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Editorial

It has been my pleasure to edit this issue of the journal. As with many science educators I have long been personally engaged with various aspects of the 'Science, Religion and Education' theme. Thirty years ago at Sydney University one of the contributors to the issue, Hugh Lacey, introduced me to philosophy of science, and in meetings of the Catholic Students' Society, to some of the fundamental questions that science poses for religious belief. The questions dealt with by the contributors to this issue range over metaphysics, ontology, epistemology, theology, foundations of education, the history of ideas, and the purposes of science education – they are basic and perennial questions that in one form or another engage most thoughtful people.

The overall theme of Science, Religion and Education has been dealt with many times in books, journal special-issues, and articles. Many of these are cited by the contributors. I believe that this issue of *Science & Education* can take its place among the more detailed and philosophically informed treatments of the theme to appear in the educational literature. The contributors are to be thanked for this, as clarity of exposition, informed opinion, and attention to detail are the prerequisites for advancing understanding of complex topics and subsequent decision making.

Martin Mahner and Mario Bunge in the volume's lead article contend that 'A science education and an education of science teachers that does not confine itself to the conveyance of factual knowledge but attempts to give serious consideration to the history and philosophy of science will have to address, among other issues, the metaphysical or ontological presuppositions of science ... The question, however, arises of what kind of metaphysics does science actually presuppose?' Most readers of this journal would echo their contention.

A liberal approach to science education does maintain that science instruction should be more than merely the conveyance of factual knowledge, or even the process skills of science: good science education should introduce pupils to the culture of science, to the methods and, importantly, the methodology of science. A science course should result in something of the wider picture of science being known and appreciated – Wallis Suchting in his (1994) and (1995) contributions to this journal has painted one view of the wider picture of science and culture. Appreciating something of the 'Big Picture' is what many have referred to as learning about the Nature of Science (Lederman 1992), and what might be called Contextural Scientific Literacy (Hurd 1977). An education that gives mere knowledge of scientific facts and processes, but leaves the learner untouched and consequently their wider culture untouched, is patently inadequate.

But the crucial question is: What kind of metaphysics (or ontology, or epistemology, or ethics, or social arrangement) is presupposed by science? This question, in one form or another, is standardly raised in multicultural situations where orthodox science is being taught in cultures and traditions that do not share the broadly Western presuppositions. But even in Western societies we know that many sub-groups have a world view that sits uncomfortably with either the general pursuit of science, or with particular scientific understandings and commitments. The teaching of Evolution and the passionate debates about Creation Science clearly illustrate this. (These matters, and the literature they have generated, are discussed in William Cobern's (1995) article published in this journal.)

Cobern, among other things, asks whether belief *or* understanding is the goal of science instruction. We know that many people can understand things that they do not believe – for instance anthropologists coming to understand a different culture's mythology, or philosophers coming to understand a variety of philosophical positions. Cobern asks whether science educators should be content with pupils coming to understand science in the same way. That is, having understanding of, for instance evolutionary theory, but not believing it? We do feel uncomfortable with this outcome, but the move from understanding to belief will frequently – for those who value consistency and rationality – entail a change in metaphysical, ontological, and epistemological commitments.

Science has had flow-on effects in culture – it has influenced philosophy, world views, religion, literature etc. Similarly the learning of science can be expected to have flow-on effects for individual pupils. The important thing is to be clear about the necessary and unnecessary, the legitimate and illegitimate, flow-on effects. Culture and individuals have been equally harmed by insulating themselves against the legitimate and rational implications of science (for instance, staying trapped in primitive and infantile approaches to nature, and consequently inadequate approaches to disease, illness etc.) and by on the other hand, accepting thoroughly illegitimate and unfounded implications (for example, scientistic triumphalism, crude reductionisms, etc.) One needs to walk a fine line between taking science seriously, and taking it too seriously. Or to put this another way, one should be prepared to affirm the factual, procedural, methodological, metaphysical, and epistemological heart of genuine science with all the consequences that flow from this affirmation, yet be guarded against affirming some caricature of science, and subsequently of distorted and flawed flow-on effects.

