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## Science: An Annotated Reading List

### Introduction

When the Gospel is brought for the first time into contact with a culture previously shaped by another vision, the missionary has to be aware of the differences between the two 'frameworks' and to find ways of making the message intelligible and challenging to the other culture as a whole. The missionary will seek to avoid two pitfalls. One is so to fail to understand the culture that the message is simply absorbed without posing a radical challenge. The second situation is what is often described as syncretism. It would be hard to deny that contemporary British (and most of western) Christianity is an advanced case of syncretism. The Church has lived so long as a permitted and even privileged minority, accepting relegation to the private sphere in a culture whose public life is controlled by a totally different vision of reality, that it has almost lost the power to address a radical challenge to that vision and therefore to 'modern western civilisation' as a whole. Looking at the world missionary situation as a whole, this failure is the most important and the most serious factor in the whole world situation, because this western culture has penetrated into every other culture in the world and threatens to destabilise them all. (Leslie Newbigin)<sup>1</sup>

Science - as both *the* method of knowing and *the* body of true knowledge - has long been a dominant force in public life. It is claimed - or just assumed - that real science is independent of the culture, politics, or religion of scientists. We have been taught that science is founded solely on empirical data ('facts') and logical rules of inference ('reason'). In short, secular science lays claim to a unique objectivity, and nothing else has ever marshalled such seductive credentials for cultural dominance. In the face of this challenge, the churches have gradually surrendered the public realm to control by secular presuppositions. Church and faith now belong solely within the private world. With no public rival, secular science has taken over the sacred, occupying the place, and playing the role, that formerly belonged to religion.

But Western humanism is increasingly showing the signs of being a spent force, and secular science is losing its hold. In the universities, the 'postmodernists' argue that all that we know - every truth claim, *even in science* - is socially and historically embedded. Furthermore, it is charged that Enlightenment rationality and scientific realism have served as ideological tools of oppression, *eg*, to legitimate Western economic and political dominance. Scepticism and suspicion characterises the postmodern world and science has not escaped. The spirit of scientific triumphalism has turned from proud badge to heavy burden. Outside the academic communities, other factors have led to a similar outcome. The quantitative and impersonal values which were once science's glory are now seen as less than human. The well-publicised scenarios of modern warfare, environmental degradation, and global pollution, are laid at science's door, leading to widespread public disenchantment and cynicism. The white-coated scientist is now often distrusted, and no longer appears in advertisements! On the whole, secular science is now rejected as an alternative to religion.

Yet, in the public realm, the rejection is ambivalent. Much in Western culture that we need to challenge and reform is still premised on the claim to 'scientific' objectivity and universality. Science may no longer be trusted to provide a metaphysics, or an ethic, but as the source of power (science *works*) and information (science *knows*) it has no effective, or acceptable, rival. Consequently the challenge to secular science is muted and the nature of its limitations subject to censorship. It is now permissible to mention the influence of feelings and emotions, of intuition and inspiration, of society and history, at least on the fringes of science - or to account for its failures! But it cannot yet be allowed that religion and philosophy are also important, even determinative. That admission cannot be indefinitely postponed: in common with all knowledge, the sciences *are* dependent on, and embedded in, frameworks of beliefs.

If we are serious about mission to the modern Western world, then we must raise a generation of world Christians who know the truth about science. They will not worship science, or be cowed by it, but nor will they denigrate it. They will affirm science, not as an autonomous, neutral enterprise, but as one of many realms for faithful discipleship, which must be held in a right relationship to all the other aspects of human life and service under God.

The aim of this bibliography is to provide an introductory guide to some of the significant studies, both Christian and secular, which address these vital issues.<sup>2</sup>

(Please note that inclusion on this list is not an endorsement.)

## 1 Worldviews and Worldview Analysis

In a secular world it is only too easy for us to limit the scope of our faith and ensure that Christian thinking has no formative impact beyond a 'religious' corner of life. But life is lived, and culture formed, under the control of some belief system or other. A failure to think Christianly will ensure that other - pagan - worldviews will shape our lives and world. At our place in history - late in a long period of secularisation and modernisation - there is no easy solution. Christian mission demands of us much hard work - the hard work of developing those critical biblical frameworks that will enable us to reflect Christianly and prayerfully on *all* of life and culture. Thankfully, much groundwork has been done; our task is to refine and extend that understanding as we put it to the test in our communities and schools, and in our daily life.

- (1)** Walsh, Brian and Middleton, Richard, *The Transforming Vision: Shaping a Christian World View*, Downers Grove, USA: IVP, 1984, 214 pp.

Still probably the best introduction to Christian worldview analysis. Noting that adulation of science, technology, and economic growth effectively shapes our public life and society, the authors long to see Christianity penetrate the structures of society, reforming and remoulding the culture. They provide essential tools for the task.

The authors have worked with InterVarsity Christian Fellowship (IVCF) in Canada. Walsh was the director of the worldview studies programme at the Institute for Christian Studies in Toronto.

- (2)** Wolters, Albert, *Creation Regained: A Transforming View of the World*, Leicester: IVP, 1985, 98 pp. Reprinted in 1996 for the Biblical Classics Library as *Creation Regained: Biblical Basics for a Reformational Worldview*, Carlisle: Paternoster, 98 pp.

Dr Wolters argues that the Bible provides a sure foundation for both thinking and living, which is vividly focused in the great themes of Creation, Fall and Redemption. Wolters applies this Biblical pattern to four topical issues: human aggression, spiritual gifts, human sexuality and dance.

Al Wolters is Professor of Religion and Theology, Redeemer College, Ancaster, Ontario, Canada.

- (3)** Sire, James, *The Universe Next Door: A Guidebook to World Views*, Leicester: IVP, 1997, 3rd edn, 237 pp (1st edn, 1976).

This book set the standard for a clear readable introduction to worldviews and it has been widely used as a college and university text. Sire covers Christian theism, deism, naturalism (including secular humanism and Marxism), nihilism, existentialism, Eastern pantheistic monism, the New Age, and postmodernism. See also Merve Jones, *The Universe Upstairs: A Cartoon Guide to World Views*, Leicester: Frameworks (IVP), 1991, 128 pp, which is based on Sire's book.

Sire is a campus lecturer for IVCF and senior editor at IVP (USA).

## 2 Religious Roots of Modern Science

- (4)** Clouser, Roy, *The Myth of Religious Neutrality: An Essay on the Hidden Role of Religious Belief in Theories*, Notre Dame: University of Notre Dame Press, 1991, 330 pp.

A radical reinterpretation of the relations between religion, philosophy, and science. Clouser claims that scientific and philosophical theories cannot help but have religious presuppositions that control and regulate them. He backs these claims by examining some of the most widely accepted theories in mathematics, physics and psychology. Free from jargon, but a penetrating work with exciting ideas for scholars in all disciplines.

Clouser (b 1937) is Professor of Philosophy and Religion, Trenton State College, Trenton, New Jersey.

- (5)** Kaiser, Christopher, *Creation and the History of Science*, London: Marshall Pickering, 1991, 316 pp.

A masterly survey of the relationship of the theology of creation to the history of science from the early Christian Fathers, through to Einstein and Bohr in the 20th century.

Kaiser is Professor of Historical and Systematic Theology, Western Theological Seminary, Holland, Michigan.

- (6)** Klaaren, Eugene, *Religious Origins of Modern Science: Belief in Creation in Seventeenth-Century Thought*, Grand Rapids: Eerdmans, 1977, 244 pp.

Klaaren argues that belief in divine creation constituted a definitive context within which the basic questions of the major figures in early modern science were raised, pursued, and developed. This belief in creation, far from being a mere forgotten assumption, was a forceful, motivating, determinative belief. (back cover)

Eugene Klaaren (b 1937) teaches in the Department of Religion, Wesleyan University, Middletown, Connecticut, USA.

- (7)** Hooykaas, Reijer, *Religion and the Rise of Modern Science*, Edinburgh: Scottish Academic Press, 1972, 162 pp.

An overview of the development of Western science in which Hooykaas argues that the Judaeo-Christian tradition exerted a healthy influence:

... one has to recognise as a simple fact that 'classical modern science' arose only in the western part of Europe in the sixteenth and seventeenth centuries ... Metaphorically speaking, whereas the bodily ingredients of science may have been Greek, its vitamins and hormones were biblical. (pp 161-162)

Hooykaas (1906-1994) was Professor of the History of Science at the University of Utrecht, Holland.

- (8)** Jaki, Stanley, *The Road of Science and the Ways to God*, Edinburgh: Scottish Academic Press, 1978, 478 pp.  
*Science and Creation: from Eternal Cycles to an Oscillating Universe*, Edinburgh: Scottish Academic Press, 1986, 2nd edn (SAC), 377 pp (1st edn, 1974).

Polemical works that claim an intimate connection between scientific creativity and the natural theology of Christian theism and provide an incredible wealth of stimulating analysis.

All great cultures that witnessed a stillbirth of science within their ambience have one major feature in common. They all were dominated by a pantheistic concept of the universe going through eternal cycles. By contrast, the only viable birth of science took place in a culture for which the world was a created, contingent entity ... The present and past of scientific history tell the very same lesson. It is the indispensability of a firm faith in the only lasting source of rationality and confidence, the Maker of heaven and earth, of all things visible and invisible. (SAC, p 357)

An assessment of Jaki and his work is provided by Paul Haffner, *Creation and Scientific Creativity: A Study in the Thought of S.L. Jaki*, Front Royal: Christendom Press, 1991.

Jaki, Hungarian-born scientist and Benedictine priest, is Professor of the History of Physics and Astronomy, Seton Hall University, New Jersey

- (9)** Pearcey, Nancy R. and Thaxton, Charles B., *The Soul of Science: Christian Faith and Natural Philosophy*, Wheaton, Illinois: Crossway Books, 1994, 298 pp.

One of the very best Christian books on the history of science. The authors show that science is never carried out in a philosophical and religious vacuum. They present a thorough case for the conclusion that Christian faith was a central root of modern science and they demonstrate that Christian convictions have very often motivated the scientific enterprise. They call for a renewed historical perspective and the rekindling of a Christian vision that claims all areas of life and scholarship.

Up to the turn of the century, Christianity was the dominant intellectual force in most areas of life and culture in the West. Christians were not a marginalised minority; they were the majority. The truth is that we cannot really understand a Newton, a Descartes, or a Cuvier without delving into the religious and philosophical ideas that drove their scientific work ... Not until the late nineteenth to early twentieth century did Christian faith lose its hold as a shared, public commitment and retreat to the realm of private, individual belief. (p xii)

Later chapters deal with the role of mathematics and with relativity, quantum mechanics and the DNA code.

Pearcey is a science writer and a contributing editor for the Pascal Centre for Advanced Studies in Faith and Science, Redeemer College, Ancaster, Ontario, Canada. Thaxton is a Visiting Professor at Charles University, Prague. He is a member of the American Chemical Society, the American Association for the Advancement of Science and the International Society for the Study of the Origin of Life, and a Fellow of the American Institute of Chemists.

The final three books in this section develop important theological critiques of the modern world. Their burden is that salient aspects of modern culture derive from a rejection of the Christian gospel and in particular of the Christian doctrine of creation. In order to mediate healing we need to understand why that rejection occurred and rediscover a truly trinitarian Christian theology.

