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FAITH AND THOUGHT

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A Journal devoted to the study of the inter-relation of the Christian Revelation and modern research

EDITORIAL

The late publication of FAITH and THOUGHT is deeply regretted. The Society has been looking for a new Editor for some time and it is hoped that an appointment will be made in the near future, so that the publication of three issues a year may be resumed.

In this issue we are publishing the Constitution of the Society. This includes the small changes which have been made since the last occasion when the Constitution was published in volume 98(1), 1970.

We are planning a discussion on the young-earth *v* the old-earth controversy. Probably few who have received a scientific education take the young earth-theory seriously but many Christians, both in the USA and now increasingly in the UK, have come round to this view over the last decade. We think a dispassionate statement of the arguments on both sides will prove valuable. Mr Malcolm Bowden, an expert in the study of fossil man, has kindly consented to present the case for the young earth. Together with other papers this issue contains the second half of Professor Robert Boyd's Lecture given to the Institute in May 1981. Dr Collis's paper on Canon Raven is now to hand and publication is expected in our next issue. Regrettably it has not so far been possible to obtain the MSS of the other papers given at the last two May meetings in 1981 and 1982 from the authors.

THE CONSTITUTION

Adopted at the first Annual General Meeting of the Members and Associates, May 27th, 1867, with Revisions of 1874-75, 1910, 1912, 1920, 1939, 1952, 1967, 1979 and 1982.

1. OBJECTS

The Victoria Institute or Philosophical Society of Great Britain (hereinafter referred to as the Society) is established to advance the Christian religion as revealed in Holy Scripture.

In furtherance of the foregoing object the Society shall have the following powers:

(1) To investigate fully and impartially the most important questions of Philosophy and Science, but more especially those that bear upon the great truths revealed in Holy Scripture, with the view of reconciling any apparent discrepancies between Christianity and Science; and to associate together men of Science and authors who have already been engaged in such investigation, and all others who may be interested in them, in order to strengthen their efforts by association, and, by bringing together the results of such labours, after full discussion, in publishing the printed Transactions of an Institution to give greater force and influence to proofs and arguments which might be little known, or even disregarded, if put forward merely by individuals.

(2) To consider the mutual bearings of the various scientific conclusions arrived at in the several distinct branches into which Science is now divided, in order to get rid of contradictions and conflicting hypotheses, and thus promote the real advancement of true science: and to examine, discuss and publish the results of such research concerning all supposed scientific results with reference to final causes, and the more comprehensive and fundamental principles of Philosophy proper, based upon faith in the existence of one Eternal God, who, in his wisdom created all things very good.

(3) To publish Papers read before the Society along with full reports of the discussions thereon, in the form of a journal or as the Transactions of the Institute.

(4) When subjects have been fully discussed, to make the results known by means of Lectures of a more popular kind, and to publish such Lectures.

(5) To publish English translations of important foreign works of real scientific and philosophical value, especially those bearing upon the relation between the Scriptures and Science: and to co-operate with other philosophical societies at home and abroad, which are now or may hereafter be formed, in the interest of Scriptural truth and of real science.

2. MEMBERSHIP

(a) The Society shall consist of Fellows and Members elected as hereinafter set forth and signifying interest in the Society's charitable work by financial contributions thereto.

(b) The roll of Fellows of the Society shall include such as are so designated on the 17th day of November 1952 and such other persons (whether previously Members or not) as the Council may deem proper.

(c) The roll of Members of the Society shall include those so designated on the 17th day of November 1952 and all others subsequently admitted by the Council as Members.

3. COUNCIL

The government of the Society shall be vested in a Council (whose members shall be chosen from among the Fellows and Members of the Society and be professedly Christians), consisting of the President, the Honorary Treasurer, and not exceeding thirteen others.

4. ELECTION OF COUNCIL AND OFFICERS

The President, the Vice-Presidents, and the Hon. Treasurer shall be elected annually at the Annual General Meeting, which shall normally be held on the Saturday nearest the 24th of May.

At the Annual General Meeting in each year, one third of the other members of the Council or if their number be not a multiple of three then the number nearest to one third shall also retire in order of seniority of election to the Council, and be eligible for re-election: as between members of equal seniority the members to retire shall be chosen from among them by ballot unless such members shall agree between themselves.

Casual vacancies may be filled by the Council and shall require ratification at the next Annual General Meeting.

5. NOMINATION FOR ELECTION

For such annual elections nominations may be made by Fellows of the Institute and sent to the Secretary not later than 1st March in any year. The Council may also nominate for vacancies, and all nominations shall be submitted to the Fellows and Members at the time when notice of the Annual General Meeting is posted.

If more nominations are made than there are vacancies on the Council the election shall be by ballot amongst the Fellows and Members in good standing and present at the Annual General Meeting.

6. MEMBERSHIP PROCEDURE

Any person desirous of becoming a Fellow or Member shall send to the Secretary an application for admission. Upon such application being transmitted to the Secretary, the candidate shall be elected by the Council, and enrolled as a Fellow or Member of the Victoria Institute, in such manner as the Council may deem proper. Such application shall be considered as ipso facto pledging the applicant to observe the rules of the Society, and as indicative of his or her desire and intention to further its objects and interests; and it is also to be understood that only such as are professedly Christians are entitled to become Fellows.

The Council shall have power to remove from the roll a Fellow or Member who by reason of improper conduct or lack of qualifications is considered to be in breach of the rules, objects and interests of the Society, but subject to a right of appeal.

7. COUNCIL BUSINESS AND RULE MAKING

The quorum for meetings of the Council shall be five. The Council may make such rules as it considers desirable for furthering the objects of the Society and regulating its business including (a) the setting up of an Executive Committee to include the Chairman of Council, the Hon. Treasurer and another or others of the Council to transact routine business (b) the setting up of other ad hoc committees to which may be appointed persons who, though not members of Council, are specially qualified to advise on some particular subject (c) arrangements for associating university and other students and Christian workers and others as Associates in the work of the Society.

8. PAPERS

Papers presented to the Society shall be considered as the property of the Society unless there shall have been any previous engagement with its author to the contrary, and the Council may cause the same to be published in any way and at any time it may think proper.

9. PROPERTY TRUSTEESHIP

The whole property and effects of the Society shall be vested in such Bank or Trust Corporation as the Council may direct and held in trust for the Institute. The Council is empowered to invest from time to time in or upon any investments for the time being authorised by statute for the investment of trust funds by trustees, and in and upon such other investments as the Council shall be advised by competent stock and sharebrokers and the Council shall have the usual powers of trustees in regard thereto.

10. FUNDS, etc.

All moneys received on account of the Institute shall be duly paid to its credit at the Bankers, and all cheques shall be drawn, under authority of the Council, and shall be signed by any member of the Council and countersigned by the Honorary Treasurer or the Secretary.

11. AUDIT

The accounts shall be audited annually by a Chartered Accountant to be elected at an Annual General Meeting of the Society for the following year, and this Chartered Accountant shall make a written Report to the Council at the first meeting after such audit, and also to the Institute, upon the day of the Annual General Meeting next following — stating the balance in the Treasurer's hands and the general state of the funds of the Institute.

