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Science, Philosophy and Faith
Reflections of a Physicist

In presenting these reflections I must emphasise that I am a physicist, not a philosopher or a theologian. My justification for speaking on this subject is that I believe that Christians who are scientists must think about the relation of their work to their faith if they are to remain integrated personalities. Their expertise in science does not however guarantee the profundity of their thoughts on such wide-ranging questions, so my remarks should be taken simply as a basis and hopefully as a stimulus to discussion (1).

There are many ways of defining philosophy. The one I like best is that philosophy is thinking about what you are doing. Thinking is hard and often painful, so we tend to do this rather seldom. Philosophy has also been described as the critique of abstractions, and more generally it is concerned with ensuring that we think logically and argue correctly. More ambitiously, philosophy can be a theory of the world, describing and explaining the purpose and interactions of all living and non-living beings. Many philosophers have proposed such systems, and inevitably they have implications for science. Some systems are inimical to science, and others allow it to flourish, so that whether science flourishes within them can be taken as a test of their truth. In this sense we can speak of the philosophy behind physics (2).

Scientists generally have rather a low view of philosophers, whom they see as engaged in abstruse speculations that have no relevance to the serious business of trying to understand the world. Rutherford summed up this attitude in an address to the Royal Academy of Arts when he said: "Quite recently there has been much interest in the metaphysical aspects of science, especially those of theoretical physics. Some of our publicists have boldly claimed that the old ideas which served science so well in the past must be abandoned for an ideal world where the law of causality fails, and the principle of uncertainty, so valuable in the proper domain of atomic physics. The great army in its march into the unknown discusses with interest, and sometimes amusement, these fine spun disputations about what is reality and what is truth. But it still goes marching on, calling out to the metaphysicians 'there are more things in heaven and earth than are dreamt of in your philosophy' " (3). This dismissive view of philosophy was to have a deleterious effect on Rutherford ‛s own research.

To see what is true and what is misleading in such an attitude it is necessary to go back to the beginnings of science. Aristotle laid the foundations of science by insisting that it is a rational attempt to understand a real world that behaves in accord with its intrinsic nature, irrespective of our wishes. He insisted, contrary to Plato, that the natural world is not a flawed copy of an ideal world, but is a real world, and we have a duty to study it for its own sake. He developed the concepts of substance and accident, defined motion in the general sense and analysed the four possible causes (4). This is the philosophy of moderate or methodological realism that is still instinctively and implicitly accepted by all scientists (5).

This is of permanent value, but Aristotle went further and developed his theories of the natural world in great detail using a method that is fatally flawed and as a result the further development of physics was prevented for seventeen hundred years.

It is convenient to distinguish between these two parts of Aristotle's work by referring to them as his natural philosophy and his physics respectively, although both are more properly described as natural philosophy. Aristotle's physics is quite different from what is now described as physics. Galileo attacked Aristotle's physics, whilst still adhering to his natural philosophy, and thus paved to way to modern physics.

There are several reasons for the failure of Aristotle's physics. Reacting against the arid materialistic world of the atomists, which had no place for all that is human, his object was to save purpose in the world. Purpose is a useful concept in biology, but not in physics. He greatly over-estimated the possibility of understanding the essences of things, and was generally averse to quantitative mathematical statements, so important for a developed science.

There is a vital difference between mathematics and philosophy. In mathematics we can have direct intuitive knowledge of concepts. Thus if we are given the lengths of the sides of a triangle was can calculate all its properties, its area, the radii of the inscribed and circumscribed circles and so on. It is wholly open to the human mind. Many philosophers have thought that the same method can be applied to matter, but this is a serious error. Matter is not open to the human mind, and we can only attain some knowledge of it by systematically making and testing hypotheses. This is a far more complicated and extensive task than Aristotle realised.

Aristotle emphasised the importance of observation, but thought that inanimate matter is relatively simple so that on the basis of a few observations he could grasp the essences of material things, and from them deduce all that he wanted to know. This led him to make a large number of pronouncements about natural phenomena that have no basis whatsoever. He recognised that biological systems are much more complicated and so require extensive observations, and so he was an excellent biologist but a poor physicist.

Aristotle believed that the knowledge gained by his understanding of essences was necessarily true and so was far superior to that gained by direct observation, so that if they differed, then so much the worse for observation (6). It was thus quite logical for Aristotelian philosophers like Cremonini to refuse to look through Galileo's telescope.