- (10)** Sherrard, Philip, *The Eclipse of Man and Nature: An Enquiry into the Origins and Consequences of Modern Science*, West Stockbridge, Massachusetts, USA: Lindisfarne Press, 1987, 124 pp.

The main purpose of this short book is twofold. It is to show, first, how the worldview of modern science ... has its roots in certain prior developments in Christian theology that partially eclipsed the full Christian understanding of man and his destiny; and, second, how the acceptance and implementation of this scientific worldview have resulted in an ever-accelerating dehumanisation of man and of the forms of his society, with all the repercussions this has had, and is still having, in the realm of nature. (p 15)

Philip Sherrard is a theologian, historian and translator of poetry.

- (11)** Gunton, Colin, *The One, the Three and the Many: God, Creation and the Culture of Modernity*, Cambridge: CUP, 1993, 248 pp.

Demonstrates that the distinctive shape of modernity's disengagement from the world - its fragmentation of culture and decline into subjectivism and relativism - derive from its rebellion against the Christian doctrine of creation. He argues that only a rediscovered doctrine of the Trinity can make unitary systematic sense of the world and place human beings in rich relationships within it.

Gunton is Professor of Christian Doctrine at King's College, University of London.

**(12)** Torrance, Thomas, *Reality and Scientific Theology*, Edinburgh: Scottish Academic Press, 1985, 206 pp.

A fascinating study of the deeply natural relations between knowledge of God and that of His world.

Torrance is Emeritus Professor of Christian Dogmatics, University of Edinburgh, and former Moderator of the General Assembly of the Church of Scotland. He has been greatly influenced by Michael Polanyi (24) and is his Literary Executor.

### 3 History of Science

**(13)** Shapin, Steven, *The Scientific Revolution*, Chicago: University of Chicago Press, 1996, 218 pp.

Currently the most concise and readable introduction to the history and philosophy of science (165 pages of text with very few footnotes!). The text is followed by a marvellous *Bibliographic Essay* (45 pages) which will guide those interested to the relevant historical work. Shapin presents a science that is human, that emerged from a wide array of early modern philosophical agendas, political commitments, and religious beliefs, that is 'the contingent, diverse, and at times deeply problematic product of interested, morally concerned, historically situated people' (p 165). Nevertheless, he does not seek to dismiss or discount science - he concludes with a strong affirmation - but to accept it for what it is, and not for what the popular fables and myths would have it to be.

Shapin, an historian, is now Professor of Sociology at the University of California, San Diego. In the early 1970s he was one of the founders of the 'strong programme' at the University of Edinburgh's Science Studies Unit (see section 6). He has also written *A Social History of Truth*, (46) below.

**(14)** Brooke, John, *Science and Religion: Some Historical Perspectives*, Cambridge: CUP, 1991, 422 pp.

A good introduction and guide to the relationship between science and religion, but not as satisfactory a treatment of science as Shapin's. Comprehensive in scope, the special feature of Brooke's book is its demonstration of the subtlety, complexity and diversity of the interaction. Also contains a valuable *Bibliographic Essay* (pp 348-403). See also the interchange between Brooke and some of his critics in (17) below.

Brooke is senior lecturer in history of science at the University of Lancaster.

- (15)** Russell, Colin, *Cross-Currents: Interactions between Science and Faith*, Leicester: IVP, 1985, 272 pp. Reissued, London: Christian Impact, 1995, with a New Prefatory Note, pp 11-12.

Shorter than Brooke and geared to the layman, it explores the powerful historical evidence of a massive mutual debt between Christianity and science. Like Brooke's, his appraisal of science itself is less adequate.

Russell is Emeritus Professor of the History of Science and Technology at the Open University and Director of the European Centre for the History of Chemistry.

- (16)** Lindberg, David and Numbers, Ronald (eds), *God and Nature: Historical Essays on the Encounter between Christianity and Science*, Berkeley: University of California Press, 1986, 516 pp.

In 18 essays, especially prepared for this book, an international group of historians cover the period from the early church to the 20th century. They support the editors' conviction that the interaction of science and Christianity has been of profound importance in the shaping of Western civilisation, and that their complex and diverse relations defy reduction to simple 'conflict' or 'harmony'. Many of the popular stereotypes are here refuted and the essays reflect the growing inclination of scholars to take science down from its traditional pedestal and treat it as intrinsically no different from any other kind of knowledge.

The editors are at the University of Wisconsin-Madison, Lindberg (b 1935) as Professor of the History of Science, and Numbers (b 1942) as Professor of the History of Medicine and the History of Science.

- (17)** Van der Meer, Jitse (ed), *Facets of Faith and Science*. Vol 1: *Historiography, and Modes of Interaction*, 396 pp; Vol 2: *The Role of Beliefs in Mathematics and the Natural Sciences: An Augustinian Perspective*, 357 pp; Vol 3: *The Role of Beliefs in the Natural Sciences*, 306 pp; Vol 4: *Interpreting God's Action in the World*. 420 pp. Ancaster, Ontario: Pascal Centre for Advanced Studies in Faith and Science/Lanham, MD: University Press of America, 1996.

This collection of essays contains conflicting perspectives on whether and how science and religion interact. Volume 2 contains articles that provide excellent background on the perspective adopted in the SCT papers.

Van der Meer is Professor of Biology and Director of the Pascal Centre, Redeemer College, Ancaster, Ontario.

- (18)** Koestler, Arthur, *The Sleepwalkers: A History of Man's Changing Vision of the Universe*, London: Penguin, 1964, 623 pp (First published in 1959).

Subject to much criticism, but nevertheless contains some insightful analysis and remains one of the most readable books on the history of Western science:

... all cosmological systems, from the Pythagoreans to Copernicus, Descartes and Eddington, reflect the unconscious prejudices, the philosophical or even political bias of their authors; and from physics to physiology, no branch of Science, ancient or

modern, can boast freedom from metaphysical bias of one kind or another ... The history of cosmic theories, in particular, may without exaggeration be called a history of collective obsessions and controlled schizophrenias; and the manner in which some of the most important individual discoveries were arrived at reminds one more of a sleepwalker's performance than an electronic brain's. (p 11)

Koestler (1905-1987) was a Hungarian-born, British novelist, journalist and critic, several of whose later works were concerned with science and creativity.

## 4 Philosophy of Science

- (19) Chalmers, Alan, *What is this Thing called Science? An Assessment of the Nature and Status of Science and its Methods* (WTS), Milton Keynes: Open University Press, 1982, 2nd edn, 179 pp (1st edn 1978).  
*Science and its Fabrication*, Open University Press, 1990, 142 pp.

WTS is an excellent and lucid summary of the debates:

Modern developments in the philosophy of science have pinpointed and stressed deep-seated difficulties associated with the idea that science rests on a sure foundation acquired through observation and experiment and with the idea that there is some kind of inference procedure that enables us to derive scientific theories from such a base in a reliable way. There is just no method that enables scientific theories to be proven true or even probably true ... there is no method that enables scientific theories to be conclusively disproved either ... those episodes in the history of science that are commonly regarded as most characteristic of major advances ... have not come about by anything like the methods typically described by philosophers. (WTS, pp xvi-xvii).

English-born (1939) physicist turned philosopher, Chalmers is now an Australian citizen and Associate Professor of History and Philosophy of Science at the University of Sydney.

- (20) Laudan, Larry, *Science and Relativism: Some Key Controversies in the Philosophy of Science* (SR), Chicago: University of Chicago Press, 1990, 180 pp.  
*Beyond Positivism and Relativism: Theory, Method and Evidence* (BPR), Boulder, CO: Westview Press, 1996, 277 pp.

SR is written as a dialogue between four scholars: Rudy Reichfeigl, a positivist (cf. Rudolf Carnap, Hans Reichenbach, Herbert Feigl), Karl Selnam, a realist (cf. Karl Popper, Wilfrid Sellars, Hilary Putnam), Quincy Rortabender, a relativist (cf. Willard Quine, Richard Rorty, Paul Feyerabend), and Percy Lauwey, a pragmatist (cf. C.S. Peirce, Laudan himself, John Dewey). A useful and enjoyable mapping of the debate, but, like BPR, SR is designed to affirm rationality in science (in the sense of rational progress).

- (21) Gjertsen, Derek, *Science and Philosophy Past and Present*, London: Penguin, 1989, 296 pp.

A penetrating and original study of the manner in which science and philosophy have interacted over the centuries. Gjertsen concludes that science is not, nor has it ever been, the monolithic and stable structure of legend.

**(22)** Toulmin, Stephen, *The Philosophy of Science: An Introduction*. London: Hutchinson's University Library, 1953, 176 pp.

**(23)** Hanson, Norwood Russell, *Patterns of Discovery: An Enquiry into the Conceptual Foundations of Science*. Cambridge: CUP, 1958, 241 pp.

If any books can be said to have launched the modern revolution in the philosophy of science in the English-speaking world, then these are they. Hanson's is a classic statement of the view that facts are theory-laden. For Toulmin today, see his *Cosmopolis: the Hidden Agenda of Modernity* (New York Free Press, 1990, 228 pp) which presents a postmodernist reappraisal of the last three centuries of Western history.

Toulmin, a former physicist, is now Avalon Foundation Professor in the Humanities at Northwestern University, USA.

Russ Hanson (1924-1967) was Professor of Philosophy at Yale University.

**(24)** Polanyi, Michael, *Personal Knowledge: Towards a Post-Critical Philosophy* (PK), London: Routledge & Kegan Paul, 1958, 428 pp.

*The Tacit Dimension* (TD), London: Routledge & Kegan Paul, 1967, 108 pp (First published by Doubleday in 1966).

The contribution of Polanyi has been almost invisible in the philosophy of science, but these are hugely important works. Polanyi argues that the complete objectivity attributed to the exact sciences is a delusion and is in fact a false ideal. The reality is that we participate personally in all our knowledge in ways that can never be fully specified. Acts of discovery are embedded in matrices of personal commitments which we *indwell* in order to explore reality. In this indwelling we focus on a coherent whole and are then only tacitly and subsidiarily aware of the details. The other works cited in this section support the conviction that faith plays an intrinsic role in science, but it is Polanyi who really develops this insight.

We must now recognise belief once more as the source of all knowledge. Tacit assent and intellectual passions, the sharing of an idiom and of a cultural heritage, affiliation to a like-minded community: such are the impulses which shape our vision of the nature of things on which we rely for our mastery of things. No intelligence, however critical or original, can operate outside such a fiduciary framework. (PK p 266)

Science is a system of beliefs to which we are committed. (PK p 171)

The effort of knowing is ... guided by a sense of obligation towards the truth: by an effort to submit to reality. (PK p 63)

... we can know more than we can tell. (TD p 4)

... it is not by looking at things, but by dwelling in them, that we understand their joint meaning. (TD p 18).

Despite his enormously insightful analysis, Polanyi still claims that in the end direct experience connects the elements of the system of modern science and guarantees its reliability, even though for each individual most of their knowledge must be held on trust. For a critique of this claim see Shapin (46).

