A STUDY OF MODELS IN SCIENCE AND THEOLOGY, PARTICULARLY THE MODELS CONCERNED IN THE VARIOUS CONCEPTS OF CREATION

Thesis

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A STUDY OF MODELS IN SCIENCE AND THEOLOGY PARTICULARLY THE MODELS CONCERNED IN THE VARIOUS CONCEPTS OF CREATION

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ABSTRACT

The thesis is a study of the use of models in science and theology, particularly those concerned in the various concepts of creation. After a brief review of the philosophical background which looks at models of science, the discussion begins with the understanding and use of models in science. These are defined, their functions and applications are classified and the limitations are noted. It is then shown how the language of models is at the present time used much more widely and includes its use in theology. The relationship of this to metaphor, analogy and symbol is briefly discussed. The study continues with the understanding and use of models in theology and this compared with that in science. From this theoretical base, specific examples are considered and it is shown how model language can be used of the Biblical understanding of God the creator, and of the creation. The question is asked of the ways in which models change or are changed, and this is considered in the context of T. S. Kuhn's book, "The Structure of Scientific Revolutions"; and it is asked if change occurs by revolution or development. Four particular topics are then considered to illustrate the themes; cosmological models from early times to Kepler (the Copernican Revolution); models of the origins of the earth (the genesis/geology debates); present day theories of cosmology; and some further biblical and theological aspects. In conclusion some general suggestions are proposed about the inter-relationships between models in science and theology.

CONTENTS

CHAPTER ONE

INTRODUCTION

This present work is the result of many years interest and concern to relate my scientific and theological interests and the conviction that they could not be kept in separate compartments of my life. This thesis focusses on an integrated approach to one area, that of the use of models in both science and theology and in particular those concerned with creation. The term creation is used in both the sense of the act of creation and that which is created, the natural world and the whole cosmos. It is clear, for instance in the great popularity of television series such as Life on Earth and Cosmos, that there is much popular interest in this subject. This is reflected also in the media's reporting on modern astronomy and space exploration and the related questions of how the universe and life is how it is. Those who are Christians need to be able to make a theological response to these issues and to offer a doctrine of creation that is appropriate for today. Often in the past, in Protestant theology, the doctrine of creation has tended to be neglected in favour of the doctrine of salvation but that is changing in response to the scientific ethos of the present time. The interest in creation leads to questions about the creator and so it seems right to pursue the inter-relationship between science and theology as they concern this topic.

Scientists have used the term 'model' as part of their language

for at least the last hundred years and it has passed into everyday usage. Now there does not seem any area of study that does not resort to it and that includes its use by theologians. Behind the present day use of the term are concepts which are certainly very ancient, and in this thesis it is hoped to show how model language can be appropriately applied today, and to explore how it has been and is being used.

My aim is to look in some detail at how models are used in both science and theology and to illustrate this by particular examples. The discussion begins in chapter two with the ways models in science are used and how they are understood. I look at how they have been defined and classified and then look at their functions, applications and limitations in a more practical way. From this I move in the next chapter to show how model language can be extended to theology and I touch upon its relationship to metaphor, symbol and analogy.

In chapter four I relate the understanding and use of models in theology to the discussion in chapter two and discuss the similarities and the differences to the use in science. From this more theoretical discussion I show how it can be applied to the Bible and ways in which model language can be used of God as creator and the creation. An important question for those who use models is how they change or are changed, whether it is by development or by revolution. This is considered in chapter five in the context of T. S. Kuhn's thesis in his book "The Structure of Scientific Revolutions". In chapter six there is a consideration of some topics to illustrate

the theme and to develop some earlier themes, and I attempt to identify possible inter-relationships.

The final chapter draws together the various strands and I suggest some conclusions.

As the work proceded it became obvious how large a subject this is and how many areas of study it involves; it also became clear that it would be easy to get diverted into interesting byways. In a paper first published in 1963, 'Mapping the logic of models in science and theology', F. Ferré says "My purpose ..... is to show that the notion of the 'model' which has received considerable attention and stimulated much controversy amongst scientists and philosphers of science, should be recognised as of central importance to theologians and philosophers of religion. In order to reach my goal I shall have to survey and attempt to make intelligible a domaine for which there exists few charts .... " (1) He develops this idea of map making in relation to models and I find this an helpful analogy; for this present study has felt like a journey of exploration. There are times when there seems no clear route on the map although others (e.g. S. McFague and I. G. Barbour) have marked out possible routes and I am grateful for their guidance. It is hoped that this thesis will mark out one possible route and be a useful contribution to the development of more accuraate maps. Continuing the analogy of map making, it is necessary to state and briefly acknowledge those features of the landscape that are accepted as given so that the journey can proceed. Thus I see four areas which need to be noted and their assumptions

acknowledged. It is assumed:-

1. That it is possible to discuss the reality of the world and of human experience. I realise that one key topic that is implicit in this discussion is that of reality. What is real? For the person who is not a philosopher, it can seem a meaningless question. Experience shows that people accept the reality of the physical world and many would also make the same claim about religious experience. Yet I recognise that for philosophers it is a vital matter and one that can be vigorously debated and even non-philosophers can find it problematic (e.g. optical illusions). As a generalisation it can be said that the perceptions of reality held by an individual are affected by the model of the universe that they hold, and this is affected by communal, cultural or religious influences.
2. That there are many 'languages' including scientific and theological, but there is sufficient in common to enable effective communication to take place. It is recognised that "specialised languages of discourse for particular purposes are products of specialised communities. Each of these communities has its own symbolic language in terms of which it interprets its experience." (2) In the past there was a tendency to assume that all scientific language was providing a literal description of reality, now there is recognition that it also can have symbolic character and imaginative qualities. There are problems with religious language for, for some, it is seen as meaning-

less and unsuited to the needs of the modern world. In all disciplines there is the necessity for explanation and elucidation in order that there can be proper communication and dialogue.

3. That it is reasonable to hold the Christian faith and that theology is relevant to today's issues and questions. I, therefore, do not offer any arguments for the belief in God as creator or justification for the views expressed on theological matters.

4. That it is worthwhile and legitimate to explore the inter-relationship between science and theology. There is an extensive literature in this area both academic and of a more popular nature which addresses many facets of this topic; this thesis highlights one area in this dialogue.

There are also commonly held assumptions, from which I would want to dissent, such as the notion that there is a complete division, even antagonism between those who hold scientific views and those who hold theological views. The examples given to justify this are of the notable conflicts (e.g. between Huxley and Wilberforce or Galileo and the Church) but this ignores the considerable number of instances of dialogue and that many people are both scientists and Christians. Another popular view is that science alone deals with **facts** whereas theology does not. Yet many scientists would argue that alongside observation, interpretation and definition of the factual there is a place for the creative imagination in scientific

endeavour. It is now recognised that significant discoveries and breakthroughs have often come about apparently by chance rather than through normal scientific procedures. An example of how such a breakthrough occurs is recorded by J. Watson in "The Double Helix" the account of the elucidation of the structure of DNA. On the one hand there was the meticulous and dedicated work of R. Franklin and M. Wilkins on the X-Ray structure of the molecule yet it was the creative approach of F. Crick and J. Watson (with the aid of structural models) that enabled the structure to be determined.

In recent years there has been reflection on the nature of the scientific method and a recognition that it is probably never possible to be completely objective. J. Polkinghorne summarises it "Experiments are always theory-laden. The dialogue between observation and comprehension is more subtle and mutually interactive than is represented by the simple confrontation of prediction and result." (3)

Like-wise it needs to be stated that theology is not just subjective. Since it is a reflection upon the religious experience of humankind, which is observable and universal, then there can be claimed a rational basis for enquiry. J. Polkinghorne "..... there is an analogy between the activities of theology and science, in that both are concerned with understanding and ordering experience ..... there is an identifiable sphere of human interaction with reality ... (which) .... is a natural source of material for the exercise of the theologians art." (4)

Lastly, it is of interest to note that in the recent (1987) report

of the Doctrine Commission of the Church of England entitled "We Believe in God" there is acknowledgement of the place of the language of models in theology and of the connections with science. "What theologians offer are much more like scientific 'models' than literal descriptions ..... Scientists work with 'models' of what they believe to be real, in order to help their understanding and exploration ..... Models are in this sense an indispensible tool of scientific thinking.... theological models ..... are creative precisely because they are not literal descriptions." (5)

These are very general observations which can only indicate something of the background to this study; further aspects will be considered as the work proceeds.

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2. I. G. Barbour, Issues in Science and Religion, p.156
3. J. Polkinghorne, One World, p.9
4. J. Polkinghorne, One World, p.28
5. We Believe in God (report), p.27-28

CHAPTER TWO

THE UNDERSTANDING AND USE OF MODELS IN SCIENCE

INTRODUCTION

In chapter one it was suggested that the use of the word 'model' is of comparatively recent origin but that the concepts which lie behind it could well be very ancient. The conscious use of the term in science has probably a longer history than in other disciplines. Here it has a universality in its application which includes all areas and while it may be used by some scientists more than others it is never entirely excluded. This chapter is of the understanding and use of models **in** science. It is acknowledged and noted that there is an extensive and wide ranging study concerning the models **of** science, which is the concern of historians of science and philosophers of science as well as practising scientists. This is a vast subject which continues to provoke much discussion with its own literature. It is recognised that the understanding of models **in** science is influenced by the models **of** science. In the context of this study it is only possible to indicate something of the various schools of thought, since a full discussion is beyond the scope of the present work. (I would also want to note that I recognise the importance of the question to the philosophers of science.) The factors that influence the present use of models in science are many and various. Some will be indicated here and others will be discussed later when specific examples are considered. The questions of particular interest are about the relationships of models to reality, of models to theories and about the status of models.

This has been summarised by I. G. Barbour in Myth, Models and Paradigms, where he outlines four theories of knowledge and their associated models of science and he indicates the corresponding understanding of models in science for each one.

1) Naive realism. This was the general scientific view until this century and "assumed that scientific theories were accurate descriptions of "the world as it is in itself". The entities postulated in theories were believed to exist, even if they were not directly observable". (1) This led to a literalistic view of models. Lord Kelvin in 1884 said, "I never satisfy myself until I can make a mechanical model of a thing. If I can make a mechanical model I can understand it." (2)

2) Positivism. The basis for this view is "that science starts from indubitable data which can be described in a neutral observation language independent of all theories. It was held that all theoretical terms must be translatable into pure observational terms by means of operational definitions". (3) This leads to the dismissal of models as unnecessary since theories can be inferred directly from observation.

3) Instrumentalism. There is some agreement with positivists but here it is argued that theories should be judged for their usefulness, it is acknowledged that there is a place for the imagination in the development of theories. Models are useful

mental devices, temporary aids to be discarded when they have served their purpose.

4) Critical Realism. Valid theories are seen as representative of the real world and can be true as well as being useful. Science involves the imagination as well as the understanding. Therefore, models are taken seriously but not literally. There are thus various views of the relationship of models to reality and this involves religious models too, an area to be discussed later. The generally accepted scientific view of reality is that there exists a physical world that is coherent, consistent and independent of the individual. It is recognised in the practice of science (particularly atomic physics) that the individual reacts, and is involved, with reality (that being observed or measured) but there continues to be a separation. Most scientists have a "sceptical and qualified realism, according to which their models are regarded as candidates for reality, that is, models of hypotheses about a real (but only imperfectly known) world to which the models approximate and the hypotheses genuinely refer". (4)

M. Hesse has argued that there is at present a move from logical to historical models of science, and this recognises the many changes that have occured, in particular the change from the mechanistic, materialistic and deterministic models of science in the 17th and 18th centuries to the dynamic and relativistic models today.

It is unlikely that a time will be reached when a final statement can be made, and as changes are noted in the past then they will surely take place in the future.

CLASSIFICATION AND DEFINITION OF MODELS

The literature offers various definitions of models in science, and from those reviewed it became clear that it is difficult to achieve a comprehensive clarity in this matter. Obviously there is overlap and often similar discussions yet there are differences in approach and application. It would seem that it is easier to observe how models are used than to define them in a concise and coherent manner; there are reasons for this including the fact that there are dynamic and imaginative qualities in their use which elude precise definition. Four different schemes will be considered from the many available, in order to provide the basis for the development of this discussion and also this will indicate some of the ways in which people have attempted the task of classification.

1. A technical and comprehensive discussion of models is given in the Encyclopedia of Philosophy and this includes a survey of the use in formal logic as well as in the empirical sciences. The former while of some interest is less relevant to this thesis than the latter but both will be looked at since scientific models lie on a continuum between these two extremes.

"Formal logic is concerned with sets of axioms and their deductive consequences and also with the interpretation of these axioms and theorems in 'models' - that is sets of entities that satisfy the axioms. These relationships are

most easily exemplified in terms of geometry." (5) This interpretation is in models and this formal and logical sense of model has been influenced and influences the empirical sciences without direct involvement apart from the carry over from logic of the idea of the interpretation of a deductive system.

At the other extreme is the use which is nearest that of everyday language where model refers to a replica or scale model. These can be used "for expository purposes or even calculating devices in cases where the building of a replica or analogue of a system as a working model is the simplest method of investigating the consequences of those natural laws that the system is believed to satisfy." (5) Many examples of these exist including wind-tunnel experiments, crystallographic models or hydraulic models of supply and demand. Before considering these two definitions a brief discussion of the relationship between model and modelled in terms of analogy is given. Two kinds of analogy can be distinguished, formal analogy and material analogy. In formal analogy there is a connection of isomorphism since the same axiomatic and deductive relations refer to the model and the modelled. In material analogy there is similarity between the parent system and its replica (as between a toy and a real car.) This relationship can imply similarity or difference, that is positive or negative analogy. The classification of models in this scheme is mainly with respect to their function in relation to theories and has three divisions:

a) Semiformal or mathematical models. In these there is unlikely to be a physical model, rather the model is a means of enabling a theory to be expressed in a way that enables

prediction or explanation. It is used in connection with the mathematical theorems of science and the analogy is of a formal kind.

b) Simplifying models. These are systems which simplify or idealise a system for convenience in research or application (for example, a scale model of a new design for an object). It also includes what are called archaic models which are of no longer held theories but which have a use in applied sciences (for example the model of heat as a fluid).

c) Theoretical models. These are involved with the structures of theories and in some cases it would seem that they are identical with the relevant theory (for example the model of the D.N.A. molecule is in some senses identical to the theory of the structure in terms of the spatial relationships but not in the nature of the bonding). However, this is not always the case, and models can lead to the development of a theory, and can be prior to it. Theoretical models do depend on some other system, in particular, they use familiar and intelligible terms to offer explanation of a phenomenon or theory.

2. A different scheme has been proposed by R. Harré in his book (The Principles of Scientific Thinking). His definitions are given in the context of his views on theories which he sees as being solutions to a peculiar style of problem. At the heart of a theory are various modelling relations which are types of analogy. Initially he distinguishes between sentential and iconic models. The former would seem to resemble those of formal logic and are concerned with mathematical models. The latter is the type used in scientific discussion.

He classes models into two broad groups homeomorphs and paramorphs which are based on his understanding of how models work. He distinguishes between the source (what a model is based upon) and the subject (what a model represents) of the model.

Homeomorphs are those where source and subject are of the same category. The relationship can be of three kinds. (i) Micro or megamorphs. The difference is one of scale and often there is some compromise in detail of structure. (ii) Teleiomorphs, which are idealisations or abstractions. (iii) Metriomorphs, which exist only as concepts as when the model represents a class (for example, the average family has 2.6 children).

Paramorphs are those models where source and subject are different and are generally concerned with modelling processes. Harré considers this in two ways. Firstly in terms of the relation to subject and proposes different levels of analogy, secondly in relation to source and recognises different degrees of connectedness. He continues his discussion with an analysis of the many philosophical problems in the relationship of models to their subjects. This is noted but not reported since this is not directly applicable to this present study.

3. F. Ferré (Philosophy and Religion ed. Gill) sets out a number of views of what constitutes a model. He lists models as mechanical contrivances; as scale models; as a mental picture; as an auxilliary concept in theory construction; as equivalent to analogue and finally as a focus of language from one domain to another. He identifies three classes of questions about models focussing on type (their degree

of concreteness); scope (their degree of inclusiveness); and status (their degree of importance). Among the types of model he notes scale models which permit relationships to be read in true proportion; structural models such as the molecular models of chemistry; mental models which defy construction but offer what he calls epistemological vividness; and conceptual models which includes mathematical models. The scope of models can be very varied in application from those limited to a single entity to those which have general application.

4. I. G. Barbour in a similar classification gives four main types; these serve a variety of purposes ranging from the solving of practical questions to the constructing of theories. (i) Experimental such as scale models or working models which are used to solve practical problems. (ii) Logical models which are used by logicians and mathematicians and are entirely mental constructs. (iii) Mathematical models which are symbolic representations of physical systems which are often used for prediction. (iv) Theoretical models which "are imaginative mental constructs invented to account for observed phenomena". (6) These connect by analogy the familiar with the unfamiliar and are the type most frequently used in science.

These four approaches give an indication of how different authors have attempted the task of classification and they provide a theoretical basis for the discussion of the **uses** of models in science.

There is also the whole question of the inter-relationship

of analogy, model and symbol. At its simplest level analogy can be defined as "an observed or postulated similarity between two situations" (7) and a model as a "systematic analogy postulated between a phenomena whose laws are already known and one under investigation." (7) Symbols are conventions, often arbitary, which may have their origins in models although they cannot become models. Symbols have an important role in the physical sciences and mathematics and as such are included in the formal and semi-formal types. This will be discussed further when the theological models are considered.