Hegel had similar confidence in the reliability of his philosophical knowledge, and confidently declared that there could only be six planets, just before the seventh was discovered. He even believed that 'astronomers should consult the philosophers if they wanted to know the laws of planetary distances' (7).

Such examples show the vital difference between the philosophical and the scientific approaches to the natural world. Aristotle thought about local motion, the most fundamental problem in physics, and hence of all science. He began with ideas that were to him so clear and self-evident that they must be true. Thus observing purpose in living organisms, Aristotle attributed the same goal to inanimate matter, saying that each particle of matter seeks its natural place, with an intensity proportional to its weight. From this it follows that the speed of falling bodies is proportional to their weights. From these ideas he proceeded to deduce how bodies in motion behave, and thus build up his philosophy of motion. It apparently never occurred to him to test his ideas by making a few experiments. He knew that his ideas are correct, so there was no need to make experiments. If he had made the simplest experiment, he would have found that his ideas are completely wrong. Much the same applies to Descartes' theory of motion.

As a scientist, Newton behaved in a quite different way. Ideas are of course the essential starting point, and one day he had the idea that it is the same force that keeps the moon in its orbit around the earth as the force that causes the apple to fall to the ground. But he did not stop there and publish his idea. He calculated the strengths of these two forces, found that they differed by 20% and concluded that his idea was wrong. Some time later, he heard about a new determination of the radius of the earth, and putting it into his calculation he found that the two forces now agreed, and so concluded that his idea was worth taking seriously. He used it to calculate many other consequences and found that they also agreed with observations, and so it became reasonable to accept it provisionally as at least a partial truth about nature.

It is hardly surprising that when he started to read a book of Descartes, he wrote 'error' six times in the margin of the first page, and then threw the book away in disgust (8). The whole of his masterpiece, the Principia, can be seen as a sustained polemic against Descartes. With Descartes in mind Newton wrote at the beginning of his book on Optics: 'My Design in this Book is not to explain the Properties of Light by Hypotheses, but to propose and prove them by Reason and Experiments' (9).

This is the way of the scientist: to test his ideas as rigorously as possible by experiment, by seeing if the numbers agree. This is why scientists have such a low view of philosophers who produce ideas without any intention of testing them.

Philosophy and science differ markedly in their progressive character. Science is undoubtedly progressive: new knowledge is gained every day. In a very few years scientific articles and books are no longer relevant to cutting edge research; they are relegated to history and are seldom read by active scientists. Physicists frequently use classical mechanics, but we never read Newton. His ideas still dominate much of physics, but his methods of calculation have long been superseded by those of Lagrange and Hamilton. However no one reads Lagrange or Hamilton either, and we obtain our knowledge of their methods from textbooks. The same can be said for the frequent use of Fourier analysis and Legendre polynomials; but we never read anything by Fourier or Legendre.

If a scientist becomes inactive, he is soon out of the running and has nothing useful to say. Philosophy is quite different: philosophers are still arguing about what some other philosophers said over two thousand years ago. It seems to scientists that they have got nowhere in all their discussions. This criticism of philosophy is not entirely fair, as it takes insufficient account of the different natures of science and philosophy. Scientific hypotheses can be subjected to strict numerical tests. An hypothesis is expressed in mathematical form, numerical calculations are made and the results compared with experiment. If the results disagree, the hypothesis is wrong or must be modified. In reality it is somewhat more complicated than this, but eventually a decisive test is made and science progresses. It is not nearly so easy to test philosophical statements but they can eventually be tested by their consequences. Thus it can be maintained that some philosophies such as positivism or idealism have been thought through to the bitter end and rejected, and this is undoubtedly progress.

This is not to say that philosophy is not important for the scientist, for if he is philosophically illiterate he is at the mercy of any philosophical ideas that he may pick up either deliberately or inadvertently.

The influence of philosophy on the progress of science is very strong, though this is not always recognised. Thus the physics of Aristotle prevented the development of physics for almost two thousand years, before its influence was broken in the High Middle Ages by the beliefs inherent in Catholic theology. Similarly in the twentieth century physics has been gravely hindered by the prevailing positivism, particularly in the form of the Copenhagen interpretation of quantum mechanics.

An example of the baleful influence of positivism on the progress of science is provided by the early work on radioactivity. Pierre and Marie Curie were hamstrung by their positivism whereas the robust but unselfconscious realism of Rutherford and Soddy enabled them to take the lead. Pierre Curie's 'choice of energetics over material hypotheses, which was dictated by his interpretation of positivism, doomed his researches to sterility'. As a result 'Pierre Curie inhibited the growth of original ideas in France' (10).