Lucid introductions to Polanyi are provided by Drusilla Scott (*Everyman Revived: The Common Sense of Michael Polanyi*, Lewes: Book Guild, 1985, 215 pp, Grand Rapids: Eerdmans, 1996, 223 pp) and by Richard Allen (*Thinkers of Our Time: Polanyi*, London: Claridge Press, 1990, 88 pp). The writings of Marjorie Grene (66) and Thomas Torrance (12) are also indebted to Polanyi.

Born in Hungary, Michael Polanyi (1891-1976) was an outstanding physical chemist before becoming an equally distinguished philosopher.

- (25)** Popper, Karl, *The Logic of Scientific Discovery* (LSD), London: Hutchinson, 1959 480 pp (First published in German, *Logik der Forschung*, Vienna, 1934).  
*Conjectures and Refutations: The Growth of Scientific Knowledge* (CR), London: RKP, 1974, 5th edn, 431 pp (1st edn, 1963).  
*Objective Knowledge: An Evolutionary Approach* (OK). Oxford: OUP, 1979, 2nd edn, 395 pp (1st edn, 1972).  
*The Myth of the Framework: In Defence of Science and Rationality* (MF), London: Routledge, 1994, 230 pp.

Popper received little esteem from the philosophical establishment but, uniquely, his ideas were accepted with acclaim by many scientists. He set out to vindicate the rationality of science and his first and major contribution concerned the demarcation of science from non-science. Popper argued that whilst no amount of positive evidence can prove a theory (*verificationism*), or even render it probable, a single item of negative evidence can show it to be false (*falsificationism*). Popper spent the rest of his long life defending and pursuing the implications of that central insight. For a Popperian, science is no longer a corpus of established *knowledge*; it is a set of as-yet-unfalsified *conjectures* selected, arbitrarily (non-rationally), out of the infinite reservoir of such conjectures. It is not the provider of reliable *truths*, but the reliable eliminator of *falsehoods*.

I think that we shall have to get accustomed to the idea that we must not look upon science as a 'body of knowledge', but rather as a system of hypotheses; that is to say, as a system of guesses or anticipations which in principle cannot be justified, but with which we work as long as they stand up to tests, and of which we are never justified in saying that we know that they are 'true' or 'more or less certain' or even 'probable'.  
(LSD p 317)

... it must be possible for an empirical scientific system to be refuted by experience.  
(LSD p 41)

A theory which is not refutable by any conceivable event is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.  
(CR p 36).

Popper also argued that the 'facts' are open to diverse interpretations. Theory

(however rudimentary) always precedes observation, so that there are no 'raw' (uninterpreted) facts. Consequently, even falsificationism can fail in practice: a refutation may be refuted – reinterpreted by a different theory – and the rejected theory reinstated.

I believe that theory ... always comes first ... we do not start from observations but always from *problems* ... *the growth of knowledge proceeds from old problems to new problems, by means of conjectures and refutations.* (OK p 258)

... there is no such thing as an uninterpreted observation, an observation which is not theory-impregnated. (MF p 58)

Overall, the crucial question for Popper concerned not the status of science, but the exercise of power in society, and how the misuse of power can be prevented. The essence of his 'Open Society' is the freedom to critically scrutinise all ideas without fear. The science he admired and supported operates *only* when scientists are free to critically evaluate *all* theories without worrying about their access to jobs, journals and funding. The problem is that science, as we know it today, does not meet that ideal.

*I hold that orthodoxy is the death of knowledge, since the growth of knowledge depends entirely on the existence of disagreement* ... discussion between people who share many views is unlikely to be fruitful, even though it may be pleasant; while a discussion between vastly different frameworks can be extremely fruitful, even though it may sometimes be extremely difficult, and *perhaps* not quite so pleasant (though we may learn to enjoy it). (MF pp 34-35)

A good introduction to Popper is provided by Bryan Magee, *Popper*, London: Fontana (Collins), 1973, 109 pp.

Sir Karl Popper (1902-1994) was Professor of Logic and Scientific Method at the London School of Economics.

**(26)** Lakatos, Imre, Falsification and the methodology of scientific research programmes, in Imre Lakatos and Alan Musgrave (eds), *Criticism and the Growth of Knowledge*, London: CUP, 1970, pp 91-196, and in John Worrall and Gregory Currie (eds), *Imre Lakatos, Philosophical Papers, Vol. 1, The Methodology of Scientific Research Programmes*, Cambridge: CUP, 1978, pp 8-101.

Lakatos sought to strengthen Popper's rationalist programme by introducing two pairs of distinctions - between the 'hard core' and 'protective belt' of a research programme ('paradigm' in one of Kuhn's senses), and between 'progressive and degenerating problem shifts'. The 'hard core' is the set of basic assumptions which are normally never questioned, whereas the 'protective belt' consists of auxiliary hypotheses, initial conditions etc. which will be modified or replaced if necessary. Research programmes are 'progressive' if they lead to the discovery of new phenomena, 'degenerating' if they do not. It can be doubted that Lakatos succeeded in bolstering the Popperian programme, but his distinctions are valuable and have been helpfully employed.

Lakatos (1922-1974) was Professor of Logic, University of London.

**(27)** Kuhn, Thomas S, *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press, 1970, 2nd edn, 210 pp (1st edn, 1962).

Kuhn is perhaps the most significant figure in that his seminal book gave rise to most of the later developments, and his ideas have influenced almost every discipline. He placed the issue of scientific change at the centre of attention and attacked the individualist mythology. The scientist is no solitary hero or heroine facing the facts. He or she lives in a research community whose membership is defined by loyalty to a *paradigm*. Paradigms are complex conceptual systems within which scientific activity is initiated, and by which it is directed and dominated. Put another way, paradigms are networks of commitments which scientific communities hold and propagate dogmatically. They are used and taken for granted by every scientist. We have no access to a paradigm-free reality, and so our location within a particular paradigm, and the historical shifts from one paradigm to another, are fundamentally non-rational.<sup>3</sup>

The competition between paradigms is not the sort of battle that can be resolved by proofs. (p 148)

... the proponents of competing paradigms practice their trades in different worlds ... in some areas they see different things, and they see them in different relations one to the other. (p 150)

The transfer of allegiance from paradigm to paradigm is a conversion experience that cannot be forced. (p 151)

Kuhn concedes that these paradigms include unproven (and even unprovable) metaphysical commitments, but a weakness of his expositions is that his paradigms apply only to scientists. He does not represent his scientists as being influenced by the worldview values and beliefs of their social and cultural context; nor are they ideologically involved in social, economic, or political issues. They appear to confront only nature and their scientific colleagues.

Not surprisingly, Kuhn has been interpreted as a relativist and as a proponent of the social construction of science – certainly, the sociology of knowledge (see (44)-(46) below) arises out of his more radical tendencies. However, his own position is uncertain; Kuhn definitely rejected social constructivism. He also appeared to retain a belief in scientific progress, *ie* that later paradigms are better than earlier ones, but there is no basis for that belief in his exposition.

Kuhn (1922-1996) was a theoretical physicist (at Harvard) before becoming an historian and philosopher of science. He was Laurance S. Rockefeller Professor of Philosophy at Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, from 1983-1991 (Emeritus).

**(28)** Feyerabend, Paul, *Against Method: Outline of an Anarchistic Theory of Knowledge* (AM), London: Verso, 1975, 339pp (2nd edn, 1988, 296 pp (AM2)).  
*Science in a Free Society*, London: New Left Books, 1978, 221 pp.

Feyerabend developed the Popperian tradition to its limit, to an outright and provocative irrationalism. He argued that there is no universal scientific method, that the scientific is not a unique kind of objective knowledge, and that it is impossible either to prove or disprove scientific theories. In the end all procedures and conclusions are equally valid (or invalid).

To those who look at the rich material provided by history ... it will become clear that there is only *one* principle that can be defended under *all* circumstances and in *all* stages of human development. It is the principle: *anything goes*.

(AM pp 27-28; AM2 p 19)

Ideas which today form the very basis of science exist only because there were such things as prejudice, conceit, passion; because these things *opposed reason*; and because they were *permitted to have their way*.

(AM p 179; cf AM2 p 121)

... the separation of state and *church* must be complemented by the separation of state and *science*, that most recent, most aggressive, and most dogmatic religious institution.

(AM p 295).

Feyerabend (1924-1994), at one time a student of mathematics, physics and astronomy, was a professor of philosophy in the University of California at Berkeley from 1958. His autobiography appeared posthumously (*Killing Time*, Chicago: University of Chicago Press, 1995, 192 pp).

**(29)** Lewis, C S, *The Discarded Image: An Introduction to Medieval and Renaissance Literature*, Cambridge: CUP, 1964, 232 pp.

An exposition of the medieval worldview as a guide to appreciating medieval and Renaissance literature. This leads Lewis to reflect on the character of all cosmic images including our own. He concludes that worldview changes precede and direct changes in science:

When I was a boy I believed that 'Darwin discovered evolution' and that the far more general, radical, and even cosmic developmentalism which till lately dominated all popular thought was a superstructure raised on the biological theorem. This view has been sufficiently disproved ... The demand for a developing world - a demand obviously in harmony with the revolutionary and the romantic temper - grows up first; when it is full grown the scientists go to work and discover the evidence on which our belief in that sort of universe would now be held to rest ... The new Model will not be set up without evidence, but the evidence will turn up when the inner need for it becomes sufficiently great. It will be true evidence. But nature gives most of her evidence in answer to the questions we ask her. Here, as in the courts, the character of the evidence depends on the shape of the examination, and a good cross-examiner can do wonders. He will not indeed elicit falsehoods from an honest witness. But, in relation to the total truth in the witness's mind, the structure of the examination is like a stencil. It determines how much of that total truth will appear and what pattern it will suggest.

(pp 220-223).

Lewis (1898-1963) was Professor of Medieval and Renaissance English Literature at Cambridge University.

**(30)** Radnitzky, Gerard, *Contemporary Schools of Meta-Science*, Chicago: Regnery, 1973, 3rd edn, 446 pp (1st edn, 1968).

Scientific research is influenced by a wide range of factors. Internal factors belong to the researchers themselves (*internal steering field*) and include world-picture hypotheses in the broadest sense - philosophical worldviews and anthropologies (images of man) - which are not testable and may be totally inarticulated (pp 379-419).

Radnitzky is a philosopher at Gothenburg University, Sweden.

**(31)** Putnam, Hilary, *Reason, Truth and History*. Cambridge: Cambridge University Press, 1981, 222 pp.

Putnam sets out to demolish such distinctions as 'facts and values' and 'objective and subjective'. He is radically opposed to the idea that it is possible to discover 'neutral facts' that do not contain any bias or 'value judgment':

The idea that values are not part of the Furniture of the World and the idea that 'value judgments' are expressions of 'prejudice' are two sides of the same coin ... The position that I have defended is that any choice of a conceptual scheme presupposes values, and the choice of a scheme for describing ordinary interpersonal relations and social facts, not to mention thinking about one's own life plan, involves, among other things, one's *moral* values. (p 215)

Later books, notably *Renewing Philosophy* (Cambridge, Mass: Harvard University Press, 1992, 234 pp) and *Pragmatism: An Open Question* (Oxford: Blackwell, 1995, 106 pp), refer to these issues.