THE APPLICATION AND FUNCTION OF MODELS

APPLICATION

So far the discussion has been on the theoretical background of the use of models in science but alongside this it is recognised that the every day work of scientists involves the use of all types of models. This use is very much part of the practice of science as will be outlined here and developed in specific examples later.

Mathematical models are used in physics and chemistry to express through equations and formulae the results of practical experiment. These with the symbols for the elements enable the chemist to discuss in a written form complex chemical reactions in a way that is universally applicable. The physicist can similarly communicate the nature of physical processes of all kinds including mathematical formulae, scale models and working models. The chemist also uses various structural models to express the three dimensional nature of molecules, and these provide a useful means of exploring the relationship

of structure and function. The simplifying models are often used in biology to demonstrate the various functions of living things. At all levels and in all branches theoretical models are proposed and are a means by which theories may be developed. Computing science is another discipline where the understanding and use of models is an integral part. This is seen for example in a practical way when computers are used to provide graphical models which can be expressed visually and dynamically. This application is now widespread in most scientific disciplines providing explanation and new ways of communicating ideas both in the mass media, as for instance, in television scientific programmes as well as in research. It is a tool that is used in education and research for it has as an advantage the fact that the models can be shown dynamically and computer graphics can offer simulations of processes of many different kinds and of very different scale, from cosmology to atomic physics! Computers have brought this application of models to a far wider audience than before and this could well have wider implications for their use. There is also the theoretical aspect which includes the complex question of the relation of computer theory to the human thought processes, a subject in its own right but which is not relevant to this study.

FUNCTIONS

In the discussion so far it has been shown that it is generally accepted models have an important function in the development of theories. Indeed some would argue that they have a necessary function. This will be further illustrated under the subsequent headings, although it is again not easy to make clear cut

classification and there is necessarily overlap. The limitations and problems will then be considered.

Communication Models are an important part of the communication among scientists and between scientists and non-scientists, since they provide an aid to the explanation and extension of concepts in all areas of science. By using the familiar and the intelligible it is possible for concepts which are difficult to be shared. This is particularly true about the very small or the vast, for atomic physics or cosmology. M. Hesse puts a similar view, "Models like metaphors are intended to communicate. If some theorist develops a theory in terms of a model, he does not regard it as a private language, but presents it as an ingredient of his theory ... None of this would be possible unless use of the model were inter-subjective, part of the commonly understood theoretical language of science". (8) Those who have the task of communicating the results of research would certainly find their task more difficult without them for complex phenomena can be simplified and made understandable by the use of appropriate models. This is particularly true where the mathematical theories of, say, astrophysics are conveyed by models. In this instance it involves models of models, that is a physical or representational model to illustrate the mathematical model. That they have this important function in communication has been borne out by the success of those television series on the status and origins of the earth and the universe.

The scientific endeavour is a communal activity, and models have an important role in this. It has already been mentioned

the place they have in chemistry. Chemists, through formulae, structural models and symbols can convey the content and results of experiments, reactions or molecular structures in a way that would be impossible in words alone. The models provide a 'shorthand' which transcends language and cultural barriers. This is also true in other scientific disciplines as any study of the literature would indicate.

Educational In education the use of models is an integral part of the study of all the scientific subjects. Teachers and lecturers would find their task much more difficult without resort to models and the young are helped in the understanding of concepts. Even those who would generally reject models accept that there is a role in education. The 'how it works' models in museums are not only a source of interest to all ages but provide useful means of enabling people to understand scientific and technical concepts, be it how a car engine works or the motion of the planets in the solar system. Mention has already been made of the use of models in the media and in computers. This function is not merely for information but also to encourage the making of new discoveries for the individual.

Interpretation and development Models can provide the basis for experiment and the development of new theories which can prove to be a complex process. At a basic level the study of a reaction or phenomenon will lead to the proposal of an hypothesis or possibly a theory; this will be explained by a model which is then able to indicate further areas of topics for investigation. However, in the practice of science

it is rarely as straightforward as this, for there is a more involved interplay at all stages. Certainly a good model can suggest a number of possible areas for future investigation. This developmental aspect of models is an important one and many would say a necessary part of the process. There can be times when a model has to be completely discarded, or changed so much that there seems little connection with the original. This raises the question of how models change and this will be considered later. Interpretation of newly discovered systems is helped by the use of models of a similar or parallel system, since they give intelligibility to that which might seem unintelligible, as for example in the development of models of the atom. Bohr proposed a model of the atom which was modelled on the ways the planets orbit the sun, a model now superceded but which still has limited educational value. Interpretation in terms of the familiar is important in the proposing of novel theories.

Prediction Models are used to make predictions of the possible outcome of theories and in particular have wide practical applications. For example, engineers will test models of new structure in wind tunnels to predict their aerodynamic qualities. Scale models also enable predictions to be made about potential hazards where it would be impossible or impractical to work in the actual situation. Predictive models are used in the behavioural and social sciences. Theoretical models can also be predictive and suggest areas for future investigation that is, if the model is valid certain deductions can be made and experiments carried out to test the deduction.

The prediction and subsequent confirmation of the microwave background radiation as a result of the 'Big Bang' is an excellent example of this and will be referred to later.

Creativity and imagination Models can be the source of new and innovative theories, and can be considered in that sense creative. It is recognised that there is a place for the use of the imagination in scientific discovery; for innovative ideas and new directions come from lateral thinking. In the past those with mechanistic and materialistic views or those of positivist views tended to deny a place for imaginative or creative thought. It is now recognised that those who have the ability to connect ideas, to use models, in an imaginative way are those who will be the leaders in scientific developments. S. McFague quotes Max Planck "that the pioneer scientist must have a 'vivid imagination for the new ideas are not generated by deduction, but by artistically creative imagination'". (9) She is also emphatic that "imagination - understood as analogical association of novel and significant similarity in spite of difference - is essential to scientific thinking" (10) It seems clear that the use of models is very much part of this. This can subsequently involve discarding one model and replacing it with another, as was the case with the understanding of the structure of the atom. Proposed models can provide the basis for fruitful discussion (or great disagreement) and knowledge is extended. The continuing debate between those who propose and oppose the model of the 'Big Bang' origin of the universe has been productive of new concepts and better understanding. There is also

a dynamic character in some models which leads to new and creative ideas.

Practical Models can enable experiments to be done which it would not be possible to do in an actual situation for reasons of safety, cost or scale. There are also a number of situations where it is not possible to carry out an experiment, cosmology being a prime example. From observation and theoretical calculation theories are proposed as to origins and further work is only possible with models. There is no possible way in which the original conditions for the formation of the earth can be reproduced! The Miller-Urey experiment provided a model for a possible scenario for the beginnings of life on earth but it is limited to being just that , a possibility, proof is never possible.

Conclusion So far the discussion has been on the positive aspects of the general function and application of models, it has also reflected something of the philosophical background. However, even those who support and value the use of models have to recognise the limitations and disadvantages. These will now be discussed.

LIMITATIONS OF MODELS

So far the discussion has shown the positive aspects of models in science, but equally it has to be recognised that there are real limitations in their use. The main limitation is that a model does not reproduce reality, (it reflects it maybe), although that is often the expectation of people. The mistake that is made is to presume that a model will give total explanation or total identity. This may seem an extreme statement but it is often the result when scientists seek to explain themselves to the general public. Ask the

ordinary person who has done some science at school how they would describe the atom. It will probably be said that it is the smallest known particle, or in terms of the planetary model, and in both cases the model will be seen as identical to the atom. Part of the problem is that the whole concept and use of models is rarely explained at any level in the education system. It is part of the language of the scientist, but it is not consciously part of the language of the pupil or at least not in the theoretical sense. The desire for total explanation can also lead to the problem of total identification of model with that modelled. For where there are tendencies to this absolutist view then the model becomes so identified with the modelled in a theory that it is difficult for it to be replaced. This is particularly true when a model becomes part of the everyday language of people but the 'rules' by which it is accepted or rejected do not. This lack of definition and explanation can lead to another limitation in the use of models. It can lead to erroneus ideas of what is being modelled. R. Schegel states "The natural world disclosed by quantum theory has a flexibility that was altogether lacking in the machine-like universe of classical physics. Particles like tiny billiard-balls, self determined in their physical properties and behaving in strictly causal patterns, have simply failed as hypothetical constructs; they do not allow the development of models that have natures richness of process and structure." (11) Similarly while it is useful to discuss the function of the brain in terms of computer models, if this is seen as a total description it can lead

to a mechanistic view which ignores(or is ignorant of) the questions of mind/body and mind/brain relationships. The thinking, feeling, living person is much more than the computer model. There is here, too, the problem of inversion. That the computer models some aspects of the brain is true, but it is not to be inferred that the way the brain works is like the computer. This limitation has particular importance when the models in theology are considered.

Many models are limited in that they can only show one aspect of that which is being modelled. There is what I would call the 'but also' factor. The planetary model of the atom is useful at some stages of learning, but also it needs the amplification and modifications of quantum mechanical models to give a fuller and more accurate picture. Alternatively this is referred to as the is/is not factor. Atoms (and molecules) can usefully be considered as solid particles - the gas laws for 'ideal' gases are derived from such a model. Yet alongside this has to be set the statement that an atom is **not** solid, the quantum description has to come to the fore.

The models which are abstractions cannot have all the qualities of the subject, and yet they can still show the potential of a theory. For example, this means it is possible to make the statement that 'atoms exist' while continually(and drastically) modifying the understanding about their nature. This limitation of is/is not is particularly relevant to physics, for there can often be no single inclusive model, for say light or electrons. Rather there is the recognition of the need for

what is described in the wave/particle principle of complementarity. Literalistic models can be a definite disadvantage here, unless they are rightly understood.

Another limitation is that models can lead to reductionist views. The argument being that models can simplify complex and difficult theories, and everything can eventually be reduced to simplicity. This has its value but it fails to account for the complexity and diversity that exists. It needs to be recognised that a model is only able to show some features or feature. A model of the solar system if it is to show some aspects of the planets and say their orbits may not be able in the same model indicate the scale of distances neither can it give any indication of origins.

It is possible that models can restrict the acquisition of new knowledge. The model becomes so identified with its source that the thinking becomes 'straight-jacketed' and theories are modified to meet the needs of the model rather than the reverse. The history of science can provide many examples of this, for example, the early chemists commitment to the phlogiston theory or astronomers to Ptolemaic cosmology. There is alongside this the cultural aspect of models. There are times when to speak of atoms in terms of billiard-balls is helpful but it has to be stated categorically that they are not like that and furthermore those who know nothing of billiards will not see the point of the model anyway.

M. Hesse draws attention to another question which is relevant to this, the underdetermination of theory by empirical data and she discusses this in relation to the models of cosmology.

"There are many alternative model universes in scientific cosmology, all more or less fitting the facts as we know them from our very limited observations in space and time, and between which further observational tests are sometimes possible but never anything like decisive." (12) If this is the case that more than one model can fit the observations then there arises the difficulty of how choice is made between models and the appropriateness of the model that is favoured. In these circumstances it is understandable that some people would prefer not to have any model at all. Another disadvantage is when models are used and the user is unaware that they are models. S. McFague urges caution concerning these 'subliminal' models, which she sees as very widespread. "Most of us live most of the time within the power of models of which we are unaware. The models are a part of 'paradigm', an entire set of assumptions .... (which are) largely unquestioned..." (13) This is probably more true in the social sciences, but it can also be true in science where the model is used without it being recognised that it is a model.

Some have argued that the disadvantages of models are such that it would be better not to use them at all, a position I would not hold, rather I would want to stress the value of models for the reasons given. Models have their limitations, they can never convey the complete picture of what is being modelled but they are a necessary part of the theory and practice of science. It is good to be reminded of R. Braithwaite's statement that "the price of the employment of models is eternal vigilance." (14)

These arguments will be developed further when the models in theology are discussed and the relationship to those in science explored.

WHAT MAKES A GOOD MODEL?

If models are accepted as a useful and necessary part of science, then there has to be an assessment of what is required of a good model. In the discussion of the disadvantages it became clear that part of this is less to do with the models themselves than with how they are used or with their effectivenes in communication. The problem then tends to become one of subjective judgement. Good models are those which function effectively, i.e communicate, have heuristic value, enable interpretation and development, have predictive potential, are practical and extend knowledge in an imaginative and creative way. S. McFague states "A good model is concrete and detailed and must be sufficiently different from its principle subject to spark insight." (15) The 'goodness' of a model is judged by the extent to which it meets these criteria and by its acceptance by the scientific community. This raises questions about both the scientific community and how models change, and these will be considered when T. S. Kuhn's work is discussed. Many models are developed from experimental and observational data and for it to be a good model requires that the model 'fits' the data and conveys the essence of the experiment or observation. A difficulty arises where, as has been mentioned, there is underdetermination of the facts. There are times when the model is the best there can be at the time. There has to

be a willingness to accept that the good model may have to be replaced by a better. Finally it has been noted that there is positive and negative analogy in the use of models. It is also recognised that for most types of model in science and in theology that there is often neutral analogy. The degree of neutral analogy can be an aid in assessing how good a model is. This discussion is particularly relevant to the discussion of models in theology and will be dealt with in chapter four.

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CHAPTER THREE

THE EXTENSION OF MODEL LANGUAGE TO THEOLOGY

INTRODUCTION

The background to this study is the conviction that for Christians it is meaningful to speak of God, the God who is known through revelation and experience. There continues to be a real problem for those who hold this faith, of how to speak to those who do not share it, since for those who are outside the tradition, there is the apparent barrier of theological language. Analogy, metaphor, and symbol have all had a role in the conveying of Christian religious experience and revelation. Today, I am sure that there is a contribution to be made by the explanation and eluciation of models in theology.

In chapter two the understanding and use of models in science was discussed and an indication was given of the philosophical debate that continues. In recent years the use of the language of models has become widespread and is to be found in most disciplines including social sciences and now is to be found in theology. As far as I can ascertain it was first used in this connection by I. T. Ramsey in his book 'Religious Language' published in 1957. Since then it has been widely used in many different contexts. As in science there is a diversity in the way the term is used and therefore classification can be equally problematic.

There is also much overlap with other terms such as metaphor and symbol, and different writers put their nuances on to

these or, in some cases,use them as synonymous. J. Macquarrie writers "When one is confronted with a notion so difficult to grasp as that of Spirit, we must turn to analogies, images, pictures, models **whatever we may care to call them** in the hope of getting some illumination. Images and analogies, do not describe in a literal or direct way, but they point us indirectly to the reality." (1) Later in the same chapter he says "there are many images of the Spirit .... Perhaps the first thing to be said in elucidation of the basic image of the Spirit as the wind is to point out that it is a dynamic model." (1) Analogy and metaphor are very common and have ancient and long usage in theology; model is recent and is probably derived from the use in science. But whether that derivation can be seen as a deliberate or conscious act or if it is rather an unacknowledged acceptance of current terminlogy is not always clear. For Ramsey (who was also a scientist) it was a conscious act, but for many non-scientists the term has become accepted more by a process of 'osmosis' and this has led to its use being less precise. Thus model is today often used by theologians and increasingly it is found to be appropriate and applicable in many and widely different areas of study. It is proving to be as useful a concept here as its use in science and although it may have a lesser role I would want to suggest that the ideas and language in one domaine can illuminate and extend those in another. The language of models can be a useful and creative method of communication within science and also within theology and between them.

Before discussing further the function and use of models in theology brief comments will be made about the use of metaphor, analogy and symbol. (a)

METAPHOR

Metaphors are very common and are a part of everyday language. Through an intelligible but odd conjunction between one context and a new or different one, new aspects and new ideas are opened up. Metaphors are not literally true, but through significant and selective analogy enable the ordering of perceptions and the sharing of experience. Poetry uses metaphor in a particularly creative way. Metaphors are dynamic, often possess emotional and valuational properties and can influence perception and interpretation of experience or observation.

S. McFague says "The most outstanding feature of the human mind is its mobility, its constant, instantaneous power of association, its ability to be forever connecting this with that." (2) This ability to make connections, to seek similarities and dis-similarities can be seen in the use of metaphors. It is difficult to offer precise definitions of metaphor because it is a way of thinking "Metaphor belongs to the semantics not the syntax of language." (3) The truth of a metaphor cannot be assessed in a literalistic manner, and this needs to be recognised since problems can arise when that does happen. "It is because some metaphors have structural

(a) There is a considerable literature which discusses, defines and applies the terms metaphor, analogy and symbol. The brief discussion here is mainly to acknowledge its existence and to recognise the necessity to note it.

possibilities that ... models can develop from them, for models are dominant metaphors with comprehensive, organizational potential." (4)

ANALOGY

There are a number of forms of analogy, and as with models there are differences in emphasis. The common definition is that analogy is the observed or postulated similarity between two situations. It is the extension of patterns of relationship drawn from one area to co-ordinate with others. Analogy is used very widely and it is frequently found in religious language.

In medieval times a solution to the problem of religious language was proposed with the development of the logic of analogy. This is a complex subject and not easy for modern minds to grasp since it requires a knowledge of the philosophical ideas of that period. However a useful summary is given by J. Hick, "Aquinas's basic and central idea is not difficult to grasp. He teaches that when a word such as "good" is applied both to created being and to God it is not being used univocally (i.e. with exactly the same meaning) in the two cases .... Nor, on the other hand, do we apply the epithet "good" to God and man equivocally (i.e. with completely different and unrelated meaning) ..... There is a definite connection between God's goodness and man's reflecting the fact that God created man. According to Aquinas, then "good" is applied to creator and creature neither univocally or

equivocally but **analogically.**" (5) This analogy is known as the analogy of being and it is presented in two different ways. There is the analogy of **attribution** (proportion). This is a direct linking of two terms (analogates) which may differ widely from each other but which one - the prime analogate - possesses a characteristic formally or intrinsically while the other has predicated a like characteristic in a derivative sense. An example quoted is that men and mountain resorts can both be called 'healthy'. Analogy of **proportionality.** This is stated as a similarity between two proportions.