Later on, Rutherford's efforts to determine the structure of the nucleus were undermined by Bohr, who told him that it is meaningless to attempt this, because the interior of the nucleus is a structureless soup (11). Rutherford did not have the philosophical strength to resist Bohr's positivism, and so abandoned his attempts. Subsequently, after Rutherford's death, the study of the structure of nuclei became an important part of nuclear physics.

The Copenhagen interpretation of quantum mechanics still seriously distorts research. It claims to be 'the end of the road', the final theory that cannot be superseded. It claims to provide all that can ever be known about each individual quantum system, and this immediately gives rise to the quantum paradoxes such as the wave-particle duality, tunnelling through potential barriers, and that associated with the double slit experiment. It is the result of an elementary error, the failure to recognise that quantum mechanics is a statistical theory that applies to ensembles of similar systems, and thus leaves open the possibility of finding a determinate substratum. The error is like that of one who takes demographic statistics as applying to a particular individual.

The fundamental difference is between believing that the physic\l world is a fully determined system governed by law at every level and the belief that it is basically statistical, so that only probability statements are possible. Einstein, fully in accord with his Judeo-Christian heritage, believed the former, while Bohr was prepared to admit the latter. This difference is brought into sharp focus by their attempts to understand the Compton effect. Bohr, together with Kramers and Slater, was prepared to admit that the conservation laws held only statistically, but not to each individual event. Einstein held that they did apply to each event, and was vindicated by the crucial experiment of Bothe and Geiger.

The history of the development of Einstein's beliefs is particularly instructive. Initially he was much under the influence of Mach, and so concentrated on observables when formulating his special theory of relativity. Later on, his experience of scientific creativity led him to a realist position, so that he strongly opposed the Copenhagen interpretation. When he was challenged about his abandonment of Machian sensationalism, he replied that, yes, he did at one time believe that, but it is nonsense all the same (12).

So philosophy is indeed important for physicists, so it is worth taking trouble to ensure that it is the right one.

It remains to consider the relation of science to faith. It is sometimes said that science is based on experimental facts whereas faith is just groundless speculation. Closer examination shows that science is itself based on faith and that reasons can be given for that faith. Every scientist implicitly assumes and takes for granted that the world is rational and orderly, so that a fundamental discovery made in one place is true for other places and times. Another belief is that the world is not a necessary world in the sense that it could not be otherwise, for if we believed that it is necessary we might think that it can be discovered by pure thought, without making experiments. The scientist must believe that in some sense the material world is open to the human mind, for otherwise there would be no point in making the attempt to understand it. Finally the scientist must recognise that research is a co-operative endeavour, so that any knowledge gained must be freely shared with other scientists.

Scientists regard these beliefs as so obvious that they are never taught explicitly; they are deeply embedded in our culture. They are however not obvious: other cultures have held different beliefs, and so science never developed within them. Thus if you believe that matter is capricious and at the mercy of gods who have to be propitiated you cannot become a scientist. If you believe that matter is inscrutable, you will never make the effort to understand it. If you believe that any knowledge you gain must be kept secret, then science will never progress.

These beliefs that underlie all science are not in themselves scientific, and yet they are absolutely necessary. If they are not firmly held, at least implicitly, science cannot develop. They are held at a very deep level by all scientists, including atheists and other non-believers. They have permeated European thought for centuries and are never questioned. It might perhaps be argued that scientists simply use them as hypotheses that are justified by the success of science; this may be possible logically, but not psychologically.

Where do these beliefs come from? Many of them can be found in ancient Greece, but they were not held as a coherent whole, and so science in ancient Greece, in spite of brilliant successes due to a few individuals, never developed into a self-sustaining enterprise. The necessary beliefs were first found as a coherent entity within those of the Hebrews. In contrast to the multiplicity of gods in the surrounding empires of Babylon, Assyria and Egypt, they believed in one God, maker of heaven and earth and all that is within it. They believed that matter is good and hence worthy to be studied. 'And God saw all that He had made, and indeed it was very good' (Gen.1.31). Man is told to dominate the world, and this implies that it is to some extent open to the human mind (Gen.1.28). God is rational, so all He creates is rational and orderly. He is also free, so that order is not a necessary order but a contingent order so that it could have been otherwise. If we believed that the order is a necessary order we might seek to find it by pure thought, as we do for mathematics. We must therefore make experiments to find that order. Finally whatever we discover must be freely shared. 'What I have learned without self-interest, I pass on without reserve; I do not intend to hide her riches (Wis.7.13).

