

1. What is science and what is the scientific endeavor?

- 1.1 The underlying assumption of science is that the universe has an independent, external reality accessible to human senses and amenable to human reason.
- 1.2 Pure science aims to come to a common understanding of this external universe; applied science and engineering develop technologies that result in new processes and products. However, the boundaries between these fields are fuzzy.
- 1.3 Scientists use a wide variety of methodologies which, taken together, make up the process of science. There is no single “scientific method.” Scientists have used, and do use, different methods at different times to build up their knowledge and ideas but they have a common understanding about what makes them all scientifically valid.
- 1.4 This is an exciting and challenging adventure involving much creativity and imagination as well as exacting and detailed thinking and application. Scientists also have to be ready for unplanned, surprising, accidental discoveries. The history of science shows this is a very common occurrence.
- 1.5 Many scientific discoveries have involved flashes of intuition and many have come from speculation or simple curiosity about particular phenomena.
- 1.6 Scientists have a common terminology and a common reasoning process, which involves using deductive and inductive logic through analogies and generalizations. They share mathematics, the language of science, as a powerful tool. Indeed, some scientific explanations only exist in mathematical form.
- 1.7 Scientists must adopt a skeptical attitude to claims. This does not mean that they disbelieve everything, but rather that they suspend judgment until they have a good reason to believe a claim to be true or false. Such reasons are based on evidence and argument.
- 1.8 The importance of evidence is a fundamental common understanding. Evidence can be obtained by observation or experiment. It can be gathered by human senses, primarily sight, but much modern science is carried out using instrumentation and sensors that can gather information remotely and automatically in areas that are too small, or too far away, or otherwise beyond human sense perception. Improved instrumentation and new technology have often been the drivers for new discoveries. Observations followed by analysis and deduction led to the Big Bang theory of the origin of the universe and to the theory of evolution by natural selection. In these cases, no controlled experiments were possible. Disciplines such as geology and astronomy rely strongly on collecting data in the field, but all disciplines use observation to collect evidence to some extent. Experimentation in a controlled environment, generally in laboratories, is the other way of obtaining evidence in the form of data, and there are many conventions and understandings as to how this is to be achieved.

- 1.9 This evidence is used to develop theories, generalize from data to form laws and propose hypotheses. These theories and hypotheses are used to make predictions that can be tested. In this way theories can be supported or opposed and can be modified or replaced by new theories.
- 1.10 Models, some simple, some very complex, based on theoretical understanding, are developed to explain processes that may not be observable. Computer-based mathematical models are used to make testable predictions, which can be especially useful when experimentation is not possible. Models tested against experiments or data from observations may prove inadequate, in which case they may be modified or replaced by new models.
- 1.11 The outcomes of experiments, the insights provided by modelling and observations of the natural world may be used as further evidence for a claim.
- 1.12 The growth in computing power has made modelling much more powerful. Models, usually mathematical, are now used to derive new understandings when no experiments are possible (and sometimes when they are). This dynamic modelling of complex situations involving large amounts of data, a large number of variables and complex and lengthy calculations is only possible as a result of increased computing power. Modelling of the Earth's climate, for example, is used to predict or make a range of projections of future climatic conditions. A range of different models have been developed in this field and results from different models have been compared to see which models are most accurate. Models can sometimes be tested by using data from the past and used to see if they can predict the present situation. If a model passes this test, we gain confidence in its accuracy.
- 1.13 Both the ideas and the processes of science can only occur in a human context. Science is carried out by a community of people from a wide variety of backgrounds and traditions, and this has clearly influenced the way science has proceeded at different times. It is important to understand, however, that to do science is to be involved in a community of inquiry with certain common principles, methodologies, understandings and processes.