12. CHANGES IN THE CONSTITUTION

No change in the Constitution or the policy of the Society shall be decided upon by the Council without prior notice being given in writing to the full Council and all Vice-Presidents and past Presidents at least six weeks before the meeting at which such change shall be voted upon and all those entitled to receive such notice shall be entitled to attend, speak and vote at such meeting. Any such change shall require ratification at the next Annual General Meeting.

MEMORY AND THE DATING OF THE GOSPELS

That a physical shock, such as a blow on the head, or an operation in hospital may impair memory has long been known. After a car accident an injured person may wake up in hospital unable to remember what had happened. Later such lost memories often return.

According to a recent paper by Elizabeth Loftus and Terrence Burns, who studied 266 university students as 'witnesses' to different filmed events, mental shock has the same effect as physical in suppressing memory. The films viewed were of the usual bank robbery kind and it was found that when a robbery was followed by unexpected violence, memory proved much impaired compared with virtually the same scenes in which no violence ensued. In the violent cases there was no black-out of memory as such — a general picture of what happened was remembered accurately enough — but incidental detail was lost. Thus the memory that a boy wore a baseball shirt with the number 17 on it was forgotten by most of those who (in the film) saw the boy shot, but remembered by many of those who did not see the shooting (*Memory and Cognition*, 10, 318; *New Scientist*, 28 Oct. 1982, p.232).

On a number of occasions in life I have been reminded by the people concerned of events in the past which seemed to have completely vanished from my memory. There was a chat I had with Sir Norman Anderson, now the President of the Victoria Institute, when we were school boys together: this was just before I entered the school sanatorium to be afflicted with the then prevalent mumps. There was a visit to the hospital in Cambridge where I read a Psalm to a young friend who had had an operation on his back; there was a conversation I had with a schoolboy pupil who later became an eminent mathematician. In each case, when reminded of those events in later years, I replied that I had no memory of them whatever, but in each case the memory later returned vivid and clear.

Memory is like this for all of us. Thousands of memories remain, but thousands more are lost, sometimes obliterated by an accompanying shock (like that for me of the onset of an illness just before I was to sit for the equivalent of the A-level examination). Later, perhaps because of a reminder by a friend, they may emerge once again from their hiding places in the mind. How interesting it would be to link up the variations in somewhat trivial details (e.g. How many times did the cock crow?) in the Gospels with the mental shock which the disciples must have experienced as a result of the crucifixion of their Lord!

A good source book for such a study has recently appeared (*Memory Observed: Remembering in Natural Contexts*, W.H. Freeman, Oxford and USA, 433 pp, HB £20, PB £8.50) edited by Utric Neisser. It contains 45 essays, many published before, which draw attention to features of what we may call natural memory — as distinct from the rote memory which, since the days of Ebbinghaus a century ago, has mostly preoccupied memory psychologists. There is a mass of information here, though little in the way of theory or understanding. We still do not know why it is that so many memories, including trivial ones, remain bright and clear while others are lost in the mists of time. A reminder, a photograph, a smell, a conversation may catalyse their return.

Experimental situations (e.g. the famous paper of William Stern, 1904, which is reproduced by Neisser as a matter of interest) emphasize the unreliability of memory. This applies particularly in courts of law when witnesses are asked to testify concerning events which at the time they in no way thought were of any importance. Even seemingly endless repetitions may fail to make memory perfect: in the religious field one clergyman read prayers from the Prayer Book at least 50,000 times over many years but still did not know them by heart. Occasionally flashbacks of memory proved to be of mixed provenance; as when one man had a vivid memory of when he first heard of the Japanese attack on Pearl Harbour. According to his memory he was, at the time, listening to a commentary on a baseball game on the radio: later he realised that it was the wrong time of year for baseball.

In Third World countries memory takes two main forms. Many African and other peoples believe that it is important to keep accurate histories of their tribes. The histories are not recorded in writing but in memories which are passed from generation to generation. "The history that is passed in this way is surprisingly accurate", we learn, even though truth is sometimes equated with what an ancestor might like to hear! The oral historians (e.g. in the Gola tribe) do not learn their history by rote "but in an integrated and intelligent way." As a general rule the children in these cultures are far better at retelling stories than children in the

USA. There is much in the NT to suggest that its writers often depended upon a similar kind of memory, with the result that in referring to the OT, in describing events or (though here translation from Aramaic into Greek may be involved) we encounter many small verbal alterations. The most striking examples are, perhaps, those found in the Book of Revelation where there are very many obvious references to, or half-quotations from, the OT and also to our Lord's teaching, but exact quotation in extremely rare.

The other type of memory involves an exact memory of a sacred text — for instance, of the text of the Koran or of some of the Jewish writings, but "no primitive peoples who have specialised in rote learning have ever been found" (p.271). Extraordinary instances illustrating the accuracy of such memories are known. One man knew the contents of the 12 volumes of the Babylonian Talmud so well that, when a volume was opened at random and attention drawn to a single word, he was able to say what word was exactly underneath it, 12 or 23 or any other number of pages further on! His statement was checked repeatedly by pushing a pin through the paper as far as the appropriate page! We are reminded also of the feats of the mnemonist studied by the Russian psychologist A.R. Luria — this man seemed unable to forget anything! But memories of this kind need not depend upon rote learning: often eidetic imagery is involved, or else its equivalent in sound.

An interesting application of what we know about natural memory is afforded by the early history of the Eucharist. It is a remarkable fact that although the early church celebrated the Lord's Supper from an early date, the command to do so is missing in the accounts of the last supper given by the two earliest Gospels, Mark and Matthew. The words "Do this in remembrance of me" are found in most early MSS of Luke (22:19b) but not all: until about 1950 most scholars doubted their authenticity. In view of the importance attached to the Eucharist as early as the time when Paul wrote 1 Corinthians (seeICor. 10:16), around 54 AD, it seemed hard to understand how, if the original version of Luke contained the command, it could ever have been omitted. On the other hand its addition by a later copyist seemed natural enough after one of the Apostles who had been present at the Last Supper had later remembered that Jesus had in fact used the words (cf. Jn 14:26). Other arguments were also advanced (see I.H. Marshall, *Gospel of Luke, Commentary on Greek Text*, 1978). The NEB and RSV (earlier editions) accordingly omitted the words: they are retained in the more recent NIV. Certainly, the authenticity of the Eucharistic command has good textual support and is now widely accepted, though we learn that there has been some reaction in favour of the earlier view (Marshall gives references). It is probably worth adding that both views may be true. Luke himself may have asked a disciple who was copying the text of his Gospel to insert the command after he had heard that an apostle had recollected what Jesus had said.

Either way the same conclusion would follow. In the very early days the Lord's supper was not (we may suppose) celebrated by the Jerusalem church — for the Eucharistic command was not remembered. In Acts we read of early disciples breaking bread together, but the context suggests that the expression had not yet become a synonym for eating bread and drinking wine in the Eucharistic sense. Rather, the breaking of bread in the Christian community was an expression of the fellowship of those who "had all things in common ... [who] day by day, attending the temple together and breaking bread in their homes... partook of food with glad and generous hearts" (Acts 2:42-46). Later, when the breaking of bread was associated with the first day of the week, as in Acts 20:7 there is a possible Eucharistic connotation but even here we cannot be at all sure. At Troas the disciples, had "gathered together to break bread" on the first day of the week but after midnight, when sleepy Eutychus fell out of the window, Paul broke bread again (v.11). Two holy communions? Surely not. Later, (Acts 27:36) the breaking of bread by Paul before his shipwreck is again mentioned without Eucharistic implication.