Hilary Putnam (b 1926) began his teaching career as a philosopher of science and has written extensively on mathematics and physics (notably on quantum logic). He is now Walter Beverly Pearson Professor of Mathematical Logic in the Department of Philosophy at Harvard University. A practicing Jew, he is married to American moral philosopher Ruth Anna Putnam.

**(32)** Stafleu, Marinus, *Theories At Work: On the Structure and Functioning of Theories in Science, in particular during the Copernican Revolution*. Lanham: University Press of America, 1987, 310 pp.

A wide-ranging and instructive analysis within the Dooyeweerdian Christian tradition (expounded in (4) above). See also his systematic analysis of the foundations of physics in *Time and Again* (Toronto: Wedge, 1980, 237 pp).

Stafleu is a Dutch physicist and philosopher of science. He is Director of the Department of Science, Mathematics, and Health Education at the Hogeschool, Utrecht, Netherlands.

**(33)** Moreland, James, *Christianity and the Nature of Science: A Philosophical Investigation*, Grand Rapids: Baker Book House, 1989, 270 pp.

A wide-ranging and stimulating book and one of the best Christian introductions to the philosophy of science. Argues that there is no single scientific method, nor any final way of demarcating the scientific from the non-scientific. Demonstrates that philosophy, science and theology interact in a number of ways and that the idea of 'Christian science' cannot be dismissed as just disguised religion.

The idea that science is a rational, truth-seeking discipline and theology is not is a widespread cultural myth. This myth often is promulgated by contending that science gains its status by its privileged use of a specific methodology not available to theology. But such a claim is itself a myth - the myth of ostrich scientism - that needs to be laid to rest. (p 101)

Moreland (b 1948) is Professor of Philosophy at Talbot School of Theology, Biola University, La Mirada, California, USA.

**(34)** Poole, Michael, *A Guide to Science and Belief*, Oxford: Lion, 1990, 128 pp.

A comprehensive popular guide, though too uncritical of modern science.

Michael Poole is a visiting research fellow, King's College, University of London.

## 5 Secular Critiques of Science

**(35)** Schuster, John and Yeo, Richard (eds), *The Politics and Rhetoric of Scientific Method: Historical Studies*, Dordrecht: D Reidel (Kluwer), 1986, 305 pp.

The myth that there is a single, privileged 'scientific method' is most thoroughly exposed .... (John Brooke)

Schuster is Reader in History of Science and Coordinator of the History and Philosophy of Science Research Group, University of Wollongong, Wollongong, New South Wales, Australia.

**(36)** Greene, John C, *Science, Ideology, and World View: Essays in the History of Evolutionary Ideas*, Berkeley: University of California Press, 1981, 202 pp.

These essays - written by this well-known American historian over a period of 23 years - demonstrate that science is not immune from worldviews. The dangers of ignoring this interplay are also spelt out:

... scientists share the general preconceptions of their time; that these preconceptions change not simply because of new scientific discoveries, which are always subject to more than one interpretation, but more through the influence of alternative views of nature coexisting with the dominant view; that crises generated by the discovery of anomalous facts are not prerequisite to the elaboration of counterparadigms; that anomalous facts challenge world views as well as specific scientific theories and encounter opposition, even among scientists, for that reason; that the typical response to the challenge of anomalous facts is a compromise theory that minimises the damage to traditional assumptions; that the challenge to a reigning paradigm may develop largely outside the relevant scientific community; that national intellectual and cultural traditions may predispose the scientists of a given nation to push their speculations in one direction rather than another... (p 5)

Greene is an historian at the University of Connecticut.

**(37)** Harding, Sandra, *Whose Science? Whose Knowledge?: Thinking from*

*Women's Lives* (WS). Milton Keynes: Open University Press, 1991, 319 pp.  
*The 'Racial' Economy of Science: Towards a Democratic Future* (RES).  
 Bloomington: Indiana University Press, 1993, 526 pp.

Leading feminist critiques of science. Accepts the social-situatedness of all knowledge, but denies that this can only lead to complete cultural relativism. She argues for a 'strong objectivity' (WS p 42):

A stronger, more adequate notion of objectivity would require methods for systematically examining all of the social values shaping a particular research process, not just those that happen to differ between the members of a scientific community. Social communities, not either individuals or "no one at all," should be conceptualised as the "knowers" of scientific knowledge claims. Culturewide beliefs that are not critically examined within scientific processes end up functioning as evidence for or against hypotheses. (RES p 18)

REC brings together a wide range of classic and recent essays on the historical and social-situatedness of science.

Harding is Professor of Philosophy and Director of Women's Studies at the University of Delaware.

The following three books come from the (socialist) radical science movement:

**(38)** Hales, Mike, *Science or Society?: The Politics of the Work of Scientists*, London: Free Association Books, 1986, 282 pp (First published by Pan Books in 1982).

A polemical, but sophisticated, overview of the relations between science and society. Hales argues that expert knowledge is political at every level and that grasping this fully raises the possibility of bringing the process of innovation under wider democratic control.

Mike Hales has studied technology and operational research and holds a doctorate in history and social studies of science. The book was commissioned in conjunction with a Channel 4 TV series *Crucibles: Science in Society*.

**(39)** Levidow, Les (ed), *Science as Politics*, London: Free Association Books, 1986, 180 pp.

The authors argue that it is not simply the case that science may be used ('abused') for political ends, but that political forces shape science and technology - the practitioners, the research questions, the conceptual frameworks, the funding institutions that promote certain directions, and the official histories of their progress. The many ways in which science is political is illustrated by reference to the Copernican revolution, social Darwinism, Neils Bohr and Salvador Luria amongst others.

Les Levidow is an editor at *New Association Books*.

**(40)** Gill, Dawn & Levidow, Les (eds), *Anti-Racist Science Teaching*, London: Free

Association Books, 1987, 324 pp.

Anti-racist approaches have been charged with illegitimately 'dragging politics into science'. The authors reject the charge, arguing that science and technology embody distinctive cultural values and assumptions, including racist ones. These are reflected in school science curricula and methods of assessment.

The world-view reflected through school curricula - and the science curriculum in particular - is rooted in Britain's colonial past and its global economic interests today. It is this perspective which underpins racism, sexism and class inequality. (p 4)

Dawn Gill is a geography teacher, has worked on curriculum development in a range of studies, and was on the ILEA anti-racist strategies team from 1983-1986.

The following two books by professional writers attracted much attention when they were first published. They were dismissed by many scientists, but acclaimed by some. The topics are as important as their assessments are controversial.

**(41)** Saul, John Ralston, *Voltaire's Bastards: The Dictatorship of Reason in the West*, London: Sinclair-Stevenson, 1992, 640 pp.

A passionate and personal tour through the last 400 years. He argues that the love affair with reason, that was expected to lead to new rational elites who could build a new civilisation, has led, rather, to coercion, control - and inhumanity.

... among the illusions which have invested our civilisation is an absolute belief that the solution to our problems must be a more determined application of rationally organised expertise. The reality is that our problems are largely the product of that application.

(p 8)

Saul is best known as a novelist (*The Birds of Prey*, *Baraka*, *The Next Best Thing*, *The Paradise Eater*).

**(42)** Appleyard, Bryan, *Understanding the Present: Science and the Soul of Modern Man*, London: Pan Macmillan, 1992, 283 pp.

Appleyard maintains that science has had a central role in shaping our lives and beliefs, but that for 400 years it has assaulted our view of ourselves and the universe, wreaking appalling spiritual damage and threatening to do even worse. Superficially anti-science and thereby easily misunderstood, it is no wonder that some scientists have reacted against the book in horror. But Appleyard writes insightfully and his book deserves to be carefully read and weighed.

Appleyard (b 1951) is best known as a features writer whose pieces appear in many newspapers and magazines.

**(43)** Midgley, Mary, *Science as Salvation: A Modern Myth and its Meaning*, London: Routledge, 1992, 239 pp.

A sharp and witty critique of the high spiritual ambitions which tend to gather around

the notion of science.

A moral philosopher, Midgley (b 1919) was formerly senior lecturer in the Philosophy Department at the University of Newcastle upon Tyne. See also her *Wisdom, Information, and Wonder: What is Knowledge For?* (London: Routledge, 1989, 275 pp) and (71) below.

The earlier developments in the philosophy of science ((22) to (28) above) led on into the sociology of knowledge, which, since the 1970s, has been a rapidly expanding field of research. A key development - now known as the 'Edinburgh school' - originated when the sociologist Barry Barnes, philosopher of science David Bloor, and historian Steven Shapin were brought together in the early 1970s on the staff of the Science Studies Unit at the University of Edinburgh. Also associated with them are Trevor Pinch (Science Studies Department, Cornell University, New York), Harry Collins (Professor of Sociology, University of Southampton) and Steve Fuller (Professor of Sociology, University of Durham). They argue that all knowledge - even scientific knowledge - has an irreducible social component. At an extreme (the 'strong programme' or 'strong thesis'), it is argued that there is no supra-social standard and that all knowledge rests on a social consensus which has no necessary connection with truth. However, they insist that they are anti rationalist philosophy, not anti science. They affirm the validity of the scientific enterprise, but regard it as a much richer and more diverse affair than that portrayed in the rationalist accounts.<sup>4</sup> The literature is already vast; the following works are good starting points which give ample references to the rest of the literature.

**(44)** Bloor, David, *Knowledge and Social Imagery*, Chicago: University of Chicago Press, 1991, 2nd edn, 203 pp (1st edn, London: Routledge & Kegan Paul, 1976, 156 pp).

One of the general and classic statements of the 'strong thesis' that tackles the many objections and gives a wealth of references.

Bloor is Reader at the University of Edinburgh's Science Studies Unit and one of the founders of its 'strong programme'

**(45)** Barnes, Barry, Bloor, David and Henry, John, *Scientific Knowledge: A Sociological Analysis*, London: Athlone Press, 1996, 230 pp.

An introductory text for graduate students, it provides a systematic account of the importance of sociology for the understanding of the scientific enterprise. It takes no vocabulary or background knowledge for granted so, although demanding, it should be accessible to anyone with an interest in the issues. The authors' main method is to focus on a number of historical case studies which are fascinating in themselves.

Barnes is Professor of Sociology at the University of Exeter, but in the early 1970s was another of the founders of the 'strong programme' at Edinburgh. Henry is Senior Lecturer at the University of Edinburgh's Science Studies Unit.

**(46)** Shapin, Steven, *A Social History of Truth: Civility and Science in Seventeenth-Century England*, Chicago: University of Chicago Press, 1994, 483 pp.

This is a detailed case study, but one that is constantly alive to wider issues. It is a

fascinating work. Harry Collins' assessment (in *Nature*) was that, 'Anyone who wants to understand the origins and meanings of modern science should read this book.', but others have questioned Shapin's account (e.g. John Schuster and Alan Taylor, *Blind trust: the gentlemanly origins of experimental science*, *Social Studies of Science*, **27** (3), 1997, pp 503-536). What Shapin establishes is the enduring and irreplaceable importance of trust, testimony and authority even in science.

