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Title	Scientific and Christian thinking: learning from Albert Einstein.
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Qualification	PhD
Year	1982

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Scientific And Christian Thinking: Learning from Albert Einstein.

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Doctor of Philosophy,
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1982.

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Abstract.

Several inveterate attitudes to modern science are discussed before raising the question, "Why think scientifically?", as the initial step toward an understanding of science. Some popular misconceptions are considered. The relevance of Albert Einstein's writings is indicated, followed by a description of the personal dilemma of the scientific researcher. Einstein's insights on the role of experience in the origin of scientific concepts and their function in ordering experience are presented. His outline of the advancement of scientific theories is given. Einstein's ideas are illustrated using his assessment of Johannes Kepler's contribution. Next, the importance of the intuitive relation is stressed and the tension between the logical and creative elements of scientific thinking is discussed.

Possible theological connections with Einstein's metaphysical framework for scientific research are faintly drawn before giving reasons for sketching the development of one brief phase of his researches. The contents of his four scientific papers published in Annalen der Physik in 1905 show the importance of scientific continuity and industry. Scientific commitment, action and freedom are considered in the context of Einstein's religious views. An assessment of his article on the mechanics of Newton underscores the consistency of his thinking and prepares the way for a discussion of various forms of subversive superficiality in Christian thinking. Differences in everyday, technological and scientific thinking are outlined as a prelude to a detailed examination of Rudolf Bultmann's defense of demythologism.

A comparison of Einstein's epistemological utterances and his four papers represents an attempt to understand basic aspects of modern scientific thinking. Some events associated with those papers are also considered. His thoughts on the relation between science and religion are given before answering the question, "Why think scientifically?" from an Einsteinian perspective of openness and justification.

Outlines of the similarities between scientific and Christian

faith, scientific and theological knowledge, scientific and theological communication, the universe and God, universal and divine unity, universal and divine authority, the rationality of the universe and Jesus Christ, and the intuitive relation and the Holy Spirit are drawn from an Einsteinian perspective. A brief discussion of motivation and community concludes this essay.

This thesis has been composed by myself and is my own work.

Preface.

Many Christians today share the view that the scientific enterprise and Christian faith are radically opposed to each other. Albert Einstein died in 1955 having achieved world fame as the foremost scientist of the twentieth century. This essay is an attempt to persuade Christians that Einstein has something distinctive and worthwhile to offer to them. This becomes strikingly apparent even when his comments on scientific research are compared with the most rudimentary notions of Christian theology. In the light of his contributions, vast areas of mutual interest are briefly illuminated. Indeed, Einstein has set the stage for contemporary discussions of the relation of science and theology by communicating that sense of action which is scientific research.

Once modern science is apprehended in terms of the openness and realism explained by Einstein, Christians can penetrate to the hospitable reality behind the hostile appearances of modern scientific endeavours. They can place themselves in a much better position to curb anti-scientific or anti-Christian bias and to contribute to the on-going dialogue between modern science and Christian theology.

It is hoped that the partial and inadequate views presented in this essay will be corrected and enriched by Christian thinkers and scientific researchers. It is with such tentativeness that this contribution is offered. Both scientific research and Christian theology have taught the author that even to fail in what is undoubtedly a great and exciting task is to make the path easier for the much more capable who follow.

I should like to express my indebtedness to my patrons, the Trustees of the Center of Theological Inquiry, Princeton, and to Dr. Lious C. Willard and the staff of the Robert E. Speer Library, who made the writing of this essay so agreeably possible. My debts to the Reverend Dr. James I. McCord, Chairman, the Center of Theological Inquiry, and President and Professor of Theology, Princeton Theological Seminary, and to the Very Reverend Dr. Thomas F. Torrance, Emeritus Professor of Christian Dogmatics, University of Edinburgh, for their sensitive encouragement and inexhaustible

kindness cannot be adequately expressed in words.

I should like also very specially to thank the Reverend Dr. S. W. Peat with whom I have been privileged to travel over many years along the pathways of science and theology, the Reverend W. Haisley Moore whose unselfishness, enthusiasm and industry enabled me to accept the leave of absence generously granted by the Presbytery of Hamilton and accommodated by the congregation of Craigneuk and Belhaven Parish Church, Church of Scotland, and Jean (Mrs. Stewart) McIntyre who prepared the typescript accurately, swiftly and cheerfully.

Iain Paul.

To my dear wife, Liz, and loving children, Findlay and Liza, who served in fuller measure.

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1. QUESTIONABLE INTRODUCTIONS

Scientists with more than a passing interest in theology are often asked by fellow Christians, "Are you capable of overcoming your scientific way of thinking?"(1) This question can be understood as a challenge to the possible assumption that theology is scientific. It can also represent an ingenuous request for an explanation of how modern science relates to theology. On the one hand, those scientific researchers are faced with an Augean task of accepting the challenge of Christians who know very little about scientific thinking. On the other hand, they are invited to precognize what can only be partially realised after the initial theological quest. Little is gained by evading a question which its propounder has already decided is easily answerable. In short, scientists studying theology are soon caught in an Einsteinian dilemma of compulsory exposure to the prior commitments of a (Christian) reporter.(2)

Unfortunately, this kind of introduction is only a small piece of a very large puzzle. No doubt within their own professions many Christians perform, for the most part, as gifted, informed and wise persons. But when it comes to modern science and its methodologies, their conversations, orations and publications show frequently a blatant disregard of professional standards. A considerable ignorance of the complexities of current scientific research is poorly concealed by an incredible confidence in its consequent deficient understanding of modern science. Without themselves having read, let alone graduated or researched, in the natural sciences many Christians write about and critically comment on modern science. Some of the same experience-shy discoursers then demand of scientific researchers what amounts to a vocational capitulation before they are allowed to read theology as a responsible approach to creative dialogue. The basic problem seems to be that many Christians weigh modern science and scientists on heavily tilted balances.

To appropriate the words of the physicist Gerald Holton, relatively few Christians "have faced the real magnitude of the problem, or are aware of the large range and amount of scientific

knowledge that is needed before one can 'know science' in any sense at all."(3) In some instances, the telling retort of Thomas H. Huxley is still relevant. "If there were an ancestor whom I should feel shame in recalling it would be a man of restless and versatile intellect who, not content with success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by aimless rhetoric and distract the attention of his hearers from the point at issue by digressions and appeals to religious prejudice."(4)

In particular, a powerfully confusing cocktail is virtually guaranteed if elements from philosophies, histories and researches of modern science are arbitrarily mixed. Another common method of clouding the issue is to equate the experiences of graduates of science, scientific researchers and technologists. Those inventions hamper severely communication among Christians and scientists. Besides, the latter cannot hope to deal with the plethora of resulting problems while introducing themselves to Christian theology. Perhaps understandably, as students of theology they are inexorably reduced to silence on those matters. The overwhelming combination of an acute thirst for theological wisdom and the inescapable vulnerability of their probing questions to misinterpretation accelerates this process. For example, persistent inquiries by a scientist can be easily construed as manifestations of a deep-seated antagonism. Other popular evasions treat them as proof of an inability to appreciate their own scientific experiences, as confirmation of their unsuitability for theological studies or simply as inarticulation. To parallel Einstein's observation, the scientist is suspect in the eyes of the Christian customs officer.(5) Fortunately not all Christians see their role as customs officers.

Nevertheless, the majority of theological students with scientific experience stifle their relevant questions. It is particularly difficult to survive prolonged exposure to such inhospitable conceptual climates. Some of those students

compartmentalize their knowledge deliberately. Others dissociate themselves slowly from theological or scientific modes of thought. Many lose irretrievably all desire to engage in constructive dialogue between science and theology. The proof of the pudding is in the eating. Traditionally, studies of the relation between science and Christian theology have largely been left either to Christians lacking scientific wisdom or to scientists with inadequate theologies. More contributions on science and theology are urgently required from Christians who have experience in both the parish church and the scientific laboratory. The following brief discussions of several habitual attitudes to modern science and some popular misconceptions about scientific thinking illustrate that most imperative need.

2. INVETERATE HABITS AND ROUTINE RESPONSES

The Christian Churches must remember the degree to which the inertia of the powerless within their files makes possible the dynamics of the powerful over their ranks. The scales of valuation need to be replaced, not recalibrated. Otherwise the Churches will remain vulnerable to the justifiable charge that they have not taken seriously, or have taken seriously and still misunderstand, the essential nature of modern scientific thinking. As things stand, the Christian Churches are major contributors to the present pervasive ecological pessimism and cultural disenchantment. Their faulty contacts with science and technology impede the flow of Christian stewardship in both society and industry. Exactly how modern Churchmen face this charge is necessarily a matter of personality. It is also of considerable academic, social and ecclesiastical complexity. Sweeping it under a cloak of quasi-authority will not make it go away. Such a response will not render Christians respectable, responsible or intelligible. Such all-too-prevalent and all-too-easy reactions are plainly superstitious. In the best interests of both theology and science, and therefore of society and industry, they should be eliminated as soon as possible.

At one level it is the old story of conflict. Science and its discoveries arising out of the empirical investigation of the world apparently threaten theology, particularly its heterogeneous teaching on such matters as the origin of humankind, its place in the universe and its world picture.(6) Granted, many Christian thinkers have paradoxically abandoned fundamentalism and literalism for de-mythologism as a formal response to the concrete contents of modern science. This movement does not, however, solve basic problems. Indeed, it seems to multiply and obscure them as will be discussed in a later section of this essay.

Sheltered behind a precarious pretext of freedom of thought, many Christian scholars visit their own insecurities and insularities on others, either intentionally or unwittingly. Just as a person's dilated pupils can alert the trained eye to a dangerous habit, so a Churchman's cultivated college can exhibit symptoms of severe addiction to several popular theological hallucinogens. A habit of confrontation has many threads, but the still-lingering tendency among Christians to point to problems which science cannot presently solve is perhaps the most worn. Forty years ago, Albert Einstein commented on the now-familiar fallacy of the God-of-the-gaps. He acknowledged that "the doctrine of a personal God interfering with natural events could never be <u>refuted</u>, in the real sense, by science, for this doctrine can always take refuge in those domains in which scientific knowledge has not yet been able to set foot." (7) But he also observed that "a doctrine which is able to maintain itself not in clear light, but only in the dark, will of necessity lose its effect on mankind, with incalculable harm to human progress."(7)

To base any argument primarily on a guess about what science cannot do in a particular age or period is clearly to build on shifting sand.(8) Few scientists, let alone Christians, are in a position to assess what modern science can do. The explanation is simple. Science is not a self-contained enterprise with

sharply delimited scope and purpose. Scientific researchers have discovered such vast continents of natural order that the lifetime of a scientist is not long enough to allow him to explore more than one valley. As far as the continent is concerned, he can only hope to read of the adventure of a few of the many kindred spirits. A very popular caricature of science depicts it as the pursuit of humankind's self-alienation from God the Creator. Its popularity depends on the ambiguities created by omitting the multidimensional cultural context which would assist a more realistic identification of both science and scientists.(9) Of course, Christians should not be condemned for their ignorance of scientific research, only for their uninformed criticisms of modern science.

The habit of fear is displayed by a considerable number of Christians. It is weaved principally from the yarn of science as a species of knowledge which dehumanizes humankind, pollutes their planet, and threatens their very survival.(10) Rich with ever-ripe tempting fruit, the tree of science is considered by them as a virulent modern variant of the tree of knowledge of good and evil. With its servile scientists the former needs no seducing serpent.

However, "a sense of cosmic danger is a totally different thing from a tragic sense of life."(11) This vital distinction is more liable to be missed by those who do not take the trouble to weigh carefully the merits of modern science. It can hardly be denied that the discoveries of science lend themselves frequently to exploitation through technology.(10) Technology supplies pesticides, vaccines, nerve gases, nuclear reactors and weapons, medical and industrial instrumentation and so much more. Their immediate appeal often conceals dangerous and addictive properties. Indeed, over thirty five years ago, Einstein realised that "economic and technological developments have highly intensified the struggle for existence, greatly to the detriment of the free development of the individual ... A

planned division of labour is becoming more and more of a crying necessity ... the spare time and energy which the individual will have at his disposal can be turned to the development of his personality."(12)

Einstein's words exude an optimism and relevance that have proved their durability with the passage of time and the ravages of modern warfare. They also show that the poignant realism of a great scientific thinker acts as an effective personal antedote to the fears of a technologically burgeoning society. Modern science gains a general awareness of the fragility of life. It does not espouse pessimism. Certainly there is cause for careful concern, but not for fear of science. In any case, as the distinguished physicist Max Born warned over a quarter of a century ago, "... fear is a bad foundation for reconciliation and solution of conflicts."(13) Reconciliation through apprehension is infinitely superior to dialogue through fear.

It is imperative that the Christian Churches recognise and communicate to their members the relatively confined current role of science in the total cultural metabolism. The fiction of dominant science providing the only intellectually acceptable view of the world is more the product of the non-scientific imagination than the conviction of the research scientist. Besides, as Holton first pointed out twenty years ago, of the vast numbers of graduates of science and engineering in the United States of America a generous guestimate is that about two percent are responsible for the major portion of scientific research.(14) Although the mass media give the impression of being genuinely concerned with science, the newspapers and radio and television stations provide possibly five percent of their space and time for distinctly factual presentation of science.(14) Basic scientific research probably has a share of only a few percent of the total annual expenditure for research and development in the United States of America.(14) There is little reason to assume

that the present state of affairs in the Western world is appreciably different.

In other words, all the noise about the threats of science to civilization amounts to the interfering echoes of an ignorance of the contemporary role of science. Such disturbances increase the grave risk of misinterpretation of informative cultural signals. The pursuit of science and scientific thinking provide important reactions that slowly, almost imperceptibly, shift the principal technological economic, political, ethical and religious equilibria already dominant in the overall system of cultural values.(15) Even within the scientific enterprise reaction rates are hardly impressive. Contrary to popular non-scientific opinion, scientific thought is notoriously conservative when it comes to the assimilation of new knowledge. Recurrently throughout science's history the profoundly original contribution was received with great suspicion.(16)

Two extremely significant recent examples of scientific conservatism were cited by Born, who was awarded the Nobel Prize for his contributions to quantum theory. "The physical world received the suggestion (that finite quanta of energy E exist which are proportional to the frequency v, E = hv) with great scepticism as it did not fit at all into the well established wave theory of light. Years passed without much happening. But in 1905 Einstein took up Planck's idea, and gave it a new turn." (17) Born also recalled that Einstein's special theory of relativity, published that same year, needed an effort to assimilate, and that "not everybody was able or willing to do so. Thus the period after Einstein's discovery was full of controversy, sometimes of bitter strife."(18) "Indeed, it was through Minkowski's semi-popular lecture, 'Space and Time' on 21 September, 1908 at the eighteenth meeting of the Naturforscherversammlung, that a number of scientists first became intrigued with relativity."(19) Scientists are characteristically wary of digging theoretical pits lest they should turn out to be intellectual prisons.

The eminent cosmologist Hermann Bondi also stressed the conceptual inertia of scientists. The basic instincts of a scientist, according to Bondi, rebel against the case of a theory that has been extensively tested and repeatedly confirmed over a long period of time and by a large expanse of empirical knowledge, and then is found wanting.(26) The refinement of measurement and the deepening of apprehension may assist in uncovering its limitations. It does not necessarily follow, however, that they will demonstrate its inadequacy within the context in which it was established. The old theory will not yield readily to a new superior rival "that does not diminish the utility of continuing to employ, in a restricted way, a method that has been well tested."(21)

Science increases knowledge. However useless it appears, that knowledge can have its application which arise often in surprising ways. No one can foresee what those uses may be. Indeed, great caution must be exercised in any application of scientific knowledge, for it is equally difficult to tell from which direction harmful side effects will come. But the intrinsically non-exploitative value of science should not be in question. What now merit critical re-evaluation are the technological uses of scientific knowledge by vested interests through applied "scientists" and engineers serving industry and government.(22) A realistic appreciation of modern science and scientific thinking can only enhance the outcome of such investigations. Of course, it is convenient, even fashionable, to blame science instead of scrutinizing the competitive pressures within industry and examining the military and political priorities of governmental agencies. Ironically, humankind can now send safely three persons five hundred thousand miles on a round trip to the moon. It has still to tackle many of the more immediate problems of dealing with five hundred thousand people travelling only three miles daily to and from their places of employment.(23)

Even the interpretation of the cosmos and the person by technological modes of human behaviour is not the prerogative of the modern scientific thinker. Thus, another cosmologist, W. J. Kaufmann III, wrote, "Only recently have we become fully aware of the ingenuity and depth of insight possessed by ancient peoples in the field of astronomy. The pyramids of Egypt, Stonehenge in England, and the ziggurats of Babylonia are impressive astronomical monuments. In studying these monuments, we realise that for ancient man to have constructed Stonehenge is no less of an achievement than for modern man to have journeyed to the moon. As far back as 3,000 and 4,000 years ago, people had devised elaborate systems by which the motion of the sun, moon and planets could be predicted ... The systems devised by the ancients for calculating the positions of celestial objects and explaining their motions are truly impressive."(24)

Many Christians presumably know from biblical, archaeological and philosophical sources that technological accomplishments preceded modern science by thousands of years. It is common knowledge that anthropologists have traced the significance of early "industry" back through hundreds of thousands of years. Interestingly, the Yahwistic pericopes of the so-called primeval prologue of Genesis appear to many scientists to bear sustained witness to the importance and abuses of technological innovations within the much broader context of cultural evolution. Evidently, threats of extinction and ecological disaster are not strangers to the people of God. Indeed, the biblical traditions can be consistently interpreted as the wonderful story of the repeated guidance and deliverance of a faithful remnant from the brink of genocide, the deluge of ecological disaster, and the fetters of technological captivity.

A habit of doom is not the appropriate apparel for a cordial approach to either biblical sources or modern science. Yet some Churchmen approach science and scientists in this very fashion.

Contrary to the intrinsic hope of both scientific and Christian thinking, this attitude of doom is commonly based on the abject assumption that humanity cannot be trusted with scientific knowledge. The people who nurse this negativism argue pessimistically that, because of humankind's lust for power, humanity will bring upon itself the ultimate catastrophe unless the triumphal manipulative march of science can be arrested.(25)

Behind such demands for what amounts to a moratorium on science lie at least two fundamental misconceptions. To adapt Holton's insights, one is scientific and the other is theological. First, research scientists do not regard their activities merely as a suitable form of employment.(25) With very few exceptions their researchers are the enactment of their creative thoughts and statements about reality. They regard their activities as small parts of that reality. They relate to the universe as apprehension progressively awakens within them. It is impossible to guard the tree of scientific knowledge so well that no scientist can pick its fruit. Like the hen that crossed the road, scientists get to the other side of a scientific theory. Consequently, it is extremely improbable that Christians will ever arrest the advance of science. At most, they might hinder its immediate progress.

Second, research scientists have been given talents like every person according to his several abilities. If scientists were to choose to bury them on the advice of fellow servants, who cannot properly assess the available options, what would the Lord say to them on returning from the far country? Surely Christians should respect the gifts of scientists, and encourage them to remain faithful over what is truly only a few things. Christians could take a leaf out of one of Einstein's books. Like many scientists, Einstein valued highly the great diversity of human talents, "In order to be content, men must also have the possibility of developing their intellectual and artistic powers to whatever extent accords with their personal characteristics and abilities." (26)

Notably, Einstein's observations cover the much maligned technologists who have long been the subjects of cultural conspiracies. Technologists have to operate within modern societies which have inherited the Grecian and Roman aversion to the use of the hands. Irresponsibly, those societies welcome the proliferation of electrical gadgetry and call for the conservation of energy. Technologists will require cooperation rather than condemnation, if their intellectual gifts are to guide their powerful hands to the cultural plough rather than the commercial sword. Modern societies have yet to implement the belief that all types of human activity are worthy of study and reverence because their pursuit and consequences can enrich or endanger the human condition. Until they do they will continue to squander valuable technological opportunities. The talents of technologists will require careful investment if they are to survive the whims of fickle financiers, the unreliability of skilled workmanship and the inflexibility of industrial management.

Technologists are presently in bondage to big-business. They are also sport on the rack of guilt-ridden social wrath. Ludicrously, the multinational corporation has greater "personal" freedom than the individual technologist. But their oppressors are not confined to private enterprise. For example, medical practitioners have long been heavily dependent on applied chemists, biologists and physicists. Shamelessly, technological consultants are seen, if at all, as the modern equivalent of barber surgeons. It would appear that many Christians are conspirators in an unjustifiable devaluation of the technologist's talents. Indeed, many people who are neither scientists not technologists are probably more practised in the dark arts of social and industrial manipulation.

The emancipation of technologists could assist the sorely needed, equitable global sharing of precious natural resources. It would nurture the long-overdue caring for the unique cultural

heritages of developing countries, and foster the urgently required daring to learn from and cooperate with the long-suffering, badly abused, under-developed nations of this small-minded world. In short, liberated technology could be given the opportunity to attain reflectively and critically determined ends for humankind without the intrusion of false messianic attitudes.

The prevalence of those inveterate habits in the Christian Churches and, therefore, in society and industry, is a major source of alienation between science and theology. In this so-called scientific age, both the person in the street and almost all of the Church leaders and theologians know, at most, very little about modern scientific thinking.(27) Many histories of science, however, point unambiguously to the conclusion that science provides the means for both a vital mechanism for cultural change and an aid to an apprehension of that change.(15)

Scientific thinking is important as part of the total response of humankind to God's Creation. Its restoration to a proper reciprocal contact with theology and a reconciliation of both with the cultural, and therefore spiritual, concerns of all persons are great hopes that can be shared by faithful Christians and committed scientists. Working alongside one another they can discover the mutual benefits of the responsible investment of their God-given talents.(3) Still, considerable difficulties have to be faced before such talk of larger visions can be anchored in reality. Unfortunately, the first step towards an understanding of modern scientific thinking is seldom taken by Christians.

3. THE IGNORED PRELIMINARY QUESTION

The situation is vastly more complicated than the preceding, now-perennial themes would suggest. Available philosophies and histories of science correctly alert interested non-scientists to the existence of philosophical presuppositions that are often tacitly held by scientists. Unless balancing scientific accounts are also consulted, Christians will tend to regard practising

scientists as philosophically blinkered, if not blind. As will become evident, such distortions contain a vein of validity, but its motherlode runs deep. The contributions of Ostwald, Mach, Hertz, Boltzmann, Planck, Poincaré, Duhem, Einstein, and many other scientists provide ample evidence of its depth. Nevertheless, ill-informed depreciative attitudes on the part of Christians can only frustrate communication with scientists.

Almost invariably such attitudes are based on inadequate conceptions of both methods at work in contemporary science and topical discussions among scientists themselves. To make matters worse, similar views are actually presented, according to Ernest Nagel, by some philosophers and historians of science. Their "accounts of scientific procedures and interpretations of scientific findings in effect deny both that a scientific theory is ever adopted in the light of a rational evaluation of the evidence, and that the validity of cognitive claims in the sciences is invariant, despite differences in social and personal outlook."(28)

Such scant first-hand knowledge of the procedural diversity of modern scientific research undermines the Christian's confidence in the warranty of scientific methods. It may also entrench the conviction that scientific thinking cannot achieve valid knowledge or evaluate the cognitive worth of its own intellectual products.(28) Perhaps if Christians are made aware of the many obstacles confronting the practising scientist, they will not undervalue, misrepresent, or dismiss scientific thinking so readily.

To anticipate subsequent sections, "there is no <u>a priori</u> formula for determining what strategies of research will turn out to be effective"(29) in any given context. There is no method for judging the comparative merits of competing hypotheses in the light of the available evidence for them."(30) Moreover, observational terms and statements are theory-laden.(31) They are only three of the diverse difficulties with which scientists

cope as they tackle the immediate theoretical and experimental problems relevant to their current investigations. If Christians can be persuaded that science exceeds the sum of all its methods and transcends its articulated content, they might reconsider the merits and diversity of scientific thinking.

The father of modern atomic theory, Niels Bohr, enjoyed telling the story of the young scientist who had a horseshoe hanging on the door of his laboratory. His surprised colleagues were unable to contain their curiosity. They asked whether he believed that it would bring luck to his experiments. The young scientist explained, "No, I don't believe in superstitions. But I have been assured that it works even if you don't believe in it."(32) Despite religious prejudice, science works. Besides, superstition would be drastically reduced were more Christians willing to learn of the distinctive features of modern scientific research. The latter are too often believed to be prescribed by current philosophies and histories of science.

For the moment, it is simply stated that scientific thinking cannot be defined by a specific philosophy of science nor confined to a particular history of science. Those points will be referred to later in the text. Granted their validity, the Christian's question, "Are you capable of overcoming your scientific way of thinking," can be seen in a different light. It can be understood as an invitation to describe some of the major hurdles encountered as one pursues both a scientific discipline and the study of Christian theology. Scientists can readily respond to this request, since an explanation must include or presuppose an acceptable answer to the question, "Why think scientifically?" This question requires an answer based on an outline of scientific thinking. Clearly, even at a very early stage in their theological studies, scientists can contribute a partially illuminating reply, given, of course, the proper circumstances. In fact, they are seldom so fortunate. Few Christians show any interest in this preliminary question.

The issue of the relation between modern science and Christian theology is as old as modern science itself. Both traditionally and currently, four basic strategies seem to have been adopted. First, science and theology are independent disciplines, with science addressing the physical domain and theology the spiritual and moral realms. Second, each discipline rejects the other. Many scientists dismiss theology as a sophisticated form of superstition, while a large number of Christians oppose science as a species of heresy. Third, theologies are modified to conform to modern scientific knowledge, apparently reducing conflict. Fourth, the metaphysical aspects of science are accentuated in attempts to increase the interface of science and theology. Surely a sensible strategy must be informed by some notion of scientific thinking together with a compatible answer to the question, "Why think scientifically?" Again, the need to raise this question in this connection is rarely acknowledged by Christians. The preliminary question in any inquiry must be correctly answered if valid answers to all the other questions are to be found.

Many Christians are wisely reluctant to give credence automatically to the utterances of anyone with a scientific background. Presumably the same powers of discrimination should predispose them to read and to learn of scientific thinking from scientists of outstanding ability, accomplishment and articulation. This essay attempts the formidable task of answering the apparently simple preliminary question, "Why think scientifically?" It draws heavily on the published thoughts and works of eminent scientists, but primarily on those of Albert Einstein. Even if its particular perspective proves problematic, it may still activate more gifted Christians with scientific qualifications and experience. If it encourages even one or two to develop, rather than to emaciate, a special interest in the scientific and technological talents of persons for the sake of our Lord, it will have been well worth the effort.

To borrow freely and intensively from the recent essay by Harold I. Brown,(1) this preliminary question, "Why think scientifically?" can be understood in at least two ways. It can be taken as a request for an explanation of why scientists should think scientifically, given that it is agreed that they should think scientifically. It can also be interpreted as a challenge to the common assumption that they should think scientifically which, to avoid begging the question, must be answered without making any assumption as to whether they ought to think scientifically. No doubt the latter has greater appeal to Christians because it does not limit them to scientific replies. However, it involves the additional difficulties of attempting to evaluate non-scientific responses to scientific apprehension. In fact, many Christians fail or simply refuse to recognise the existence of such problems. Those difficulties are never far from the minds of scientists. They can recall so easily their own painful experiences of learning how to grasp the right end of the research stick. Consequently, they are liable to ask of Churchmen, philosophers and historians what credentials and justifications they think they have for describing scientific apprehension.

The second version is certainly more fundamental. It is intimately related to theology, but it must presuppose some understanding of scientific thinking. It is more sensible, therefore, to begin with the relatively simpler first version. In any case, even a negative answer to it can serve as a reasonable preparation for tackling an acceptable answer to the second version. Of course, Christians can always avoid the issue by simply ignoring this preliminary question, and many do just that.

Without a clear notion of what scientific thinking is, no explanation can be given why scientists should think scientifically. Obviously, the nature of scientific thinking must be the immediate topic of discussion. However, granted the presupposition that

scientists should be scientific in their thinking, only scientific answers to this question are acceptable from them. A failure on their part to provide such an explanation why they ought to think scientifically will obviously count against this initial assumption. Their responses must meet any tests for scientific thought that they develop as they attempt to answer this question. But their first concern is to shed some light on what it is to think scientifically. The initial step in every scientific investigation is to prepare the bench by removing recognized obstacles. An analogous preparation will now be attempted.

4. POPULAR SCIENTIFIC FICTIONS

As already indicated, philosophies and histories of science are frequently at variance with the practice of scientists. Actually a large number of scientists remain unaware of those circumstances, while others have merely committed them to memory. When they encounter the inquisitive Christian, however, they are often informed or sharply reminded of harsh reality. This shock treatment also exposes them to the great popularity of a simplistic fiction among Christians. There is a widespread belief that modern scientists are typically proponents of some rudimentary version of Francis Bacon's seventeenth century description of scientific method.(33)

Seen through the eyes of Bryan Magee, this common misrepresentation has the following general content.(34) Apparently scientists believe that researchers experiment under carefully controlled conditions. They measure meticulously their observations, and record systematically their findings. They share their accumulated data with fellow scientists by publishing them in an appropriate form. As the published observations multiply, it is presumed that they recognise general features. Using the latter, they formulate hypotheses that causally relate and embrace all the available data. Next, they test those hypotheses by seeking further observational and experimental confirmations. Supposedly scientists believe that

when they succeed in verifying the hypotheses they advance the frontiers of scientific knowledge by discovering new fields of investigation. Last but not least, scientific statements, being based on observational and experimental evidence, are facts that alone represent for scientists absolutely certain knowledge.

It is not a question of Christians deliberately setting up the modern scientist as a straw-man just for the pleasure of knocking him down. In their own undergraduate studies many Christians learned from philosophers that the method of basing general statements on the accumulated observations of specific instances or events is known as induction. They also realised that, according to a very popular view of science, it is the inductive method which distinguishes from non-science. The same philosophers taught them that David Hume pointed out long ago that no number, however large, of singular observational statements could logically entail an unqualified general statement.

The whole of science is apparently based on an independent logical principle (induction) which is incapable of being inferred either from experience or from other logical principles. Consequently, the scientists' talk of facts and their great confidence in the results of scientific research rest uneasily with many thoughtful Christians. The scientists' relative lack of interest in philosophical and historical subtleties only aggravates the situation. In the absence or exclusion of constructive dialogue, Christians often conclude that modern scientists believe foolishly that they attain absolute truth and certainty within the above Baconian framework or its like. It is also frequently assumed that scientific researchers swallow the Baconian exaggeration of factuality but strain at explanation and critical reflection. (33) A commonly associated assumption is that scientists are more amenable to the exploitation of their knowledge than to its cultivation. Or, in the extreme form, scientists practise the subjugation of the natural order, while preaching its investigation.

More enlightened Christians can point to abundant documented evidence to show that, at least until the latter part of the nineteenth century, scientists themselves thought and wrote generally but diversely in terms of a single scientific method. (35) Unquestionably, a prominent thread in the procedural web was the description of the pursuit of science given by Isaac Newton. The views of the world's most successful natural philosopher on hypotheses as deduced from observations received considerable attention from practising scientists. Indeed, they persisted in some (distorted) form or another for the next two centuries.

A more critical examination of the practice of scientists reveals, however, overwhelming evidence to the contrary. It shows that science has no logic of discovery, no general procedure, nor simple continuous progress.(36) For instance, only Einstein produced the special and general theories of relativity, although the relevant knowledge was available to many of his contemporaries. In the case of the special theory, for example, he had to tap his own creativity in order to provide his several principles, to define his own operational procedures, and to advance conjointly along apparently divergent conceptual lines. Significantly, his achievements emphasized the role of the scientific principle or postulate. The same can be said of other great scientists, including Nicolaus Copernicus, Johannes Kepler, Galileo Galilei and Isaac Newton.

Nevertheless, the researchers of the majority of scientists, at any given time, can probably be best described as basically unspectacular, essentially routine and logically consistent.(37) Deceptively, the unexpected result, the chance discovery, the thoughtless mistake, or the illogical leap sometimes integrates scientific thought. Any one of them can even catapult the scientist from relative obscurity to epochal eminence. Louis Pasteur's famous remark is always, of course, a realistic rider,

"In this field of observation chance favours only the prepared mind."(38)

Having at last learned their lessons from science's history, many scientists recognise that science depends on the use of certain fundamental principles, which are educed neither from observations and experiments nor from logical and mathematical ratiocination. Most contemporary scientists also acknowledge that adherence to a single scientific method is a simplistic inhibitive misrepresentation. Scientific method is often described as if it were a set procedure. There is no such thing as the scientific method. This can be demonstrated by asking half a dozen eminently successful scientists who will outline six different methods. Something more than a standard prescription or a definitive description is needed to do justice to the modern scientific enterprise. In the twentieth century science is known to be a very complex endeavour.

Another common misconception among Christians is that scientists claim that scientific statements are necessarily certain. In this view, all scientific thinking is "not merely true or well-founded but indubitable."(1) Almost every natural scientist is familiar with the elementary aspects of non-Euclidean geometries, quantum theory and both the special and general theories of relativity. Probably he knows a little about Babylonian, Chinese, Egyptian, Grecian, Indian, Islamic and Sumerian contributions to the origin of modern science. He has learned, perhaps, a little more about the rise of modern science. Above all, he is acquainted with recent theoretical and expermental advances in his own specialism. Therefore, he recognises only too well the elusive nature of "certainty" in science, and will tend to avoid an ambiguous use of the word "truth"(39,40). In the words of Hermann Bondi, "My own inclination is that science has nothing to do with truth, but I am not sufficiently well versed in this to argue about it at any great length."(41)

Of course, there are always gifted exceptions, like Albert Einstein, to any rule.

Modern scientists must come to terms with the ever-present Horation deficiency, the inability to account for many important things in heaven and earth.(42) For instance, they must try to accommodate the rapidly increasing demands on the novice's ability to master enough existing science to reach the frontier. Otherwise their progeny may be unable to advance it. Somehow they must anticipate the possible physical or economic limitations which nature itself could impose on their capacity to secure data. Those engagements, and their like, leave little time to flirt with "certainty".

Nevertheless, a profound lesson learnable from every branch of science is that what "is inconceivable to one man, or in one age, is not necessarily so by another man, or in another period... Some discoveries which are unattainable in one age or state of knowledge become attainable in another; for instance, the laws of electro-magnetism or of electro-chemical action could not have been discovered when electro-currents were unknown, nor could the principle of the conservation of matter and of energy have been arrived at when science was in its infancy."(43) Science breaks new ground and improves the cultivation of old fields. That is its business. While certainty is elusive, hope is abundant.

According to Albert Einstein and Leopold Infeld, "nearly every great advance in science arises from a crisis in the old theory."(44) In the most significant cases "the new theory shows the merits as well as the limitations of the old theory and allows us to regain our old concepts from a higher level. This is true not only for the theories of electric fluids and fields, but for all changes in physical theories, however revolutionary they may seem ... We can still apply the old theory, whenever the facts within its region of validity are investigated. But we may as well apply the new theory, since all the known facts are contained within the realm of its validity."(45) By directing attention to

its realm of validity, Einstein could relate to both the demise of a scientific theory and its surviving applications without referring to "certainty" or recognising "revolutions".

Generally, scientists are motivated by the desire to apprehend, the need to believe and the will to search. "Throughout all our efforts, in every dramatic struggle between old and new views, we recognize the eternal longing for understanding, the ever-firm belief in the harmony of our world, continually strengthened by the increasing obstacles to comprehension."(46) Scientists thrive on "dramatic struggle" and know that "death alone can save one from making blunders."(47) New concepts, questions, problems, and theories are "born in the painful struggle with old ideas"(48) because "there are no eternal theories in science."(44)

Hence, hope, commitment and tenacity blossom in the absence of "certainty". Scientific thinking flourishes even as the scientific rank and file presently diminish. To demand "certainty" as a necessary condition of all scientific thinking is already to have misunderstood the nature of modern science. There is no need to claim longevity, let alone immortality, for any scientific theory. Its validity stands and falls as it points scientific investigation beyond itself toward greater precision and fuller apprehension.(49)

Through experience, both observational and experimental, scientists learn how to relate a particular datum to a definite cause. They believe that in doing so they are thinking scientifically. They are not philosophers, nor do they claim to be, although they are convinced that as scientists they behave rationally. As Einstein replied to the epistemologists, "(the scientist) accepts gratefully the epistemological analysis, but the external conditions which are set for him by the facts of experience, do not permit him to let himself be too much restricted in the construction of his conceptual world by adherence to an epistemological system."(50) For Einstein and a large number of practising scientists, scientific inferences are

grounded in observational and experimental experiences. They are part of a freely created logical manifold.(51) They are never indubitable. En masse they represent what scientists believe is a relevant rational response to reality.(52)

Recognising, then, that a thought, statement or theory need not be certain to be scientific, it is appropriate to return to the problem of "truth" in science.(52) At the risk of offending some Christians by stating the seemingly obvious, it is a mistake to assume that scientific researchers identify the truth of a statement with its being scientific. Truth is not sufficient for scientific thinking.(52) As many post-graduate science students will confirm retrospectively, it is pointless to offer a conjecture to one's research supervisor and expect that just because it happens to be true, he will accept it.

An anecdote from the physicist R. V. Jones illustrates the point neatly.(53) One night the research students of Francis Simon were working with liquid hydrogen in his laboratory. Shortly after midnight, there was an explosion causing extensive damage. One of the research students telephoned the professor to inform him of the accident. The only initial response he could get from Francis Simon was, "All right, I know what day it is!" It was the morning of April 1st. The frustrated research student was reminded that he must also provide adequate scientific grounds for the acceptance of a conjecture. Scientific statements are not conveniently labelled "true" or "false" for scientists.

Equally apparent, truth is not necessary for scientific thinking. As just noted, the assessment of a conjecture is a matter of examining its scientific grounds. For scientific researchers to claim that a statement or theory is scientific means that they are asserting that the basis on which it is to be accepted is the currently available scientific experience. When Isaac Newton's theory of gravitation was proposed, astronomers used it to predict the positions of planets and satellites and to forecast and retrodict eclipses. Originally published in 1687,

"it was not until well into the eighteenth century that Newton's theory became generally accepted."(54) Gradually as the grounds for its acceptance were laid down - estimated by Bondi as well over a hundred thousand tests(55) - its scientific status grew. This occurred despite the considerable initial reservations about action at a distance, until by the middle of the nineteenth century it ruled supreme.

However, with the benefit of hindsight, specifically Einstein's theory of gravitation or one of its variants, it is now realised that while Newton's theory was scientific it was not the "truth". Even before the turn of the century evidence of its limitations was available to all who were familiar with the refined calculations of the advance of the longitude of the perihelion of Mercury's orbit.(56) Although consistent with a great wealth of empirical data, the demise of Newton's theory eventually came. It fell not simply as the "victim of the increasing precision of observation and calculation"(55) but as the glorious forerunner of a new and more powerful theory. Its defeasance is a salutary reminder to scientists that they should never again rest easy with the truth-content of any scientific theory.

There is, then, light at the end of the research tunnel. The birth of the general theory of relativity was dependent on the pre-existence of Newton's theory. Clearly, progress in scientific thinking cannot be adequately described as monotonically increasing with time, or as knowledge becoming more and more certain or true. But there is ample evidence to suggest that the scientists' reliance on the interaction of theory and experiment will continue. This interplay has long enabled them to move from existing theories describing ranges of phenomena to new theories encompassing even greater, but still limited, domains of experience.(55) Consequently, the vast majority of scientists are content to explore the intellectual uplands known as scientific thinking. The high peaks of "truth" and "certainty" they tend to leave for philosophers and theologians to tackle.

Nevertheless, there is a residual hankering. Born expressed it in the following way. "The scientist's urge to investigate, like the faith of the devout or the inspiration of the artist, is an expression of mankind's longing for something fixed, something at rest in the universal whirl: God, Beauty, Truth. Truth is what the scientist aims at. He finds nothing at rest, nothing enduring, in the universe. Not everything is knowable, still less predictable."(57) Perhaps the most impressive words of all came from Isaac Newton: "... I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."(58)

With the more obvious obstacles to a re-valuation of modern scientific thinking set aside, it is appropriate to sketch in broad strokes some of the many limitations of the present investigation.

5. ALBERT EINSTEIN, THE SKILLED GUIDE

Although very few scientists can, and less than a handful do, become an Albert Einstein, people of such calibre have commented on various aspects of scientific thinking, including the roles of "truth" and "certainty". Their deliberations bear a unique brand. They come from persons who are not restricted to talking <u>about</u> science. They are the reflections of individuals who have become eminently successful <u>in</u> science. Clearly, they have a special claim to relevance. Specifically, few scientists would challenge the view that Einstein was the most profound scientific thinker since the time of Newton. As an approach to modern scientific thinking, some of the published thoughts of Einstein are, therefore, presented together with selected comments from other distinguished scientists. In addition, granted that scientists should think scientifically, his explanation of why they should think scientifically is interpolated.

In his <u>Autobiographical Notes</u>, written in the evening of his remarkable life, Einstein gave his "credo" as his only concession

to a systematic epistemology.(59) His "occasional utterances of epistemological content" are contained in numerous published articles, letters, and even quotations, making their integration difficult. Such an exercise probably runs counter to the better judgment of Einstein himself. However, if this attempt at thematic synthesis remains sensitive to Einstein's reservations, the interests of clarity and integrity will not be betrayed.

Some of the topics that are not addressed directly in this essay include the following: the role of the Michelson-Morley experiment in the origin of the special theory of relativity, the original contributions of Poincaré, Lorentz and Einstein to the special theory of relativity, Mach's influence on the conceptual development of Einstein, Einstein's understanding of the role of Mach's principle in the formulation of the general theory of relativity, Einstein's criticisms of quantum mechanics and his search for an unified field theory.

Those subjects would require such detailed investigations that they would inevitably carry the discussion too far afield. They would also court the danger of obscuring the unity, consistency and originality of Einstein's work, a hazard that is not without its victims. It is assumed that an acceptable evaluation of Einstein's views on scientific thinking will cast a feeble light on those matters. The present purpose is, however, to provide an answer to the preliminary question, "Why think scientifically?"

The inclusion of some comments from other scientists also merits a few words of explanation. In general, scientists do not claim to be philosophers or historians and philosophers of science. They draw almost exclusively on their scientific experience as they communicate their views on science and scientific thinking. Since this essay is an attempt to encourage Christians to read the extramural works of modern scientists, it makes references, where possible, to those equally acceptable sources rather than the more inaccessible

academically respectable literature. Although they do not aspire to epistemological grandeur, the quotations selected show that working scientists have many instructive thoughts on the nature of science and scientific thinking. Therefore, they deserve a fair hearing from Christians. At the very minimum Christians can ask them to account for the intriguing observation that scientists of almost every conceivable philosophical persuasion have made significant advances in modern science.

To recap, most scientists are effectively laymen with respect to philosophies and histories of science. Very few have any claim even to the title of amateur theologian. Their scientific researches have probably been basically unspectacular, essentially routine and logically consistent. However, the contributions of Einstein raise for many of them several interesting questions. The answers are, of course, beyond the scope of this essay.

Why did the philosopher of science, Karl R. Popper acknowledge the importance of Einstein's scientific researches but, for the most part, ignore Einstein's available epistemological utterances? Did Popper, like the logical positivists, use Einstein's work and comments expediently? Did the scientist Michael Polanyi tacitly integrate his knowledge of Einstein's essays and researches? Or did Polanyi arrive later and independently at virtually identical bases for scientific realism? Is the historian of science Thomas K. Kuhn conceptually indebted to Einstein or Polanyi? Why are many modern introductions to epistemology and scientific realism silent about Einstein's writings, most of which were published well over forty years ago?

Of course, mere coincidence of views is no proof of influence, but the extent and context of a coincidence can imply some influence. More relevant in the present context is the obvious way in which those questions point to the importance of Einstein's contributions. While this essay merely hints at some possible answers to them they are placed starkly before the Christian

customs officer to challenge at the outset his scales of valuation. Scientists are not philosophers, but they are quite definitely versatile rational thinkers. However, to learn from Einstein, this short essay does not end with blinding conclusions. Its unspecifiable but deliberate aim is to urge other Christians beyond its limitations and inadequacies to greater precision and fuller apprehension through the personal participation of interested parties.

6. SCIENTISTS, THE UNCOMMUNICATIVE SOLITARY FELLOWS

To allay residual suspicion about the choice of Einstein as skilled guide rather than infallible authority, gross features of the personal dilemma of the academic researcher are silhouetted against the contradictory public image of the scientist as a dispassionate manipulator. By outlining Einstein's vocational kinship, awareness of his colossal scientific stature is heightened.

Earlier, reference was made to grand visions of a reciprocity between science and theology and a reconciliation of both with culture in general. On hearing these imaginative expressions of hope, many Christians will respond with a wry smile. To them such aspirations must sound rather like naive variations on an old theme. Apparently irreconcilable differences have long been signalled by the more conspicuous patterns of scientists' behaviour. Indeed, the social responsibility of scientists, or more precisely their supposed lack of it, has been a subject of controversy for centuries. Throughout that time, many scientific researchers have staunchly defended the view that scientific thinking requires freedom from humanitarian motivations. Consequently, in their professional capacities, they have tended to shy clear of direct societal involvements. Some of them have also claimed that scientists can exercise this freedom while denying all knowledge of it. It is hardly surprising to learn, therefore, that a large number of Christians have found and still

find it difficult to relate to what appears to them as endemic social myopia.

According to many scientific researchers, society benefits and suffers as the consequences of scientific thinking are evaluated and utilized by applied "scientists" and technologists. In other words, they recognize legitimate but distinct roles for scientists and technologists. Somewhat enigmatically, if not arrogantly, most practising scientists believe that, in due course, the results of their researches will become vital to society, not by their direct intervention but through technological expertise.(60) Even "the most abstract and remote ideas may one day become of great practical importance - like Einstein's law of equivalence of mass and energy."(61) Still, the increasing number of difficulties is becoming progressively more acute as scientific achievements are ever more rapidly exploited by industry with ever less thorough assessments of the possible long-term and long-range effects. But they are neither the products nor the concerns of scientific research.(62)

The task of science is to describe, to the greatest possible extent, a reality in space-time which is independent of the perceiving subject.(63) However attractive and satisfactory scientific thinking appears, no matter how valuable scientific results may seem for the immediate material advantage of civilization, "it is most dangerous to apply these methods beyond the range of their validity, to religion, ethics, art, literature and all humanities..."(64) Scientific methods should be "restrict(ed) to that domain where they reasonably belong."

Scientific optimism should not be confused with the ill-informed popular optimism which regards the solutions to all humankind's problems as technological. The latter contrasts sharply with the much more realistic optimism of practising technologists and also with the more restricted optimism of scientists. Scientific optimism sees an increasing apprehension of the universe as an enrichment of life. It is based on what

science has already accomplished through the labour and activity of scientists. It looks forward to a greater fulfilment which will entail the transformation of present scientific experience. Scientific optimism has its feet firmly on the ground of achievement and its head freely soaring in the air of anticipation.

