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Habits of Mind, Scholarship and Decision Making in Science and Religion

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Abstract. Recent papers have drawn a contrast between habits of mind in science and religion and it has been argued that, because of the different nature of these habits of mind, science education and religious education are necessarily in conflict with each other. The present paper draws on research into habits of mind in science and their relationship with wider scholarly activity and decision making and presents a case that habits of mind in science and religion are much more alike than has been presumed. In contrast to the dogmatic materialism which others have claimed lies behind the practice of modern science a more tentative form of naturalism is advocated in this paper for those who carry out scientific research. Some aspects of the nature of exemplary religious education are pointed out and implications for science education are discussed.

1. Introduction

For almost all of the 20th century intense interest has been shown in identifying those characteristics which are important in science and much of the focus has been on the habits of mind valued in science – what some people have called the scientific attitude (see Gauld & Hukins 1980). It has long been obvious that simply knowing about the ideas and theories of science and the accepted procedures for doing science is insufficient for doing science successfully; there must be some incentive or motivation for using these elements of scientific knowledge and method and applying them in appropriate ways to solve scientific or technological problems. Attitude or habit of mind has been identified as the characteristic which compels the individual scientist to work as he or she does and, for many people, this attitude is also something which the ordinary person would benefit from developing (Gauld 1982). Thus, it is no surprise to find in science curriculum documents, such as the influential *Science for all Americans*, scientific habits of mind listed as important for schools to develop (Rutherford & Ahlgren 1990, Chapter 12).

More recently a number of writers (for example, Mahner & Bunge 1996a, b; Good 2001) have drawn a contrast between these scientific habits of mind and religious habits of mind and have argued that these are necessarily in conflict with one another. Because of this they conclude that science and religious education are incompatible with one another. Implications have been drawn from their conclusions for science and religious education. In what follows the natures of the scientific and religious habits of mind are discussed and it is argued that good science and good religious education should be expected to promote similar critical attitudes.

2. Scientific Habits of Mind, Scholarship and Evidence

The notion of habits of mind focus attention on the activity of individual scientists rather than on the general scientific enterprise. A number of habits of mind make up the scientific attitude. Two most frequently mentioned in the literature are *open-mindedness* – the 'openness to new ideas' of *Science for all Americans* (Rutherford & Ahlgren 1990, p. 173) – and *skepticism* in which all new ideas are potentially open to critical appraisal (p. 174). *Rationality* and *objectivity* are frequently mentioned focussing, first, on the need for appeal to good reasons (including the use of appropriate evidence) and logical argument by which to link ideas, evidence and reasons together in an appropriate way and, second, on the need to reduce the idiosyncratic contributions of the investigator to a minimum. *Mistrust of arguments from authority* is a particular example of the skeptical attitude. *Suspension of belief* is required if there is not sufficient evidence to make a decision and so one should not rush in too quickly in support of some particular idea or theory. *Curiosity* is somewhat different from all the other habits of mind in that it refers to something which is required to begin and to continue scientific work rather than something which guides the way that scientific work is carried out.

Following an extensive study of the literature (Gauld & Hukins 1980) the scientific attitude was described in these terms:

> The scientific attitude as it appears in the science education literature embodies the adoption of a particular approach to solving problems, to assessing ideas and information or to making decisions. Using this approach evidence is collected and evaluated objectively so that the idiosyncratic prejudices of the one making the judgment do not intrude. No source of relevant information is rejected before it is fully evaluated and all available evidence is carefully weighed before the decision is made. If the evidence is considered to be insufficient then judgment is suspended until there is enough information to enable a decision to be made. No idea, conclusion, decision or solution is accepted just because a particular person makes a claim but is treated sceptically and critically until its soundness can be judged according to the weight of evidence which is relevant to it. A person who is willing to follow such a procedure (and who regularly does so) is said by science educators to be motivated by the scientific attitude. (Gauld 1982, p. 110)

