Chapter 9
The Benefits and Limits of the Scientific Method:
2,000 Years of Human Endeavor

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ABSTRACT

The underlying, and at first sight rather outrageous, hypothesis of science, is that there is order beneath the surface complexity of everyday life. In other words, there is an underlying simplicity which explains this complexity. Gaining even partial knowledge of this underlying simplicity has allowed us to produce all of the technology which sustains our modern world. But how did this all come about? The objective of this chapter is firstly to give you an understanding of the power of science. It represents about 2,000 years of human endeavor and is one of the greatest cultural achievements of the human race. Some of the current challenges to the scientific process and method, as we currently understand them, are then discussed, with illustrations drawn from advanced Quantum Physics. These are sketched out in plain English, without the use of mathematical equations.

INTRODUCTION

In considering their environment, the reality 'out there', all humans can ask some simple questions. For example, there appear to be many different materials from which things are made (leaves, trees, stones, the sun, the moon….). Are all these things made of a material unique to them or is there some underlying order? Apples falling, rainbows developing after a storm, clouds chasing across the sky; all can wonder if these changes are unique and impossible to understand or can be explained in some way which links them together.

It could have been that everything is unique; that there is no order below the surface of the complexity which the everyday world throws at us. In that case science would never have lifted off the ground. The underlying, and at first sight rather outrageous, hypothesis of science, is that there is an external reality and that there is order beneath the surface complexity of everyday life. In other words, there is an

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underlying simplicity which explains this complexity. Gaining even partial knowledge of this underlying simplicity has allowed us to produce all of the technology which sustains our modern busy and crowded world; electricity, computers, the internet, intensive agriculture…………the list goes on almost forever. The effect has been, among other things, to lift the burden of manual labor from many of our shoulders, and leave us free to dream.

The objective of this Chapter is firstly to give an understanding of the power of the scientific method, using advanced Physics as an example. This represents the culmination of about 2,000 years of human endeavor and is one of the greatest cultural achievements of the human race. Some of the current challenges to the scientific approach, as we currently understand it, will then be discussed, with illustrations drawn from current Quantum Physics, where 'the shoe pinches the most'; i.e. the constraints and dilemmas are most acute. These will be sketched out using plain English, without the use of mathematical equations.

BACKGROUND

Since the evolution of the human species, all groups of people have had a need for what in science would be called a theory or 'hypothesis' about where our reality has come from. In Western society and in the Middle East, in the12-13th Century a,d., thinkers such as Omar Kayyam and St Thomas Aquinas looked back to the philosophy and mathematics of ancient Greece for inspiration. This is also where this story begins. Not when Galileo pointed a telescope at the planets, but about 1500 years earlier in Greece with the development of geometry. The geometry developed by Euclid ('Euclidean geometry') all those years ago, made a key step. All of Euclidean geometry depended on just a few basic assumptions, which were called 'axioms' (Russell, 1897; Wilson, 2006). These are fundamental core ideas which cannot be broken down any further. Euclid and his followers were clearly driven by the need to distil the surface complexity of the everyday into just a few fundamental assumptions. They showed that all of the complicated theorems of his geometry could be derived by cleverly manipulating and exploiting these axioms.

The other key step made in Euclidean geometry was that it is actually all about 'invariants'. These are things that remain the same (not varying) even when the frame of reference is changed. For instance, if a straight line is shifted, it is still a straight line – provided that the surface is flat. Thus Euclid's geometry deals with concepts such as points and straight lines, which stay the same when moved around on a flat surface.

As time went on, some began to question Euclid's axioms. One of them seemed to stand out from the others as being too complicated. This dealt with the question of what it means for two lines to be parallel to each other (Lewis, 1920). Could this condition be explained or derived from the other axioms? To begin with, mathematicians assumed variations of the parallels axiom in order to derive what they thought would be absurd conclusions, thereby showing the real truth of all of Euclid's axioms. However, a strange thing happened. Rather than being absurd, these 'alternative geometries' actually made sense. They were the geometry of shapes moving around on a curved rather than flat surface, (for example curved like a globe, or a horse's saddle) and by modifying Euclid's original axiom, a form of mathematics could be developed which was consistent with this curvature. It is noted here that an immense debt is owed to the Islamic mathematicians of the Middle East who preserved, and significantly added to, our knowledge of geometry and algebra following the collapse of the Greek and Roman empires.

There is still a part of the story missing, which concerns how things move - their dynamics. The start of this part of the story also goes back to the same roots – the geometry of the ancient Greeks, but takes

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