Sheer hope propels scientific research. It also fosters the belief that scientific findings will eventually prove valuable to a modern highly mechanized civilization with its harnessable technological talents.(65) Yet, "hope is a word one hardly finds in the literature of (science). A paper starts with the planning of an experiment or with a theory based on expectation. But there is hardly any talk of hope." Born continued, "However, when I remember my actual experiences during a long scientific career, I have one inextinguishable memory: the disappointment when a result was different from what I had expected. But disappointment could only occur when there was hope."(66) Often, when discourse distrains, scientists fall back silently, perhaps complacently, on their optimism. Frequently they retire to the laboratory, the computer room or the library leaving the world to its own devices.

No doubt Christians are reasonably familiar with the apparently antisocial antics of scientists. Few of them volunteer for a debate for which they are neither properly prepared nor suitably equipped. They are trained for research, not dissemination. The former is objective, problematic, tangible and rewarding, while the latter promises to be subjective, argumentative, ambivalent and frustrating. Consequently, the vast silent majority of working scientists are content to leave the discussion of societal issues to a very small vocal competent minority of established figures.(67) Nevertheless, their task is not made any easier by disillusioned science graduates or disenchanted technologists excluded or released from scientific or industrial institutions. Further complicated by the speculative renderings of mass media career oriented popularizers, those circumstances are hardly optimal for progress towards a better mutual understanding among

Christians and scientists.(68)

It is not easy to become one of the very small vocal competent minority of scientists who can present scientific subjects in an acceptable, authentic, popular manner. Einstein, who was an outstanding member of this fraternity, outlined "the great difficulties of such an attempt. Either (the scientist) succeeds in being intelligible by conceding the core of the problem and by offering to the reader (listener or viewer) only superficial aspects or vague allusions, thus deceiving the reader (listener or viewer) by arousing in him the deceptive illusion of comprehension or else he gives an expert account of the problem, but in such a fashion that the untrained reader (listener or viewer) is unable to follow the exposition and becomes discouraged from reading (listening or viewing) and further ..."(69) The delicate art is to encourage a lively interest.

"It is of great importance that the general public be given an opportunity to experience - consciously and intelligently - the efforts and results of scientific research ... Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty."(69) Many scientists concede readily that there has been an abysmal failure on the part of scientists to communicate with the public at large. The situation will only degenerate further, however, if incompetent conflators and incomprehensible expositors are allowed to multiply indiscriminately. Consequently, scientists tend to err on the side of silence rather than risk joining the ranks of the misemployed.

Interested Christians could do more to encourage suitably gifted scientists to convey to non-scientists something of the joy, excitement and anticipation of scientific researches. Humankind stands miraculously between the macrocosm and the microcosm. Homo sapiens lives midway between the immensity of intergalactic space receiving its complex intimations from the distant past and the invisibility of atomic processes with their

statistically predictable futures. Some scientists are more than capable of communicating their awareness of this experience as they run the rapids of scientific research. The need for them to do so surely cannot be overstated in an age when "spiritual poverty" takes the form of a moribund materialism. The whole world of difference between materialism and material well-being should be explained.

It is almost impossible to paint a realistic picture of the typical modern scientific researcher. Rigid generalisations about the scientist are misleading. They are insufficiently comprehensive and invariably arbitrary. What can be sketched about scientists does not offer much to encourage initiatives toward reconciliation. Generally it serves to reinforce low opinions of scientists' societal commitments. During an address delivered at a celebration of Max Planck's sixtieth birthday in 1918 before the Physical Society of Berlin, Albert Einstein spoke bluntly. "Most (scientists) are somewhat odd, uncommunicative, solitary fellows, really less like each other, in spite of common characteristics, than the hosts of the rejected."(70) With the future in their blood, their innubilous optimism sees little other than the eventual success and the ultimate importance of their researches.

Their tunnel-vision often taxes severely the patience and eyesight of colleagues, especially when their attempts to communicate depend on inadequately prepared slides.(71) On rare occasions, communication deteriorates drastically. The theoretician Eugene P. Wigner intimated that "(Wolfgang) Pauli was a brilliant lecturer if he prepared his address. Once when I invited him to address our colloquium in Princeton, he did not. The audience became restless and, feeling somewhat responsible for the event, I wanted to help out. He did not define the mathematical symbols he used and I thought that if he explained them, it would help us to understand what he was trying to present.

'Pauli,' I said, 'could you tell us again what your small a

stands for?' (The 'again' was sheer politeness: he had not in fact defined it.)

Pauli was flabbergasted by my question and stood there speechless for a few seconds. However, he recovered, 'Wigner,' he said, 'you just have to know everything.'

The audience did not laugh."(72)

Of course, scientists manage, on the whole, to communicate their ideas. In this respect, they are a little like moles. Most of their time is spent in their own research tunnels. Consequently, on their brief, relatively infrequent excursions into the scientific limelight, they have to adapt to circumstances. Lack of time for adequate preparation, pre-occupation with current problems, eagerness to announce the most recent findings, the desire to convey both the breadth and intensity of a research project, and the demands and opportunities of the occasion are just some of the many variables to be taken into account. In this light, the infrequent misdemeanour is hardly surprising.

Since there is evidence of inattention to societal details within their ranks, even greater lapses are to be expected elsewhere. In an article dedicated to the astronomer F. M. Stratton on the occasion of his seventieth birthday, Born recorded a delightful anecdote about Karl Schwartzschild. A remarkably gifted astronomer and one of Born's teachers(73) Schwartzschild discovered the first "rigorous" solution to Einstein's field equations.(74) After informing his readers of the enthusiastic, versatile, all- embracing mind of Schwartzschild, Born began his tale.

A group of young professors and lecturers were in the habit of meeting for lunch at a certain table in a local restaurant not far from the Göttingen observatory. Until his marriage, Schwartzschild had been one of the group. Only a few weeks after the wedding, he was again in his favourite seat at the lunch table. Schwartzschild was deeply involved in a lively discussion about some scientific problem, when someone asked him: "Now, Schwartzschild, how do you like married life?" He blushed, jumped up, and said, "Married

life - oh, I have quite forgotten -" then got his hat and ran away.(73) Many marriages are exposed to scientists' spasmodic lapses from domestic diligence. Familial sacrifices are not uncommon. Behind many scientists there are self-effacing partners and children who provide timeous encouragement and support.

Most scientists are deeply committed to and absorbed in their work.(75) Of course, scientists sometimes carry commitment too far. For instance, Born admitted at the International Relativity Conference in Berne in 1955: "I remember that on my honeymoon in 1913 I had in my luggage some reprints of Einstein's papers which absorbed my attention for hours, much to the annoyance of my bride. These papers seemed to me fascinating, but difficult and almost frightening."(76) Scientists tend to place a very high value on learning for its own sake, independent of any economic or social rewards.(77) Naturally, they have feelings like everyone else. They are sometimes appointed to a chair, elected a Fellow of the Royal Society, or awarded the Nobel Prize. Such mild discomforts are accommodated, but they are not the driving force to scientific research. The thrills of seeking and the joys of finding have to be experienced to be believed and safeguarded.

Science cannot flourish in a selfish, secretive climate. In fact, scientists are likely to find distasteful the competitiveness, expediency and personal restrictions of industry and governmental establishments.(77) They are liable to exhibit patterns of behaviour that they developed in childhood as reactions to personal isolation.(78) Probably adolescent lack of societal involvement influenced strongly their choice of a scientific vocation, precisely because it appealed to their already developing interest in things as opposed to people.(75)

A superb example of the intensity of scientists' interest in things was provided by the historian and philosopher of science, Herbert Dingle. "... A considerable earthquake occurred at Long Beach, not many miles from Pasadena, and the shock was distinctly

felt there. I was in the office that had been allotted to me and at once hastened back to the Athenaeum to see if all was well. On the way I passed Einstein and Gutenberg a distinguished seismologist who had come to work at Pasadena with the hope of experiencing an earthquake which he was unlikely to do in central Europe. They were standing on the campus closely examining a large sheet of paper. Only later did it transpire that what they had been studying was the plan of a sensitive new seismograph and they had been so absorbed in it they had failed to notice the earthquake!"(79)

The stubborn devotion of scientists to the pursuit of scientific "truth" is not a literary fiction. Unquestionably, it is better for a scientist to destroy privately his own illusionsthan to be publicly discredited by his colleagues. Besides, many scientists are naturally drawn to introspection and isolation.(80) Shades of those tendencies can be detected in Ernst Straus's account of an unusual exchange with Einstein. Straus reminisced: "(Einstein) had a firm conviction, which I do not think was justified, that he could explain (his ideas) to everybody. For instance, as I remember quite clearly, we were working on something in unified field theory and he came down rather cheerfully and said, 'I explained it this morning to my sister and she also thinks that it is a very good idea.' Now, his sister was a very intelligent woman, but she was a philologist and had not the slightest idea of any of his work. Since she was a very good listener, he liked to explain his newest ideas to her."(81) Most scientists must learn to cope with the frustration of being unable to articulate their deepest interests to those whom they love.

The ways in which scientists report their findings tend to hide rather than to reveal their personalities. They minimize personal unresolvable disputes, elevate logical aspects and repress emotions, opinions, preferences and intuitions.(82) The Nobel laureate, George Thomson admitted that, within the relative privacy of scientific circles, controversies in science have often been bitter and not always fairly conducted, but on the whole they have helped not hindered progress."(83) "Much of the misunderstanding of scientists and how they work is due to the standard format of

articles in scientific journals. With the terse accounts of successful experiments and well-supported conclusions they show little of the untidy nature of research at the frontiers of knowledge."(84)

As scientists write up their researches for publication, they provide a scientific context by citing relevant published works. The latter are sometimes discerned in the light of new findings. An element of justification is involved, and possibilities for further studies are often indicated. Only pertinent details of the actual scientific discovery appear in the reported, standardized, repeatable methods as pale shadows of the original colourful course of events. Advisedly, scientific papers do not advocate such crudities as the precipitation of new compounds in the sink. The addition of a specified volume of freshly distilled water to a non-aqueous solution of known concentration at a definite temperature is much more scientific (and much less embarrassing for the discoverer). Of course, the checking of an experiment requires a knowledge of it. Consequently, there is logically speaking no such thing as rigorous repeatability.(85)

With the emphasis on objective reporting, scientific publications do not display the great gifts of persons like Isaac Newton, Michael Faraday or Ernest Rutherford. They "knew what to ask and how to pay attention not so much to what Nature was saying as to what Nature was whispering."(86) Nor do scientific papers or reviews capture such raptures as the rhapsodies of Ludwig Boltzmann on J. Clerk Maxwell, recorded in his contemplation of the latter's dynamical theory of gases.(87) In fact, "these are attitudes and feelings which every scientist knows are at the centre of scientific research."(84)

Scientists can only aspire to the economy of thought, the repeatibility of action and the neutrality of scientific peer approval. As far as possible they avoid all unnecessary risks of lowering their productivity and reputation. Such consequences could result so easily from an uncharacteristic preoccupation with

social action and comment. There is little sense in Churchmen or anyone else preaching to scientists on the role of social responsibility. Scientists have to deal primarily with objectivity, not ethics and morals.(88)

The morality of science is implied in its pursuit. The commitment of scientists to increased apprehension of the non-moral universal order can only be expressed by the distinctive features of scientific thinking. They include thorough self-criticism and reliable reporting. Ethical questions about modern science are as difficult to ask as to answer. Too many unknowns cloud the issues. When scientists ask questions such as "What is the value of my work? What is the meaning of my vocation? What is the justification of my scientific research?", they can only give answers which rest ultimately on intuition and optimism. Attempts to do otherwise would demand too much diversification of effort beyond the bounds of scientific thinking. They would require, of course, the appropriate gifts, learning and, above all, motivation. Comparatively few scientists are so extensively equipped. The vast majority of scientists are convinced that the purpose of scientific research is to expand physical knowledge by first improving personal scientific understanding. It represents the desire to use to full advantage the human mind in apprehending nature.

It seems the bottom line reads that scientific performance and social involvement are inversely proportional for most scientists. (89) Scientific researchers, therefore, are extremely reluctant to change their characteristic spots. Holton put it succinctly when he wrote, "The major reason why some of these scientists can neglect the complex, tenuous long-range links that attach to their science is that they are so successful doing what they are doing. The short-range forces, which they master, completely saturate their capability for forming and perceiving long-range connections."(90)

Because so few scientists display an overt enthusiasm for "social responsibility" many Christians rashly conclude that all scientists are socially irresponsible. Some even believe that scientists are

abetting the forces of cultural disintegration. Other than those who are experiencing the nightmare of statelessness, scientists are hard working citizens paying taxes. They are generally parents who are inevitably involved in concrete social responsibilities. By recognizing their limitations and concentrating on their specialisms, scientists avoid the abdication of their humanity. They express, through labour and activity, their beliefs that their particular disciplines have peculiarly important possibilities within the cultural matrix. They would probably recoil, however, from making their convictions explicit. Like Ulysses, the practising scientist binds himself to the mast of objective apprehension lest the siren song of "social responsibility" draws him overboard to drown in subjective speculation. In any case, too often in the past, the public statements of many accomplished scientists have met the united resistance of societal factions that had previously proclaimed diverse precognition of "social responsibility".

It is in the natures of science, scientific thinking, and scientists themselves that they must remain somewhat detached from the immediacy of the interests, problems and concerns of humankind. Einstein often said that the ideal social position for an original thinker is to be a light-house keeper.(91) In equally picturesque Einsteinian terms, the "delicate little plant (of the curiosity of inquiry), aside from stimulation, stands mainly in need of freedom; without this it goes to wreck and ruin without fail. It is a very grave mistake to think that the enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty."(92)

A rigorous analysis of the socio-political and economic framework of the scientific enterprise is beyond the wildest dreams of industrious scientific researchers. They know science as a human activity whose practice of discovery defies evaluation. Elitism, mysticism and egotism may intrude from

time to time, but science has already outlived many generations of scientists and countless attempts at coercion.

To make contact with scientists, Christians should first try to understand a little of their work, thinking and vocational idiosyncrasies. In short, Christians should approach the scientist as a person with a vocation. "But the years of anxious searching in the dark, with their intense longing, their alterations of confidence and exhaustion and the final emergence into the light - only those who have experienced it can understand that."(93) Consequently, there is nowhere better to begin than with some of the thoughts, researches and characteristics of the world's most renowned twentieth century scientist.

Albert Einstein described frankly his perspective on the dilemma of the academic researcher as he honoured his old friend and colleague, Max Planck.

"A finely tempered nature longs to escape from personal life into the world of objective perception and thought, this desire may be compared with the townsman's irresistible longing to escape from his noisy, cramped surroundings into the silence of high mountains, where the eye ranges freely through the still, pure air and fondly traces out the restful contours apparently built for eternity.

"With this negative motive there goes a positive one. Man tries to make for himself in the fashion that suits him best a simplified and intelligible picture of the world; he then tries to some extent to substitute this cosmos of his for the world of experience, and thus to overcome it. This is what the painter, the poet, the speculative philosopher, and the natural scientist do, each in his own fashion. Each makes this cosmos and its construction the pivot of his emotional life, in order to find in this way the peace and security which he cannot find in the narrow whirlpool of personal experience."(70) Einstein's powerful insights are, so to speak, the finger-prints he left

behind to show how he had carefully handled that fragile dilemma.

7. SCIENTIFIC CONCEPTS AS FREE CREATIONS

Much to the surprise, pleasure and enlightenment of lesser mortals, the brilliant physicist, Albert Einstein, found rather unusual ways of referring to his contact with reality. "All I have is the stubbornness of a mule; no, that's not quite all, I also have a nose."(94) Einstein's "nose" signified for him the ability to find and to follow the right track of scientific research. On the one side, his innate faculty for penetrating to the very heart of a problem and, on the other side, his native ability to recognise the significant implications of any hypothesis were probably sharpened to a keen edge by his work at the Swiss Patent Office. In Berne his duties demanded the patient rewording of applications and the definitive identification of their basic innovation.(95) It is small wonder that this intellectual giant came to believe so strongly that the task of a scientist is to find the most important question, and to pursue it without losing contact with the main problem.

Not only did he believe such things, he also practised them. His struggles for almost ten years in relative obscurity or effective isolation towards what became the special theory of relativity taught Einstein the value of "stubbornness". After a further seven years wrestling with the formative notions of the general theory of relativity he was even more attached to his "nose". Einstein had been seeking a unified field theory for the last seven years or more when, with great conviction, he told Hermann Weyl in 1923 that tracking was neither easy nor painless. "Mathematics are all well and good but nature keeps dragging us around by the nose."(96) With his unique brand of delightfully arresting humour carefully masking an acute sensitivity, Einstein made serious points about the deep problems of the role of experience in the origin of concepts and the function of concepts in ordering experience.

Concerned about the fundamental problem of "the eternal

antithesis between the two inseparable components of knowledge, the empirical and the rational."(97) Einstein reasoned that "the whole of science is nothing more than a refinement of everyday thinking."(98) He believed "that the first step in the setting of a 'real external world' is the formation of the concept of bodily objects and of bodily objects of various kinds. Out of the multitude of our sense experience we take, mentally and arbitrarily, certain repeatedly occurring complexes of sense impression ..., and we attribute to them a meaning - the meaning of bodily object ... logically this concept is not identical with the totality of the sense impressions referred to; but it is an arbitrary creation of the human ... mind ... the concept owes its meaning and its justification exclusively to the totality of sense impression that we associate with it."(99)

Einstein emphasized the creative aspect of thinking while indicating the necessarily personal interpretation of experience. Sense impressions are "given" as a "multitude" of prior indirect knowledge of reality requiring the creativity of the individual or scientists to bring order out of their lack of logical unity.(100) The creation of this order is also the process of explanation. According to Einstein, the best explanatory account of experience offers only highly warranted knowledge. Expressed differently, the creativity of the scientist produces a concept which integrates some range of the multitude of sense impressions to yield both limited meaning and justification.

Einstein explained "that one property which is characteristic of the notion "bodily object" is the property which provides that we co-ordinate to it an existence, independent of (subjective) time, and independent of the fact that it is perceived by our senses. We do this in spite of the fact that we perceive temporal alterations in it."(101) Otherwise stated, when a real existence is attributed to a bodily object, it is given a significance which is largely independent of the sense

impressions that originally gave rise to it. His creativity enables the scientist to decide what repeatedly occurring complexes of sense impressions are relevant to a given investigation. In current terms, facts are theory-laden(102), but, as far as Einstein was concerned, that was not the whole story. To risk obscuration, scientific apprehension "ultrasenses" and the senses of scientists "infrathink". Both kinds of activity span the logically unbridgeable gulf which separates the worlds of sensory experience and concepts. The empirical and rational contents of scientific knowledge are actually inseparable. With this belief, Einstein resolved the apparent tension between the logically free creation of a concept and the attribution to it of a real existence independent of the sense impressions that gave rise to it.

Conceptual systems are not just arbitrary sets of abstractions. They are empirically-loaded. Such an ascription is solely justified by the manner in which the concepts and the mental relations between them enable orientation in the labyrinth of sense impressions. It is never completely guaranteed, never absolutely certain.(99) This implies that unproven beliefs lie at the basis of all knowledge. All characteristics of sense impressions are specified in relation to posterior constructions.(103) To say that a scientific statement is valid is to authorize its assertion which may or may not be legitimately made at a subsequent stage in conceptual development. In other words, the concepts that arise in scientific thinking, statements and theories are logically free creations of the human mind, free inventions of the human intellect, that cannot be derived inductively from sensory experience.(104) On the other hand, purely logical thinking cannot by an operation within its province provide knowledge of the world of experience. All knowledge of reality begins and terminates in experience.(104) Einstein challenged the traditional prejudice that the mind trained in logic and language can achieve meaningful results in all fields of human endeavour without recourse to experience. He rejected a priori approaches to scientific knowledge as attacks

on its empirical contents.

Scientific concepts both order and survey experience. They are tested by their success in structuring the manifold of sense experiences. Scientific knowledge is neither accessible through pure thought alone nor can it be gained through the senses alone. Einstein rejected the notion of purely inductive reasoning. He also dismissed the ideas of hypotheses readily verifiable or falsifiable by immediate experience. Instead, he concentrated on the intrinsically constructive and inherently co-ordinative elements of rational conceptualization. His concern was for the scope and creativity of scientific thinking. Both are ultimately dependent on the personal apprehension of the scientist. The detailed psychological aspects of his experiences are, for scientific intents and purposes, largely eliminated.(105) However, the constructive nature of concepts leaves them open to the danger of being obscured by the everyday habits of combining certain concepts and conceptual relations definitely with specific sensory experiences.(106)

In what Einstein jokingly referred to as his own obituary, his autobiographical essay in Albert Einstein: Philosopher-Scientist (editor: P. A. Schlipp), he actually raised the question, "What, precisely, is thinking?"(107) For him neither the emergence of memory pictures at the reception of sense impressions, nor a series of such pictures - each member calling forth another - has crossed the threshold of thinking. They furnish the raw material from which concepts are constructed. The appearance of a particular picture in many such series becomes an ordering element for such series by connecting the otherwise unconnected series. "Such an element becomes an instrument, a concept."(107)

Einstein's reference to a concept as an instrument has profound implications. It likens the free conceptual play of the natural scientist to the skilful activity of the painter, the poet and the speculative philosopher, comparisons that he made explicitly elsewhere.(70) Einstein was sensitive to both the

presence of hidden qualities in the scientist and the existence of undiscovered order in nature. Somehow the combination of those two guided scientists in their researches.

The particulars of a skill are generally unspecifiable, although the person is never ignorant of them. With such comparisons in mind, Einstein suggested that his own associative conceptual play involved elements "of visual and some of muscular type."(108) Full consciousness of such activity appeared to him to be "a limit case which can never be fully accomplished," because of what he termed the "narrowness of consciousness".(108) Especially, in research thought, do mental pictures or internal words present themselves in the full consciousness or in the fringe-consciousness ...?"(108)

Scientists organize their conceptual reactions to the natural order in ways similar to the co-ordination of muscular and visual responses during skilful activity. The highly pertinent common characteristics of all types of process is the presence of non-articulate conceptual elements. These elements are responsible for the fluidity of concepts and theories. Inveterate habits and routine responses always introduce rigidity at the expense of heuristic attentiveness. If a system of concepts, or a theory, is regarded as a closed immutable entity, then the definable, operational characteristics of its concepts have effectively eclipsed its cosmic connections. The resulting "certainty" is unreal and frustrates further striving.

According to Einstein, scientific theories have something in common with the images of the poet. Both stimulate the intuition of the individual as resources for the apprehension of reality. Basically, any scientific theory embodies aspects of reality that are not explainable in terms of that theory. Scientific theories are not comprehensive instruction manuals. They survey empirical knowledge but necessarily with limited logic and precision. Scientific research is always returning from abroad with intimations of new continents, their differing phenomena, and the

novelty of their diverse life-forms. Scientists glimpse aspects of the natural order through the limited logical unity of scientific theories which always point beyond themselves. In short, Einstein's notion of a concept presupposes the rationality of the universe, without which it would have no vital future. On this presupposition rests the fundamental faith from which all scientific hope springs. Like artists who envisage their creations by working confidently toward them, scientists create their visions of the hidden pattern of the physical world and labour optimistically to refine their concepts of that reality.

The transition from free association of sense impressions, memory pictures, or images to thinking is characterized by the essentially dominating role of concept. But, as indicated, a concept need not be correlated with "a sensorily cognizable and reproducible sign (word)," although it is through such correlations that thinking becomes communicable.(107) Private thought does not necessarily wait for this stage. On the contrary, it "goes on for the most part without the use of signs (words) and beyond that to a considerable degree unconsciously." (107) Each particular concept seems to be originally a heuristic probe or a cognitive compass, but not a map. It assists, so to speak, navigation through the uncharted inexpressible deep of private thought.

Conscious of muscular and visual analogies, Einstein always maintained that the pre-articulate phase of conceptualization was not amenable to exact formulation. Under those circumstances scientists engage in the heuristics of apprehension while denied what have yet to become the definable, operational characteristics of conceptualization. They breathe, as it were, the scientific atmosphere while exploring its chemistry. Even as they enmesh new instruments or concepts as a logical complex of concepts, their non-verbal and intrinsically heuristic aspects are retained. Those aspects of conceptual innovations remain partially unrealised by virtue of their elusive empirical

connectivity. Just as a description of a person cannot acquaint one with him, so a definition of a scientific concept cannot provide an exhaustive understanding of it. Scientists must live alongside it to learn how it behaves in a variety of circumstances. Scientific concepts are never comprehensively exposable to lucid critical inspection because of the nature of their contacts with reality. Their empirical grounding ensures that scientific concepts are fundamentally non-arbitrary, although from a logical point of view, they are free creations of the human mind. Consequently, concepts must be discovered. They cannot be made. Throughout Einstein's writings, he talks consistently of the discovery of scientific concepts and theories. By personal participation scientists grasp the bearing of concepts on experience and expand their visions of the "eternally unattainable in the field of scientific endeavours."(109)

Conventional words or other signs are involved, according to Einstein, at a secondary stage after the concepts are secured and reproducible.(108) Only when a concept has been caught in a logical net does it become definable, quantitative and operational. As already noted, it retains its heuristic character by virtue of its qualitative connectivity.(110) Defined concepts have, therefore, a heuristic coefficient of meaning. In fact, their continued survival ultimately depends on their connectivity to undefined aspects of other complexes of concepts. This openness means that the scientist need not be trapped in the "narrow whirlpool of personal experience."(70) Indeed, his apprehension of the natural order represents a constitutive characteristic of knowledge. Progressively the scientist detaches himself from self-centred passions and illusions by the very practical pursuit of objective knowledge of the universe. In doing so, he nurtures his "sympathy with the natural order."(111) Ultimately, scientists rely, not on themselves, but on reality. By striving to submit to an

independent reality through the co-ordinative role of concepts, scientific thinking rises above the "merely personal"(112) to the level of the personal, above the subjective to the rational. Subjectivity is avoided by the universal reference of the scientist's participation.

8. SCIENTIFIC THEORIES OR GAMES

As far as Einstein was concerned, "all our thinking is of the nature of free play with concepts; the justification for this play lies in the measure of survey over the experience of the senses which we are able to achieve with its aid. The concept of 'truth' cannot yet be applied to such a structure; to my thinking this concept can come in question only when a far-reaching agreement (convention) concerning the elements and rules of the game is already at hand."(113) Einstein was pointing through the visible, audible manipulation of thought to its grounding in reality. His repeated use of the word "play" keeps to the fore the notion that the meaning of scientific research lies in itself. Scientists don't work at conceptualization. They delight in playing at it. In other words, their awareness is primarily of reality not just of some particular task. According to Einstein, scientists are struck by thoughts as well as observations. In scientific thinking, Einstein found not only a logical manifold but also a heuristic dynamics.(51) A heuristic play requires the refinement of apprehension by expanding the logical survey through a responsive re-ordering or re-interpretation of experience. It is intrinsically irreversible because the scientist experiences a growing sympathy with the natural order.

To use an analogy, the scientist travels along a continuous series of conceptual hysteresis loops as his theories are variously created during every cycle. In principle, each loop begins with a heuristic departure from an established theory. The vehicle is an original non-articulate concept.

This venture is a creative act of faith. A formalizing return carries apprehension beyond the old theory to its successor. This activity produces an expanded logical survey. Both halves of the cycle must be traversed before a new theory is discovered. In reality, it is difficult to isolate the two movements. Without the continual heuristic tremor action of the mind's eye, creativity disappears. The discovery of a scientific theory exercises both creativity and analysis. It also stimulates the expectation and intuition which lead to experimentation and the next cycle.

In plain terms, how does one actually arrive at what Einstein called the rules of a scientific game? As indicated, Einstein's discussion of scientific thinking starts with the memory picture and the concept of bodily object of everyday thinking. The refinement of thinking, he believed, was achieved by means of levels or strata of knowledge. On the fundamental level, common to everyday thinking and the first phase of scientific development, concepts are directly connected with sense experience and their inter-relating theorems.(114) The concepts and theorems of all strata are "from the point of view of logic freely chosen conventions ... The relations between the concepts and propositions among themselves and each other are of a logical nature, and the business of logical thinking is strictly limited to the achievement of the connection between concepts and propositions among each other according to firmly laid down rules which are the concern of logic."(115)

"While the rules themselves are arbitrary, it is their rigidity alone which makes the (scientific) game possible. However, the fixation (of the rules) will never be final. It will have validity only for a special field of application."(114) There are, in principle, an unlimited number of games involving different rules, concepts and their relations. None of them can be regarded as providing absolutely certain knowledge. Judgements of significance and coherence can be made only within

a scientific game. A scientific game is heuristically active when it prompts scientific players in other games to alter their rules to improve those conceptual systems. Nevertheless, those players only change the rules as they pursue the rationality of the universe in which all scientific games are rooted. In any particular game, the concepts that are directly and intuitively connected with complexes of sense experiences are called primary concepts. All other notions are connected with them by theorems and derive their meaning by virtue of these connections. They are "statements about reality" in so far as they express "indirect relations between primary concepts, and in this way between sense experiences."(115)

Einstein provided an illustration of the two indispensable characteristics of scientific theories. "Suppose an archaeologist belonging to a later culture finds a textbook of Euclidean geometry without diagrams. He will discover how the words 'point,' 'straight-line,' 'plane,' are used in propositions. He will also recognise how the latter are deduced from each other. He will even be able to frame new propositions according to the rules he recognised. But the framing of these propositions will remain empty play with words for him so long as 'point,' 'straight-line,' 'plane,' etc., convey nothing to him. Only when they convey something will geometry possess any real content for him ..."(116)

"... This extra-logical problem is the problem of the nature of geometry, which the archaeologist will only be able to solve intuitively by examining his experience for anything he can discover which corresponds to those primary terms of the theory and the axioms laid down for them. Only in this sense can the question of the nature of a conceptually presented entity be reasonably raised."(116) Logical investigation cannot reveal the connections between theories and experience. It can only show how concepts relate to one another. Their empirical contacts endow theories with real content. Clearly, Einstein looked beyond algorithms to empirical grounds for the truth-

contents of scientific theories.

According to Einstein, the search for greater logical unity in the world picture characterizes scientific thinking. It cannot rest content with the established standards of everyday thinking.(100) Aiming at as complete an apprehension of the totality of sense experiences as possible, science strives for "the use of a minimum of primary concepts and relations."(100) Scientists invent systems progressively poorer in concepts and relations, but retaining the primary concepts and their relations as logically derived concepts and relations. They arrive at systems of considerably greater logical unity. The latter are still compatible with complexes of sense experiences. In such an enterprise, heuristically poorer intermediate levels gradually disappear with a concomitant loss in ease of understanding As Einstein explained in a letter to a student of philosophy, "it is true that the grasping of truth is not possible without empirical basis. However, the deeper we penetrate and the more extensive and embracing our theories become the less empirical knowledge is needed to determine those theories."(117) Each new theory surrenders previously accessible modes of apprehension, introduces more intricate mathematical methods and postulates the existence of new processes not necessarily open to immediate scientific investigation.(118)

An outstanding case in point is the sequence of transitions from Newton's laws of motion to the special theory of relativity and to the general theory of relativity. In Einstein's words, "The theory of relativity is a fine example of the fundamental character of the modern development of theoretical science. The initial hypotheses become steadily more abstract and remote from experience. On the other hand, it gets nearer to the grand aim of all science, which is to cover the greatest possible number of empirical facts by logical deduction from the smallest possible number of hypotheses or axioms. Meanwhile, the train of thought

leading from the axioms to the empirical facts or verifiable concequences gets steadily longer and more subtle. The theoretical scientist is compelled in an increasing degree to be guided by purely mathematical, formal considerations in his search for a theory, because the physical experience of the experimenter cannot lead him up to the regions of highest abstraction."(119) Einstein recognized that the further scientific theories are removed from the empirical data the more they are underdetermined by the narrow selections of those data. This trend increases the scientist's dependence on mathematical and formal criteria. The latter, of course, represent highly sophisticated contacts with empirical data. The development of modern science does not follow, however, a simple hierarchical pattern of conceptual complexity.

9. JOHANNES KEPLER: A PARTICULARLY FINE EXAMPLE

To summarize the two preceding sections and to illustrate their direct bearing on scientific research, Einstein's two articles on Johannes Kepler are correlated. Einstein underscored the greatness of Kepler's achievement by outlining "his problem and the stages of its solution."(120) As he did so, Einstein demonstrated both the dominant role of concept in Kepler's work, and its dependence on "purely mathematical, formal considerations." (119) This exercise also shows the consistence and coherence of Einstein's thought over a considerable period of time.

Kepler spent "decades of hard and patient work"(120) wrestling with the problem of "the empirical investigation of planetary motion and the mathematical laws of that motion."(120) In other words, he struggled with a particular manifestation of the fundamental problem of "the eternal antithesis between the two inseparable components of knowledge, the empirical and the rational."(97) "Out of the multitude" of the observations and records compiled with such care by Tycho Brahe, Kepler has to bring "order" and explanation.(121) Actually, these data "dealt

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not with the movements of the planets in space but with the temporal shifts undergone by the direction earth-planet in the course of time."(122) But Kepler held an unproven belief in the heuristic power of the Copernican system with the sun regarded as at rest and the planets, including the earth, revolving about it. Indeed, his heliocentric perspective raised the problem of the determination of the motions of the planets as they might appear to an observer on the nearest fixed star.(122) As Einstein pointed out, this problem had to be solved before Kepler could begin to formulate the mathematical laws governing the planetary motions.(122)

Kepler constructed as "an arbitrary creation of the human mind" (121) the concept of "the straight sun-earth line."(123) He used it as an "element" or "instrument."(107) Kepler ascertained how its direction changed in the course of the year. He discovered that these directions lay in "a plane stationary with reference to the fixed stars and that the angular velocity of the sun-earth line varied in a regular way ..."(123) The achieved "measure of survey" (107) over the observations both justified the construction of, and gave meaning to, the concept of "straight sun-earth line."

Kepler also realized "from observation of the sun that the apparent path of the sun against the fixed stars differed in speed at different times of the year, but that the angular velocity of this movement was always the same at the same time of the astronomical year, and, therefore, that the speed of rotation of the straight line earth-sun was always the same when it pointed to the same region of the fixed stars."(123) He associated with these "repeatedly occuring"(121) conditions the concept of a closed planetary orbit. This heuristic device, "which was by no means obvious a priori"(124) imposed a restriction. At the end of each planetary year the planet returned to the same position in planetary space. With the available data on Mars Kepler was able to use this fixed point and that of the sun as reference points for the calculation of angular magnitudes.(125) By employing the standard methods of triangulation and assuming that space was Euclidean, he "discovered the true shape of the earth's orbit and

the way in which the earth described it."(126) Identical procedures were applicable to the other planets. In this phase of his work, Kepler "determined empirically"(126) the planetary orbits.

To establish "from the empirical data"(126) the laws of planetary motions, he had to select a mathematical curve to describe the orbit. He tested his selection against the data, and repeated the process until an acceptable solution was found. In other words, "Kepler had first to recognize that even the most lucidly mathematical theory was of itself no guarantee of truth, becoming meaningless unless it was checked against the most exacting observations in natural science."(127) Although ultimately dependent on his personal apprehension of the universe, Kepler realized that the scope and creativity of his scientific thinking had to be grounded in the observed data. "After tremendous search, the conjecture that the orbit was an ellipse with the sun at one of its foci was found to fit the facts. Kepler also discovered the law governing the variation in speed during one revolution, which is that the line sun-planet sweeps out equal areas in equal periods of time. Finally, he discovered that the squares of the periods of revolution round the sun vary as cubes of the major axes of the ellipses."(126) While skilfully exercising his hidden qualities as a scientist, Kepler detected the existence of previously undiscovered order in nature by looking through and beyond the Copernican system.

"Kepler lived in an age in which the reign of law in nature was as yet by no means certain."(120) He freed himself from traditional habits of mind with "his faith in the existence of natural law." (120) This faith combined with a heliocentric perspective derived from Copernicus(120) to sustain and to guide him in his "search for a greater logical unity in the world picture."(100) His Copernican vantage point was so to speak, "abstract and remote from experience."(119) Kepler was compelled, therefore, "to be guided by purely mathematical considerations in his search for a theory, because the physical experience of the experimentor cannot lead him

up to the regions of highest abstraction."(119) In general terms, "the mysterious harmony of nature into which we are born"(126) enables "the human mind to construct forms independently before we can find them in things. Kepler's marvellous achievement is a particularly fine example of the truth that knowledge cannot spring from experience alone but only from the comparison of the inventions of harmony into which we are born" played a fundamental role in Einsteinian thought. Indeed, it merits considerable attention.

10. THE INTUITIVE RELATION

Belief in an external world independent of the observer is, in Einstein's opinion, the foundation of all science.(128) This assertion takes precedence over all others. The objectivity of scientific research is the on-going discovery of the rationality of the universe. It is subordinate to the given natural order which always transcends current scientific apprehension. The development of science had demonstrated to Einstein's satisfaction that among all conceivable constructions at a given time, one had proved itself to be unconditionally superior. This is Einstein's exclusion principle which depends on much more than observational and experimental evidence.

Science "can teach us nothing beyond how facts are related to and conditioned by, each other. The aspiration toward such objective knowledge belongs to the highest of which man is capable ... Objective knowledge provides us with the powerful instruments for the achievements of certain ends, but the ultimate goal itself and the longing to reach it must come from another source."(129) Einstein was fully convinced that commitment to the scientific enterprise has roots that run much deeper than current objective scientific knowledge. This commitment is perficient and pre-reflective. Although no logical path leads from perceptions to theory, the world of

perceptions practically determines the theoretical system. It does so through intuition which feeds a growing sympathy with the natural order.(111) Scientific researchers combine penetrating intuition and personal assessment, as they respond to an irrepressible commitment to make greater contact with reality.

Meeting with Einstein's approval, Victor Lenzen re-affirmed that "the relational structure of an independent reality can be cognized by virtue of a pre-established harmony between thought and reality." (130) Einstein's conceptual debts to both his former professor Hermann Minkowski(131) and the founder of quantum theory Max Planck(132) are obvious. This pervasive harmony imposes an important restriction. For a physical theory to be complete, every element of physical reality must have a counterpart in the physical theory. In this view, modern science appears as, at most, the pursuit of truth. The attainment of truth would require the comprehension of reality. But scientists are always immersed in more sense experiences than they can cope with at any given moment. They must repeatedly decide, therefore, to disregard some of them and to pre-select others. How they do so depends on the particular stage of scientific development.

The grasping of what is significant in physical theories is not exclusively governed by the condition that "the theory must not contradict empirical facts."(133) There is an obvious but entirely arbitrary and unsatisfactory way of meeting this demand. The rejection of a general theory can be deferred indefinitely by resorting to the use of "artificial additional assumptions."(133) Those artifices adapt the established theory to new empirical data. With such options almost invariably open, this particular criterion is seldom, if ever, sufficient for the confirmation or refutation of a theory. In any case it is limited by its dependence on available empirical data. The latter are themselves pre-selected through theory-laden observations and experiments. In fact, as Holton has consistently explained for nearly twenty years, Einstein had definite scientific occasion to draw attention to those very

weaknesses.(134)

In defense of the special theory of relativity, Einstein maintained(135) that the incompatible experimental results of Walter Kaufmann(136) were insufficient in scope and diversity to warrant a final verdict. He argued that, although those results did match more closely the predictions of the rival theories of electron motion of A. H. Buherer and Max Abraham, these theories were not integral parts of a much more extensive theoretical system. As things turned out, Kaufmann's equipment was inadequate and Einstein's theory became generally accepted. What is highly pertinent to the present discussion is that Einstein placed a far greater emphasis on factors other than any correspondence of theory with "empirical facts." In plain language, Einstein rejected the experimental results of Kaufmann in favour of the formal merits of his own theory. Einstein believed that scientific wisdom includes and supervenes upon the apprehension of scientific fact. He denied that scientific thinking is exclusively analytical. By implication, he dissociated himself from all philosophies and histories of science which insist on the refutability of scientific theories by experimental evidence alone.

Three quarters of a century ago, Einstein argued effectively in the scientific literature that scientific theories cannot be justifiably abandoned solely because a series of counter-instances is discovered.(137) Yet according to Karl R. Popper writing decades later, the characteristic feature of science is its bifurcated process of discovery.(138) This process is supposedly sharply divided into the inexplicable non-rational choice of a hypothesis, conjecture, or guess(139) and the strict testing of the chosen conjecture. By deducing consequences from such a hypothesis deliberate attempts can be made to refute it. In this view, refutation is logically possible, while confirmation is not.(140) Popper believes that competent scientists are continually submitting their conjectures to

criticism. Apparently they are invariably prepared to drop their guesses like hot potatoes as soon as they are refuted. According to Popper, the testing of scientific theories serves the growth of knowledge by leading to sounder and maturer theories of increasing content but decreasing probability.(141)

Popper and Einstein agreed that scientific thinking does not require truth and certainty. They disagreed markedly, however, on what counts as telling contrary scientific evidence. Popper, the philosopher of science, concentrates on the logical aspects of published scientific studies. For him, a counter-instance is sufficient to falsify an universal hypothesis. Einstein, the practising scientific researcher, valued the intuitive relation. According to him, there were other equally significant scientific matters to be considered beyond the strict testing of scientific theories. Einstein believed in a mediated type of knowledge which informed an appetitive sensibility to non-quantitative intimations of reality. In fact, the dispassionate negatisism of Popper contrasts sharply with the committed optimism of Einstein. The former irrationalized scientific discovery, while the latter relished its prospects.

In his defense of the special theory of relativity Einstein appealed to a second criterion, "not concerned with the relation to the material of observation but with the premisses of the theory itself."(133) Defying "exact formulation," this criterion relates to what Einstein referred to as the "naturalness" or "logical simplicity" of the "basic concepts and of the relations between these which are taken as a basis."(133) It concerns the "inner perfection" of the theory, whereas the first criterion refers to the "external confirmation" of the theory. Einstein differentiated clearly between the criticisms of a theory and the grounds offered for it. For example, he realized that in his special(and general)theory of relativity causal relationships are determinate, but that causality is unobservable. The intuitive relation which expresses his unshakable belief in the knowability

of the universe ensures that causality as a logically free creation, need not be observable in order to be meaningful. With this distinction the profound significance of the pre-established harmony between thought and reality begins to emerge.

The bold intuitions of scientists involve private associations, preferences and even preconceptions. They are free creations of the human mind but only within this greater given order. The pervasive structure of that order presents through the intuitive relation all that scientists seek to apprehend. As already noted, it is always greater than what they can define and quantify. When scientists explore the unknown and encounter the unexpected, they are guided "to a considerable degree unconsciously" by its comprehensive rationality. In this view, scientists participate personally in the act of assimilating knowledge. The intuitive relation implies that scientific knowledge cannot be wholly explicit. It is never "objective" in the sense that its content is entirely determined by observation and experiment. A scientist's intuitive grasp of the significance of a theory depends on "a kind of weighing of incommensurable qualities."(133) It involves assaying the various relevant factors and reaching a rational decision where certainty is not possible.(142)

Clearly, scientific thinking is not impersonal, abstract, and disembodied. It requires much wider cognitive powers than traditional conceptions of knowledge would suggest. It is, of course, the relation of the intuitive and explicit components of scientific knowledge that allows for the existence of unspecifiable notions like "naturalness" or "inner perfection." This unspecifiability is the characteristic of scientific thinking with which Einstein grappled. It has been largely ignored or severely underrated by many who have subsequently offered descriptions of modern scientific methods. Theoretical statements are never equivalent to sets of observation statements. In fact, the former relate to reality in an indefinite variety of ways. Observational predictions are not rigorously warranted by a theory. Indeed, as already implied,

Einstein rejected the naive view that the success of a scientific theory can be judged exclusively on the basis of prediction and control. Unknown factors are always operative during any scientific investigation. This precludes pre-established rules to determine the fate of a theory or hypothesis in the event of experimental failure. Still the scientific enterprise is in very good health.

Convinced of the reality of an independent universal order, whose rationality they can only partially intuit at any given moment, scientists often judge a theory on the basis of non-quantitative tokens of reality. The latter include conceptual beauty, correlative capacity and heuristic connectivity. Scientists relate to the economic, systematic and intimative qualities of a theory, particularly in the absence of immediate extensive empirical contact. "A theory is the more impressive the greater the simplicity of its premisses, the more different kinds of things it relates, and the more extended is its area of applicability."(143) It was precisely on those grounds that Einstein planted the flag for the special theory of relativity. He did not regard scientists as the modern intellectual equivalents of primitive big-game hunters. According to Einstein, scientists do not run their conceptual quarry, the scientific theory, to a stand-still in the heat of the empirical day in order to kill it and discard its exposed framework. Nor did he offer a simple account of science as based on an unshakable foundation of fact. On the contrary, he stressed repeatedly that scientists cannot construct with certainty the accumulating laws of nature by means of a well defined logic or a tailor-made method. Only in recent decades have philosophers of science been sentisized to the tentative and transformative aspects of twentieth century science, characteristics to which Einstein responded with the intuitive relation so long ago.

The pre-established harmony between thought and reality is effectual through personal intuition. It is operative not just

in the mature criticism of physical theories but throughout the working lives of scientists. Its impact is felt in the very early states of their intellectual development. In fact, Einstein believed that we are born into the mysterious harmony of nature.(126) He drew attention to his own remarkable intuitive ability in physics "to differentiate clearly the fundamentally important, that which is really basic," from "the multitude of things which clutter the mind and divert the essential."(144) His apparent lack of it in mathematics strongly influenced his decision to become a physicist.(144) According to Einstein, the possibility of seeing a problem or focusing the most significant aspects of a subject depended on his intuitive ability to frame proper questions and to make legitimate associations. Both searching questions and innovative associations helped him to span the logical gap.

As a student of physics, he was much more impressed by "the achievements of classical mechanics in areas which apparently had nothing to do with mechanics" than by "the technical construction of classical mechanics or the solution of complicated problems."(145) Einstein did not isolate the tackling of a particular problem, or the study of a specific topic, from the general scientific context. His greater visions provided him, even as an apprentice, with vital wider intimations of universal order. The validity of a scientific statement, solution or theory depends on more than its local legitimation. It relies also on its broader capacity to reveal reality or to guide an intuited sense of hidden implications. According to Einstein, scientists cannot meaningfully study valid theories without at least considering their bearing on the immediate corpus of scientific knowledge.

In an article entitled "on the Generalized Theory of Gravitation," Einstein raised the following questions. "What, then, impels us to devise theory after theory? Why do we devise theories at all?"(148) He offered the following answer.