The evidence is, then, that in the very early church our Lord's command to "do this in remembrance of me" was unknown. Later one of the apostles must have remembered it and when reminded of it the memories of the others would have revived. Can we learn anything from this?

It is often said, and said rightly, that we cannot base a reliable conclusion on the fact that certain information is omitted in an ancient text. But here we are dealing with something more than mere omission. The situation at the Last Supper was one in which forgetfulness of a detail which did not *at the time* concern the disciples was very likely to be forgotton. Jesus spoke to them of many things, but chiefly of the suffering He was about to endure. In the days that followed they were to suffer a profound trauma. The single short sentence "Do this in remembrance of Me" had no more relevance to the immediate situation than the number 17 on the shirt of the boy we have described. Only after Jesus had risen and ascended to His Father did it begin to have meaning. What was more natural than that is should have been forgotten? And what more natural too than that, at a later date, one of the disciples who had been present should have remembered the words and asked the others if they remembered them too. And they did. Jesus had told them that this kind of thing would happen. The Holy Spirit, He said, would bring to their remembrance the things He had said to them.

The first conclusion we may reach would seem to be compelling. Matthew and Mark must have been written before Paul wrote 1 Corinthians, that is before about 54AD. The second conclusion is that a later generation of Christians did not feel free, as has sometimes been conjectured, to alter and add to the original texts even statements which they knew to be true. Though accepting the importance of participation in the Eucharistic feast, they made no attempt to rewrite Matthew and Mark accordingly.

My thanks are due to Prof. F.F. Bruce, the Rt. Rev. Dr J.A.T. Robinson and especially to Rev. John Wenham for comments and suggestions.

GOD AND THE ATOM

The story of modern physics relates to Christianity in more ways than one. The Oppenheimer affair brought home to all men the knowledge that even the most recondite intellectual study could effect the entire world. For the first time, perhaps, hardened mathematical physicists could say with Robert Oppenheimer that physicists had known sin.

A recently published book, Emilio Segrè's *From X-Rays to Quarks: Modern Physicists and their Discoveries* (W.H. Freeman, 1980, pp.337, HB £11.70; PB £5.40) tells the story of the development of atomic physics. It is a well-written beautifully produced volume, filled with anecdotal and personal material of great interest and profusely illustrated. The author, a Nobel Prizeman, is a pioneer in physical research and has known all or most of those who have advanced man's knowledge of the atom over half a century. The book will prove of great value to those studying physics but though addressed to scientists rather than the general public much of it makes for easy reading.

It is astonishing to learn how lacking in grace some men of science can be to others. On one occasion, after lecturing, Segrè left the room with Pauli and another man. Pauli said to him, "I never heard a worse speech than yours." Then he turned to the other man and added "except when I listened to your inaugural address at Zurich." If you told him about a new theory he always said "rubbish" (quatsch), though later, if interested, he was helpful. After the eclipse of 1919 Einstein suddenly became famous. He behaved tactlessly, accepted the role of a movie star, and soon made bitter enemies. Other scientists even founded an anti-Einstein scientific society! When invited to speak on relativity he would accept "but the occasions were disrupted by his opponents and transformed into scurrilous political demonstrations". At least one of his friends was murdered.

In the history of mathematics and physics the pride of man often emerges. Renowned discoverers and scholars have often announced that man has at last unravelled the last main secret of nature! We encounter the same note here. In the late 1920s Fermi and others attempted to popularise the new knowledge of physics in Italy. After extended consultations with Fermi, Senator O.M. Corbino, an otherwise humble and self-effacing man, delivered a speech with the title "The New Goals of Experimental Physics." "I do not hesitate to assert an opinion that may seem over daring. I believe that modern physics already possesses the basic knowledge of the possible phenomena that may develop or be produced on earth. Therefore... our descendants will not be able to participate in the revelation of great new discoveries in physics. They will not share the experience of those who saw the birth of electrical science, or the development of optics, or the discovery of new radiations." The only exception to this, he thought, might lie in the field of artificial modifications of the atomic nucleus.

It is a pity that the author does not tell us more about his own participation in the discovery of atomic fission, but he does give us the background of events (p.202f). With Mussolini's encouragement Senator Corbino, himself a physicist, was intent upon reviving research in Physics in the University of Rome where stagnation had set in for a century. Enrico Fermi was appointed Professor and Segrè, then aged 20, with others was appointed to the staff. Artificial radioactivity was at the centre of interest at the time but it needed a million alpha particles striking aluminium to bring about one disintegration. Fermi reckoned that neutrons, (discovered by Chadwick in 1932) being uncharged would make better projectiles than alpha particles. With his collaborators, including Segrè, he irradiated all available elements with the result that about 40 new radioactive substances were obtained.

Uranium, element number 92, was the last to be bombarded — this early in 1934. At first it seemed that a new radioactive element, No.93, had been formed. But chemical methods showed that none of the products were heavier than lead — a result soon to be confirmed by others. It became difficult to locate the hypothetical first-formed product at the end of the periodic table "we had the impression of being confronted by a mystery".

Fermi was urged to name the hypothetical element by some name (such as Littorio) in honour of the fascists. He replied that its half-life was so short that this might be inappropriate.

In 1935 a German woman chemist — Ida Noddak — published a note suggesting that the uranium atom had broken into two large fragments. The note was widely read but the idea was rejected. We need to look elsewhere (N.P. Davis, "Lawrence and Oppenheimer", Cape, 1969, p.96f) for a continuation of the story where Segrè is quoted as saying, "Fermi and I read it [Noddak's note] and we still did not discover fission. The whole story of our failure is a mystery to me. I keep thinking of a passage from Dante: O crucified Jove, do you turn your just eyes away from us or is there here prepared a purpose, secret and beyond our comprehension?" Segrè goes on to wonder what would have happened if they *had* made the discovery of fission. The two scientists owed their employment to Mussolini who was lined up with Hitler. Had they understood what should have been so obvious, and in fact was obvious to Ida Noddak, work on the bomb could have started secretly in Germany in 1934. Hitler might well have had the bomb by 1939 or 1940 and would have been in a position to blackmail the world. In fact the possibility of a bomb was not recognised till 1938. Is not the most natural explanation of what happened, this: that God blinded the eyes of two of the most brilliant scientists in the world and that in doing so he saved our world from Nazi domination? Here is the comment of one of Fermi's students: "God for his own inscrutable reasons made everybody blind at that time to the phenomenon of nuclear fission." (Robert Jungt *Brighter than a Thousand Suns*, 1958 p.58).

LANGUAGE

Noam Chomsky is well-known for his linguistic studies; in particular his view that humans have an innate ability to acquire language. Chimpanzees and other mammals are unable to exercise such a facility, he argues, not merely because of unsuitable vocal chords, but because a special kind of mental organisation is needed and this is not simply a higher degree of intelligence, but shows the emergence of a new phenomenon in the evolutionary process.