Both seventeenth-century and present-day 'moderns' widely advertise direct experience as the surest grounds for factual knowledge, just as they identify reliance upon the testimony of others as an insecure warrant for such knowledge. Similarly, both sets of 'moderns' celebrate proper science as a culture which has indeed rectified knowledge by rejecting what others tell us and seeking direct individual experience. In contrast, I argue that no practice has accomplished the rejection of testimony and authority and that no cultural practice recognisable as such could do so. (p xxv)

Shapin is Professor of Sociology at the University of California, San Diego. For another key work by Shapin, see (13).

- (47)** Latour, Bruno, *Science in Action: How to Follow Scientists and Engineers through Society*, Cambridge, Mass: Harvard University Press, 1987, 274 pp.  
 Latour, Bruno and Woolgar, Steve, *Laboratory Life: The Construction of Scientific Facts*, Princeton, NJ: Princeton University Press, 1986, 2nd edn, 294 pp (1st edn, 1979).

Latour has directly studied how scientists actually carry out research in their laboratories, an anthropological approach that has grown in importance since the mid-1980s. Individual scientists may think that they are engaged in 'pure' scientific research, but in reality they are in a war where the objective is to win (prestige, funding, better facilities, improved journal provision etc.). Whether they know it or like it, they are involved in wider social and political issues. Science cannot be separated from the rest of life.

Latour is Associate Professor at the Centre de Sociologie de l'Innovation at the Ecole Nationale Supérieure des Mines, Paris.

## 6 Listening in on the Debates

Opportunities to listen in on scientific argument and counter-argument on major theories are rare, but a few books provide just that.

- (48)** Brockman, John (ed), *The Third Culture: Scientists on the Edge*, New York: Simon & Schuster, 1995, 413 pp.

A lively and challenging guide to the latest scientific theories and research in the words of both protagonists and critics. Illuminating.

- (49)** Cornwell, John (Ed), *Nature's Imagination: The Frontiers of Scientific Vision*, Oxford: OUP, 1995, 212 pp.

Another set of lively essays by top scientists and philosophers.

Leaving aside the debates over origins (on which see section 9 below), there are other biological debates over (social) behaviour, heredity (genetics) and (embryological) development. These debates are vigorously pursued within biology, but very little of the controversy has yet invaded the media, and school science texts know nothing of it. However, there are a few more popular books which will give the flavour of the deep disagreements that exist.

**(50)** Kaye, Howard, *The Social Meaning of Modern Biology: From Social Darwinism to Sociobiology*, New Haven: Yale University Press, 1986, 184 pp.

An excellent investigation of the way in which sociobiologists, past and present, have used scientific myth in their writings. Kaye suggests that their reductionist efforts, buttressed by unwarranted claims of scientific objectivity, may prove dangerously attractive and dehumanising to a culture fearful of its own survival.

Kaye (b 1951) is Associate Professor of Sociology at Franklin and Marshall College.

**(51)** Lewontin, Richard, *The Doctrine of DNA: Biology as Ideology*, London: Penguin Books, 1993, 128 pp.

A powerful critique of biological determinism, focusing on the claim that all of human existence is controlled by DNA. See also his essay, 'Genes, Environment, and Organisms' In *Hidden Histories of Science* (Robert Silvers ed), USA: New York Review of Books, 1995 (London: Granta Books, 1997), pp 115-139.

Lewontin, one of the world's leading geneticists, holds the Alexander Agassiz chair in Zoology at Harvard University.

**(52)** Hubbard, Ruth and Wald, Elijah, *Exploding the Gene Myth: How Genetic Information is Produced and Manipulated by Scientists, Physicians, Employers, Insurance Companies, Educators, and Law Enforcers*, Boston: Beacon Press, 1993, 206 pp.

A hard-hitting critique of genetic reductionism, whose title speaks for itself. See also Hubbard's essays, Human nature, and Genes as causes, chs 2 and 3 (pp 27-51) in Shiva and Moser (eds), 1995, (55) below.

Hubbard (b 1924) is Emeritus Professor of Biology at Harvard University.

**(53)** Goodwin, Brian, *How the Leopard Changed its Spots: The Evolution of Complexity*, London: Weidenfeld & Nicolson, 1994, 233 pp.

The 'leopard' of the title is modern biology and Goodwin provides a fascinating postmodernist critique of mainstream biology which he sees as modernist (positivist, mechanistic, reductionist, authoritarian). He describes a (process) structuralist biology, a science of qualities, that resonates with similar developments in other areas of society, to hold out hope for the future.

Goodwin is a leading developmental biologist and has been Professor of Biology at the Open University since 1983.

**(54)** Shiva, Vandana, *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*. London: Zed Books, 1993, 184 pp.

A passionate and disturbing study of what is, in effect, the relation between worldviews and policy and practice in agriculture.

Shiva is Director of the Research Foundation for Science, Technology and Natural Resource Policy, Dehra Dun, UP, India.

**(55)** Shiva, Vandana and Moser, Ingunn (eds), *Biopolitics: a Feminist and Ecological Reader on Biotechnology*, London: Zed Books, 1995, 294 pp.

A collection of key articles which explore the hidden implications and likely consequences of defining biotechnology as the latest wonder cure for the crises in ecology and development. Here are important reflections on the nature of scientific knowledge.

Moser is a Research Fellow at the Centre for Technology and Culture, University of Oslo, Norway.

## 7 The Galileo Affair

The final two sections deal with the Galileo Affair and the Darwinian Revolution. The reason for selecting these two events out of the whole history of science, is their pivotal significance in relation to the issues addressed in this bibliography. Popular accounts continue to wrap both episodes in glorious myth, portraying them as major moral victories in the war of enlightened science with obscurantist religion. The actual stories are very different - and much more interesting - as the literature cited will show. As episodes that involve the interaction between science and religion, they call for examination to see what lessons, if any, may be learnt from them. But beyond that, they were key episodes for the understanding of Western history as a whole. A major implication of the Western rationalist tradition is that knowledge, or at least the accreditation of knowledge, is the preserve of a small elite of trained experts. During the Christian centuries, those experts were pre-eminently the Church theologians (reason, it must be remembered, was not then taken to exclude divine revelation). It was Galileo who initiated the modern period in which scientists have claimed the status of supreme expert and have asserted the pre-eminence of science and of the scientific way to truth. Thus Galileo launched the developments that were to issue in the science-based secularism of recent history (see CST.RES2, section 3). The Darwinian revolution - the extension of the secularist programme to cover even human origins and nature - was the apotheosis of those developments.

The Galileo affair remains the *cause célèbre par excellence* for reflecting on the science/religion relationship. It is therefore decidedly unfortunate that much reflection is still based on the myths peddled by popular accounts. Maybe this is partly due to the fact that although the popular picture is 'totally false', it is, as the Dutch historian Edward Dijksterhuis continues, '... much more vivid than any of the

genuine ones.' (*The Mechanisation of the World Picture*, OUP, 1969, p 334). In it we have not only science and religion, but also the beginnings of modern science, issues of science and society, controversy and controversy about the controversy, and finally rich human drama and tragedy - what more could anyone desire?

The Galileo Affair is adequately covered in the sources listed above (e.g. in Brooke (14) and Russell (15); cf., Koestler (18); and Feyerabend (28)). Here are listed other works that contain key documents, or give detailed background information and analysis.

**(56)** Poole, Michael, The Galileo Affair, *School Science Review*, **72** (258), 1990, pp 39-48

A valuable summary for school teachers. Galileo is also covered in his (34), Part 7, pp 82-95, and in his *Beliefs and Values in Science Education*, Buckingham: Open University Press, 1995, Chapter 6, pp 99-113.

**(57)** Drake, Stillman, *Discoveries and Opinions of Galileo* (DOG), New York: Doubleday (Anchor), 1957, 301 pp.  
*Galileo* (G), Oxford: Oxford University Press, 1980, 100 pp.

DOG provides translations of four of Galileo's most important writings with introductions which place them in biographical and historical context. *Galileo* gives Drake's mature assessment of the affair. For critique see Fantoli (61).

Its full understanding requires much more than an assumption of inevitable conflict between science and religion ... If any simple explanation existed, it would rather be in terms of the customary ruthlessness of societal authority in suppressing minority opinion, and in Galileo's case with Aristotelianism rather than Christianity in authority.  
(G p v)

Drake, b 1910, was Professor of the History of Science, University of Toronto.

**(58)** Finocchiaro, Maurice, *The Galileo Affair: A Documentary History*, Berkeley: University of California Press, 1989, 382 pp.

Contains all the important documents, retranslated and arranged into a readable narrative. There are informative notes and a very valuable introduction that places the affair in its historical and philosophical context, and carefully distinguishes all the issues involved and the possible responses. The whole affair was too complex to justify a simple anti-Catholic conclusion (or, indeed, an anti-Galileo one).

To summarise, a balanced approach to the study of the Galileo affair must avoid the two opposite extremes exemplified by the anti-Galilean and the anti-Catholic interpretations. There is no easy way of doing this, but it may help to distinguish scientific from epistemological issues, factual correctness from rational correctness, essential correctness from total correctness, the several epistemological issues from each other, intellectual from external factors, and the several external factors from each other (personal, psychological, social, economic, political) ... the point is not to deny their interaction but to make sure they are not confused with one another. (p 10)

Finocchiaro (b 1942) is Professor of Philosophy and Barrick Distinguished Scholar at the University of Nevada, Las Vegas

- (59)** Redondi, Pietro, *Galileo: Heretic*, Harmondsworth: Penguin, 1989, 356 pp (First published in Italian, 1983, and in English translation in the USA in 1987).

Extremely valuable for Redondi's reconstruction of Galileo's cultural and political milieu. But his reinterpretation of the trial of 1633 in terms of a dispute over the eucharist is unconvincing.

Redondi is a researcher in the section for historical studies (modern history) of the French National Council for Scientific Research and associate director of the Centre Alexandre Koyré for the History of Science, Ecole des Hautes Etudes en Science Sociale.

- (60)** Feldhay, Rivka, *Galileo and the Church: Political Inquisition or Critical Dialogue?*, Cambridge: Cambridge University Press, 1995, 303 pp.

This book is unique in its concentration on theology and on the complex intellectual/institutional field in which the Galileo affair developed. She argues that the Dominicans and Jesuits represented two different cultural orientations that divided the Catholic Church, institutionally as well as theologically. Galileo, operating under court patronage, threatened what was then a precarious cultural balance. Feldhay's database of representative (?) individuals is slender, so her detailed interpretations are vulnerable. But her book is another salutary reminder of the complexity of the affair. By setting Galileo in a fuller context, Feldhay effectively highlights the cultural significance of his perspective and methods. Galileo claimed that the book of nature was much easier to understand than Scripture; if the right procedures were followed then certainty, proof, was attainable. In short, Galileo was claiming cultural hegemony for the scientists and their mathematical methods. Where Feldhay disappoints is in her failure to connect some insightful analysis with any later developments.

Feldhay is Senior Lecturer at the Cohn Institute for the History and Philosophy of Science and Ideas at Tel-Aviv University, Israel.

- (61)** Fantoli, Annibale, *Galileo: For Copernicanism and for the Church* (trans George Coyne). Vatican: Observatory Publications (distributed outside Italy by University of Notre Dame Press, Notre Dame, IN, USA), 1996, 2nd edn, 567 pp.