The Incarnation of Christ gave matter a new dignity, as it was deemed worthy to become His body. The Incarnation was a unique event and so broke the concept of recurring or cyclic time, a depressing treadmill and debilitating fatalism that stifled originality and prevented the rise of science in all ancient cultures (13). The development of Christology in the succeeding centuries reinforced these beliefs. The Nicene Creed emphasised that in the beginning God created heaven and earth. Christ is God's only-begotten son; He alone is begotten and has the same substance as the Father. The universe is made, and this excludes the pantheism that inhibited the growth of science. All things are created through Christ, and so all the world is good, and not a battleground of the forces of good and evil. Finally we have the obligation to see that science is used to feed the hungry and give drink to the thirsty.

These beliefs, as a coherent whole, gradually permeated the mind of Europe through the first millennium, and were part of the Christian beliefs of the Middle Ages. They gave mankind a new confidence, a wholly new attitude to the natural world. Since matter is created by God, it behaves in a completely consistent way according to its God-given nature. Furthermore its order is open to the human mind; we can do much more than just seek empirical relations, we can penetrate to the deeper order behind them. As the Abbe Lemaitre, the originator of the big bang theory, remarked: 'The believer has the advantage of knowing that the enigma has a solution, it is in the final analysis the work of an intelligent being; so the problems posed by its nature are here to be solved, and the degree of difficulty is without doubt appropriate to the present and future capacity of humanity' (14). It was Whitehead who observed that 'the Middle Ages formed one long training of the intellect of Western Europe in the sense of order,' and went on to say that 'the greatest contribution of medievalism to the formation of the scientific movement' was' the inexpugnable belief that every detailed occurrence can be correlated with its antecedents in a perfectly definite manner, exemplifying general principles. With out this belief the incredible labours of scientists would be without hope. It is this instinctive conviction, vividly poised before the imagination, which is the motive power of research: - that there is a secret, a secret that can be unveiled.' This conviction was generated by medieval theology (15). Thus it was that the intellectual movement of the Middle Ages formed a fertile soil that made possible the birth of modern science in the hands of Buridan, Oresme and many others. This is the vital connection between the Faith and modern science.

It is also argued that modern science can provide support for our theological beliefs, and even lead to new ones. Certainly modern physics provides new and compelling evidence of the wonders of nature, but this simply enhances what we already know by direct observation. It is further maintained that cosmological theories such as the big bang provides evidence for creation, and that Heisenberg's uncertainly principle provides a way to understand freewill and God's action on the world. Such inferences are untenable because of the provisional nature of scientific theories.

The connection between our Faith and science is thus to be found in the roots of science but not in their fruits.

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References

1. A more detailed discussion is in my book 'Theology and Modern Physics' (Ashgate Press, 2005).
2. T.A.Brody (1993), The Philosophy Behind Physics. Edited by Luis de la Pena and P.E.Hodgson. Berlin: Springer-Verlag.
3. Marcus Oliphant (1972), Rutherford. Cambridge: Cambridge University Press. P.66.
4. Richard J. Connell (1988), Substance and Modern Science. Centre for Thomistic Studies
5. Etienne Gilson (1990), Methodological Realism. Front Royal: Christendom Press.
6. Stanley L.Jaki (1988), The Savior of Science. Washington: Regnery Gateway. P.41.
7. Stanley L.Jaki (1966), The Relevance of Physics. Chicago; Chicago University Press. p.48.
8. A. Koyre. Newtonian Studies. London: Chapman and Hall 1965.
9. Isaac Newton (1972), Opticks. London: Dover Publications Inc. p.1.
10. M.Malley. The Discovery of Atomic Transmutation: Scientific Styles and Philosophies in France and Britain. Isis. 70. 213. 1979.
11. D.Wilson. Rutherford, Simple Genius. London: Hodder and Stoughton. 1984.
12. Werner Heisenberg (1971), Physics and Beyond: Encounters and Conversations. London: George Allen and Unwin. P.63.
13. Stanley L.Jaki (1974), Science and Creation. Edinburgh: Scottish Academic Press.
14. 14.Quoted by V.F.Weisskopf (1991), The Joy of Insight. New York: Basic Books. P.287.
15. A.N.Whitehead (1925), Science and the Modern World. Cambridge: Cambridge University Press. P.17.

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