" Hinting at the roots of this analogy in Greek mathematics, the analogy of proportionality is sometimes symbolised:

$$\frac{\text{God's qualities}}{\text{God's nature}} = \frac{\text{creature's qualities}}{\text{creature's nature}}$$

Either the two are to be linked (as in mathematics) by an equality sign, or they are not. If the first alternative is chosen the relation between proportions is identity, and God's goodness is to God exactly as man's goodness is to man. Identity in the relation leads to univocation and a threat to God's uniqueness. If, on the other hand, the equality sign is replaced by some other link between proportions then the analogy loses its precision and usefullness." (6)

Another problem is that 'being' is not used today in the sense used in the medieval logic of analogy and therefore it is difficult for it to add anything to our present understanding. This form of analogy at its best provided a

"framework for certain limited statements about God, without infringing upon the agnosticism, and sense of mystery of the divine being, which have characterised Christian and Jewish thought at its best." (7)

Analogy involves the creative, the imaginative and the poetic, the problem arises once analysis is attempted or if a literal interpreptation is put upon the words. The same problem that has been observed with the use of models.

In the discussion of models in science it was noted that the relationship between model and modelled can be in terms of analogy. The analogy can be of three types, positive, negative or neutral and these types are equally applicable to models in theology. Positive analogy is the obvious type and is noted in the making of relationships and the offering of explanation from the familiar to the unfamiliar. At its simplest it is seeing obvious **likenesses**. Negative analogy is the recognition of what models are **not** claiming to explain or identify. It is the dissimilar, the unlike. The criteria for deciding where negative analogy is observed seems partly from commonsense and experience and partly from experience in other areas. Negative analogy is important in theology, e.g. where it is seen in the Old Testament prohibitions against idolatory. There has to be a recognition of what God is not, for example, the understanding that humans are made in the image of God does not mean that God is made in their image. Theological insight sees the Creator as other than the Creation. In all models there is the requirement of not taking the model literally

- the recognition of negative analogy should prevent this. It is in neutral analogy that there can be productive and creative use. S. McFague says "A good model in science, and, we would add, in theology, is one with a large fund of neutral analogy, unexplored potential for connections. It is the neutral analogy that provides further possibilities for discovering new relations between model and modelled." (8)

SYMBOL

Symbols are a part of religious language and experience not only in Christianity but in all religions. The relationship between symbol and model requires consideration for in some ways there are aspects common to both, in everyday language as well in the more specialised usage in science and theology. Basically a symbol has a capacity to stand for something other than itself. Symbols are "born out of life" and "appear to be built into man's experience." (9) This aspect has been given much attention by Jung, who saw symbols as part of the collective unconscious, and therefore they cannot be created by human imagination. Symbols of light and darkness are there as part of human experience of the world. Although the same symbols are found in various religions, cultures and times and they do have a universality which derives from common experienc and a common manner of responding to that experience there are real differences in the meaning given in different cultures. (Water is used as a symbol in many religions but obviously the symbolism will have a different context in the Sahara to that in Scotland!) Even so, symbolic language can communicate the symbol to others and enable religious experience to be expressed and shared. The Bible is full of symbols which speak of the relationship of God and humankind, and this is an essential aspect of symbols in theology. T. Fawcett argues therefore

that this intuitive, experiential aspect of symbols means that they cannot be created or destroyed by intellectual argument. Symbol is used widely in science and mathematics to denote algebraic terms, physical constants or chemical elements etc. Although it perhaps would be more appropriate to describe these as signs; they are not symbols in the religious or psychological sense, but do have a universal significance and application. In some cases it would seem that symbol and model are synonymous but in general it can be said "Symbols do not denote things which are already understood but attempt to push forward the frontiers of knowledge and to mediate the reality of things." (10) There is a subjective, experiential aspect in symbol not observed in models. Models can come to have a symbolic value and symbols may be given new and deeper meanings from scientific models. Light is one of the symbols that is universal and ancient but some have found new understanding of its significance from the present scientific models of light and their paradoxical nature. A model can also come to have symbolic value when it evokes a personal response. It would seem that it is here that there is much overlap between scientific and theological models. Strictly speaking a scientific model is seen as objective and indifferent to human response, the personal is excluded if at all possible. Yet the images evoked by the scientific models can have an effect on the imagination, as has already been indicated that this aspect can be taken into religious understanding.

Metaphor and symbol will continue to have an important role in our communication of ideas, thoughts and experience. The

extension of model language to theology is proving to be an additional and valuable tool in communication today. The influence of science is ubiquitous and increasingly it is seen to affect the ways of thinking and speaking in all disciplines. This is reflected in the moves from the ontological to the dynamic, from being to becoming, which require new modes of speech: this is offered in the language of models. How the term can be applied in theology and to the Bible will be illustrated by the examples in the next chapter.

SOME EXAMPLES OF THE USE OF MODEL BY THEOLOGIANS

I. T. RAMSEY

His particular concern was with the use of model to illustrate a theory about religious language and his view is limited to that and he offers no discussion of this in context to the relation to its use in science (a). In his book 'Religious Language' he seeks to establish a logical structure for the traditional language of philosophical theology. In particular he develops the idea of the qualified model. "The function of the model is to found the theological story on empirical fact; the qualifier (a) develops such stories until a typical religious situation is evoked and then (b) claims an appropriately odd logical placing for the word "God". (1) Ramsey begins his discussion

(a) For example there is an acceptance by Ramsey of God's immutability and impassibility which other theologians would not hold. His emphasis on the 'oddness' of some religious language reflects the background of his time and the concern with linguistic analysis. However, while acknowledging these reservations about his views it is important to recognise that he probably instigated the use of the term model in theology and others have developed this for themselves.

with a consideration of what kind of situations are religious and what for these situations is the appropriate language. The nature of religious language is dependent on the understanding of the claims of religion to discernment and subsequent commitment. He considers how it is possible to talk about God, and the attributes of God. Ramsey proposes ways in which an answer can be given. Firstly, there is 'negative theology' whereby the emphasis begins with perceptual situations and then contrasts them by denial in order to speak of God. Secondly, by using the method of contrasts, where say simplicity is studied, and then its opposite - complexity - and by analysis an understanding is reached. It is the third way that he proposes that is of interest in this study, and this is by the use of **models and qualifiers**, and how they invoke a characteristically religious situation. Ramsey defines model thus "It is a situation with which we are all familiar and which can be used for reaching another situation with which we are not so familiar." (12) The model is modified by a qualifier which "is a directive which prescribes a special way of developing those model situations." (12) He then gives a number of examples of qualified models which illustrate his argument. For example the phrase 'first cause' where the model 'cause' is qualified by 'first'. It is possible to discuss the meaning, use and context of cause, it is generally understood what the word means, and its relationship to other situations. The qualifier 'first' leads the thinking about cause further and further backwards until a situation of discernment is evoked and the statement first cause leads to a religious statement about

God as First Cause. Similarly with the phrase 'creation ex nihilo' Creation as a model is understood in a straightforward sense, and is part of the language of the poet, artist, musician as well as the theologican. Qualified by ex nihilo there is a movement from the ordinary to an understanding of a relation with the whole universe - and there is cosmic discernment. Yet creation is always out of something in ordinary language; ex nihilo qualifies the model in a way in order to evoke a religious situation, and is not like the phrases which indicate that from which something is created. Religiously it makes a present claim about God rather than a statement about the past. These two examples given an idea of how Ramsey dealt with the problem of language as he saw it, and how he introduced the use of model into theological thought. However, when his discussion is considered in the context of the last chapter it seems that his use of model is a limited one. I recognise it is a tentative beginning but for me it does not really illuminate the problem of religious language mainly because his models are not like the scientific models and the use of 'qualifiers' is not now an issue.

F. FERRÉ

I have already referred to Ferré's article (chapter one, reference 1) and his use of model language in the context of what he calls 'map-making' and of how he sees the importance and practical application of the term for theologians. Thus he uses the idea of making maps as the basis for his discussion and in a clear and concise manner discusses the place of models in science. He develops his argument and suggests that as there

are models in science so there should be models in theology. His main conclusion is that models in both fields are useful as "instruments for understanding." (14) In conclusion he notes the common features and the divergent features of the use of models in science and theology. Some of these will be referred to later. Here is the stated aim of making and relating the two uses in a positive way, a way which begins the development of the philosophical understanding in theology of the place of models.

S. McFAGUE

In her book 'Metaphorical Theology' she offers the fullest discussion of models in theology of all the works which I have consulted. She notes that this is comparatively novel, although, the seeds of the idea are present in many places. She says "In the continuum of religious language from primary, imagistic to secondary, conceptual, a form emerges which is a mixed type; **the model.** The simplest way to define a model is as a dominant metaphor, a metaphor with staying power ..... . Models are necessary, then for they give us something to think about when we do not know what to think, a way of talking when we do not know how to talk." (15) She sets out her understanding of models in science and of models in theology, where they agree and where they differ in order to develop her contribution to theological thinking and its relevance for today.

From these three authors, whose writing covers some twenty years, it can be seen how the model language has been extended to theology. McFague shows the most developed and thorough survey of models in theology and science as they pertain to

her particular theme and her views have been useful to me in this thesis.

Others have also used the term model in their writings including I. G. Barbour, J. McQuarrie and A. Peacocke and N. Pittenger and these are quoted in other chapters.

There is no doubt that models have become a part of the theological vocabulary but as yet few have developed the philosophical aspects in the extensive and varied way that exists with scientific models.

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CHAPTER FOUR

THE UNDERSTANDING AND USE OF MODELS IN THEOLOGY

INTRODUCTION

In chapter two I considered the understanding and use of models in science, in this chapter I am considering models in theology along the same lines. I have already shown how the language of models has nowadays become part of theological language reflecting the extensive use that is made in all areas of life. Difficulties arise when an attempt is made at concise classification but this is probably no more difficult here than it was for models in science. As the use becomes even more widespread then subtle changes are noted, with different people placing different nuances on the word and maybe only in the longterm will a fuller analysis become possible. However, there is sufficient consensus for the present discussion and to make comparisons between science and theology. It is clear that 'model' is a valuable tool for communication, with considerable scope for creative thought. To conclude this chapter examples to illustrate the uses will be given from the Biblical models of Creator/creation.

The majority of philosophers of science agree that models have a necessary place in the practice and theory of science; although a few would argue that they can ultimately be discarded. The fact that they are being increasingly used in theology would indicate a similar status for them - they are necessary - but it is also argued that they are essential. For instance Ferré is emphatic "For not only are the models of theology essential for the interpretation of theological discourse

within the language using community but - at least equally important - these models are necessary for the expression of religious beliefs to the world at large." (1)

This discussion is concerned with models **in** theology and to compare and contrast their understanding and use with models **in** science. The questions of models **of** science was briefly mentioned, however, it is not as simple to do the same for models **of** theology. To even begin to discuss models **of** theology with all the historical, doctrinal and philosophical implications is beyond the scope of this study. There is one significant difference, for instance, between science and theology which should be noted. Science is an academic discipline and at one level theology is also studied academically, but it is far wider than that for it is rightly claimed that theology can be a proper concern of all Christian people since it relates to all of life. The models **of** theology are far more numerous, diverse and have greater consequences for attitudes and actions than those of science. To indicate this diversity one needs only to look briefly at some of the models of God. There is general agreement that one of the divisions in the models of God is between the 'monarchial' ones which stress the transcendence of God and the 'organic' which stress the immanence of God. The monarchical models have traditionally been dominant, where God is seen as sovereign ruler of all that is and is completely distinct from the created world. This model sees the relation of God to the world as asymetrical and the omnipotence of God is emphasised. The problem with this is that it can become a model where God is seen as "cosmic

manipulator, imperial Caesar, ruthless moralist, defender of the status quo and dominant male" (2) and the model has justified despotic rulers, tyranical government and the despoilation of the environment. An alternative to that one is the organic model which sees a more symmetrical relationship between God and humankind. God is involved in the world and affects and is affected by it. This is more dynamic and stresses interdependence. Other models of God are identified by other writers and Barbour, for example, lists five, monarchical deist, dialogic,agent and process models. There are limitations to all of these and the organic ones can be seen as tending to pantheism.

There can be seen some similarity here with those of science, since the model affects and reflects the approach and attitudes in science. The key difference is the claim for all theological models that they are comprehensive and involving in a way not known for science, for there is behind all the models a 'model of models'. McFague makes this point strongly "The broadest type of theological model - the metaphysical model of the relations between God, human being, and the world - is without limit ..... (it) is understood as a cosmic, metaphysical drama of relationships, of action and response, which includes everything that exists." (3)

APPLICATION AND FUNCTION OF THE MODELS

APPLICATION

The examples already given show how widespread is the application of models in theology. In fact the use is so general in all areas be it doctrine, liturgy, ethics, 'popular' religious writing or in the spoken word, that the term is found present

in much everyday language. However, when compared to the applications in science there are differences. One obvious difference is that there are no equivalents to the mathematical, structural or scale models to be found in science. The prohibitions against the making of idols would prevent the attempt to make a scale model of God! Furthermore, there is the matter of the possibility or rather the impossibility of suggesting what could be on a scale with infinity - the infinity of God. So it is with the theoretical models that the discussion is concerned and in the various examples that have been and will be given the applications will become clearer.

FUNCTION

It is possible to make some general classifications of models in theology in the same manner that I classified those in science, whilst recognising that this cannot be clear cut in either field. These will be outlined here and further developed when the similarities and differences are considered.

Communication It has already been noted that there is an extensive use of models and they have become very much part of the common language both within and between subjects. Therefore it becomes necessary to use them as a means of communicating theological truths and religious experience. In the past, allegory, images, metaphors, analogies and stories have been variously used to enable the relevance and significance of difficult concepts or religious experiences to be shared and this is seen in the writers of the Old Testament, the New Testament and through subsequent Christian history. Some material has been described at different times, in different ways, for example the parables of Jesus are called stories, metaphors and now are seen as models (by Ferré). It is of

the essence of Christianity that it is a faith to be shared, so to use model language to do this is appropriate today. Like science, theology is a communal activity and an expression of corporate as well as individual experience. Communication by models can assist the ordering of experience and its interpretation and the integration into the totality of human experience. "They not only direct attention to particular aspects of and patterns in experience but provide a frame work within which a variety of types of experience can be integrated." (4) This function will be further explored as the work proceeds.

Educational There are no equivalents of, say, the working models used in science but the models under discussion will obviously have an important role in education and teaching. As in science the same caution has to be exercised but models enable concepts to be grasped in a positive and useful way.

Interpretation and development The role of models in interpretation is as necessary a part of the process of communication in theology as in science, but it is a very different role because of what is being communicated. In theology the emphasis is on the revelatory and experiential. There is no place for the experimental as in the physical sciences. However, it could be said that there is a limited form of experiment existing when it is observed how any model works out in life and belief; some models may be discarded for the results they produce. Ferré has argued that models in theology are essential for making intelligible interpretations of experience. McFague makes a similar claim that "the central role of models in theology is to provide grids or screens for interpreting

this relationship between the divine and human". (5) The variety and nature of religious experience is considerable and it is extensively recorded and reported. Part of the function of models is to interpret the many types of experience and to relate them to other experiences and to put them into wider context. Then if the models function effectively they enable the development of new understanding of concepts and lead to new commitments for the individual and the community.

Prediction Models in science have an important role in the development of new theories and the prediction of the possible outcome of experiments. It is difficult to see a similar role for models in theology. Partly it is because they are within the unidirectionality of time in a way models in science are not, for I can repeat an experiment in science but there is no equivalent means of repeating a religious experience. Yet is also is recognised that there are models in science which are not derived from the results of repeatable experiments, e.g. models in cosmology, so again there is not a clear demarcation.

There is, however, a different kind of predictive role in theology in the sense that some models are used to suggest possible divine-human relationships in the future and give ways in which we (and God) will behave, or to indicate the probable consequence of present actions. This role is about relationships and this is different from the role in science.

Creativity and imagination Many of the models in theology are dealing with those areas of human life that are difficult or even impossible to quantify - the poetic, the imaginative,

the creative, the numinous or the emotional. There may be no doubts about the reality and the universality of religious experience but it cannot be measured in a scientific way or repeated as in an experiment! While it is recognised that models in science involve the creative and the imaginative aspects of human thinking, the aim is rather different. At its simplest it could be said that science deals with the objective, theology with the subjective but immediately examples can be given to contradict that. Probably it is best to see a continuum from objective to subjective and to see that part of the function of models is in a creative and imaginative use within that continuum.

For there are times when a scientist responds in a subjective way both in the physical and human sciences and is more involved in the models than is often assumed and theologians would claim that there is an objective reference in their studies. As examples are studied it will become clearer that there can be much valuable interplay between models in science and theology which is both creative and useful. (see appendix 1)

LIMITATIONS

There are limitations to the use of models in theology as there are to those in science and these limitations are similar in both, for example, literalism, inversion and the recognition of the nature of the relationship between model and modelled. The very human desire for certainity often leads to a literalism which fails to take into account the is/is not character of models.

Literalism can take a number of forms when the models in theology are considered and it can be a more extensive problem here than for scientists. In the Old Testament there is a continuing concern which is reflected in the laws prohibiting idolatory; the people were forbidden to make physical representations of God as objects for worship, i.e. in present day language, not to make models. Although it must be recognised that there are no prohibitions against verbal images, indeed there is a wealth of these in the Bible. One factor in the concern about idolatory was that there be no inclusion of influences from the religions of Israel's neighbours.