"New theories are first of all necessary when we encounter new facts which cannot be 'explained' by existing theories. But this motivation for setting up new theories is, so to speak, trivial, imposed from without. There is another, more subtle motive of no less importance. This is striving towards unification and simplification of the premisses of the theory as a whole (i.e. Mach's principle of economy, interpreted as a logical principle)."(148)

A passion for apprehension motivates scientists. In comparison with the intuitive searching of scientists, the discovery of new facts plays a relatively minor role in the construction of scientific theories. Einstein was convinced, for instance, that without the principle of general relativity no amount of collections of facts could lead to the equations of general relativity.(149)

As an accomplished researcher, Einstein reminisced that he had had "no serious doubts" about the strict validity of "the law of the equality of inertial and gravitational mass" even "without knowing the results of the admirable experiments of Eötvös, which - if my memory is right - I only came to know later."(146) "Never one to give excessive weight to observations"(147), Einstein placed all his scientific hope in "the discovery that a reasonable theory of gravitation" could only be obtained "from an extension of the principle of relativity."(147) Once again Einstein assumed the fundamental point that concepts are discovered, not made. Obviously the discovery of the concept of an extension of the principle of relativity was initially unspecifiable. It developed from Einstein's interpretation of the significance of the equality of inertial and gravitational mass. In other words, he committed himself to a non-arbitrary, non-verifiable, non-falsifiable hypothesis. His strategy successfully led him to the general theory of relativity. The insatiable desire to understand more fully the rationality of the universe by ordering more consistently the ever-changing facts,

observations, and experiments is the motivation behind all science. The intensity of the scientist's "sympathetic understanding" of the natural order reflects his passion for apprehension.

Einstein indicated a little of the nature of the role of the pre-established harmony between thought and reality. But he made no attempt to explicate its detailed functions. On the contrary, he was "satisfied with the mystery of the eternity of life and with the awareness and a glimpse of the marvellous structure of the existing world, together with the devoted striving to comprehend a portion, be it ever so tiny, of the Reason that manifests itself in nature."(150) In fact, he believed that it was not possible to say anything about the exact way in which concepts are formed and connected or about how they are coordinated to experiences.(151) Einstein was convinced that important, unspecified elements are at work in scientific knowledge. Einstein was content, therefore to fall back on explicit qualitative consequences of the intuitive relation. The existence of the higher harmony between thought and reality could not be proved. Nevertheless, he was prepared to make extraordinary scientific hypotheses, non-arbitrary, non-falsifiable, non-verifiable commitments based ultimately on his prior scientific preferences. (152) Einstein did so particularly in what could be described as scientific emergencies when only a transfusion of intuition could save the corpus of scientific knowledge.

Einstein was not unique in this respect. For example, his old friend and fellow physicist, Born admitted freely, "My attitude to statistics in quantum mechanics is hardly affected by formal logic, and I venture to say that the same holds for Einstein. That his opinion in this matter differs from mine is regrettable, but it is no object of logical dispute between us. It is based on different experience in our work and life."(153) However, if Einstein's good news is that the intuitive relation is operative throughout the working lives of scientific researchers,

his bad news is that scientific researchers are unavoidably exposed to delusion and fantasy.

11. DELUSIONS AND FANTASIES

From an Einsteinian perspective, there is always a tension between the logical and creative elements of scientific thinking. The connection between concepts and sense impressions is not of a logical nature. It should not be obscured by a theory of induction. Such a correlation is always a deliberate act of fallible intuition. Einstein stressed repeatedly the logical independence of concepts and sense impressions. On one particular occasion he did so with the following characteristically vivid humour. "The relation (of concepts and sense impressions) is not that of soup to beef but rather of wardrobe number to overcoat." (154) As Holton emphasized, the Einsteinian view of thinking as free play with concepts simultaneously highlights the role of creativity and the risks of delusion and fantasy.(155) This mixed blessing arises because the latter are dependent on exactly the same elements of thinking as the former. Of course, Einstein himself had underscored the tentative nature of the differentiation between sense impressions and representations. (It) is not possible; or, at least, it is not possible with absolute certainty." (156)

With no rule to tell them the next step in research, scientisits must decide for themselves what is reasonable doubt and bold intuition. Research scientists are more or less in situations similar to the one in which the mischievous physicist Carl Bosch once played a newspaper correspondent.(157) The window of the laboratory where Bosch worked as a research student overlooked a block of flats. Giving free reign to his scientific curiosity, Bosch found his unsuspecting victim in a flat with a telephone in full view from the laboratory. Bosch phoned him and introduced himself as his own professor. He announced that he had perfected a new television device which enabled the user to see the speaker at the other end of the phone. The pressman was incredulous, but

Bosch offered to give a demonstration. He invited the newspaper correspondent to adopt a series of postures, and then described them accurately. The result of this deception was an article in the next day's paper. There followed a bewildered verbal exchange between the victim and the real professor. The research scientist is always poised, so to speak, to play similar tricks on himself.

From the very beginnings of modern science, scientists have had to be forcefully reminded of the ever-sounding sirens of conceptual complacency. Recurrently, well-rehearsed performances mesmerize scientists until they founder on contact with reality. Classic cases from the annals of science's history include the absolute authority bestowed on the Ptolemaic system, Euclidean geometry, Newton's laws of motion and the indivisibility of the atom. Born commented on one example, "(Euclidean geometry) first showed that objects in the external world follow strict laws as regards their spatial properties. Later, delight in the beauty of these laws had the result that the empirical foundations of geometrical science were disregarded or even denied, and the study of its logical framework became an end in itself."(158)

An amusing tale told of the theoretician P. A. M. Dirac, supposedly while he was still a student, exaggerates the point. (159) Allegedly, Dirac attended a mathematical congress at which he was presented with the following problem. Three fishermen were so preoccupied with their unaccustomed success that they found themselves in darkness on a secluded island. Agreeing to spend the night on the island, each settled beside his boat. Two men were soon fast asleep, but one was unable to sleep. He decided to go home. Rather than disturb his companions, he threw the extra fish into the sea and divided the rest into three equal parts. He departed with his share of the catch.

About two hours later, a second fisherman awoke. Noiselessly he prepared to leave. He tossed the extra fish along the beach and divided the remaining fish into three equal parts, without

realising that his friend had already gone. He too set off with his fish for the mainland. When the third fisherman arose, it was nearly morning though still dark. Unaware of the activities of his companions, he dumped the extra fish in the sea and divided the other fish into three equal piles. Pleased with his spoils, he also left the island quietly.

Dirac was asked to determine the least number of fish that the fishermen could have had. He proposed that there were initially (-2) fishes. The first fisherman threw one away leaving (-2)-1 = (-3) fishes. He took (-1) with him, leaving (-3)-(-1) = (-2) fishes. The second and third fishermen did exactly the same. When asked to solve this particular problem, Dirac is reputed to have responded in a characteristically "anti-social" way.

This is, of course, a delightful flight of fantasy about the scientist who fished the positive electron - the positron - out of the sea of electrons. It illustrates both the foolishness of solving a problem as an end in itself and the absurdity of losing contact with reality. It also exposes the inadequacy of Popper's view that only operations dictated by an algorithm are rational.(139) On the contrary, in accordance with an algorithm and violating no laws of logic, the unknown author of this tale obtained an irrational solution to the problem. Most practising scientists have painfully experienced the difference between faulty logic and irrationality in science.

Einstein's recognition of the recurrent neglect of the ambivalence of scientific theories was faithfully recounted by Lenzen. "Concepts that have proved useful in the constitution of an order of things readily win such an authority over us that we forget their earthly origin and take them as changeless data." (160) In fact, this is a quotation from Einstein's eulogy of Mach, published in 1916. It continued, "Then they become 'necessities of thought', 'given a priori', etc. The path of scientific progress is then, by such errors, barred for a long

time. It is therefore no useless game if we are insisting on analyzing current notions and pointing out on what conditions their justification and usefulness depend, expecially how they have grown from the data of experience. In this way their exaggerated authority is broken. They are removed, if they cannot properly legitimate themselves; corrected, if their correspondence to the given things was too negligently established; replaced by others, if a new system can be developed that we prefer for good reasons."(161)

Clearly, Einstein and those who appreciated the experimental grounds of his instructive insights saw the need to remain mindful of the ever-present dangers of scientific conservatism. By allowing the definable and operational characteristics of concepts and their relations to suppress, or effectively eliminate, the heuristic qualities of those concepts, scientists can develop a false sense of security. In other words, the logical ordering of sense impressions always threatens the free creations of the scientific mind. Familiarity with the success of existing rules and theories tends to breed contempt for their constructive origins. This contempt, in its turn, inhibits greatly the acceptance and the advancement of non-arbitrary, non-falsifiable, non-verifiable hypotheses.(162) Einstein realized that while theories are created by scientists, these inventions can come alive, turn upon their creators, and coerce them, and therefore their experiments, to conform to the resulting biologies.

Many scientists can surely be forgiven for assuming that Thomas S. Kuhn has transfigured Einstein's ideas into a retrospective classification for an analysis of science's history. Kuhn describes scientific research either as periods of scientific revolution involving new "paradigms" or explanations, or as periods of "normal" science characterized by an inattentiveness to "paradigmatic" foundations.(163) "Normal" or paradigmatic science addresses itself to "puzzles"

because they are known to be solvable in principle, whereas "revolutionary" science accompanies the acknowledged failure of an entrenched paradigm to account for significant phenomena. This classification cannot cope, for instance, with the complex issues of the contributions of Poincaré, Lorentz and Einstein in the special theory of relativity. Nevertheless, the basic correspondence with Einstein's original thoughts is clear. Einstein, however, related in terms of scientific reorientations. He was careful not to obscure the dominant continuity of modern science with talk of scientific revolutions. For Einstein, the working scientist, continuity is rooted in the intuitive relation as are the free conceptual constructions of a general theory or "paradigm." However, what is referred to as "normal" science by Kuhn was a resurgence of debilitating authoritarianism in Einstein's view.

Scientists fashion, often unwittingly, their apprehensions of reality with habitual beliefs or routine assumptions. They visit them on the situations they confront. For instance, Newton's first law is untestable and remained effectively unchallenged for centuries until Einstein's powerful intellect penetrated its intrinsic ambiguity. He adapted this law in the light of the equivalence of gravitational and inertial masses. Inertial mass represents the reluctance of a particle to acceleration and gravitational mass its tendency to be pulled by another mass.(164)

A related hazard is the temptation to reduce reality to the sum of constructive constituents. This illusion prevents scientists from seeing beyond their models to the given rationality of the universe. According to Einstein, the pursuit of science relies heavily on the attitudes of scientists towards their hypotheses. Scientific advance depends on the commitment of scientists to the search for a greater logical unity. This search can uncover "paradigmatic" clues either in the course of essentially routine, basically unspectacular and logically consistent scientific researches, or during a premeditated attack on the foundation of a general theory. Outstanding

examples are Planck's classical investigations of black body radiation and Einstein's early researches published in 1905, respectively. Einstein's intimate knowledge of quantum mechanics and the theories of relativity had convinced him of the presence of undiscovered dynamic order in nature. Consequently, he could neither associate himself with reductionism nor abandon causality to blind chance and static necessity. One of his inimitable sayings condensed his thoughts. "God is not playing dice."(165)

As already indicated, science seems to be ultimately a matter of faith. Scientists believe in the intelligibility of the universe and hope to discover aspects of it. Bluntly, their researches rely on reality impinging on them through intuition and carrying them into a new manifold. In plain language, Einstein rejected abstraction ultimately on the basis of conviction. When faced with the criticism that the complexity of scientific concepts masks the logical relation of concepts and reality, Einstein had to revert to his faith in the correlation of mind and matter. "The successes reaped up to now by science do, it is true, give a certain encouragement for this faith."(154) "It is the aim of science to establish general rules which determine the reciprocal connection of objects and events in time and space. For these rules, or laws of nature, absolutely general validity is required - not proven. It is mainly a program, and faith in the possibility of its accomplishment in principle is only founded on partial successes."(166) Science also "seeks to reduce the connections discovered to the smallest possible number of mutually independent conceptual elements. It is in this striving after the rational unification of the manifold that it encounters its greatest successes, even though it is precisely this attempt which causes it to run the greatest risk of falling a prey to illusions."(167)

In the final analysis, "a system has a truth-content according to the certainty and completeness of its co-ordination-possibility

to the totality of experience."(168) With his deep conviction of the rationality of the universe, it seems that Einstein's "nose" for truth was far more precious to him than any presumptuous claims to "truth." In fact, Einstein could not attach a precise meaning to the term "scientific truth." Nevertheless, he "believed that scientific research can reduce superstition by encouraging people to think and view things in terms of cause and effect."(169) "As for the search for truth," wrote Einstein, "I know from my own painful searching, with its many blind alleys, how hard it is to take a reliable step, be it ever so small, towards the understanding of that which is truly significant."(170) According to Einstein, scientists discover the truth-contents of scientific theories by relying on faith and action to unmask delusion and fantasy.

12. POSSIBLE THEOLOGICAL CONNECTIONS

When seen against this brief outline of Einstein's views on scientific thinking, his occasional utterances reminiscent of biblical statements appear less enigmatic. Any mist around remarks like "only a life lived for others is a life worthwhile," (171) "the true value of a human being is determined primarily by the measure and the sense in which he has attained liberation from the self,"(172) or "the creations of our mind shall be a blessing and not a curse to mankind"(171) begins to clear. Besides, such comments presuppose a broader context for the unrelenting strivings of individual scientists.

Although Einstein, like the vast majority of scientists, never formulated a rigorous metaphysics, he knew only too well that, in so far as scientists use reason, they can be said to embark on the philosophical enterprise. If they refuse to acknowledge this, they increase the risk of falling into severe contradictions. Einstein realised that modern science could not avoid philosophy. In fact, he saw the available explicit and implicit philosophies of scientists as reducible to two fundamental types. The first,

the ontologistic, is characterised by an emphasis on the logical elements of science. It is based upon an underlying identity between scientist and nature. The second, the cosmological, concentrates on empirical aspects of science. It is commonly represented by positivism, and assumes the discrete co-existence of scientist and nature.

While it is fairly common knowledge that, at some stage or another, Einstein rejected Mach's philosophy as untenable, his dissatisfaction with the ontologistic type is less generally recognised. Indeed, on occasions, Einstein's views have been associated with the ontologism which suits Oriental religions. Actually, Einstein implied that each of the two types of philosophy provides a metaphysical basis for some aspects of modern science, but that each also precludes other equally important characteristics.

Oriental mystics are engaged in the quest for knowledge in the sense of immediate certainty. Einstein regarded scientific knowledge as mediated through sense impressions and intuitive faculties. He also saw the concomitant dangers of delusion and fantasy. In short, he reasoned that the possibility of error in scientific research precludes certainty. Hence the immediacy demanded by the mystic cannot be attained through the scientific enterprise. From an Einsteinian perspective, the fundamental issue appears to be: What do scientists accept as their criterion of the real - logic, experience or something else? The ontologistic position sees the denial of the supremacy of logic as a threat to all thinking and communication. Logic, therefore, is taken as normative for reality. By attempting to dictate to reality, the ontologistic approach fails to provide an adequate metaphysical framework for Einstein's views of modern scientific research.

According to Einstein, a "firm belief, a belief bound up with deep feelings, in a superior mind that reveals itself in the world of experience, represents (his) conception of God."(169)

This relation presupposes the plurality which the mystical or unitive ontologistic approach seeks to overcome.

For Einstein, scientific wisdom is conditioned by the commitment of the scientist. In contrast to the ontologistic way, his "eternal longing for understanding"(175) and his "ever-firm belief in the harmony of our world"(175) motivate him. Hence scientific knowledge is not primary. "Behind every achievement exists a motivation which is at the foundation of it ..."(176) Clearly, the inadequacies were too numerous for the ontologistic approach to be espoused by Einstein. Consequently, having also rejected positivism, Einstein had to find a third type of philosophy.

The pre-established harmony between thought and reality provides for an intuitive relation between the private thinking and seeking of scientists and the world at large. This relation accommodates the influential spectra of physical, biological, cultural and spiritual events. The latter are cogent through the associations, preconceptions, commitments and emotions of every scientist.(177)

Einstein saw the inquiring, searching and probing scientist as individually open through intuition to the rationality of the universe or the whole of the natural order. Christians, or at least some of them, believe that the asking, seeking, and knocking Christian is personally open through the Holy Spirit to the Word of God by whom all things were made. He is open, therefore, to the entirety of the divinely created order. From an Einsteinian perspective it would appear that theological and scientific thinking might have epistemological points of contact. Indeed, if a suitable interaction model were found, such apparent parallelisms might provide a way in which science and theology could be mutually enriching. However, the development of science has repeatedly shown that false paths can be followed by mistaking analogy for evidence. The validity of such parallelisms should be established before they are taken too seriously.

Objectivity is certainly the hallmark of published scientific theories and data. Still, scientists are free to identify with whatever and whoever assists them in their theorizing and experimentation. In reality "hard experimental tests combine with the intellectual discontent, intellectual movement, intellectual attitudes of the moment. Certain kinds of theory, certain kinds of explanations, are then considered acceptable, and others are not considered acceptable."(178) Contrary to popular opinion, scientists are not depersonalized by scientific research. Modern science is a human activity on which the whole gamut of human experiences have a bearing. Nevertheless, scientists are always guided by and subject to the immediate intimations of the rationality of the natural order.(154) "Every scientist, in working out his own research, gravitates to particular points on the boundary which separates the known from the unknown, and becomes inclined to take his particular perspective from these points."(179) The scientist's personally chosen expertise, provides him with the necessary specificity to engage uniquely in the general quest for scientific knowledge. Expressed differently, the scientist's personal perspective on scientific knowledge, as Einstein conceived it, takes into account the totality of presuppositions which represent his claims to knowledge. His private scientific thinking stems from his personal involvement or calling to serve in "the temple of science."(180) In other words, scientific "personalities are not formed by what is heard or said, but by labour and activity." (181)

Einstein was acutely conscious of the indispensability of the individual liberty of scientists. To reject this freedom, or to ignore it, is to introduce a very dangerous dichotomy. The latter invites the relegation of discovery to realms of irrationality. It also encourages the recasting of scientific statements into statements without empirical foundation. Scientific thinking

is thinking of, and on the basis of, the given reality of the rational universe. It is valid only in so far as it derives from that rationality and refers back to it. This two-fold reference is achieved through the free individual labour and activity of scientists.

Many Christians are correspondingly sensitive to the theological significance of the personal freedom of the Christian. To infringe on this God-given privilege, or to surrender it, is to identify with disjunctive disobedience. The latter degenerates life to anarchic chaos and culminates in death. It also degrades theological statements to statements without conformity to the self-communication of the Word of God. Theological thinking is thinking of, and grounded in, the Reality of the economic condescension of God. This means that the Eternal Word, without ceasing to be Word, has accommodated Himself to humankind in its weakness and incapacities in order to effect communion. Theological thinking is authentic only in so far as it respires that Word and aspires to His sacrificial communication. This dual identification is accomplished through the free personal worship and mission of the Christian. The intriguing fact is that such alluring parallels between scientific and theological thinking can be sketched so readily. It suggests that a greater familiarity with the nature of scientific thinking might benefit Christians, if only to allow them to distinguish more effectively between the two.

Einstein's emphasis on the difference between private scientific thinking and public scientific knowledge requires a qualitative differentiation between scientific wisdom and scientific information, between assimilation and acquisition. He was convinced that "if a person masters the fundamentals of his subject and has learned to think and work independently, he will surely find his way and besides will be better able to adapt himself to progress and changes than the person whose

training principally consists in the acquiring of detailed knowledge."(182) Scientists with first-hand apprehension of their disciplines are capable of deliberating on the relevant issues. People who lack this wisdom are not competent to make scientific decisions. Scientific judgment of significance and coherence can be made only within a scientific game. Persons who, so to speak, have not played the game, are obviously incapable of arriving at scientific conclusions. Harold Brown's description of rationality is not new.(183) Indeed, it bears a striking resemblance to views expressed by Einstein well over forty years ago.

It is very easy for scientists to acquire so many facts, so much data, that they swamp their powers of assimilation. They also have ample opportunity to apply particular theories in a variety of ways without necessarily coming to grips with their fundamental principles. Indeed, on one occasion, Einstein criticized severely an eminent fellow scientist saying that he "couldn't really understand how anybody could know so much and understand so little."(184) Learning the facts and memorizing the theories can never compete with learning the theories and memorizing the facts. Only the latter can develop a keen sense of scientific direction.

There are usually mitigating circumstances. "It is, in fact, very common in physical investigation," wrote Born, "to find it easier to derive a formal relation from extensive observational material than to understand its real significance. The reason for this lies deep in the nature of physical experience; the world of physical objects lies outside the realm of the senses and of observation, which only border on it; and it is difficult to illuminate the interior of an extensive region from its boundaries."(185) On the other hand, Born had strong words for offenders of a different persuasion. "A theoretician who, immersed in his formulae, forgets the phenomena which he wants to explain is no real scientist, physicist or chemist,

and if he is estranged by his books from the beauty and variety of nature I would call him a poor fool."(186)

The physicist Lewis Branscomb described a related incident in the working life of Vladimir Rojansky.(187) Rojansky was asked to interpret the experimental results of a fellow physicist. Two weeks passed before the experimentalist inquired about Rojansky's progress. "Ive almost solved the problem," said Rojansky, "but give me another week. I'm having trouble explaining the high temperature behaviour." In awe of the theoretician the experimentalist showed patience. A few days later, Rojansky appeared with the fruit of his labours. His ingenious theoretical prediction went right through all of the experimental points, including the troublesome one in the lower right-hand corner. "It was easy to explain the steady rise with temperature," Rojansky reported, "but I had a terrible time understanding the phenomenon that turns the curve over so suddenly at that last point." "But that point," gasped the experimentalist, "is part of the legend!" To be fair to Rojansky, it should be stressed that this incident arose out of a simple misunderstanding rather than any wilful estrangement from nature on his part. Nevertheless, as both scientists knew, the resulting formulae had no bearing on reality.

Christians are well aware of those who have ears to hear and eyes to see but who do neither. Perhaps some of them cannot because of the erratic contrivances of modern biblical scholarship. The inexhaustible extra-biblical solutions that could be used to appease the imagination of the scholar present formidable problems. They promise to reduce biblical content to infinite dilution in the absence of an appropriate principle of relevance. The accumulation of information from "comparative" sources, "identified literary" sources, "conventional" forms, hypothetical "oral traditions," and philological and etymological studies is not equivalent to the growth of understanding. From this swelling tide of data it is too easy to fish "anti-theological" creations which illustrate the foolishness of speculative self-indulgence. Without some cognizance of the intrinsic rationality common to all biblical

sources, the acquisition of information using diverse theological accoutrements inhibits assimilation. Modern biblical techniques remain entirely arbitrary until their underlying assumptions are grounded in some higher rationality. Without this grounding those procedures have little in common with modern science. It is, therefore, dangerously misleading to refer to them collectively as "critical science." To avoid sheer mechanical manipulation, biblical techniques should always be placed in an adequate theological context of which they are only necessary parts. It should also be noted that when theological contexts or Christian dogmatics become autonomous, they too have been reduced to mechanical contraptions.

Evidently scientific and theological thinking are susceptible to similar seditions. While science is currently confused with technology, theology is presently bemused by the techniques of biblical studies. Baseless speculation and a logic of contriving threaten both modern science and Christian theology. Einstein, the physicist, knew that "for us human beings, our mutual behaviour and our conscious strivings for our goals are much more important than any factual knowledge." (171) Thinking scientifically involves assessments on the basis of relevant scientific evidence. The demand to be scientific obligates scientists to search for scientific grounds on which they can make scientific decisions. Thinking theologically presumably consists of somewhat similar aspirations.

The perspicuity and perspicacity that are attested by Einstein's scientific work are equally affirmed by his epistemological utterances. They are also confirmed by almost everyone who met him. They are franked by courage and unconventionality. The essence of Einstein's wisdom lay in his childlike simplicity to think things that many others had thought many times before him, but to think them in entirely new connections. For example, everybody had known for about seventy years that the law of electromagnetic induction

depended on relative motion. Nobody had been sufficiently bothered by the fact that the theory did not take this circumstance into account.(188) Einstein was the exception who arrived at the special theory of relativity. Again, the knowledge that inertial and gravitational masses are equal, the principle of equivalence, had been known for about two hundred and fifty years. By brooding over this principle, Einstein was able to build the general theory of relativity.(189)

Clearly, scratching the surface of Einstein's "occasional utterances of an epistomological content"(189) is sufficient to reveal the possibility of connections between scientific and theological thinking. However, before one can pursue those matters, one must have some notion of how and why Einstein "trie(d) to make for himself in the fashion that suit(ed) him best a simplified and intelligible picture of the world."(70) As he himself said, "Behind every achievement exists a motivation which is at the foundation of it and which in turn is strengthened and nourished by the accomplishment of the undertaking."(190) Obviously, a discussion of some aspects of Einstein's achievements is advisable before their origins are considered.

13. GOOD REASONS

Many Christians will probably concede that even a bird's-eye view of the development of Einstein's scientific researches is worth the effort for its own sake. Most of them are likely to resist the suggestion that it is particularly meaningful to Christians interested in the general nature of scientific thinking. Indeed, many of their expressed opinions and their expedient references bear witness to the strength of this resistance. Moreover, Einstein himself admitted that scientists are essentially "uncommunicative solitary fellows." Does it make any sense then for Christians to consider in detail selected aspects of one specific case? Actually there are several reasons why this task merits attention, despite the probability that it will shoot far more questions than it can possibly bag.

First, Albert Einstein was not an ordinary Nobel laureate. His scientific achievement has made it "inconceivable that there will be any general reversion to pre-Copernican, pre-Newtonian or pre-Darwinian assumptions concerning the general nature of the universe and man's place in it(.T)here will likewise be no return to the world-view of Einstein's predecessors."(191) Einstein's scientific contributions challenged humankind by presenting it with a whole variety of options. When taken up, they changed the course of human history. Modern Christians can only benefit from a clearer understanding of the important distinction between Einstein's achievement and humankind's applications of it. One way to seek such clarity is to glean direct from Einstein's work a little about the personality and modes of thought behind it.

Second, a cursory inspection of the principal connections between one brief phase of Einstein's researches and the contemporary public scientific knowledge demonstrates that continuous scientific development undergirds local methodological discontinuities.(192) Such an appraisal raises doubts about what some philosophers and historians of science refer to as "scientific revolutions." It also highlights the conservative, instructive and regulative roles of scientific learning.

Third, Einstein's scientific researches show the great power of the intuitive relation, especially when placed in a semblance of the concrete where, when, and from whom he assimilated heuristic concepts. In particular, they demonstrate that the "labour and activity" of the individual scientist is of far greater consequence for understanding scientific research than preconceived notions of a simple standardized scientific method.

The opposite extreme, of course, is to describe modern scientific research as anarchic or irrational. There are powerful inducements to lapse into subjectivism. Deceptively, some of the most profound and creative scientific researches were accomplished by individuals who responded to the singular circumstances of distinctly personal experiences. In a half-waking dream Friedrich August Kékulé saw a

snake eating its own tail as his original conception of the formation of molecules of benzene and its derivatives. The snake became chains of carbon atoms coiled into hexagonal rings.(193) Presented in 1865, this description was accepted by most chemists long before modern theories of chemical valence explained the stability of aromatic compounds. It seems that a hypnagogic state and a strong conviction conspired to advance stereochemistry.

In 1911 Ernest Rutherford's students presented him with some astonishing but convincing evidence. It proved that an occasional α-particle emitted from a parent radium atom rebounded backwards from its metallic foil target.(194) Collision with an electron could not account for this unexpected phenomenon. The α-particle is thousands of times more massive than an electron. Rutherford's vivid imagery captures that moment. "It was almost as incredible as if you had fired a 15-inch shell at a piece of tissue paper and it had come back and hit you."(195) On the basis of available theories of statistics, those results seemed to be beyond belief. Boldly, Rutherford interpreted them as indicating that the structure of the atom resembled that of the solar system. He concluded that the atom's central tiny heavy nucleus was surrounded by electrons traversing the vast emptiness of atomic space and went off to learn the mathematics. Apparently, a combination of serendipity and imaginative brilliance associated the infinitely large and small to provide the rudiments of modern atomic theory.

In 1935 Hideki Yukawa suggested his meson theory of nuclear forces. He developed it from a nuclear model based on the structure of the atom. Yukawa postulated for the proton-neutron pair a parallel to the continuous quantal exchange of the nucleus-electron pair.(196) This required the existence of a new kind of particle, called the meson. Its mass, if charged, would be intermediate between those of the electron and proton. In 1936 Carl David Anderson made the first observation of such a particle. It appears that a fantastic flash of intuitive insight led to the first rational account of nuclear binding forces.

The sequels to a chemist dozing in his armchair by the fire, happy accidents in the laboratory of an experimental enthusiast, and the intuitive hunch of a theoretical physicist were seminal developments in organic chemistry, atomic theory, and sub-nuclear physics, respectively. Frustratingly, many scientists doze but do not, thereby, discover. Few of the millions of accidents in the scientific laboratories have happy endings. Even more rarely do intuitive hunches pay such large and immediate dividends. Nevertheless, these are the things Nobel laureates are made of, or so some would have Christians believe.

A closer look at only four of Einstein's scientific publications will alert open-minded Christians to the grave distortions that can result from scant descriptions of the fruits of decades of personal scientific learning, labour, and commitment. Although the transitional point from a scientific problem to its solution may be signalled by an exceptional personal experience, this is not invariably the case. To isolate this type of event as the crucial factor in scientific discovery is to respond, naively, to scientific results. It is reasonable to assume that such transitions indicate the presence of an intuitive component in scientific thinking. The frequency of their occurrences does not automatically justify, however, interventionist interpretations of scientific creativity.

Those, then, are a few important reasons why Christians should learn something of the salient features of the development of the Einstein's scientific researches. But most significantly, by doing so they will prepare the ground for a realistic appreciation of modern scientific thinking. However, the benefits of brooding are only seen at hatching.

14. SCIENTIFIC CONTINUITY

In 1905 Einstein published in Annalen der Physik four papers that accelerated markedly the advance of the natural sciences. Each paper included the solution to a major scientific problem. However, as Einstein pointed out, all four contributions were

products of his general preoccupation with "the electro-magnetic foundations of physics."(197) Born's apposite aphorism is, "Einstein's conception of the physical world cannot be divided into watertight compartments."(198)

In the earliest of these papers Einstein considered the current differing theoretical treatments of the discontinuous nature of gases and other ponderable bodies and their energies, on the one hand, and of the continuous character of electromagnetic processes in "empty space," on the other.(199) Toward its end he discussed the anomalous effect which had been a stone in the scientific shoe for many years. Heinrich Rudolf Hertz had discovered that certain metals in a high vacuum emitted electrons on irradiation with ultra-violet light (the photoelectric effect).(200) Subsequently, Philip Lenard had investigated this effect. He obtained experimental results in sharp contrast with expectations based on Maxwell's theory. Three years later in 1905, Lenard was awarded the Nobel Prize and Einstein provided an explanation of the puzzling experimental data.

The wave theory of light predicts that "a certain definite proportion of the energy of radiation is transformed into energy of motion of the electrons."(201) It also requires "the velocity of the emitted electrons to increase if the intensity of the light increases."(201) The experimental results indicated that the energy of the emitted electron is independent of the intensity of the light. Moreover, they showed that its energy decreases proportionally as the wavelength increases. "The remarkable thing about the process is that only the number, and not the velocity, of the electrons emitted depends on the intensity of the light. The wave picture of light is of no use in understanding this: for, if we move the metal plate away from the light source, the incident wave becomes weaker and more and more rarified, and it is incomprehensible how it can always communicate the same energy to an electron."(202)

In his treatment of this effect Einstein showed that the

experimental evidence is consistent with a description of the radiation as a stream of minute particles, quanta or photons. Intuitively, he adapted the ideas of Max Planck who had used discreteness of energy to resolve the problem later referred to as the Ultra-violet Catastrophe. By explaining the photoelectric effect in this fashion, Einstein illustrated the heuristic power of the quantum hypothesis. Only in the following year did he realize that Planck had also introduced discreteness into the physics of charged harmonic oscillators.(203) In particular, Planck's work concerned the emission and absorption of light, not the structure of the radiation itself. It represented the origin of quantum theory, whereas Einstein's contribution signalled the development of quantum theory. The latter was acknowledged as such by the Nobel prize committee in its award to him. Einstein had absorbed Planck's theoretical construct, produced a conceptual variant, and applied it to the anomalous phenomenon discovered by Hertz and investigated by Lenard.

Actually, Einstein did not use Planck's radiation law. He argued correctly that the earlier and simpler law of Wilhelm Wien represents the limiting case for low radiation density. Under the latter conditions, the corpuscular character of the radiation is more evident.(204) Einstein ascribed discontinuities to the emitted energy, whereas Planck had done so only to the emitter. Nevertheless, it is abundantly clear that the common interests of all five scientists were the properties of electromagnetic radiation and the area of applicability of Maxwell's theory.

In 1856 the young physicist James Clerk Maxwell had developed a mathematical description of Michael Faraday's intuitive ideas of the "field." In doing so he had unified electricity, magnetism and optics.(205) Maxwell's equations did not include even the basic equations of Newton's theory. Still they accounted for numerous and diverse phenomena, so much so that their explanatory power as a fundamental theory rapidly and seriously

rivalled that of Newton's theory. As Einstein and Infeld stated, "The formulation of (Maxwell's) equations is the most important event in physics since Newton's time, not only because of their wealth of content, but also because they form a pattern for a new type of law. The characteristic features of Maxwell's equations, appearing in all other equations of modern physics, are summarized in one sentence. Maxwell's equations are laws representing the structure of the field."(206)

In immediate practical terms, Maxwell's theory had indicated that visible light waves represent only a small part of a vast range of electromagnetic processes. The discovery of infra-red and ultra-violet radiation encouraged the search for hitherto unobserved forms of electromagnetic radiation. By 1886 Hertz had generated and detected radio waves and demonstrated their diffraction, interference and polarization effects.(200) Characteristic of the self-correcting heuristics of science, this work led to the discovery of the photoelectric effect. More generally, it revealed that Maxwell's theory had raised its own brace of anomalies.(207)

Against this scientific background, Einstein's interest in the wave-particle duality appears eminently rational. This duality epitomized the confrontation between Newtonian and Maxwellian physics. A robust platform of scientific development allowed Einstein to pioneer this particular field. He learned from the explorations of others, maintained established links in the conceptual chain, and secured new connections in theoretically and experimentally familiar ground. His paper pointed scientific investigation beyond itself toward greater precision and fuller apprehension.

In another contribution to Annalen der Physik in 1905, Einstein dealt with the applicability of statistical mechanics to microscopically observable phenomena.(208) Three years earlier, he had extended the work of Ludwig Bolzmann. His efforts amounted to "a rediscovery of all the essential features of statistical mechanics" as thoroughly and

independently treated by Josiah Willard Gibbs the previous year.(209) Einstein had then proceeded to an analysis of the random motion of a small particle suspended in a fluid. He assumed that such a particle is continually bombarded by molecules conforming to a statistical mechanical description. This assumption enabled him to derive an expression for the magnitude of molecular dimensions in terms of experimentally determinable quantities. Significantly, Einstein predicted an observable effect and tentatively correlated it with what had been observed as Brownian motion.(197) His hesitancy reflected a meagre knowledge of that kind of motion.

The naturalist Robert Brown had observed seventy years earlier the zig zag motion of minute pollen grains or inorganic dust particles suspended in a fluid. This type of motion, named after him, was not caused by any external influence. It remained unexplained until Einstein accounted for it on the basis of his molecular and statistical hypotheses. The "fundamental step taken by Einstein," Born stressed, "was the idea of raising the kinetic theory of matter from a possible plausible hypothesis to a matter of observation, by pointing out cases where the molecular motion and its statistical character can be made visible."(210)

In more than one sense, Einstein's researches followed the activities of Maxwell. Neither scientist confined his attention to electromagnetic theory.(211) Maxwell was the first to apply the idea of probability to the seventeenth century creation, the kinetic theory. According to this notion, a gas is composed of vast numbers of tiny particles speeding around in all directions. They collide with one another and bounce off the surface of their containing vessel. From this invisible chaos Maxwell extracted order. He showed that the distribution of energy among the particles can be calculated precisely because the motions, collisions and bombardments of the particles are random. The outstanding feature of his mathematical description is its independence of the detailed nature of both the particles

and the forces they exert on each other. His treatment pointed to a fundamental property of matter in equilibrium. This concept flamed the intuition of scientists like Boltzmann, Gibbs and Einstein. In particular, Boltzmann interpreted the Second Law of Thermodynamics in terms of probability, and as already noted, both Gibbs and Einstein developed aspects of the former's pioneering work.

Einstein's treatment of Brownian motion along with Planck's earlier determination of molecular size from radiation studies convinced most sceptical scientists of the reality of atoms and molecules. Once again, its dependence on, relevance to and continuation of, prior scientific studies encouraged scientists to regard this Einsteinian contribution as a sizable local movement of science which is continually bombarded by new theoretical and methodological entities.

A third paper presented the now-familiar special theory of relativity. Its title On the Electrodynamics of Moving Bodies indicates that it arose out of the same scientific milieu.(212) In fact, Einstein explained the close association of ideas.(213) The small particle suspended in a fluid became a "freely moving quasimonochromatically reflecting mirror" in a space filled with radiation. The bombarding molecules became bombarding quanta of radiation. The photoelectric effect was seen as a typical example of the general wave-particle nature of microscopic phenomena. Newtonian theory could not cope with the time irreversibility of the Second Law of Thermodynamics or the wave-particle duality of electromagnetic radiation. Maxwell's theory could not account for the corpuscular nature of microscopic processes. A new unifying theory was needed.

After considerable time spent in despairing efforts to construct an alternative theory on the basis of the facts, Einstein eventually concluded that an analogy to the Second Law was required. He discovered one, but not without prolonged deliberation.(214) His appeal to the Second Law of Thermodynamics was based on an earlier discovery. This law applied to both electromagnetic

radiation and ponderable particulate aggregates.(215) The Second Law was general in this respect. Therefore, it appeared more fundamental than either Maxwell's equations or Newtonian mechanics with its associated concepts of mass and force. There was nothing arbitrary about Einstein's thinking. On the contrary, it was firmly rooted in his private scientific experience of the continuous growth of public scientific knowledge.

From his reading of the philosophical writings of David Hume and the scientific writings of Ernst Mach, Einstein learned the value of critical reasoning, particularly of epistemological analysis.(216) Maxwell's equations predicted that the speed of light is finite and independent of both the source and the observer. In empty space the velocity of all electromagnetic waves is the same.(217) Those equations imply absolute rest in the sense that bodies "at rest" should behave differently from those in uniform motion. Specifically, a charged electrical condenser with parallel plates should rotate when moving, but not if at rest. Absolute rest meant at rest relative to the medium in which the light was transmitted. In his critique of the Newtonian theory of motion, Mach had returned to Newton's views on the kinematical irrelevance of absolute space and time.(218) Some change was needed, therefore, in order that Maxwell's equations, like Newton's, would apply in all inertial frames. Einstein proposed that the velocity of light was a fundamental invariant independent of the motion of the source and the observer. Therefore, the concept of a "light medium" or "luminiferous ether" was superfluous. Actually, as early as 1899 Jules Henre Poincaré had expressed doubts about both the existence of the ether and the detection of absolute motion.(219) But Einstein did not know of Poincaré's consecutive investigations.(220)

The measurement of motion depends on the measurement of time. The latter is based on the concept of simultaniety. This concept relies on the use of light signals. The conceptual key

was Einstein's realization that the velocity of light is only practically infinite in daily life.(221) While the idea of the simultaneity of two events occurring in the same place is acceptable, the corresponding action for two events at different locations presents problems.(221) In fact, it has no physical meaning. This led Einstein to "the recognition of the relativity of the concept of simultaneity."(222) If simultaneity is relative, so are distance, speed, acceleration, force, energy etc. In other words, the basis of the natural sciences is transformed.

By assuming that the laws of nature are independent of the choice of the inertial system, i.e., by extending the principle of relativity operative in Newtonian mechanics to all physical processes(223), Einstein arrived at "relations of a new type (Lorentz transformations) ... for the conversion of co-ordinates and times of events." Einstein's desired "restricting principle for natural laws, comparable to the restricting principle of the non-existence of the perpetuum mobile which underlies mechanics," turned out to be that "(t)he laws of physics are invariant with respect to Lorentz-transformations (for the transition from one inertial system to any other arbitrarily chosen system of inertia). (224) The principle of relativity does not assert, however, that all things are only relative. In fact, it requires that natural laws are determinate despite the reality that all observers do not experience the same effects. The private times and spaces of different observers do not exist in isolation. They all belong to a single objective public space-time called the universe. For Einstein, reality is invariant. A real external world exists which can be discovered through scientific research. The objective laws of nature are invariant in all frames of reference. By distinguishing the variant from the invariant scientists penetrate the dynamic structures of reality. They lose the notion of an extended rigid body but gain deeper apprehension of physical reality whose objectivity contrasts sharply with all forms of

cultural relativism.

In this third paper Einstein derived the Lorentz transformations. Unknown to him, an alternative derivation had been presented earlier by Hendrik Anton Lorentz.(225) Einstein's theory was, however, profoundly different. Lorentz had obtained his equations by using ad hoc assumptions to modify Newtonian theory.(226) The special theory of relativity was based on two fundamental postulates. Those conjectures were not arbitrary. They were firmly rooted in available scientific theories and observations.(227) Through them it was shown that the Lorentz transformations had universal validity. Einstein admitted freely that he had known of the earlier studies of Lorentz, but not of his later work(1904).(228) But as Einstein explained, the important new feature of his theory was the realization that the bearing of the Lorentz transformations transcended their connections with Maxwell's equations. It concerned the nature of space and time. Set against the knowledge that Maxwell's equations did not account for the microstructure of radiation (photoelectric effect etc.), this feature had particular significance for Einstein. It gave him somewhere to hang his hope of penetrating the underlying interdependence of all his researches.(228)

The Lorentz transformations reduce in the limit of small velocity to the familiar Galilean transformations. Similarly, the relativistic transformation of velocities reverts to classical form. The effects of length contraction, time dilation and velocity-dependent mass, all derivable from the Lorentz transformations, are integral aspects of Einstein's theory. This paper also contains a new theory of the Doppler shift, a new treatment of Bradley's aberration of light, and modified electromagnetic equations, based on Hertz's formulation, from which the law of conservation of charge can be derived. A new theory of motion of the electron including an outline of an experimental test represents the conclusion and the aim of this impressive contribution. As a charged ponderable body, the electron had to

obey both a theory of mechanics and some form of electromagnetic theory. Einstein produced a unifying theory of the electrodynamics of moving bodies.

The fourth short paper spells out the now-famous proposal that all energy has mass as a novel consequence of the theory of relativity. It indicates a tentative correlation with observed properties of radium salts.(229) The realization that "radiation conveys inertia between the emitting and absorbing bodies"(230) points scientists beyond the old discrete-continuous disunities. Two years later, Einstein propounded the more important formula $E = mc^2$, which asserted that all mass is equivalent to energy. Thus, his short note of 1905 represented the first major step towards a deeper understanding of both the instability of radioactive atoms and the stability of the stars as they continue to radiate vast quantities of light and heat.

Consistently, all four papers reflect Einstein's great interest in theoretical particulars, and his relative reticence about experimental details.(231) Those publications demonstrate his concern with fundamental principles. At times, they betray his ignorance of some recent scientific literature. It has to be remembered, of course, that they were conceived in effective isolation. As Ronald Clark put it, "(Einstein) had the run of the Patent Office library, strong on engineering but weak on physics, and he read the leading physics journals published in German. But he had access to little else. Neither did he work, nor could he talk and debate on social occasions, inside a university environment with its incessant point counter point argument, its constant cross-fertilization of ideas and its stimulating climate of inquiry ... thus from 1902 until 1905 Einstein worked on his own, an outsider of outsiders, scientifically provincial and having few links with the main body of contemporary physics."(232)

Nevertheless, there was nothing isolated about the scientific content of Einstein's researches. His explanation of the

photoelectric effect was eventually recognized as the birth of quantum theory with Planck's innovation regarded as its conception. The Brownian motion was hailed in the light of Einstein's work as penultimate to the observation of atoms and molecules. The special theory of relativity, reducible to Newtonian theory in the limit of terrestrial velocities, reconciled kinematics and electromagnetism. It replaced the two logically independent concepts of electric vector field and magnetic vector field by a single tensor field. It also collapsed into one law the laws of matter, momentum and energy conservation. The attribution of mass to energy pointed the way to a fuller apprehension of atomic structure. Later, the equation of mass and energy provided a quantitative basis for the earlier work of Rutherford and others, who had already established through their studies of radioactive decay that the atom contained vast energy resources.(233)

Louis de Broglie has described Einstein's four papers as "blazing rockets which in the dark of the night suddenly cast a brief but powerful illumination over an immense unknown region."(234) All four publications planted the seeds of new scientific theories though Einstein did not care to nurse them unduly. Repeatedly, he outlined possibilities for experimental investigation, but paid little attention to practicalities. Einstein's papers published in 1905 were relevant to the work of Bradley, Boltzmann, Brown, Doppler, Fitzgerald, Helmholtz, Hertz, Jeans, Kirchhoff, Kohlrausch, Lenard, Lorentz, Mach, Maxwell, Michelson, Morley, Newton, Ostwald, Planck, Poincaré, Rayleigh, Riemann, Rutherford, Voigt, Weber and Wien to name only a few leading scientific lights. As already noted, Einstein himself declared that "in science ... the work of the individual scientist is so bound up with that of his scientific predecessors and contemporaries that it appears almost as an impersonal product of his generation."(235) Prior converging lines of scientific research met in Einstein's work as the focal point.

From it they emerged to illuminate a new diversity of phenomena amenable to scientific investigation. The hallmark on Einstein's achievement reads "science." The term "revolution" is totally inadequate.(236)

In 1928, Born emphasized the importance of continuity to scientific research. He discussed it in relation to Maxwell's equations, Fresnel's proof of diffraction, the theory of relativity and quantum mechanics.(237) Twenty three years later his conviction remained firm.(238) Bondi stressed repeatedly that the development of the special theory of relativity stands "four-square on Newton's first law of motion."(239) Almost thirty years ago, Holton commented, "The more urgent fact is that 'revolutionary' ideas arise only very rarely compared with the large number of workable or even great ideas conceived within the traditional setting, so that the individual scientist is wisely predisposed to favor the type of advance which he knows and believes in from personal experience."(240) Eight years later, he too re-affirmed his adherence to the theme of continuity. "The so-called scientific 'revolution' turns out to be at bottom an effort to return to classical purity. This is not only a key to a new evaluation of Einstein's contribution, but indicates a fairly general characteristic of great scientific 'revolution'."(241)

15. COMMITMENT AND ACTION

Einstein's four papers had a powerfully heuristic impact on scientific development because it had first had an unrivalled influence on him. "At that time Einstein's gift for divining such correlations was almost uncanny." Born continued, "It was based on a (basically) thorough knowledge of experimental facts combined with a profound understanding of the present state of the theory, which enabled him to see at once where something strange was happening."(242) With so much learning under his belt, Einstein was sufficiently edified to look through and

beyond its conservative, instructive and regulative roles.

