ideas at the time*.

Do these ideas, graphic and detailed though they are, describe facts about the universe? The observations today will tell us that none of these ancient concepts make any sense. They are speculations not backed by facts. Yet they represent the most basic human aspiration to know the answer during one's lifetime.

This aspiration remains strong even today. . .despite the scientific requirement that all that we speculate about must have some basis in fact. Time and again we hear statements about science reaching the end of its goals, about the so-called end of physics, when everything fundamental is understood and details only need to be sorted out. Certainly, with the help of science we have begun to understand many of the details about the universe that baffled our

ancestors. As Albert Einstein put it so graphically: 'The most incomprehensible thing about the universe is that it is comprehensible.' We know *what* makes the Sun shine. We know *how* the planets move around the Sun. We are able to figure out the interior of the atom, the smallest piece that makes up the various chemical elements. But how well do we know the universe as a whole?

In this book we follow up man's quest to find the answer to this question. Rather than present the modern picture in a cut and dried form, we shall try to present the developments and convictions that led to it. The progress towards understanding reality has not always been straightforward. But it is instructive to look with hindsight. We follow this historical path, although the main stress of our story will be on the more recent developments dating back a hundred years or more. Our bottom line is that although we know a lot about the universe, there is much more that we do not know.

2

The Greek epicycles

The central fire

School children have encountered the name of Pythagoras in their geometry books. His theorem about the square of the hypotenuse of a right-angled triangle being equal to the sum of the squares of its two perpendicular sides is a formidable one and plays a key role in Euclid's geometry, especially where measurements of distances are involved. Pythagoras was from Samos in Greece but left there for political reasons and settled in Kroton in Italy. He had to leave Kroton too because of opposition to his views and eventually died in Metapontum. He was a great thinker, a mystic and a religious reformer.

The followers of Pythagoras are known as Pythagoreans and amongst these was Philolaos who hailed from Thebes. The concept of the Sun–Earth system put forward by the Pythagoreans under Philolaos was, if anything, bizarre. Yet it gained acceptance in those times. What did it propose?

It stated that the Earth goes around a *central fire*, and not around the Sun! The Sun lay, according to this belief, outside the Earth's orbit. Why don't we see the central fire, some sceptics asked. The believers got around this difficulty by inventing a *counter-Earth* that also goes around the central fire but in an inner orbit in just such a way that it blocks the view of the central fire from the Earth! This argument silenced the critics, but only just. For they came up with another question: 'Why don't we see the counter-Earth?' To this the believers replied that Greece is on the other side facing away from the counter-Earth.

But eventually some sceptics sailed around to view from the other side and could not find the counter-Earth. So the hypothesis eventually died a natural death.

In this book we will have occasion to return to the hypothesis of the counter-Earth, for it very well illustrates what happens to a hypothesis that is not based on facts but is propped up by speculations. A wrong hypothesis

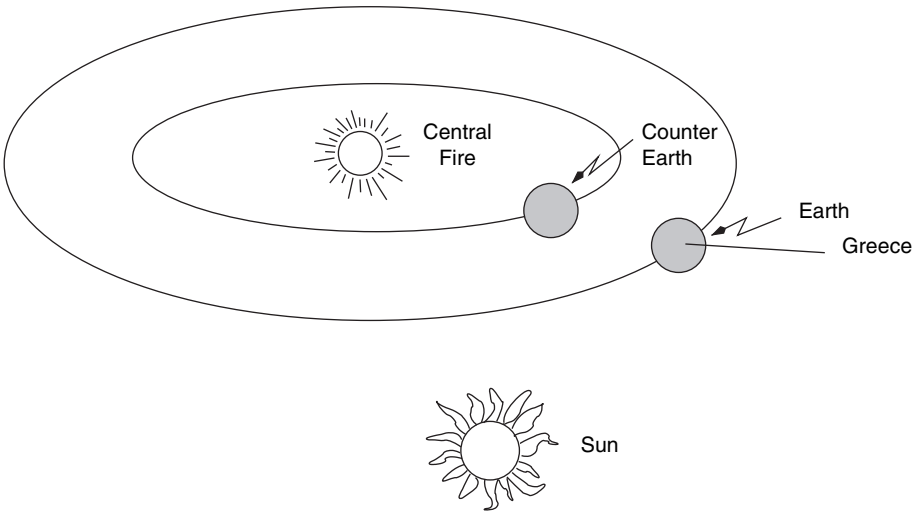

Fig. 2.1. The Pythagorean picture of the Earth and the Sun. The Earth moved around a central fire, whose view was blocked by a 'counter-Earth' that also moved around the fire. The counter-Earth could not be seen because Greece was on the other side.

inevitably encounters some factual evidence going against it. But, rather than abandon the hypothesis, a strong believer is tempted to invent an additional hypothesis to help cope with the discordant fact. This process does not end here. Often as more and more factual evidence accumulates, the supporters of the wrong hypothesis add on to it additional unproven assumptions to sustain it against the discordant facts. In most cases the entire structure becomes top-heavy and eventually collapses.

By contrast we will also come across hypotheses that are on the right track; in such cases additional evidence *supports* the hypothesis, which thus gains more credibility. Science advances through a trial and error process in which right as well as wrong hypotheses play their roles.

Let us examine another hypothesis about the cosmos that survived for nearly two millennia, until it could no longer continue under the burden of facts.

Epicycles and the geocentric theory

In contrast to the ideas described in the last chapter, the Pythagorean concept of the central fire and the counter-Earth marked progress towards the scientific approach in one respect. *The Pythagoreans proposed a hypothesis that could be tested.* The concepts of Brahmanda or the world tree did not have this property...they were entirely speculative. A scientific hypothesis must be