A series of statements by Professor Chomsky[1] concerning the evolution of language are briefly reviewed and commented on by Dr. Clifford Wilson[2] in a supplement to Newsletter No.29 of the North American Creation Movement. Dr. Wilson draws attention to Chomsky's assertion that there is no continuity between the vocal gestures of animals and the articulated language of humans; in fact it is difficult to see what links these stages at all. They seem to involve entirely different processes and principles. Such statements are the more interesting, coming as they do, as Dr. Wilson reminds us, from a specialist who is far from accepting a Christian position.

The ability to imitate sounds is obviously important for language communication, yet some birds can do this better than most mammals; they do not, of course, use reasoned speech. Chomsky quotes Professor Thorpe's application of sixteen design features, associated with human speech, to various animals. Wilson comments that their unpatterned distribution amongst a variety of unrelated species again highlights the unacceptability of a linear evolutionary model.

Human language, moreover, is not necessarily informative; it can be used to mislead, to display cleverness, or simply for play. We find no striking similarity to animal communication systems, apart from gestures. Human language is not simply a more complex form of animal behaviour. Language and intelligence appear to be related but separate abilities, as Dr. Wilson adds.

Chomsky suggests that the most promising way to explore the distinctive properties of human intelligence is to study the underlying structure of language — to try to discover those universal principles that govern its use and organisation.

Dr. Wilson finally draws attention to two important aspects of language mentioned by Chomsky. Firstly, that there are rules of great complexity governing linguistic competence. Although these are never made explicit to small children, they are rapidly acquired, no matter what the culture. Children can even acquire two languages at the same time. A theory of evolution does nothing to explain how such rules could have been developed. Secondly, language can be expressed in "a potentially infinite number of sentences". Over and over again we hear and construct sentences that have never been formed before, without a prodigious task of memory being needed. No animal could possibly make the variety of combinations of words which the human infant makes spontaneously and with no special training. Chomsky wrily points out that "it is perfectly safe to attribute this to evolution, so long as we bear in mind that there is no substance to this assertion".

1 Noam Chomsky, Linguistic Contributions to the Study of Mind: the Future, in *Language in Thinking* (Ed. Parveen Adams), Penguin, 1973.

2 See full text in Clifford Wilson, *The Language Gap*, to be published by Zondervan/Probe Ministries.

DAVID BURGESS

* * *

Interesting arguments on the origin of language will be found in George A. Miller's *Language and Speech* (Oxford Freeman, Dec. 1981, PB £3.50, HB £8.20). The author thinks that language originated between 10 and 100 thousand years ago. He cites the work of

Morris Swadish who discovered that in languages whose history is known, 14% of terms for common concepts change their roots every thousand years. Comparing languages spoken throughout the world, Swadish reckons that all languages may have had a common ancestor only 10,000 years ago. That language must be a recent acquisition of mankind is also suggested by the extremely slow development of technology in prehistory — if the hominids of the archaeologists are precursors of man, there was little technological development over several million years, a fact best explained by lack of ability to communicate. There are also discussions of Chomsky's theories and of the anatomy of the throat which makes possible the use of language.

ARE WE ALONE?

In a vigorously argued article ("We are alone in the Galaxy", *New Scientist*, 7 Oct 1982) Professor F.J. Tipler, a mathematical physicist of Tulane University, New Orleans, argues that all attempts to find intelligent life elsewhere are likely to end in failure. "I believe that... we represent the only intelligent species ever to exist in our Galaxy, and quite possibly the only intelligent species ever to exist in the entire visible Universe."

He argues his case on the grounds; (1) that all contemporary experts in the theory of evolution "are unanimous in claiming that the evolution of an intelligent species from simple one-celled organisms is so improbable that we are likely to be the only intelligent species ever to exist." (2) Interstellar travel is not only feasible but could be achieved quite inexpensively by an intelligent species only slightly in advance of us. "If such a species existed there would, therefore, be evidence of its existence on Earth or in the Solar System". Given an intelligent species, all parts of the Galaxy capable of supporting life would have been populated within a million years — an exceedingly small interval in terms of the life of the Galaxy. Suitable chemical elements being present universally, a self reproducing probe would soon have been invented so that no large (and therefore expensive) number of launchings from a single planet would have been necessary.

These arguments are, of course, by no means new (see this JOURNAL 108, 113): they seem plausible enough if God the Creator is left out of account. If we bring God into the argument it seems impossible to make headway. Does He perform creative acts on many suitable planetary homes? Is sin confined to Earth or our Galaxy? If not, as C.S. Lewis suggests, has God invented a way of dealing with it quite beyond our understanding? Bearing in mind the ingenuity found in nature (brains which form pictures of the world based on magnetism, smell, electric potentials etc. as well as electromagnetic radiation) may there also be 'minds' which perceive angels, affection, intelligence or forms of matter unperceived by us but constructed of particles other than quarks and electrons? Truly we see through a glass darkly until the Great Day dawns.

UNIFORMITARIANISM

Uniformitarianism, associated in particular with the names of James Hutton (1726-97), John Playfair (1748-1819) and Sir Charles Lyell (1797-1875), is the doctrine that all the geological features of the earth may be explained by the self-same forces of nature which we see at work around us today, acting slowly over geological time. A basic assumption was that in the past these forces (erosion, strata formation, volcanism etc.) operated with an intensity which differed little from their present intensity. A great attraction was always the apparent elimination of miracle from the past history of the world: it seemed that science itself disproved the beliefs of Christians and since "all things have continued as they were from the beginning of creation" (2 Pet 3:4) it followed both that the Flood of Genesis and the second advent of Christ were ruled out (vs. 4, 5-6).

Starting with the discovery of the laws of thermodynamics in the mid-19th century, the doctrine suffered some hard blows. The world was not eternal after all, as Hutton and Lyell supposed (Lyell even described a geological perpetual motion machine to keep it on the go!). Kelvin had many a lively encounter with Tyndall and others who always came off worse.

Recently the doctrine, still at the core of didactic geology, has suffered some more radical setbacks. A considerable number of continental meteoric craters have now been located which were formed within the past 100 Myr. Fifteen of these have diameters over 10 km, two more than 50 km. On average the oceans occupy three times the area of the continents and about half the ocean bed has been in existence over the past 100 Myr. It might be expected, therefore, that large meteorites must have fallen into the oceans over this period a good deal more often than they have fallen on land. Yet strange to say no one has seen a crater under the sea which might have been formed in this way. Presumably therefore permanent craters are not formed in deep water. The key to the problem is, then, what to look for.

G.C. Rogers (*Nature* 299, 341) suggests that the great ocean plateaus, of which there are at least five in the Pacific Ocean (he gives a map) may indicate where meteorites have fallen in past ages.