The same can be said of Kékulé, Rutherford, and Yukawa, none of whom could have benefited from their distinctly personal experiences without the "labour and activity" so necessary to attune them to the harmonies of nature.(110) To select an example, Rutherford had already won the Nobel prize when he discovered the atomic nucleus. The prize had been awarded for his demonstration that naturally occurring radioactive atoms decay spontaneously into other atomic species. This achievement had encouraged chemists and physicists in their attempts to understand atomic structure. Continuing with his research on the atomic nucleus, Rutherford the Nobel laureate was the first to change one atomic species into another by artificial means. This sequence of closely related successes was once vexingly referred to by a friend who said to Rutherford, "You are a lucky man ... Always on the crest of the wave!" The eminent researcher replied, "Well, I made the wave, didn't I..." Rutherford had not worked very hard on his modesty, but he had driven himself remorselessly for decades in search of "the theory of matter."(243)

Rutherford's commitment matched that of the finest scientists. What Einstein said of Johannes Kepler's commitment, for instance, on the occasion of the three hundredth anniversary of his death, is equally applicable to Rutherford's devotion. "How great must his (Kepler's) faith in the existence of natural law have been to give him the strength to devote decades of hard and patient work to the empirical investigation of planetary motion and the mathematical laws of that motion, entirely on his own, supported by no one and understood by very few!"(120) In general what scientists get out of their researches depends to a considerable extent on what they put into them. According to Einstein, facts are theory-laden and theories are empirically loaded. Achievements do not visit scientists like bolts out of the blue, although the manner of their appearances might suggest otherwise to non-scientific observers.

The cumulative, corporate nature of public science communicates to individual scientists through the intuitive relation its received intimations of the rationality of the universe. The research student's apprenticeship and his supervisor's associations with colleagues foster, but cannot guarantee, the transmission of a wide range of skill, information and wisdom. All are necessary in the continuous pursuit of science. The learning of an old theory or the discovery of a new one is simultaneously an irreversible heuristic enterprise and a reversible logical exercise. Their desires for greater logical clarity and unity transform scientists both intellectually and appetitively. They respond to hopes of refined contacts with reality, by entering conceptual hysteresis loops of scientific research. Thus, they expand their scientific apprehension and experience. Always they relate to the mystery of reality directly as individuals. Yet, to a considerable extent, they perform reflectively as members of the scientific community.

As scientists study the basic principles, and also the published literature, relevant to their subjects, they discipline themselves. They learn to do so by reappraising past developments and current reorientations within their specialisms. They strive continually to assimilate, to improve scientific wisdom, in order to be more capable of recognizing and pursuing original scientific insights.(97) Scientific genius seems to be the personal labour of setting one's fire with wood chopped by others and then lighting it with a match taken from a growing sympathy with the natural order. That sympathy thrives as long as scientists identify with the work of other scientists. Of course, they must react creatively to it. There is a sense in which the scientific genius possesses a deeper apprehension than the ordinary scientific researcher. This sense is not easy to specify. Certainly, it includes, among other things, a keener awareness of the implications of scientific theories and a wider range of scientific interests.

Actually, the Einsteinian view that scientific knowledge is not primary but depends on the commitment of the scientist places considerable emphasis on the severely underrated notion of scientific freedom. The modern scientific enterprise depends heavily on the decisions of its researchers. For example, they must decide for themselves the range of their interests, the nature of their specialisms, and the intensity and extent of their labours. Scientific researchers can neither act nor think without at least implying criteria of significance and coherence. The idea of a completely orderless scientific freedom precludes the possibility of such criteria. Hence, decision is eliminated and, therefore, scientific freedom is meaningless. Obviously, scientific freedom must be structured in some way if it is meaningful. The ordering of its structure must originate beyond the scientist himself. As far as Einstein could see, the rudimentary framework of a theory of scientific knowledge could not be formulated without some such external reference. The central question for him was: "What are acceptable scientific criteria of significance and coherence?"

Einstein avoided complete relativism in scientific knowledge because he believed in an external world independent of the observer.(128) The invariance of the laws of nature permits a multiplicity of scientific games or partial views of reality, while guaranteeing its superior rationality. The pre-established harmony between thought and reality enables the scientist to apprehend aspects of the natural order. As already noted, all knowledge of reality begins and ends in experience.(244) Sooner or later, all scientific theories are shown to be inadequate. In other words, delusion and fantasy are exposable by scientific experience because scientific theories have less freedom than the scientist himself.

In fact, the rationality of the universe is vastly superior to that of the individual scientist. Consequently, Einstein assessed scientific concepts and theories by their success in

structuring the manifold of sense experience. He safeguarded the freedom of the scientific researcher by subordinating his decisions ultimately and exclusively to the natural order. In so far as a scientific theory is merely a tool in the hand of the scientist, both have entered, so to speak, into a compact of deceit. The scientist confers on the theory a false authority, and in return he receives an illicit sense of certainty. At some stage, this double-duplicity betrays the theory. The only kind of scientific theory that could invariably resist such complicity would be one with the freedom to oppose the scientist's decisions. Einstein believed that that scientific theory is the rationality of the universe and that the pre-established harmony between thought and reality is its means of expressing its resistance.

Einstein went much further. A decision is always made by someone, not by something. Besides, whatever evidence the scientist accepts, whether that of experience or that of logic, it will depend neither on experience nor on logic alone. All scientific knowledge is ultimately based on a decision in favour of one or the other or both. Scientific knowledge always presupposes the freedom of the scientist who makes a decision, even if it is to abandon the pursuit of science. Consequently, Einstein placed his faith in a God who could give the scientist "a sense of the ultimate and fundamental ends. To make clear these fundamental ends and valuations, and to set them fast in the emotional life of the individual, seem(ed) to (him) precisely the most important function which religion has to perform in the social life of men."(129) Such ends "came into being not through demonstration but through revelation, through the medium of powerful personalities. One must not attempt to justify them, but rather to sense their nature simply and clearly."(245) These references to both revelation and personalities provide further evidence of Einstein's opposition to the ontologistic approach.

However, in spite of his candid comments on religion, Einstein

could not countenance the idea of a "personal" God with the power to act in the world. In his view, the hypothesis of causality was indispensable.(246) His God is neither playing dice nor interfering with the causal order or, for that matter, the freedom of the scientist. Understandably wary of the common subjective interpretations of the "personal," Einstein was eager to escape from the "merely personal,"(112) from "the futility of human desires and aims(,to) the sublimity and marvellous order which reveal themselves both in nature and in the world of thought." (247) In general, he was fully committed to a comprehensive emancipation of the individual from all forms of anthropomorphism.

Yet only a living God could have already made ultimate decisions which allowed the scientist to relinquish his own subjective ones. Nothing less than a superior Being could provide for the exposure of delusion and fantasy. On one occasion, Einstein spoke at some length in terms of the "superpersonal," (248) in spite of its anthropomorphic associations. For him, the initiative lies with God who has already expressed Himself in the causal order, and who, therefore, has no need to be causally efficacious in the world. While the scientist is free from theologies of fear and works, he is motivated by a cosmic religious feeling.(246) Scientists are "profoundly religious people"(174) who take the works of God extremely seriously. Einstein himself regarded the scientific enterprise as a religious attempt to retrace the lines drawn by God. In a "superpersonal" or "extra-personal" sense, his God is the scientific way, truth and life.

Einstein's distinct view of scientific freedom involves a relation beyond the self. It presupposes a centre of freedom as external reference, a living God behind the universe who engenders a cosmic religious feeling in the scientist. This feeling is not achieved by taking thought, but only by being inspired from beyond oneself. Scientists in their freedom are

trapped in a vicious circle of perpetual delusion and fantasy unless they are open through the intuitive relation. Scientific commitment arises not because individuals choose science, but because science chooses them. Indeed, the scientist lives by faith. He believes in a superior intelligence and strives to apprehend what he had already expressed in the causal order. The scientist grows in a trust and knowledge of the rationality of the universe. He responds to that rationality through the intuitive relation in order to help his unbelief. The Christian thinker can hardly miss the conceptual affinities.

It is of the very nature of modern science to identify and to advance beyond the inadequacies of existing ways of scientific thinking. Scientific wisdom involves continuing revision and reinterpretation. Refutation is only a possible logical check on commitment to an ever-expanding apprehension of the universe.(134) Without such commitment to responsive, responsible action, scientific wisdom degenerates into scientific information. Consequently, in the hands of non-scientists, the inevitable compilations are infinitely difficult to integrate. In fact, part of the business of scientists is to root out false discontinuities in their private thinking. This conceptual grooming renders them more capable of recognizing and investigating real discontinuities in the public corpus of scientific knowledge.(249) Without an adequate grasp of fundamental principles to guide them or the necessary freedom to pursue intrinsic connections, scientists are left stranded on the apparently incohesive factual surfaces of their disciplines.

Although there are discontinuities in modern science, fragmentations have no place in scientific researches. Scientists do not shatter existing unity, unless it can be surpassed. The unification of scientific theories is extremely hard to achieve. The theories of science stand on explicated ground inspiring wonder and anticipation. Even the novice captures a sense of mystery. The labour of generations of committed scientists has been co-ordinated.

Throughout the centuries, scientists have started from where others have finished. Always experiencing the impressive present and viewing the past and future through it, modern scientists realize that those theories are the proximate products of a corporate human enterprise with a direction and a purpose. In this basic respect, Einstein was no exception.

A discussion of Einstein's article on "the mechanics of Newton and their influence on the development of theoretical physics," (250) serves several purposes. It demonstrates the utter consistency of Einstein's thinking and his invariant commitment to scientific research, even while referring to historical scientific matters. It also exposes the intuitive relation as the backbone of scientific continuity. Lastly, it illustrates the heuristic power released by another exceptionally gifted scientist with a thorough knowledge of fundamental principles.

16. THE MECHANICS OF NEWTON

For Einstein, "the mechanics of Newton and their influence on the development of theoretical physics"(250) bristled with relevance to current scientific thinking. Einstein saw Newton as a "brilliant ... inventor of certain key methods." He acknowledged that this great scientist "had a unique command of the empirical material available in his own day." He was also greatly impressed by the Newtonian mind which "was marvellously inventive as regards detailed mathematical and physical methods of proof."(250) But Einstein singled out as most important of all Newton's contribution of a "self-contained system of physical causality." This theoretical edifice represented some of "the deeper features of the empirical world."(251) In other words, it appealed directly to Einstein's persistent concern about "the eternal antithesis between the two inseparable components of knowledge, the empirical and the rational."(97) "This self-contained system" did not use a multiplicity of "artificial additional assumptions."(252) It was based on

"the greatest possible sparsity of ... logically independent elements (basic concepts and axioms)."(168) "Deeper features of the empirical world" had been grasped by Newton as "the most nearly possible certain (intuitive) and complete co-ordination with the totality of sense-experiences."(168) At the beginning of this essay, Einstein directed the attention of his reader away from traditionally narrow, totally explicit accounts of scientific knowledge and development.

Scientific methods and an admirable acquaintance with the empirical data played only supporting roles. By starting from non-arbitrary hypotheses Newton was able to deduce a theoretical framework which pointed the way to greater apprehension of the structured universe. Einstein's discussion accentuated Newton's heuristic activity as grounded in scientific experience. To a historian of science, this introduction to an essay written on the occasion of the two hundredth anniversary of Newton's death might appear rather strange, perhaps even superficial. Clearly, Einstein was not contributing to a history of science. He was presenting a personal scientific appraisal of Newtonian mechanics.

After baldly claiming that "the existence of a chain of physical causation"(251) was only "a bold ambition"(251) lacking "co-ordination with sense experiences"(168) in the minds of ancient Greek materialists and all philosophers before Newton, Einstein described Kepler's law as "empirical".(251) Despite his monumental labours, Kepler's three laws provide "a complete answer to the question of <u>how</u> the planets move around the "sun" but "do not satisfy the demand for causal explanation."(251) They are not "self-contained." Being "logically independent," they have "no inner connection with each other."(251) Most significantly, they do not reflect "deeper features." In particular, they cannot answer the general question of "<u>how the state of motion of a system gives rise to that which immediately follow it in time</u>." This deficiency persisted

because they are "integral and not differential laws."(253) Similarily, Galileo's germane discoveries of the law of inertia and the law of bodies falling freely in the gravitational field of the earth "refer to the motion as a whole."(253)

Newton's brilliance recognized that "only by considering what takes place during an infinitely short time (differential law)"(254) could a formulation be reached which applied to all motion. Of Newton's three laws of motion, the second (differential law) carried the heaviest load. It combined an invented concept of mass, a concept of force borrowed from the current science of statics, and a "double limiting process." (253) Still, "the motion was only determined by the equation of motion in cases where the force was given."(254) "A completely causal concept of motion was achieved" using Newton's "idea that the force operating, on a mass was determined by the position of all masses situated at a sufficiently small distance from the mass in question."(254) Einstein emphasized that "it is the combination - Law of Motion plus Law of Attraction - which constitutes that marvellous edifice of thought which makes it possible to calculate the past and future states of a system from the state obtaining at one particular moment, in so far as the events take place under the influence of the forces of gravity alone. The logical completeness of Newton's conceptual system lay in this, that the only causes of the acceleration of the masses of a system are <u>these masses themselves</u>."(254) In view of Einstein's researches, it is hardly surprising to find him underscoring this particular feature.

The importance of Newton's achievement was not restricted to a logical basis for the science of mechanics. His system effectively "formed the program of every worker in the field of theoretical physics."(255) This is an alternative way of indicating that it related to "the deeper features of the empirical world." With a law of force extendable to a great

diversity of events, his system had the powerfully heuristic quality of obvious multiple connectivity. Its openness and incompleteness invited wider applications. Basically, "(a)ll physical events were to be traced back to masses subject to Newton's laws of motion."(255) The influence of the mechanics of Newton can be traced in theories of light, heat, gases, electricity, and magnetism, and even in the wave theory of light.(255) In fact, "Newton's fundamental principles were so satisfactory from the logical point of view that the impetus to overhaul them could only spring from the demands of empirical fact."(255) Through "inveterate habits,"(256) the generations of scientists who followed Newton became progressively less aware of the weakness of his system. Newton himself had wrestled with those deficiencies. His scientific progeny were less ambitious. Their familiarity with the successes of Newton's system turned their attention almost exclusively to its applications.

According to Einstein, Newton represented his system "as necessarily conditioned by experience." He "introduce(d) the smallest possible number of concepts not directly referable to empirical objects."(257) That condition forced Newton to acknowledge that "observable geometrical quantities and their course in time do not completely characterize motion in its physical aspects" (the bucket experiment).(257) This intimation of the incompleteness of his system was not ignored by Newton. On the contrary, he responded with the concepts of absolute time and space. He realized that space must "possess a kind of physical reality if his laws of motion are to have any meaning."(257) "This shadowy concept"(257) was "undefined" and "underived."(168) It revealed both the greatness of Newton's scientific wisdom and the weakness of his system. Without it his theory would have been logically more acceptable. With it his system was much more meaningful.

Newton admitted that forces acting directly and instantaneously

at a distance are not characteristic of the processes of everyday life. He also conceded that "his law of gravitation is not supposed to be a final explanation."(257) Besides, his theory could not account for the strange coincidence that "the weight and the inertia of a body are determined by the same quantity (its mass)."(257) Einstein saw all three defects as relating to the "naturalness" of the theory and its "inner perfection."(252) Space affected masses but was uninfluenced by them. Mysteriously, inertial and gravitational masses were equal. Gravitational interaction was strikingly atypical. As Einstein remarked, "they merely represented unsatisfied desires of the scientific mind in its struggle for a complete and uniform conceptual grasp of natural phenomena."(217) The mind on display was, of course, that of Newton. His personal commitment to the rationality of the universe had carried him to the limitations of his own scientific theory.

Characteristic of science, "Newton's mechanics prepared the way for the field theory." It provided the differential law as "the first decisive step."(258) The resulting (Maxwell's) equations became the first serious rival to Newton's theory of motion. They formalized Faraday's concept of the "field," a new kind of physical reality in addition "to the mass point and its motion."(258) They also established that electric and magnetic interactions are propagated through space at a finite speed. Inevitably, this sequence of events increased reservations about forces acting instantaneously at a distance. Developments in the theory of the electromagnetic field, particularly Hertz's experimental work and Lorentz's theoretical labours, encouraged attempts to explain the Newtonian law of motion on the basis of field theory. Thus, Maxwell's theory "led inevitably to the special theory of relativity which, since it abandoned the notion of absolute simultaniety, excluded the existence of forces acting at a distance."(258) The special theory of relativity showed the equivalence of mass and energy, the variability of

mass, the speed of light as the limiting velocity, and Newton's law of motion as the limiting case of a new law of motion.(258) Einstein argued a strong case for the continuity of scientific research.

"The general theory of relativity formed the last step in the development of the program of the field-theory."(258) According to Einstein, the causal absoluteness of space, the coincidence of the equality of inertial and gravitational masses, and the independence of force laws, the three defects of the Newtonian theory, were all eliminated. "Inertia, gravitation, and the metrical behaviour of bodies and clocks were reduced to a single field quality."(258) Spanning the centuries between Newton and modern science was an "organic development of Newton's ideas." But the findings of more recent researches involving radiation, atomic spectra, radioactivity etc., indicated "a limitation of the applicability of this whole conceptual system."(259) In particular, the current interpretations of quantum theory were characterized by indeterminism and delocalization, both of which opposed relativity theory. Einstein regarded quantum theory as useful for calculations or correct predictions but incapable of providing an adequate description of reality. Basically, Einstein could not accept the assertion that the laws of nature had to be formulated in terms of probability; nor could he reconcile himself to the reinstatement of action at a distance.

Many of his fellow scientists were convinced that the law of causation had collapsed. Einstein did not agree. Instead, he looked for a solution to the contemporary dilemma in the connections between field theory and the de Broglie-Schrödinger method, their common dependence on differential equations and the latter's treatment of discrete energy states. His concluding words, therefore, challenged those scientists who would presume to decide such ponderous matters on the basis of the available evidence. Such a momentous decision would reorient the "course

of Western thought, research and practice." It would transfigure modern science as determined by Newton in a manner "like no one else before or since."(250) It might even return science to some form of pre-Newtonian acausal chaos.

It would be a grave error, however, to assume that Einstein was appealing to the authority of Newton. Indeed, Einstein implicitly rejected such tactics by demanding that "every man be respected as an individual and no man idolized."(109) Einstein was pointing through the continuous development of theoretical physics to an intuitively expanding apprehension of reality. To him, what was really at risk in a premature abandonment of the law of causation was the "whole conceptual edifice" of modern science. This edifice included corporate non-articulate scientific experience. In the Einsteinian analysis, Newton had a "greater importance than his genius warrants because destiny placed him at a turning point in the history of the human intellect."(251) Science chooses the scientist.

Einstein's urgent intention was to discourage current tendencies to reject "the modern physicist's demand for causality." (253) He served it by indicating how the laws of causation and the differential law had provided the ultimate bases of all natural science from the time of Newton to the rise of modern quantum theory. Einstein was fully committed to causality. For example, in the special theory of relativity space and time are distinguished on the basis of causality. Time-like intervals represent causally related events. They are time-like intervals in all frames of reference. Likewise, space-like intervals represent non-causal events. They are space-like intervals in all frames of reference. In other words, causally related events are temporally related, whereas non-causally related events are spatially related. Consequently, simultaneity is only relevant to the former. Einstein's conceptual key, the constancy of the velocity of light, closed the door on the observation of causally independent events. Only measurements of causally past events of the world are obtainable. His own researches made him acutely aware, therefore, that

causality could not be "observed." Nevertheless, they convinced him that causality was indispensable.

Einstein communicated those beliefs to Born, "I am well aware that no causality exists in relation to the observable; I consider this realization to be conclusive. But in my opinion one should not conclude from this that the theory, too, has to be based on fundamental laws of statistics."(260) This quotation refers to quantum theory. It is based on the intuitive relation. With no logical bridge between concepts and sense impressions, causality expresses itself in scientific theory. Consequently, Einstein refused to accept the indeterminism of quantum theory. "... I should not want to be forced into abandoning strict causality without defending it more strongly than I have so far. I find the idea quite intolerable that an electron exposed to radiation should choose of its own free will, not only its moment to jump off, but also its direction."(261) Clearly, Einstein saw in the indeterminism of quantum theory a threat to the determinate causality of relativity theory and, indeed, the ultimate basis of modern science. The scientist should have greater freedom than the electron.

In this essay, the referenced contacts with his epistemological utterances are too numerous to be ignored. The dominant theme of causality is closely associated with representations of "the deeper features of the empirical world." Even Newton is given second place after the intuitive relation because scientists are created and re-created through involvement in science. The inescapable conclusion is, therefore, that Einstein's scientific thinking forced him to address scientific questions about current scientific thinking. He tackled a contemporary scientific issue with a modern reappraisal of the achievement of Newton. He appealed to its continuous relevance as he saw it unfolded through the intervening centuries. In fact, Einstein

seems to have pursued similar aims in many of his essays. A common theme appears to be the emancipation of scientific creativity from all kinds of pseudo-authority. According to Einstein, the historical details of Newton's synthesis, or even the breakthrough itself, is not as vital to science as its inexhaustible and inextinguishable light. Newton's system has enlightened scientific thinking throughout the subsequent development of theoretical physics.

Einstein was interested in the fuller significance of the mechanics of Newton. It transcended mere historicity. On another occasion, he explained how a scientist approaches his discipline. "The way in which he regards its past and present may depend too much on what he hopes for the future and aims at in the present; but that is the inevitible fate of anybody who has occupied himself intensively with a world of ideas."(244) In addition to historical background, a scientific perspective always includes an heuristic horizon. Private scientific apprehension is invariably an incomplete expression of an attempt to handle personal reactions to a reality which is only gradually accessible. To "deeply underscore the role played in the process (of scientific development) by the older theory's occasional failure to meet challenges posed by logic, experiment or observation"(262) was not Einstein's urgent concern. What was at stake was the law of causation, and with it the intuitive relation, scientific continuity and learning. Einstein demanded a stay of execution to give science time to commute the death sentence to hard labour for scientific life.

17. SUBVERSIVE SUPERFICIALITY

In general terms, Einstein believed that a scientific theory, particularly one with qualities like those of Newton's mechanics, has the power to reach across the subsequent development of modern science with a message. It addresses contemporary scientific issues at a level deeper than its articulated content. Einstein was referring, of course, to the co-existence of non-eternal

scientific theories and the invariant laws of nature. The unity of the natural order exists amidst a variety of scientific theories. The rationality of the universe from which the intuitions of scientists come is contemporary with every scientific period. The laws of nature are already invariant as scientists search for a fuller apprehension of them. Scientific experience, therefore, is required to relate effectively to that invariance. Consequently, Einstein dismissed the notion of a rigid separation of the history and interpretation of science. In his view, such things as the history of Newton's mechanics were not discoverable by so-called unbiased historical inquiry.

Basically, Einstein assumed that scientists are able to discover and to accept the inadequacies of scientific achievements like the Newtonian system, to see beyond their structures, and to trace the processes of transformation begun by their originators. According to Einstein, Newton's edifice, for example, not only initiated new kinds of scientific inquiry, it perpetually outlines their basic characteristics and inspires their development. Nevertheless, it is always possible to adhere to a scientific theory in such a manner as to ignore or to miss the promptings of the intuitive relation which can guide scientists along the way of deepening apprehension. It is also tempting to cling to particular aspects of the corpus of scientific knowledge so as to exclude or to reject the larger context in which those aspects are a part. However, scientists are "called" to serve in the temple of science, to grow up into a fuller and fuller understanding of the universe. In general, therefore, the intuitive relation disturbs their scientific complacency and enables them to resist the onslaught of failure. Scientists are liberated from fear and hesitancy into trust and hope. They realize scientific freedom and creativity mingled with a humble dependence on the natural order.

Einstein believed that, like Newton, scientists can relate to present scientific theories from beyond them, for the rationality

of the universe inspires them so to speak. In a profound sense, Newton and that ilk are pioneers to every scientific period, not just their own. There is always the intuitive relation which must not be forgotten. The scientific enterprise is not merely a series of generations of scientists each encased on its own theoretical and experimental setting. It is rather a scientific community of experience stretching across those generations so that the theories which it discovers can evoke the scientific past in a way which strikes a chord in the experience of the scientific present. It is not simply a question of logical rules of the past and present. As Einstein demonstrated, past scientific achievements can still enlighten scientists as individual researchers with particular insights.

By the presence and impact of the intuitive relation the corpus of scientific knowledge transmits with power, is received with power and justifies itself wherever science advances. It conveys apprehension about the universal significance of science. The continuing influence of scientific researches gives resilience to the faith and hope of scientists. Their feeble rationality cannot cope with the rationality of the universe. However, the rationality of the universe comes to them in the form of the intuitive relation, and scientists are justified by faith. Ever conscious that they fall far short of comprehension, scientists are guardians of the delicate unity of humility and assertion. That frail unity proclaims not the merits of a scientific system, but the rationality of the universe to which all science points.

From an Einsteinian perspective, the claim that the four Gospels address contemporary issues of Christian living seems inoffensive to reason. When coupled with the assertion that the various Gospels present aspects of the Word of God who is the same yesterday and today and for ever (Heb. 13 v.3), it has a vaguely familiar ring. If it is also associated with the proclamation that there is one Lord, Jesus Christ, through whom all things are and through whom we exist (Cor.8 v.6), then interested

scientists are immediately carried beyond mere curiosity to the realms of formal analogy. They anticipate that the counterpart of scientific experience, Christian living, is required in order to relate authentically to Jesus Christ. Consequently, they assume that the historical and interpretative elements of the biblical record of Jesus Christ are inseparable and, therefore, the historical Jesus can never be detected by impersonal, abstract and arbitrary literary techniques.

Reasoning by analogy does not, of course, guarantee apprehension. But when an extensive correspondence is so far from exhaustion, it is necessary to look carefully at both enterprises, in case the pursuit of one could formally enrich the pursuance of the other. In fact, few Christian thinkers could read the last few paragraphs without wondering whether the author had not adapted elements of theological thinking to cope with the complexity of modern science. The discussion of the origins of Einstein's views on scientific thinking presented later in this essay will dispel such suspicions. Meanwhile, it is simply observed that Einstein's aversion to ad hoc methods was hardly conducive to deliberate adaptions.

To get back on the rails, the role of the intuitive relation appears once again as a pale reflection of the ministry of the Holy Spirit, and the rationality of the universe sounds like a faint echo of the Word of God. The sequential discoveries of scientific theories are formally similar to the progressive revelations of the biblical approaches to topics like the problem of suffering. Apparently, modern science has its major prophets including Kepler, Galileo and Newton, but one rational unity, while Christianity has the Apostles, but one Lord. Complacency in both science and theology stultifies all understanding but its own. The scientific community of experience resembles in several respects the Church Universal. Both transcend cultural and temporal differences. Their members live in hope, are justified by faith, and are known by the

fruits of their labours. Perhaps there is more than formal analogy involved. A full investigation is required. In any case, it is apparent that scientific and theological thinking are not necessarily diametrically opposed.

Obviously scientists of an Einsteinian persuasion find it particularly difficult to communicate with Christians who have selected information from philosophies and histories of science and modern science. Using non-scientific criteria, non-scientists tend to pluck ideas from those sources to support preconceived notions of scientific method. Scientists cannot accept such exercises as legitimate attempts to do justice to scientific research and thinking.(263) For all most scientists know, those concoctions may be acceptable approaches to an ecclesiastical history of ideas. What practising scientists have learned, sometimes at great cost, is that reasons which sound good are not the same as good sound reasons. For them, acceptance of such descriptions of the development of scientific research is tantamount to a rejection of science. Basically, they deny all that Einstein defended.

In any case, many Christians reap what they sow. Their fragile systems cannot survive contact with the concrete contents of modern scientific research. Sooner or later, they run up against the boundaries set up by their arbitrary constructions. When this happens, they become confused or enslaved by their inventions because they lack scientific wisdom. However, they will not be denied conclusions. The sooner they hit inconsistencies, the more chance they have of concluding that modern science is anarchic or that scientists don't really know what they are doing half of the time. In exceptional cases, theologians even attempt to convince their students of the intellectual bankruptcy of scientists and technologists. Their comments on science and technology sometimes even include contextually denuded quotations of eminent persons. For example, the theoretician John Robert Oppenheimer once said, "Scientific

discussion is explaining to each other what we don't know."(264) Or the technologist Werner von Braun stated that "Basic research is what I am doing when I don't know what I am doing."(265) Those remarks presuppose a sound working knowledge of scientific research. When isolated, they become easy targets for the humourless arbitrary logic of theological extremists. Fortunately, more enlightened scholarship seems to prevail. However, arbitrary constructions cannot in general protect and promote the freedom of thought. They are incapable of respecting new knowledge by which interdisciplinary exchange is accelerated.

The later Christians meet self-imposed limitations, the less likelihood there is that they will recognize what arbitrary conceptual devices are and what damage they can do. Consequently, they are ill-prepared for the discovery that science and scientists can only be appreciated through an openness to the instructive, regulative and conservative roles of scientific learning. They are in no position to agree with Einstein that scientific learning supplies the "hygiene in the sphere of the mind."(266)

The Christian's need of scientific learning was probably never more urgent. The growth of scientific knowledge in the various natural sciences is so rapid that it is impossible for one person to embrace it. Increasing specialization makes any attempt to integrate scientific information appear foolish. An apparently more manageable, but actually no less ambitious enterprise, is the formal unity of scientific knowledge. It appeals to many Christians because it confines attention to form, i.e., to an analysis of conceptual devices and experimental procedures (methodology). Also, results, discoveries, theoretical details and case studies, in short the concrete contents of science, can be regarded as ripe for the illustrative picking. In this view, they merely serve the so-called universality of the scientific method or methods and remote discussions of induction, definition, hypotheses, falsification

etc. An almost exclusive methodological emphasis re-orients interest from the empirical grounding of scientific concepts toward self-defeating arbitrary constructions. According to Einstein, scientific knowledge and experience must be combined in order to make contact with reality.

Repeated reference has been made to the years of "labour and activity" of individual scientists. Those years have more than their fair share of unsuccessful attempts to construct acceptable theories, to explain anomalous effects, to synthesise new compounds, to design novel experiments, and to observe unfamiliar phenomena. Yet scientists struggle on and seldom report negative results. All this work is not entirely lost to science. The success of one theory often annihilates the tenability of several others. The synthesis of a new family of compounds increases the chemist's knowledge of molecular structure. Frequently, the reported method of synthesis conveys a great deal of information to experimentalists. Implicitly, it can prohibit useless repetition of unpublished unsuccessful procedures. In a nutshell, scientific achievements communicate to scientists much about the feasibility of alternative approaches to particular problems. On occasions, they also rely on a knowledge of past unpublishable scientific failures. "To be sure, it is not the fruits of scientific research that elevate a man and enrich his nature, but the urge to understand, the intellectual work, creative or receptive. Thus, it would surely be inappropriate to judge the value of the Talmud by its intellectual fruits."(172)

Non-scientists cannot hope to read those signs properly, even if they suspect their existence. Consequently, as they attempt to integrate scientific information, there is always the likelihood that they will reintroduce errors already disposed of along the arduous course of scientific development. To borrow freely more of Brown's words, Christians are strongly advised to find out from scientific sources what they are going to talk or write about.

This will make it a good deal more likely that they will present and publish credible comments and reviews.(267) Thinking scientifically is a matter of judging on the basis of all kinds of scientific knowledge and experience. Without the acquaintance and guidance of the latter the probability of increasing scienfific apprehension is drastically reduced. Indeed, there is abundant evidence to show that Christians who are very poorly read in science rarely make valid pronouncements on scientific subjects.

This state of affairs may not unduly perturb those Christians who continue to erect prefabricated edifices using culled scientific ideas. It is subversive as far as science is concerned. Holton made this abundantly clear. "The detailed study of the historical situation is, to my mind, an important first step in those discussions which try to base epistemological considerations on 'real' cases. This is not always done easily; but it is through the examination of historically valid cases that we can best become aware of the preconceptions which underlie all philosophical study."(268) A brief look at Einstein's four papers supports Holton's views.

If students of the natural sciences listen to, or read, contrived accounts of "scientific method," they have a reasonable chance of recognizing discrepancies, omissions and incongruities. Still, if Einstein is correct, even they will encounter considerable difficulties. "Only those who realize the immense efforts and, above all, the devotion without which pioneer work in theoretical science cannot be achieved are able to grasp the strength of the emotion out of which alone such work, remote as it is from the immediate realities of life, can issue."(246) Non-scientists, on the other hand, have almost no hope of exposing prefabrication. They are more liable to be impressed by authorative poses than by authentic detailed case studies. Thus, they are confined to superficial connections bounded by the tenets of some philosophical, historical, or theological contrivance. In other words, too many Christians are content

with tacit dogmatism. The latter is, of course, anathema to the freedom of scientific thought. It is also contemptuous of the regulative, instructive and conservative roles of scientific learning. It is small wonder that many of the clergy are heard loudly decrying the triumphalist militancy of science. After all, they are attacking an arbitrary product of their own imaginations.

Philosophers and historians of science have disciplines in their own right. If Christians are wise enough to familiarize themselves and others with the rudiments of those subjects, who are scientists to interfere? In this regard scientists are laymen. But they are entitled to expect authentic representation of their subject. In its absence, they will suspect Christians' understanding of both philosophies and histories of science. This fundamental inadequacy does not, of course, prove an incompetent grasp of philosophies and histories of science. But, when a proposed analysis of science is so far from examining its primary material, it is necessary to look closely at the arguments presented.

No one can possibly provide a valid presentation of science unless he first distinguishes modern science from philosophies and histories of science. In deference to all three disciplines, and therefore to theology itself, Christians should recognize, spell out and respect the disciplinary differences. The alternative is to maintain a prudent silence where apprehension fails and until homework is done. However, the part of a passive spectator is unworthy of the Christian. As the course of events has already shown, it is bound to result in cultural disaster or ostracism. Christians should realize that, if their teachings ignore or isolate the great scientific corpus and its dynamics, their words, however eloquent and elegant, will probably receive the same treatment from many scientific researchers. Christians should, therefore, encourage those with scientific experience to participate in theological dialogue. This will counteract to some extent the damage done by others who dogmatically dismiss such contributions as irrelevant even on

scientific matters.

To depend exclusively on philosophies and histories of science appears strange, if not perverse, to working scientists. Those subjects rely ultimately on private and public scientific accounts of researches. Without first-hand experience of research, many philosophers and historians of science reinterpret, refashion and recontextualize what practising scientists have said or reported. They risk false integrations and premature systematizations of scientific information. One need search no further than the theories of relativity for examples of scientific knowledge which have been appealed to as supporting numerous diverse extra-scientific studies. Christians interested in modern science and scientific thinking should take the bull by the horns. They should relate as directly as possible to scientific research.

One way of achieving this is to pursue enthusiastically committed Christians who have attained distinction within their scientific disciplines. The humble activity of listening to them as they talk of other forms of knowledge, scholarship and service will not be pointless. Currently many scientists relate in this manner to Christian theology. What can possibly exempt professors of Old and New Testament studies, practical theology, the philosophy of religion, ecclesiastical history and systematic theology from similar roles? Or are many of them only prepared to pay lip-service to apprehension and reconciliation? The road to chaos has long been paved with lip-service to unworkable and unworked ideas. Bluntly, if Christians impose directly or indirectly an arbitrary logic of contriving on scientific information, they can only end up with some bizarre form of mythology.

Of course, Christians are free to pursue their creations for subjective aims. But they have no excuse for subjecting unsuspecting persons to their speculative devices. To project publicly false images of science is to engage in a form of cultural sabotage. As Einstein stated well over sixty years

ago, "Nobody who devotes himself to science from other reasons than superficial ones, like ambition, money making, or the pleasure of brain-sport, can neglect the questions, what are the aims of science, how far are its general results true, what is essential and what based on accidental features of the development?"(269) As more Christians begin to talk and write about science responsibly, distinguishing it from technology and philosophies and histories of science, they will inevitably strengthen opposition to subversive superficiality. In the meantime, too many of them relate to science and scientists in estranged pragmatic terms. Indifferently, they talk of social responsibility, are unable to recognize legitimate technology, and remain answerable for alienating mythological modes of thought in theology and mission. Rudolf Bultmann's defense of his programme of demythologizing displays all of those characteristics. However, a discussion of scientific, technological and everyday thinking prepares the way for a brief consideration of Bultmann's views of modern scientific thinking.

18. SCIENTIFIC, TECHNOLOGICAL AND EVERYDAY THINKING

If scientific thinking is so special, why did Einstein claim "that the whole of science is nothing more than a refinement of everyday thinking?"(270) Without any specialized training, the average citizen gathers an enormous amount of reliable information about people, events, and objects within his environment. Herbal cures, proverbs, rules of thumb, and skilled crafts have been handed down through countless generations of cultures throughout the world. Many of them have survived both the rise and progress of modern science, whereas much superstition and ignorance have been eliminated. Clearly, there are vast resources of information more astonishing than scientific knowledge. Indeed, modern science draws unrefined material from them as it expands human propensities for apprehending, relating to and living in the world. Polanyi clothes the bare affinities sketched by Einstein.

"The solution of riddles, the invention of practical devices, the recognition of indistinct shapes, the diagnosis of an illness, the identification of a rare species, and many other forms of guessing right seem to conform to the same pattern" as that of "the recovery of a lost recollection" and "discovery in natural sciences."(271)

With such an immense wealth of diverse information so readily available, the average citizen does not need to keep abreast of scientific progress. The relentless flow of new material from modern science convinces him that such a task is impossible anyway. Consequently, cultural affinities and technological prowess conspire to convince non-scientists, including many theologians, that they can evaluate the scientific enterprise on the basis of its practical results. Thus, as Einstein explained, they arrive at a completely false conception of science. Inevitably, they confuse science and technology and, therefore, the progress of science and the development of technology.

According to Einstein, common-sense conceptual systems are constructive and speculative.(272) They too are based on both experience and intuition. Their greater logical disunity makes them more vulnerable than scientific theories to the same forms of criticism. Yet the validity of common-sense systems is largely taken for granted by most people until a problem raises doubts. As long as those systems work satisfactorily, doubts about them are usually suspended. Distinctively, science in its search for greater logical unity wrestles with doubts for fundamentally different ways of perceiving the world. It attempts to bring them to the microscope, to identify them and to learn from them. Scientists achieve this through openness to the rationality of the universe. By exercising freedom of inquiry but subordinating intuitive and critical faculties to the natural order, scientists glimpse new horizons. Contrary to popular opinion, those activities are not the preserve of the privileged. They are not confined to scientific genius. All

scientific researchers practise them in varying combinations. Even Niels Bohr agreed with Einstein about basic features. "The task of science is both to extend the range of our experience and to reduce it to order .... As our knowledge becomes wider, we must always be prepared, therefore, to expect alterations in the points of view best suited for the ordering of our experience."(273)

Bondi is convinced that "much deep physics may be hidden, not in the basic structure of our minds, but in what entered and formed our minds at an early age in a rather simple way."(274) Behind his repeated references to the amount of physics tacitly learned in the first few years of childhood lies the realization that much of what a person learns as a child he continues to believe as an adult. Amazingly, children accommodate an enormous influx of information as common sense, whereas adults absorb the same material only after intense intellectual effort. Bondi also claimed that "a good deal of the high-grade physics, derived normally from rather refined observations, is already inherent in what is common knowledge."(274) However, as a child grows he learns from others how to speak of the things around him and how to relate to them. He conforms by using the conceptual constructions of parents, peers and pedagogues.(275)

There are, of course, exceptions. Einstein offered an interesting explanation of his great success in science. "I sometimes ask myself," he admitted frankly, "how did it come that I was the one to develop the theory of relativity? The reason, I think, is that a normal adult never stops to think about problems of space and time. These are things which he has thought of as a child. But my intellectual development was retarded, as a result of which I begun to wonder about space and time only when I had already grown up. Naturally, I could go deeper into the problem than a child with normal abilities."(276)

Einstein recognized that the societally limited critical abilities of children tend to confine their attention to imitation, repetition and acquisition, often at the expense of creative play and investigation. To a great extent, the individual acquires

conceptual systems from elders. This process occurs either overtly by education or covertly by societal contacts. "The greater part of our knowledge and beliefs has been communicated to us by other people through the medium of a language which others have created." (277) It seems that most of the things that a child believes are necessary to a satisfactory performance in life. Later in life, the vast majority of people find it difficult, if not impossible, to recall their original reasons for believing them.(275)

The more a person relies on the primitive concepts of everyday life "the more difficult it becomes amidst the mass of inveterate habits to recognize the concept as an independent creation of thinking."(256) In fact, few people can persuade others of the validity of their beliefs. They have taken most of them for granted for so long. Besides, the very foundation of those beliefs have probably moved with the general growth and processing of scientific information.(27) In other words, the advance of science has slowly, almost imperceptibly, shifted the various equilibria in the overall system of cultural values.(3)

This diffusion of information cuts the beliefs of many people adrift.(278) The decreased logical unity requires a conceptual readjustment. There are, however, inertial factors. Progressively, the concepts used to describe the constraints imposed upon a person by the social and natural world become more strongly infused with his own values, interests and perspectives. Satisfaction with previous performances waxes with age. The spirit of inquiry wanes with increasing responsibilities. They conspire to widen the gap between apprehension and information, and to entrench outmoded systems of thought.

The difference between apprehension and information in the hands of the young and old is neatly captured in a story told of the young Max Planck. Not long after he had arrived in Berlin, Planck stopped at the entrance office to the university. He asked the elderly man in charge, "Please tell me in which room does Professor Planck lecture today?" The old man patted the forgetful Planck on the shoulder as he advised, "don't go there, young

fellow. You are much too young to understand the lectures of our learned Professor Planck."(279) Eventually, established ways of thinking become so deep-seated that they close the individual off from reality. It requires deliberate and sustained effort to keep this particular wolf from the door. In one way or another, everyone behaves as a pragmatist at some time or another. Scientists do, for example, when they apply, but refuse to assimilate, a new theory.

Einstein believed that "scientific concepts begin with those used in ordinary language for the affairs of everyday life, but they develop quite differently. They are transformed and lose the ambiguity associated with them in ordinary language, gaining in rigor so that they may be applied to scientific thought."(280) He cited the vector as a simple illustration. Polanyi agreed with Einstein's description of the nature and origins of scientific concepts, "Natural science deals with facts borrowed largely from common experience. The methods by which we establish facts in everyday life are therefore logically anterior to the special premisses of science and should be included in a full statement of these premisses."(281) Scientific concepts and propositions are founded on measurements lending themselves to mathematical formulation.(282) The progress of science depends on the expanding expression of the sum total of its knowledge. Like the terms of a geometric series, science spans sequentially greater domains within the natural order. In the process, it is transformed by the inclusion of higher terms. The unification of scientific theories is a response to the unity of the universe. Science expresses itself most effectively, but always incompletely, in mathematical terms. In doing so, it depends on a continuing refinement of the ancient inventions of language, writing and counting.

Actually, that "things" are "as they are perceived by us through our senses" is an illusion that "dominates the daily life of man and animals(.That) is also the point of departure in all of the

sciences, especially of the natural sciences."(283) The visible spectrum forms only a small band within the vast range of electromagnetic radiation. The mechanics of terrestrial bodies involves velocities small compared with the speeds of galaxies and light. The global fluctuations of temperature and pressure are extremely narrow relative to those of stellar events. Audible tones represent "a small province in the world of inaudible vibrations."(284)

Einstein's theme of refinement is clearly apposite. The explanatory power of scientific theory is required to apprehend those natural orders. Creativity and mathematical rigour carry scientists beyond the immediate limitations of the senses to the invisible and inaudible via the inarticulate. Scientific researchers are uniquely part of the more general pattern of cultural advancement. "Without creative personalities able to think and judge independently, the upward development of society is as unthinkable as the development of the individual personality without the nourishing soil of the community."(277)

In creating modern science humankind invented and developed ways of thinking how to relate complex phenomena which go far beyond direct experience. Certainly, no one could have known in advance how far-reaching those ways would be. Nor can anyone predict their future relevance. However, for most thinkers the present theories of biology, chemistry, mathematics, physics and the other sciences represent an achievement whose magnitude and intensity are both surprising and impressive. It would be perverse to deny modern science its achievements simply because they have been exploited by those seeking wealth or power for their selfish interests, instead of being used for the general benefits of humankind.

Human sensory equipment is limited. Nevertheless, with the combination of intuition and reason, scientists have managed to apprehend multifarious aspects of reality. They range from sub-nuclear processes through mechanisms of neutral transmission

and chemical reactions of inheritance (the genetic code) to life-histories of stars and galaxies. With sound reasons for assuming that the laws of physics and chemistry are the same throughout the universe, scientists estimate the age of the universe, its present size and the total numbers of galaxies, stars and atoms. (285) Einstein spoke for many scientists when he expressed his unfading wonder that scientific thought finds order to exist among the apparently disparate phenomena of nature. "It is a fact that the totality of sense experiences is so constituted as to permit putting them in order by means of thinking - a fact which can only leave us astonished, but which we shall never comprehend. One can say: the eternally incomprehensible thing about the world is its comprehensibility."(286)

In order to be able to understand scientific thinking, Christians must first come to terms with how scientists cope with the "eternally incomprehensible thing about the world." Every scientist knows that scientific research alters his perception of the world. On the pedestrian level, hexagonal structures encountered in everyday life remind organic chemists of aromatic compounds. Wall-paper designs trigger the crystallographer's knowledge of two-dimensional space groups. A jet flying across the clear blue sky recalls the tracking of an elementary particle in a cloud-chamber.(287) Scientists change with their apprehensions of the natural order, whereas technologists adapt the natural order to meet their immediate requirements. Both are, of course, committed to unknown unforeseen consequences which will probably dictate long-term changes. The vital distinction, drawn by Einstein, is that scientific change is discovered, unlike technological change which is made.

The prime example of the unintended consequences of modern technological development is the cultural impact of the automobile. It has changed community living, eating and work habits, recreational outlets, sexual behaviour, transportation networks, trading patterns, governmental taxation, national

foreign policies and international commerce. The natural environment, the social structure and the physical condition of the individual have been influenced beyond all expectations of those who produced the first generation of automobiles. As already indicated, the twentieth century faces an irreversible, unfathomable disruption of deeply instilled cultural modes caused by the profusive gadgetry of commercially enslaved technological innovation.

