1.1 The Birth of Modern Science

The beginnings of modern science are rooted in a period of great conceptual development, which took place in Western Europe from 1500 to 1750. There were earlier origins, going back to the Greeks; Aristotle developed detailed theories of physics and biology, while Galen contributed to medicine and physiology, and Ptolemy to astronomy. They are coherent theories, based on a robust rationality that only began to slowly crumble when confronted with new facts arising from observation and experimentation. The initial development of modern science was a relatively peaceful process, if we ignore some extreme episodes of opposition offered by the Church, such as the burning of Giordano Bruno at the stake, or the persecution of Galileo. The process was led by a small intellectual minority, and passed largely unnoticed by the vast majority of the population. It was a highly discreet movement in the context of contemporary religious uprisings and the wars of reformation. Despite this contrast, science ended up deeply affecting the mentalities of future generations; even today, certain ways of thinking pioneered by science in the 16th to the 18th centuries still constitute a template for current scientific practice.

Perhaps the greatest legacy we have inherited, and which is now deeply rooted, is an eagerness to seek out relationships between bare and irrefutable facts and general abstract principles. We stress the importance of observation, experimentation, and a detailed analysis of natural phenomena, allied with the search for abstract generalisations that connect them.

In the origins of modern science, there is a new interest in observing phenomena and objects in themselves, stripped of their meaning and utility. It was necessary to develop a capacity to form the idea of an object just as it is, purely physical and devoid of all sensorial qualities. It was necessary to be able, through abstraction, to uncloak objects of their distinct qualities, rough or smooth, coloured or uncoloured, useful or useless, friend or foe. It was necessary to rethink nature in a geometrical form and reduce it to its physical properties. The physics of Aristotle is based on a doctrine characterised by ends, purposes, and meanings. This way of thinking
together with the anthropomorphic concepts of nature fail to make sense in modern science. The behaviour of nature, ruled by universal laws and expressed by means of mathematical formulae, is inexorable and completely indifferent to man, to how he feels, and to his worries and anxieties.

This new vision had deep cultural consequences. The human experience became separated from the workings of nature, and this helped to open a conceptual path for the conquest and domination of nature. Only in the 19th and 20th centuries did we start to grasp the meaning of this domination, and to realise that in the end we are conditioned by deep ties of dependence on nature which we need to understand and preserve, rather than break.

The other essential characteristic of modern science is an instinctive conviction about the existence of an intelligible order in nature spanning all levels, from the smallest particle to the immensity of the cosmos. The initial belief in that order was not an attitude that resulted exclusively from an exercise in logic. It sprang from an intuition and a belief that proceeded to feed upon the successes of scientific endeavour, and particularly upon its predictive capacity. It could not be justified by inductive reasoning alone. It had its origin in the perception and understanding of nature’s behaviour, revealed by observation and experimentation. The leading actors of the modern science movement from the 16th to the 18th centuries dared to believe in an intelligible nature capable of description through laws expressed in the abstract language of mathematics. For Alfred North Whitehead (Whitehead, 1953) this conviction resulted, in a subconscious way, from the insistence on the rationality of God, which was present in medieval European theology over many centuries. In other regions of the world, God was too impersonal, arbitrary, or despot to imbue the way of thinking with a belief in logic.

### 1.2 Philosophy and Science

While for the Greeks science was a branch of philosophy, modern science moved slowly away from it, and became clearly separated in the 19th century. The relationship between them during this process was nevertheless very creative. In the 17th century, philosophical thought found, exposed, and explored various difficulties in the foundations and methodology of science. The philosopher David Hume (1711–1776) considers in his *An Inquiry Concerning Human Understanding* (1784) that each effect is an event distinct from its cause, and as such cannot be found in the cause. In other words, he denies the possibility of knowing causal relationships and considers that there are only connections between events, with no logical guarantee that they are not entirely arbitrary. In this form of empiricism, any rational foundation for prediction and determinism becomes impossible. According to Hume, the use of inductive inference, which plays a central role in the methodology of science, cannot be logically justified. In induction, we use propositions about objects or events that we observe and examine in order to reach conclusions about objects or events that we do not see and examine. Hume considers that this