Imagine, says Rogers, a meteorite or asteroid of 5-10 km diameter falling into the sea. With a body of this size, relatively little energy would be absorbed by water a few km deep. An ocean crater of around 100 km diameter would be formed and the crustal rocks would be shattered down to the level of the liquid magma. Vast quantities of steam and molten magma would rapidly raise the central area of the crater and the deep ocean floor would be raised to near or even above sea level. (A central uplift of 1/10th crater-diameter is often found on land.) The thin ocean floor would be extensively fractured for a great distance around so that volcanism would be extensive but volcanic rocks so formed would be lighter than before the event since the cracks would contain water or gases. Over the next million years or more the structure would slowly sink back into equilibrium. The result would be a plateau raised above the level of the deep ocean. What we observe about the oceanic plateaus seems in many ways to be consistent with what we might expect if they were originally formed as a result of impacts, though consistency is not proof. Several lines of possible research are suggested which might serve to confirm or disprove the hypothesis.

Rogers asks whether the meteorite or comet believed to have hit the earth 65 Myr ago and to have caused the extinction of many forms of life agrees as to date with one of the plateaus. However, the three largest of the Pacific plateaus are older than 100 Myr. Other areas need examination and it must be remembered that plateaus cannot be expected to stay in position permanently: a hit might have taken place near a subduction zone, for instance.

Interest has also centred once again on tektites. It seems as if the origin of the tektites, small glassy objects, found only in a few areas of the earth's surface, may at last have been solved. The chemical evidence indicates that they were formed by the melting of preCambrian continental sediments. The suggestion that they originated from volcanoes on the moon now seems ruled out for no known lunar rocks have a similar composition. They seem rather to have been formed when the earth was hit by comets on four main occasions over the last 35 million years. This explanation, it is admitted, may seem somewhat exotic. "But somehow it does not seem so these days. Recent calculations on the frequency with which comets large and small might be expected to reach the Earth's surface, and the remarkably cool way in which the earth science community has been willing to consider seriously the suggestion by Alvarez *et al.* (1980) that cometary impact may have been responsible for... [the extinction of the dinosaurs] ... suggest that the rigid anticatastrophism characteristic of geological thinking since the time of Hutton and Lyell is now dead." (P.J. Smith, *Nature* 1982, 300, 217).

Mountain building has also come in for some new (or a revival of old) thinking. The current view is that of plate tectonics — vast solid areas of crustal rock move over the earth's surface and, where they push into one another, raise the level of the land. This process is necessarily slow, mountains taking millions of years to form. But Dr. R.A. Lyttleton (*The Earth and its Mountains*, Wiley, 1982) has produced much evidence for thinking that mountains may be formed in another way. The earth is cooling and contracting and every now and again (he thinks about twenty times in all) the crust, which now has to cover a reduced surface, is thrown into a state of vast rapid convulsion with the formation of new mountain ranges. This view does not discredit the slow plate tectonic explanation ("the case for plate tectonics is too strong to be ignored" says the Editor of *Nature*, 300, 681): both processes are probably at work.

These developments are of great interest to Christians who are disposed to take prophetic passages more literally than has been common in the past. Passages such as Lk 21:25, Rev. 8:8,10; perhaps 9:1; 16:18-21 and many others come to mind.

M.F. MAURY

Matthew Fontaine Maury (1806-1873) the American hydrographer, had a long, varied and distinguished career, his last post being that of Professor of Meteorology in the Virginia Military Institute. His best known work was *Physical Geography of the Sea*, 1855, which was translated into a number of languages.

In an interesting article ("The Life and Philosophy of Matthew Fontaine Maury", *Creation Res. Sci. Qrly.* 1982, 19, 9-91) Dr. J.R. Meyer examines Maury's motivation and philosophy. Maury repeatedly referred to the Bible in his scientific work. When criticised by fellow scientists for quoting the Bible in confirmation of theories of physical geography, he replied, "The Bible, they say, was not written for scientific purposes, and is therefore no authority in matters of science. I beg pardon! The Bible is authority for everything it touches. What would you think of the historian who should refuse to consult the historical records of the Bible, because the Bible was not written for the purposes of history?" When led to the discovery of a new insight into the "physical machinery of the earth" Maury said "I feel as if I had thought one of God's thoughts and tremble". Scripture played a decisive role in Maury's decision to study ocean currents and winds. He thought often of Ps 107: "They that go down to the sea in ships ... these see the works of the Lord, and his wonders in the deep." The words of Ps 8 "Thou madest him to have dominion over the works of thy hands... and whatsoever passeth through the paths of the seas" convinced him that there must be natural paths in the sea, just as there are natural paths through mountain passes. These were, of course, the natural ocean currents, such as the Gulf Stream, and Maury studied them intensively, accumulating atmospheric and marine data which resulted in greatly improved charts and sailing directions. Maury has "left to us a heritage of outstanding achievement, not only in science, but also in the successful integration of both natural and Biblical revelation", concludes Meyer.

Maury's outlook is not accepted in all Christian quarters today. It can hardly be denied, however, that in the last it was highly productive in the scientific field.

EARTHQUAKES

Various ways of predicting earthquakes have been tried in the past: though often promising, none has proved reliable. Another has now been proposed. Observations before three earthquakes in northern Japan have shown that over the space of a few hours before the quakes there was heard a strong radio noise at a very low frequency. It is not understood how the radio waves are generated, but they also result when specimens of rock are crushed in the laboratory, though it is difficult to understand how they could pass through any great thickness of rock. It seems possible that warnings might be given if long wave radio waves were monitored regularly. But again all earthquakes do not arise in the same way and perhaps they do not all give radio wave warnings (*Jour. Geophysical Research* 1982, 87 (B9), p.7824; see also this JOURNAL 102, 102).

Man-made earthquakes are also in the news. Dr. R.D. Adams of the University of Reading has recently discussed the man-made earthquakes which may result from building of reservoirs (*Nature* 301, 14). The effect was first noted in 1945 but not much publicised until 1967 following the filling of Lake Kremasta in Greece when for the first time damage was attributed to man's activity. More than a hundred instances have now been studied. In some cases large earthquakes have resulted, the largest induced event to date being in India at Koyna when the magnitude of the quake was 6.5 and the deaths numbered over 200 with considerable damage. It appears that deep reservoirs, especially those over 100 m deep, are more prone than others to produce seismic effects. The Aswan High Dam in Egypt, although the second largest in the world, has a maximum depth of only 72 m and caused little trouble until 6,years after attaining full depth,an unexpected earthquake of magnitude 5.6 was recorded in November 1981. Man-induced quakes are characterised by long-continuing aftershocks. It is thought that reservoirs release strains already stored in a region rather than by creating new strains. There may, of course, be other ways (nuclear bomb testing underground?, desertification?) in which man triggers earthquakes but evidence is lacking as yet (see Mk 13:8 etc.)

CHURCH, SCIENCE AND BOMB

Eric Jenkins, writing on the Church and the Bomb, with special reference to the World Council of Churches' Report ("Before it's too Late", chaired by the Bishop of Durham), the Church of England General Synod's Report ("The Church and the Bomb" Hodders, £4.50) and that of the Church of Scotland ("Faslane — Facts and Feelings") all of which, though not out and out pacifist in tone, make outright moral condemnation of the use, possession and conditional threat of the use of nuclear weapons. It is easy, he points out, to say that politically such Reports are ineffective, but this is hardly so seeing that they do tend to change public opinion. These reports by influential churchmen stress the immorality and perils of the nuclear arms race. "When will the science establishment do as much?" asks Jenkins. "In the U.K. where are the voices of the Royal Society, the British Association and the University Vice-Chancellors?" (*New Scientist*, 2 Dec. 1982).