A magnificent work of scholarship. It is not easy reading, but it is undoubtedly the most authoritative analysis currently available. He emphasises the complex interplay among numerous factors, but concludes that the Pope's personal conviction that Galileo had betrayed him was decisive. In common with most recent Galileo scholarship, he agrees that the affair could have turned out quite differently.

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## 8 The Darwinian Revolution

### Historical and Philosophical Studies

The Darwinian Revolution is less well covered in the general sources (but see, e.g. Lewis (29), and Greene (36)); hence a fuller listing here.

- (62)** Gillespie, Neal, *Charles Darwin and the Problem of Creation*, Chicago: University of Chicago Press, 1979, 201 pp.

Behind the arguments of Darwin's *Origin* lay prior beliefs about knowledge, about nature and about God. The point of conflict was the intellectual autonomy of science and the nature of scientific knowledge.

When Darwin began to consider the problem of species extinction, succession and divergence, he did so as an evolutionist because he had first become a positivist, and only later did he find the theory to validate his conviction. The well-known evidence .... became evidence, and its explanation a problem, only because Darwin had grown accustomed to positivistic explanations as a result of bending his mind to geology.

(p 46)

Gillespie (b 1931) is Professor of History at Georgia State University.

- (63)** Moore, James, *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America 1870-1900*, Cambridge: CUP, 1979, 502 pp.

The finest and most extensive study of theological responses to Darwin. Moore mounts a thorough critique of the 'warfare' model of the relations between science and theology. He reveals a paradox - that Darwin's theory was accepted in substance only by those whose theology was distinctly orthodox, and not accepted by liberal Christians. He attributes this difference to affinities of Darwinism with orthodox theology whereas the affinities of other evolutionary theories lie with liberal and romantic theologies. See also Pearcey and Thaxton (9) who argue that out of the complex interplay of Christian and Greek thought three major worldviews emerged that influenced the development of science: Aristotelian, neo-Platonic (romantic) and mechanistic. In Darwin's day Christian Aristotelians and Christian mechanists largely remained theological orthodox, but the former rejected Darwinism while the latter accepted it. Christians with romantic leanings were attracted to non-Darwinian forms of evolution and embraced theological liberalism (see Livingston (67) below).

Jim Moore (b 1947) teaches the history of science at the Open University.

- (64)** Desmond, Adrian and Moore, James, *Darwin*, London: Michael Joseph, 1991, 808 pp.

A *tour de force* that seeks to place Darwin into his historical context, and set him against the backdrop of the domestic, social, political, religious and industrial history

of Victorian Britain (see also Desmond's, *The Politics of Evolution: Morphology, Medicine and Reform in Radical London*, Chicago: University of Chicago Press, 1989, 503 pp). In reality it is a piece of deconstruction by two materialist historians who believe that social and economic factors have great explanatory power in accounting for scientific ideas. It may be doubted that Darwin was as politically aware or sensitive as the authors claim, but they do raise important matters. In a recent response to reviews (Cutting both ways - *Darwin* among the devout, *Perspectives on Science and Christian Faith*, 1994, **46** (3), 169-172), Moore astutely notes that some evangelical scholars seem to place as much faith in rationalism in science as in supernaturalism in theology (p 171).

Desmond (b 1947) is an honorary research fellow at University College, London.

**(65)** Moore, James, *The Darwin Legend: Are Reports of his Deathbed Conversion True?* London: Hodder & Stoughton, 1995, 158 pp (First published in the USA by Baker Book House in 1994).

A marvellous piece of historical detective work. He reveals an unexpected core of history in the stories, but concludes that none of the parties to the controversy got it right. There has been much economy with truth.

**(66)** Grene, Marjorie, *The Knower and the Known*. London: Faber & Faber, 1966, 283 pp.

Inspired by Michael Polanyi (see (24) above), Grene tackles many key issues in the philosophy of science, especially that of Darwinian reductionism. She argues that Darwinism is not primarily or fundamentally a matter of science (method) or logic, but of ontology and metaphysical faith.

(See quotation in Chapter 2, Part II, Section 3)

Grene (b 1910) was Professor of Philosophy at the University of California at Davis.

**(67)** Livingston, James, Darwin, Darwinism and theology: recent studies. *Religious Studies Review*, 1982, **8** (2), pp 105-116.

A useful survey of some 40 studies (1958-81), demonstrating that the response to Darwin was highly complex and that the persistent notion of 'conflict' or 'warfare' must be carefully qualified, if not rejected. More significantly, he notes that the 'evolution' accepted by many Christian scholars was, and is, unacceptable to Darwinian positivists - 'Darwinisticism' rather than Darwinism. The debate is not a thing of the past.

Livingston teaches at the College of William and Mary, Williamsburg, USA.

**(68)** Jones, Arthur, *Connectedness and Continuity: The Religious Roots of Evolution*, Bristol: Jones, 2nd edn, 1992, 39 pp (1st edn 1991).

Attacks the notions that science can be separated from philosophical and religious

commitments, and that *evolutionism* as ideology can be regarded as an illicit addition to *evolution* as scientific theory. Traces the evolutionary faith back to its roots in Greek rationalism, *ie*, in the conviction that the only way of accounting for the unity and orderliness of a (self-existent, uncreated) universe is if it is one undivided being - a gapless continuity. Hence - as both paragon and justification of autonomous rationality - evolutionist science is the great non-negotiable for all secularists:

Evolution has served simultaneously as both the guiding motif for rationalistic science and as the central mythology of mysticism and spiritualism. (p 6)

**(69)** Livingstone, David, *Darwin's Forgotten Defenders: The Encounter Between Evangelical Theology and Evolutionary Thought*, Edinburgh: Scottish Academic Press, 1987, 210 pp.

Demonstrates that leading 19th century representatives of evangelical Christianity - in the areas of both science and theology - accepted evolution. From this he argues, *first*, that evolutionism ought to be seen as an acceptable variety of evangelical orthodoxy and, *second*, that the popular belief that science and religion are inevitably at odds is unfounded. He concludes that the acceptance of evolution was 'just the latest expression of the long-standing Puritan assurance that God had revealed himself in the book of Scripture and in the book of Nature.' (p 169). However, he fails to analyse what Christian scholars really meant by the 'Darwinism' they accepted (cf. (67) above), and accepts the two books tradition too uncritically (on that tradition and the 'Baconian' rationalism which it enshrines, see James Moore, *Geologists and Interpreters of Genesis in the Nineteenth Century*, In Lindberg and Numbers, 1986 ((16) above), pp 322-350).

Livingstone (b 1953) has been Professor of Geography in the School of Geosciences, Queen's University of Belfast since 1993.

**(70)** Eldredge, Niles, *Reinventing Darwin: The Great Evolutionary Debate*, London: Weidenfeld & Nicolson, 1995, 244 pp.

A window into one of the impassioned debates in evolutionary biology.

(See quotation in Chapter 2, Part II, Section 3)

Eldredge is a palaeontologist; curator in the Department of Invertebrates at the American Museum of Natural History in New York.

**(71)** Midgley, Mary, *Evolution as a Religion: Strange Hopes and Stranger Fears*, London: Methuen, 1985, 180 pp.

A fascinating exposé of the way in which scientific doctrines, especially the notion of evolution, become distorted by strange myths.

(See quotation in Chapter 2, Part II, Section 3)

A moral philosopher, Midgley (b 1919) was formerly senior lecturer in the Philosophy Department at the University of Newcastle upon Tyne. See also **(43)** above.

## Theistic Evolution?<sup>5</sup>

Astonishingly, the religious vision of evolution has been widely accepted by Christian scientists. Clearly this is not unrelated to the fact that evolutionary naturalism completely dominates the modern scientific enterprise. Therefore, the first thing to note is that for Christians this is a debate primarily about the Bible and its interpretation.

**(72)** Cameron, Nigel, *Evolution and the Authority of the Bible*, Exeter: Paternoster, 1983, 123 pp.

A wide-ranging study which demonstrates the incompatibility of (macro-) evolution with biblical teaching.

Cameron is now Associate Dean, Academic Doctoral Programs and Chair in Systematic Theology, Trinity International University, Illinois, USA.

**(73)** Morris, Henry M. and Morris, John D. *The Modern Creation Trilogy, Volume I, Scripture and Creation*, Green Forest, AR: Master Books, 1996, 228 pp.

This trilogy is written by two well-known creationist authors from the Institute for Creation Research. It lacks a systematic awareness and critique of the foundational worldview issues, but that said it does present a solid biblical case for creationism. It is particularly valuable for its survey of evolutionist opinion on Christianity and evolution (Chapter 7), especially the testimonies of prominent secular scholars such as Michael Ruse and Edward O Wilson (pp 97-100, 110-111).

Henry Morris is founder and President Emeritus of the Institute for Creation Research, El Cajon, California. John Morris is President of the Institute and son of Henry Morris.

## Methodological Naturalism?<sup>6</sup>

Theistic evolutionists usually do not question the secular scientific enterprise. They generally take it for granted that secular science is essentially objective and neutral (with regard to personal philosophy or religion) and so they accept that it must deal in solely naturalistic explanations. The inflated view of science is dealt with in the literature cited above, so here it is the naturalism that warrants further comment. It is widely believed that all scientists must adopt *methodological naturalism*, explaining as much as possible of created reality without reference to God, or to ideologies, moral convictions, or religious or theological commitments. Thus Christians in science *must* work for evolutionary explanations. However, there are enormous problems with this defence of theistic evolution:

**(74)** Gilson, Etienne, *From Aristotle to Darwin and Back Again: A Journey in Final Causality, Species, and Evolution*, Notre Dame, Indiana: University of Notre Dame Press, 1984, 209 pp (First published in French, 1971).

Against the Darwinian denial of purpose, design and universals, Gilson mounts a vigorous defence of final causality (natural teleology) arguing that it is a

philosophical inevitability and, consequently, a constant of biological philosophy. Sadly little known or noticed, the work is full of rich insights.

Etienne Gilson (1884-1978) was a French Christian philosopher and historian of medieval thought, and one of the most eminent international scholars of the 20th century. He was a Professor at the Pontifical Institute of Medieval Studies in Toronto from 1951 until his retirement in 1968.

**(75)** Ward, Keith, *God, Chance and Necessity*, Oxford: Oneworld Publications, 1996, 212 pp.

A trenchant attack on the 'new materialism' or 'evolutionary naturalism' of Stephen Hawking and Peter Atkins (cosmology), Richard Dawkins (biology) and Michael Ruse (sociobiology). Ward accepts evolution, but his book is excellent for its exposure of philosophical mistakes and fallacies, and for its clear statement of the inability of naturalism to account for the facts of consciousness and for the importance of the ideas of virtue and truth (and of knowledge and science). For further analysis see his *Religion and Creation*, Oxford: Clarendon Press, 1996, 351pp.

Ward is Regius Professor of Divinity, University of Oxford.

See also Alvin Plantinga, Methodological naturalism? (in Van der Meer (ed), (17) above, Vol 1, Chapter 9, pp 177-221), Johnson, (86) below, and, in Moreland, (83) below, the chapters by J.P. Moreland (Theistic science and methodological naturalism, Chapter 1, pp 41-66), Stephen C. Meyer (The methodological equivalence of design and descent: can there be a scientific 'theory of creation'?, Chapter 2, pp 67-112) and William A Dembski (On the very possibility of intelligent design, Chapter 3, pp 113-138, especially pp 131-133).