The discussion in this issue between Mahner and Bunge and their critics is focused on delineating these necessary and unnecessary changes in philosophical commitments that should follow from taking science seriously. That science is often enough learnt, but not taken seriously is another, but not quite unrelated matter. Some studies show that even the learning of science is dependent upon certain changes in philosophical outlook or commitment –Thijs & van den Berg in this journal (1995, pp. 330–338). Thijs and van den Berg quote an African science educator, Ogunniyi, pointing out that 'faulty conceptions about the external world could create learning difficulties in science. For instance, the rainbow cannot be explained as a sign of good omen on the one hand and as the refractive dispersion of sunlight in rain droplets or mist on the other. The two viewpoints are certainly inconsistent with each other' (p. 330).

Despite the disagreements between contributors on the compatibility of science with religious belief, all are in agreement that a culturally beneficial science education should address the question of the historical and contemporary interactions of science with religious, and more generally philosophical beliefs. Students should learn *about* science as well as learning the content of science. Indeed, for advocates of any serious education, the distinction is difficult to sustain. Can one learn art without learning something *about* art? Or understand literature without learning *about* literature?

Despite the fact that historically the major Western scientists regarded their work as proclaiming the majesty of God, little is heard of this in the typical science classroom. Students learn often enough that Newton discovered three laws, and the formulae for them; they learn less often that Newton said, when he wrote his *Principia*, 'I had an eye upon such principles as might work with considering men for the belief of a Deity; and nothing can rejoice me more than to find it useful for that purpose' (Thayer 1953, p. 46). Students also learn that Boyle formulated the important law connecting pressure and volume of gases; they learn less often that he left a provision in his will for a set of public lectures 'for proving the Christian religion against notorious infidels' and that he believed his own mechanical philosophy admirably suited for proving the existence of a Designer of the universe. And one can continue down the roll-call of great scientists who were religious, and who thought that their religious belief impinged on their science – Charles Lyell, Michael Faraday, James Clerk Maxwell, Max Planck and so on up to the present time.[1] There are engaging psychological, cultural and philosophical stories about the convictions of these people that are worth exploring. However the role of religious belief in the motivation and conceptualizations of scientists is usually ignored in the science syllabus. Max Planck, for instance, concluded his *Scientific Autobiography* with the claim that 'Religion and natural science are fighting a joint battle in an incessant, never relaxing crusade against scepticism and against dogmatism, against disbelief and against superstition'. A science student who can learn the formula for Planck's Constant, can surely learn something of Planck's conception of religion, and the role it played in his scientific and political life.

Both sides agree that *merely* showing that great scientists have been believers is insufficient to establish most of the points at issue. It does establish that religious belief and science are not *as a matter of fact* incompatible. But they may well be *in principle* incompatible – after all we well know that individuals can, in fact, simultaneously believe all sorts of strange and wonderful, but strictly inconsistent, things. It is important to reveal the psychological and epistemological *connections* between scientists' religious belief on the one hand, and their scientific belief and practice on the other.

The fact that science deals with important questions, mostly in ways that are counterintuitive, makes conflict with traditional belief systems inevitable. But conflict has not been confined to traditional belief systems. The effect of Copernican astronomy and the New Physics on medieval society, the effect of Darwinian naturalism and evolutionary theory on nineteenth-century religion, are Western examples of scientific conflict with fundamental cultural values, causing pain in many circles, and readjustments of basic belief systems.[2] Western and non-Western students can, with profit to their overall education and development, be introduced to the personalities and intellectual issues in these major historical episodes.[3]

The Galileo Affair, for instance, has perennial and near-universal educative value.[4] Issues of epistemology, scientific method, personal style, cultural values, institutional and political power, hermeneutics are all involved. Galileo championed the new science, but he did so in the tradition of Augustine and Aquinas, who were very cautious about tying culture and religion to any particular scientific understanding.[5] Augustine had said: 'One does not read in the Gospel that the Lord said: I will send you the Paraclete who will teach you about the course of the sun and moon. For He willed to make them Christians, not mathematicians' (Langford 1966, p. 65). And Aquinas restated the point as follows: 'since Holy Scipture can be explained in a multiplicity of senses, one should adhere to a particular explanation only in such measure as to be ready to abandon it if it be proved with certainty to be false; lest Holy Scripture be exposed to the ridicule of unbelievers and obstacles placed to their believing' (Langford 1966, p. 66). This Augustinian tradition of Scriptural interpretation (or hermeneutics as it became labeled in the nineteenth century, and discussed by Martin Eger in this journal (1993, 1995)) recognised the primacy of science in understanding the world; culture and theology were to adjust to what science established as the *indisputable* facts of the matter. But much hinged, of course, on what was to be regarded as indisputable.