It is encouraging to note that clerical opinions are veering so strongly towards the abolition of nuclear weaponry. This was not always so. BBC Radio 4 (Religious programme, 28 Nov. 1982) recently referred to a new film which highlights the attitude of mind of the religious world on the subject of the atomic bomb in the 1940s, 50s and 60s. Although the material is selectively edited and chosen we are assured that it is all authentic footage. The comment runs: "And as you might expect on a subject as far reaching as universal extermination God has something to say about it, or at least His servants do... So following President Eisenhower's reminder to the American nation that the country is the greatest force for good that God has allowed on his footstool Earth", we have several clerics asserting in the news programme that the atomic bomb should be used to keep it that way. Several of the clerics interviewed thank God for the gift of the atomic bomb or "pray that God will show how to use it in His ways". The commentary continued "A [super?] bomber has just dropped one on Hiroshima and several other Japanese cities are earmarked for similar presents".

The dangers of the accidental start of a nuclear war are highlighted by the recent accidental firing of a missile by a Phantom jet which destroyed a Jaguar though the pilot was able to parachute to safety. At the RAF court held in W. Germany it transpired that there was a fault in the circuit breaker which should have prevented the firing of live ammunition and that no one even thought of the possibility that a pilot's leg might nudge it and fire the missile (*Times*, 12 Jan. 1982). If despite all the precautions and rules imposed by the RAF such an event can take place, it seems possible that the same might happen when nuclear weapons are being carried.

MEDICAL ETHICS

The statement by Dr. Robert Edwards that he has observed (but apparently not experimented with) 17 live human embryos in test tubes artificially inseminated outside the womb caused a good deal of misgiving. Such embryos die within a week or so and as yet it has not proved possible to make them grow in an artificial environment. The purpose of such work is, of course, to enable couples who otherwise could not have children to procreate. Healthy children have developed after such embryos have been implanted in the mother's womb. But Edwards allows many of the embryos to die, making his own decisions as to which should live (*Times*, 29, 30 Sept. 1982 etc.).

It is pointed out in medical circles that although it is not yet possible to keep test tube embryos alive, a way of doing so may soon be found. It might then be possible to rear babies to produce spare parts for those who need them. But the ethics of producing "battery children" are highly suspect.

Problems concerning medical ethics are related to the sacredness of life. But when does life start? Sperm itself was once believed to contain life; its wastage being akin to murder. Even today many regard a fertilized ovum as in some sense alive in the human sense.

So when does human life start? At fertilization? When the fertilized egg attaches itself to the human womb? Or when, after 40 days or so, the first growth of cerebral cells begins to produce form? When heart or brain begins to function? Or electrical activity commences in the brain? When the mother feels the movements of the child within her body and knows that the child is her own? When the child is born and begins to breathe? Or might we argue that although at earlier stages the child is alive and has a 'soul' it does not differ essentially (save for potentiality) from an animal until it begins to experience self-awareness or to realize the difference between right and wrong? (In the Bible souls are ascribed to animals.) The questions seem endless and the limitations of science are such that the scientific method is powerless to solve them. As Christians we must insist on a reverence for life, especially human life, but there may well be differences of opinion on the legitimacy or otherwise of such practices as abortion.

We may note that traditional Christian theology does not endow the fertilized ovum with a soul which was supposed to be implanted only after forty days for a male and eighty days for a female. The present Roman Catholic doctrine seems to be that since human life is assumed to start with fertilization, artificial fecundation is to be "absolutely rejected" while "experiments in artificial fecundation *in vitro*.. must be rejected as immoral and absolutely illicit" (Pope Pius XII, 1956 quoted by W.S. Fothringham, *Times*, 8 Oct. 1982).

SHORT NOTES

Risk. Increasingly risks are being subjected to mathematical treatment. Risk is usually measured in terms of the product of the probability of an event multiplied by the magnitude of the outcome. This may however give a very false picture of the situation. The certainty of receiving a thousand pounds and a one-in-a-thousand chance of receiving a million pounds are hardly equivalent. This consideration "makes nonsense of attempts to show, for example, that coal mining is more dangerous than using nuclear power. There are some risks which, however slight, must *never* be taken: steps on the path to nuclear Armageddon are such a case." (K.W. Hawkins, Letter, *New Scientist*, 4 Oct. 1979).

"If we look at the risks of dying from various causes, from snake-bite to smoking, there doesn't seem to be much connection between probability and anxiety" (Stephen Cotgrove, *Nature* 299, 659).

DNA. The common assumption that "all the information needed to synthesize a human being is coded in the DNA of a fertilized egg cell" is challenged by M.E. Deutsch of Bedford (Letter, *New Scientist* 11 Nov. 1982). Deutsch draws an analogy from architecture. "All the information needed to construct a building is *not* found in the complete blueprints required for this construction." Suitable tools and the knowledge of those who work in the construction firm are also required. The cell, too, may require a great deal of information not contained in the DNA: we can hardly imagine naked DNA turning into a human being! (Ps 139 may be read again in this connection.)

Age of the Universe. It has been held by most astronomers for sometime now that the age of the universe is around 20,000 million years. However, on the basis of the present rate of expansion, G.

de Vaucouleurs has recently argued for 10,000 Myr (*Nature*, 299, 303). *(See Note p.110)*

Atheist Clergy. Some of our theologians (or 'theologists' as they are now being called) are rapidly losing their faith. One of the latest to turn atheist is Rev. Don Cupitt, Dean of Emmanuel College, Cambridge. In his *Taking leave of God* he claims that it is no longer intellectually acceptable to hold that God is a reality: science and philosophy have demolished the very idea. In an article "Does God Exist? Faith gets a Lift" Clifford Longley (*Times* 12 Jan. 1983) contrasts the situation with what is happening among many of the philosophers and scientists. Dr. Keith Ward, lecturer in philosophy at King's College, London, one time atheist, recognises in Cupitt's position the views which he himself held only ten years ago. Now, however, he has joined the orthodox Christian camp. In his *Holding Fast to God*, he reckons that Cupitt's idea of Christianity is a caricature. Cupitt fancies that truth depends upon the availability of verifiable evidence but such a definition of truth cannot itself be verified or ojectivized. The roles of the academics are becoming reversed. "Leading scientists who profess belief are legion... and among the high priests of advanced thinking, the Oxford and Cambridge professors of philosophy, a majority are Christian" says Longley. In reply to Longley Cupitt says, "I continue to speak of God and pray to God" but by "God" he means "the way talk of God bears upon the will." (*Times* 14 Jan. 1983). Orthodox Christianity makes metaphysical claims, he complains. Is a prayer addressed to the way people talk about God any less metaphysical? one wonders.

Natural Theology. In secular society today there has developed a form of "consciousness that has banished from conscious perception the various clues and hints of the existence of God which once made the belief a natural and obvious one." Perhaps "the Reformation's insistence on salvation by faith alone has now been transformed into belief in God by faith alone, which invites the elimination of naturalistic grounds for belief". (Clifford Longley, *Times* 15 Nov. 1982).