Plantinga is Professor of Philosophy, University of Notre Dame, Notre Dame, Indiana. Meyer is Professor of Philosophy at Whitworth College, Spokane, Washington and a Fellow of the Pascal Centre, Ancaster, Ontario. Dembski holds doctorates in mathematics and philosophy and is at Princeton Theological Seminary, Princeton, New Jersey.

## General Scientific Studies

Competent accounts of evolutionary science are readily available in any academic bookshop, whereas lucid and accurate critiques of evolution are hard to discover.

The best sources are the publications of the main creationist organisations:

**(76)** **Creation Research Society**, P.O. Box 8263, St Joseph, MO 64508-8263, USA. Email: CRSnetwork@aol.com  
 Website: <http://www.iclnet.org/pub/resources/text/crs/crs-home.html>  
 Membership Secretary: Glen W. Wolfrom PhD

Founded in 1963. Publishes *Creation Research Society Quarterly* (from 1964). This is one of the leading academic creationist science journals. The Creation Research Society also publishes *Creation Matters* (newsletter, from 1996).

**(77) Creation Science Foundation Ltd**, P.O. Box 6302, Acacia Ridge D.C., Queensland 4110, Australia

Publishes *Creation Ex Nihilo* magazine (popular) and an excellent *Creation Ex Nihilo Technical Journal* (from 1984) which can be ordered from:

Creation Science Foundation (UK), P.O. Box 1427, Sevenhampton, Swindon, Wilts SN6 7UF. Registered Charity No 1024543  
 Director: Graham Scott Phone: 01793 512268 Fax: 01793 861462  
 CSF (UK) also sells books and videos.

**(78) Biblical Creation Society**, PO Box 22, Rugby, Warwicks CV22 7SY  
 Scottish Registered Charity  
 Phone: 01788 810633 and 01509 213868 (answer-phone only)  
 Email: BCS@post.com Website: <http://www.pages.org/uk/org/bcs/>  
 Administrative Officer: Mrs Liz Reeves Administrator: Mr Brian Watt  
 Secretary: Dr David Tyler (Phone: 01457 766335)  
 Travelling secretary: Dr J H John Peet  
 Address: 24 Brittens Close, Guildford, Surrey, GU2 6RJ  
 Phone/Fax: 01483 233713; Email: [johnpeet@thenet-uk.com](mailto:johnpeet@thenet-uk.com)

Founded in 1976. Publishes twice-yearly *Origins* (from 1987, previously *Biblical Creation*, 1978-1986) - balance of academic and semi-popular articles. Also publishes *Journal Alert* and sells books, booklets and leaflets (list available).

**(79) Creation Science Movement**, 50 Brecon Avenue, Cosham, Portsmouth, Hants PO6 2AW Registered Charity No 801745  
 Chairman: Dr David Rosevear Phone/Fax: 01705 293988  
 Also *Creation Centre* (*Genesis Expo* exhibition and CSM Office) at 17-18 The Hard, Portsmouth, but not yet open to the public in late 1997.

Founded in 1932 as the *Evolution Protest Movement*. Member of the *Evangelical Alliance*. Publishes *Creation* journal (popular). Also sells books, pamphlets and cassettes.

**(80) Creation Resources Trust**, Mead Farm, Downhead, West Camel, Yeovil, Somerset BA22 7RQ. Registered Charity No 1016666

Phone/Fax: 01935-850569 Email: [101775.137@compuserve.com](mailto:101775.137@compuserve.com)  
 Secretary: Geoff Chapman  
 Website: <http://ourworld.compuserve.com/homepages/creationresources>

Founded in 1981 as the *Somerset Creation Group*. Member of the *Evangelical Alliance*. Sells books, other literature, slides, videos and cassettes (the audio-visuals are available for loan as well as sale). Source of materials for children (especially quarterly *Our World*) and students (especially termly *Original View*).

Another helpful website is that of Leadership University (USA) which features

popular and scholarly resources concerning intelligent design and philosophical theism: <http://www.origins.org>

The following books are some of the best known to us:

- (81)** Ratzsch, Delvin, *The Battle of Beginnings: Why Neither Side is Winning the Creation-Evolution Debate*, Downers Grove, USA: IVP, 1996, 248 pp.

A much-needed study that seeks to clear away the barriers to meaningful debate, and challenge both sides to think more clearly. Ratzsch exposes the entrenched positions, fallacies, misunderstandings, misconstruals of the nature of science, philosophical confusions, logical missteps, and other snarls that have blighted the debate from both sides. Ratzsch knows that his book, 'maybe .. will just make everybody on both sides mad.' (p 12), but hopefully it will have a salutary effect.

Del Ratzsch ( b 1945) is Professor of Philosophy at Calvin College.

- (82)** Davis, Percival and Kenyon, Dean, *Of Pandas and People: The Central Question of Biological Origins*, Dallas, Texas: Houghton Publishing Company, 1993, 2nd Ed, 170 pp.

Includes an overview and in-depth treatments of six areas of biological science bearing on the question of origins: the origin of life, genetics, speciation, fossils, homology and biochemistry. Presents a scientific rationale for the concept of intelligent design to balance that for an evolutionary frame of reference.

Davis is Professor of Life Sciences, Hillsborough Community College, Tampa, Florida, since 1968. Kenyon is Professor of Biology at San Francisco State University, San Francisco, California.

- (83)** Moreland, James (ed), *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer*, Downers Grove, USA: IVP, 1994, 335 pp.

Eleven scholars - including a philosopher, a mathematician, a physicist, a linguist, a theologian, a biophysicist, an astronomer, a chemist and a palaeontologist - assert that there is substantial evidence that the debates have not been settled in favour of macroevolution and scientific naturalism. Another sustained argument for intelligent design.

Moreland (b 1948) is Professor of Philosophy at Talbot School of Theology, Biola University, La Mirada, California, USA.

- (84)** Milton, Richard, *The Facts of Life: Shattering the Myths of Darwinism*. London: Corgi, 1993 (with new *Preface*, pp 9-11), 334 pp (First published by Fourth Estate, 1992).

Milton (b 1943) is an engineer and science journalist. He is not a creationist, but mounts a radical challenge to evolutionary orthodoxy, which created a storm of controversy when it first appeared. Milton makes some good points, but generally is not a reliable guide to the scientific debates. The book is more important for the

evolutionary fundamentalism it exposed (see the new Preface).

- (85)** Morris, Henry M. and Morris, John D. *The Modern Creation Trilogy, Volume II, Science and Creation*, Green Forest, AR: Master Books, 1996, 343 pp.

The second volume of three by these two well-known creationist authors (see (73) above). At the time of writing the most comprehensive survey of scientific evidence for young-Earth creationism.

Henry Morris is founder and President Emeritus of the Institute for Creation Research, El Cajon, California. John Morris is President of the Institute and son of Henry Morris.

- (86)** Johnson, Phillip, *Darwin on Trial*, Washington: Regnery Gateway, 1991, 195 pp (Crowborough, UK: Monarch, 1994) (2nd edn, Downers Grove: IVP, 1993, with new epilogue).  
*Reason in the Balance: The Case Against Naturalism in Science, Law and Education*, Downers Grove: IVP, 1995, 245 pp.

Johnson (b 1940) is Jefferson Peyser professor of law at the University of California, Berkeley. He used a sabbatical in 1987-88 to study the way in which scholars were handling the origins issue. He came to the conclusion that, under the guise of a scientific theory, an evolutionary naturalism had become another kind of fundamentalism that was promulgated aggressively in education and media with all the resources of government. Whoever questioned evolution was simply excluded from the scientific community. Johnson attempts to counter the naturalist hegemony by focusing on the mechanism of evolution, on the philosophical presuppositions, and on issues of design and purpose. In following this strategy, Johnson has chosen to operate almost exclusively within the academic world, has consulted widely, uses the incisive logic of a legal scholar to good effect, has interacted regularly with his opponents, and has been personally involved in some of the controversies, particularly over academic freedom. For all these reasons his work is much superior to Milton's. Johnson has virtually launched a movement and items (9), (82), (83), and (95) are by participants.

## **Thermodynamics<sup>7</sup>**

- (87)** Williams, Emmett (ed), *Thermodynamics and the Development of Order*. Norcross, Georgia: Creation Research Society Books, 1981, 141 pp.

Creationist arguments from thermodynamics are often pooh-poohed. Needless to say, creationists are aware of the counter-arguments. If you want a definitive creationist presentation then this one can be recommended.

Williams, now retired, was Professor of Physics at Bob Jones University, Greenville, South Carolina (1966-1979) and then Scientist Associate at the Lockheed-Georgia Company, Marietta, Georgia (1979-1990).

See also Thaxton *et al.* (91), Chapter 8, Thermodynamics and the origin of life, pp 127-143, and Chapter 6, Evolution is not even possible, in Morris and Morris, (85),

pp 125-160.

## Astronomy

- (88)** Mulfinger, George (ed), *Design and Origins in Astronomy*. Norcross, Georgia: Creation Research Society Books, 1983, 151 pp.

Covers a wide range of topics. Written in the 1970s, but much of the content is still valid.

Mulfinger (1932-1987) taught at Bob Jones University, Greenville, South Carolina, USA.

- (89)** De Young, Donald, *Astronomy and Creation: An Introduction*. Creation Research Society Books, 1995, 59 pp.

Provides a concise overview of origins, order, structure, time scale and change.

De Young is Professor of Science at Grace College, Winona Lake, Indiana, USA.

## Origin of Life

- (90)** Aw, Swee-Eng, *Chemical Evolution: An Examination of Current Ideas*. Singapore: University Education Press, 1976, 155 pp.

A comprehensive critique of origin-of-life theories. In a recent survey, Aw reinforces his negative assessment: The origin of life: a critique of current scientific models. *Creation Ex Nihilo Technical Journal*, **10** (3), 1996, pp 300-314.

Aw was Associate Professor of Biochemistry in the Faculty of Medicine, University of Singapore until 1978. He is now Head of the Department of Nuclear Medicine and Director of Clinical Research at Singapore General Hospital.

- (91)** Thaxton, Charles, Bradley, Walter and Olsen, Roger, *The Mystery of Life's Origin: Reassessing Current Theories*, New York: Philosophical Library, 1984, 229 pp (Dallas, Texas: Lewis & Stanley, 1993).

Another comprehensive critique using established principles of physics and chemistry and introducing some new analytical tools. They conclude that there are fundamental flaws in all current theories of the chemical origin of life.

Thaxton is a Visiting Professor at Charles University, Prague (see (9) above). Bradley is Professor and Head of the Department of Mechanical Engineering at Texas A & M University, College Station, Texas. He is a Fellow of the American Society of Materials. Olsen is a geochemist working in industry.

- (92)** Croft, Laurence, *How Life Began*, Darlington: Evangelical Press, 1988, 176 pp.

Another critique of theories of chemical evolution by a lecturer in biological science

at the University of Salford.

## Comparative Biology

- (93)** Bergman, Jerry and Howe, George, *'Vestigial organs' are Fully Functional*, St Joseph, MO, USA: Creation Research Society Books, 1990, 97 pp.