One interesting feature of the habits of mind listed above is that they are not necessarily related to science but could be considered as necessary for undertaking any scholarly activity. For example, Hasker (1983) presents a number of maxims required for doing philosophy well. These include (a) having '*good reasons* for the assertions we make' (p. 18), (b) believing that '*nothing* is immune to challenge' (p. 20), and (c) heeding expert authority but with the proviso that 'the claims made by [some] authority can in the end still be rejected if we have weighty enough reasons for doing so' (p. 22). Ziman (1968) points out that 'a peculiar quality of the research scientist – and this he shares with professional academics and scholars in all faculties – is that he has very high internal critical standards for arguments within the context of his discipline' (p. 79). The existence of scholarly literature in any field provides an arena in which ideas can be presented and challenged, where scepticism about and critiques of those ideas which have been published can themselves gain an airing. This also enables authorities to be challenged and often, in time, replaced. In such an arena personal preference and sloppy argument are alien elements and failure to maintain adequate standards of rationality and objectivity usually leads to rejection of submitted papers or of the position presented in them. Although examples of publications which contravene these norms can be found, reputable scholarly journals (including theological ones) would uphold and affirm them.

The feature which is omitted from general statements of the scientific habits of mind and which link these to science relates to the nature of the evidence considered to be appropriate. In the first half of this century it was clear that, for most science educators, 'evidence' meant 'empirical evidence.' According to science educators during that period, when decisions were to be made about the acceptability of scientific theories only empirical evidence was to be taken into account. For the verificationists empirical evidence was used to prove the truth of hypotheses while for the falsificationists empirical evidence was used to prove their falsity. More recent developments – in particular those which have investigated the use of empirical evidence in the history of science – indicate that, for science, more than empirical evidence is probably involved when scientists make scientific decisions in their work (Gauld 1973, 1982).

A modification of the simple scientific attitude outlined above emerged from Merton's studies, in the middle of the twentieth century, of the social structure of science. Merton's (1938, 1957, 1976) investigations into the scientific ethos led to the identification of a number of norms by which institutional control was exerted over scientists. These were *universalism*, *organized scepticism*, *communality*, and *disinterestedness* [to which Barber (1952) added *rationality*, and *emotional neutrality*] and are closely related to scientific habits of mind listed above. However, in later research Merton (1963, 1968, 1976) identified the existence of counter-norms which 'represent pressure from the scientific institution to act legitimately (i.e., in the interests of science) in the opposite direction to that specified by the original norms' (Gauld 1982, p. 114), a general situation which Merton and Barber labelled 'sociological ambivalence' (Merton & Barber 1963; Merton 1976). Merton (1976) wrote that 'only through such structures of norms and counter-norms, we suggest, can the various functions of a role be effectively discharged' (p. 58). Mitroff's work in the early 1970s (Mitroff 1974) demonstrated the operation of both norms and counter-norms in the behaviour of moon scientists (see Table I). Holton (1978, p. 71), as a result of his study of Millikan's notebooks, felt it necessary to introduce the notion of *suspension of disbelief* to explain Millikan's treatment of his laboratory data. Holton argued, on the basis of Millikan's laboratory behaviour, that it was appropriate, 'during the early period of theory construction and theory confirmation to hold in abeyance final judgments concerning the validity of apparent falsifications of a promising hypothesis' (p. 71). This contrasted with another aspect of Millikan's work – 'the standard classical behavior of obtaining information in as depersonalized or objective manner as possible' (p. 71). Both habits of mind were appropriate at different stages in the research process. Bauer (1992) pointed out that

> the raw stuff of frontier science has those characteristics of uncertainty, subjectivity, and lack of discipline that one should surely expect whenever human beings try to do what has never been done before. But after successive filterings through the institutions that science has evolved over the centuries, what remains easily gives the appearance of being objective and true. In point of fact, what remains is (relatively) impersonal rather than strictly objective, and it is hugely reliable and trustworthy rather than warranted true for all time. (pp. 47–48)

Table 1. List of norms and counter-norms (adapted from Mitroff 1974)

Norms	Counter-norms
Faith in the moral virtue of rationality	Faith in the moral virtue of rationality and nonrationality
Emotional neutrality	Emotional commitment
Universalism	Particularism
Communism	Solitariness or 'miserism'
Disinterestedness	Interestedness
Organised skepticism	Organised dogmatism

When more active disagreement exists between proponents of two different theories Margolis (1993) offered another reason for the existence of attitudes in science other than those generally identified as 'scientific'. He pointed to a tension which exists in decision making

> between jumping-too-soon and hesitating-too-long … A person whose ability to act is damaged by a failure to choose will not remain paralyzed between alternatives. So a bystander to a scientific dispute might see the situation as too unclear to make a judgment. But for a

participant who needs to get on with her work one way or another, that is almost always cognitively intolerable. (p. 148)

The situation envisaged here is one where there might not be sufficient evidence of appropriate weight to make a clear decision but where, for any progress to take place, a decision must be made. In this case the pressure to make a judgement on the basis of insufficient evidence is very strong.