Today perhaps the problem is the mental pictures some people have as a result of thinking in a literal way; the inadequate or misleading ideas which can lead to a crude view of God as 'the old man with a beard who lives in the sky'. This may seem extreme but at a more general level there are problems with the model of God as father, for this is not to identify God with earthly fathers but rather to say that there are characteristics of the experience and understanding of people in their family relationships which can provide the basis of the model. A different aspect of literalism is seen in some of the extreme fundamentalist views as expressed in 'creationist' arguments. Here is found a literal understanding of the first chapters of Genesis which is seen at odds with the understanding of the origins of the earth from all other evidences available.

There is another limitation which is referred to as inversion. The model instead of reflecting and illuminating those aspects

of the relationship, for example between God and persons which are like father/child is used to insist that human fathers have a divine right to dominate. The focus thus being on only **one** aspect of a model and restricting the analogies rather than recognising the potential in the neutral analogies for many interpretations.

In some instances one **model** becomes so dominant that it is seen as the only possible model, for example, the monarchical one of God which dominated theology for many years and lead to authoritarian views of government. A dominant model is difficult to replace and a 'revolution' may be required before it can be demoted. (see the next chapter) These limitations do raise questions about the interpretation and how a community or individual recognises orthodoxy or even if there ever can be an agreed view.

SIMILARITIES AND DIFFERENCES

Some of the similarities and differences have already been considered in the discussion so far and these will be now further developed.

Similarities There is much similarity in the use, status and characteristics of models in science and theology. Barbour has summarised it thus "First ..... they are analogical in origin, extensible to new situations and comprehensible as units. Second, they have similar status. Neither is a literal picture of reality, yet neither should be treated as a useful fiction. Models are partial and inadequate ways of imagining what is not observable. They are symbolic representations, for particular purposes of aspects of reality

which are not directly accessible to us. They are taken seriously but not literally. Third, the use of scientific models to order observations has some parallels in the use of religious models to order the experience of individuals and communities. Organising images help us to structure and interpret patterns of events in personal life and in the world." (6) This last function is an important aspect. This century has seen a dramatic growth in information in every branch of life, particularly in science but also in psychology and sociology which affect the understanding of theology. Models enable new knowledge to be integrated into present knowledge. Although models in theology mainly originate out of experience and history and those in science mainly out of experiment and observation both have this same integrating function. The integration of new knowledge into present knowledge involves interpretation and there is often an interplay between interpretation and integration which is part of the dynamic aspect of models as well as emphasising the importance of their neutral analogy. The identification and recognition of the types of analogy (positive, negative or neutral) has already been noted.

Models in science and theology depend for some of their effectiveness on their ability to provide a focus for the imagination for in both there is much that is not directly observable. Increasingly it is realised that science has a place for a creative imagination which was not always recognised in the past. The understanding of science that developed in the seventeenth century was mechanistic and deterministic

and this view lasted to this century and it discouraged imagination. Yet in modern physics and astronomy the scientist is working with that which is often not directly observable (no one has seen a black hole or an atom). To convey the knowledge the scientist uses imagination to make connections, to see analogies and so suggest models. This creative imaginative aspect is similar to that in theology where the experience of God who is not seen is expressed in models. Similar historical problems are part of the ethos of seventeenth and eighteenth century Protestantism which also had little place for imagination or symbolism. It could be that the present increased use of models in theology is a way of restoring the balance and as in science the imagination will again be valued. Imaginative thinking provides models but also models lead to creative thinking, through the recognition of the neutral analogy. In both areas an awareness of the neutral and negative analogy is vital for new thinking.

Science and theology are both communal activities each with their own paradigms. Paradigm is used in the sense given by Kuhn "Paradigm ..... stands for the entire constellation of beliefs, values, techniques and so on shared by the members of a given community." (7) In such a paradigm community models provide a common means of communication and interpretation. There is a qualitative aspect in the ability of models to do this. A good model should transcend cultural and national barriers and be able to provide a common language for the religious or scientific community. The scientist communicates the discoveries that are made through the use of models,

and these can be shared and discussed. Similarly in theology, good models enable the sharing of experience and the insights of revelation. Their educational and heuristic value in both science and theology has already been discussed and shown to be of importance in teaching and communication. In both cases there is the pragmatic justification for their use, they communicate, they are useful but above all they **work.**

In both communities the traditions are transmitted through exemplars or foundational models. Barbour says "A religious tradition, like a scientific tradition is transmitted more by the memory of its exemplars than by a set of explicit principles. For the Christian community, many incidents in Christ's life ..... for a scientific community by contrast a narrower range of incidents such as Newton's experiments and ideas in mechanics..." (8) Although, I think that this is less so for scientists and there is considerable variation in attitudes to the past; for while scientists acknowledge their historical roots they are far less committed to them. (This will be discussed further in the next chapter) The question of whether the models of one community influence that of the other will be considered later.

In the next section the differences in the use of models will be discussed. One of these is the effect of models on behaviour or the way of life. However if consideration is given to other branches of science than the physical sciences, there are similarities. Models in medicine and in ecology evoke response and direct action in ways much like that of

models in theology. A mechanistic model of human sickness will lead to a doctor treating a person with drugs or surgery. Whereas with an holistic one there will be a very different approach with a concern for the psychological as well as physical causes of illness. In ecology certain models of the inter-relationships in nature will lead to action in conservation and preservation. These scientific models evoke a response and a course of action at a personal level - in some cases quite independent of a religious viewpoint - which is very similar to the response evoked by those in theology.

Ferré summarises three similarities between the models as they are seen in what they do, "First, then, a modelsimplifies the data at hand ..... (with the result that) ..... the theologian, like the scientist is justly grateful for his model. But both, need to be wary ..... a model filters facts ..... Third, that the reliance upon models ..... demands that we learn how to employ an epistemologically immediate conception "without being committed to any theory founded on the domaine from which that conception is borrowed." " (9)

Whilst many theological models are concerned with the nature of God (see I. T. Ramsey), others are concerned with the relationships between God and human beings. McFague stresses this latter function of models to interpret relationships and likens it to her observation that "scientific models .... focus not on picturing entities but on comparing and contrasting processes, relations and structures." (10)

Differences There are many differences between models in science and models in theology. At the most basic level it could be said that whereas models in theology interpret

experience and express and evoke distinctive attitudes and allegiances those in science interpret observation and suggest theories which can be tested. However, these differences are often a matter of degree than of absolute contrast, except that in theology there is no equivalent to the scale, structural or mathematical models in science. There are also many more models in theology illustrative of the complexity and richness of the God/human relationships; these also have an inter-relatedness with much variety and degrees of concreteness as well as abstraction not found in science.

A basic and key difference is that in theology the central model is all inclusive and all-embracing in a way that has no equivalent in science. This is defined by McFague as the 'original model' or 'model of models' (see reference 3), and is the model of relationship between God and the world. Ferré refers simiarly to a "composite picture, what we may call the biblical model of reality; master models which are often a panoramic mosaic picture of reality." (11) Theological models invoke a response and a reaction in the individual and in the community. They involve God/person and person/person relationships that are expressed emotionally, practically and socially, and can affect the lifestyle and life orientation of individuals and groups. Models in the physical sciences have none of this in their use; although it has been indicated there is some similarity with those from the medical and ecological fields. It could be said that there is a similarity between models in theology and

science since they both involve commitment but the commitments are of a different kind. Theological models involve personal commitments in relationship. The scientist is committed to models as the means of ordering knowledge and in their ability to provoke new ideas, but not in any personal sense. This is not to suggest that there is not a personal commitment among scientists for often there is valuable and productive commitment among members of say a research group but it is of a different kind. It is also noted here that if models **of** science were being considered then it would need to be recognised that they very much affect attitudes. There is no real equivalent in science of the role-model in theology. Role-models have an important place in theology, chiefly in the patterning of an individuals life on the that of the model of Christ or of other significant individuals. Communally this is expressed in the model of the church as the family of God. Models of God lead to worship, the outward expression of the relationship of a person to God. Kuhn and others have discussed the role of community paradigms in scientific communities, and these in some respects are similar to the role-models of theology but the difference is in **what** is modelled. The nearest scientists may come to the experience of worship in respect of their models could be the sense of awe that may be present in the face of the vastness of space, in the models of cosmology.

The personal aspect of models in theology is seen in their effect on and direction of, behaviour in the believer. Models

in the physical sciences are concerned with discovery amd systematic structures and do not affect behaviour. Again this has to be modified in respect of the human sciences, where, as has been mentioned for example in medicine, models do affect behaviour. Although in this area the model is limited to a particular area of life and is not all-embracing as the theological models.

The second key difference is to be seen in the status of the respective models. Models are basic and essential in theology, they provide the explanation of abstract concepts and enable experience to be interpreted. Ferré has claimed "The model is a **necessary condition** of theological theory." (12) It is claimed that theology could not operate nowadays without models; and this seems to be a reasonable claim because as has already been stated that this is how concepts and experience are communicated and the observation of the development of model language out of metaphorical/symbolic language. The situation is different in the physical sciences, and there is considerable debate about the necessity of models. It has already been noted that there are those who claim that they are "useful fictions" in the interim but eventually a situation is reached where they can be discarded, for at that point explanation is complete and expressed in say, a mathematical statement or a particular law. The more general view is that models have a useful and constructive value but they are not essential in the sense of theological models. The value of models in science has already been discussed in chapter two.

To summarise, models in theology are generally more comprehensive, inclusive and behaviour-directing, whereas those in science are more specific and limited; for example, the model of the atom reflects models of the planetary system but that is the extent of the influence and it is not applied elsewhere. Although there are those revolutionary scientific models which have significantly influenced the world-picture, such as the mechanistic models of Newton and the relativistic ones of Einstein.

Theological models also support many metaphors, e.g. the model of God as Father implies that human beings are God's children and that provides models of family relationships (both good and bad). In science there is not this metaphorical relationship, models are more localised and limited in application. The differences can be expressed also in terms of quantitative and qualitative properties of models. Science is concerned with the observation and evaluation of phenomena, basically the questions asked are "how" and "why", the connections are between persons and objects. It is quantitative and question of values are not normally relevant. Models in theology are concerned with meaning and value and therefore the qualitative aspects of experience, and the connections are between person and person or person and God. In the end there can be no final and clear cut agreements or distinction In the ways that the models are used there are different levels of understanding which defy clear demarcation. As a generalisation it can be said that models in theology tend to be more permanent and resist change whereas those in science are more readily discarded and replaced; the way in which models can and do change will be considered in the next chapters.

WHAT MAKES A GOOD MODEL?

In chapter two this question was asked about models in science and what was said there also applies to those in theology. A good model, as Pittenger suggests "must stand up to knowledge from many fields of expertise, must be capable of being imaginatively grasped and it must be engaging of the total personality of those who accept it." (13) The models must have internal consistency, be comprehensive, and be appropriate in the context of the parts of theology being studied. A good model will elicit a positive response enabling sense to be made of individual and communal religious experience and knowledge. A significant feature of a good model is the extent of its neutral analogy, so that new connections are seen, creative insights encouraged with an openess to further exploration, productive of new ideas so that significant new trains of thought result. There are many examples of this in theology, one being the model of the Spirit as "the wind", with all the wealth of images provoked by the exploration of the varied experience of wind; it is felt not seen yet its effect can be observed, a gale compared to a breeze etc. It is recognised that in this study the models are those in Christian theology and therefore the criteria for assessing a good model is within that context and does not take in account different cultures and religions.

THE BIBLICAL MODELS OF CREATOR AND CREATION

In order to illustrate the use of models in theology at this stage in the discussion I will focus on the Biblical understanding

of creation and God as creator, and to show how model language can be applied to this theme. (a) (The scientific models of creation will be discussed with other related topics in chapter six.) It is recognised that other religions and cultures have their own models of creation and also that there continues among Biblical scholars much discussion of the external influences on the Biblical texts, but this is not being included here.

An overview of the Biblical texts raises an immediate difference between theological and scientific models of creation and that is in respect of the **time scales** involved. The Old Testament grew out of a long oral tradition, and the written record covers many centuries. There are many strands and layers in the writing and it is difficult to make a definitive chronological scheme of the development of the models of creation. The development of the scientific ones in comparison is much clearer, more recent and in a much briefer time scale. Furthermore, the Bible does not offer a view of creation as a separate doctrinal or philosophical statement which can be set alongside and compared with modern scientific statements. For the writers of the Bible, there are no credal statements about God as creator, since for them there was no alternative. Westermann makes this point strongly, "the Old Testament notion of belief presumes the possibility of an alternative .... an alternative to belief in creation

(a) I would emphasise that what is being attempted is the application of the use of model language in the ways already discussed.

or creator is quite unthinkable. The creation of the world is not an object of belief but a presupposition for thought." (14) Therefore the models of creator/creation have to be accepted in that context and are not open to revision in the sense that scientific ones are revised. The biblical conviction is of God as creator and the creation as God's sphere of action, and many models are used to express this, as will be shown.

It was partly their experience of the natural world by the people of the Old Testament that led them to their convictions of God as creator. Their observation of, for example, storms or earthquakes led to reflection and to the interpretation and expression in some of the models of creator/creation. This "method" has some parallels in science but the scientific method and the models that result come by a different route. The scientific models assume the **reality** of creation, as do the religious models but the latter also involve the concept of revelation as well as observation and they also are based on the presupposition that this reality is not self-explanatory. In all the models of creator/creation there is one connecting and pervasive theme which can be summarised thus, that there is a moral, ethical and practical relationship between creator and created. God has concern for all of creation and, in particular, for humankind, because it is God's creation. In response humankind should offer worship and live lives in recognition of this fact. The acceptance of God as creator grew out of historical experience and is an implication of their understanding of salvation history. There is nothing

similar in the physical sciences to this response although as it has already been noted in some other disciplines such as medicine and ecology models can be seen to affect moral attitudes and action. The theological models of the Old Testament are not a response to philosophical enquiries about origins. Westermann has argued forcefully that they are rather a response to a threatening environment. He says "It was not the philosopher inquiring about his origins that spoke in the Creation narratives; it was man threatened by his surroundings. The background was an existential not an intellectual problem." (15) The scientific models are therefore very different to the religious models in this respect, partly because they come out of a different intellectual and cultural environment. As nature ceased to be existentially threatening then the leisure for its dispassionate study arose. In the earlier discussion, it was emphasised that it is important to recognise the negative aspects of all models. There are limitations to any model in the recognition of what they are not representing. This is particularly true in theological models and is expressed in the biblical tradition in the prohibitions against idolatory. The models of creator/creation are varied and are often expressed in poetic language, but always the inference is of that which is beyond description and sometimes to the limits of human understanding and imagination. This is equally true of scientific models of creation. There is also in the biblical tradition a rejection of certain models found in other traditions, such as the dualistic ones of some religions. This raises

the question of how models come to be accepted by a community, both scientific and religious communities would seem to be selective. The models of one community can well be different to those of another and there is then the matter of how they change. These questions of acceptance and how models change will be considered in the context of Kuhn's work in later chapters.

The models of creator and creation in the Bible show a richness and comprehensiveness which is not found with the scientific models which are more specific to a theory and therefore more limited. Also the religious models are used together, to reinforce and emphasise the theme and in a way which encourages the imagination. This as has been shown makes classification more difficult, for the reasons already given.

B. W. Anderson has indicated that there is much debate about the earliest understanding of God as creator and whether God was even originally for the Jewish people a creator deity. It is difficult to know what is read back into earlier ideas. He argues that the earlier traditions were of God as creator of a people rather than of the cosmos, an idea that came later. "In the Mosaic tradition, mythopoeic creation language is used to speak of the creation of a people who are given identity and vocation. In the royal covenant tradition, the language functions to show that the mundane social order is stable and wholesome by virtue of its relationship to the created order of the cosmos. And in Israelite wisdom initially sponsored by the royal court, the language expresses cosmological interest in God's past and present activity." (16)

Thus in general, Biblical scholars agree that the understanding of God as creator and the nature of the creation was not a response to questions of origins but came out of the experiences of the people. It was the experience of salvation in the history of the people of the Old Testament (particularly in the Exodus), their understanding of covenant as well as their observation and experience of ordinary life and the natural world that led to the development of the statements about the God who created all that is and continues to be active in his creation. Thus it is clear that the models of creation in theology developed from a very different perspective from those in science, and have a different status. Some of the biblical material will next be reviewed and in chapter six I will continue the discussion about models in science and in the history of Christian theology which are relevant to the theme.

SPECIFIC EXAMPLES

It is implicit in the biblical tradition that God is creator and is involved with the creation in such a way that it is not possible to consider the one without the other. Also in this study I am using the word creation in the dynamic not static sense. There is a strand in theology - the static - which stresses that the work of creation was completed in the beginning.

"And on the seventh day God finished his work which he had done" (Genesis 2 v.2). The static models have their value in the reinforcing and maintaining of a stable society. Stability can well enable people to be at peace and to be secure.

Yet there are other strands - the dynamic - which emphasise the continuing work of God in creation which will reach its culmination in the new creation at the end of time. It is recognised that this touches on the nature of God's providence but the relation of that to the present topic is outwith the scope of this discussion. Moltmann is one who has emphasised that creation is a 'process'. "It follows from this that theology must talk about creation not only in the beginning, but also in history and at the end. That is to say, we must have in view the total process of divine activity. ..... If theology wants to sum up God's creative activity, then it must view Creation as the still open, creative process of reality." (17) God not only created in the beginning but continues to sustain that which was created. The first chapter of Genesis sets this dependence in the context of origins. Anderson states "the Genesis story portrays the radical dependence of the cosmic order upon the transcendent Creator .... The cosmos is not eternal and self-perpetuating as Greek philosophers maintained: it is sustained in being by the Creator." (18)

It has been noted that there is a rich diversity in the models of creator/creation in the Bible and these can be grouped under various headings but clear demarcation is not possible since there is much overlap in concepts. Some of these will now be identified.