I have elsewhere written on Galileo's treatment of pendulum motion (Matthews 1994, chap. 6), and argued that, if pendulum motion is taught in a contextual or liberal manner, then this commonplace curriculum topic can illustrate something of the complex interaction of science with culture, philosophy and commerce. But Galileo's treatment of pendulum motion is not unconnected with the great religious issues of his time, issues prompted by Luther's launching of the Reformation (1517) and the Catholic Church's response in the resolutions of the Council of Trent (convened in 1545, just two years after the publication of Copernicus's *De Revolutionibus*). The Council decreed in 1546 that 'Furthermore, to control petulant spirits, the Council decrees that, in matters of faith and morals pertaining to the edification of Christian doctrine, no one, relying on his own judgement and distorting the Sacred Scriptures according to his own conceptions, shall dare to interpret them contrary to that sense which Holy Mother Church, to whom it belongs to judge their true sense and meaning, has held and does hold ... those who do otherwise ... will be punished in accordance with the penalties prescribed by law' (Blackwell 1991, p. 183). This decree cast a very long shadow, certainly reaching to Galileo one century later in Florence.

To modern readers, it seems odd that Galileo would go to so much trouble to provide mathematical proofs, or demonstrations, of his claimed properties of the pendulum. This becomes a little clearer when it is seen that mathematics (Euclidean geometry) was then regarded as a body of certain knowledge. Galileo remarked at one point that our knowledge of geometrical theorems is the equal of God's knowledge of those theorems. For Galileo, and his contemporaries, nothing less than certainty was the goal of science. Thus with Galileo we have a case where an overall epistemology affected the conduct of his science.

But, further, his epistemology was in turn influenced by his religion. Galileo's physics was put forward in the service of the Copernican world-view. It was known that Copernicus's helio-centric theory of the solar system was in conflict with the standard readings of Scripture and with traditional Church teaching. Following the Augustinian tradition of Scriptural interpretation, it was widely held, certainly by the Inquisition and by Galileo, that Scripture had to be taken at its face value except in situations where demonstrable and certain secular knowledge conflicted with it. In the case of, and only in the case of, such conflict could Scripture be reinterpreted in a metaphorical or poetic manner. For the Catholic Church this became a particular concern during the Counter Reformation. Thus to establish Copernicanism, and to ward off the attentions of the Inquisition, Galileo needed certainty in his physics. Geometry gave him this, even though his embryonic mathematisation of physics was in violation of widely accepted Aristotelian precepts against conjoining mathematics and physics.

It maybe thought that the issues connected with Science, Religion and Education have run their course, and particularly in secular Western cultures are, for non-believers, now dated. But this is not so.

In the West, antiscience is on the rise.[6] As children's chemistry sets become increasingly unprocurable, tarot cards, crystals and astrological charts are becoming increasingly available in shopping centres; as graduate physics teachers disappear in the U.S.,[7] the training of suppressed-memory therapists becomes a growth industry; whilst the 1990 NAEP assessment showed that 50% of US eighth-graders could not work out simple proportions (e.g., find one-sixth of 30), they worked out how to watch more hours of television than any other comparable cohort in the world (20,000 hours by the age of 18 years). A study at one Canadian university found that a majority of students believed in astrology, extrasensory perception, and reincarnation; while another study estimated that 11 per cent of U.S. citizens claim to have seen a ghost (Cromer 1993, p. 34). Surveys conducted over a three year period at the University of Texas revealed that 60 per cent of students thought that some people could predict the future by psychic powers, 35 per cent believed in Black Magic, and the same percentage believed in ghosts. Another survey of U.S. biology teachers – yes, teachers, not students – estimated that 35 per cent believe that psychic powers can be used to read other people's minds, 30 per cent reject the theory of evolution, and 20 per cent believe in ghosts. (This evidence, and associated literature, is reported in Michael Martin's (1994) contribution to this journal.) A recent survey by the Australian Institute of Biology of 4,225 first-year biology students from 17 universities in all States showed that one in eight (12 per cent) believed that 'God created man pretty much in his present form at one time within the last 10,000 years'.