It appears that appeal to some notion such as that of counter-norms is necessary before decisions can be made, at least in the early stages of theory development, about whether to support or reject a scientific theory – especially one about which there is some controversy and where different people weigh up the same evidence in different ways. Mitroff's view is that a scientific theory gains a better hearing if it is supported passionately by those who adopt it and opposed passionately by those who reject it. In this model scientific disputes are carried on like those in a courtroom where the most powerful evidence is provided by these who feel most strongly about one side or the other. In science those who are committed to a theory are most likely to provide the evidence which supports it while those who reject the theory are most likely to come up with evidence that opposes it. In the end the relevant scientific community arrives at a position supported by most members even though groups may still exist which continue to oppose the majority consensus. For Bauer (1992) and Ziman (1968) it is this increasing consensus within science – from the 'inchoate ferment' of frontier science to the 'hugely reliable and trustworthy' science of undergraduate textbooks – which constitutes the establishment of scientific knowledge.

3. Scientific Habits of Mind and Decision Making

Scientific theories should be consistent with the empirical evidence available but are not always unambiguously determined by this evidence. Duhem (1954, pp. 183–190) claimed that, because the propositions which constitute a scientific theory were linked to a whole network of other propositions, all that could be falsified by empirical evidence was the whole network. In the face of disconfirming evidence a theory may be false but the problem may also be located elsewhere in the network. Quine expanded this network beyond the scientific propositions to include logical premises as well. He suggested that some of the problems indicated by quantum mechanics may be resolved by eliminating the law of the excluded middle (Quine 1961, p. 43; for an extended discussion of the Duhem-Quine thesis see Harding 1976). Popper (1963, pp. 238–240) argued that one might be able to separate the propositions relevant to a scientific theory into core and background propositions and that the background propositions might be considered, in the first instance, unproblematic in the empirical testing. Lakatos (1970, pp. 133–138) divided the propositions of a theory into those which were more open to change (the 'protective belt') and those which were not (the 'hard core'). It is only after sustained challenges which could not be accommodated by modifications to the outer layers of the theory that changes to ideas in the core may need to be considered.

There are two extreme views about the role experimentation plays in making decisions about scientific theories (see Franklin 2002, pp. 1–35). Both agree that a scientific dispute is resolved when theoretical predictions and experimental results agree although they differ on how this agreement is reached. At the strong constructivist pole the results of experiments play little decisive role in this process because other things can always be changed to bring about this match. At the strong rationalist pole validated experimental results are the only significant things in the resolution process. Radder (2003, p. 10) believes that 'a balanced philosophical study of this issue' may profit from consideration of both approaches so that the final outcome about the role of experiment in theory choice would be somewhere between the two extremes. Franklin considers that his position is close to the rationalist extreme while Hacking would place himself, in some respects, closer to the other pole (Franklin 2002, p. 32).

It is possible that part of the difference between these two positions is that strong rationalists like Franklin largely use, as their source of evidence, published papers while the constructivists more often use interview and ethnographic procedures which focus attention on the less public activities of scientists. Some of the more idiosyncratic features of the activity of scientists are exposed by the second methodology but not the first.

Franklin (1986, 1990, 2002) has shown that, in modern physics at least, a strong version of the Duhem-Quine thesis – that it is always possible to find a way of protecting strongly held theories from the threat of disconfirming evidence – is not tenable. The network of propositions consisting of a theory and the context in which it is embedded is not infinitely pliable. He has shown there are good grounds for believing that, when science is practised, a reasonable decision can eventually be made about the status of experimental data and those things which should be changed when there is a discrepancy between theoretical predictions and experimental results. The solution (if one is found) to what he calls the 'Duhen-Quine problem' can be expected to be different in different circumstances. It appears then that the Duhem-Quine thesis is rather a guide to possible strategies for resolving the conflict between theories and disconfirming evidence. It indicates alternatives to the stark claim that in the face of disconfirming evidence the theory should be changed. Instead one should also look as well at theories in which the experiment itself is embedded or to the background propositions related to the theory or even to the validity of the experimental data themselves. Franklin's case studies provide examples of all of these strategies as a body of scientists come to a conclusion about the implications of a set of experimental results.