Many years ago, Einstein wrote, "Science cannot create ends and, even less, instill them in human beings; science, at most, can supply the means by which to attain certain ends."(288) Currently, society legislates for profiteering in genetic engineering, while committed scientists consolidate their pioneering. The legitimate way to deal with "the comprehensibility of the world" is to experience a growing sympathy with it. This can be achieved only in so far as scientists are prepared to trust and obey its orders. Of course, scientists can abandon their vocation at any time. The freedom of science depends on the personal freedom of the scientist who can defect without recrimination. By patenting their discoveries scientists can deny their debts to scientific predecessors and contemporaries. But they cannot have their cake and eat it. Science is answerable only for the discoveries. It has nothing to do with the making of commercial processes, products or profits. Personal commitment to science precludes ulterior enterprises. Science never strays from the fold. It is the fold from which the wealth-wolf snatches a few scientists.

As already indicated, the personal commitment of the scientist does not eliminate scientific objectivity. On the contrary, scientific researchers submit their theories to objective reality, the rationality of the universe. Nevertheless, objective reality is apprehended by empirically-loaded theories and theory-laden observations and experiments. In other words, there is no neutral foundation beyond the rationality of the universe. Scientists are

wholly committed to increasing humankind's apprehension of the natural order. In fact, this commitment derives from the pre-established harmony between thought and reality. It transcends the limited apprehensions of individual scientists and their reliance on objectivity. It is pre-reflective and perficient. Like a "little piece of nature"(289) the scientist changes when the realms of science are expanded. Strictly impersonal knowledge cannot exist. On the other hand, scientific knowledge is not "merely personal" or subjective. It is personal in the sense that it is guided only by the rational requirements of reality.

Einstein's dynamic conception of knowledge is utterly dependent on his postulate of the fundamental intuitiveness of knowledge. Scientists are always intimately involved in the scientific enterprise and, therefore, in scientific thinking. They are constrained by the greater unobservable rationality as it intimates itself in the lesser observable phenomena. Scientists travel along personal hysteresis loops, experiencing an ever-expanding apprehension of the natural order. Scientific theories are rational because they expose and explain intelligible dynamic structures in nature. In short, they contact reality.

Incontrovertibly science makes possible the contriving of things that improve or devalue life. But it is not unique in this respect. As already noted, science does not deal with societal issues. It neither dictates nor recommends technological transformations of possibilities into actualities. It leaves such matters to society and technology to decide and to harness, respectively. A succinct description of technology was provided by Polanyi. "Technology comprises all acknowledged operational principles and endorses the purposes which they serve."(290) In contradistinction, scientists guard jealously the freedom of research and the conservative, regulative and instructive roles of scientific learning. The "delicate little plant of curiosity

of inquiry stands mainly in need of freedom."(92) Of course, its fruits are always inspected and given the stamp of public scientific approval before they appear on the market of ideas. Without this "inner freedom," scientists cannot remain open to the rationality of the universe. Its loss places scientific commitment in jeopardy. Besides, when denied access to the free exchange of scientific knowledge within the scientific community, scientists are more severely exposed to the dangers of fantasies and delusions. The notion of patenting scientific discoveries is, therefore, intrinsically non-scientific.

To the vast majority of non-scientists talk of scientific freedom seems too remote, if not irrelevant. They are inclined, therefore, to confuse scientific progress with technological development. In Scotland, the study of physics retains its old name of natural philosophy as a salutary reminder that science is a search for an understanding of nature, not a striving for power over it.(291) Contemporary science does not promise a comprehensive explanation of the universe. It is too aware of the incompleteness and uncertainty of its theories to claim mastery of nature. To confer extraneous authority on science is just another way of depriving it of its freedom. According to Einstein, the universe alone, or more precisely the God who reveals himself in it, has the authority to grant scientists the freedom to choose to believe, to inquire or even to defect.

Information promises power. Who would deny that the scientific knowledge gained over the past sixteen decades or so has been matched by immense technological development? The most senior of our citizens knew in childhood the horse as the only alternative to the steam engine.(291,292) The candle or oil-lamp was their standard form of domestic illumination. Gas-light was a splendid improvement, electric light a rare luxury. The journey to the moon was listed under science fiction. The physicist A. M. Taylor hit the nail on the head when he said, "This transformation of our civilization has come so swiftly that our thinking is distorted."(291) Decades earlier,

Einstein had predicted that "the morbid symptoms of present-day society" will be explained by future historians "as the childhood ailments of an aspiring humanity, due entirely to an excessive speed at which civilization was advancing."(12) Since before the turn of the century, the rates of scientific progress and technological development have made it extremely difficult for non-scientists to avoid confusing them. However, Einstein the optimist believed that contemporary societal troubles are only the preclude to a greater material well-being.

Nevertheless to dismiss scientific research as a means of enhancing the "possibility that man may at last be freed from the burden of physical toil"(281) is to misunderstand the whole scientific endeavour. Science does not issue permits for the technical control of nature. Even a cursory investigation of Werner Heisenberg's uncertainty principle is sufficient to show that. Prediction has limited application in science. Attempts to extend its range to large scale manipulations of nature do not appeal to scientists. The belated emergence of organo-metallic, fluorocarbon and metallic cluster chemistry are further striking examples of the limitations of prediction in the natural sciences. Failure and ignorance are constant companions in scientific research. They are permanent reminders of the subtlety of nature and the futility of hidden agendas for its exploitation or control. The unpredictability of science is beyond question. Most scientists, like Einstein, have found that "being where the future was being brewed"(293) is difficult enough to handle without the additional restrictions of ulterior motives.

"Those whose acquaintance with scientific research is derived chiefly from its practical results easily develop a completely false notion of the mentality of men who, surrounded by a skeptical world, have shown the way to kindred spirits scattered wide through the world and the centuries. Only one who has devoted his life to similar ends can have a vivid realization of

what has inspired these men and given them the strength to remain true to their purpose in spite of countless failures."(247) Even fresh graduates of science have considerable difficulty in identifying properly with Einstein's remarks. This should come as no surprise to the clergy. It is common knowledge that raw graduates of divinity rarely lecture convincingly on matters relevant to life in the parish until they have personally experienced that enriching vocation.

In the absence of personal scientific experience, the plethora of biological, chemical, electrical, mechanical and atomic applications encourages the popular imagination to equate technological devices and feats with scientific achievements. Consequently, the motives behind the beating out of swords or ploughshares and the reasons for constructing nuclear bombs or reactors are frequently identified as those which led to the discovery of malleable ore and nuclear energy. Besides, by interpreting the experimental nature of science as the vehicle of its instrumental aim, many non-scientists argue that technology is implicit in the predictive aspirations of science. In this view, a scientific experiment can be described as 'breaking and entering' the natural world. Denied the key to nature, scientists pick the lock, smash a window or kick down the door. As far as most scientists are concerned an experiment is a question put to nature without intimidation. Of course, both the question and its answer have personal elements. The scientist's passion for apprehension is as necessary to him as the air he breathes. But, for him, the manipulation of nature is piracy on the high seas of rationality.

The felony is compounded, for example, by the powerful technological medium of television.(294) Many of its advertisements depend on tenuous references to scientific constituents or properties of products or processes. Simultaneously they exploit and reinforce the common misconceptions that scientific statements are infallible and immutable. No responsible scientist

would make such claims. Nor should anyone concede them. The inability to discriminate between modern science and its commercial exploitation on the small screen predisposes many people to regard those perversions as authentic manifestations of manipulative scientific thinking. Although it is not a new problem, this particular form of misrepresentation has grown to pernicious proportions in a socially-disintegrating mass-communications-ridden age. In large measure, the mass media are restricted by vested interests and self-seeking opportunists. They have contributed greatly to the decline of conversation while gaining an excessive influence on public opinion. Most important of all, they have abused their privileges by inexorably commingling scientific fact and fiction.(295)

The twentieth century is not a scientific age. Human activity includes a great deal of scientific research, but it can hardly be described as the dominant preoccupation of humankind. Scientific apprehension is not common place. What is characteristic of modern societies is the unebbing effort to use the results of scientific researches for the whole spectrum of human purposes. In this particular pragmatic age, there is a widespread awareness of the continuous increase of technological capacity which the results of scientific research make possible. The intrinsic value of science is generally ignored or even denied with inevitable consequences. Science and technology are seen then as the twin horns of the major societal dilemma. The energy that should be used to apprehend the realities is consequently dissipated by pragmatic minds employing expedient means to achieve unjustified ends, including the extermination of unrecognizable modern scientific thinking. The story of the Tower of Babel is also the story of this so-called scientific age.

On one occasion, Holton first reminded his reader that Einstein had said, "I AM A LITTLE PIECE OF NATURE."(289) He then proposed the following general hypothesis. "There is a mutual mapping of

the style of thinking and acting of the genial scientist on the one hand, and the chief unresolved problems of contemporary science on the other."(296) Christians can probably hear distant echoes of the theme of the garden of Eden. They might even be reminded of the miracle that, in the birth, life, death, resurrection and ascension of Jesus, the Word of God offered Himself as humanity's true response in person, word and activity to God the Creator. Both scientists and Christians are left stranded when they reject the respective higher rationality. Apostasy renders them unable to refine authentically everyday thinking, for their ways are no longer the ways of the universe nor of its Creator. The ways of Bultmann are now considered.

19. THE WRONG EQUATIONS

Reputedly one of the greatest scholars in the field of New Testament studies, Rudolf Bultmann, described in the Shaffer and the Cole Lectures of 1951 what is involved in "de-mythologizing." He also dealt with objections levelled at his programme. Published in 1958 as a booklet entitled Jesus Christ and Mythology, their contents were delivered, at least in part, at thirteen theological institutions in North America. This was fifteen years after the publication of Einstein's essay on Physics and Reality.

According to Bultmann, "the task of de-mythologizing received its first impulse from the conflict between the mythological views of the world contained in the bible and the modern views of the world which are influenced by scientific thinking..."(297) Distinctively, "... de-mythologizing takes the modern world-view as a criterion. To demythologize is to reject not Scripture or the Christian message as a whole, but the world-view of Scripture, which is the world-view of a past epoch ..."(298) Bultmann's "method of interpretation of the New Testament ... tries to recover the deeper meaning behind the mythological conceptions... Its aim is not to eliminate the mythological statements but to interpret them."(299) On first encounter, Bultmann's programme

appears to be a reasonable enterprise. But many scientists have immediate reservations about the existence of a singular modern world-view.

Related problems become more apparent as Bultmann's references to modern science are examined closely. "But for the present purposes," Bultmann claimed, "it is enough to say that the thinking of modern man is really shaped by the scientific world-view, and that modern men need it for their daily lives."(300) Earlier, he had stated that "mythological conceptions of heaven and hell are no longer acceptable for modern man since for scientific thinking to speak of "above" and "below" in the universe has lost all meaning ..."(301) Later he went on to say that "(the Christian) delivers up the faith in miracles to the criticism of science and in so doing validates such criticism." (302)

As scientists begin to correlate all of those statements, their common content arouses suspicion. Consistently, they claim or presuppose an influential relation between scientific thinking or a modern scientific world-view and everyday thinking or modern views of the world. Significantly, Bultmann confined himself to repeated references to causation. According to Einstein, it had remained but a "bold ambition" in the minds of the Greek materialists and all philosophers before Newton.(251) This raises important questions. Did Bultmann believe that "modern man" thinks scientifically? Or did he consider that the influence of science on the thinking of "modern man" was adequately described as an encouragement to think and view things in terms of cause and effect?

As repeatedly noted, Einstein believed that "the whole of science is nothing more than a refinement of everyday thinking." (270) He was also convinced that "scientific research can reduce superstition by encouraging people to think and view things in terms of cause and effect."(169) He did not consider, however, scientific and everyday thinking as equivalent. On the contrary,

he stated clearly that scientific thinking cannot be satisfied with the lack of logical unity characteristic of everyday thinking.(100) Scientific thinking is the cultivation of everyday thinking by a persistent search for greater and greater logical unity in the scientific world picture.

Scientists think and experiment their way to a scientific description of the rainbow as an optical phenomenon. The everyday thinker accepts this information from scientists largely on trust. Without any sustained effort at conceptual integration, he relates pragmatically to this phenomenon. He can not suddenly think scientifically about rainbows. "The fact that on the basis of such (scientific) laws we are able to predict the temporal behaviour of phenomena in certain domains with great precision and certainty is deeply embedded in the consciousness of the modern man, even though he may have grasped very little of the contents of those laws."(166) Einstein was referring, of course, to the very important distinction between prediction and apprehension. Many Christians assume that, because they can relate in terms of prediction, they can communicate on scientific matters. Realistically, if there is such a thing as a contemporary world-view, it is intrinsically incoherent and intractably pragmatic.

Bultmann was correct when he claimed that modern views of the world are influenced by scientific thinking. But he appears to have misunderstood the nature of that influence. In fact, the description of mythology provided by Bultmann applies equally well to both the so-called world-view of biblical times and modern views of the world. Compare the following quotation with its supplied alternative reading. "Myths (pragmatic beliefs) speak about gods (ecology) and demons (technologies) as powers on which man knows himself to be dependent, powers whose favor he needs, powers whose wrath he fears. Myths (pragmatic beliefs) express the knowledge that man is not master of the world and of his life, that the world within which he lives is full of riddles and mysteries and that human life also is full of riddles and mysteries. Mythology

(a modern view of the world) expresses a certain understanding of human existence. It believes that the world and human life have their ground and their limits in a power which is beyond all that we can calculate or control. Mythology (a modern view of the world) speaks about this power inadequately and insufficiently because it speaks about it as if it were a worldly power."(303)

For many scientists, the preceding alternative reading represents a fairly accurate description of the current state of affairs. Bultmann's selection of "the modern world-view" as a criterion is, therefore, fraught with difficulties. It seems to jump from the frying pan into the fire. If every scientist, as well as layman, behaves as a pragmatist at some time or another, how can one ever hope to demythologize or to talk meaningfully of "the modern world-view?"

Curiously, the germ of the preceding criticism is contained in the following extract. "(Biblical eschatology) will not rise in its old mythological form but from the terrifying vision that modern technology, especially atomic science, may bring about the destruction of our earth through the abuse of human science and technology."(304) By referring to "atomic science" as a form of "modern technology," Bultmann is out of step with Einstein, Polanyi, Bondi, the vast majority of scientists, and a considerable number of technologists. This conferred equivalence on science and technology is not an isolated incident in Bultmann's defense of his programme. Nor is it without consequent conceptual distortions.

According to Bultmann, "the development of science and technology ... procures the illusion that man is master over the world and his life."(305) "The scientific world-view engenders a great temptation, namely, that man strive for mastery over the world and over his own life."(306) These contentions are vaguely familiar, but diametrically opposed, to Einstein's description of scientific thinking.(307) They are at odds with Bondi's defense of the role of technology in scientific progress(308) and

Polanyi's views on scientific research.(309) Basically they obscure the originative difference between science and technology. Those remarks support the suspicion that Bultmann misunderstood essentially how scientific thinking influenced modern views of the world. Einstein, on the other hand, had already explained in The Christian Register that "science, in the immediate, produces knowledge, and, indirectly, means of action. It leads to methodical action if definite goals are set up in advance. For the function of setting up goals and passing statements of value transcends its domain."(310)

Moreover, if the choice had been left to Bultmann, Einstein's "delicate little plant" would never have seen the clear light of day. "By means of science men try to take possession of the world, but the world gets possession of men. We can see in our times to what degree technology brings with it terrible consequences."(311) Yet, "... faith acknowledges that the world-view given by science is a necessary means for doing our work within the world."(312) Considered separately, each of the many quotations can perhaps be explained away in some fashion or another. When viewed collectively and in the light of Bultmann's own emphasis on the need for freedom in the life of the Christian, suspicion hardens into conviction. Because he did not understand the rudiments of modern scientific thinking, Bultmann confused science and technology, and scientific and everyday thinking.

Amazingly, the very words used by Bultmann to describe the role of freedom in the life of the Christian are equally applicable to the part it plays in the working life of the scientist. "Genuine freedom is freedom from the motivation of the moment; it is freedom which withstands the clamour and pressure of momentary motivations. It is possible only when conduct is determined by a motive which transcends the present moment, that is, by law... This can only be a law which has its origin and reason in the beyond."(313) Contrast those statements with Bultmann's remark that "freedom of subjective arbitrariness believes itself to be master of the world through science and technology."(305)

Clearly, had Bultmann taken the scientific enterprise seriously enough, he might not have conferred equivalence on science and technology. On the contrary, he might have recognized crucial distinctions between the commitment and freedom of scientists and the motivation and logic of contriving of technologists, respectively. Had he read Einstein's available contributions, he would have learned of the decisive difference between scientific and everyday thinking. Instead, Bultmann oscillated between valid comments like "modern man always makes use of technical means which are the results of science,"(314) and invalid remarks such as "modern man acknowledges as reality only such phenomena or events as are comprehensible within the framework of the rational order of the universe."(315)

Some telling evidence of Bultmann's disregard of scientific thinking taxes the credulity of all who have had any contact with modern science or philosophies and histories of science. Bultmann believed that "the method of scientific thinking and inquiry is in principle the same today as it was at the beginning of methodical and critical science in ancient Greece."(300) Why didn't he conclude, therefore, that the method of scientific thinking and inquiry has always been, and always will be incompatible with current world-views of the contents of the Bible? Had he done so, he might then have recognized that humankind has always had its mythologies.

Actually, Bultmann explained away the concrete connection between scientific and everyday thinking. "The science of today is no longer the same as it was in the nineteenth century, and to be sure, all the results of science are relative, and no world-view of yesterday or today or tomorrow is definitive. The main point is, however, not the concrete results of scientific research and the contents of a world-view, but the method of thinking from which the world-views follow."(315) In other words, Bultmann avoided the former conclusion, precisely because he was convinced that the unchanging ancient "scientific" modes

of thought had become those of the "modern man."

According to Einstein, "we reverence ancient Greece as the cradle of Western science. Here for the first time the world witnessed the miracle of a logical system ... - I refer to Euclid's geometry. This admirable triumph of reasoning gave the human intellect the necessary confidence in itself for its subsequent achievements ... But before mankind could be ripe for a science which takes in the whole of reality, a second fundamental truth was needed ... all knowledge of reality starts from experience and ends in it. Propositions arrived at by purely logical means are completely empty as regards reality. Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the father of modern physics - indeed, of modern science altogether."(316) Moreover, Newtonian mechanics came later, and several more centuries had to pass before Einstein made his contributions. Once again, Bultmann betrayed his ignorance of modern science.

Bultmann gave as an example of "non-mythological terms" the statement that "the finiteness of the world and of man over against the transcendent power of God contains not only warning, but also consolation."(317) As far as most scientists are concerned, this statement has borrowed and, therefore, transmuted scientific and theological terminology. It employs scientific terms divorced from scientific content and is, therefore, consistent with Bultmann's separation of scientific methodology from scientific content. Like many other remarks of Bultmann, it militates against the possible acceptance of his claim that "in our day and generation, ... we no longer think mythologically."(318) The course of history has not refuted mythology, only mythologies.(314)

By his own admission, Bultmann's programme stands or falls with his criterion. As has been shown, it depends on two erroneous assumptions, namely; the equivalence of the progress of science and the development of technology, and the parity of scientific and everyday thinking. Many Christians spend a great deal of

time discussing this particular programme. It seems reasonable to assume that some of them have discussed it through the years with graduates of science, scientific researchers and technologists. At least a few of the latter must have been able to expose it. One can only conclude, therefore, that their relevant questions were stifled or dismissed as products of estranged or deficient modes of thought. Certainly, many modern scientists remain puzzled by the powerful influence of Bultmann's programme on contemporary Christian theology.

A past president of the British Society for the Philosophy of Science, L. L. Whyte, told the following story about Einstein and his new assistant Cornelius Lanczos. It contrasts sharply with the predicament of Bultmann and his followers. "...(I)n the early days of October 1928 - Einstein put before Lanczos a new type of wave equation or field equation and asked Lanczos to see if he could find a solution which should have certain properties. I will call them alpha, beta and gamma. Lanczos understood the problem perfectly, was intensely proud of being given such a task by Einstein, and went away feeling very humble and unsure. But he studied the equation and after three or four days - flash! - there came into his mind the perfect solution. It had all three properties that Einstein had asked for ...

(W)hen he reached Einstein ... he said, 'Yes, I have been able to find a solution'. He showed it to Einstein and he demonstrated that it had the required three properties. Einstein looked at him and said, 'Yes, very interesting, quite remarkable.' There was a short silence, and then he exclaimed, rather impatiently, 'But don't you see, I gave you the wrong equation. It was quite wrong!' There was a silence. These two highly intelligent men did not need to say anything, for they knew what ... had happened."(320)

Unlike Einstein, Bultmann did not realize that he had given the wrong equations. Some Christians are still trying to find solutions to his particular problem. Too often, their silence on

Bultmann's confused statements about science and technology precludes valid criticism. When it does, the credibility of their theological comments on science and technology plunges, like Rojansky's curve, below the legend. Interested scientists have grave doubts about the responses of Bultmann's followers to the created order and, therefore, about their repercussions upon theology and mission. In short, many scientists are reminded of the urgency with which Christians should seek a realistic understanding of modern scientific thinking.

20. SCIENTIFIC EXPERIENCE AND APPREHENSION

A comparison of Einstein's epistemological utterances and his four scientific papers of 1905 represents a limited but realistic attempt to understand the basic aspects of modern scientific thinking. A number of events associated, either directly or indirectly, with those papers have been discussed on many occasions and in diverse contexts. Their contents are not technical. On the contrary, they are particularly suitable for the present purpose. In any case, if the preceding preparatory discussion of Einstein's epistemological views and this phase of his scientific researches have proved intelligible without conceding the core of the matter, the following exposition should present few difficulties. An inkling of how his epistemological views and scientific researches interrelated throughout the working life of this exceptional scientific thinker casts some light on the origins and the strength of the motivation behind his remarkable scientific achievements.

First, Einstein opened his paper On a Heuristic Viewpoint Concerning the Production and Transformation of Light by contrasting the theoretical representations of mechanics and electromagnetic theory.(199) In fact, he pointed out that, at low frequencies or high temperature, Planck's results indicated the inadequacy of both theories. Clearly, Einstein had read Planck's famous paper on the theory of black-body radiation.(321)

Only in the following year did he realize that Planck had introduced the notion of discrete energy levels of charged harmonic oscillators into physics. Planck had produced a mere device to facilitate further calculation.(322) Later, he referred to his innovation as "an act of desperation, for by nature I am peaceful and against dubious adventures."(323) Planck's admission was a direct acknowledgement that, on this occasion, he had spurned epistemology as he turned to intuition.

The mathematical complexity of Planck's work probably retarded recognition of its original conception of intrinsic discreteness in nature. This did not, however, totally eclipse its abortion. Einstein produced another form of quantization by treating radiation as a stream of localized particles or quanta. Apparently, Einstein had assimilated the "dominating role of the concept" of discreteness from Planck's work. He had "played freely" with this heuristic device "to a considerable degree unconsciously." Ultimately, he enmeshed it as a definite operational property of radiant energy by indicating some "measure of its survey over scientific experience."(107) This incident has all the markings of a striking example of what Einstein believed was the way scientists apprehend the natural order. In particular, the operation of pre-articulate elements of scientific thinking early in Einstein's scientific research probably influenced his epistemological views.

Second, there was the remarkable simultaneous development of statistical mechanics by two different scientists working at distant locations.(209) Three years before the appearance of his paper dealing with his statistical description of Brownian motion(208), Einstein had prepared his ground. He had completed and published his treatment of the conditions of thermal equilibrium and the Second Law of Thermodynamics in terms of probability.(324) As Born noted, Gibbs is not mentioned in Einstein's paper.(209) In the previous year Gibbs had published a thorough investigation of the same topic.(209) The similarity of the two approaches is particularly noticeable, although

Einstein's work is less abstract. In his Autobiographical Notes Einstein reported that he had not known of the earlier investigation of Gibbs who, he admitted, had actually exhausted this subject.(197) "No logical path"(168) led Gibbs or Einstein from perceptions to theory, but "a growing sympathy with the natural order" could account for the coincidence.(111) The close parallelism certainly lends support to the view that scientists are guided by and subject to the rationality of the universe.(99) If one postulates the operation of the intuitive relation, this parallelism loses its element of surprise. On this basis, the scientific apprehension and experience of both scientists would be expected to follow roughly similar heuristic tracks. From an Einsteinian perspective, the coincidence looks less convincing but more impressive. Einstein had probably personal cause to think about things like the intuitive relation.

Third, two alternative approaches to Einstein's electrodynamics of moving bodies had already been published in the previous year. Two other scientists had started independently from different presuppositions. Einstein wrote to Carl Seelig in 1955, "... I knew only Lorentz's important work of 1895 - La Théorie electromagnétique de Maxwell and Versuch einer Theorie der elektrischen und optischen Erscheinungenim bewegten Korpen - but not Lorentz's later work, nor the consecutive investigations by Poincaré. In this sense my work of 1905 was independent."(228)

In a paper published in 1904 Poincaré discussed the Galilean Principle of Relativity and current developments in electromagnetic theory.(325) Like Lorentz, he suggested that no velocity can exceed that of light. Casting doubt on the need for an ether, he indicated that an entirely new theory was necessary. In another paper of 1905, Poincaré was the first to use the expression "Lorentz transformation." He also introduced the idea of an imaginary fourth component in the definition of the fundamental geometrical interval.(326) Many scientists think that Poincaré, the leading French mathematician of his time, would have produced

the special theory of relativity had Einstein failed, or even dallied, in his quest.(327)

Lorentz was convinced that the Newtonian theory of motion was basically sound. He believed that its modification would resolve known anomalies. Still, he confessed near the beginning of his paper that "Poincaré has objected to the existing theory of electric and optical phenomena in moving bodies that, in order to explain Michaelson's negative result, the introduction of a new hypothesis has been required, and that the same necessity may occur each time new facts will be brought to light. Surely this course of inventing hypotheses for each new experimental result is somewhat artificial. It would be more satisfactory if it were possible to show by means of certain fundamental assumptions and without neglecting terms of one order of magnitude or another, that many electromagnetic actions were entirely independent of the motion of the system."(328)

The hopes of Lorentz and the criticisms of Poincaré were satisfied beyond all expectations by Einstein's theory. Regardless of his confession, the number of ad hoc hypotheses in Lorentz's paper ran into double figures.(329) With his heroic style, Holton has suitably dramatized this situation. "Lorentz's work can be seen somewhat as that of a valiant and extraordinary captain rescuing a patched ship that is being battered against the rocks of experimental results, whereas Einstein's work, far from being a direct theoretical response to unexpected experimental results, is a creative act of disenchantment with the mode of transportation itself - an escape to a rather different vehicle altogether."(329)

Einstein started from two fundamental postulates "conditioned by observed facts."(236) He avoided the use of mathematical approximations, and demonstrated the invariance of Maxwell's equation.(212) In a letter to Paul Ehrenfest in 1919 he explained, "... your difficulties with the development of relativity theory...

arise simply because you want to base the innovations of 1905 on epistemological grounds (non-existence of the stagnant ether) instead of empirical grounds (equivalence of all inertial systems with respect to light)."(330) Scientific research had taught Einstein that epistemology only offered a negative logical check, whereas the natural order provided a positive intimation of the special theory of relativity. The commitment of Einstein's intuition was expressed as complete confidence in the principle of relativity. Unlike Lorentz and Poincaré, Einstein dared to build on it.(331)

Sixteen years later, in a lecture given at King's College, London, Einstein drew "attention to the fact that this theory is not speculative in origin: it owes its invention entirely to the desire to make physical theory fit observed fact as well as possible. We have here no revolutionary act but the natural continuation of a line that can be traced through centuries. The abandonment of certain notions connected with space, time and motion hitherto treated as fundamentals must not be regarded as arbitrary but only as conditioned by observed facts."(236) Significantly, there is no denial that his theory is constructive. Indeed, Einstein referred to it as inventive. The claim is rather that it is "not speculative in origin." This critical distinction was carefully stressed by Einstein who pointed out that observed facts "conditioned," as opposed to dictated, the "abandonment of notions."

In fact, Einstein believed that he was following in the footsteps of Newton whose "... endeavours to represent his system as necessarily conditioned by experience and to introduce the smallest possible number of concepts not directly referable to empirical objects are everywhere evident..."(257) Einstein saw his theory as much more than a mere ad hoc adaption of Newton's theory. Nevertheless, he regarded it as a continuation of Newton's work, methods, and aspirations.(259)

"It is one of the essential features of the theory of relativity that it is at pains to work out the relations between general

concepts and empirical facts more precisely. The fundamental principle here is that the justification for a physical concept lies exclusively in its clear and unambiguous relation to facts that can be experienced."(332) Einstein knew that the use of ad hoc or arbitrary additional assumptions had previously and repeatedly proved inadequate in the search for a greater logical unity. Both Lorentz and Poincaré had expressed dissatisfaction with such expediencies. His own theory is far more impressive because of the simplicity of its premisses, the diversity of phenomena which it correlates, and the range of its applicability.(143) Its "inner perfection" or "naturalness," though defying "exact formulation," became particularly apparent on comparison with Lorentz's work.(252) In short, very soon after the publication of his theory, Einstein had a dress rehearsal for his subsequent performance in defense of the special theory of relativity against the prosecuting results of Kaufmann.

Years later, Einstein remained consistent under much more favourable circumstances. He surprised one of his students, Ilse Rosenthal-Schneider, who recorded the incident. "Once when I was with Einstein in order to read with him a work that contained many objections against his theory ... he suddenly interrupted the discussion of the book, reached for a telegram that was lying on the windowsill, and handed it to me with the words, 'Here, this will perhaps interest you.' It was Eddington's cable with the results of measurement of the eclipse expedition(1919). When I was giving expression to my joy that the results coincided with his calculations, he said quite unmoved, 'But I knew that the theory is correct'; and when I asked, what if there had been no confirmation of his predictions, he countered 'Then I would have been sorry for the dear Lord - the theory is correct'."(333) The theory referred to is, of course, his general theory of relativity.

Undoubtedly, Einstein was far more impressed by the logical unification or simplification of theoretical foundations than by corroboration of particular details. His scientific experiences had seen to that. The more he researched in science, the more

convinced Einstein became of the pre-established harmony between thought and reality. The conviction impelled him to search for decades for a unified field theory.(334) Einstein was not overawed by scientific prediction. Scientific research had repeatedly shown him the value of an intuitive grasp of the significance of a theory.

Fourth, while discussing the origins of the special theory of relativity in his Autobiographical Notes, Einstein recalled how he hit upon a paradox at the age of sixteen, "his first insight into the problem of the nature of light."(214) "If I pursue a beam of light with velocity c (velocity of light in a vacuum), I should observe such a beam of light as a spacially oscillatory electromagnetic field at rest. However, there seems to be no such thing, whether on the basis of experience, or according to Maxwell's equation. From the very beginning it appeared to me intuitively clear that, judged from the standpoint of such an observer, everything would have to happen according to the same laws as for an observer who, relative to the earth, was at rest. For how, otherwise, should the first observer know i.e., be able to determine, that he is in a state of fast uniform motion?"(133) Light at rest is a contradiction in terms.

In adolescence, Einstein devised by "free play with concepts" a remarkable thought (Gedanken) experiment. It involved Maxwell's equations, the velocity of light, and the states of motion of two observers. This intuitive association of ideas represented what he called "the germ of the special theory of relativity."(214) Notably, its appeal to both theory and observation went unanswered. His resilient mind was not robbed of its youthful enthusiasm. One might say that the thought experiment remained a twinkle in his mind's eye. With continued striving the two postulates of the special theory of relativity would eventually emerge. The conception of this free creation and its subsequent period of gestation correspond vaguely to what Einstein described as the invention of, and free play with, heuristic "elements" in that phrase of "private thinking" which

goes on "without the use of words" and "to a considerable degree unconsciously."(335) The similarities hint, yet again, at experimential grounds for his epistemological utterances. This particular correspondence seems even more probable in the light of Einstein's comments to the eminent phychologist, Max Wertheimer. In 1916, Einstein emphasized to him that curiosity and doubt, rather than logical clarity and scientific conviction, were characteristic of his thoughts at that time.(336)

Both as a student and in his early scientific work, Einstein was greatly influenced by David Hume and Ernst Mach. Hume's penetrating criticism of "common-sense assumptions and dogmas" (337) had a lasting effect on Einstein. It is reflected, for instance, in Einstein's recurrent allusions to the constructive nature of concepts.(106) "Mach's influence was more direct and at the same time more complex."(337) Attempting to eliminate metaphysical elements from science, Mach concentrated his attention on the epistemological and methodological aspects of scientific research. Although not in sympathy with Mach's general philosophy of science, his critical writings appealed to Einstein's irrepressible sense of independence. Einstein's continuous striving for freedom of thought from the debilitating abuse of tradition had had very early origins.

The twelve years old Einstein had compared the contents of popular scientific books with those of biblical stories, and concluded that the latter were false. Thoroughly disillusioned, he became suspicious of all forms of authority and tradition. Parenthetically, throughout the centuries awakening young minds have abandoned the Christian faith at the impressionable age. They have turned to popular scientific books, often because of the responses of Christians to their genuine openness and spirited inquiries. Defensive evasions, offensive condemnations, and extensive prohibitions were exclusively conservative and transparently authoritarian. Christianity is nothing, if not honest. Young minds should not be forced into the false dilemma

of having to choose between faith and honesty.

Einstein, in particular, turned his back on what he regarded as intentional deception. The contemplation of the world seemed to offer freedom from an existence "dominated by wishes, hopes, and primitive feelings." It appeared to promise liberation from the chains of the "merely-personal."(112) This devastating experience left a profound and permanent impression with Einstein. It is readily detectable, for instance, in his address delivered at a celebration of Planck's sixtieth birthday.(70) Moreover, throughout Einstein's writings emphasis is repeatedly placed on both the rationality of the universe and the freedom of scientific researchers. Indeed, his scientific publications are monumental testimonies to what can be achieved when that freedom is subjected only to the pre-established harmony between thought and reality.

In this regard, Einstein found particularly acceptable Mach's criticism of Newton's ideas concerning space and time and his critical examination of Newtonian mechanics.(338) As he noted in his Autobiographical Notes, "I see Mach's greatness in his incorruptible skepticism and independence; in my younger years, however, Mach's epistemological position influenced me very greatly ..."(133) Mach held "that facts by themselves can and should yield scientific knowledge without free conceptual construction."(213) Initially drawn by the force of Mach's critical thinking, Einstein was to learn as a working scientist that even Mach fell the victim of the corroboration and prolonged usage of scientific concepts. He misunderstood the status of the empirically given, "in consequence of which he condemned theory on precisely those points where its constructive-speculative character unconcealably comes to light, as for example in the kinetic atomic theory."(133) Einstein's reference to the kinetic atomic theory is surely non-arbitrary. By pointing directly to the beginnings of his productive scientific life, Einstein was specific about his "younger years."(59)

In his memorable paper of 1905 On the Electrodynamics of Moving

Bodies(339), Einstein first presented a simple epistemological analysis of the concepts of space and time. Next, he defined simultaneity in terms of quantitative operational procedures dependent on the transmission of light signals. Einstein then discussed the relativity of lengths and times in the context of rigid rods, clocks, and moving bodies. A positivistic influence of Mach is not difficult to imagine, although to do so exclusively, one must overlook two formative postulates; the "principle of relativity" and the principle of the constancy of the velocity of light. The whole paper rests on those two principles. As "conceptual constructs" inaccessible to direct empirical confirmation, they are basically opposed to Mach's "anti-metaphysics." It is clear, then, that Einstein learned so well from Mach that he could not accept Mach's views uncritically. To use his own words, Einstein acted as an apparently "unscrupulous opportunist," (50) subordinating the epistemological elements of his thought to the primary creativity of scientific thinking. Indeed, in his article on Bertrand Russel's theory of knowledge, he recorded that the immediate difficulties encountered in research, more than anything else, led him to his epistemological views.(5)

Fifth, Einstein's former mentor, Hermann Minkowski, a mathematician, re-interpreted the special theory of relativity. Using the concept of a four-dimensional pseudo-Euclidean geometry of space-time, he showed that the Lorentz transformations were the four-dimensional counterparts of rotations in three-dimensional space.(340) The new four-dimensional space accentuated the role of physical invariance. Minkowski's formalism provided a concise conceptual framework for the discussion of topics like simultaneity and causality. Its simple graphical representations of physical reality provided additional advantages. Rather than concentrating on the prominent operational aspects characteristic of Einstein's presentation, Minkowski used mathematics to simplify the description of the physical world. The four-dimensional

space-time interval or vector ds seemed to point beyond measurement to axiomatics.(341) Consequently, Minkowski stressed that his apprehension of space-time had "sprung from the soil of experimental physics."(340)

The metaphysical elements of Minkowski's thought surfaced in the concluding sentence of his semi-popular lecture. He referred to "the idea of a pre-established harmony between pure mathematics and physics."(342) This correlation placed considerable emphasis on the value of constructive thought in general, and on Einstein's two postulates in particular. It also recognized a necessary role for empirical investigation. Obviously, when Einstein abandoned his own interpretation in favour of Minkowski's formulation, he moved deliberately against Mach's untenable epistemological position. Specifically, this strategy opposed Mach's doctrine that the laws of science are only summaries of experimental results. It is worth repeating however, that Einstein, as a working scientist, was never in sympathy with this dogma.

The importance of Minkowski's contribution was generously recorded by Einstein.(343) For him, it represented a concise in-course correction on his heuristic space-time journey to the general theory of relativity. As General Whitrow commented, "Minkowski's fame today rests on his invention ... of the concept of space-time, which had such a decisive influence on Einstein's development of general relativity, and is now recognized as one of the most important contributions ever made by a mathematician to natural philosophy."(344)

In reality, Einstein overcorrected. He became so strongly committed to Minkowski's space-time physics that he could recall forty years later how difficult it had been to leave the orbit of its influence. "The fact of the equality of inert and heavy mass thus leads quite naturally to the recognition that the basic demand of the special theory of relativity (invariance of the laws under Lorentz-transformations) is too narrow, i.e., that an invariance of the laws must be postulated also relative to

non-linear transformations of the co-ordinates in the four-dimensional continuum. This happened in 1908. Why were another seven years required for the construction of the general theory of relativity? The main reason lies in the fact that it is not so easy to free oneself from the idea that co-ordinates must have an immediate metrical meaning."(345) Evidently, Einstein had first to liberate himself from what had acquired an undue authority over him, before he could effectively tackle the problem of universal gravitation. Minkowski's use of geometry to describe physical reality was, nevertheless, a directive to success.

In his Notes on the Origin of the General Theory of Relativity, Einstein explained, "... the inclusion of non-linear transformations, as the principle of equivalence demanded, was inevitably fatal to the simple physical interpretation of the co-ordinates - i.e., that it could no longer be required that co-ordinate differences should signify direct results of measurements with ideal scales or clocks. I was much bothered by this piece of knowledge, for it took me a long time to see what co-ordinates at all meant in physics. I did not find the way out of this dilemma until 1912 ... The solution ... was ... as follows: A physical significance attaches not to the differentials of the co-ordinates but only to the Riemannian metric corresponding to them ... I worked on these problems from 1912 to 1914 together with my friend (Marcel) Grossmann."(346) In fact, while this collaboration helped to convince Einstein that gravity was not a force but a property of space-time, he had yet to provide a satisfactory mathematical description.

There can be little doubt, therefore, that Minkowski's formulation had a profound effect on Einstein's scientific work and epistemological views. Indeed, Einstein implied as much in a letter to Cornelius Lanczos, dated January 24th 1938. "I began with a skeptical empiricism more or less like that of Mach. But the problem of gravitation converted me into a

believing rationalist, that is, into someone who searches for the only reliable source of Truth in mathematical simplicity."(347) There was not, of course, an instantaneous conversion, only a growing sympathy with the natural order because of the pre-established harmony between thought and reality.(347)

Banesh Hoffmann asked and answered the all-important question, "What were the seeds that gave rise to (the) wonderfully unique structure (of the general theory of relativity)? Such things as Newton's theory, and the special theory of relativity of course, and Minkowski's idea of a four-dimensional world, and Mach's powerful criticisms of Newton's theory. Also the mathematical framework already prepared (in collaboration with Grossmann, and built by Karl Gauss, Wolfgang Bolyai, Nikolai Lobachevski, Bernhard Riemann, Elwin Christoffel, William Clifford, Gregario Ricci and Tullio Levi-Civita). But after that what? The principle of equivalence, the principle of general covariance, and - why, essentially nothing else."(348)

A galaxy of mathematicians had prepared the way for Einstein. How could he ever turn his back on scientific continuity and learning? With many "years of anxious searching in the dark"(346) behind him, Einstein had been painfully persuaded that "knowledge exists in two forms - lifeless, stored in books, and alive in the consciousness of men. The second form of existence is after all the essential one; the first, indispensable as it may be, occupies only an inferior position."(349) A generation before Einstein, Reimann had invented a geometry of curved surfaces logically independent of any physical basis. Einstein had taken it from the "books," used it to represent a law of motion, and provided a theory that excited the scientific world. Besides, while the Newtonian view of space as a passive container is rejected in both theories of relativity, the general theory endows space with physical qualities due to the interdependence of gravity and matter. This correlation of mathematics and physical reality re-introduced the notion of an "ether." With the cat once again

among the pigeons, Einstein's theory was very much alive in the consciousness of scientists. Einstein's epistemological perspective was oriented by his working life as a scientist. Indeed, it was firmly rooted in, and grew out of, his scientific apprehension and experience.

In the opening remarks of his Autobiographical Notes, Einstein warned his readers that "the exposition of that which is worthy of communication does nonetheless not come easy - today's person of 67 is by no means the same as was the one of 50, of 30, of 20. Every reminiscence is coloured by today's being what it is, and therefore by a deceptive point of view."(350) Several paragraphs later, readers are reminded of the misting of memory by intervening experiences. "In this case it is well possible that such an individual in retrospect sees a uniformly systematic development, whereas the actual experience takes place in kaleidoscopic particular situations."(112) Advancing only a few more pages, one learns that Einstein's epistemological "credo actually evolved only much later and very slowly and does not correspond with the point of view I held in younger years."(59)

Einstein's repeated references to the tricks played on memory by experience hint at the strength of his conviction that the working life of a scientist moulds his epistemological views. In his Reply to Criticisms he addressed the subject directly. "The reciprocal relationship of epistemology and science is of noteworthy kind. They are dependent upon each other. Epistemology without contact with science becomes an empty scheme. Science without epistemology is - in so far as it is thinkable at all - primitive and muddled. However, no sooner has the epistemologist, who is seeking a clear system, fought his way through to such a system than he is inclined to interpret the thought-content of science in the sense of his system and to reject whatever does not fit into his system. The scientist, however, cannot afford to carry his striving for epistemological systematic that far."(189) Scientists cannot serve two masters.

Therefore scientific researchers give pride of place to the intuitive relation. Epistemology takes a lesser but important position.

"Nobody who has really gone deeply into the matter will deny that in practice the world of phenomena uniquely determines the theoretical system, in spite of the fact that there is no logical bridge between the world of phenomena and their theoretical principles; that is what Liebnitz described so happily as a "pre-established harmony." Physicists often accuse epistemologists of not paying sufficient attention to this fact."(111) "This fact" represented the fulcrum of Einstein's epistemological lever.

He believed that scientists are guided by and subject to the rationality of the universe. In so far as they are open to the natural order, scientists increase their apprehension. In Einstein's figurative words, "the liberty of choice, however, is a special kind; it is not in any way similar to the liberty of the writer of fiction. Rather it is similar to that of a man engaged in solving a well designed word puzzle. He may, it is true, propose any word as a solution; but, there is only one word which really solves the puzzle in all its forms."(154) Scientists strive to remain obedient to the pre-established harmony of thought and reality. They manage it within the limitations of their apprehension and experience.

There is, therefore, abundant evidence to support the simple conclusion that Einstein's comments on epistemological aspects of scientific research were grounded in personal, patient, and profound labour and activity. In fact, his essays on scientific research only began to appear after he had produced both the special and general theories of relativity. Einstein could "see, on the one side, the totality of sense experiences, and, on the other, the totality of the concepts and propositions which are laid down in books."(59) He could see, on the one hand, the totality of scientific experience, and, on the other, the totality of epistemological and methodological propositions.

The two hands had to be intuitively clasped to yield a consistent, open and therefore incomplete description of nature, of which he was a little part. Specifically, Einstein rejected abstraction which led to Newtonian physics for the intuitive relation which had taken him to the special and general theories. He avoided epistemological systems. He believed that a scientist should be, first and foremost, scientific in his thinking. Only scientific answers should be given by a scientist to questions on scientific thinking.

21. SCIENCE AND RELIGION

The metaphysical significance of space-time has been discussed by many Christians since the appearance of Einstein's special theory of relativity in 1905. In fact, this theory has a particular fascination for those interested in the mystery of time. In classical physics, space is described as a three dimensional Euclidean continuum. It is homogeneous and isotropic. Very few people have difficulty with the concept of the distance between Princeton and Bethlehem, but how many can make any sense of the corresponding interval between Princeton now and Bethlehem at the moment of Jesus' birth? The spatio-temporal interval between spacially separated, non-simultaneous events is not even a quantitative concept in classical physics. Space and time are measured in disparate units.

The invariance of the velocity of light (c) renders the results of spatial and temporal measurement comparable in relativistic physics. Time intervals can be multiplied by c to obtain space-like intervals. The resulting intervals of space-time have the same value for all observers. The spatial and temporal measurements are relative to the state of motion of the observer. There are no absolute juxtapositions nor are two events simultaneous for one observer also simultaneous for another. Nevertheless, this scientific theory does not dispense with the distinctive characteristics of space and time. Neither is reducible to the other.

Indeed, Einstein's special theory, like Newton's edifice, has the powerfully heuristic quality of obvious multiple connectivity as the interpretations of Einstein and Minkowski illustrate. Besides, the diversity of interpretations is even more marked in the case of the general theory of relativity. There is nothing internal to the special theory that proves one particular interpretation to be unconditionally superior. On the contrary, it was largely Einstein's search for a more general theory that encouraged him to adopt Minkowski's formulation. Moreover, the laws of classical and relativistic physics are causal in much the same sense. In the latter, an infinite set of contemporary events is always irrelevant to the prediction of any particular event, whereas in the former, all events are obscurely relevant in principle.

Einstein responded to the interpretative uncertainties by relying on scientific criteria, or rather the intuitive relation. Otherwise he would have opened the flood-gate of unbridled speculation. His reservations about epistemological systems had "sprung from the soil of experimental physics."(340) Clearly, without a basic understanding of relativistic physics, Christians must depend on hearsay or blind chance. Yet such an understanding reveals that there is no unique path from relativistic physics to theology.