The model of sustaining creator is found in many places including the Psalms (Psalm 104) and Job (38-41). Thus in the book of Job there is a long passage where the Lord in a series of rhetorical questions speaks of how the world has been sustained since the beginning of time. It is a model whose purpose is to lead to worship of the creator and recognition of dependence. "When I look at the heavens, the work of thy fingers ... What is man that thou art mindful of him ... O Lord, our Lord, how majestic is thy name in all the earth!" (Psalm 8.v.3, 4 and 9). The model is also of a creator who not only sustains but cares for the creation (Psalm 33, Psalm 146, v. 5-7, Isaiah 40, Isaiah 42 v. 5-7). This is expressed in personal terms, within the context of the created order, "As a father pities his children, so the Lord, pities those that fear him." (Psalm 103 v.13), or a mother cares for her baby (Isaiah 49 v.15). In respect of earlier comments about the model of God as father it is worth noting the use of a feminine model.

The model of the continuing creative activity of God is also found frequently throughout the Old Testament particularly in the Psalms and in Isaiah. Various biblical scholars have pointed out that in Hebrew, the language is expressed far

less in noun concepts and rather more in verbs which are active and the thought is expressed in dynamic, vigorous, and personal terms, with metaphor and analogy used widely. (a) This continuing activity of the creator is vividly expressed in the passages already quoted as well as in Genesis (1 and 2) and parts of Isaiah.

Another model of creation is that it is purposeful, for example, the creator formed the earth to be inhabited (Isaiah 45 v.18-19). This is seen particularly in the first account of creation in Genesis 1, with its refrain 'it was good', for the word good in this context means fit for the purpose. This model has a particular use in that it provides a basis for the claim that human life has a purpose and meaning in a way that is not found in scientific models.

There are also the monarchical models of God as creator, the one who is ruler and lord over all that is, God rules over the natural world which is part of creation, "O Lord God of hosts, who is mighty as thou art .... Thou dost rule the raging of the sea ..... The heaven is thine, the earth also is thine ..." (Psalm 89 v.8-14), also Job 9 v.4-10. God rules over the Israelite people and is active in their history as for example in the Exodus (Exodus 15) but also in other nations (.Isaiah 45 v.5-6). This model has had a great influence on attitudes to authority and has been used at

(a) e.g. Westermann in "What does the Old Testament say about God" (S.P.C.K. London 1979)

times to justify the authoritarian rule of kings and emperors. The models need to be taken together to avoid the limitations of literalism and absolutism which have already been discussed. Macquarrie makes a simpler division of the models in his discussion of creation (a) and gives two; the first being the model of **making,** the second the model of **emanation.** The model of God as 'maker' sums up the Biblical models, it has its origins in Genesis "God saw everything he had made and behold it was very good" (Genesis 1 v.31) as well as elsewhere. The analogy is partly that of a craftsman who has made that which is fit for its purpose but also that of the artist who is intimately and emotionally involved in the making of that created. This model stresses the transcendence of God. In addition the model of "making", is often seen in terms of God the Father, but it has to be recognised that the theological models of creation have to take in account Trinitarian doctrine. The model of 'emanation' although less directly Biblical stresses the immanence of God and can be inferred from the changing concepts of wisdom in the Bible and the understanding of the work of the Holy Spirit. In the Wisdom literature of the Old Testament and the Apocrypha it is possible to discern aspects of the descriptions of wisdom for which the language of models is appropriate. There is the model of Divine Wisdom who is active in creation, giving

(a) J. Macquarrie - Principles of Christian Theology (S.C.M. London 1977)

giving meaning and purpose and is personified. R. S. Barbour describes it thus "It is a metaphysical entity, or a mythical entity, but also a recognizable moral characteristic of human beings" and "Many metaphors and similies describe this nature and activity of Wisdom .... master-workmen .... pattern or blueprint of creation .... light .... tree." (19) Words to which the term model can suitably be applied.

The process by which the features of Old Testament **wisdom** became connected with the concept of **word** are complex and are debated by scholars but the general concensus is that in the prologue to the Gospel of John the two are united and seen as applying to the person of Christ (a). In the New Testament there are the seeds of the Trinitarian doctrine which would come to fruition in later centuries and would include the doctrine of creation.

In the New Testament the concept of God as creator is generally implicit rather than explicit and continues the developments of the Old Testament understanding of creator/creation. In Paul's speech to the Athenians (Acts 17 v.22-30), the model is of the God who is creator and sustainer of all life from the beginning. The development of the ideas and understanding of the meaning and purpose of the coming of Christ into the world can be seen in the way the models of God from the Old Testament are applied to Christ, (1 Corinthians 8 v.6, Colossians 1 v.15-16, John 1 v.3, 10). How much this application can

(a) e.g. R.S. Barbour and A. Heron in Creation, Christ and Culture (T. & T. Clark, Edinburgh 1976)

be described as revolutionary will be discussed later in more detail but it can be argued from the evidence of the New Testament and all the developments of Christology, that the final and ultimate model is to be seen in the person of Christ.

I have attempted to give some general indication of how models can be used in the interpretation of the biblical understanding of God as creator and of the creation to illustrate the theme.

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CHAPTER FIVE

HOW DO MODELS CHANGE?

In the previous chapters I have already touched on the important question in the use and understanding of models - how they change or are changed. The study of the history of science can show this to be the case, the changes in the cosmological models being one example among many, and I have also indicated that models in theology also change. The examples of change are many and various and specific examples will be explored in greater detail in the next chapter.

When the limitations in the uses of models were being discussed a number of problems were identified. It was observed that some models did not change, particularly when a model becomes so identified with its source that thinking becomes 'strait-jacketed' and the acquisition of new knowledge is restricted and no change seems possible (e.g. the refusal to accept the heliocentric view in cosmology on alleged scientific and theological grounds). Progress in science, which is a response to and reflection of the understanding and interpretation of new knowledge will require the replacement of old models by new ones. Sometimes a model just ceases to be used, it becomes redundant and is quietly forgotten (e.g. the Phlogiston theory of chemists). However it is more usual for the change to be more dramatic and involve the discarding of one model and its replacement by a new and fundamentally different one. The changes are in some instances so extensive that they can only be described as revoluntionary. This is true for science, and it is possibly true for theology. The discussion is not if models change but how they change. T. S. Kuhn has made a significant contribution to this whole

discussion. In his book "The Structure of Scientific Revolutions" he makes the claim for the revolutionary nature of the changes in science. His book has been productive of a considerable literature and discussion among scientists and philosophers. I find his general argument persuasive and it has provided a useful starting point in this particular study for how models change. Many have expressed reservations about some of his arguments and conclusions and this is a continuing debate. In a way his thesis can be likened to a good model for it encourages new thinking, new ideas and he could become his own example if a new model for the way things change is proposed!

THE STRUCTURE OF SCIENTIFIC REVOLUTIONS - reviewed

Kuhn starts his study by looking at the history of science and its influence on the present day understanding of the scientific endeavour. Science is mostly represented by what he calls 'normal science' and this normal science proceeds by the accumulation of facts, theories and methods and this is reflected in the textbooks. The basis of normal science is that the scientific community presumes it knows what the world is like and there is general resistance to change. Kuhn then introduces the term **paradigm** which is a keyword in his argument and which has a number of definitions. In the postscript to his book he recognises this and makes clearer his use of the term. Basically it is used in two different senses and Kuhn defines these as follows, "On the one hand, it stands for the whole constellation of beliefs, values, techniques and so on shared by members of a given

community. On the other, it denotes one sort of element in that constellation, the concrete puzzle-solutions which employed as models or examples can replace explicit rules for the solution of the remaining puzzles of normal science."(1) Thus paradigm refers to both the **content** of science and the **communal function** of those scientists, and so provides the basis for the pursuit or normal science. In some uses of the term he would seem to see models as paradigms, "Scientists work through models acquired through education and through subsequent exposure to the literature often without quite knowing or needing to know what characteristics have given these models the status of community paradigms." (2) The sense in which he uses the term model seems to reflect some of the ambiguity that surrounds paradigm. Problems arise in normal science when discoveries are made which cannot be accommodated by contemporary theories or anomalies arise in an experiment which cannot be accounted for from previous experience. It is at this point that there is often a proliferation of theories and the associated problems of articulation which bring about a situation of **crisis.** Kuhn argues that the response to this crisis situation within normal science is varied, from the rearguard action that seeks security in the established paradigm to the willing acceptance of a new paradigm. There will be in some instances the recognition of anomaly and this results in many divergent solutions which can lead to an experience of confusion. The resolution of the crisis needs a reconstruction, a new way of 'seeing', a transition to a new paradigm in short, a **revolution.**

The second half of Kuhn's book explores the nature of these scientific revolutions. He argues that they are "non-cumulative developmental episodes in which an older paradigm is replaced in whole or part by an incompatible new one." (3) The choice between conflicting paradigms is a choice between incompatible modes of community life. In the end there is the need to change the meaning of established and familiar concepts to new and different ones and this creates the problem of the relationship between old and new paradigms. He says "the normal-scientific tradition that emerges from a scientific revolution is not only incompatible but often actually **incommensurable** with that which has gone before." (4) He sees this as the essence of the revolution and it will involve conflict and the re-education of the scientists perception. That which was seen in the context of the previous paradigm is now seen in an entirely new way, and this is likened to a 'gestaltswitch'. The difficulty in such a situation is the problem of how this is communicated for the meaning of words is changed and there is breakdown in communication. In the revolutionary experience there is no resort to a 'neutral language'. Kuhn argues convincingly that revolutions do occur but the process by which the new replaces the old is less clear. He raises the question of verification and falsification of theories and elaborates more on his understanding of incommensurability between old and new paradigms. He justifies this in a number of ways including the different use of language (e.g. 'curved' space in Einstein's theory of relativity), the different world views (e.g. before and after Copernicus), and the different problems to be solved and the different standards

and definitions. The new paradigm will succeed as it is able to solve problems, make positive predictions and enable science to continue to be practised. Revolutions cause turmoil and discomfort mentally but enable progress to be made and creativity to flourish.

SOME COMMENTS ON KUHN

The critics of Kuhn raise many points including the question of how often revolutions do occur, the meaning of incommensurable, and the tensions between developmental and revolutionary views. An initial and personal response was to note how he often uses language which is religious with his concepts of conversion and faith. The resistance of some scientists to change seemed familiar to those who reject change in religious matters! It could well be that in these ways some connections can be made between scientific and theological models and Kuhn's argument can be applied to both disciplines. For example he says "Scientists then often speak of the "scales falling from their eyes" or of the "lightening flash" that "inundates" a previously obscure puzzle, enabling its components to be seen in a new way that for the first time permits its solution." (5) Also "I would argue, rather that in these matters neither proof nor error is at issue. The transfer of allegiance from paradigm to paradigm is a conversion experience that cannot be forced." (6) Religious language indeed!

If Kuhn is right then he has illustrated very well the way in which models can change and that way is often revolutionary, the old model is discarded and new put in its place. It could be said, though, that he has chosen his examples carefully to illustrate his argument, which of course is reasonable

but it does leave other questions unanswered. Another difficulty with his view is that it seems to reject the idea that there can be any connection between the old and the new. Yet it can surely be said that the 'seeds' of any revolution will be found in what went before, no revolution, be it in politics, religion or science is without a history.

His views continue to be controversial and only some points can be considered here which are relevant to this study; these will be commented on in a general way here and further developed in the next chapter.

(i) Models which do not change.

The development of models in certain subjects can lead to those which are unlikely to change. This seems particularly true of mathematically based models and some of the structural models in the physical sciences. Developments in modern instrumentation has led to greater accuracy and more precise measurements but the models remain the same and continue to have universal application, (e.g. in the structural models of chemistry greater accuracy leads to refinements in say bond lengths but not to change in structure.) This is also true in much of modern technology for engineers will base their work on Newtonian mechanics for at this level they are appropriate; whereas the atomic physicist uses quantum mechanical standards. (The question for Kuhn is not about practical applications but if Newton's dynamics can be derived from relativistic dynamics or if they are incommensurable.)

There are instances where as a result of new discoveries entirely new models can be proposed, which are not derived or related to earlier models, they are novel not revolutionary, (e.g. the models of some aspects of brain function in terms of computers).

(ii) Incommensurability.

There has been much controversy over Kuhn's use of this term. He has stated that in a revolution there is no neutral standard for the comparison of paradigms and there are no rules by which it is possible to prove that one paradigm is superior to another. "It is the scientific communities judgement which is the ultimate locus of sciences rational authority." (7) This emphasis on the community by Kuhn has been seen by some of his critics as irrational. Yet this emphasis on the community has a wider significance for the use of models than for science alone for it is also applicable to theological models. Kuhn, it seems to me also recognises the psychological situation, which may be at variance from that of the strictly logical viewpoint. Another difficulty is whether there is a qualitative judgement involved in a change of models, and this is another aspect of incommensurability. In some cases it may well be that a new model is better than the old, but very often they deal with different questions and so a judgement cannot be made. From a pragmatic and educational view it is the model which is most universally able to convey what the scientist wishes to say that could be said to be the best. This raises the question of relativism and is part of the criticism made of Kuhn, yet it is because he is attempting to articulate the actual experience of scientists rather than establish a basis for qualitative judgements. Incommensurable is more of a comment on the inability of groups to communicate than on what is communicated. R. G. Bernstein has discussed this problem and looked at the various arguments and basically he supports Kuhn. He stresses that it is necessary to distinguish

between incompatibility, incommensurability and incomparability, since they are not synonymous. He writes "In summary we can say that for Kuhn rival paradigm theories are logically incompatible (and therefore, really in conflict with each other); incommensurable (and therefore, they cannot always be measured against each other point-by-point); and comparable (capable of being compared with each other in multiple ways without requiring the assumption that there is or must always be a common fixed grid by which we measure progress)." (8) This is useful when looking at how theological models change, for in say the incarnation of Christ it can be claimed that there is a revolution in models to which the language of incommensurability seems appropriate.

(iii) Development or revolution.

Kuhn can seem dismissive of the place of culmulative change in science. His chosen examples are mainly for the physical sciences and do illustrate his argument for revolution. Yet in all revolutions in whatever area there are certainly some continuities, e.g. a political revolution can significantly change the direction of a society but there will be continuities; there is always something from previous history present in the present.

In many instances the evidence is that models change gradually as new information is obtained and it is only in retrospect that changes can be identified. Yet even when the change is rightly described as revolutionary there will be development before and after that event. In the end it is not a matter of either/or rather a matter of both/and. Thus two parallel schemata can be identified to show how models change:-

old model _____ development _____ new model

old model _____ revolution _____ new model

Perhaps part of the difficulty is that the term 'revolutionary' makes it seem that something traumatic and on a large scale is taking place in a short space of time whereas some of the revolutions are small scale, limited in scope, and in some instances over a long time scale. It has been commented that the Copernican revolution took 150 years to complete.

THE APPLICATION OF KUHN'S THESIS TO MODELS IN THEOLOGY

In the discussion of Kuhn's work it has already been noted that his ideas have been widely applied and are being applied to models in theology. It is therefore appropriate to consider further if revolutions do occur to these and in particular the models of creation/creator. There are very real difficultie in answering this question because of the nature of the Biblical material and its history. In the first instance it is easier to see it in development terms; discussion by theologians is often in terms of the development of concepts about God throughout the history of the Jewish people and how that continued in the Christian era. However there are crucial events in that history that could be called revolutionary in their impact on the models. The Exodus being the key event for the Jewish people; for the memory of how they had been saved from slavery in Egypt and the reflection on, and interpretation of the event over the centuries dominated and directed their religious life in a way that is revolutionary. It is the time scale that is part of the problem, the revolution in the models that occurred took a very long time compared to most scientific ones. Later experiences also affected the models, the Exile and the destruction of the Temple and the contacts with

the Hellenistic world.

The development of the models is continued in the New Testament and in the teaching of Jesus there is seen an acceptance of the models of the past at times. However it is in the person of Jesus that there is that which can be called the key revolution, because of who He was, He is seen as with God in the beginning of creation and in the new creation its ultimate explanation. This raises vast questions about Christology which are not within the scope of this study but it is clear that the perception of God and the understanding of the relationship between God and the world has changed dramatically. The way this happened is along the paths as indicated by Kuhn, the comments already made about connection between old and new are appropriate here.

Kuhn noted that there is often resistance by a community to a change in its accepted paradigms and such a resistance is very strong in respect of theological models. The community of the faithful will resist change and invoke divine revelation to justify that resistance. The existence of resistence may be indicative of the actuality of a revolution in models! This involves the question of the comparison of rival models and is part of Kuhn's use of incommensurable. If there is no neutral observation language how is it decided which model is the 'best' one. Part of the function of a community is in the assessment of what makes a good model using the criteria already mentioned.

SUMMARY

In answer to the question of how models change I would summarise it briefly and simply. Some models change by development, others are discarded (sometimes deliberately, often by neglect) but there are those for which the change is so total that

the term revolution is appropriate. Kuhn has shown how that can happen and his view has wide application. In the next chapter a number of topics will be considered which it is hoped willdemonstrate and illuminate the points raised here and in the previous chapters.