Franklin has also shown that some components of this procedure are relatively protected from scrutiny for a variety of reason. In his case study of the discovery of parity nonconservation between 1924 and 1957 (Franklin 1986, Chapters 1 & 2) two such components were (a) Dirac's relativistic quantum theory of the electron and (b) the law of conservation of parity in weak interactions. Evidence gradually emerged which showed reasonably convincingly that Mott's theory of electron scattering (which was based on Dirac's theory) predicted incorrectly the results of double scattering experiments. Franklin argues that the reason why Dirac's theory was not seriously questioned even though it was part of the theory being tested was its previous success in predicting the previously unexpected existence of the positron. On the other hand there was apparently no experimental evidence for the strongly held law of conservation of parity in weak interactions. This fact surprised Lee & Yang (1956) when they reviewed the literature to find the evidence upon which this law was based. They also believed that the prospect that this law might not be true would be even 'more startling' (Franklin 1986, p. 14).

During the process of finding where the fault lies when theoretical predictions and experimental results disagree scientists will go about their work (certainly before the outcome of the work is published) with some ordering of the components of the problem in mind. Thus in the previous example Dirac's theory and parity conservation were seen to be less open to criticism than other components of the problem (such as experimental results or Mott's theory). While the reason for this attitude may often be past empirical success this need not always be the case. Dirac (1963) described how Schrödinger developed a relativistic wave equation but found that it did not fit the experimental data. Since a nonrelativistic form of the equation did fit the results this was the form in which it was published. It was later found that the relativistic form of the equation fitted the data when electron spin was taken into account. The moral Dirac drew from this story was 'that it is more important to have beauty in one's equations than to have them fit experiment' (1963, p. 47). Dirac was not suggesting that Schrödinger should have published his original theory with the claim that it was justified by its beauty in spite of the discrepant experimental results. Instead he was suggesting that Schrödinger would have been better, at that early stage, proceeding with his original work on the basis of the beauty of the equations and with the expectation that the problem presented by the experimental results would eventually be resolved. Dirac implied that this habit of mind at that stage in the development of quantum theory would have been an appropriate one for Schrödinger to have adopted. Dirac's suggestion presumably also rested on the fact that, as Franklin has shown, experiments are 'fallible and corrigible' (Franklin 1990, pp. 1–5, 193–196).

Thus it appears that, in the context of theory testing, there is a hierarchy of propositions with those deeper in the hierarchy being relatively protected by those higher up. Resolution of the Duhem-Quine problem is sought first by seeing if changes to the less important components of the theory–experiment network can be made. Changes to more fundamental components are resisted – with different strengths by different scientists depending on their affiliations – for as long as possible although, in the end, these changes might be forced on those involved in making decisions about the theories. In other words, those components of a theory which are less central are dealt with by individual scientists, as far as empirical testing is concerned, through the exercise of the normal scientific habits of mind and are more easily changed if the evidence seems to warrant this. Those components which are nearer the heart of the theory are dealt with through the exercise of habits more consistent with Merton's counter-norms – that is, they may be held onto, at least for some time, in spite of the evidence.

To set this discussion in a broader context a further layer must be added to the hierarchy proposed above when considering the testing of scientific theories. In human thinking, worldview provides a more fundamental framework than those ideas discussed above which are deeper in the hierarchy. A person's worldview represents those basic commitments he or she adopts, for example, about the world, the things it contains and how reliable knowledge is gained about these things. According to Cobern (1996) 'worldview provides a person with presuppositions about what the world is really like and what constitutes valid and important knowledge about the world'. Cobern claims that 'a worldview is a set of fundamental nonrational presuppositions on which [particular] conceptions of reality are grounded' (Cobern 1996). Mahner & Bunge (1996b) admit that 'nobody can argue in a vacuum, that is, without a basis of assumptions or presuppositions that are not questioned in the given context. In particular, nobody can do without a general outlook or worldview'. In his paper Good (2001) states that 'Science assumes that all of Nature, including all that occurs in our minds, can be studied and explained in rational, real terms' (p. 9). If Good himself believes this assumption to be true (which presumably he does) such an assumption – unproved and unprovable – would provide one of the elements of his worldview.