As already noted, Einstein used the concept of "cosmic religious feelings" to explain his motivation in science. He believed that this "feeling is the strongest and noblest motive for scientific research,"(246) but that "it can give rise to no definite notion of God and no theology."(247) Einstein was frank about his unusual religious views. "A knowledge of the existence of something we cannot penetrate, of the manifestations of the profoundest reason and the most radiant beauty, which are only accessible to our reason in their most elementary forms - it is this knowledge and this emotion that constitute the truly religious attitude; in this sense, and in this alone, I am a deeply religious man."(351) In fact, he could not conceive of a genuine scientist without a profound faith "in the possibility that the regulations valid for

the world of existence are rational, that is, comprehensible to reason."(352)

The cosmic religious feeling is intimately associated with belief in an external world independent of the perceiving subject as the basis of all natural science.(63) Einstein depended on the past faithfulness of the rationality of the universe while exercising his creative faculties. Without this faithfulness, the motivation of the scientist is chaotic and tends to fade simply because it cannot deepen by virtue of experience, struggle and growth. Alternatively, motivation almost devoid of creativity does not progress far beyond learning. When both faithfulness and creativity are held together, the scientist experiences what Einstein meant by "the cosmic religious feeling" which is grounded in the inseparability of "the empirical and rational components of knowledge."

According to Einstein, the scientific enterprise requires such faith because "... mere thinking cannot give us a sense of the ultimate and fundamental ends. To make clear these fundamental ends and valuations, and to set them fast in the emotional life of the individual, seem(ed to Einstein) precisely the most important function which religion has to perform in the social life of man."(129) Einstein's scientific life illustrates how the belief of the scientist can strengthen commitment to and interpret this religious feeling. Although he seems to have used the terms passionate devotion,(282) unselfish desire,(103) passion for comprehension,(148) and cosmic religious feeling more or less interchangeably, different aspects of the last are accentuated by the other three. The cosmic religious feeling sets itself apart from objectivism or dispassionate neutrality, subjectivism or selfish desires and extreme rationalism or unimpassioned understanding. Its aim is progressive liberation from the disunity of everyday experiences.(353) The vehicle that carries the scientist to freedom is the self-discipline of scientific standards of research powered by preoccupation with

superpersonal validity. "Certain it is that a conviction, akin to religious feeling, of the rationality or intelligibility of the world lies behind all scientific work of a higher order."(120)

The law of causality, according to Einstein, rules supreme in the universe. He even assumed that life, itself, would be deducible from it.(111) Presently, life is known to obey "the rule of fixed necessity."(166) Indeed,"the more a man is imbued with the ordered regularity of all events, the firmer becomes his conviction that there is no room left by the side of this ordered regularity for causes of a different nature. For him, neither the rule of human or the rule of divine will exist as an independent cause of natural events."(354) Einstein regarded "the universal operation of the law of causation"(246) as convincingly illustrated by the "organic development of Newton's ideas"(258) across the centuries. Its operation is the will of God,(129) the revelation of the mind of God. Undoubtedly, Einstein's thoughts on God's omnipotence were greatly influenced by his knowledge of the implications of the defects of Newton's edifice and his own scientific theories. A transcendent God who expresses his omnipotence in such terms in neither "a Being who interferes in the course of human events"(246) nor One who "exists as an independent cause of natural events,"(7) nor One who acts instantaneously at a distance.

Einstein could not reconcile his views on causality with the notion of a "personal" God who grants human petitions.(352) Besides, a God who is "personally" active in the world as a causal agent is, in Einstein's view, radically implicated in the problem of evil.(352) Einstein's God is not. His will is eternally expressed in terms of causal invariance which caters for the decisions of the individual. Einstein believed that man can be freed from fear of God and the struggle for personal salvation, freed to become "religious" in a cosmic sense. Einstein seems to have intellectualized the religious quest to a quasi-scientific enterprise, a rational form consistent with,

but not equivalent to, the scientific endeavour. Indeed, he revealed his priorities with the remark, "science without religion is lame, religion without science is blind."(266)

From an Einsteinian perspective, the basic conflict between science and religion arises from the incompatibility of anthropomorphic conceptions of God and "the universal operation of the law of causation."(103) Fundamentally, science and religion tackle different tasks. While science "is the attempt of the posterior reconstruction of existence by the process of conceptualization,"(103) religion deals only with the moral, ethical and emotional life of individuals.(103) Einstein was convinced that "... science can only ascertain what <u>is</u>, but not what <u>should be</u>, and outside of its domain value judgments of all kinds remain necessary. Religion, on the other hand, deals only with evaluations of human thought and action; it cannot justifiably speak of facts and relationships between facts."(6) False conflicts between science and religion commonly spring from "fatal errors" that confuse these distinctive functions.(6) Nevertheless, "scientific method itself would not have led anywhere, it would not even have been born without a passionate striving for clear understanding."(355) Evidently, Einstein was not sufficiently motivated to pursue the problems associated with the concept of a superpersonal Being. As a scientist, he focused his attention on the inexhaustible difficulties of apprehending the revelation of that superior Mind.

In so many respects, Einstein appears to have stood before the threshold of the Christian faith. The incompleteness of his utterances of religious, epistemological and scientific content demonstrates the penetrating consistency of Einstein's scientific thinking. It also shows how the scientific enterprise can lead the scientific researcher to the question, "Why think theologically?" Scientific endeavour, however, cannot provide the motivation necessary to pursue the theological quest. This

desire must come from a different direction. Nevertheless, a healthy regard for theological thinking can be generated by scientific thinking as illustrated by Einstein's reluctance to borrow supposedly well-known theological terms. In fact, many scientists attempt to answer the question, "Why think theologically?" If they have learned from Einstein, they might even take the study of theology too seriously for many fellow Christians.(356)

22. OPENNESS AND JUSTIFICATION

An outstanding feature common to all of Einstein's remarks is openness to an independent physical world. Einstein explained his views on gravitation in characteristically lucid terms. "It is sufficient - as far as we know - for the representation of the observed facts of celestial mechanics. But it is similar to a building, one wing of which is made of fine marble (left part of the equation), but the other wing is built of low grade wood (right side of the equation). The phenomenological representation of matter is, in fact, only a crude substitute for a representation which would do justice to all known properties of matter."(357) The equation in question relates the Riemannian geometry of space-time to the energy-momentum tensor of distributed matter and energy. Einstein expressed his dissatisfaction with the general theory of relativity by indicating where he believed its weakness lay. He maintained that the mathematical treatment of space-time is essentially "the right way" to proceed. Nevertheless, by his reckoning, a great deal of work had still to be done on the representation of matter before the scientific house could be put in proper order.

Clearly, Einstein was as eager to have his own theories improved, as he was to see beyond those of other scientists. According to Otto Frisch, a pioneer of nuclear fission, "When anybody contradicted him (Einstein) he thought it over and if he found he was wrong he was delighted, because he felt that he had

escaped from an error and that now he knew better than before. For the same reason he never hesitated to change his opinion when he found that he had made a mistake and to say so."(358) The incident with Lanczos is a good example (vide supra). The reactions of most scientists do not quite match Einstein's unqualified devotion to the pursuit of truth. He was convinced, for instance, that "as far as propositions of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality."(359) Such insights entrenched his determination to remain open to the intuitive faculties of other scientists. The research courses run by scientists are heavily fenced with likelihoods. Conjointly, they jump the unknown and unexpected in thinking and doing. Where possible, they avoid the handicaps of unbridled speculation and blinkered certainty.

Einstein's Herbert Spencer Lecture On the Method of Theoretical Physics,(360) was delivered at Oxford in 1933. He raised the question of the non-logical relation of the sense experiences and freely invented concepts. As he did so, his uncompromising commitment to the openness of scientific thinking was never more obvious. "Can we hope to be guided safely by experience at all when there exist theories (such as classical mechanics) which to a large extent do justice to experience, without getting to the root of the matter? I answer without hesitation that there is, in my opinion, a right way, and that we are capable of finding it. Our experience hitherto justifies us in believing that nature is the realization of the simplest conceivable mathematical ideas. I am convinced that we can discover by means of purely mathematical constructions the concepts and laws connecting them with each other, which furnish the key to the understanding of natural phenomena."(360) Of course, the inseparability of the empirical and rational components of knowledge ensures that even "purely" mathematical constructions are empirically loaded.

Einstein answered the question, "Why think scientifically?"

A scientist ought to think scientifically because it is his most effective way to increase humankind's apprehension of the natural order. Adapting Brown's words, this answer has no force unless it is assumed that a scientist ought to pursue this goal.(267) Einstein knew that the pursuit of science was ultimately a matter of faith. He said so repeatedly. His "nose" for truth was precious to him. Obviously, he accepted this goal and also the imperative that a scientist ought to pursue it. According to him, the sole justification for a scientific thought, statement, or theory resides in the inherent rationality of the universe. It may become part of the corporate experience of the scientific community, but it always originates as personal scientific experience.

As scientists stand open to the structured world, they abandon notions of final solutions to scientific problems and epistemological systems.(70) Bondi, for example, believes that vain strivings "at ultimate equations, to come to ultimate final complete statements, to theories unifying all that we know ... is a very dangerous tendency ..."(361) In equally general terms, Einstein and Infeld suggested that "a complete solution (to the mystery of the universe) seems to recede as we advance."(362) Scientists have to live with an unfinished view of the universe. They will never cease to ask new questions. Hopefully, they will continue to be confronted with new discoveries and problems. The endless quest of science is a candid search for apprehension, not comprehension. "To obtain even a partial solution the scientist must collect unordered facts available and make them coherent and understandable by creative thought."(363)

Einstein never saw himself as a philosopher.(364) With his great gifts he found the most important scientific questions. Faithful to his intuited beliefs, he pursued those questions without losing contact with the main problems. If, in the process, he could contribute occasionally to epistemology, then there was no harm in that. But he never allowed himself to be

side-tracked by a search for a logic of scientific research. Einstein devoted his life to research in science. His commitment was to much more than a prescribed scientific methodology. He knew scientific research to be greater than the sum of all scientific methods as laid down in books. His apprehension exceeded intuitively the articulated content of science. To borrow his own words, nothing can be said concerning the detailed manner in which scientific thinking is to be accomplished and refined, and how it is to be co-ordinated to experience,(151) only that it is alive in the consciousness of the scientific researcher.(349) Einstein's "credo," presented in his "obituary," testifies to the openness of scientific thinking. In fact, it reads rather like an epistemological parallel to the description of his general theory of relativity.(59) This association of ideas and its like lay behind his repeated warnings to the reader in the early paragraphs of his Autobiographical Notes. In this contribution, Einstein stated plainly that "actual (scientific) experience takes place in kaleidoscopic particular situations," (107) not in accordance with an algorithm.

Elsewhere, Einstein commented, "If you want to find out anything from the theoretical physicists about the methods they use, I advise you to stick closely to one principle: don't listen to their words, fix your attention on their deeds."(97) He did not mean, however, that a scientist's description of scientific procedures is totally unreliable. Nor was he implying that only observations and experiments are worthy of consideration. Certainly, there are some people who teach such things, but they miss the very point that Einstein took pains to make. As Filmer Northop indicated, Einstein was far too good a scientist, too profound a thinker, to forget for one moment the mystery of the inseparability of the empirical and theoretical components of knowledge.(365) This mystery, for example, lies at the heart of the general theory of relativity and at the core of determinate nature. That is why Einstein prefaced the above advice with the

following statement. "To him who is a discoverer in this field (theoretical physics), the products of his imagination appear as so necessary and natural that he regards them, and would like to have them regarded by others, not as creations of thought but as given realities."(97)

Einstein was primarily concerned about the tendency among scientists to forget the intuitive connections of their theories to the physical world. The inclination to regard them as empirically given increased through sheer force of habit. To understand scientific thinking one must look behind the words of the scientific researcher to the theories of the natural sciences, to their concepts, and to the methods actually used by scientists. Those are the "deeds" to which Einstein referred as he raised the fundamental problem of belief in scientific thinking. Basically, Einstein was suggesting that anyone sufficiently interested in scientific research should get down to concrete cases. As previously noted, it is not what is heard and said by spectators or critics that carries research along, but the labour and activity of scientists.(366) That labour and activity includes the logically free creations of scientific minds.

Einstein admitted freely that the scientist "must appear to the systematic epistemologist as a type of unscrupulous opportunist: he appears as realist in so far as he seeks to describe a world independent of acts of perception; as idealist in so far as he looks upon the concepts and theories as free inventions of the human spirit ...; as positivist in so far as he considers his concepts and theories justified only to the extent to which they furnish a logical representation of relations among sensory experiences."(50) The ease with which selected aspects of scientific thinking can be associated with diverse philosophical traditions hints at the subordinate role of epistemology in scientific thinking. It sheds some light on how a scientist can appear to be philosophically inconsistent, while remaining

scientifically rational. It also helps to explain how scientists can function effectively despite individual allegiances to the spectra of modern philosophies and theologies. Lastly, it indicates how many Christians can be misled by the appearance of scientific thinking as both confused and ill-founded. It cannot, however, exonerate them from the charges of premature judgment and ignorance of the "deeds" of scientists.

Actually, Christians should be especially reluctant to draw such conclusions for they have to come to terms with similar circumstances. A prominent feature of modern Christian theology is that it does not address univocally contemporary confrontations of culture and technology. The prevalent inconsistencies and ambiguities reflect a whole range of so-called theological thinking. At one extreme, biblical representations or images are taken as mere conventions with no anchorage in the objective Reality of God as revealed in the Person of Jesus Christ, the Lord and Saviour of the world. Their significance relies exclusively on the presuppositions and desires of the particular individual. At the opposite extreme, biblical statements are seized as pictorial representations or models to be exhaustively studied and rigorously applied. Yet beyond their arbitrary encapsulation of biblical "truths," they are detached from all creative reference. On the one hand, many Christians are threatened by subversive superficiality and, on the other hand, numerous believers risk slavery to evacuated objectivism. Only as Christians allow their presuppositions and desires to be creatively questioned by the objective Reality of God can they hope to transcend idiosyncratic interpretations and incoherent rationalizations.

Apparently, the inseparability of the theoretical and empirical components of knowledge, the divergent views among scientists on particular methods and theories, and the complexity of scientific thinking are problems which have counterparts in modern theology. They should strike chords of sympathy as they remind Christians of the domestic frailties and strengths of modern theological

thinking. In neither case, however, is the face of adversity quite sufficient to arrest the pursuit of appropriate personal beliefs.

It is not the buisness of scientists to become bogged down in epistemological details or to qualify scientific beliefs out of existence. Bondi first gave Newton's second law as an example of an open theoretical statement based on the available data. Then he wrote, "It is an essential part of science that (a scientist) be able to describe matters in a way where he can say something without knowing everything."(367) "All science is full of statements where you put the best face on your ignorance, where you say: true enough, we know awfully little about this, but more or less irrespective of the stuff that we don't know about, we can make certain useful deductions."(368) As long as scientists operate meaningfully within a broad basic framework of scientific beliefs, their precise methods of inquiry are largely determined by the detailed nature of current research activities. In the laboratory or at the office, it is not a question of confusion or ill-founded methods. Personal intuitions and evaluations meet the standards, but not necessarily the immediate support of the wider scientific community. In the long run, they must, of course, speak persuasively to that community.

Every research scientist practices conceptual "parsimony" by every method he can. Scientists have no inviolable epistemological principles, but on occasions they will defend every one of them. Many scientists worship in church at weekends and with their researches for the rest of the week. With rare exceptions, they are self-disciplined researchers who delight in their own logically free creations. Briefly, scientific researchers strive as scientific realists to advance scientific theories.

In particular, Einstein cautiously limited himself to the field of physics.(5) He had no new scientific method to propound, no novel comprehensive epistemology to offer, and no startling proof

that scientific theories or statements are indubitable. This brilliant scientist rejected both scepticism and idealism. He believed in an independent reality which he could see only dimly. On the basis of his scientific wisdom and well over forty years ago, Albert Einstein provided a scientific answer, a realistic, coherent open reply, to the question, "Why think scientifically?" Perhaps surprisingly, his answer raises the question, "Why think theologically?", but a responsible reply to it would require another essay.

Instead, a much less ambitious but no less relevant topic is briefly discussed in the subsequent sections of this essay. As already observed, reasoning by similarity does not guarantee apprehension. But when an extensive correspondence is so far from exhaustion, it is necessary to look more carefully at both the scientific enterprise and theological activity. Their similarity is now outlined with the aim of urging other Christians beyond the limitations and inadequacies of this outline to greater precision and fuller apprehension through the personal participation of interested parties. From an Einsteinian perspective, sound critical thinking becomes possible only where reliable working knowledge of the subject has been assimilated. It seems rational, therefore, to adhere in the present context to the scientific way by setting up some of the apparatus that will assist the investigations of the much more capable who follow.

23. STUMBLING BLOCKS

The theology of this century, like its science, is not that of the last century. Nor will it be the theology of the next century. But many people are not content to wait for decades on theological change in this so-called scientific age. The science of today, unlike its theology, is not that of yesterday. Nor will it be the science of tomorrow. Even scientists find it difficult to keep abreast of current scientific developments in areas far removed from their own researches. By contrast, the barely perceptible dynamics of modern theological concepts often causes interested

scientists to doubt the value of systematic theology. Moreover, the descried immutability of theological concepts encourages some of them to regard the technical vocabulary of theology as mere camouflage to conceal contradiction, paradox and creative impotence.

Understandably, the relatively slow development of modern theology tends to frustrate the heuristically tuned scientific mind. Yet, that does not give scientists the right to dismiss theology as a contrived system for the transference of real mysteries to the obscurity of a technical library. Scientists seldom venture too far in their theorizing from the data of experience. This proclivity causes many of them to question, often involuntarily, the relevance of an apparently remote discipline like systematic theology. The latter deserves careful consideration, however, if only for the sake of science itself.

To many educated citizens, for whom scientific research and technological development are distinguishable, both science and theology seem too distant from the urgencies of every day living. Daily life demands immediate solutions to pressing practical problems, not high performances in what appears to be sheer intellectual indulgence. Consequently, when those people hear of scientists condemning theological activity as an excessive elaboration of Christian teaching, they are reminded of the pot calling the kettle black. Moreover, this instinctive identification of a profound similarity is not to be despised. In the face of it, scientists who are also Christians cannot evade their responsibilities.

Perhaps surprising to many scientists, Albert Einstein's comment on a common misreading of scientific researchers is readily applicable to a popular misrepresentation of theologians. "Those whose acquaintance with scientific research is derived chiefly from its practical results easily develop a completely false notion of men who, surrounded by a skeptical world, have shown the way to kindred spirits scattered wide through the world and the centuries."(332)

The relatively low profile and population density of modern systematic theologians together with the comparatively high rate of technological innovation in modern pragmatic societies conspire to elevate the man of immediate action, even within Christianity.

The person who produces speedy results is rapidly idolized while those who concern themselves with the bases of faith are soon branded as people who think too much for their own good. It is of very little consequence to some that quick results frequently promise eventual failure in the things that really matter. In short, empathy is a luxury more often currently denied the devoted theologian than the dedicated scientist. Yet, their respective conceptual systems can only change in so far as scientists and theologians are prepared to strive long and hard to experience and to learn more. However, in spite of the disinterested or discouraging populace, numerous persons are inspired to pursue the arduous aims of scientific research and theological activity.

Modern science and systematic theology have a common concern with all that lies between the birth of the universe and the end of the world. On the one hand, science studies the text of the book of natural order. On the other hand, it reads the available charts of the landscape of scientific thought. Similarly, on the one side, systematic theology explores the contents of the sacred and inspired Scriptures. On the other side, it ponders the received doctrines as the condensed Christian reflection of generations. Scientific research stretches from the nature of the sub-nuclear particle to the structure of the universe, while systematic theology reaches from the jot and tittle of Scripture to the Alpha and the Omega of the creation. In neither case are the problems arbitrary. Always, they arise within a living context and, therefore, they exhibit a dynamic continuity. Each discipline displays a vibrant form and a creative content developed through the centuries by the co-ordinative tension between experience and reflection. This tension characterizes

both activities that have much more in common than is generally appreciated.

Albeit obliquely, Einstein actually underscored the kinship of the scientist and the theologian. "Only one who has devoted his life to similar ends can have a vivid realization of what has inspired these men and given them the strength to remain true to their purpose in spite of countless failures."(332) Of course, Einstein was referring to the dedication of scientists, and his words may not be acceptable to the theological rigorist. Nevertheless, they do capture something of the spirit of theological activity.

His own researches had convinced Einstein that an immoderate emphasis on practical results is atypical of those who are intimate with the intensive demands of an exacting discipline.(133) Indeed, acutely aware of their own inadequacies, scientists and theologians know, as a rule, the ease with which they can lapse into an inflated sense of achievement. Over sixteen hundred years ago, Athanasius stated the theological case bluntly, "... to turn away from the Word of God, which is, and to fashion ... one that is not, is to fall to what is nothing."(369) Seductive expediency and rampant speculation are equally blind to scientific discovery and theological inquiry. They are formidable adversaries who never retire from the intellectual arena. It takes more than idle curiosity or mild interest to stay in there with them and to strive hopefully for long-term objectives.

Theological thinking, like scientific thinking, requires what Einstein called passionate devotion.(282) A theological necessity constrains members of the Church to seek a greater apprehension of God and of his universe. Likewise, a scientific necessity is laid upon some members of society to discover a deeper understanding of nature.(100) In both cases the mandate is clearly to commit oneself fully, including all the mind, to an ever changing world which presents new problems, questions and opportunities.

The meaning and justification of scientific or theological

reflection lie in the corresponding activity itself, not in previously preferred results. The awareness of scientists or theologians is primarily of the reality which exists before and beyond the particular topic in hand. In scientific or theological thinking there is a logical manifold or reasoned coherence which results from a heuristic dynamics or exploratory propulsion.(51) By expanding a logical survey through a responsible re-ordering or re-interpretation of experience, the scientist or theologian engages in a heuristic event. This act is rationally irreversible being grounded in that reality which alone nourishes apprehension. In other words, anti-intellectualism has no legitimate place in modern science or in Christian teaching.

Neither, for that matter, has hyper-intellectualism which raises its own crop of problems. By hyper-intellectualism is meant that condition of mind which regards all forms of ignorance, except its own, as manifestations of gross inferiority. For example, a theoretical or exegetical apparatus, when wielded as a club to defend occupied territory or to display erudition, transforms discussions into disputes. Then, severely debilitating blows are inflicted on innocent observers and guilty participants alike. Instead of being intellectual ploughshares, those creations become surrogate swords in the hands of the fickle for the intimidation of the uninitiated. But the matter does not always rest there. Previously wounded by such unfortunate experiences, many people no longer set much store by modern science or by systematic theology.

Frequently, in both science and theology those who hanker after wisdom are discouraged from diagnosing internal disorder by their exposure to its painful symptoms. In many instances, the hiatus between motivation and apprehension coupled to a lack of practical experience, goes virtually undetected. The consequent distorted presentations of data repel further interest indefinitely. The fundamental point is that the formal machinery of science or theology, if idolized, is likely to scythe the ripening aspirations

of those who seek genuine illumination. Formal idolatry invariably gains ground as scientists or theologians convert the powerful potentialities of increasing apprehension to aberrant species of possession. When passionate devotion, which demands humility, gives way to wilful manipulation, faith, freedom and enthusiasm are slowly strangled. That is, the story of the tower of Babel is re-enacted daily in science and theology. Clearly, they are not as different as rock and sand. At the very minimum, their foundations and frameworks leave ample scope for similar kinds of abuse.

24. SCIENTIFIC FAITH

The similarity can be recognized positively in the sense that both science and theology rest ultimately on faith. According to Einstein, "The belief in an external world independent of the perceiving subject is the basis of all natural science."(128) Moreover, "To this there also belongs the faith in the possibility that the regulations valid for the world of existence are rational, that is, comprehensible to reason."(370) Although there is some doubt about the way and the time that the debt was incurred, very few modern scholars would deny that modern science borrowed from Christian theology the basic belief in an external rational world independent of the observer.

The first book of the Bible, Genesis, opens with an anti-mythological statement. "In the beginning, God created the heavens and the earth."(371) This declaration together with the introductory words of John's Gospel make it perfectly clear that God's creating is second to his begetting.(372) "In the beginning was the Word, and the Word was with God, and the Word was God; all things were made by Him, and without Him was not anything made." (373) It follows, therefore, that the foundations of Christian theology were prepared by God for mankind in his Word before the creation of the world.(374) God made all things by his eternal Word.

God gave substantive existence to the creation. But he did not

expose it to the risk of running its own chaotic course only to drop back out of existence.(375) Creation is made not merely to move, but to move in the right direction.(376) By the ordering action of the Word, the creation is sustained. The uncreated Source of rationality, the Word, enables the world to abide securely as a composite created unity. Obeying the Word, things on earth have life and things in the heavens have their order.(377) Consequently, to speak of God, the Father, the Son and the Holy Spirit, as the Object of Christian theology is to recognize, among other things, that the Creator of the universe gave to the creation a distinctive, ordered and harmonious existence which continues through its unique dependence on the triune God.

If a blind eye is turned on this dependence, the dynamically structured reality of the universe may be seen in the light of the basic belief of modern science. Indeed, Einstein could not conceive of a genuine scientist without that profound faith.(370) For him, scientists remain "genuine" in so far as they are not overpowered by their scientific theories. Many theories have a wide range of achievement and an extensive logical manifold. They require forms of reflection that demand considerable understanding and devotion. Hence, it is all too easy to abandon or to ignore their limitations. The temptation is to lose sight of what Einstein called profound scientific faith. To follow or to apply scientific theories is not necessarily to identify with that faith which is the basis of all genuine scientific endeavours.

Clearly, the hydra of apostasy can rear its heads in science as well as theology. Throughout its history, science has certainly been plagued by the stultifying tendency of current apprehensions of the world to become dominant criteria in the investigation of the natural order. The Plotemaic system, Euclidean geometry, Newtonian mechanics and the indivisibility of the atom are notable examples. Even Einstein had to contend fiercely with such an adulterant. It took the form of an unjustifiable adherence to Hermann Minkowski's formulation of the special theory of relativity.(345) It is small wonder that Einstein often referred in his

discussions to the potency of this particular kind of apostasy. (106)

Scientific faith relates directly to the external world. Of necessity, it remains partially non-formal, although it is neither aformal nor anti-formal. Well-seasoned scientific researchers recognize that it cannot depend exclusively on or be fashioned solely by prevalent scientific theories. For instance, Johannes Kepler held a non-formal faith associated with but not restricted by the Copernican system. His profound faith in the existence of natural law gave him the strength to devote decades of hard and patient attention to the investigation of planetary motion. In particular, he had to believe in closed planetary orbits before he could determine their precise shape. In his work Kepler subordinated aspects of public scientific wisdom to his private undefinable notions in order to obtain his three famous laws.

Other examples are not hard to find. Initially, Einstein exercised a blatantly non-formal faith in an extension of the principle of relativity. On this basis, he searched for many years for a theory more general than the special theory of relativity.(378) By doing so he arrived eventually at the general theory of relativity. Originally unspecifiable, his personal commitment to an extension of this principle only found definite expression through his interpretation of the observed equivalence of inertial and gravitational masses.

At the turn of the century, Max Planck resolved what was later to be called the Ultra-violet Catastrophe. He placed his faith in the eventual apprehension of his mere device for new calculations. This artefact insinuated the idea of discrete energy levels of charged harmonic oscillators. It laid the foundation of modern quantum theory. Yet, Planck referred to his innovation as "an act of desperation, for by nature I am peaceful and against dubious adventures."(323)

Only eleven years later, Ernest Rutherford concluded on the strength of his students' astonishing experimental evidence that

the atom's central tiny heavy nucleus is surrounded by electrons traversing the vast emptiness of atomic space.(243) Non-formal private faith in a vague model, in the relevance of current theories of statistics and in the importance of almost incredible experimental evidence compelled him to master the mathematics necessary to formulate his preliminary notion of the structure of the atom as resembling that of the solar system.

In general terms, every scientific effort is bound up with an act of pre-reflective faith in the rationality of the universe. The private manifestations of scientific faith are partially non-formal precisely because they deal with cosmic processes. They are non-arbitrary, empirically grounded and heuristically virile. They must never be controlled by the ever changing ideas of historical studies, philosophical investigations or current scientific trends. Certainly, they may be beneficially influenced by those factors, but they should not be restricted by them.

Basically, faith motivates scientific research. The subject and its impact are inseparable. How scientific research is accomplished is inextricably bound up with the reason why it is undertaken. A history of science reconstructed apart from scientific faith cannot represent the foundations of that faith. A philosophy of science posited without reference to perficient faith cannot account for its dynamics. A programme of scientific research hidebound by prevalent scientific theories cannot serve the fundamental purpose of scientific faith. Methods, theories and results developed in science are always determined "where the future is being brewed."(293) They are drastically misunderstood if they are prized as entities of historical and philosophical interest instead of as testimonies to scientific faith. Einstein pointed out that the successes of science give considerable encouragement to this faith.(154)

Contrary to popular opinion, private belief can never be entirely eliminated from scientific endeavour. As already indicated, scientific theories are discovered or investigated by

individual scientists who hold strong convictions. In this respect, the scientific enterprise resembles the theological reach for the unsearchable riches of Jesus Christ. In both pursuits private faith is subordinate to the objective content of that faith. Indeed, the fact that scientists believe in the eventual transformation of their non-formal notions into definite scientific theories is largely taken for granted by the scientific community. It concentrates on the theories themselves. Likewise, the Church strives for a contemporary doctrinal exposition of God as the Object of Christian theology. What genuine scientists believe, the actual content of their faith, is vitally important to the wider community. Until private belief becomes public wisdom, it remains ineffectual. Einstein's apposite words have strong theological connections, "only a life lived for others is a life worthwhile,"(171) although he was speaking from scientific experience.

The scientific community receives from individual scientists necessarily incomplete intimations of the rationality of the universe. They are, so to speak, interpretations of certain events or processes within the natural order. Scientific theories disclose increased surveys of objective reality by which personal scientific faith breathes. But those theories remain silent about the workings of private faith. This thought lay behind Einstein's comment that "the true value of a human being is determined by the measure and sense in which he has attained liberation from self."(172) Once more, Einstein's remark is readily applicable to theologians who, for the most part, study the objective riches of Christian living. Dealing with questions regarding what may be believed, they work for their Lord. By doing so they also discover their own personhood and they learn how to serve their fellow men.

Objectively related to the universe, all scientific theories carry scientists out of the confinement of styles of subjectivism and into the richness and freedom of personal scientific enterprise. To stand on the shoulders of Einstein again, "whoever has undergone the intense experience of successful advance in this domain

(science) is moved by profound reverence for the rationality made manifest in existence. By way of the undertaking he achieves a far reaching emancipation from the shackles of (private) hopes and desires and thereby attains the humble attitude of mind toward the grandeur of reason incarnate in existence, and which, in its profoundest depths, is inaccessible to man."(167)

More mundanely expressed, scientific researchers are not primarily interested in themselves or in the mechanisms or origins of their private faith. Planck's innovation is an excellent example (vide supra). The vast majority of scientists are far too busy trying to break new ground to stand back to ponder the intricacies of how they gained novel insights. They are as fully concerned with the rationality of the universe in which they believe as theologians are with the uncreated Source of that rationality who is the Saviour of the world. Invariably, scientists must meet the natural order on its own terms, if they are to attain a greater apprehension of it. The theological correlate is that, in Jesus Christ, God is known as He comes to mankind. Without this Word, theologians are left in the confusion of endless permutations of meaningless words. The proud are scattered in the imagination of their hearts. Similarly, scientists cannot achieve anything by themselves. Without references to experience, they are cut adrift on the high seas of limitless speculation, unable to take bearings. Observation, experimentation and theorizing, all of which thrive on experience, will strengthen, however, their already irrepressible commitment to make a greater contact with reality. As Einstein declared, "all knowledge of reality begins and ends in experience."(244)

The natural order, of which scientists are part, discloses its own givenness. This givenness is apprehensible and apprehended only in so far as it is respected and obeyed. It is reflected effectively, but always incompletely, in the language of scientific concepts and theories. Even as individual scientists, the wider community receives those coherent open statements and theories

as witnesses to the unity of the objective natural order. In other words, they are assimilated as facets of the concrete meaning of what it is for them to believe in the rationality of the universe.

According to Christian teaching, man does not have the capacity to hear for himself the voice of God. Only the givenness of Jesus Christ could unveil the hiddenness of God. Consequently, as God's unowed offering, the Word became flesh and lived among men.(379) The free gift of Jesus Christ to all mankind is solely attested by the sacred and inspired Scriptures, of which the doctrines of the Churches are guides and interpretations.(380) This unique unmerited givenness is only understandable and understood inasmuch as He is loved and followed.(381) He is foreshadowed in the Law(382) and the Prophets.(383) The record of his life and teachings together with the writings of the Apostles complete the instruction and revelation given for all ages.(384)

The mystery of God cannot be explained but, in the Person of Jesus Christ, what is incomprehensible and inaccessible is made available to men.(385) Systematic theology, therefore, attempts to interpret the Scriptures faithfully, but it does so within severe limitations. The language of theological concepts and doctrines is necessarily inadequate. The object signified is of infinitely greater significance than the signs which signify it.(386) Nevertheless, theological activity, like scientific research, continues in the knowledge that it is prone to error by omission and commission. It hopes that succeeding generations may think more faithfully, incisively and expansively. Most theologians find the confidence in the Word to exercise, as best they can, the God-given freedom to hear and to listen to that Word, and to serve the world for which He died. For them, that is the concrete meaning of what it is to believe in Jesus Christ as Saviour and Lord. They are drawn onward in the knowledge, love and grace of Christ, provided they are obedient to the bound freedom they have been given in and through Him.

The givenness of the natural order allows scientists the

personal freedom to explore reality. The availability of this freedom is not a consequence of any scientific effort. Its very possibility exists by virtue of what Einstein called "the pre-established harmony between thought and reality,"(111) that mysterious harmony of nature into which mankind is born.(126) Where scientists strive independently of nature, they speculate to the detriment of science. They run counter to their native disposition towards the universe. When they choose to meet reality, as indeed they often do, the ground rules are laid down for them. As scientists, they may try to follow those rules or, alternatively, they may decide at any stage and as mere speculators to ignore their existence. Only the former procedure will contribute significantly to scientific apprehension.

The fact that reality is so constituted leaves scientists astonished. Obviously, modern science is not deprived of indissoluble mystery. Scientists shall never fathom the depths of the mystery of this pre-established harmony. The incomprehensible thing about the universe is its apprehensibility.(151) As "a small piece of nature",(289) the scientific researcher realizes that he is in the midst of a continuously self-disclosing world. Reminiscent of the miracle of new life in Christ, this world grants to him the freedom to apprehend it and to live more abundantly in it. The universe is understood to the extent that he appreciates its orders. The only authentic course open to him is the one which binds him to its rationality while freeing him to acquire a new confidence in reality and himself.

If scientific faith motivates research, it does so by fostering trust in the reliability of the universe. In many respects, the reliability of the universe is to the scientist what the faithfulness of God is to the theologian. For scientists, this means that they may place a considerable emphasis upon the effective repeatability or reproducibility of observations and experiments. Of course, logically speaking there is no such thing as rigorous repeatability,(85) but scientists are not restricted

to logic. They relate rationally as they theorize and experiment. Rather than trust themselves, they trust the universe. By doing so they closely parallel theologians. Whereas the latter trust in the promise and guidance of the Word of God, the former exercise their freedom to rely heavily on the findings of scientific research, that is, the received intimations of reality. Those findings actually include both empirical and theoretical discoveries.(97)

To return to personal confidence, scientific faith in the natural order delivers scientists from fears, but not the occurrences, of fantasy and delusion.(155) Since their rationality is always insignificant compared to the rationality of the universe, scientists are incapable of strict obedience to the latter rationality. Even scientists cannot keep their promises. In this, they are near neighbours to theologians, who often wander from one distortion to another. Scientists are perpetually open, therefore, to the risk of new fantasies and novel delusions. This is partly why science may be properly referred to as an adventure in faith. Clearly, failure and disillusionment are recurrent hazards on the scientific trail. By trusting reality, however, they can still surmount such obstacles to gain greater vistas of its pervasive harmonious order.

At every new turn, the guidance of reality promises to reveal fresh frontiers. There is one God for theologians, and one world for scientists. The scientists' belief that they are not left stranded by their own devices is handsomely rewarded as they depend on the impact of the unfolding universe. Thus, in spite of countless failures, apparent contradictions and persistent paradoxes, they can continue to believe in an objective, ordered and harmonious world.

In fact, modern science's history attests to the mystery that scientific faith flourishes in adversity. The struggles of Kepler, Rutherford and Einstein are outstanding examples. Scientific researchers pursue their special interests no matter the extent or

severity of private hardship and regardless of the intensity or complexity of public controversies. Coping with errors and disappointments is certainly frustrating, but it is just part of the exciting parcel of modern scientific research.

The immensity, coherence and grandeur of reality are enough to inspire wonder and to keep most scientists wary of the limitations of their theories and experiments. Probably the greatest obstacles to progress are the reluctance to shed outmoded ways of thinking and acting and the tendency to forget the restrictions of topical types of theorizing and experimentation. The former is a product of illegitimate conservatism. The latter is a consequence of immoderate enthusiasm. It is hardly surprising to find that there are equally powerful theological excesses. After all, scientists and theologians are only human beings. Yet, faith is the required antidote because it is prior to all theorizing, experimentation, reflection and systematization.

Like its Christian counterpart, scientific faith is never tentative, although it may fluctuate with the scientific climate. In both cases, the anchor of authentic faith is firmly embedded under the ebb and flow of private manifestations. Apparently resembling more the Noahic Covenant than the New Covenant in Jesus Christ, scientific faith is held fast and exclusively in the rationality of the universe. It is bound firmly to the natural order granting to scientific researchers the freedom to experience their personal bouyancy within secured moorings and giving them the openness to respect that there are theological crafts afloat.

25. SCIENTIFIC KNOWLEDGE

A similarity between modern science and theological activity can also be found in the natures of scientific and theological knowledge. The aim of science is to describe to the greatest extent possible the rational world independent of the observer.(119) Consequently, scientists try to paint a simplified and intelligible picture of that world.(70) Yet, their conceptual systems

are neither arbitrary chaotic sets of abstractions nor absolutely true immutable descriptions. The discoveries of the Copernican system, non-Euclidean geometries, the special theory of relativity and nuclear fission are suitable reminders of the mortality of even the hardiest breed of scientific theory.

Bluntly, "there are no eternal theories in science."(44) Challenging questions, novel concepts and new theories are "born in the painful struggle with old views."(48) That pain is experienced, of course, by scientific researchers who learn that every theory stands and falls as it directs investigation beyond itself toward greater precision and fuller apprehension.(49) In the most significant cases, the new theory shows the merits as well as the limitations of the old theory. It also allows scientists to regain old concepts from a broader but restricted logical basis.(45)

The aim of systematic theology is also necessarily limited for God is beyond comparison.(387) Systematic theology does not try to solve, nor does it ignore, the reality of the mystery of God.(388) Its object is not to encapsulate meanings with formulae or concepts.(389) The purpose of theological activity is not to provide instant doctrinal relief for all the ailments of Christian thinking. Its intention is less ambitious but more courageous. Like that of scientific theories, its validity resides in its capacity to point beyond itself to a fuller apprehension of the inexhaustible reality of God. Yet, God the Creator is invisible and inaccessible to originated things.(390) As Athanasius confessed so long ago, ".. all created beings and especially we who are men, find it impossible to speak adequately concerning the things that are ineffable."(391)

The heart of the matter is the mystery that divine activity cannot be measured by the nature of men.(392) God cannot be known by the unaided powers of human knowledge. He is known by his own decisions and actions. Human interpretations, therefore, always fall short of the biblical notion of God which, by means of things

known to men, allows them to apprehend a little of what they can never comprehend.(393,394) Hence, the humble task of systematic theology is to enable Christian thinking to shed more readily the encumbrances of answers that are too small for Him who is the Truth.(395) Its work is to find where the theological shoe pinches and to make room for the reflective movements of Christian living.

All scientific theories have truth-contents commensurate with their realms of validity. Every scientific concept and theory relates to the rationality of the universe. Indeed, that rationality is the only truth to which it can relate. Whereas for theology the Word is the eternal Truth, for modern science the rationality of the universe is the singular truth. In no sense is it provisional. The laws of nature are already invariant as scientists search for a deeper understanding of them. This truth reveals itself in scientific concepts and theories as meaning, that is, as truth-content to be assimilated. To borrow Einstein's words, "a system has a truth-content according to the certainty and completeness of its co-ordination-possibility to the totality of experience."(168) The concrete meaning or the truth-content of a theory is the way in which that theory succeeds in ordering and correlating definite ranges of sense experiences.(114)

Modern science points to the rationality of the universe with its own restricted theoretical systems. Those systems express themselves most effectively, but always incompletely and openly, in mathematical terms. Scientific theories are not, however, speculative in origin.(236) They are logically free creations of the scientific mind, but they are based on sense experiences. (99) As Einstein pointed out, the grasping of scientific truth is not possible without empirical basis.(117) It is widely recognized that the deeper science penetrates reality and the more extensive and embracing its theories become the less empirical knowledge is needed to determine those theories. Nevertheless, all scientific theories are ultimately empirically grounded.

This grounding endows them with real content. They survey real knowledge but with limited logic and precision.

Perhaps surprising to many scientists, disciplined theologians rarely depart in their theologizing from the data of Christian experience, that is, the reality of God in their lives.(396) To select a well-known example, the doctrine of the Trinity was not officially accepted in the Church until the fourth century. It does not appear in the New Testament. Yet, this doctrine grew out of the early Church's experience of God as the Father, the Son and the Holy Spirit. Its existence is not due to the illicit private allegations of a group of presumptuous theologians. This doctrine resulted from the freedom of objective reflection on the personal Christian experience of the early Church. The trinitarian formulation and its mysterious "three-in-one" language, like all systematic theology, is an attempt to give ordered expression to experience. In this respect, modern quantum theory with its wave-particle descriptions plays a somewhat similar role in science. The main point is that Christian experience always precedes theological activity which surveys real knowledge incompletely but openly. Theology rests securely on empirical knowledge.

The emergence of the doctrine of the Trinity in the fourth century came from neither a need to define God nor a decisive new revelation, but from the experienced reality of God. This doctrine represented the desire to express what had been the Church's worship and experience of God from its beginning. It was built from the mortar and bitumen of the Incarnation and Pentecost. The reality of Jesus' humanity could not be denied in the light of the experience of the first disciples. Justice could not be done to it by simply describing Jesus as man or God or as part man and part God. As surely as non-formal scientific faith required thinking of the electron as a wave and also as a particle, so partially non-formal Christian faith demanded new ways of thinking of God as the Father and the Son. Indeed, the

latter became necessary modes of speaking of God for the first disciples through the compelling reality of Jesus Christ in their lives.

Again, with the experience of Pentecost, the early Church discovered that God was present in their lives in a profoundly powerful and new way. Still, it was not entirely new. It intensified their sense of the presence of the one God whom they had known through Jesus. This discovery of the early Church was more concrete than the scientific revelation that the classical particulate behaviour of the free electron is co-essential with the wave character of the electron. Gifted with this blend of the familiar and the original, the early Church spoke informally of God as the Father, the Son and the Holy Spirit. While it is correct to say, therefore, that the doctrine of the Trinity is not present in the New Testament, the worship and experience of the Trinity is faithfully recorded there. This experience made it both necessary and possible to formulate the doctrine of the Trinity when the Church in mission attempted to communicate to the world what it believed about God.

The doctrine of the Trinity, like any other Christian doctrine, is empirically grounded in historic data that are recorded in the sacred and inspired Scriptures. Those events occurred in space and time, and they tell of what men saw, smelled, heard, tasted and touched. Christian doctrines survey those events with limited logic and precision, but they can only be known to do this in so far as they are anchored in personal Christian experience. Logical investigation cannot reveal the connections between theological concepts and Christian experience. It can only show how concepts relate to one another. Their anchorage in Christian life endows them with real living content.

Precisely because scientific theories rest on empirical knowledge, scientific knowledge is created when those theories are either discovered or assimilated. To use an extended analogy, a scientist responds to the presence of the universal rational

field by reorienting the concepts of one of the established theories. He initiates this response with a heuristic departure from that theory. This reaction is a creative act of faith, probably involving a non-formal, perhaps non-articulate, concept. The first half of a conceptual hysteresis loop is completed when that notion intimates its ability to re-structure and to enlarge an known range of sense experiences. This act of discovery prompts a formalizing return which carries apprehension beyond the old theory to its successor.

What has just been described is, in fact, the husk of Christian living. Its kernel is Jesus Christ who is the Way, the Truth and the Life.(397) If, in the preceding description, the Word is heard from his rightful centrality, He is also recognized as the Truth who irradiates all the creation. Christians respond to this living Truth by realigning themselves to point more nearly along the Way to God. Throughout their lives they offer their diverse personal responses to his presence as ventures in faith that cannot always be fully expressed in words. Nevertheless, when faithfully carried to completion, these reactions culminate in a re-ordering and an expansion of their lives. Thus, they fulfil Jesus' promise that He came that men may have life and have it abundantly.(398) Since the acts of Christian faith bring with them enrichment of life through its reorientation, it is hardly surprising to find that an echo of this rationality is captured by modern scientific research.

During scientific research it is difficult, if not impossible, to isolate the venture in faith from the unfolding of knowledge. In any case, a full conceptual loop has to be traversed, so to speak, before a new scientific theory can emerge as the next point of departure. Since, in this view, scientific theories are evidently testimonies to scientific faith, the latter cannot possibly be irrational or anti-rational. Actually, scientific faith is rational only in so far as it derives from the rationality of the universe. The well-known theological correlate is

that the rationality of Christian faith rests exclusively on the Word of God. Moreover, any established theory, like any Christian doctrine, initially involved an act of faith. This act enabled scientists or theologians to apprehend some process or event. At the same time, the act opened up the possibility for scientists or theologians to make those phenomena apprehensible to others. To put it in a nutshell, scientific faith is like Christian faith in that both breed knowledge, that is, scientific researchers and theologians believe in order to understand.

Both scientific faith and theological faith are concerned, therefore, with the re-orientation of conceptual systems, the expansion of apprehension. The one has to do with the object of faith, the universe of which scientific theories speak, the other with the one God who is the Source of all reality. As already noted, however, it is of the natures of God and of his universe that they are apprehensible and apprehended solely by self-disclosures. Whereas God has made Himself known to man in the Word incarnate, the universe declares itself to scientists in its own distinctive way. Neither scientific researchers nor theologians can think anything out for themselves without external stimulation. There is no logic of scientific or theological discovery. No general scientific or theological procedure can be set down for scientists or theologians to follow. Modern science or theology does not obey a simple law of continuous progress.(399)

A full comparative study of the cited achievements of Kepler, Planck, Rutherford and Einstein will readily support the scientific content of those statements. It will also illustrate how an illogical leap, a chance discovery, an unexpected result or an intuitive hunch can transport a scientist through an existing conceptual barrier. The effectiveness of such diverse breakthroughs in scientific research indicates that knowledge of reality, like knowledge of God, is not merely an option to be taken up as it suits the individual. Scientific knowledge occurs where there is actual experience that reality discloses its undiscovered order.