Kimbolton School. The cover of *Chemistry in Britain* for November 1982 portrays a beautiful firework display at Kimbolton School given by Rev. Ronald Lancaster who teaches chemistry and divinity at the school. He describes himself as a scientist who takes a theistic approach to life. He illustrates the way he combines the two disciplines with the remark, "For example if one is discussing Mendeleev's table and the way that he was able to predict that the rest of the elements, as then undiscovered, were going to fit into his pattern, one cannot help but throw in a religious comment about there being some kind of pattern to life" (Vol.18, p.788).

Dishonesty in high places. In a television interview former President Nixon of USA said that a President is not always lying in an immoral sense "when he says something that he does not believe. Hypocrisy, he said, is a part of politics: without it one might not get elected." *Times* 28 Oct. 1982 "The Potter household was barren soil for one of Beatrice's deeply mystical and emotional temperament. She frequently remarked that her only hope of happiness lay in going 'heart and soul into religion', yet she early recognized that such a path was closed by the atmosphere of rationalistic positivism and 'utilitarianism of the more short-sighted kind' in which she had been reared. 'It is a misfortune that I was not brought up to believe that doubt was a crime'" *Times Literary Supplement* 15 Oct. 1982 in review of *The Diary of Beatrice Webb*, vol.1, 1873-1892.

Silver cord. "Or ever the silver cord be loosed... and the spirit return to God who gave it..." (Ecc. 12:6). Many people believe that they sometimes have an out-of-the-body experience (OBE) in which they seem to float away from their physical body, even seeing the latter from a distance. One fifth of those who have OBEs feel themselves to be in a duplicate body and some of these claim that the two bodies are then connected by a silver cord. (Susan J. Blackmore, *Beyond the Body*, Heinemann, 1982, £8.50). Though it appears that there is as yet no independent way of verifying the reality of OBEs, mention of a silver cord is interesting in view of the passage quoted above.

Gravity Waves. Despite claims, (see this JOURNAL 99, 175 etc.) it has not yet been possible for certain to detect gravity waves reaching the earth from space. (Weber's work has not been convincingly repeated.) The gradual change in the orbit of a binary pulsar, whose partner is invisible, has now been watched for more than six years and it is claimed that the change in its observed orbit is exactly what would be expected if it is losing some of its energy by propagation of gravity waves according to Einstein's theory. (J.H. Taylor and J.M. Weisberg, *Astrophysical Journal* 253, 908 and *Nature* 297, 357.)

Expansion of the Universe. Is there enough mass in the universe to pull it together again after its expansion has expended its force? The answer is not yet known. There are vast numbers of neutrinos and it has been suggested that they may possibly have a residual very small mass which would be sufficient to provide the missing mass, enough to make the universe condense once more. Particle theorists have now predicted the presence of new particles called *photonoes* and *gravitinoes* (*Phys. Rev. Lett*, 1982, 48, 223; *Nature* 297, 102), which again, *if* they exist, *might* supply the missing mass. All of which underlines how little we know about the world in which we live.

Arab Countries. Writing on Syria in the *Times* (30 Nov. 1982) Edward Mortimer comments on the fact that until 1970 revolutions and *coups d'état* were an almost annual occurrence, but for the last dozen years one ruler, Assad, has been in charge. This stability if reflected throughout the Arab countries. Though oil revenues have enabled rulers to buy off revolutionaries "the main factor has undoubtedly been a growing mastery by governments of the techniques of surveillance and repression combined with a willingness to apply them with whatever degree of ruthlessness is needed to retain total control." In Syria in early 1982 the Muslim Brotherhood rebelled. Assad's retaliation was ruthless in the extreme.

The Occult. The dangers of the occult are in the news again. In 1976 Christopher Taynton, 34, took part in the occult play *illuminatus*, the subject matter of which was the effect of unseen forces upon human behaviour. Thereafter he came to believe that he himself was possessed and as a direct result attempted to murder a middle aged woman because, for him, she symbolised evil. He succeeded in blinding her, destroying vision in one of her eyes. (*Times* 7 Sept. 1982).

According to the media witchcraft, practised in secret, is becoming increasingly prevalent. A serious case, resulting in a ten year and other shorter sentences, came up for trial in the Northampton Crown Court in September 1982 (*Times* 9 Sept.) A man, calling himself Lucifer, with his wife and sister-in-law, ensnared children and young girls into a black magic ring. Serious sexual offences were perpetrated.

Illiteracy. According to UNESCO statistics illiteracy is increasing. In 1970 it was estimated that there were 760m illiterates: today the figure is 824m (*Times* 10 Sept. 1982).

Note

Both figures are, of course, of the same order of magnitude. When dealing with such far flung extrapolations it is indeed remarkable that such agreement can be obtained despite entirely different methods of computation.

ROBERT L.F. BOYD, FRS

CREATION OF THE COSMOS

PART 2 - CREATING

The World of God; Reason, Design and Form,
Intelligence, Whose workshop spans the stars
Expressed within the Cosmos and alike
In what seems chaos; He Who works as much
In randomness as order, Who to make
Man in His image scorns not to create
By patient evolution on a scale
Of craft divine which dwarfs a million years.

Faith and Thought, 1975, 102, 182

God's Workshop

In Part 1 we grappled briefly with the scale of creation and the relationship of the Creator to it as understood in biblical Theism. We saw time and space as co-related in a way so closely as to make them partially interchangeable aspects of a single entity — space-time — and we saw this as a creature of the Creator upon Whom it is utterly and always contingent and Who as its giver is both beyond and forever the source of this whole.

We spoke of belief in the intelligibility and uniformity of nature, which in any case are but developments of the knowing and trusting without which science is impossible and we recognise that these beliefs were strongly present in the Psalms and Prophets which implicitly record their cultivation in a symbiotic relationship. Modern science is founded on these ideas of intelligibility and uniformity which in a complementary way we can rightly speak of as a divine revelation from God to His human "analogue". The general trustworthiness of these ideas is demonstrated by the success of science in bringing and ordering our understanding and in making possible the outstanding technical achievements which, for good or ill, characterise our time.

We saw that the most successful efforts to piece together our understanding and observations of the Universe lead us to the view that it all started in a "big bang" some fifteen thousand million years ago or that if it had a previous existence that cannot be traced through the confused instant $t = 0$. Granted then that the Christian sees the being of this whole as given then and always by God we must now ask what God would seem to have been up to during the ensuing fifteen thousand million years. What has He been doing in this workshop? Of course the short answer is everything, which would imply a more detailed answer of infinite length. Here, however, we shall limit ourselves to the more manageable task of exploring some of the creative activity of the Creator in the Cosmos. According to the Psalmist "the works of the Lord are great, sought out by all those that take pleasure therein". This pleasing exploration is therefore a truly biblical idea. It is our research into God's creative activity. As we have seen, the strongest word for create at the very beginning of the bible (bara) is used also of God's contemporary activity in animal birth, "Thou sendest forth thy breath they are created and Thou renewest the face of the Earth". (Ps. 104:30)

In seeking to give a good though brief account of this divine creativity in nature we will do so with the quaint words of Cromwell in our minds, "I pray you in the bowels of Christ consider that ye may be mistaken" but at the same time with the confidence that nature reflects the trustworthiness and constancy of its Giver.