REFERENCES

(1) T. S. Kuhn - The Structure of Scientific Revolutions p. 175

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(4) Ibid p.103

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(6) Ibid p.151

(7) ed. Gary Gutting, Paradigms and Revolutions p.3

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CHAPTER SIX

CONSIDERATION OF SOME TOPICS ILLUSTRATIVE OF THE THEME

Thediscussion so far has been on the understanding and use of models in science and theology and the question of how they change or are changed has been considered in the context of T. S. Kuhn's thesis. In this chapter some specific topics will be considered in greater detail to illustrate the theme and to show how this can be applied. The four topics to be considered are : -

1. Cosmological models from early times to Kepler, which includes a consideration of the Copernican revolution, Models of Status.
2. Models of origins of the earth, a study of the genesis/geology debate.
3. More recent understanding of origins and status including the present theories of cosmology.
4. Further Biblical and theological aspects.

All these are vast topics in content, time and complexity; what I am attempting to do is to trace a path through them, identifying some of the many models, showing how they have changed and trying to indicate connections between science and theology. To use F. Ferré's analogy of maps, this is a route plan rather than a large scale Ordnance Survey map. There are times when the distinction between theology and science is not clear, at other times there are no connections and, of course, there are the noted times of controversy between the two.

1. COSMOLOGICAL MODELS - THE Copernican revolution

INTRODUCTION

From earliest times humans have observed the stars and astronomy was one of the first sciences. The practical need to know the times and the seasons, the need to navigate on land and sea, and the observations of the regularities of nature all contributed to a model of the universe. The model enabled calculations to be made and it was possible to predict eclipses for example. The Greeks two centuries before Christ had developed a system of astronomy which was able to predict eclipses and calculate the position of stars and planets. Ptolemy is credited with the model in which the earth is in the centre and the planets circle around it. This proved acceptable for many centuries, since it was seen as being aesthetically and religiously pleasing as well as meeting the known scientific observations. As time passed and more accurate observations were made it was found to need modification and more complicated mechanisms were needed to make the model fit the theory. In the sixteenth century, Copernicus, a mathematician, realised that there was need of a new model and he proposed that the sun should be the centre and all the planets would orbit it in concentric circles. In the early seventeenth century, Galileo used the newly invented telescope to investigate Copernicus's theory. His experiments led him to agree with the theory although he subsequently came in conflict with the church authorities over this heliocentric view and was persuaded to deny it. The model however

was soon generally accepted and although modified by Kepler is still that in use today. This model of the solar system remains although modern measurement has improved beyond the imagining of the scientists of the sixteenth and seventeenth centuries, it serves us well and has enabled the modern space exploration to proceed. Astronauts can go into space and the Voyager space mission to the planets is possible on the basis of this model.

Development of models. In the discussion of the Biblical models the point was made that there are difficulties in tracing the development of the concepts and of recognising revolutions partly because of the long time-scales and the difficulty of knowing how much is read back into the accounts. The same questions arise when looking at the other cosmological models, particularly those from other cultures such as that of ancient Greece. The history of astronomy from the earliest times to that of Ptolemy shows many strands with many models being proposed; for this was a time of development in scientific observation and calculation. The Greeks achieved a great deal in the eight centuries from 600 B. C. and their astronomy was dominant until the middle ages. Their philosophy was closely inter-related with their science and this was to have a significant influence on Christian theology.

Aristotle (384-322 B.C.) being one of the most influential of the philosophers. He linked theory with observation and produced a model of the earth as a sphere. P. Moore says "Moreover, he gave three experimental proofs. First, he reasoned that a sphere is 'the shape that a body naturally

assumes when all parts of it tend toward the centre' - a first glimmer of the idea of gravitation. Secondly, he pointed out that the stars appear to change in height above or below the horizon according to the observer's position on the earth ..... something which is only expected if the Earth is a globe. Thirdly, he drew attention to eclipses of the Moon. As the Earth's shadow on the Moon is curved, it follows that the surface of the Earth must be curved." (1)

During this period Plato was also at work, his philosophical ideas were to have a great influence on subsequent thought. He did not study astronomy but from his reasoning he concluded that "the shape of the world must be a perfect sphere, and that all motion must be in perfect circles at uniform speed." (2) Here is an example of a model derived from theory allied to a philosophical understanding of perfection. This concept was to dominate thinking and is still to be seen in the early work of Kepler at the end of the sixteenth century. In 1596 he published his book, the "Mysterium Cosmographicum" where he suggested that the universe is built around the five regular solids of geometry. In these all the faces can be inscribed and circumscribed by a sphere. The model is complex and is an example of an attempt to use models to fit a philosophical theory for Kepler was a religious man with a theological background and in this work he desired to show the perfection of God to be reflected in the perfection of God's creation (see Appendix 2). Kepler was a brilliant theorist but he was not an observer and and so this model

is based only on theory and would later be discarded. Throughout this long period there does not seem to be any indication of a Kuhnian type of revolution, rather there was a gradual development in the ideas which reached their culmination, in the model of the universe proposed by Ptolemy (120-180) which would last until the time of Copernicus. The model was earth centered with the planets in circular orbit round it. He accepted that since "the circle is the perfect form and nothing short of perfection could be allowed in the heavens .... (it means) ..... all orbits had to be perfectly circular."(3) However, there was a difficulty for it had been observed that theplanets did not move across the skies in a regular manner but showed retrograde movement. His solution was to assume that a planet moved in its own circle (epicycle) the centre of which (the deferent) itself moved round the earth in a perfect circle (see diagram in appendix 3).

This modified model met the philosophical requirements of the time, i.e. the circularity of all heavenly motion and the immobility of the earth at the centre and this ensured that the desire for stability and permanence was met. This model was concerned with the status of the cosmos only, for the Greeks did not apparently ask questions about origins. The model worked in a practical way for it supplied the basic information that people needed for time-keeping and calenders as well as for navigation.

The Copernican revolution. In chapter five I discussed Kuhn's thesis and made the point that some revolutions took a long time to complete and this is certainly true of this one but

there can be no doubt that it can be so classified.

Copernicus (1473-1542) had a varied career, he practised medicine, was a statesman and a canon of the church. His main interest was astronomy, not as an observer but as a theorist and most of his work was based on the observations of others. While he was still young he began to have doubts about the Ptolemaic system and in a short treatise (written probably between 1510 and 1514) - The Commentariolus - he set out his reasons for this and sets out his own system in his seven axioms which state that the earth is not the centre of the universe but that the sun is and that the earth rotates on its own axis. It was not until almost the end of his life that he published the book which set out his evidence for these views. It has been told that he only received the first copy of "De Revolutionibus Orbium Caelestium" as he was lying on his deathbed. The **revolutionary** statement is that the earth **moves.** He provided a comprehensive system for how this might be. The consequences of this were vast since they affected the ideas of religion and philosophy. The conventional wisdom of the time with its origins in Greek philosophy was of a stable, unchanging earth which was at the centre of the universe. This was also reinforced by the theological thinking of the time, God had established the earth on firm foundations, it could not be moved, it was at the centre and to suggest differently was not only heretical but also upset the established political system. If the earth revolves around the sun, if it is a planet like

other planets, if it is not at the centre of the universe, then where is God in the limitlessness of space (a). It was others who developed and consolidated the Copernican theory but the revolution had begun with him and is rightly called after him. It took some fifty years before the ideas became accepted and three men in particular are significant in this, Kepler, Tycho de Brahe and Galileo, all in different ways put the theory on a sound scientific basis.

Consolidation: Kepler (1571-1630) while a student became convinced that the Copernican system was correct and he tried to establish a mathematical basis for the system. He was a brilliant theorist but he was not an observer and in his later work he used the observational data of Tycho de Brahe. As a result of all the turmoil of the Reformation he was forced to leave his home and he joined Tycho de Brahe in Prague and after the latter's death he studied his observational data and continued the task of working out a system which fitted that data. In particular, he worked on the orbit of Mars and after much mathematical calculation he came to the correct conclusion that the orbit was elliptical not circular. Here was another part of the revolution, and there is the added fact that the Copernican model is put on a sounder basis.

From this he went on to ask the question of why this was the case and to see that there were laws which were applicable to the solar system and he drew up the Three Laws of Planetary

(a) It could be said that this questionis implicit in the Ptolemaic model as well!

motion which are the basis of subsequent theories. In summary these state, one, that a planet moves round the sun in an ellipse, two that the radius vector of the planet sweeps out equal areas in equal times and, three, that for any planet, the square of the sidereal period is proportional to the cube of the planet's mean distance from the sun. The Copernican model has now been put on a sound mathematical basis.

The establishment of these laws was only possible as the result of the work of Tycho de Brahe (1546-1601) who was a diligent observer who made accurate, precise and continuous measurements of the stars and planets. However, it is known that he never accepted the Copernican model, partly because of his religious views and partly because it would mean that the stars were unimaginably remote. He accepted the Aristotelan view of the unchanging heavens and his model was one in which the planets revolved around the sun and the sun, moon and planets orbited the earth. Yet it was his observations that enabled Kepler to put the Copernican theory on a scientific basis.

Galileo (1564-1642) was a great experimenter and he is regarded as the founder of experimental mechanics. He became professor of mathematics at Pisa and this required that he also taught astronomy. He became convinced that the Copernican theory was correct although he was still required to teach the Ptolemaic system. In 1609 be heard of the invention of the telescope and constructed one for his own use. Between 1610 and 1619 he used his telescope and by its means made a number of important discoveries which provided the confirmation of the Copernican

system. His observations of Venus showed that the full range of phases, from crescent to full disc could be seen; this is only possible if Venus orbits the sun and if the sun is at the centre. He also observed that Jupiter had four satellites orbiting it, in contradiction to the traditional view that the earth was at the centre of everything. Galileo had firstly observed the moon and discovered that the surface is rough and mountainous like the surface of the earth. He made drawings of what he saw and attempted to measure the height of the mountains. In 1632 his book "Dialogue Concerning the Two Chief World Systems" was published, which sets out his arguments for the heliocentric system. The consequence of this was the conflict between him and the church; a complex story which ended with his trial and recantation in 1632. (He lived on under virtual house arrest until his death in 1642.)

Galileo and Kepler had briefly correspondedbut they never met and it would seem each worked independently of the other. It has been noted that Kepler had used the extensive observational data of Brahe for his own theoretical work. All three contributed to the establishment of the Copernican model on a sound scientific basis and this model of the solar system has remained unchanged since that time.

This brief historical survey gives a general overview of how the model changed; the question is whether it merits the description revolutionary according to Kuhn's thesis. I think that it provides a good example; there had been a long period of increasing modifications to the Ptolemaic

model to deal with discrepancies, leading to a crisis and after a time to a resolution and the establishment of a new model. In this time not only did the model change but there were such significant changes in the world view that the new can be said to be incommensurable with the old. Macintyre has summed up this "What the scientific genius, such as Galileo, achieves in his transition, then, is not only a new way of understanding nature, but also and inseparably a new way of understanding the old science's way of understanding nature." (4) The revolution in the understanding of the scientific model can be summed up thus:-

a) The centre of the solar system is the sun not the earth.

b) The earth revolves on its own axis.

c) The orbits of the planets are elliptical and not circular.

d) The moon orbits the earth and Jupiter also has its own orbiting satellites.

e) New 'stars' are observed (the supernova) and the telescope indicated that there were many more stars than had been thought. In particular the work of Galileo led to a **changed understanding of science.** This has been usefully summarised by Barbour. "The Middle Ages sought explanations in terms of the true **form** or intelligible **essence** of an object and the **purpose** it fulfilled. Attention was directed to the final end and not to the detailed process of change ..... medieval science was primarily **deductive** ..... rather than inductive .... Galileo deliberately set aside all questions of purpose and "final cause" and introduced a totally different kind of concept for the interpretation of nature." (5) There was a **changed**

picture of the universe. Christian Theology and the Aristotelean and Ptolemaic cosmology of the Middle Ages had combined to give a model of the universe which was static, everything had its proper position and destiny, status was graded in a heirarchy of reality and the natural world was complete and unchanging. Now this was changed, a new and different picture was proposed, one that would eventually lead to the modern day understanding. Kepler had shown that the laws of physics were universally applicable and Galileo had made the connection between experiment and theory explicit. Lastly, there was a **changed understanding of theology.** It is noted that the changes were due not only to the Copernican revolution but also to the turmoil of the Reformation. The Scholastic thought focussed in the teaching of Aquinas, provided an integrated intellectual system. "Reason is an important preamble to faith ..... But this natural theology remained secondary to revealed theology..... Revelation is necessary because the most important truths are not accessible to reason. ..... faith is ..... the acceptance of revealed truth on the authority of the church ..... the Bible was only one element in this total system." (6) Humankind was at the centre of the created order and nature was the setting of the divine plan. This was all to be changed, the vastness of the universe, that the earth was no longer the centre and the first forays against Biblical literalism all meant that a new understanding of the place of humans in the divine plan was required. However, it should be said that in spite

of all these changes there were few signs of the conflict of science and religion that was to dominate later thinking. Kepler and Galileo remained faithful Christians throughout their lives and saw their work to be a means of increasing the knowledge of God's world. (Also see section 3).

2. MODELS OF THE ORIGINS OF THE EARTH

Introduction. Another area which is particularly relevant to this study are the genesis/geology debates which occured in the late eighteenth and early nineteenth centuries. It is a complex area with many strands but it provides further illustrations of the inter-relationships of models in science and theology and of Kuhn's thesis about revolutions.

In the period under consideration (1780-1830) the attention was upon the earth itself; the heliocentric model of the solar system had been accepted for over one hundred and fifty years and although there had been considerable improvements in the quality of telescopes and observational techniques, it remained unchanged. At this time there developed, mainly in Britain, a very vigorous debate about the origins of the earth among those who studied the new science of geology. Geology had grown out of the study of mineralogy and the study of natural history. There were strong religious overtones in this search for understanding and interpretation of the observations, for they were expected to be in accord with the understanding of the book of Genesis. The majority of those who were involved assumed the literal veracity of the accounts in Genesis both of the creation and the flood, and that Moses was the author of the book. The flood in particular

being crucial to the arguments . C. C. Gillispie in his book, "Genesis and Geology" gives a detailed study of this discussion and this work provides the basis for this section. The result of this debate was to establish a new model for the origins of the earth which would be incommensurable with the old one. This new model would subsequently be one of the factors in the development of Darwin's theories and later to the separation of scientific and theological models. In order to show how the revolution came about the main historical factors will be briefly reviewed.

Beginnings. It is a complex story and in order to outline the key issues and individuals I have summarised them in chart form (appendix 4). However, this is a simplification and it cannot therefore indicate all the subtleties of the discussion. The latter part of the eighteenth century was a time of great increase in scientific research, both qualitatively and quantitively. It was the time of the foundation of new scientific societies in Britain, including the Linnean Society, the Lunar Society in Birmingham and the Royal Society of Edinburgh. (The Royal Society of London had been founded in 1660.) These were broad based and showed little specialisation and all subjects of interest were discussed; natural philosophy, religion and politics and the results of their deliberations were published in their journals. It is in these that much of the geological material was published.

William Paley (1743-1805) in his writings, particularly in "Natural Theology, or Evidences of the Existence and Attributes of the Deity, collected from the Appearances of Nature" summed up the general understanding of his time. In fact, it could be said that the title of his book sums it up! He was utilitarian

in outlook and expediency was the key to his thinking; he saw the evidence for the existence of God as designer in the purposeful and benevolent aspects of nature. "There cannot be design without a designer; contrivance without a contriver; arrangement without anything capable of arranging ..... Arrangement, disposition of parts, subserviency of means to an end, relation of instruments to a use, imply the presence of intelligence and mind." (7)

Paley's models of God and of science were typical of his time and have their origins in the mechanistic models of Newton. It was still a static model of the world and the task of the scientist was seen to be that of elucidating and describing the natural world. Around 1790 when the debate was about to begin the consensus of views has been summarised by Gillespie thus:-

"1. It was recognised that fossils were the residual remains of living creatures.

2. Noah's flood probably accounted for the presence of fossils on mountain tops.

3. The flood was universal and was the agent of vast changes and accounts for the present appearance of the earth.

4. The earth was not of great antiquity, it had a beginning and was thought to be about six thousand years old.

5. There were two views of the creation of animal and vegetable life; one stated that there had been one act of creation, the other that there had been a number of special creations. Both views assumed the permanance and immutability of species and that humankind was of recent origin.

6. God was governor as well as creator and Genesis was taken in a completely literal way." (8)

The general concerns were to ensure that the geological models did not contradict Genesis and that atheistic interpretations were not allowed to infiltrate from elsewhere. The models of origins were required to fit the theological models derived from the understanding of that time of the book of Genesis. In the background there was a desire for stability which had its own history in the politics of the time. This is the background from which the arguments proceeded and which would undergo a change so extensive that it can certainly be termed a revolution according to Kuhn's criteria.

The debate. As the debate began there were two main schools of thought, the Neptunist and the Vulcanist. The founder of **Neptunist** geology (or geognosy as it was termed), was A. G. Werner of Saxony and his system was expounded by Robert Jameson of Edinburgh and Richard Kirwan of Ireland. Their argument was that all rock formations had been precipitated either chemically or mechanically from aqueous solution and this had taken place in clearly defined stages which accounted for the strata to be observed in the rocks. The problem was that this system could not explain the existence of non-horizontal strata or where all the water had gone, but its advantage was its simplicity and that it made no demands for a lengthy time scale.