It is important to make clear here that one's worldview can change just as more central ideas in strongly held scientific theories can change and one can point to many people who have undergone such a transformation. Quine's suggestion that the law of the excluded middle might be eliminated is an example of something which lies outside the boundary of the scientific network but which could be altered if the pressure in that direction were great enough. One's worldview can be probed and investigated and discussed. However, one of its main features is that, besides being very transparent, it is very resistant to change. Because it provides the foundation for other ideas, those other ideas are more likely to change than the ones which constitute the worldview.

The discussion above about the structure of scientific theories and about the nature of worldviews indicates that the results of prior decisions may play a large part in determining the weighting attributed to items of contemporary empirical evidence and that if some implications of a possible decision conflict with already accepted central items or worldview assumptions then this decision is generally avoided in the first instance. It is only after a great deal more subsequent investigation and consideration that a position is arrived at where a decision can be reached about whether or not the proposed modification should be made.

In the first instance, the standard scientific habit of mind is appropriate when dealing with those aspects of a theory which are more vulnerable to change while the counter-norms are more appropriate when dealing with the central ideas of a theory or research programme or with beliefs associated with a worldview. However, none of these more stable components are completely insulated from change.

One can begin to see from the portrayal above that the attitudes which scientists legitimately adopt when doing science are more complex and varied than those few components outlined in *Science for All Americans* (Rutherford & Ahlgren 1990, Chapter 12) and discussed approvingly by Good (2001). The existence of apparently contrary habits of mind modify the role played by the traditional scientific habits of mind in the way decisions are made about scientific theories.

4. Habits of Mind in Religion

Good (2001) and Mahner & Bunge (1996a, b) deal with habits of mind in both science and religion. Their account of the scientific attitude is consistent with that found in *Science for all Americans*. Good characterises religious habits of mind in the following way.

> The habits of mind associated with most religious beliefs include faith in the authority of holy books and religious leaders. Accepting without evidence what a holy book or a religions leader says is one of the hallmarks of the religious habit of mind. To challenge the basic assumptions (i.e. doctrine) of one's religion is often the beginning of the end of those, particular beliefs, resulting in adoption of other religious beliefs or perhaps giving up on the supernatural altogether. …
>
> Questioning those who make claims without evidence, a hallmark of scientific, rational thought, is not accepted practice in most religious circles. …
>
> The religious mindset of unquestioning acceptance of predetermined dogma must inevitably conflict with a scientific mindset that requires open inquiry into all parts of the natural world, including people's minds. (Good 2001, pp. 4–5)

For Mahner & Bunge (1996a) the religious habit of mind is part of what they term the endoaxiology of religion. They write that this

> seems to have only one issue in common with science: the quest for truth. However, whereas the truth looked for by religionists is absolute or ultimate, scientific truth is partial or approximate. Neither exactness nor logical consistency, neither clarity nor testability are strong in religion. Moreover, it can be asserted that many religious beliefs can only be upheld by disregarding such values. Otherwise it would not be possible to cherish the mysterious or confess *credo quia absurdum*. A religious value that is alien to science is (blind) faith, which allows the religionist to always retreat to commitment or fideism if pressed by rational analysis. Finally, religion contains an ethos of acceptance and defense of unquestionable doctrines, i.e., dogmas. (p. 106)

Because of Mahner and Bunge's presuppositions about the nature of the religious frame of mind they simply state that 'If genuine research takes place, such as historical investigation, this research is not accomplished by religious but scientific means even if undertaken by theologians' (Mahner & Bunge 1996a, p. 107). Good (2001) claims without any argument that the fact that some scientists are religious 'shows merely that some scientists are able to maintain their religious beliefs… while doing their work as a practicing scientist' (p. 5). Such conclusions as these seem to be based on assumptions about the religious habit of mind rather than on careful consideration of evidence about the consistency with which theologians and religious scientists carry out and think about their work. The structure of the argument they both use is something like this: If the scientific and religious habits of mind are like those described then it follows that all religious scientists must compartmentalise their different habits so that their religious attitude does not intrude into their scientific work. The conclusion only follows if the premise is true. It would also follow that if empirical evidence showed that the conclusion were not true then doubt would be cast on the premise. That Mahner and Bunge and Good have apparently not examined this empirical evidence demonstrates a lack of that scientific habit of mind which they are promoting.