Considers all the oft-quoted examples, demonstrating their important roles and refuting the arguments for evolution that have been built upon them.

Bergman holds seven degrees (including two PhDs) in biology, psychology, and evaluation and research; he is currently Professor of Science at Northwest State College, Archbold, Ohio, USA. Howe is Professor in the Division of Natural Sciences and Mathematics at The Master's College, California.

- (94)** Scherer, Siegfried, *Typen des Lebens*, Berlin: Pascal-Verlag, 1993.

Surveys research into the identification of the created kinds (Basic Types) of animal and plant. An overview is followed by chapters focusing on a number of Basic Types. He provides evidence (primarily from hybridisation data) for identification at the family level in current classifications (variously family, sub-family or tribe). Currently the most significant creationist work in this area. See also Scherer's paper, *On the limits of variability: evidence and speculation from morphology, genetics and molecular biology* (In E.H. Andrews, W. Gitt and W.J. Ouweneel (eds), *Concepts in Creationism*, Welwyn, Herts: Evangelical Press, 1986, Chapter 9, pp 219-240.

Scherer is Research Associate in the Department of Biology at the University of Konstanz, Germany.

## Biochemistry and Molecular Biology

- (95)** Behe, Michael J, *Darwin's Black Box: The Biochemical Challenge to Evolution*. New York: Free Press (Simon & Schuster), 1996, 307 pp.

Behe argues that Darwinian selection is an unconvincing explanation for the incredible complexity of biological structures at the molecular level and sets out the scientific grounds for concluding that the cell was intelligently designed.

Mike Behe is Associate Professor of Biochemistry at Lehigh University, Bethlehem, Pennsylvania, USA.

- (96)** Denton, Michael, *Evolution: A Theory in Crisis*, London: Burnett Books (Hutchinson), 1985, 368 pp.

A wide-ranging critique, but Denton – not a creationist – is a molecular biologist and the critique of molecular theories is especially interesting.

Neither of the two fundamental axioms of Darwin's macroevolutionary theory - the concept of the continuity of nature ... and the belief that all the adaptive design of life has resulted from a blind random process - have been validated by one single empirical discovery ... since 1859 ... Ultimately the Darwinian theory of evolution is no

more nor less than the great cosmogenic myth of the twentieth century. (pp 345, 358)

In 1985 Denton was a researcher at the Prince of Wales Hospital, New South Wales, Australia.

See also Chapter 10, A chemical code: resolving historical controversies, in Pearcey and Thaxton ((9) above), pp 221-248.

## Genetics

**(97)** Lester, Lane P and Bohlin, Raymond G, *The Natural Limits to Biological Change*, Dallas: Probe Books, 1989, 2nd edn, 207 pp (1st edn, 1984).

A scientifically sophisticated critique of the principal contending theories of evolution – Neo-Darwinism and Punctuated Equilibrium – and a presentation of the evidence that there may be limits to biological change.

Lester is Professor of Natural Sciences at Emmanuel College since 1995; previously he was Professor of Biology at Liberty University, Lynchburg, Virginia (1979-1994). Bohlin is Director of Research, Probe Ministries, Richardson, Texas. He has an MS in population genetics.

## Geology

There are now some good examples of creationist geological research and reinterpretation in the main creationist journals. However there are at present very few good books, though there are several candidates in the pipeline.

**(98)** Austin, Steven (ed), *Grand Canyon: Monument to Catastrophe*, Santee, California: Institute for Creation Research, 1994, 292 pp.

A magnificent field guide to the Grand Canyon, but also of great value as a general creationist geology text that covers almost every relevant topic. The authors defend the 'breached dam theory' for the formation of the Grand and Marble Canyons. They leave some loose ends, so there is much work still to be done. A 55 minute video, *Grand Canyon: Monument to the Flood* (ICR, 1993), is also available.

Austin is Professor of Geology at the Institute for Creation Research, San Diego, California.

## Fossils

**(99)** Gish, Duane T, *Evolution: The Fossils Still Say No!*, San Diego, California: Institute for Creation Research, 1996, 391 pp. (New edition of a book first published as *Evolution: The Fossils Say No!* in 1973 and then revised as *Evolution: The Challenge of the Fossil Record* in 1985.)

The most thorough and well-documented critique of palaeontological and anthropological evidences by a creationist.

Gish (b 1921) spent 18 years in biochemical research and is now Vice-President and Professor of Natural Science at the Institute for Creation Research.

**(100)** Sunderland, Luther, *Darwin's Enigma: Fossils and Other Problems*, Santee, California: Master Books, 1988, 4th Ed, 180 pp.

Sunderland (1929-87) was a well-known aerospace engineer who spent over 20 years studying the scientific evidence for theories of origins. In 1978 the New York State Board of Regents directed the New York State Education Department to carry out a detailed study of how theories of origins should be taught in schools. Sunderland was invited to supply pertinent scientific evidence to the Bureau of Science Education which was conducting the study. During 1979, he conducted taped interviews with leading scientists at five natural history museums containing some of the world's largest fossil collections: Colin Patterson (London), Niles Eldredge (New York), David Raup (Chicago), David Pilbeam (Boston) and Donald Fisher (New York) This book presents the substance of those interviews. The tape transcripts are available (ERIC microfiche ED 228 056, *Darwin's Enigma: The Fossil Record*). Dated now, but fascinating material.

## Human Origins

Tattersall is a secular evolutionist, Bowden and Lubenow are creationists, the final book gives a Hindu, non-evolutionary perspective.

**(101)** Tattersall, Ian, *The Fossil Trail: How We Know What We Think We Know about Human Evolution*, New York: Oxford UP, 1995, 276 pp.

A comprehensive survey that acknowledges the weaknesses of the evidence and concludes that we are still very far from understanding our origins:

He gives us a succinct picture of what we presently think our 'family tree' looks like, paints a vivid insider's portrait of paleoanthropology, and perhaps most important, Tattersall looks at all these great researchers and discoveries within the context of their social and scientific milieu, to reveal the insidious ways that received wisdom can shape how we interpret fossil findings, and how what we expect to find colors our understanding of what we do find. (back cover)

Tattersall is Head of the Anthropology Department, American Museum of Natural History, New York.

**(102)** Bowden, Malcolm, *Ape-men: Fact or Fallacy*, Bromley: Sovereign Publications, 1981, 2nd edn, 257 pp.

A comprehensive survey charging that we frequently find very speculative theories based upon inadequate fossil evidence, and that the circumstances surrounding the discoveries are also often dubious. Outdated now on some matters, but much is still pertinent.

Bowden is a creationist writer and speaker.

**(103)** Lubenow, Marvin, *Bones of Contention: A Creationist Assessment of Human Fossils*, Grand Rapids: Baker, 1992, 295 pp.

Another comprehensive survey and currently the best defence of a creationist anthropology.

Lubenow has researched in depth the scientific literature on human origins for 25 years. He is Professor of Bible and Apologetics at Christian Heritage College, El Cajon, California, USA.

**(104)** Cremo, Michael and Thompson, Richard, *Forbidden Archeology: The Hidden History of the Human Race*, San Diego, California: Bhaktivedanta Institute, 1993, 914 pp. Also available in a condensed version, *The Hidden History of the Human Race*, Badger, California: Govardhan Hill Publishing, 1994, 352 pp.

A massive and meticulously researched review of the scientific evidence on human origins, including that which has 'disappeared from view' because it does not fit the dominant paradigm. Their conclusion sets them apart as unique: anatomically modern humans existed on earth millions of years ago! They also provide a sociological, philosophical and historical critique of science reminiscent of Paul Feyerabend, (28) above.

Cremo and Thompson are members of the [Hindu] Bhaktivedanta Institute, Cremo specialising in the history and philosophy of science, and Thompson in mathematics and biology.

## Human History

**(105)** Woodmorappe, John, *Noah's Ark: A Feasibility Study*, Santee, California: Institute for Creation Research, 1996, 298 pp.

A systematic evaluation of the biblical account of Noah's Ark with special reference to the housing, feeding, watering and waste-disposal requirements of the animals. A demonstration that the account is entirely credible.

Woodmorappe holds a bachelor degree in biology and bachelor and master degrees in geology. He has been a university research fellow and a school science teacher.

**(106)** Cooper, Bill, *After the Flood: The Early Post-Flood History of Europe*, Chichester, Sussex: New Wine Press, 1995, 256 pp.

The fruit of more than 25 years of research, Cooper demonstrates, through contemporary accounts, that European history can be traced back to the flood and the descendants of Japheth.

Cooper holds an honours degree in History of Ideas and English Literature.

## Conclusion

For much of this century Karl Popper, (25) above, laboured to vindicate the rationality of science. He successfully nurtured some of our most wide-ranging and critical scholars. Popper doubtless never expected that many of them would

eventually conclude that science's claim to rationality must be radically qualified, or even rejected. Indeed, over the last 30 years there has been a general cultural drift towards 'postmodernist' positions. We cannot ignore this phenomenon; nor should we seek to evade the challenge it brings to us as Christians. Even today, that which is presented as a scientific conclusion based on the rational analysis of empirical evidence, may, largely and primarily, flow from (unrecognised) philosophical and religious commitments.

For many this leaves no alternative to relativist and irrationalist conclusions, and leads them to despair about knowing truth. Surprisingly, there is actually nothing new in all of this and for Christians the despair is unwarranted, as, e.g., Clouser (4), and Polanyi (24) have shown. But, at the very least, concern for truth demands that no presentation at the level of scientific fact, theory, or paradigm can be adequately assessed without a great deal of hard work:

- the hard work of digging out and critiquing an array of undergirding philosophical and religious commitments;
- the hard work of addressing their embodiment, not just in science, but also in society and culture at large;
- the hard work of developing a distinctively Christian (biblical) philosophy that can be articulated into every discipline.

Which brings us full circle. Given the universality of faith, not of reason, every scientific tradition is fundamentally a faith tradition. Christian faith must issue in a distinctively Christian approach to, and perspective on the sciences. The teaching of science cannot but embody and transmit a particular faith. But after generations of immersion in secular humanist culture, the redevelopment of Christian understanding is far from easy. But it has been started and this book brings together some samples of the work that has been done. It is the hope of the Science Curriculum Team that their work will inspire many others to take the work forward. It will certainly continue to be hard going, but worthwhile - both in time and for eternity.

## Notes

<sup>1</sup> Newbigin, *The Other Side of 1984: Questions for the Churches*. Geneva: WCC, 1983, pp 22-23.

<sup>2</sup> This is a selective list. For a wider listing of science and religion books and articles, see the bibliographic essays in Shapin, (13), and Brooke (14). See also Steve Bishop, Introductory resources for the interaction of science and Christianity, *Themelios*, **19** (2), 1994, pp 16-20.

<sup>3</sup> Kuhn was seeking to redefine rationalism in relation to science; he did not regard science as an *irrational* activity.

<sup>4</sup> See Briefing: science wars. *Nature* **387** (6631), 22 May 1997, pp 331-335.

<sup>5</sup> For further discussion see Chapter 2, Part II, Section 4.

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<sup>6</sup> For further discussion see Chapter 2, Part II, Section 5.

<sup>7</sup> See also Chapter 1, Part III, Section 3, Appendix: First principles of evolution?

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