The opposite view, the **Vulcanist**, was put forward by James Hutton in his "Theory of the Earth" (1795), which was the first comprehensive treatise on geology. This book was concerned

with the dynamics of the earth rather than its origins; John Playfair of Edinburgh developed the ideas further. The approach was vigorously empirical, requiring that only that which is observed now is relevant. It was observed that basically two kinds of rock were present, the igneous and those of aquatic origin, and that only intense heat could cause the observed effects. Volcanic eruptions were the source and sign of this great and powerful heat. The theory explained much that the other did not but it required the assumption that a vast length of time was needed for the changes since they were very slow and this view was not yet acceptable. Hutton's views were attacked by Kirwan basically because Hutton did not seem to accept the literal understanding of Genesis and was not concerned about origins. Kirwan argued that Moses must be taken as the guide to the events of the earth's history and geological theories must be set alongside the Mosaic account. Jean André Deluc, although supporting the Neptunist view, suggested that there were two distinct eras, the first formative period which gave rise to the continents which could have taken a very long time, the second was the recent period which began with a great flood and resulted in the earth as we now know it. Playfair responded by defending Hutton against the charge of atheism and emphasised the religious dimension of their views and how these testified to the work of God the Designer.

So the argument continued, with others becoming involved; there was as a result a number of different models of the origins of the earth but which all had in common the desire

of their proposers to relate the geological to the Biblical. Certainly no one seemd to question the historicity of the account of the flood in Genesis. Yet it can be seen that there was (perhaps unconsciously) a movement from the static models to more dynamic ones.

Resolution. Between 1791 and 1799, William Smith, through his work as a drainage engineer had observed the fossil content of rocks and he realised that the "proper way to investigate, classify, and describe stratigraphical structure was by means of the characteristic fossil content of successive formations." (9) The significance of his work was not recognised until the 1820's and then only through the writings of Joseph Townsend, who rejected most of both the Neptunist and Vulcanist arguments and yet still claimed that the geological evidence was consistent with the Biblical accounts.

Between 1820 and 1830 a different theory was proposed by William Buckland that of **catastrophism** and he was supported by Georges Cuvier, a comparative anatomist who had observed that there were fossil remains of animals which no longer lived on earth. They suggested that the changes had been caused by cataclysmic events which had occured throughout the history of the earth, culminating in Noah's flood which was assumed to be a universal deluge. Buckland continued in the tradition of seeing in the study of geology the study of God's creation and he argued that the facts were consistent with Genesis. In 1821 he made a thorough investigation of a large cavern in Yorkshire where a vast number of bones of prehistoric animals were found and which he saw as firm evidence of the

flood. (Evidence for his diluvial theory). Increasingly at this time, there were questions about the evidence and its interpretation, in particular there were reservations about the extent of the flood, catastrophic chronology and the age of the earth.

The **resolution** came in the work of Charles Lyell in his three volume work "Principles of Geology" (1830-3), and a new model was proposed, a model which did not require that geology conform to a literal understanding of Genesis. Gillispie says "Lyell's ideas seem to have formed rather suddenly." (10) In the context of my reading of Kuhn this is a key factor in a revolution, "these ..... (crises) .... are terminated, not by deliberation and interpretation but by a relatively sudden and unstructured event like the gestalt switch." (11)

His **Uniformitarian** theory was to provide the basis of the new model. "He did not, of course, deny the reality of change, but he insisted that all change had been uniform, proceeding in cycles in time rather like the orbits in space through which the planets swing." (12) An example of how models in one area can be suggested by those in another and a part of their creative aspect.

The changes to be observed had come about through a variety of causes, the action of the atmosphere, of living organisms, of earthquakes, of volcanoes and above all the action of water. The consequence was that the Biblical flood was no longer seen to be the primary and universal geological agency or even necessary for the chronological classification. More importantly was the acceptance of the great age of the

earth, although this was still far less than the figure accepted today. But the revolution had occured, the new model replaced the old; there would still be debate before this would be accepted, the usual consequence of a revolution. There could be no return to the past and the way was prepared for Darwin's theories which would be part of the separation of science and theology.

3. MODERN COSMOLOGICAL THEORIES

Introduction It is in the last hundred years that there has been a considerable development in the scientific models of the origins of the earth and of the universe and this development has been separate from any of the theological thinking. Thus compared to the two topics already discussed, it is a very different scene and illustrative of how the scientific models today are independent of the theological. It, therefore, becomes a task for theologians to offer reflections and reactions to the scientific models.

The Copernican model of the solar system is limited by the assumption that it is a uniform, unchanging, static system and it does not offer any answer to the question of how it is as it is. At present the key question is about the beginning and a number of models have been proposed, the one that is now most widely accepted is the 'Big-Bang' model. (However it is salutary to be reminded as by M. Hesse that in this area as in most of what has already been discussed that the evidence on which the theories are based is underdetermined.) However, this view does not take account of the imaginative power of a model which can lead to a new and better understanding and interpretation of the albeit limited information.

The traditional view that the solar system is uniform is still held and has been extended to the Universe; the acceptance of this is the result of a number of different observations which will be noted later. J. Gribbin sums this up "the idea that the Universe at largelooks the same wherever you are in it - in other words, not just isotropic but homogeneous. The idea that the Universe ought to look the same, in broad outline, in all directions and to all observers in it is so important that it is called the cosmological principle - and without this uniformity, there could be no successful science of cosmology." (13) The model of the Universe now is that it is uniform, changing and expanding. The basis for how this can be, will now be explored.

Einstein model In 1916 and 1917 Einstein published his papers on general relativity which provided the basis for modern mathematical cosmology. The papers only indirectly mention astronomy, but the results of his theory were to revolutionise thinking on the subject. This revolution in the models proposed was far-reaching since it altered the framework of rules from which predictions about the world can be made. W. McCrea sums up the change "Classical physics uses a universal three-dimensional space and a universal one dimension time. Special relativity physics uses one four-dimensional "flat" space-time. General relativity uses four-dimensional space-time. General relativity is expressed in mathematical equations and the result is that there is a single entity which models space-time and matter. There are no boundary conditions, and a system so defined is termed a universe." (14) Einstein in a final short paragraph

to his paper, mentions the actual Universe of astronomy and expresses the possibility that his model might roughly approximate to it. His model is a self-consistent **theoretical model** which provided a new theory of gravitation. The model is derived from Einstein's **thought**, not from observation and is an excellent example of a theoretical or mathematical model. (See chapter two.) From this theoretical model three predictions were made, firstly the advance of the perihelion in planetary motion, secondly the bending of light rays in a gravitational field, and thirdly the gravitational red-shift of lines in spectra of radiating massive bodies. The first was verified by the known and hitherto unexplained discrepency in the orbit of Mercury. During an eclipse of the sun in 1919, observations were made which verified the second and the third is a consequence of the equivalence of mass and energy, (Einstein's equation $E=mc^2$) and which experiments in physics have confirmed. Yet, as J. Gribben says "Einstein's equations describe the geometry of space-time, and naturally he wanted to apply them to the geometry of all space-time - the Universe itself. He tried to do this in accordance with the then current paradigm that the Universe is isotropic ..... homogenous ..... and static. But he failed. The simplest interpretation of the equations only allowed non-static models." (13)

Friedmann models. In 1922 Friedmann produced solutions to Einstein's equations which showed that the Universe had to be either expanding or contracting. Observation indicates that it is expanding and this proposed model is now generally accepted. If the Universe is expanding then it must have

been more compact and taken to the limit there must be a point beyond which it is not possible to go, that point being the Big-Bang. Penrose and Hawkins have concluded from the general relativity theory that the Universe must possess one 'singularity' at least. "In the context, singularity is a sophisticated concept to define, but it means an event in space-time where the physical behaviour, that holds good at non-singular events, breaks down. This implies that there cannot exist a relativistic cosmological model that does not exhibit a big bang or some such set of features." (15)

Big-Bang models. From these models, a new theoretical model was proposed and formalised in 1948 by Gamow, Alpher and Hermann as the Big-Bang model. The significant fact in these models is that they provide instances of the interplay between theoretical and observational models and also examples of the power of prediction that exists in a good model. Prediction that is subssequently confirmed through observation, experiment and calculation. From the Gamow model came three predictions, firstly that the universe is expanding, secondly that there should be a background radiation and thirdly that there is a definite hydrogen/helium proportion in the Universe. In the 1920's Edwin Hubble made many observations and from these deduced that there were many galaxies which are evenly distributed across the sky. Through his measurements of the 'red shift' of these he was able to make estimates of distance and suggested that they are proportional. This became known as Hubble's law and is evidence for an expanding universe and since all galaxies are apparently moving away

from every other one, this is seen as further evidence for a uniform Universe. The proposed big-bang would have generated a vast quantity of heat which would have gradually dissipated and the residual heat should therefore be observable. In the 1960's Penzias and Wilson were working on radio communications and were puzzled by a universal background 'noise'. Investigation showed that the origins of this was in deep space and that it showed a spectrum of thermal radiation at 3K. This microwave radiation was further evidence of the big bang and provided the means of estimating the age of the Universe. (10-20 thousand million years.)

Observations had shown that helium accounted for about twenty five per cent of the mass of visible matter in the Universe and that hydrogen accounted for most of the rest. This again is found to be uniformally distributed. Theoretical calculation from the known constants of physics, estimates of the expansion rate of the Universe at the time when the reactions to produce helium would have occured produced a similar result which thus confirms the theory.

Conclusion. Other models have been proposed as for example, thesteady-state theory and there continues discussion about the Big-Bang theory and there are many unanswered problems. There does not as yet seem to be a revolution in Kuhn's terms rather a developing and growing understanding. It could possibly be argued that the present state of cosmology is in the 'pre-revolutionary' stage with a number of conflicting views. V. Clube has summarised Kuhn's argument for revolutions

in respect of the cosmological theories and says "Let us have no illusions about the position - many experienced astonomers are quite certain that revolution is round the corner. From this fact springs much of the excitement in modern astronomy." (16) Only time will tell!

Anthropic principle An interesting aspect of the discussion of the models is that philosophical questions are being raised including those about the ultimate fate of the Universe, the fact that all the features are essentially determined by a few basic physical laws and constants and this universe is comprehensible. Brandon Carter has enunciated what he calls the 'anthropic principle' which says "that a world containing men is not any old universe, 'specified at random' so to speak, but it has to have a very particular character in its basic laws and circumstances." (17) This could possibly lead to a new argument from design and thus bring back a theological dimension into the discussion.

4. FURTHER BIBLICAL AND THEOLOGICAL ASPECTS

Introduction The Biblical models of creator/creation have been considered in chapter four and the way the first chapters of Genesis were used in the geological debates has also been discussed. Throughout most of Christian history, the Bible has been central to the understanding of doctrine although the exegesis and methods of interpretation have changed. For example in the early centuries allegorical interpretation predominated, to be replaced for a time by a literalism which still has reverberations today in some fundamentalist groups. The difficulty is how far it is possible to think oneself back

into a different cultural and religious understanding and so discern how people saw the question of God as Creator and the nature of creation. It is a complex and long history and all it is possible to do is again make some 'markers on the map'.

In the earlier sections I have outlined how the Greeks had studied astronomy and the influence of the Ptolemaic model which persisted until the Middle Ages. There is little evidence that the Jewish people studied astronomy apart from the practical requirements of establishing an accurate calender so that the dates of festivals could be determined and in particular the start of the Passover. R. Hookyas emphasises the difference between the models of the Greek philosophers and those of the Bible and the consequences of this. "There is a radical contrast between the deification of nature in pagan religion and in a rationalised form, in Greek philosophy, and the de-deification of nature in the Bible ..... In the first chapters of Genesis it is made evident that absolutely nothing, except God, has any claim to divinity." (18)

That there were differences is clear but the background assumption was that there was no separation between sacred and secular and it was not until the 19th century that the division came about. Both types of models were linked through the influence of Greek philosophy on theology.

The Reformation and after The revolution in models of cosmology that took place at this period was to have an impact on the concepts of the world. As a result of the work of Kepler and Galileo it was no longer possible to hold that circular motion was the ideal and what the Creator must have intended, nor after the observation by Brahe of a new star that the

heavens remain as they were created at the beginning. There are the beginnings of the recognition that this is a changing not static world, and that the models will also change. Yet in all this the aim of the scientists was the desire to express their conviction that they were studying God's world. The title of a book by John Ray published in 1691 "The Wisdom of God manifested in the Works of Creation" in fact sums up the attitude exactly. There is much debate about the effects of the Reformation on scientific research and the reasons for the great explosion of work among those of Protestant and Puritan persuasion. Robert K. Merton in 1936 in an important paper said "It is the thesis of this study that the Puritan ethic, as an ideal-typical expression of the value-attitudes basic to ascetic Protestantism generally, so canalised the interests of seventeenth century Englishmen as to constitute one important **element** in the enhanced cultivation of science. The deep rooted religious **interests** of the day demanded in their forceful implications the systematic, rational, and empirical study of Nature for the glorification of God in His works and for the control of the corrupt world." (19) There is yet no indication of a division between science and theology, but the question of a literalist view of the Bible was being raised. Some writers, for example, suggested that the authors of the Bible had written at the level of the uneducated. John Colet in 1500 said "Moses proceeds in due order to deal with particular objects and set before us the arrangement of the universe in detail. And this he does in such a way, in my opinion, that we may

perceive him to have regard to popular conceptions and to the uneducated multitude whom he taught." (20)

Newton (1647-1727) is rightly remembered for his significant contributions in science but he also wrote on theology. The result of his and others thinking resulted in the mechanistic model of creation; God was seen as a Divine Clockmaker who set the world going and then had left it to its own devices.

Newton also suggested a model of God as Cosmic Manipulator who stepped in when necessary to make corrections to the progress of the movements of the planets in the solar system.

The scientists saw themselves involved in a religious task but from the formularies of the churches there is little evidence of any impact of science on the official teaching. The Book of Common Prayer (1662) and the Thirty Nine Articles merely refer to God as Creator in the creeds. The Westminster Confession adds slightly to this "It pleased God the Father, Son and Holy Ghost, for the manifestation of the glory of his eternal power, wisdom and goodness, in the beginning, to create, or make of nothing, the world, and all things therein, whether invisible or invisible, in the space of six days, and all very good." (21)

It was in the eighteenth century that there was the development of study of Natural Theology as for example in the work of William Paley (1734-1805). He sought to prove the existence of God from the evidence of nature. His arguments owe much to earlier ideas but his approach was clear and summed up the theological thinking of his time. His book was to become a classic and influenced thinking throughout the nineteenth century. The model of God as Creator that can be derived

from his work was that which was generally accepted in Britain. The model was deterministic and mechanistic, the key idea was still of the Divine Clockmaker which was explored with its implications and predictions, in a consistent manner. The literalism in the genesis/geology debate was partly as a consequence of this view. The very many developments in science and in biblical theology in the nineteenth century are only indirectly of concern in this thesis and it is not possible to review them here. That there was much controversy is clear and this controversy can be seen focussed in the debates on Darwinism. The result of these complex and at times very heated debates was to see the division of science from theology. The consequences were that two key changes can be observed in the scientific models, firstly to see that nature is dynamic, it is in a state of change and that there are many interacting forces to be seen, and secondly that the rule of scientific laws could be extended from the physical to the biological world. The argument from design was challenged and it became realised that humankind was part of the animal kingdom and not necessarily a special creation. This scientific model would eventually lead to a reconsideration of the theological models.

Present day In chapter four I sought to show how extensive is the use of model language in theology today, and that it is in all areas not just in the subject of this thesis. The relationship between models in science and theology is a changing feature as has been indicated, from the close inter-relationship of earlier centuries to the divisions of last century to the new influences today. It is recognised

that there are two aspects of this, firstly the use of scientific models in the arguments for a belief in God - the emergence of a new form of the argument from design and secondly the implications for the models of God as for example in renewed emphasis on the place of the imagination. From what has already been discussed it is clear that as there has been a revolution in scientific models from, for example, the static to a dynamic understanding of creation, so there has been a similar revolution in theological models in recent years. One notable attempt to express a dynamic model of continuing creation occurs in process theology; this is a subject which is too large to approach here. (It is noted and I realise that it could be an area for future investigation for me.) The consequences of present theological study is to provide some new models; the models of God are of a creator who is active in the creation, who is in relationship with it, who is a suffering God, who cannot be defined in only masculine terms but must include the feminine and yet is beyond time and space. In a similar way there are those who argue that creation must be seen as dynamic and continuing and which is an 'open' system, views which are very different from earlier centuries.

Conclusion

Four topics have been considered to illustrate my theme showing the application of model language and considering the nature of the changes in the understanding of creator and creation that have taken place. In the study of the Copernican revolution it was observed how the theological and philosophical perspectives

of the period often dictated the nature of the scientific approach. This is still to be observed in the genesis/geology debate, where those involved tried to be true to the then generally accepted literalistic interpretation of the Bible. However, when the recent scientific theories of cosmology and the proposed models are considered, it is clear that these are considered quite separately from any theological viewpoints. Generally it seems that in this century it is the scientists who have "set the agenda" and the theologians who have followed along; or at least that is how it can appear to those outside and it is relevant to ask how far theology is or should be dependent on scientific models for its expression. In this thesis I have tried to show the nature of possible inter-relationships, and I think that is a valid area for exploration with both disciplines making useful contributions to the fuller understanding of the issues involved. I stressed earlier the creative and imaginative features in models both in science and theology, and it is here that I feel there can be positive and valuable communication between scientists and theologians.

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CHAPTER SEVEN

CONCLUSIONS

I have considered the understanding and use of models in science showing how philosphers have explored the different theories of models and then how they are used in practice. The functions and applications were explored to show the extent of that use. It is recognised that there are limitations in their use, and that for some people these limitations are such that they would want to discard models altogether. However it has been my aim to show that in science they are a necessary component in the development and communication of theories and concepts. I then continued the discussion to show how the language of models is extended to theology and to indicate the relationship with analogy, metaphor and symbol. The next chapter looked at the understanding and use of models in theology along the same lines as those in science. Here it was shown that there are ways in which they are similar, particularly in the ways that they function and in their ability to be effective in creative and imaginative thought. Consideration was given to the effect that models have on the thinking and action of individuals and communities and it was recognised that in both spheres they evoke response albeit of very different kinds. Yet there are differences, (which were discussed in chapter four) and these are mainly that the models in theology interpret experience, whereas those in science interpret observation. I also argued that models in theology are more comprehensive

and inclusive and support many more metaphors then in science.