One needs only to examine the writings of Christian scientists such as Berry, Jeeves and Polkinghorne to see that they scrutinise their religious beliefs as carefully as they do their scientific ones and take seriously the task of examining their compatibility (Jeeves & Berry 1998; Polkinghorne 1994; 2000; see, also Barbour 1998; Forster & Marston 1999). None of these writers have the problems (in areas such as cosmology, evolution, genetics and brain studies) that Good's true believer apparently has. They might, however, draw different philosophical implications from current scientific research than Good does.

While the notion of blind faith and the acceptance of unquestioned dogma correctly characterises some religious positions it does not seem possible to cast all religious thinking into the same mould. For some reason, Mahner &

Bunge (1996a) restrict their notion of religion to 'ordinary life religion' and 'are not interested in any sophisticated philosophical or theological conception of religion' (p. 105). However, their argument appears to be directed against all religious positions – both ordinary and sophisticated. If one applies the framework used above to portray scientific argument – namely, worldview elements, more central ideas, and more peripheral ideas – one can see that, just as in science, there will (necessarily) be notions or beliefs which lie deep in the conceptual structure of a religious position and which are substantially protected from criticism, at least in the first instance. Some of these will have to do with the existence of God and his relationship with the world and its people, with the role of religious books, and with the trustworthiness of the religious teacher one follows.

However, even these are not protected from scrutiny by religious scholars and the scholarly Christian literature contains sustained discussions about many of these basic concepts and how one should understand them. The acceptance of the importance of a religious book such as the Bible does not mean that one should not question how it is to be understood and debates in these and other areas use all the available tools of scholarship. The Christian philosopher, Wolterstorff (1976), asks 'What happens when incompatibility emerges for the Christian scholar between the results of science and what he regards as the belief-content of his authentic commitment?' (p. 88) and he points out (primarily to his Christian colleagues) that

> The possibilities of revision are two: he can revise his scientific views, even to the extent of setting out to reconstruct some branch of science; or he can revise his view as to what constitutes the belief-content of his authentic commitment, thereby also revising his actual commitment. For some time it may be unclear which of these is preferable. … (pp. 88–89)

> The scholar never fully knows in advance where his line of thought will lead him. For the Christian to undertake scholarship is to undertake a course of action that may lead him into the painful process of revising his actual Christian commitment, sorting through his beliefs, and discarding some from a position where they can any longer function as control. It may, indeed, even lead him to a point where his authentic commitment has undergone change. (pp. 92–93)

What is being advocated here is something other than 'blind faith' or 'acceptance of unquestionable dogmas'. It leads one to ask what is the basis of Good's and Mahner and Bunge's so confidently made assertions about the nature of the religious habit of mind. They do not appear to rest on a careful scrutiny of the writings of Christian scholars.

In the above discussion it has been argued that, when one considers a wider range of evidence than Good has done, the scientific and religious habits of mind are more similar to one another than he acknowledges. In both cases openness to argument and evidence, skepticism, rationality and objectivity are all held in high regard; in both some ideas are more protected from attack while others are more open to challenge; and in both, at any time, there are various degrees of commitment to theories from skeptical rejection to passionate endorsement. Both habits of mind stem from the same scholarly attitude and any difference between them is probably due to differences in what are counted as appropriate evidence and good reasons. For example, in the Christian religion historical evidence and evidence from human agency and self-awareness are more important than they apparently are in physics.

5. Metaphysics and Presuppositions of Science

Mahner & Bunge have argued vigorously that modern science presupposes a materialist metaphysics and that, without such a framework, science as we know it would be impossible (1996b, p. 190). They admit that it has not always been like this but that, as science developed, immaterial entities have been gradually eliminated from its theories. They assert, too, that even the theories of those scientists who claim to be theists apparently contain no such entities (1996b, p. 192). In a similar fashion Good's worldview assumption, 'that all of Nature, including all that occurs in our minds, can be studied and explained in rational, real terms' (2001, p. 9) appears to be understood in a materialist sense. He interprets his assumption in a way which eliminates non-material entities (things he labels 'imaginary') leaving only material entities such as 'plants', animals, rocks, etc. (which he labels 'real'). He claims that 'Nature has no interest in the supernatural beliefs of humans' (without realising that, since humans beings are part of nature and at 1east some of them have an interest in the supernatural, his statement, as it stands, cannot be true!) and that 'As long as religious beliefs include intervention (miracles, prayers answered) by supernatural agents, conflict with science, is inevitable'. (p. 9)

Even if one were to accept the claim that, for the past two or three centuries at least, science has been guided by a materialist framework one must distinguish two possible roles – ontological and methodological – for such a presupposition. One may see it as a statement of how things are – ontological materialism – or one may attempt to see how far one can get by assuming such a framework – methodological materialism. In the second one might well say that the framework of science at present is materialist *as far as is possible*.