Reminiscent of Christian teaching, scientific knowledge presents itself to the receptive hidden qualities of the open mind in such a manner that the scientist cannot fail to grasp its significance, but personal freedom is never abused.

While it is certainly true that nature favours the prepared mind, knowledge does not take place under conditions that are completely controlled by the scientist. There are always unknown factors operative during any scientific investigation. Knowledge occurs under those circumstances where the scientist is confronted by reality. In other words, science chooses the scientist, that is, destiny places the scientist at a turning point in the development of the human intellect.(251) The close parallel to Christian living can hardly be missed. Experience that God speaks is the locus of knowledge of God. It takes place only when and where divine revelation occurs. God calls the person to serve as He wills, and the Word of God, the uncreated Source of rationality, teaches the person how to live at the melting point in the salvation of mankind.

Einstein expressed his unshakable belief in the knowability of the universe in terms of the intuitive relation. "The relational structure of an independent reality can be cognized by virtue of the pre-established harmony between thought and reality."(130) This pervasive harmony imposes the important restriction that, for a scientific theory to be complete, every element of the correlated realm of reality must have a counterpart in that theory. The attainment of scientific truth, therefore, would require the comprehension of all reality whose processes and events are so enmeshed in the universal manifold as to provide a dynamically ordered and harmonious unity. But scientists are always immersed in more sense experiences than they can cope with at any given moment. Hence, they must repeatedly decide to disregard some of them and to attend exclusively to others. In this view, modern science is only capable of following in the footsteps of the truth.

For theologians the Truth is inseparable from his Incarnation.

The Word became flesh.(379) His task is to bear witness to the truth. For this was He born; for this He came into the world.(400) Christianity is, therefore, a revealed religion, not a human invention. Convictions respecting it are inscrutably based on partially non-formal faith, for the Word has no parallel with others.(401) Those convictions, however, become more and more articulate as they are practised and learned in the laboratory of daily life and work. The Word became incarnate as the Truth to be learned and lived.

This requires reflection. To borrow Einstein's description of scientific theories, theology "is the attempt at the posterior reconstruction of existence by the process of conceptualization."(103) It cannot be otherwise since, in their apprehensions of the life of, in and through the Son of God, theologians must follow the Word incarnate. While the acreage of systematic theology is as large as Christian experience itself, it can only aspire to co-extension with the Truth. Jesus Christ declares in his Person that God's truth is of universal scope and objectivity.(402) Whether or not Jesus is personally known, understood or believed, He remains the Truth.(403) Consequently, his rationality subordinates all ventures in faith and reason(404) and all theological activity humbly glimpses the Truth in a poorly prepared mirror.

The pervasive structure of the universe is infinitely greater than what scientists can define or quantify. Indeed, it presents through the intuitive relation all that scientists seek to apprehend. When they investigate the unknown or encounter the unexpected, they are confronted and guided by its comprehensive reality. The pre-established harmony between thought and reality is effectual through personal intuition. Intuition allows the practising scientist "to differentiate clearly the fundamentally important, that which is really basic,"(405) from the plethora of concepts and experiences that tend to congest the mind and divert it from the essential. It enables the scientist to frame proper

questions, to make legitimate associations and to construct forms independently before they can find them in things. Intuition cannot be defined. It involves a mediated type of knowledge which informs an appetitive sensibility to non-quantitative tokens of reality.

Clearly, the intuitive relation implies that scientific knowledge is not wholly explicit. Such knowledge is never "objective" in the sense that its content is entirely determined by observation and experiment. Scientific theories refer to the limitless universal implications of their subject. The relation of the intuitive and explicit components of knowledge caters for the existence of those non-formal unspecifiable notions that are so important in scientific research. Theoretical statements and their vague but authentic forerunners relate to reality in an indefinite variety of ways. Their heuristic connectivities preclude pre-established rules to determine the fate of a theory or hypothesis in the event of experimental failure. In any case, scientific wisdom generally supervenes. For example, throughout his scientific life, Einstein held firmly to the conviction that "a scientific theory is more impressive the greater the simplicity of its premisses, the more different kinds of things it relates, and the more extended is its area of applicability."(143)

Scientists often judge a concept or a theory on the basis of non-formal tokens of reality, including simplicity, correlativity and applicability. As far as they are concerned, the validity of a theory depends on more than its local legitimation. It relies also on its broader capacity to reveal reality or to guide an intuited sense of hidden implications. Many theologians depend on very similar characteristics in their investigations and expositions of the doctrines of the Churches. Basically, the mysterious harmony into which the scientist is born enables him through intuition to feed a growing apprehension of the natural order and to make even greater contact with independent reality.(126)

As discussed earlier, God and the universe are knowable through themselves. When the theologian or scientist experiences this, he is emancipated, liberated to apprehend God or the universe, respectively. Knowledge of reality has truth-content precisely because it is determined in theology by God and in science by the universe. It cannot be the truth since it is knowledge confined by the frailties of scientific or theological reasoning. In science, awesome universal references are always carried in awkward human relevancies, while theology refers to the uncreated Creator using the creations of creatures.

Scientific concepts and theories are not even adequate to grasp the knowability of this comprehensive rationality. Much the same can be said of Christian doctrines. Yet, wider cognitive powers than traditional conceptions of knowledge seem to be at work in both scientific research and theological activity. Consequently, where knowledge breaks through into science or theology, there is no cause for an immoderate sense of personal achievement. As Einstein modestly echoed the fellowship of the universal Church, "the work of the individual scientist is so bound up with that of his scientific predecessors and contemporaries that it appears almost as an impersonal product of his generation."(235) In addition to this corporate dimension, there is also, of course, the commitment of the scientist or theologian to the rationality of the universe or its Source, respectively. This commitment carries the person, no matter the immensity of his own achievement, to the limitations of his scientific theories or theological contributions, as the case may be. Such an experience is at once humbling and challenging.

To repeat, scientific faith and Christian faith have to do with the reorientation of rationality, the expansion of apprehension. Whereas Christians are free to enjoy the abundance of life, scientists are able to explore without compromise the truth of the universe. This truth is a creative truth, and knowledge of it is creative. Scientific faith breeds scientific knowledge. It is,

therefore, a completely rational activity. But the truth of the universe is also an empirical truth, and knowledge of it is factual. Scientific faith is co-essentially empirical. It follows that this kind of faith has both an empirical and a rational truth-content. In fact, the two must not be separated. (97) What is actually involved is a creative truth-content. The empirical and rational constituents of scientific knowledge are, as it were, two sides of the same coin. And once again, by making the appropriate changes, the theologian can provide a rather detailed parallel description of Christian theology as living knowledge through its empirical grounding and rational basis in Jesus Christ, the Word incarnate.

It is probably more instructive to speak of scientific wisdom rather than of scientific knowledge, although scientists tend to object to such terminology because of its religious associations. With decades of "anxious searching in the dark"(346) behind him, Einstein was persuaded that "knowledge exists in two forms — lifeless, stored in books, and alive in the consciousness of men. The second form of existence is after all the essential one; the first, indispensable as it may be, occupies only an inferior position."(349) Most scientists are suitably sensitized to the fact that modern science depends on working knowledge. Experimental and observational researches are obviously practical pursuits, but so is theoretical science. Einstein's general theory of relativity is a superb example. Scientific wisdom not only conveys knowledge, but it also possesses potentialities for action, like the detection of the bending of starlight or radio waves by the sun. The composite of the empirical and rational elements of knowledge, known as scientific wisdom, is alive within the consciousness of the scientist equipping him for his scientific expeditions. It is the craft by which he travels across both the rich pastures and the arid deserts of scientific exploration. To journey in this way is the very meaning of scientific knowledge with its accent clearly on action.

Christian knowledge means following in the truth of Jesus Christ, and scientific knowledge involves pursuing the truth of the rationality of the universe. The former represents the theologian's living trust in the uncreated Source of all rationality while the latter is the scientist's concrete trust in the natural order. Authentic tenable trust is necessarily founded on the respective truth. As science's history shows, there is no concept, theory or datum, no genuinely scientific knowledge which does not have the sign of this truth, that is, some indication of the order and harmony of nature. Because scientists follow this truth, search in the light of a knowledge of reality, and therefore expand their rationalities, they enlarge their confidence in the meaning of the order and harmony of all natural events and processes. Like theologians, they become surer of the meaning of the ground of all existence as they live in the midst of their surveys and co-ordinations. As new uncharted continents appear before them, scientists sense that wonder which comes from experiencing what it is to know even in part the truth of the universe. It is, as already noted, a liberation from self. Through intuition the scientist is led into truth, freed "to find a peace and security which he cannot find in the narrow whirlpool of (merely) personal experience."(70)

By trusting and knowing something of the rationality of the universe the scientist enacts the meaning of scientific research. He is too busy to ask what that meaning is. The believing scientist resembles the theologian in that both act out the meaning of their lives. The scientist knows that the work he does gives him a legitimate place and activity within the natural order of which he is a little part. Where scientific faith reigns, there is also instated through trust in the universe a peace and a security that come before apprehension, and that, for this reason, make the scientific enterprise possible. With this peace and security, scientific researchers are well equipped to pursue the scientific way, truth and life. They can also begin

to appreciate that by doing so their activities remarkably resemble those of theologians who follow Jesus Christ.

26. SCIENTIFIC COMMUNICATION

The similarity between science and theology is reflected in their modes of communication. Both Christian theology and scientific research begin and end with a desire to apprehend,(406) a need to believe(407) and a will to search.(408) "Throughout all our efforts," wrote Einstein and Infeld, "in every dramatic struggle between old and new views, we recognise the eternal longing for understanding, the ever firm belief in the harmony of our world, continually strengthened by the increasing obstacles to comprehension."(46) These remarks refer to the personal activities of scientists, but theologians are also engaged in an essentially personal process. Whereas scientists are part of the eternal mystery between reality and thought, theologians are immersed in the ineffable mystery between God and man. Each process or "delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wreck and ruin without fail. It is a very grave mistake to think that the enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty."(92) To breathe, Christian theology and scientific research must have the invigorating atmosphere of freedom.

Athanasius provided an excellent image of Christian freedom which, with few changes, captures the essence of scientific freedom.(409) The world is like the sea to Christians (or scientists). Persons float on this sea, as with the wind, through their own free-will, for everyone directs his course according to his will. Either under the pilotage of the Word (or the universe), he enters into peace, or, laid hold on by subjective currents he suffers shipwreck, and is in peril by storm. For as in the ocean there are currents and storms, so in the world there are speculations and conflicts. But having their senses exercised in self-control and being strong in Christian (or scientific) faith, the committed continue and are delivered by awakening the Lord (or

the rationality of the universe).

To elaborate on Einstein's thoughts, scientific research is based on the freedom of the universe to disclose itself to the scientist and on the "inner freedom" of the scientist to respond to these disclosures. The latter freedom is a gift. It is not earned but it is part of the givenness of the universe. The theologian claims that this freedom is an aspect of the creation which God in his freedom wills for man. Above all, this means that, where scientific faith or Christian faith is operative, concrete events are taking place, history is being made. Substantive reactions occur where the freedom of the universe and the personal freedom of the scientist intersect, and when the freedom of God and the personal freedom of the Christian meet.

Scientific faith is, as it were, the universe's mystery breaking through at those intersections, while Christian faith is the experience of God's mystery revealing itself in the work and Person of Jesus Christ. Without those breakthroughs the inexhaustible mysteries of the universe would remain forever inaccessible and invisible, and modern science could never have arisen. For scientific research rests on faith in the rationality of the universe. When scientists speak of the harmony and order of the natural world, they are pointing to the wonder that the world is not a static formless chaos, but that it exists as a dynamically ordered harmonious universe.

Theological thought acknowledges that the ways and thoughts of God are not those of man.(410) But in the birth, death, resurrection and ascension of Jesus Christ, God revealed himself once for all. Theological activity is centred on the Word incarnate from whom rationality radiates to order and to harmonize the whole of the creation. Christian faith is man's privileged reply to the historical existence of the Word of God. As the only acceptable answer from the human side to the New Covenant in Jesus Christ, it is invariably associated with the formation of a fellowship of believers. It is a community of the faithful, a

group who do not exist for themselves, but who have a message to proclaim to the world outside of this communion. This fellowship is the Church, the Body of Christ, which has a historical form and content dependent upon its concrete obedience to God's historical work and word in the Person of Jesus Christ.

Scientific research has always a historical dimension in the cosmological sense that the invariant determinate laws of nature structure space-time and govern the scientific enterprise. Everything to which science witnesses depends on those laws. In this view, therefore, scientific research represents the scientist's response within and to the historic continuous processes and events of the universe. Thus, the historical character of modern science makes its presence felt in the investigations and communications of the scientific community. This fraternity reaches across the divides of culture, nation and generation. Indeed, by means of this global brotherhood, modern science serves not its own purposes but the non-scientific world in so far as that community reacts obediently through its researches and publications to the rationality of the universe.

Obedience to the objectivity of the universe is the scientist's reply to the questions that are put to him by nature. For scientific research to be a breed of obedience, the universe must present scientists with a choice, just as the Gospel of Jesus Christ confronts persons with a decision. In both cases, the choice is between trust and unbelief, knowledge and ignorance, wisdom and superstition, peace and fear. Einstein, for example, was convinced that "scientific research can reduce superstition by encouraging people to think in terms of cause and effect."(169) In other words, scientific endeavour relates the scientist to the universe as an integral part of the natural order, that is, in accordance with the invariant determinate laws of nature. Athanasius said as much centuries ago while discussing how man must respond to God in ways appropriate to God.(411)

In scientific research there can be no neutrality beyond the

rationality of the universe. Consequently, as the scientist searches and reports, he acknowledges his obligation towards independent reality. In this way he escapes from private life into the public world of responsible objective thought and action. The theologian must also rise above private senses and interpretations through the objective Word of God,(412) who nourishes the sense of Christian fellowship. Without this affinity for corporate identity, scientific research and faith revert, slowly but surely, to mere superstition and contrivance. In contradistinction, those scientific researchers, who believe in the intelligible universe, follow its rationality, are guided by intuition, contribute to and are enlightened by the public corpus of scientific knowledge.

All scientists are free to trust the rationality of the universe and to apprehend that rationality, as all Christians are at liberty to believe in and to understand the Word of God. Those two freedoms, however, are neither sufficient for the scientific research nor Christian living. By using some or all of the five senses, everyone trusts implicitly the rationality of the universe or its Creator. Moreover, the freedom to believe in God or the intelligible universe is necessarily accompanied by the identification of definite historical events or recurrent manifestations of universal order, that is, by a recognition of empirical knowledge. Obviously, trust without empirical knowledge would be groundless and, therefore, null and void. Yet, much speculation throughout the history of civilization has rested on both an empirical knowledge and a trust of nature. Clearly, other factors were required in order to induce the birth of modern science.

One of those factors is the freedom of public accountability. This freedom is as important to science as the additional freedom to proclaim the Gospel is to theology. By their self-disclosures the universe and God declare themselves to sentient creatures. However, to remain faithful to the universe or its Creator, as the case may be, scientists or Christians must also announce publicly

their new discoveries of universal order. They are committed by action and thought either to the elucidation of the rationality of the universe or to the proclamation of the revelation of God in Jesus Christ. Scientific researchers, therefore, are rarely indifferent to the modes of communication of scientific results.

Where there is scientific faith, the scientific wonders of the world are published for all to ponder and to appreciate. When there is Christian faith, the miracle of Jesus Christ is proclaimed for everyone to know and to share. In spite of the Horation deficiency, the inability to account for many important things in heaven and earth, theologians have the inalienable liberty to express their knowledge and trust in the Word of God, and scientists are irrepressibly free to report the details and results of their researches. This public accountability of trust in the rationality of the universe and of apprehension of that rationality is the compelling reason for the whole of the academic scientific literature.

Equivalently, the theological literature represents the Church's most precise form of proclamation. It has developed technical language with its own special history in anticipation of those circumstances that require the rigorous exposition of the deep things of Christian faith. Above all, it is a language of the Bible and of Christian tradition involving concepts by which the Church has received, defended and proclaimed through the ages its apprehension of God and his creation.

Ineluctably, scientific public accountability within the scientific community also needs technical language. All scientific disciplines have their own unique histories to which they bear witness with the continuities of their concepts and theories. This means that the modes of communication are progressively specialized. According to Einstein, "the whole of science is nothing more than a refinement of everyday thinking."(98) As far as Einstein was concerned, "Scientific concepts begin with those used in ordinary language for the affairs of everyday life, but

they develop quite differently. They are transformed and lose the ambiguity associated with them in ordinary language, gaining in rigor so that they may be applied to scientific thought."(280) The length, vector and tensor illustrate Einstein's remarks.

Basically, scientific concepts and theories are founded on measurements and observations that lend themselves to mathematical formulation.(282) In general, the history of science may be described as the expanding expression of the sum total of its knowledge. Somewhat like the terms of a geometric series, science spans sequentially greater domains within the natural order. In the historical process, it is transformed by the inclusion of higher terms, so to speak. The resulting unifications of scientific theories are responses to the unity of the universe. Science expresses itself most effectually, but always incompletely, in mathematical terms. By doing so it depends, as Einstein implied, on the conceptual continuity of scientific knowledge, that is, on a continuing refinement of the ancient inventions of language, writing and counting.

It is evident, then, that scientists find in the language of their discipline the freedom to be publicly accountable for their scientific faith and wisdom. When they communicate through lectures, text-books or scientific papers, they relate invariably to the unique history of their subjects. Every concept and theory to which they refer has a concrete but complex case history. This complexity arises primarily because scientists organize their conceptual reactions to the natural order in ways similar to the co-ordination of muscular and visual responses during skilful activities.(108) The important point is that non-articulate conceptual elements are responsible for the fluidity of concepts and theories. This comes as no great surprise to theologians. Athanasius, for example, wrote of the non-articulate nature of conceptualization in the fourth century.(413)

Just as the description of a person cannot acquaint one with him, so a definition of a scientific concept cannot provide an exhaustive understanding of it. Scientific researchers must

live alongside it to learn how it behaves in a variety of contexts. The nature of the chemical bond is an excellent example. This means that scientific theories and concepts, like their theological correlates, are never comprehensively exposable to lucid critical inspection. The elusive empirical connectivity of a concept or theory is the heuristic factor in its development. An authentic study of its case history must, therefore, take this factor into account.

The heuristic coefficient of scientific knowledge nourishes the language of a scientific discipline as a living language, a language of public accountability in which scientists are obliged to report. In those languages, modern science has discovered, assimilated and published its knowledge across the centuries and the continents of the world. And, if the discoveries of science and its commitment to objective reality are to continue to be expressed as effectively as possible, then mathematics vitalized by conceptual continuities and empirical connectivities must inevitably and continuously form the bases of scientific languages.

To repeat the obvious, when scientists present their theories as they communicate their faith in the intelligible universe, they speak or write in the special languages of their disciplines. To report otherwise would necessarily be at the expense of clarity and precision. Indeed, the very existence of scientific languages testified that there are certain concepts and theories that can be best expressed directly in those languages. It is imperative, therefore, that this be done in the academic scientific journals, the learned presence of august societies and the text-books of science. But there is also another side to scientific publication.

Einstein, like many scientists, was convinced that "it is of great importance that the general public be given an opportunity to experience — consciously and intelligently — the efforts and results of scientific research. It is not sufficient that each result be taken up, elaborated and applied by a few specialists in the field. Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual

poverty."(69) Clearly, Einstein was opposed to the idea that scientific faith and wisdom should be restricted to scientific institutions and academic literature. Modern science is uniquely part of the more general pattern of cultural advancement. Scientists are creative persons who think and judge independently. They are wholly committed to increasing mankind's apprehension of the natural order. Without them and their artistic, philosophical and theological cousins, "the upward development of society is as unthinkable as the development of the individual personality without the nourishing soil of the community."(277)

Modern science is meaningless unless it exists for the sake of mankind. Science must address itself, therefore, to the world in which it lives. It does so by presenting scientific wisdom in an authentic but acceptable popular manner. Yet, comparatively few scientists have both the gifts and the opportunities to communicate their awareness of the joys, excitements, anticipations and achievements of modern science. Nevertheless, through the industry and dedication of a small competent minority, popular accounts of the progress of science are made available. Those sources serve several purposes. Primarily, they demonstrate that scientists do not exist for themselves alone. At the same time, those accounts kindle enthusiasm in young minds, enrich those with an educated concern and entertain others with only a passing interest.

It is important to note, however, that recruitment, education and entertainment must be legitimately promoted by scientists. The enjoyment of apprehending and searching cannot be instilled by means of coercion and a sense of duty,(92) not even in the uninitiated. Authentic popular accounts of science are acceptable in so far as they limit themselves to a presentation of the subject avoiding wherever possible ulterior motives. As Einstein wrote many years ago, "science cannot create ends and, even less, instill them in human beings; science, at most, can supply the means by which to attain certain ends."(288)

Indeed, modern science would not have been born without a pre-reflective passionate striving for clear understanding. The personal commitment of the scientist teaches him that what his popular accounts of science do in the hands of the common man depends entirely on the nature of the goals alive in him.(414) He is content, therefore, to present his expositions in the language of the world and to let nature argue her own case, as it were. After all, if the scientist believes in such things as the rationality of the universe and the intuitive relation, surely he can be expected to try to live up to the promises of his scientific faith for the sake of mankind. Most of that small competent minority do. Einstein, for example, was firmly of the opinion that "the creations of our mind shall be a blessing and not a curse to mankind."(171) Einstein believed, of course, that the freedom of science meets the freedom of the person in the absence of all forms of coercion. Under those circumstances, science is free to choose the scientist, and vice versa.

Similarly, Christian faith is authentically proclaimed only if the word and work of the Person of Jesus Christ is allowed to declare itself through the ministry of the Holy Spirit. Proclamation in eloquent language, however, is not enough. It must be backed by the manner of living which prepares the theologian to apprehend God's love and concern for all mankind.(415) Such a way of life convinces him readily that men are able to learn more directly about the things of Christian living using the language of the world.(416) Christian thinking is not just to be learned within the confines of theological language or the Church. The Church exists for the world. It is the embodiment of the claim that Christian theology addresses effectually the problems and adversities of everyday life. That is why Jesus sent his disciples into the world with its everyday language. But coercion is anathema to the Gospel of Jesus Christ. "It is not the mode of speaking, but the intentions of the heart and a godly conversation that recommend the faithful Christian."(417) The freedom of the

Gospel must meet the freedom of the person if he is to choose God who has already chosen him.

It is obvious that the personal decisions of scientists and theologians have much common ground. The modes of communication in science and in theology are sufficiently similar to encourage the hope that their interface could be enlarged considerably. Certainly, they provide ample scope for an enriching empathy between the scientist and the theologian. Both are fully committed to service which demands the synergy of thought and action using technical language that must be translated to the benefit of all mankind.

27. THE UNIVERSE

Often scientists speak of the universe and theologians refer to God in some remarkably similar ways. By faith, Christians apprehend that the world was made by the Word of God,(418) but that the bare notion of God transcends human thoughts.(419) The word God signifies the One who is different from things that are made and from all the creation. God illumines the world.(420) He is the almighty Deliverer from the shackles of man's illusions and imaginings.(421) This means that the Christian exodus cannot rest in anything or anyone other than Him who is the Saviour. The Christian life involves seeking and searching along the way of and to God who is neither detected nor invented by men. Indeed, according to Christian teaching, the universe subsists in reason, wisdom and skill and is perfectly ordered throughout because God is over it and has ordered it as the Reason or Word of God.(422) Falsifying all alternative claims, God alone is the Truth. Yet, beyond all possible expectation, man meets the Reality whom he never found for himself or discovered by himself, the Reason who miraculously gifts him the abundant life.

By faith in an external world independent of the perceiving subject(128) and in the possibility that the regulations valid for the world of existence are rational,(352) modern science apprehends the world. But the object of scientific faith, the

universe, transcends scientific theory. It cannot be comprehensively described or fully understood. As a complete entity, it can only be regarded qualitatively. Scientific research is always subordinate to the given natural order of which current scientific apprehension is like a drop in the ocean. Moreover, many of its familiar quantitatively expressed details are actually reminders of the existence of the vast unexplored and unknown stretches of universal structure. They are intimations of "the eternally unattainable in the field of scientific endeavours." (109) Still, the reality of the universe provides the foundation for scientific activity, meaning and hope. The invariance of its pervasive rationality represents the matrix necessary for scientific experience, research and growth.

Like God, the universe is not a product of the scientific imagination. It cannot be lightly dismissed as an arbitrary invention of the human intellect. On the contrary, it is, so to speak, the great liberator which frees scientists from the fears of delusion and fantasy, and which guides them across the wastelands of manipulation. Just as God has called Christians not to the spirit of bondage to fear but to liberty,(423) so the practical pursuit of objective knowledge of the universe detaches scientists from self-centred passions and illusions. In fact, such a claim is not anathema to Christian faith. It is virtually embraced, for example, by the Athanasian declaration that "the Lord touched all parts of creation and freed and undeceived all of them from every illusion."(424)

Although modern science is characterised by seeking and searching, there is peace and security in the reality that the universe itself is neither invented nor discovered by scientists. By relying on the co-ordinative role of scientific concepts, scientists can submit to an independent reality in order to raise their thinking and doing above the "merely personal"(112) to the rational. Somewhat like its Creator, the universe excludes all other claims to authority and meaning as it directs scientists

along its distinctive way.

God is by nature invisible and incomprehensible, having his Being beyond all created existence.(425) God is above the feelings, strivings, derivations and motivations of the human being. His power far outreaches the littleness of images.(426) God is real in the sense that God is unoriginate. Like the universe, God is a whole, but unlike the universe He is not a number of parts. He does not consist of diverse elements, but is himself the Maker of the system of the universe.(427) Consequently, God is manifest and made manifest to human persons only through himself. For man to feel, to think, to search and to find to the utmost of his abilities are not enough to disclose or to discover God. Man has fallen far short of being able to comprehend and know his Maker.(428) Nevertheless, God has chosen to make himself knowable to man. He has united himself to man in the Word incarnate who in his divine-human freedom is beyond the control or manipulation of man.

Likewise, the basic principles of modern science cannot be understood properly without the knowledge that the universe is the source of scientific freedom and wisdom. It is ultimately beyond the control and manipulation of man. As Einstein explained, "the contemplation of this world beckoned like a liberation, and I soon noticed that many a person whom I had learned to esteem and to admire had found inner freedom and security in devoted occupation with it."(112) Clearly, for Einstein, and indeed for the vast majority of scientists, scientific research involves confrontations with reality. Scientists are struck by thoughts as well as observations. Those encounters are primarily invitations extended by the universe which stands like a great eternal riddle only partially open to scientific thinking and current investigation.(112)

Scientists can respond freely, although the universe stretches out beyond their deepest intuitions and keenest strivings. Similarly, theologians discourse with freedom of religious faith even

as the good news of the Word incarnate surpasses the power of human telling.(429) Fundamentally, the universe is accessible and made accessible to scientists only by its own actions. It is beyond the realms of validity of the most general scientific theories. Host to the scientific enterprise which is only a little part of nature, the universe remains the undisputed master in its own house. It tolerates no rivals. As far as science is concerned, there is one universe which declares itself to be real and knowable and before which there can be no others.

Scientists are not at work to prove the existence of the world. This requires no proof for it is both active and determinate. The universe is apprehended in the natural order which intimates its existence. In Einstein's words, "the rational structure of an independent reality can be cognised by virtue of a pre-established harmony between thought and reality."(111) But the comprehensibility of the universe is inaccessible and its existence cannot be discovered by scientists. In its profoundest depths, the rationality of the universe is unsearchable.(167) Consequently, scientists speak of the world knowing that it cannot be successfully defined or adequately described. Rarely do scientists forget that they are looking into the kaleidoscope of sense experiences at a particular time and location on the boundary of the infinitely unknown.

"It is a fact that the totality of sense experiences is so constituted as to permit putting them in order by means of thinking — a fact which can only leave us astonished, but which we shall never comprehend. One can say: the eternally incomprehensible thing about the world is its apprehensibility."(151) Thus, scientists refer to the universe as the reality of a partially disclosed givenness which is inconceivable. In any case, if scientists cannot explain its knowability, how can they hope to define the universe? To grasp in scientific concepts the universe in its entirety is obviously impossible. This non-formal notion — excepting cosmology — is used, therefore, when

scientists speak of a dynamically ordered, harmonious, creative entity which discloses itself to mankind. Yet, even limited knowledge of it is still knowledge of its existence, activity and order. In fact, modern science is the story of man's heuristic and reflective responses to the unfolding universe.

Christian theology starts from the teaching of both the Old and New Testaments.(430) The Bible speaks of the One of whom human nature cannot get any idea at all.(428) God, like the universe, cannot be grasped in human concepts. God is inconceivable. In the words of Athanasius, "God is invisible and inaccessible to originated things, and especially to men on earth."(431) Consequently, the God who is to be seen and heard in the Bible cannot be proved to exist. Like his world, God acts and in the work and word of the Person of Jesus Christ He proves that He is a living God who is unsearchable and undiscovered in his profoundest depths. God's deeds correspond to his nature, so that the actor is made known by his act, and the action is ascertainable from his nature.(432) Who can declare the Father by number, so as to discover the powers of his Word? Only He who is the Word. His deeds in history prove the existence of God. They describe his nature and being. The God who was hidden from mankind has revealed himself in Jesus Christ, and what was thought impossible by men, Jesus demonstrates as possible.(385)

But Athanasius wisely cautioned that the achievements of the Word incarnate "are of such a kind and number, that if one should wish to enumerate them, he may be compared to men who gaze at the expanse of the sea and wish to count its waves. For as one cannot take in the whole of the waves with his eyes, for those which are coming on baffle the sense of him that attempts it; so for him that would take in all the achievements of Christ in the body, it is impossible to take in the whole, even by reckoning them up, as those which go beyond his thought are more than those he thinks he has taken in. Better is it, then, not to aim at speaking of the whole, where one cannot do justice even to a part ...."(433)

Evidently, Athanasius and Einstein shared a common concern for humility in the pursuit of truth and wisdom.

Nevertheless, by the Word revealing himself in the whole of the creation, all things have been filled with the knowledge of God.(434) And knowledge of God is knowledge of his existence, life and revelation. A covenant was set up between God and man. God came as a little child, died on the Cross and redeemed man. God became visible in Jesus who is the only image of the Father and the unique way of reaching the concept of the Father.(435) There are no other gods. Jesus Christ is the image of the invisible God, the first-born of all creation; for in, through and for Him all things were created, things visible and things invisible, and He is the Head of the Body, the Church.(436) Perceiving the Word of the Father, men are able through Him to gain some conception of the Father, and knowing their Creator, to avoid fashioning for themselves one invention after another.(437) This covenant in Jesus Christ is the Reality in whom God lives, acts and makes himself known.

The Word incarnate corrected man's neglect by his own teaching, restoring all that was man's by his own power.(438) Consequently, no novelties and no abstractions must be made if the nature and existence of God are to be known.(439) Only God's work of grace and mercy opens up the reality that, in his covenant in Jesus Christ, men experience love and freedom. Without God, men fall from love and freedom into bondage and tyranny, into arbitrary inventions and chaotic illusions. But, if they are rooted and grounded in love, they may have power to apprehend what is the breadth and length and height and depth, and to know the love of Christ which surpasses knowledge. They may be filled with all the fulness of God.(440) However, in their thinking, theologians must be like Athanasius who was ever conscious of the vast ocean of God's love.

The rationality of the universe is, so to speak, the covenant between man and the world. For scientists, reality is invariant.

A real world exists to be appreciated by scientific research. Inconceivably, the universe behaves as the world of man. It has established this covenant with man as the guarantee of the enrichment of his life in return for his commitment and obedience to the natural order. Scientific thinking is, therefore, thinking of, and on the basis of, the given reality of the rational universe. Reflecting its Creator, the universe exists, acts, makes itself known as the reality which is this covenant. The objective laws of nature are determinate. Scientists exercise scientific freedom by humble dependence on the natural order. Amidst a variety of scientific theories, the unity of the natural order constrains scientists by its greater unobservable rationality as it intimates itself in the lesser observable phenomena.

No disembodied arbitrary abstractions must be made if the nature and existence of the universe are to be properly investigated. Scientific wisdom can only spring from the soil of experimental science,(340) from the comparisons of the inventions of the intellect with observed facts.(128) Scientific thinking is not impersonal or abstract but depends on the correlation of mind and matter. Ultimately, of course, abstraction is rejected by scientists on the basis of the conviction that the universe expounds itself. Scientific researchers, therefore, learn exclusively from it of the riches of scientific freedom and wisdom. This instruction is only gained on encountering and obeying the self-disclosing universe.

Obviously, scientific freedom must be structured in some way if it is to be meaningful. The ordering of its structure originates beyond the scientist in the universe itself. Without this freedom, scientific wisdom cannot be assimilated. Apart from this wisdom, scientific freedom is little different from all the other forms of intellectual slavery that have their bases in superstition. But, if scientists are firmly anchored and securely bound to the rationality of the universe, they may have power to understand the world and to know its rationality which outreaches all scientific

theory. They may experience "a rapturous amazement at the harmony of natural law."(174)

In brief, the bare notions of the universe and God transcend human thought. The scientific enterprise and the Christian life involve seeking and searching along the unique ways of the universe and the Word incarnate, respectively. Neither God nor the universe are invented or discovered by unaided human reason. God and the universe are real and make themselves knowable. In their distinctive ways, they can liberate the person from fear, illusion and manipulation while excluding all other claims to authority and meaning. There are no other gods or universes. Both God and the universe are unprovable, inconceivable and unsearchable in their profoundest depths. Nevertheless, even limited knowledge of God or of the universe is still knowledge of their existence, activity and self-disclosure. Whereas Christians experience love and freedom in God's covenant in Jesus Christ, scientists exercise wisdom and freedom by humble dependence on the rationality of the universe.

It would appear that there are sufficient common conceptual grounds to encourage the hope that those scientists who are anchored and bound to the rationality of the universe and those theologians who are grounded in the love of God will be capable of and inclined to a mutual understanding of the special powers that they have been freely given.

28. UNIVERSAL UNITY

Another parallelism of the ways that the natures of God and of the universe can be apprehended is now outlined. All scientific endeavour is pointless if the universe is not a unified whole, a unity. From an Einsteinian perspective, however, universal unity is not the same as arithmetical unity. In attempting to understand experience, scientists arrive at the assumption of the universe as a unified whole. But they claim no more than a non-formal notion of universal unity. This notion amounts to an object of faith which accounts for the observed regularities of nature.

Certainly, they acknowledge its arithmetical unity. Nevertheless, this does not exhaust the concept of the unity of the universe to which all arithmetical unities point through the multiplicity of its events and processes. Moreover, familiarity with things like the periodic table of chemical elements is sufficient to convince most practising scientists that science rejects the uncritical presupposition that an entity which exhibits arithmetical unity is thereby more intelligible than an object which exists as a complex of members or operations. The atom, the nucleus, the stars and space-time are only a few of the many equally poignant reminders of the limitations of arithmetical unity, concepts that, in fact, serve as indices or echoes of universal unity.

Similarly, Christian theological activity is groundless if God is not a unity. But from the biblical record of divine acts, it is clear that the unity of God is not a simple arithmetical unity.(441) As the theological mind seeks to apprehend the significance of these acts, a non-formal notion of divine unity assumes a more definite content whose validity depends on the fidelity with which the relations within the biblical record are ordered. In other words, theological reflection surveys the empirical evidence of the early Church and attempts to formulate who God is. Theological thought always centres in the birth, death, resurrection and ascension of Jesus Christ and the gift of the Holy Spirit. As it does so, it realizes that, in seeking to express itself systematically, human language and concepts fall far short of the demands made upon them. Hence, it concludes that divine unity is not only an arithmetical unity, but an essentially mysterious unity to which the multiplicity of divine acts points.

To state that the universe is a unity is to believe that, in its profoundest depths, this is valid. Modern science does not assert that all things are only relative. Natural laws are determinate despite the reality that all observers do not experience the same effects. The private times and spaces of different

observers do not exist in isolation. They all belong to a single objective space-time called the universe which is invariant. By distinguishing the variant from the invariant, scientists penetrate the dynamic structures of reality, that is, they relate to the universe as a unified whole Consequently, the unity of the universe is not merely a label attached by scientists to indicate that they think they know all about unity and have transplanted this term. Such a stance would be inconsistent with the self-disclosure of the universe and with the intuitions of generations of scientists. When scientists describe the universe as a unity, they mean that it is the source of all unity.

Theologians believe that the good news of what God has done and is doing in this world points beyond itself to the One who is a unified whole, a unity. What they have to proclaim is empirically grounded in the multiplicity of the events of the Gospel. Their reflection is quite definitely a rational activity involving acceptance of the biblical record without wilful distortion, deliberate rationalization, or the solving of problems as an end in itself. Yet, this activity requires the acknowledgement of both the divine unity and the three divine Persons.(442) The Holy Spirit is inseparable from the Son and the Son is inseparable from the Father.(443)

This rational problem cannot be easily explained away, nor should it be dismissed as some figment of the theological imagination. Its authenticity is readily shown by its ability to account for the observed and recorded evidence. There is no alternative, therefore, but to recognise that divine unity is a dynamic unification of the three Persons, a unified whole from which the whole creation and all its unities derive their meaning. The doctrine of the Trinity is a formal expression of this ultimate mystery. It is not a closed statement made to obscure an irrationality. On the contrary, it is an open declaration of Christian faith, a humble acknowledgement that God permits successive generations to glimpse both what their mentors apprehended and what can prepare

their progeny for greater clarity and understanding.

The universe is a unified whole in the sense that the content of modern science is only a pale shadow of its unity. It is not that there can be a human conception of unity and then a special instance of universal unity. What scientists call unity is derived from universal unity which is the origin and seat of all scientific unities. Incidentally, the same relation applies to the rationality of the universe as the source of all rationality. Yet, the nature of this unity lies beyond apprehension. It exists as the comprehensive unity that unifies the plentitude of natural, including arithmetical, unities of scientific experience. Universal unity intimates itself through the intuitive relation in the lesser observable unities of the world and in doing so illumines their multiplicities. As Einstein and Infeld explained, "a complete solution (to the mystery of the universe) seems to recede as we advance."(362)

Like all other concepts, the non-formal notion of universal unity is continually under revision as more and more of reality is experienced and apprehended. As scientists stand open to the structured world, they abandon ambitions of final solutions to scientific problems and epistemological systems.(70) Nevertheless, the basic features of this concept remain essentially unchanged and fundamentally heuristic. The universe is a unified whole with an internal multiplicity, the echoes of which reverberate throughout the length and breadth, the height and depth of modern science.

According to Einstein, universal unity presents itself to scientists in the three activities of the independent world, its rationality and its intuitive relation.(120) Each of these is only known by its actions. The three are equally distinct but interperficient in that the universe exists by virtue of their mutual conditioning. There is a continuity known as the universe and a multiplicity observed as existence, order and knowability. The way in which independent reality acts is governed by natural laws and by the pre-established harmony between thought and reality.

This interperficiency reveals the triunity of the universe, a mysterious unity in trinity.

An external world without structure would be chaos. An independent structured world without intelligibility would be utterly inaccessible to the human mind. The independence of the universe is disclosed in its rationality and together they form the basis for the intuitive relation. The three activities of the universe are necessary to explain the totality of scientific experience, and scientists are faced, therefore, with the mystery of an interperficient universal unity. However, most scientists are like Einstein who was "satisfied with the mystery of the eternity of life and with the awareness and a glimpse of the marvellous structure of the existing world, together with the devoted striving to comprehend a portion, be it ever so tiny, of the Reason that manifests itself in nature."(150)

Interperficiency is somewhat similar to the technical term perichoresis used by theologians to denote the dynamic unity of the one divine Life of the three Persons of the godhead. This unprovable correspondence between the creation and the Creator may appear to some Christians as verging on idolatry. But by his own Word, God gave the universe the order it has.(425) Moreover, knowledge of the unity of the godhead as revealed in Jesus Christ is knowledge of the Creator from whom the unity of the universe has its existence. Just as the unities of the world reflect the unity of the universe, so the latter mirrors the unity of its Creator. The believing Christian, of course, humbly acknowledges that only by the grace of God can his eyes be opened through the Holy Spirit to see the significance of such a correspondence. In fact, neither the unity of God nor of the universe can be comprehended. But it does not follow that what cannot be understood is untrue. They are mysteries that cannot be ignored since they account for the recorded empirical evidence of Christian life and modern science. In a nutshell, each demands an act of faith.

For Christian theology, the one God is the Father, the Son

and the Holy Spirit. If the Son is named, the Father is in the Son, and the Holy Spirit is in the Son.(444) These three Persons are not three gods. God is not tritheistic but monotheistic. God is not divisible.(445) There is one divine Nature.(444) Theology understands the Trinity as a single God.(444) All that is recorded and experienced of the three Persons cannot be separated from the one revelation of the one God. In speaking of God as the Father, the theologian refers to Him as the Source and Origin of the Son who is distinct from the Father in his Person but identical with Him in his Divinity. God the Father begets God the Son(447) and the Reality of God is complete in the third Person of the Holy Spirit(448) who proceeds from both the Father and the Son. God the Father declares to mankind his Fatherhood in the Son and together they are the Origin of the Holy Spirit through whom persons become children of God.(449)

In speaking of the universe, scientists of an Einsteinian persuasion are already committed to its rationality and to the intuitive relation. What is said of the external world independent of the perceiving subject, or of the rationality of this world, or of the intuitive relation refers to the one universe. It is not a static entity but a dynamic creative whole exhibiting an abundance of internal motions. It confronts scientists in that profusion through which they come to know the natural order.

For scientists, the universe is real, rational and self-disclosing, a whole in three activities. The independent world is the source of that activity known as its rationality. But their mysterious interrelation does not exhaust the nature of the universe. There is a third activity of the universe called the intuitive relation. All that the universe is to scientists, independent reality, the invariant laws of nature and self-disclosure is the inconceivable wholeness of the universe. Because the universe is what it is, the intuitive relation allows them to share in its complex motions, to investigate the events and processes of the world. Science is just a little part of the

natural order. Scientists co-operate with nature as motes dancing in the universal beam. They do so simply because nature requires it of them. They are chosen to be co-workers with the universe in its rationality through the intuitive relation. Scientific research is readily understood in this way.

Although this distributive analogy is not proof, it does have the merit of demonstrating that modern science and Christian theology sometimes follow closely similar tracks in their search for a greater understanding of reality. At the very least, it shows that science is not without its irreducible mysteries, and that the mysteries of theology can be better appreciated, on occasions, in the light of scientific thinking. The unities of God and of the universe illustrate these points. It would be foolish, however, to claim much more from such a rudimentary comparison. Nevertheless, the indications are that a more thorough investigation will amply reward those scientists and theologians who are committed to open dialogue.

29. UNIVERSAL AUTHORITY

Authority seems to play somewhat similar roles in modern science and in Christian theology. On the one side, whatever scientists say of the universe, it can never be more than an indication of its nature. On the other side, as already noted, theological statements about God are essentially inadequate. Scientific theories do not circumscribe the natural order. Instead, they are limited by remaining subject to the ultimate authority of the universe. Likewise, all theological concepts owe obedience to the authority of the Word of God. At no stage in the development of science can universal authority be rigorously defined from a scientific appreciation of its manifestations. This authority is determined solely by what the universe is, just as the authority of God is uniquely grounded in who God is. Scientists can only speak non-formally of universal authority while theologians talk of God's authority in incomplete and open terms.

Most scientists tacitly acknowledge that the universe does what it does, is not answerable to science and has an authority second to none. For theologians, God is who He is, is accountable to no other and is the Authority of all other authorities. As far as modern science is concerned, all other forms of authority are conditioned and limited by universal authority which has no authentic rivals. Science is a search for an understanding of nature, not a striving for power over it.(291) This search is always too promising and too humbling to encourage delusions of mastery of nature. Besides, history shows that the subtlety of nature repeatedly frustrates human endeavours for its exploitation or control.

The Word incarnate is the Alpha and the Omega of the creation, but the universe has the first and last word in scientific research. It has the authority. Yet, that authority is not the universe. Nor is the authority of God to be mistaken as God. Indeed, the universe exposes for science the falsity of all abstract notions of authority. Such abstractions are as fundamentally opposed to the structure and harmony of the universe as they are to the nature and revelation of God. By setting themselves above either the rule of natural law or the reign of divine love, these pseudo-authorities deny themselves any basis in reality. Their roots are grounded in self-assertion and their branches hold the fruits of manipulation.

Many decades ago, Einstein emphasized that "science cannot create ends and, even less, instill them in human beings; science, at most, can supply the means by which to attain certain ends."(288) Such claims are valid simply because science obeys the natural order. Yet, it cannot apprehend the universe without, at the same time, opening up possibilities for contriving things that improve or devalue life. This includes the arbitrariness of abstract authority which, in its turn, bites the hand that feeds it. As the history of Christian doctrines shows, theology is vulnerable to similar abuses but it cannot progress without risking new heresies or old ones in new guises.

The authority of the universe resides in the power of natural law. The unity of the natural order exists amidst a variety of scientific theories. The interplay of non-eternal theories and invariant laws of nature enables scientists to discover and to move beyond the inadequacies of current achievements. These laws are contemporaneous with every scientific age. They represent the order that exists in the external world, and their rationality is the source of all that is meaningful to scientists. In them, the authority of the universe becomes visible and active as enriching and enlightening power. By them, the universe sets the limit of all that is possible, including chaotic abstraction.

But the claims that the universe makes upon scientists demand more than mere intellectual assent. They require personal scientific responses, committed reactions, to the events and processes of nature that come to them as authoritative. The obligation which lies upon all scientists is to pursue the truth and to surrender themselves to what they are given to apprehend. Scientists are citizens of the universe. They are, therefore, in no position to dictate its terms of government.

The authority of God is given in the Person of the Word incarnate who came not to abolish but to fulfil the law of God. (450) Hence, it confronts mankind as the power of love in Jesus Christ who obeys the law of God. The power of love is, therefore, the ordering power that unifies the creation. There is one Lord Jesus Christ but a multiplicity of doctrinal interpretations. In the light of God's authority as the eternal Word, theologians can recognise and counteract distortions in their temporal theological systems. Thus they can modulate the prevailing winds of theological change. This Word is contemporaneous with every age. In Him, theologians find all that is redemptive and rational. The authority of God is revealed and activated in the Word as enlivening power. He establishes all that is real and possible. He exposes all that is imaginary and impossible. In his birth, death, resurrection and ascension, He commands authoritatively

the personal commitment of theologians who are granted citizenship of the Kingdom of God.

The Word incarnate declares to mankind that God is the Creator of the universe. He demonstrates that God is not dependent upon the thoughts of men. His life shows that the thoughts of men are not the thoughts of God. The reality of God is to be seen in Jesus Christ who, unpredictably and inconceivably, opened up the way of and to God. Theological activity starts and ends with God the Father, the Son and the Holy Spirit. And with this awareness, the profound mystery is seen to be the New Covenant in the body and blood of Jesus Christ.