I hope that in this discussion and the comparisons of the understanding and use I have shown that they have an importance and value particularly in communication and interpretation. Particularly in theology it would seem necessary for communication to be in contemporary language and that will mean that this will include the use of models. I would want to stress their usefulness while still recognising the limitations and the need for understanding of the theoretical and philosophical background.

Another consequence of this study has been the recognition of the significance of models in the exposition and interpretation of the doctrine of creation. Since the time of Darwin, Christians have often been on the defensive when faced with the evidences of science, for say, evolution or the origins of the cosmos. For some the response has been to retreat into literalistic interpretation of Genesis and a rejection of the scientific consensus about origins; others have interpreted the Biblical accounts of origins only in the context of the scientific theories. The language of models, properly understood offers one way for a positive theological approach to these responses and the means of making connections with the scientific understanding. A number of authors, including some of those I have cited, have in a variety of ways sought to do this. The language of models has become one of the tools that is used. The obverse of this is the acknowledgement of the place of the creative imagination in science and that the concepts of, for example cosmology or atomic physics are productive of ideas which are more than the mere scientific statements.

I recognise that care has to be taken not to confuse logical types. Thus the question has been raised as to whether the complementary models as in physics (e.g. wave/particle duality) can be extended to theology. It is an interesting matter but there are difficulties chiefly in that the relationships involved are in very different categories. I would see this as an area for further exploration but this is beyond the scope of this work, however, I do think that there can be useful 'cross-fertilisation' of ideas.

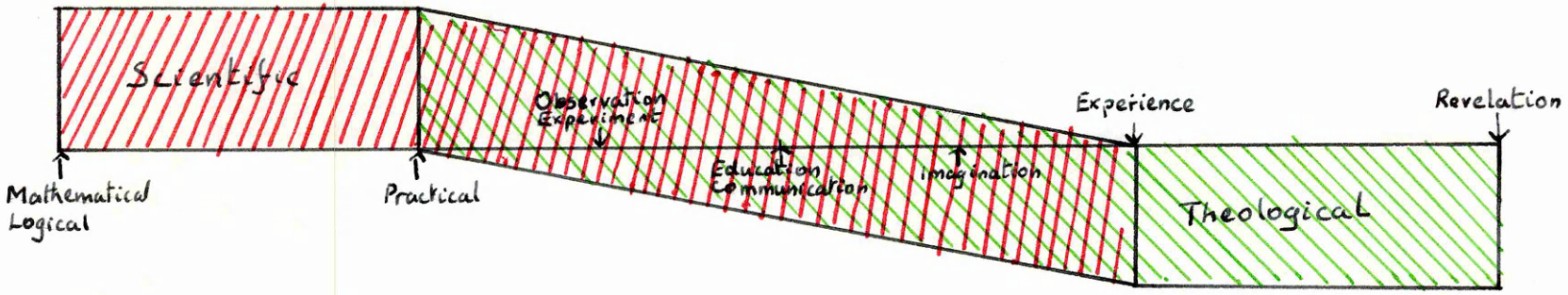
I find the subject of the way in which models change or are changed of particular interest. This has been discussed in the context of T. S. Kuhn's thesis and it has been applied in the examples given. I think that his whole argument on the nature and extent of revolutions has wide implications and is relevant to theology and personal experience. Conversion experiences for an individual or within the cultural experience of a Christian community can have something of the character of a revolution. The models of theology as they affect the present way of life may well be incommensurable with what went before. This though emphasises the problem of incommensurability and it is useful to be reminded of R. Bernstein's distinctions, so that there can be incompatibility and incommensurability between old and new, but still there is comparability. (Chapter 5, reference 8).

Through the various aspects of this thesis I have sought to expand and develop the understanding and use of models in science and theology. I have focussed on the various concepts of creation

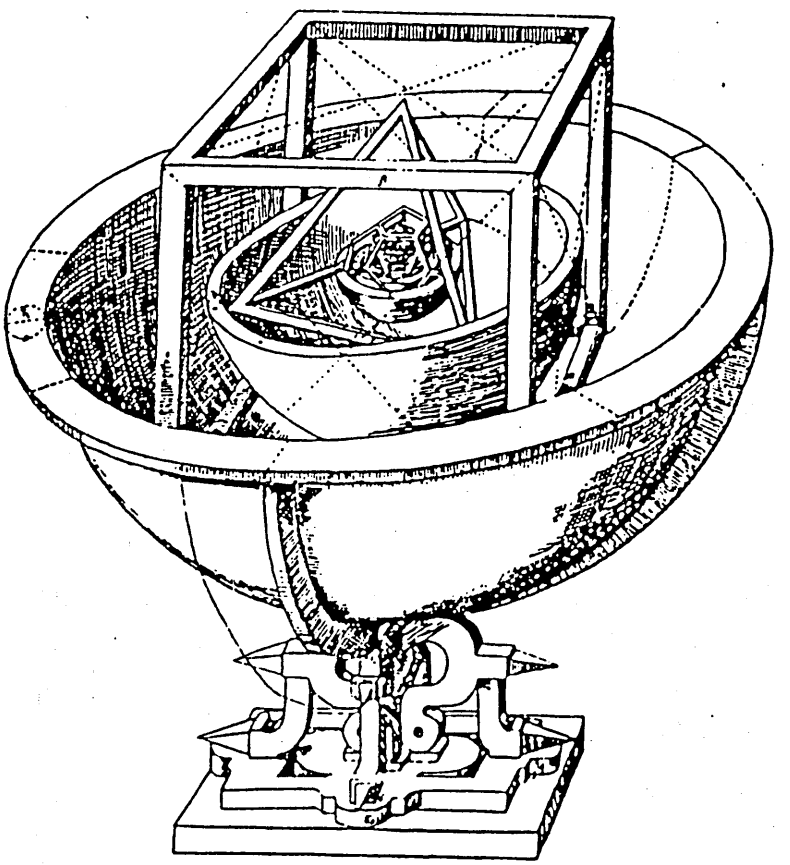
and I have shown by the chosen examples how this can be applied and developed. Throughout, there has been an underlying desire to explore possible inter-relationships between science and theology and it is hoped that a contribution to this has been made in the course of this work.

At the beginning, I used the analogy of map-making and to conclude I want to express the hope that I have succeeded in marking out a useful route and that this thesis can make a further contribution to the map.

Relationships between scientific and theological models

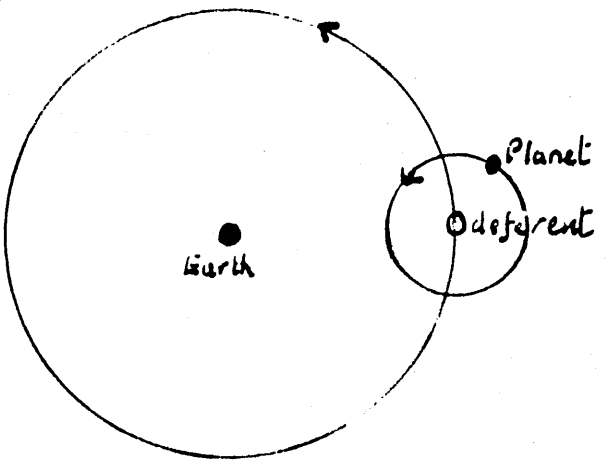


Appendix 2



Model of the universe; the outermost sphere is Saturn's.
Illustration in Kepler's *Mysterium cosmographicum.*

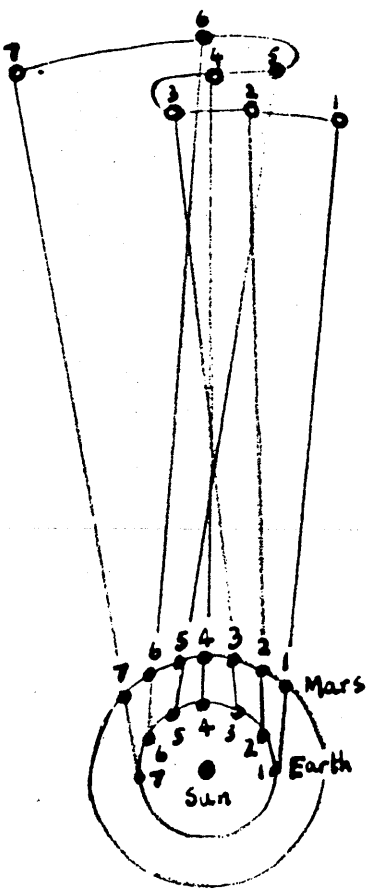
(A. Keostler, The Sleepwalkers, p252)



The Ptolemaic Theory

According to this, a planet moved in a small circle(epicycle), while the centre of this itself moved round the earth in a perfect circle.

(P. Moore, History of Astronomy, p.25)

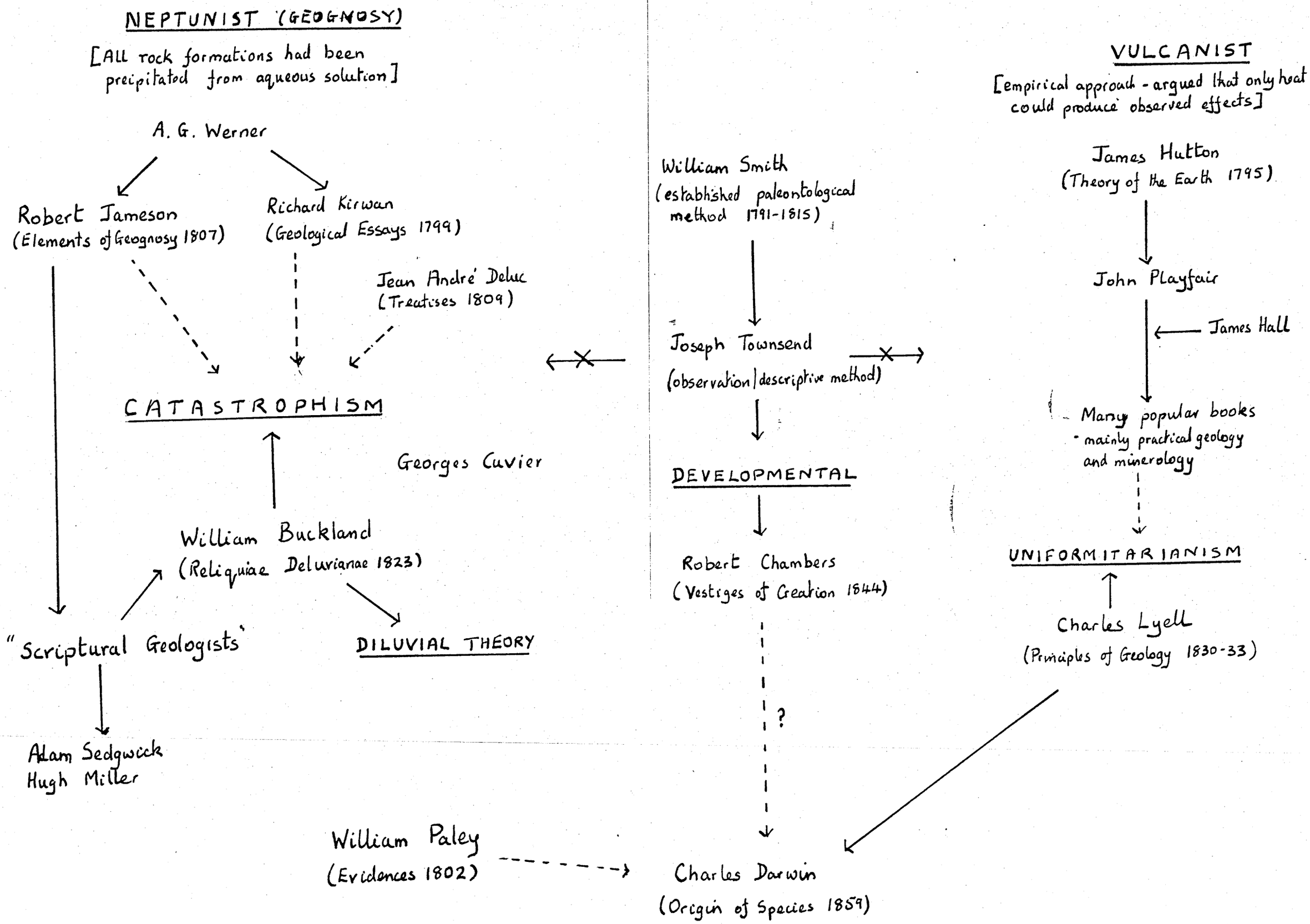


Retrograde Movement of Mars

The apparent path of Mars in the sky is given at the top of the diagram, and the actual relative positions of the Earth and Mars at the bottom. It will be seen that between positions 3 and 6 the Earth catches up on Mars and for this period Mars seems to move in a retrograde or backward movement among the stars. Behaviour of this sort was very difficult to explain on the old theory and was one of the reasons why Ptolemy was forced to add further epicycles.

(P. Moore, History of Astronomy, p.33)

Appendix 4


NEPTUNIST (GEOGNOSY)
[ALL rock formations had been precipitated from aqueous solution]
A. G. Werner
Robert Jameson
(Elements of Geognosy 1807)
Richard Kirwan
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CATASTROPHISM
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William Buckland
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DILUVIAL THEORY
Adam Sedgwick
Hugh Miller
William Paley
(Evidences 1802)
William Smith
(established paleontological method 1791-1815)
Joseph Townsend
(observation | descriptive method)
DEVELOPMENTAL
Robert Chambers
(Vestiges of Creation 1844)
?
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(Origin of Species 1859)
VULCANIST
[empirical approach - argued that only heat could produce observed effects]
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POSTSCRIPT

REVIEW OF MODELS AND MYSTERY - I. T. RAMSEY

In Models and Mystery, I. T. Ramsey develops his understanding and use of models in theology which was originally set out in Religious Language (reviewed in Chapter Three). This work answers some of the criticisms made of the earlier book, and he makes some useful connections between the use of models in a variety of disciplines. He says "It is by the use of models that each discipline provides its understanding of a mystery which confronts them all". (1) In particular he affirms his belief in the mystery that is at the heart of theology; this mystery is assumed in this context and not justified or explored as such.

In the first chapter, he begins by asking what a model is, and answers the question by discussing the historical scientific use. Then a model was thought of as a replica, a scale model or a mechanical model. Ramsey refers to these as 'picturing models' and indicates that they still have a useful place in science. He suggests that some theological discourse also uses picturing models, and in both disciplines it makes possible the articulation of concepts and to offer reliable genuine descriptions. However, the assumption of identity can obviously lead to problems and it becomes necessary to find an alternative. He quotes Max Black's use of the term 'analogue models' in science and suggests the term 'disclosure models' for those in theology which are not pictorial models. (The problems of identity of model with that modelled is discussed further in chapters two and four of this thesis). He continues by looking at some uses of analogue models in science and then considers parallel uses in theology and suggests they enable us to articulate that

"(1) models can be seen as builders of discourse ....

(enabling) .... interpretations of phenomena .....

(2) models .... enable us to make sense of discourse whose logical structure is so perplexing as to inhibit literacy .....

(3) ....models enable us to talk of what eludes us " (2)

Then it becomes possible to be reliably articulate in theology, as in science, providing that the models relate insight with experience. However, it is recognised that models in theology cannot be judged for their success or failure by reference to the possibility of verifiable deductions, as in science, but rather by their success in harmonising events over a wide range - their 'empirical fit'. Ramsey concludes the chapter thus "Models, whether in theology or science, are not descriptive miniatures, they are not picture enlargements; in each case they point to mystery, to the need for us to live as best we can with theological and scientific uncertainties." (3)

In the second chapter, Ramsey discusses the use of disclosure models in psychology and the social sciences, in order that they will enable these to be articulate and to have a degree of scientific precision, while still recognising they deal with individual persons. These particular discussions, whilst of general interest, are not relevant to the subject of this thesis. I was interested to note that he uses the analogy of map-making, which analogy I have referred to elsewhere.

The third and final chapter discusses the relation between metaphors and models and Ramsey notes the similarities, suggesting that metaphors like disclosure models "enable us to be articulate and are born in insight". (4)

Good metaphors like good models offer many possibilities for a whole cluster of inferences. (In my discussion of analogy, I suggested that a good model was one which had a large fund of neutral analogy - see page 34/5). He does not explore in any detail the relationship between metaphor and model, but stresses again the place of 'insight' across all the academic disciplines mentioned. He also touches on the importance for him of the imagination - an aspect of models which I have discussed. Both insight and imagination are of particular importance in theology; "for theology .... is founded in occasions of insight and disclosure ..... when theology neglects the mystery in its heart .... its life breath disappears." (5) Metaphors and models are the basic currency for mystery, and the task is to elucidate more faithfully this mystery.

He continues by making the point that theology demands and thrives on a diversity of models, and he returns to the need for "qualifiers" for models (see discussion in chapter three p.37-9), since at the heart of theology there is permanent mystery. He illustrates this by an example of a practical and theological question - what is meant by the unity of the church? - and shows how the understanding and use of models can be of value in elucidating an answer to this question and to other topics of concern to thinking people.

This book provides a useful expansion of the ideas initially expressed by Ramsey in Religious Language. There is overlap with other writers, who have been considered and whose understanding of use of models has been discussed in the thesis. This book adds another example to those I have already given of how the use of model language has rapidly been included in much theological discussion.

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1. p.1

2. p. 14-15

3. P.21

4. p.47

5. p.58

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