It is not easy to see what evidence allows a presumption of ontological materialism to be made with such conviction. The present success of science is not sufficient to raise such an assumption to an incontrovertible maxim. Bunge's materialist theory of the mind (1980) is a clearly articulated set of proposals which at this stage provides the framework for a particular approach to research. Bunge himself described it as 'too new in the sciences of the mind to be anything other than a faith and a program but it is a reasonable faith rather than a groundless dogma, and it is a promising program rather than a device for discouraging research' (1980, p. 218). It is therefore presumably also too new to be taken as something which all should feel compelled at this stage to believe. Mahner & Bunge (1996a, b), as one of the reasons for disbelieving the existence of immaterial entities, rightly say that no account can be given yet of how such entities can interact with material entities. This appears to be a plausible rather than a compelling reason for eliminating them from scientific thinking. Similarly, Bunge's appeal to the law of conservation of energy as a reason for not believing in the existence of immaterial entities presumes that such a law will always continue to be true – something which itself may or may not be so. His own account of the nature of that law (Bunge 2000) suggests that it is true almost by definition rather than being true on the basis of empirical data. Thus on the basis of such arguments from the present state of scientific knowledge it does not seem to be possible to erect a metaphysics which everyone should be expected to adopt. The best one could expect from these arguments is that one should adopt such a materialism *as far as it is possible to do so* – that is, a methodological materialism – and leave open the possibility that something could emerge in the future which forces us to alter our understanding of the foundations on which we presume science to rest.

Bunge (1988) has argued that religious ideology would hinder the progress of science by, for example, introducing immaterial entities such as life essence, soul, and the like which cannot be investigated by science. However, it is not clear that this has happened. What is the empirical evidence that this has been the case for the last 400 years? Christians, adopting such an ideology, have been prominent in doing science successfully and in 17th century England this was overwhelmingly so (Merton, 1970). The claim that such Christians necessarily hold back the progress of science is simply a rhetorical one with little evidence to support it. It is based on a prior stipulation of what proper science involves and an unsubstantiated conception about the nature of the religious habit of mind.

In spite of their theistic beliefs many Christians happily endorse a view in which immaterial entities and causes are excluded from their theories and 17th century Christian scientists committed themselves to the pursuit of the new science on the basis of such a procedure (Merton 1970; Hooykaas 1972). Similarly, many 19th century Christians happily accepted, with few significant reservations, the Darwinian theory of biological descent (Moore 1979; Livingstone 1987) as being consistent with their worldview. A substantial proportion of Christian scientists then and now are certainly happy to see the world as a lawful entity which reflects God's creative and sustaining action and would see their whole-hearted participation in scientific activity as thoroughly consistent with their theological worldview rather than being at odds with it as Good and Mahner and Bunge seem to believe must be the case.

While possibly not willing to adopt the methodological materialism discussed above most Christians who are also scientists would adopt a 'methodological naturalism' which excludes reference to the supernatural *as far as is possible* from scientific activity (Thorson 2002a, b; but see the contrary view of Plantinga 1997). This allows the practice of science to continue in the successful mode it follows at present but does not eliminate by decree the possibility that such success might some day cease to follow from the use of such a methodological presupposition. It allows the serious promotion of views, argument and evidence which would be excluded if the scientific materialism of Bunge were to be elevated to unchallengeable dogma as Good appears to desire. In the present situation religious scientists who wish to introduce immaterial entities into their explanations of the world have to argue just as hard – but at least they are able to argue rather than be prevented from doing so by 'scientific' legislation. In the current situation all points of view in this debate are able to be presented and the scientific habit of mind, rightly conceived, ensures a fair hearing for all of them.

6. Educational Implications

If students are to be encouraged to develop scientific habits of mind to assist them in making decisions in an appropriate way then a richer version of the habits of mind which operate in science must be taught. Critical thought should not only be encouraged about those things which we as scientists, science educators and philosophers of science feel are incorrect or inappropriate but also about our and our students' presuppositions and the proposals which experts promote. Understanding scientific theories should precede any encouragement by the teacher in the classroom for students to accept them.