The fact that theology is part of the work of the people of God, that it has a legitimate function within the life of the Church, emerges from the rule of love in the Servant-Lord. The Lord commands the free exercise of all human gifts for the glory of God. Christian freedom, therefore, derives its reality from the Word incarnate. It is freely gifted but mercifully limited by Jesus Christ who, himself, has been given full authority in heaven and on earth.(451) All Christian freedom is, therefore, a pale shadow of God's freedom in the Word incarnate. In fact, theologians are only free because the Son of God grants them the freedom to choose to obey the New Covenant and its law of love. Of course, they can always reject the authority of Jesus Christ in favour of self-assertion and its consequent chaos.

The universe intimates authoritatively that there is a reality distinct from the thoughts of scientists. It is recognizable in its rationality. Reality is open to scientists in the natural order, and, astonishingly, that openness is the intuitive relation. According to Einstein, scientists begin with the external world, its rationality and the intuitive relation. And from that standpoint, the great riddle is the intelligibility of the world, the fact that science is possible. The universe originates the scientific enterprise as part of its co-inherent dynamics. Consequently, scientific freedom does not possess its reality of itself.

It is established and limited by its subjection to natural law which prevails universally and intelligibly. All scientific freedom is only a weak reflection of universal freedom. Scientists are free by virtue of the superior freedom of the universe. Their freedom to choose is given by the universe. It is the freedom to decide for obedience to its order. Should scientists choose to abuse this freedom, they opt deliberately for power-sapping speculation, expediency and manipulation. By doing so they turn their backs on the authority of the universe and, therefore, depart from the scientific way.

Perhaps surprising to many non-scientists, modern science rejects as false the authority of a definitive world-view. In the course of the centuries, mankind has passed through several world-views, none of which adequately expressed the content of the contemporaneous science. Modern science is essentially free in regard to all world-views. It resists successfully, sooner or later, all attempts to restrict visions of reality by limited world-views based on incomplete and uncertain scientific theories.

Likewise, theologians realize that all expressions of the reality of God must sound like inchoate mumblings to the Word incarnate. Yet, they do not need to rely on their own resources to construct or to assimilate general views of the world. Jesus Christ has the authority to release them from the temporal conceptual restrictions of world-views. Christian theology cannot serve two masters. It must not, therefore, become the servant of any world-view, past or present. Theological language may reflect something of a particular world-view, but that does not mean that it acknowledges the authority of that world-view. In fact, the sacred and inspired Scriptures make many references to the ancient Near Eastern picture of the world without being confined by its conceptual limitations.

Einstein recognised that throughout science's history certain concepts that have proved useful in the constitution of an order of things readily win such an authority over some scientists that

they tend to forget their origins and regard them as changeless data.(161) Theology's history tells a remarkably similar tale. However, less inhibited scientists or theologians insist on analyzing current notions and investigating their justification and their empirical grounds. In this way, their exaggerated authority is exposed and their deficiencies uncovered. Without this relentless pursuit of truth, the logical ordering of empirical data crystallizes as a rigid system, perhaps even as a definitive world-view. Inevitably, it tries to rival the authority of the universe or Jesus Christ, as the case may be. Obviously, scientific research and theological activity do not progress under those circumstances. At most, existing methods and concepts are entrenched. But obedience to the authority of the universe or Jesus Christ frees scientists or theologians, respectively, from the fear and futility of attempting to form a world-view of reality by relying on themselves.

From Einstein's outline of scientific thinking, it appears that the scientific mind depends heavily on topological thinking. It seems to do so not only in communicating knowledge but in apprehending reality. If this is a valid representation, it offers further resistance to the notion of a world-view in scientific thinking. All scientific theories are like signposts along the way of greater precision and fuller apprehension.(49) On the one hand, they combine faith with understanding. On the other hand, they surpass logical thought but are vulnerable to distortion by extraneous psychological factors. Briefly, scientific theories are indispensable but fallible. Significantly, there are no scientific theories of the unique and natural events and processes are correlated in ways that are not comprehensively reducible to common definable characteristics. These restrictions are hardly consistent with the holding of a definitive world-view.

Einstein placed great emphasis on the ordering and the surveying of sense impressions. This conceptual activity involves a pre-articulate phase which depends on creativity to bring order out of their lack of logical unity.(100) It is clear that a

scientific concept does more than define common properties in a complex of particular instances. Actually, it is more like a member of a set of conceptual functions directing understanding beyond that set to its invariants as its basis in reality. It seems that Einstein explained the formation of concepts in simple topological terms.

Topological thinking applies the same theory in several different empirical contexts demonstrating its flexibility to serve beyond its original setting. According to Einstein, scientists have to deal not only with precise analysis and mathematical expression but also with personal participation which defies description. Hence, the objectivity of scientific theories can only reside in the invariance of the natural order, that is, in regions beyond the compass of any world-view. The relevant point is that the meanings of successive theories are topologically related by recurrent references to the increasing empirical surveys. Indeed, this is the only hope of eliminating extraneous pyschological elements.

From an Einsteinian perspective, topological thinking makes possible the apprehension of what is not understood on the basis of what is understood. It achieves this simply because it relies on both empirical data and hidden conceptual connectivities. It is justified by the reliability with which its application orders and surveys new ranges of scientific data. Its only valid contact with reality comes from the universe which alone originates natural events and processes. The latter are beyond the scientist's intellectual abilities to create or to anticipate. Scientists can only reproduce and predict them. In their givenness, they are free from psychological distortion and, therefore, function as objective references in the development of scientific concepts and theories. The universal rationality to which they testify is the ground of all topological or scientific thinking which is, by nature, opposed to the formation of world-views.

Topological thinking also appears to give authentic expression

to Christian theology. The Ten Commandments serve as guidelines directing human behaviour towards the constancy of God's love. The sayings of Jesus of Nazareth point through aspects of everyday living to the spiritual qualities of life. The pedagogic value of topological thought in communicating the good news of God in Jesus Christ cannot be seriously called in question. Besides, theological activity always represents the attempt to understand more fully the deep things of Christian faith. At least to the open scientific mind, theology often appears to employ topological thinking in order to exceed logical restraints.

Surely, for example, to describe the Church as the Body of Christ or as the Bride of Christ is to speak topologically. Moreover, the theologian is encouraged to look beyond these two images to their common basis in God's love for mankind. In fact, their use forces theologians to ascribe a meaning to the Church which transcends their sum. If there is a legitimate place for topological thinking in Christian theology, there can be no room for a Christian world-view since they are mutually exclusive. Certainly, the role of topological thinking in theology deserves considerable attention in view of the current popularity of demythologism.

As scientists and theologians stand midway between the microcosm and the macrocosm, they inhabit the boundary between the known and the unknown. They can sense this environment and apprehend it. Faced with the inaudible, invisible and inarticulate, scientists realize that they cannot control the universe, while theologians acknowledge Jesus Christ as Lord. Indeed, scientific theories and experiments rely on universal authority but the validity of theological systems resides in the Word of God.

The flexile nexus of the conceivable and the inconceivable is characteristic of both scientific research and theological activity. It appears as a sign of the authority of the universe in every scientific concept, theory and experiment, in each scientific experience. This nexus reminds scientists that,

although universal authority lies beyond the current limitations of science, its existence is still indicated within the events and processes of the natural order. Likewise, the variable boundary occurs as the hallmark of the authority of Jesus Christ on every theological concept, doctrine and system, on each theological experience. It sensitizes theologians to the miracle that, although the authority of the Word incarnate surpasses temporal theological systems, that authority is revealed in the birth, death, resurrection and ascension of the Lord Jesus Christ. Clearly, Christian theology and modern science have much more in common than meets the eye.

30. THE RATIONALITY OF THE UNIVERSE

In many respects the rationality of the universe is to scientists who Jesus Christ is to theologians. It must be abundantly clear from the preceding sections that any discussion of modern science or independent reality must inevitably make some reference to the rationality of the universe. In parallel, the centrality of the Word incarnate is indicated by all outlines of Christian theology and of God the Creator. Obviously, to talk scientifically of the universe is to relate on the basis of its rationality and to presuppose the pre-established harmony between thought and reality. Similarly, to speak theologically of God is to communicate on the ground of the Word incarnate. This rationality represents the heart of science whereas the Word is the centre of theological activity. But universal rationality is not the product of scientific deliberation nor is the Word an utterance of man. The former belongs necessarily to the universe and the latter comes uniquely from God. Not only does this rationality spring from the external world and issue in the intuitive relation, it illumines both of them. It resembles the Word incarnate who came from God the Father, who sent the Holy Spirit and in whom the other two Persons are seen.

Fundamental to modern science is the wonder that the universe is intelligible.(151) The corresponding miracle of Christian

theology is that the Son of God became flesh and dwelt among men. All scientific theories, all scientific statements about the universe and the intuitive relation, can only amount to an extuberant expression of the natural order. The theological correlate is that all valid systematic theologies are necessarily expanding expositions of the nature of God. Consequently, wherever scientists or theologians attempt to theorise abstractly, they are trapped sooner or later in their own contradictions. The chemistry of the so-called inert gases and the Arian heresy are well-known examples. The same thing occurs either when scientists try to explain scientific researches exclusively in terms of illogical leaps or chance discoveries, or when theologians attempt to base expositions solely on subjective experiences. Then science or theology is apparently reduced to a sophisticated form of anarchy and the continuous development of science or theology is ignored in favour of methodological discontinuities or technical innovations, respectively.(192)

Actually the intuitive relation, like the Holy Spirit, is responsible for much more than sporadic flashes of insight. The Holy Spirit inspires all that Jesus Christ is to Christians and the intuitive relation inosculates all that the rationality of the universe means to scientists. Beginning with this rationality, scientists apprehend the pervasive harmony of nature to which they refer in amazement, yet about which they, like Einstein, can say relatively little.(167) In Jesus Christ alone theologians can see the miracle of the New Covenant between God and man, the communion that surpasses description. Only the rationality of the universe encompasses the natural order. Uniquely, the Word incarnate is the light of the world. Consequently, the theologian accepts Jesus Christ as Lord and the Holy Spirit as the Interpreter, and the scientist, being an iota of nature, acknowledges gratefully that the intuitive relation explicates this rationality.(111) For the scientist, all knowledge of reality begins and ends in experience of the rationality of the universe.(96) The relation between

the truth of the universe and the truth-content of scientific theories is discernible and discerned in the light of this rationality,(168) just as the Truth of God for man is Jesus Christ.

The nave of science is the rationality of action and the action of rationality, and the hub of theology is the word of the Life and the life of the Word. The everyday distinction between thinking and doing, therefore, disappears in both science and theology. Theological activity and active theology are the two sides of the one coin. Theoretical science and experimental science are like two different craftmen working on the same cathedral. This is why Einstein referred collectively to the theories, concepts and methods of science as the "deeds" of scientists.(96) What is involved in scientific research and theological activity is the pursuit of truth and the truth of pursuit. The rationality of the universe acts, declares itself, and scientists react to its illumination of the external world. The **Word** incarnate lives, reveals himself, and theologians respond to the revelation of God the Father.

All that is properly called scientific or theological knowledge is knowledge of this rationality or the Word, respectively. Universal rationality confronts scientists with the mystery that the universe has an ordered content which is largely unexplored and inaccessible,(167) while the Word incarnate beckons theologians to believe that God identifies himself in human flesh, that He who is inconceivable and unapproachable was made man. Theologians or scientists stand humble before the Word or nature as they receive intimations of reality. On the one hand, this rationality dwarfs scientific knowledge(174) and, on the other hand, it invites scientific investigation.(101) On the one side, the Word exposes the frailty of human reasoning and, on the other, He commands the adventure of love. He does so by approaching man as a fellow creature in history. Similarly, this rationality alone explains the totality of the universe while reaching out to scientists in

the multiplicity of natural events and processes. It is, so to speak, the reality of the covenant between the universe and man, just as Jesus Christ is the Reality of the New Covenant between God and man.

When scientists recognise novel aspects of the former covenant, they are empowered to theorize anew about independent reality. As theologians participate in the New Covenant, they are enlivened to articulate freshly the love of God the Father. In the Word incarnate they meet the concrete form of God, and in this rationality scientists are able to apprehend the real structure of the universe. Scientists of an Einsteinian persuasion are encouraged in the face of this covenant to speak of the intuitive relation by which the universe inspires and guides them. Moreover, this guidance cannot possibly be an accident since it conforms to the laws of nature that exhibit invariance across the entirety of space-time. In view of the New Covenant, theologians talk confidently of the reality of the Holy Spirit who counsels and comforts them as they venture in faith to meet the challenges of their generation.

For theologians, there is no other God than the God who revealed himself in the birth, death, resurrection and ascension of Jesus Christ. In thinking theologically Christians begin with Jesus the Christ, the unity of God and man, who is the Truth. God embraces persons in Jesus Christ who immerses them in the truth and love of God. There is no place to hide from this sustaining love which can liberate persons from the bondage of sin. Theological systems cannot, of course, capture the Truth but they can be grasped by Him. In so far as they echo the Truth, they proclaim freedom from the slavery of building conceptual pyramids. And in pointing beyond themselves, they resemble the Truth for He witnesses not to himself but to God the Father from whom He came, and to God the Holy Spirit who proceeds from both the Father and the Son. To adapt Athanasian terms, God the Father, the Son and the Holy Spirit are the Source, the Radiation and the

Action of the light of Truth or Rationality. Theological activity is essentially a journey in pursuit of the Truth. Like Abraham, theologians depart in faith from familiar conceptual ground for unknown destinations. En route, they enjoy the privilege of the guidance of the Spirit of Truth as they follow the Way of Truth to the Source of Truth.

From an Einsteinian standpoint, there is no other universe than the one that is disclosed in rational action and active rationality. In thinking scientifically, scientists have from the beginning to think of the rationality of the universe. The unity of the universe and the scientist, this covenant, is inescapable. It envelops him in its rationality which promises his release from delusion, fantasy and contrivance. Granted that his theories are somewhat remote from this rationality,(363) they are nevertheless faint reflections of that rationality and as such they promote liberation from illusion. (112) Simultaneously, this rationality points to independent reality as its origin and to the operation of the intuitive relation as its consequence. The universe is, as it were, the sourcebook of rationality and the intuitive relation is the tutor who takes scientists through the course. They find themselves reading this course in faith and their personal progress gives them specific views of the structured world.(179) In short, this rationality sets the stage for the performances of modern science.

According to scientific faith, this rationality is the unique decisive disclosure of the external world. As already noted, it is the book of nature written by the universe with binding authority on scientists. They are influenced by many other factors, even intoxicated from time to time by their own theories, but nothing has the power of this rationality in science. Only it can free them from all lesser authorities that abandon them before the savagery of ambiguity or relativism. It confers on valid scientific theories the status of ambassadors. As scientists experience more and more of the natural order, they dispense with their extrinsic convictions, enthusiasms and preferences because of their

deepening commitment to the objectivity of the structured world. Clearly, when they talk of this rationality, they refer to that supreme power which is the disclosure of the universe.

The reality of which scientists speak, this disclosure in rationality, is exclusive and authoritative. Scientists are concerned with nothing less than that reality which is the universe itself. Its rationality is distinguished by them as compelling and objective. In its rationality, the universe challenges scientists to use their inferior powers of logic and rationality to apprehend its manifestations. Confronted by the unfathomable depths of this rationality, they accept this challenge to investigate and to abide by the invariant laws of nature. Characteristically, every scientific theory, statement and concept has an objective content associated with this rationality. In other words, modern science rises above mere opinion in so far as it acts and communicates on the basis of the natural order.

God's revelation in Jesus Christ is the singular comprehensive Message who proceeds from God the Father. This proclamation is none other than the eternal Word expressed uniquely and authoritatively in human flesh. The labours of theologians can be affected by a whole variety of pressures including self-satisfaction with their own systematizations. Yet, all of them lack the real authority to direct activity beyond themselves. Sooner or later, theologians realize that they are caught by the force of a narrow whirlpool of subjective conceptualization. Only Jesus Christ has the power to free them from provisional systems and ambivalent enthusiasms by binding them to the objective, conclusive, personal Word of God. The Word incarnate is the touchstone of all theological activity. As theologians grow in a knowledge, love and grace of the Lord Jesus Christ, they abandon progressively their excessive subordinal baggage preferring the primary objective, economic authority of the Person of the Word. They acknowledge and adore the sovereign Power who is above all powers,

the Word incarnate.

Since God's revelation in Jesus Christ is the work and word of the Person of the Son of God, theologians know that God himself is involved exclusively and authoritatively. The Word is uniquely the Reality of God disclosed in and to man personally and, therefore, objectively. In the Word incarnate, God invites persons to use their capabilities and propensities to understand, even as they live by, the New Covenant. Faced with the abundance of the life of the Word, theologians try to abide by the new commandment of love. They seek to apprehend more fully the good news of God in Jesus Christ. This is the only way to ensure that theological systems, statements and concepts have an objective content originating in the Word himself. In short, theological activity leaves the subjective behind in so far as it works for and witnesses to the Person of Jesus Christ.

Jesus Christ is the Lord. This means that Christians belong to Him. In particular, it commands that theologians serve Him in all that they try to accomplish. As just noted, they are freed from the fears of subjectivism into the hope of objectivity. This is the correct word because the Word incarnate is concerned about all persons whether they know it or not. Each person must decide how to respond to Jesus the Christ who is the Alpha and the Omega. Clearly, Christian faith is the decision to acknowledge Jesus Christ as Lord, to recognize his sovereign authority over one's life and over all the creation. Yet, the power of the Lord Jesus is not a blind force over Christians. This power orders the whole creation and, therefore, in the Word incarnate human wisdom attains supreme order or wisdom. This objective order is established apart from theologians who must subject themselves to it for it alone imbues all theological activity with real content.

In an important sense, the rationality of the universe claims scientists as its own. Scientific researchers obey it in all that they seek to do. In return, they escape from subjective life to the world of objective perception and thought.(70) But the matter

false hopes for scientific faith and wisdom. Scientists are not in business to convert the whole human race to scientific ways of thinking and doing, but they are prepared to share the experiences that enrich their lives. They are willing to point to that rationality which has the power to give them such freedom of inquiry.

Christians are followers of Jesus Christ, the adopted children of God the Father, who believe that they have a message of salvation to proclaim to the world. Their mission within the world is objectively grounded in the Word incarnate. Moral considerations flow from the freedom persons find in the Lord Jesus Christ. They are not prior to this sense of belonging, but result inevitably from it. The Body of Jesus Christ, the Church, is held together by obedience to their Lord. Obedience requires personal decisions, and schisms occur where disobedience reigns.

The power of the Word incarnate, however, cannot be diminished. He laid the foundation of the Church and exposed the inadequacy of all other powers. Jesus Christ unifies his followers as the company of believers although He does not need the worship or recognition of this fellowship. Knowledge of Him who is the Truth comes as God elects Christians to serve their Lord in their day, generation and location within his Church. Theologians are personally called to increase understanding of the Reality of God and to communicate it to the Church and the world. Yet, they are not commissioned to convert the whole Church to theological thinking and language. They labour to explicate humbly the deep things of Christian faith that point beyond all human endeavours to the Word incarnate who gifts to all persons true freedom of inquiry.

Apparently, the function of the rationality of the universe in science is like a pale reflection of the work and word of the Person of Jesus Christ in theology. The similarity is, of course, strictly limited since there is no interpersonal bond between the universe and man that corresponds to the communion of God and man. Nevertheless, a fairly extensive correlation is readily sketched and it

does not end there. The existence of a rational universe has consequences for all men whether they realize it or not. Because this rationality is and was and will be within space-time, men may decide how they will react to its existence. Scientific faith is the decision to acknowledge the authority of this rationality. The value of this rationality is its power over scientists, not a power for power's sake, but the ordering power of scientific wisdom. An objective order exists apart from scientists, an order to which scientists must be submissive, an order which represents the concrete coherence of all scientific thought and action.

Scientists are children of the universe, people who believe that they contribute to the harmony of the world. Their activity within the natural order is objectively established. Primarily, there is no morality involved but, since scientists are given the freedom to research, morality plays a necessary but secondary role.(88) The scientific community is held together by obedience to the rationality of the universe. That obedience requires personal decisions. However, before homo sapiens appeared or apprehended it, the power of this rationality prepared the ground for him. This preparation includes the scientist's deliverance from bondage to all other powers. It energizes the scientific community. Yet, the truth of this rationality does not depend on the formation of such a community or its recognition of this truth.

Knowledge of this truth occurs as the rationality of the universe places scientists at turning points in the history of the human intellect.(251) They are called personally to serve in "the temple of science,"(180) that is, to serve this rationality and to communicate their understanding of it, perhaps even to the world at large. If science is to be obedient to this rationality, it must exist for the sake of mankind. What it discovers it must pass on through skilled interpreters within the scientific community. By doing this, it avoids setting itself up as a rival authority to the rationality of the universe and it reduces the risk of raising

cannot be lightly dismissed by scientists or theologians without disparaging their own disciplines. Those common foundations, if not origins, seem to hold the key to much more detailed investigations that promise a better understanding between scientist and theologian.

31. THE INTUITIVE RELATION

Whereas Christians believe in the Holy Spirit, scientists of an Einsteinian persuasion believe in the intuitive relation. Theologians understand God the Father, the Son and the Holy Spirit as referring to God, God-man and God indwelling man, respectively. In parallel, scientists look upon the external world, the rationality of the universe and the intuitive relation as independent reality, its comprehensively ordered nature and its relevance for scientists. As already discussed, the three activities of God or of the universe are inseparable being properly understood only in their unities.

Nevertheless, the intuitive relation specifically reminds scientists that they are actively immersed in the dynamics of the universe, that they belong to the universe. Correspondingly, the Holy Spirit convinces theologians that they participate in the work of God, that they are co-workers with God. Scientists or theologians have faith in objective rationality, a faith that is exercised and, therefore, deepened as they investigate the wonders and ways of nature or of God. That scientific research is possible is due primarily to the existence of the intuitive relation, the mysterious vanguard of the universe. Christian theology is essentially and ineffably dependent on the Person of the Holy Spirit.

Theological activity is a necessary but partial response of the Church to Jesus Christ who came to fulfil the law of God. Jesus was born for mankind. He lived, died and rose again for the whole of humanity. Whether or not men acknowledge it, Jesus Christ is the Word incarnate. By Him all things were made. Every man owes his existence to the eternal Word although each person must decide for himself how he will relate to the creative objective Rationality who is the Son of God. Persons who believe and live in Christ

and who have freely committed themselves to systematic expositions of the work and word of the Person of Jesus Christ are called theologians. Through the Holy Spirit, they experience the confidence and hope that spring from creative Reality and the joy and peace that radiate from objective Reason.

Similarly, scientific research is man's commitment to the laws of nature. Scientists share this common basis in so far as they depend on the structures and regularities of nature. This dependency remains blind or superstitious, however, until they recognize and relate to the all-embracing rationality which releases them from the terrors of caprice. Persons who believe in this comprehensive rationality and who are liberated from fear to investigate and to apprehend its manifestations are called scientific researchers. Through the intuitive relation, they are free to enjoy the peace and security of objective reality, privileged to experience the flight of ignorance and superstition.(169)

But not all persons are scientists, and not all scientists are physicists. Scientific freedom seems to come as a distinct gift of the universe to the person.(144) While such a gift must be developed, it cannot be achieved by human capacities or strivings. Indeed, nothing can be said concerning the exact nature of this freedom or of the relation between the rationality of the universe and the scientist beyond the assertion that the intuitive relation is the inconceivable movement from this rationality to man. Scientists are those who are receptive and also responsive to this infusion. All else about this relation remains hidden in the mystery of the universe. Its existence is known only through its consequences, that is, through the involvement of scientists in the events and processes of the universe.(151) By responding personally to the rationality of the universe through the intuitive relation, individuals act as citizens of the universe in the special sense that they obey its orders and acknowledge its work as their own. They become scientists, the standard-bearers of its rationality.

It is equally apparent that not all persons are Christians.

Followers of Jesus Christ have mysteriously received the gift of the Holy Spirit. This gift gives them the freedom to apprehend the word and work of Jesus Christ and to live as the children of God. Where the Spirit of the Lord is, there is a movement of God toward man which precedes and enables a movement of man toward God. Jesus Christ breathes his Spirit upon persons empowering them to proclaim the message of his Church. In particular, theologians are enlivened to explicate the deep things of the Christian faith. While the indwelling Holy Spirit is a mystery to man, a miracle wrought by the love of God in Jesus Christ, this human experience engages the will and the mind, in fact, the complete person. Yet, Christians do not possess the Holy Spirit. On the contrary, they are the bearers of the good news of God, of the Word incarnate, in so far as they are obedient to the promptings and guidance of the Holy Spirit.

An openness to the Word incarnate is the God-given freedom that theologians nurture as they receive the counsel of the Holy Spirit. This means that they can relate validly to the sacred and inspired Scriptures as they systematize the proclamation of the Gospel. They are acutely aware of the wonder that, if they grasp after Christian freedom, they will chase it away, but that, if they are to be caught up by this freedom, they must put self-assertion to flight. A personal relationship with Jesus Christ through the Spirit of Truth is the basis of a keener commitment to and an increasing apprehension of the task of Christian theology. The theologian is personally called to follow in the footsteps of Him who is the Truth. To do this, he must become totally immersed in the endeavour, holding nothing back. Unconditional commitment to the Word incarnate surpasses limited understanding and theologians experience the abundant life in Christ as the Holy Spirit guides them along the ever-expanding way of Truth.

The sacred and inspired Scriptures record sufficiently all that is required of necessity for Christian theology. The Bible

bears witness to the actions of God the Saviour, to the revelation of God, and theologians formulate the doctrines of the Christian faith by reflection on these divine acts. The theologian, however, cannot afford to carry his striving for a systematic theology to the extreme of self-closure. Through the guidance of the Holy Spirit, they achieve open systems that serve Him who is the incomparable expression of God the Father.

The meaning of those systems depends on the fidelity with which their conceptual relations accord with the coinherence of the activities of God that centre in the birth, death, resurrection and ascension of Jesus Christ. Without the Holy Spirit such a correspondence cannot be discovered or maintained simply because theological activity engages more than the intellect. The whole person is involved. Passionate devotion is at work rather than neutral abstraction. As theologians submit to the authority of Jesus Christ in their lives, the Spirit of Christ prompts their thinking and doing. Thus, they strive long and hard to find the most appropriate theological utterances that can never be more than indicative in character. Ineffably, the Holy Spirit provides the message and prepares the person to receive it.

A sensitivity to the rationality of the universe is the freedom that scientists develop as they reply positively to the intuitive relation. They proceed in a scientific way, always conscious of the fact that, if they try to possess this freedom, they will lose it, but that, if they are possessed by it, they can travel in the right direction and in good company. In their openness through the intuitive relation, scientists undergo a growing understanding of and a strengthening commitment to this rationality. They move from existing theories describing ranges of phenomena to new theories encompassing even greater, but still limited, domains of experience.(55)

The scientist is called as a person to exercise this freedom. He is recruited as a tracker of truth who puts his whole being into the pursuit. Scientists are inevitably intimately involved

in the scientific enterprise. Because their commitment to the rationality of the universe transcends their fragmentary apprehensions, they themselves are changed as the realms of science unfold before them. Einstein's dynamic conception of scientific knowledge is utterly dependent on his postulate of the fundamental intuitiveness of knowledge. The intuitive relation stimulates scientists who travel along personal hysteresis loops, experiencing an ever-expanding apprehension of the natural order.

The disclosure of the universe is not given in abstractions but in actions. The rationality of the universe presents itself through the intuitive relation as ceaseless series of acts whose number and coordination defy all attempts to quantify or to define them. The intuitive relation guides scientists through the labyrinthine ways of cosmic rationality, enabling the bold intuitions of scientists, as logically free creations of the human mind, to maintain contact with independent reality.(104) Scientific theories are formulated by reflection on the meaning of the actions of the external world. Their validity is measured by their success in structuring the manifold of observed actions.(99) So far as scientists can understand, their theories and concepts could not have been discovered by reflection apart from the intuitive relation. The plain fact is that new scientific concepts and phenomena are encountered in situations that are never exclusively intellectual.

When scientists are confronted by a new phenomenon or concept, it makes a claim upon them which demands more than intellectual assent. The demand is for a personal response to this novel experience, an involvement that includes the consideration of non-quantitative tokens of reality. Einstein referred to this type of involvement as "a kind of weighing of incommensurable qualities."(216) Contrary to popular non-scientific opinion, scientists cannot dispassionately examine the credentials of a new discovery which makes an authoritative claim upon them. Unavoidably, their immediate scientific statements can only be non-formal in character.

Subsequently they search for the appropriate quantitative language in which to express their intuitive appreciation of the importance of their discovery.(108) Mysteriously, the intuitive relation provides the essential condition of effectual scientific intuition, the coincidence of an universal act and a scientific mind prepared to apprehend its meaning.

God is his own Interpreter and, through the Holy Spirit, the biblical record is made plain for all to see. Inspiration, new vision, is accompanied by a command to conform to the Word incarnate and by a confidence in his all-embracing rule of love. Theologians, therefore, are compelled to recognize and to follow what they believe to be the way of Truth and to direct their lives accordingly. Preconceived notions will necessarily obtrude but, given the opportunity, a humble openness to the ministry of the Holy Spirit will eventually triumph. Only the Holy Spirit can preserve and sustain that communion of believers who labour to set aside disreputable ideas derived from purely subjective interpretations. Theologians are inspired by the Holy Spirit to venture honestly and intelligently in faith for Jesus Christ and his Church.

Their labours find expression in theological formulations that are the fruits of extensive and intensive reflection and experience. Because they have had their ears unstopped, they can hear and listen to the Word of God for their day and generation. Their systems represent contributions to the continuous theological dialogue between past and present. Yet, this dialogue is never more than theology in outline. It says more than theologians can hear. Consequently, their progeny hear both what their fathers heard and more. As the Holy Spirit gives them new insights into the richness of the revelation of God in Jesus Christ, the profundities and the inadequacies of older theological systems are more fully appreciated. Each theological generation must experience for itself the reality of the New Covenant in Jesus Christ. To do this, every theologian must steep himself in the ambient theology but not to the neglect of the biblical record of the actions of God the Saviour. Inspired

by the Holy Spirit, he can then go on in faith to face new horizons in theological endeavour.

In general terms, scientists humbly acknowledge that, by the courtesy of the universe, their eyes have been opened through the intuitive relation to see the significance of its rationality. This new sight brings with it an obligation to obey that rationality and a sense of security in its comprehensive invariance. Hence, scientists are obliged to accept and to respond favourably to whatever they believe to be meaningful. They must direct their researches not along predetermined lines but as sperate reactions to their discoveries. The exposure of falsity and error in science depends on their responses to that obligation. Indeed, the intuitive relation holds together a community of scientists each of which, in his individualized personality, pursues bold intuitions that are never certain but that are honestly believed and intelligently investigated. (99)

Scientific theories, however, have mathematical form because they are the products of prolonged deliberation and experimentation by scientific researchers. Since those researchers have seen the light, as it were, they are capable of finding succinct terms for scientific exposition. Their formulations bear the record of scientific progress to future generations. But the things that they seek to express are always greater than they surmise. Thus as science advances, those theories can mediate apprehension in unexpected ways.

All scientists are open through the intuitive relation to the rationality of the universe and so successive generations apprehend both what their predecessors understood and more.(104) Consequently, old theories appear in new contexts with previously unknown interconnections articulated. By the interplay of thought and action, the intuitive relation gives scientists new insights and each scientific generation learns for itself what has been recorded by the original discoverers in science, albeit in a much more condensed form. In every age, scientists must soak themselves in the available

scientific knowledge relevant to their particular discipline.(101) Thus imbued, they can tackle scientific research with intuitive faculties finely tuned. They are prepared as far as is humanly possible for those experiences when, through the initiative of the intuitive relation, the solution to a problem appears on the conceptual horizon.

Such an experience is not a chaotic irruption or a haphazard intervention. The years of scientific training enriched by subsequent research together with continued study of the recent literature of his discipline and stimulating discussions with colleagues, all of these exercise his intuitive abilities. They help to equip him to receive illumination in unfamiliar situations. Bluntly, what appears to the non-scientist to be conceptual bolts from the blue are instances of the initiative of the intuitive relation carrying the responsive scientist beyond what was antecedently apprehended. The scientist is equal to the novel and unprecedented situation because he can rely upon this relation to raise him to meet the scientific emergency. The intuitive relation promotes the growth of scientific wisdom and freedom.

Apparently, the role of the intuitive relation in science is like a faint echo of the work of the Holy Spirit in theology. Once again, the similarity is restricted by the absence of an interpersonal bond between the intuitive relation and the scientist. Clearly, the indwelling Holy Spirit is the divine Person who ministers to persons. Still, a remarkable correspondence becomes evident when science is viewed from an Einsteinian standpoint. This particular congruity represents one more facet of an extensive correlation of scientific research and theological activity, a correspondence which strongly suggests that modern science and modern theology have considerable common origins. On those foundations it may be possible to build a new bridge between science and theology that will serve the interests of both.

32. MOTIVATION AND COMMUNITY

From an Einsteinian perspective, an extensive correspondence between

modern science and Christian theology comes readily to light. Einstein, however, was firmly convinced that, although "a cosmic religious feeling is the strongest and noblest motive for scientific research,"(246) this feeling "can give rise to no definite notion of God and no theology."(247) Obviously, he was well aware of the quasi-religious nature of science but he also saw the need in science to avoid all pretensions of the transcendental. According to him, "science without religion is lame, religion without science is blind."(266) While conceding that science has a religious basis and that religion includes scientific vision, he refused to equate the roles of the scientist and the theologian. He referred to the correspondence as "a conviction, akin to religious feeling, of the rationality or intelligibility of the world (which) lies behind all scientific work of a higher order." (120) And the more one considers such comments the more one appreciates the great wisdom which gave them utterance.

Certainly, modern science should be treated with respect by theologians for, as Einstein sensed, it can raise old theological questions in new contexts.(356) It would appear, for example, that intuition is to theory in science what revelation is to doctrine in theology. Sometimes, intuitions visit scientists like revelations. Einstein's experiences had led him to believe in a God who could give the scientist "a sense of the ultimate and fundamental ends. To make clear these fundamental ends and valuations, and to set them fast in the emotional life of the individual, seems to me precisely the most important function which religion has to perform in the social life of men."(245) Those ends "came into being not through demonstration but through revelation, through the medium of powerful personalities. One must not attempt to justify them, but rather to sense their nature simply and clearly."(245) Could it be that revelation is actually a human problem and not a distinctively theological question?

Hope and faith are kindled by scientific research. The way of life offered by science fires conviction and enthusiasm in ways

that seem to many people to be more open and appealing than those of Christianity. Couldn't theologians learn something from the candour of scientists about their uncertainties despite the depths of their convictions? The scientific enterprise does not promise to provide answers to all the questions, demands and miseries of mankind. But, because it can supply the means by which to attain such ends, it enjoys considerable prestige.(288) Perhaps, if the Church were more outspoken about the creative role of theology and less critical of the pedagogic value of theology, it could become more convincing about the reality that theology is never a substitute for Jesus Christ who is the only answer to all men's needs.

Scientific researchers should, in their turn, respect Christian theology for, as Einstein acknowledged, religion provides the basic motivation for science. He realized that "science, in the immediate, produces knowledge, and, indirectly, means of action. It leads to methodical action if definite goals are set up in advance. For the function of setting up goals and passing statements of value transcends its domain."(310) It is, perhaps, only those who have lived in the midst of modern science and theological activity for a while who can realise in how deep a sense the latter has shaped the background and the unconsciously accepted principles of the former, though the number of scientific researchers who are also devoted Christians may be relatively few. There are many scientists of sound realism and commitment who never read Christian theology and consider themselves agnostics but as a matter of history owe much to theology.

The depth and relevance of Einstein's insights are indicated but not exhausted by the preceding sections of this essay. Of course, mere coincidence of views is no proof of influence but the extent and context of the coincidence of scientific and theological thought can imply influence. Unquestionably, science owes a great deal to Christian theology, a debt that has been largely ignored and grossly underestimated until relatively recently. There is

still much work to be done before the historical accounts are properly balanced. Christianity, in spite of its checkered past, provided, for example, the paradigms for intellectual freedom, integrity and humility in modern science. And science's history has reinforced the Christian lesson that persons cannot accept knowledge solely on the authority of someone else nor assume that there is no understanding except by their own limited reflections. Christianity taught science the value of tradition and unfortunately demonstrated many of its abuses. In the authority of Jesus Christ, it also paved the way for the authority of the rational universe and it proclaimed that real authority is not dictatorial but relates to personal insight. Consequently, scientists as individuals depend on ears open to both the harmony of nature and the voices of their fellow researchers.

From the very beginnings of modern science, researchers were not restricted to their own small experience. They assimilated freely what others claimed before them as they themselves apprehended those claims. Copernicus, for instance, built his heliocentric system upon the Ptolemaic system. Like Kepler, Galileo and all the other fathers of science, Copernicus was indebted to many previous pathfinders. In this important respect, modern scientists are not any different. Even Einstein owed much to Newton. Bluntly, a scientist is not worth his salt if he neglects the accumulated wisdom of the centuries. In science, as in theology, integrity must be clothed in humility. Obedience is the order of the scientific day and that demands a profound sense of humility. The scientist is free to choose to obey his intuition in order to convert it into scientific theory. He is free to decide to listen humbly to whoever can advance his thinking and doing. Hence, the scientific researcher learns whenever and wherever he can. Scientific research mixes as well with pride as oil does with water.

Nevertheless, there is a great temptation to over-estimate the logical nature of science, a trend that could be partially reversed

by informed theologians. Mathematics alone does not sustain the scientific endeavour. In fact, the contrary can sometimes occur. For centuries, Euclidean geometry reigned supreme in science as if by divine right until the advent and application of non-Euclidean geometries expanded scientific horizons. Characteristically, the salient point was made by Einstein. "As far as propositions of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality."(359) Einstein knew that the intuitions of scientists baffle the ranges of words and mathematics. In those intuitive moments, there is, no doubt, a logical element but it is inadequate and secondary. Mathematics or logic becomes predominant only when the door to analysis and reporting is opened.

A scientific theory is more or less an agreed statement of the scientific community. This logically free imperfect creation is an attempt to express what it means to glimpse the wonder of the universe in terms of its own rationality. But the truth-content of a theory is not the same thing as the intuition of the scientist. The former only points to the latter. A scientific theory is ineffective and misleading in so far as it diverts attention away from that intuition. Scientific theories are more than persuasive mathematical expositions. They touch an intuitive nerve as they inject a sense of wonder evoking a response which involves the mind, will and being of the scientist. In other words, science deals with concepts that always break through mathematics and escape comprehension. This does not diminish, however, scientific faith which rests in the universe, not in the theories of science.

In so many respects, therefore, theological concepts are like their scientific counterparts. Logic is not the exclusive basis of theology. Logical investigation cannot reveal the connections between theological concepts and Christian experience. The moment of revelation defies comprehensive articulation. Christian doctrines are agreed statements of the Churches that try to convey something of what it means to experience the miracle of the Word

incarnate in terms of his Rationality. Those doctrines are not the same as the revelation of God to man. They are only signs along the way. Theology involves concepts that burst out of logic and elude definition. They do not thereby threaten Christian faith which is anchored in the eternal Word of God, not in transient theological formulations. Clearly, the theologian is well equipped to converse with and encourage the scientist and to maintain a healthy regard for logic and mathematics.

By recognizing the discursive, topological and heuristic qualities of scientific thinking, theologians and scientists, alike, can prepare themselves for the constructive discovery that they already share much more than they realize. For example, both systematic theology and scientific research presuppose the surmounting of difficulties and their statements are not meaningless even if they cannot be reduced without remainder to prosaic definition. Because the universe is invariant, its disclosures to scientists are the same for it is the one and only universe that self-discloses. Because God is unoriginate, his revelation to all persons is the one Lord Jesus Christ. Yet, scientists, theologians and generations are different. Insight varies from person to person. Consequently, intuition or inspiration leads to different scientific or theological expositions whose common terms point to the same reality. At best, science or theology can only ever begin to understand reality. Of necessity, scientists or theologians remain in awe of the immeasurable mystery that enfolds the world and human life. They all experience a sense of wonder as they explore the whole of which they are but tiny fragments. In fact, it is questionable whether any scientist or theologian can really believe in the rationality of the universe or the Person of Jesus Christ unless they have personally experienced how inconceivable and incredible life really is.

Like the Church, the scientific community is an assembly of believers. Its members participate of their own free will in the mystery of the harmony of the universe. They exchange honestly

scientific knowledge and they teach sincerely their theories. The same can be said of theologians and their doctrines. The meaning of this universal scientific association resides in its cooperation with the rationality of the universe as communicated by its theories and experiments. Compare it with the reality of the Church which is its participation in the work and word of Jesus Christ by worship and mission. This scientific community mediates its involvement in the natural order and in the freedom deriving from it, just as the Church witnesses to its Lord and its God-given liberty. The centre of scientific gravity lies in its identity as the assembly of all believers of which the personal freedom of the scientist is the basis and strength. Christian freedom plays a similar role in the Church. Scientists associate with one another, sooner or later, because they belong inalienably together through the intuitive relation and they communicate either by direct contact or by means of the scientific literature. Likewise, Christians are indissolubly united the world over by the one Holy Spirit and they interrelate personally or by means of the Christian literature. Evidently, the natures of the scientific community and of the Church display some common features.

The scientific community is the sphere of activity of the intuitive relation which emanates from the external world and its rationality and which propagates to all scientists. Correspondingly, the Church is the province of the ministry of the Holy Spirit who proceeds from the Father and the Son and who inspires all believers. While scientists believe in the rationality of the universe, they also acknowledge the existence of this scientific fraternity which conducts its business in relative isolation from the non-scientific world. Yet, in spite of its frailties and deficiencies, this fraternity belongs to the universe and, therefore, to all mankind in the sense that it adds to the quality of human life. Similarly, the Church is in the world, for the world but not of the world.

The separateness of this community, reminiscent of the holiness of the Church, demands unconditionally the unity of all scientists.

But unity is not uniformity either in the Church or in the scientific community. There is always room for honest disagreement in science as in theology. Disputes do not obscure the underlying unity of all scientific researches or of all Christian proclamation. Instead, by highlighting areas that have been inadequately apprehended or investigated, those disagreements focus attention on the supreme rationality of the universe or the unique revelation of God in Jesus Christ.

As already indicated, the scientific community or the Church numbers only a part of mankind among its members. The business of the Church or of the scientific community lifts its members beyond the bounds of nation, culture or sex. The universality of these communities is closely linked with their unities. Both depend on the progressive modes of thought developed and communicated throughout many generations. They maintain their continuities because their members pursue personally and relentlessly the appropriate way. As the privileges of minorities, these pursuits must dominate every aspect of the life of the community. In other words, the separateness, unity, universality and continuity of the scientific community are as intimately connected as are the holiness, unity, catholicity and apostolicity of the Church. Indeed, these attributes can be regarded as the criteria of the great human adventures embarked on by the assemblies of believers in the rationality of the universe and in the Lord Jesus Christ. Obviously, the marks of science echo to some extent the marks of the Church.

Nevertheless, there are significant differencies between the scientific community and the Church but they can be better appreciated in the light of their resemblances. From the preceding sections of this essay, it is fairly evident that modern science offers the scientist a vocation, a calling to serve "in the temple of science".(180) This involves a faith that, in many ways, seems to match the Christian faith. Indeed, scientific faith appears to be an intensively intellectual, individualized, solitary variant of Christian faith. Dealing with the non-moral universal order, it

encourages scientists to develop an interest in things as opposed to persons.

Scientific thinking requires freedom from humanitarian motivations. Scientific optimism sees an increasing apprehension of the universe as an enrichment of the quality of human life. Scientists are trained for research, not dissemination. According to Einstein, most of them are "somewhat odd, uncommunicative solitary fellows, really less like each other in spite of common characteristics, than the hosts of the rejected."(70) Few of them do not appreciate that it is better to destroy privately one's own illusions than to be publicly discredited by one's colleagues. The personal gifts of scientists are obscured by the emphasis on objective reporting in the scientific literature. The short range interests of many scientists who are successful researchers completely saturate their capabilities for forming long-range connections.(90)

Still, science provides the means for both a vital mechanism for cultural change and an aid to an apprehension of that change.(15) Consequently, modern science has found itself misunderstood in many parts of the world as a remarkable rival spiritual movement to Christianity. For many disillusioned minds, it represents a passionate idealism which speaks of a new order of society without privilege of birth, wealth, or greed. It anticipates that poverty, hunger and illness shall no longer afflict the common man. Yet, as Einstein indicated, there is no direct connection between these hopes and ideals on the one side and modern science on the other. In reality, they are incompatibles. The fiction of dominant science providing the only intellectually acceptable view of the world is more the product of the non-scientific imagination than the conviction of the scientific researcher. It is tragic for both modern science and Christian theology, and for mankind as a whole, that the much needed hope for civilization should be linked with superficial materialism.

The theologian must not dismiss too lightly, however, such interpretations of the scientific enterprise. Having so much in common, modern science could reasonably be described as Christian theology

operating in a different gear. Exacting personal commitment, learning and experience characterize scientific research. And scientists will need more than a logical refutation to convince them of the futility of some of their hopes for the unpredictable future, particularly when those hopes are already externally motivated. Equally, scientists should be more open to the commitment, learning and experience of theologians whose forebears seem to have set the stage for the enthralling performances of modern science. The urgent call is for honest dialogue based on extensive personal participation, that is, founded on both Christian and scientific realism.

Perhaps, the preceding sketches of the similarities between scientific and Christian faith, scientific and theological communication, scientific and Christian knowledge, the universe and God, the rationality of the universe and the Lord Jesus Christ, the intuitive relation and the Holy Spirit, and the scientific community and the Church will encourage others of greater insight to contribute to the exciting, promising and reconciling dialogue which is still in its infancy. At minimum, they suggest that science and theology are not independent disciplines, that each discipline should not reject the other, that theology is no more a form of superstition than science is a species of heresy, and that the metaphysical aspects of science hold out the promise of an increased interface of science and theology. They also point to the powerful significance of Einstein's thoughts on modern science.

Through scientific wisdom, which appears to be a daughter of Christian wisdom, there lies the possibility of a better life on this planet. Science itself, however, does not motivate the determination that there shall be a new world order. As Einstein said, this motivation must come from another source.(129) Generally, it springs from the Christian background and, therefore, specifically from Jesus Christ. While every scientist recognises

that the purpose of the universe must lie beyond the universe itself, if it has a purpose, and that some day human history will disappear in the cosmic flux, he is motivated by the desire to apprehend, the need to believe and the will to search. He places his hope in the rationality of the universe which he can only see dimly, the same rationality which begins and ends in the Person of the Lord Jesus Christ.

33. Notes.

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