Solving textbook problems and doing cookbook laboratory classes do not impinge greatly on this tide of antiscience. It is notorious that much antiscience is found among science graduates. Thus, one study some years ago showed that belief in astrology was basically unaffected by completion of a U.S. science degree. Four years of science instruction just washed over students.

As well as antiscience, there is a rising tide of ambiguous middle-ground, popular literature, sometimes associated with ecological, feminist and counter-cultural movements. Paul Davies' work, discussed in this issue by Peter Slezak, is an example of this, as is Jim Lovelock's writing on the Gaia Hypothesis (Lovelock 1979), or Fritjof Capra's Eastern interpretation of modern science (Capra 1975, 1982) or Barbara McClintock's work. This *genre* of scientific/speculative writing has spawned numerous best-sellers that are freely available in railway bookstores, and read by many science students. Teachers can profitably engage with students in appraising this work. One task is to identify what in this middle ground is taking human understanding forward, and what is taking it off the track; to identify what is intellectual wheat and what is chaff. Most of the supposedly old issues of science and religion – delineated and discussed in this volume – are being raised again, but in a new context.

Undeniably these are all complex matters, and the best one might hope for is to have good students appreciate the questions, rather than believe they have answers. No one expects that the long-running issue of the compatibility of science and religion will be solved in the science classroom, but the issue can be raised, and some account of its complexity and history can be given. Senior students, in particular, can benefit from engagement with this issue, as it often bears upon their own personal affairs, and upon discussions in their literature, religion, art and history courses. Working through the standard issues about science, religion and education will increasingly be useful in appraising issues about pseudo-science and perhaps pseudo-religion.

And as with so much advocated in the liberal approach to science education, the discussions and curricular proposals urged here make onerous demands on science teachers, demands for which they are poorly equipped by their standard programmes of preparation. The domination of teacher education by methodology and psychology needs to be loosened in order to make provision for historical, philosophical and sociological studies of science. Such studies need to be included in pre-service and in-service teacher education programmes in order for teachers to deal intelligently and usefully with the wide range of questions that the theme of Science, Religion and Education raises. Hopefully this issue of *Science & Education* can contribute a little to advancing understanding of some of these questions.

Notes

[1] See Mott's edited collection of essays by contemporary religious scientists (Mott 1991).

[2] Moore (1979) is an excellent discussion of religious reactions to Darwin. The 'Galileo Affair' is documented in Finocchiaro (1989). It is discussed in Langford (1966), Poupard (1987), Redondi (1988) Blackwell (1991).

[3] Discussion of the interactions between Western science and religion can be found in, among countless other sources, Brooke (1991), Funkenstein (1986), Hooykaas (1972), Mascall (1956), Laki (1978), Russell, Stoeger & Coyne (1988), and Lindberg & Numbers (1986).

[4] One of the contributors to this issue, Michael Poole, has provided an admirable example of the educative value of a rich and contextural approach to teaching about Galileo in the science classroom (Poole 1995, chap. 6. See the Book Notes section of this issue).

[5] The central document is Galileo's 1615 *Letter to the Grand Duchess Christina* in Drake (1957).

[6] See discussion and literature in Passmore (1978), Holton (1993) and Gross & Levitt (1994).

[7] In 1992 there were only 12 physics graduates in teacher training programmes in the entire state of New York. The American Physical Society predicts that there will be no physics graduates in teacher training at the close of the century. Pearson & Fechter (1994) is a good source of depressing information on this topic, as is Darling-Hammond & Hudson (1990).

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