In the papers by Good and by Mahner and Bunge science education is characterised, in part, by the development of a scientific habit of mind and religious education is characterised, in part, by blind faith and unquestioning acceptance of dogma. There are indeed examples where these characterisations do apply but the evidence is that a great deal of science education is textbook driven and dogmatic and fails to develop critical thinking in spite of the encouragement from enlightened science educators (Rennie et al. 2001, p. 455). Rennie and her colleagues conclude that, in Australia at least, 'the actual picture was one of great variability, but overall, it was bleak'. The book edited by McComas (1998) was written as an attempt to rectify widespread deficiencies in particular aspects of present practice in science classrooms. Thus there is a difference between good and poor science education. Poor science education seems to be very much like the religious education described by Good and by Mahner and Bunge!

On the other hand there is evidence that good religious education is nothing like that described by Good and by Mahner and Bunge. Hill, a Christian philosopher of education, provides many examples of what he considers to be poor education but for him 'the development of a secular ideal of a general education for all, emphasising skills of social survival, critical rationality and a commitment to the welfare of persons in community has been a good thing. Any school, public or Christian, will strive to attain it' (Hill 1985, p. 80). Of the Christian school he asks 'Are students encouraged to examine critically both the faith-basis of the community of commitment which is sponsoring their own school, and the ideologies of their neighbours in the multi-faith society? If not', he says, '… they are not being educated but indoctrinated' (Hill 1985, p. 68). Elsewhere, he writes 'Not only is it good education to help students to weigh alternative points of view, but it is honoring to God to help them to become as responsible as they may for the decisions they make and the beliefs they decide to adopt'. (Hill 1982, p. 120) In a recent article dealing with the notion of indoctrination in Christian education Harkness (2002) shows that support for Hill's position is widespread among Christian thinkers. It is clear that this concept of education for Christians advocates the development of those habits of mind which, it has been claimed above, are common to all scholarship.

Good science education and good religious education are promoted by many science and religious educators but the outcomes in both types of classrooms shows how difficult this goal is to achieve. Good's portrayal of the attitude of many Christian students as dogmatic and uncritical describes also the attitude of many other students to the science they learn. Much has to be done in both areas to change this situation.

As a result of his analysis of the nature of science and of scientific and religious habits of mind Good (2001) draws the following three further implications for science education:

(a) teaching about the nature of science should be interwoven with the teaching of the scientific content;
(b) scientific habits of mind should be taught explicitly; and
(c) historical examples of the conflict between science and religion should be used to teach about the (supposedly) contrasting habits of mind in each.

The first of these suggestions is quite compatible with what has been said above. In the second, what has been said above about norms, counter-norms and the process of decision making in science would suggest that Good's portrayal of scientific habits of mind is somewhat limited and a fuller picture would do science education students a greater service (see, Gauld 1982). The third suggestion presumes that the conflict over, for example, the heliostatic model of the solar system in the 17th century and over evolution in the 19th century were simply the result of different habits of mind in scientists and Christians. However, closer scrutiny of the contexts shows that this was probably not the case. For example, Moore (1979) and Livingstone (1987) have shown that scientists and clergymen alike adopted all sorts of positions (both favourable and unfavourable) with respect to Darwin's proposals. Even the criticism of Darwin's theory by Bishop Samuel Wilberforce at the meeting of the British Association for the Advancement of Science in 1860 was probably more substantial and even-handed than is often portrayed (Gauld 1992). Historical examples, if they are to be used when teaching science, should reflect the best of historical scholarship rather than simply reproducing the myths deplored by Franklin (1986, pp. 1–3).

7. Conclusion

The model of the role of scientific habits of mind developed in this paper leads to different implications for education than those discussed by Good and by Mahner and Bunge. In the classroom the teacher usually chooses which things will be up for discussion and which will be left unchallenged. This will be the case whether science or religion is the topic under consideration. However, in exemplary instances of teaching in both cases, skills of critical inquiry and rational argument should also be taught and applied to the matters under discussion. The contrast in Good's paper (and also in those of Mahner and Bunge) is often between good science and poor religious education. Developing a respect for evidence (whether empirical or otherwise) and skills of critical inquiry should be an aim of good religious education as it is for good science education.

Note

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