Probability and Uncertainty

As scientists we no longer believe as did the cynic Omar Kayaam that "the first morning of creation wrote what the last dawn of reckoning shall read" for the determinism which characterised classical science has given way to the ideas of quantum physics in which the only certainty about physical events is statistical.

In modern physics this probabilistic aspect of nature is found to be very important and is enshrined quantitatively in Heisenberg's well verified "Uncertainty Principle". One form of the Principle says that there is a fundamental uncertainty in the energy of anything related by the very small quantity h known as Planck's Constant, to the time over which we are considering it. Quantitatively if we consider the energy stored, for example, in the spring of a balance over a small time interval Δt then while the instant to which the energy value applies is uncertain to an extent Δt the value of the energy is uncertain to an extent ΔE. Heisenberg's Principle records that the uncertainties Δt and ΔE are very simply related, their product being not less than 10^{-34} joule seconds.

Contemporary Creation and Annihilation

It may seem that the Uncertainty Principle is all about what measurements are in principle possible and to what precision. In a sense that is true. But science is about the observable world. It is without scientific meaning to say that something is quantitatively the case although it cannot ever be determined. To say that the energy of anything in a given microsecond is so much to an accuracy much greater than 10^{-28} joules is to make a metaphysical statement incapable of verification. That is not science.

A great deal of progress has been made in understanding nature at its most microscopic level by interpreting Heisenberg's Principle in a very positive way so that we do not merely say we cannot, in principle, measure certain pairs of quantities more accurately than so much but rather that the quantities must be considered as actually having a range of values within the potential uncertainty of their determination. A very dramatic example of the positive application of the Principle is that interactions between the elementary particles, from which we picture all matter as constructed, are modelled by supposing that certain other particles can have a transient existence, coming into being and disappearing again, providing their life is no more than given by the Uncertainty Principle. In the equation

$$\Delta E \times \Delta t = 10^{-34} \text{ joule seconds}$$

we let ΔE be the uncertainty in total mass/energy of the transient particles. Now obviously if ΔE were zero the particle would not exist but if $\Delta E = mc^2$ where m is the mass of a transient particle then it can exist and exhibit the inertial properties of a mass m. Since ΔE can, by Heisenberg's Principle exceed mc^2 for a brief instant a transient particle of mass m may spontaneously come into being for a time not longer than that instant. To be quantitative

$$\frac{10^{-34}}{\Delta E} = \frac{10^{-34}}{mc^2} \text{ seconds}$$

This time is quite long enough for the transient particle to pass from one atomic constituent, say a proton in the nucleus of an atom, to another, and our current understanding of the way nuclear constituents are being held together involves this very real and important behaviour of transient mesons. In special circumstances if energy is supplied adequately the transience of the particle is no longer set by Heisenberg's Principle and the particle can pass out into its surroundings with a life of its own. Energy has been converted into matter. A new particle has been created.

A very important facet of this for our topic is that the idea of matter as inviolate, uncreatable and indestructible, is no longer valid. Even if we broaden the concept of the conservation of matter into a conservation of total energy, in which any matter is represented by its energy equivalent according to $E = mc^2$, we still have to permit an overdraft of energy on the bank of Heisenberg's Principle sufficient to account in the way I have just described, for such real phenomena as the stability of atomic nuclei.

So we find that in the world we know today particles can be created from energy and even occur briefly "virtually" without an expenditure of energy. The reverse is also true. Particles can be annihilated leaving only their energy behind.

General Relativity

The beginning of the Universe open to our investigation, some fifteen billion years ago has a great deal to do with creation, but not necessarily in any special theological sense because, as we have seen, on the one hand there may have been an "earlier contraction" when *ex nihilo* would not apply in any material way and, on the other, creating as a divine activity cannot properly be limited to *ex nihilo*. The creating that started t = 0 was of the kind I have been describing in the last section and was accompanied by annihilation, also in the sense the physicist uses the word, on a grand scale.

We have three rather good reasons for accepting a hot big bang as the best interpretation available to us at present of what nature is saying about the start of it all. Perhaps I should rather say of the Word of God in nature. The first reason we have already mentioned. It is the existence of a faint flux of microwave (very short wavelength radio waves, almost infra-red) radiation coming to us continually from every direction in space. The second reason is the apparent ages of the galaxies and the third is the observed ratio of atoms of helium to those of hydrogen in space. These three observational facts find a more satisfactory explanation in the big bang than in any other cosmology and at the same time point to the cosmic validity of General Relativity, or something very like it, and the general correctness of our thinking as physicists. Einstein's inspired thinking that led to his formulation first of Special (1905) and then of General (1916) Relativity depended substantially on arguments involving ideas of self consistency and symmetry and very little on already known physical data. The Special Theory sought a formulation of physical laws which would be consistent for all observers irrespective of their uniform motion through space (a concept that was thereby stripped of much of its meaning). Michelson and Morley had done a famous experiment which pointed strongly to the idea that the laws of physics are the same for observers moving uniformly relative to one another although Einstein claimed to have been little influenced by it. The General Theory sought a formulation of physical laws which did justice to the idea that since there seems to be no way of distinguishing between inertial mass (i.e. resistance to acceleration, e.g. the tension in a string swinging a brick in a circle) and gravitational mass (i.e. response to the attractive force of another mass, e.g. tension in a string from which a brick is hanging above the Earth), inertial and gravitational mass should be regarded as one and the same property. This implies that acceleration and gravity are the same and, startling as that may seem, Einstein succeeded in representing them as a unity by choosing a new geometry for space. Not only was the Euclidean geometry, in which for example Pythagoras' Theorem held, abandoned but time retained the characteristic fourth dimension aspect it had in the Special Theory and the relevant Space-Time continuum had a geometry whose local properties were determined by the presence of matter and accounted for its gravitating properties. The General Theory predicted three important effects which were, in principle, observable. Firstly light should be subject to deflection by gravity, secondly, and in view of the first, light should be reddened on climbing its way out of the gravitating field of a star and thirdly the motion of bodies in orbit (specifically the planet Mercury around the Sun) should depart ever so slightly from that described by Kepler and accounted for by Newton's Theory of Gravity.

Each of these predictions has been amply verified. A star observed as its light grazed the Sun, during a total solar eclipse which made the observation possible, was seen to suffer an apparent displacement from its normal position quantitatively in accord with prediction. Very recently a distant quasar has been seen as a pair (in radio "light") as the radio waves have reached the telescope apparently around opposite sides of an unseen massive galaxy. There have also been reports of another case in which a trio of mirages caused by gravitational deflection have been found.

The most dramatic demonstration of the gravitational redshift was made in 1960 when the change in frequency of gamma rays (very short wavelength "light") on travelling 22.6 metres from the bottom to the top of a laboratory was shown to be within 10% of prediction. The very small changes in the orbits of Mercury, Venus and the Earth due to General Relativity were verified in 1956.

I have spent some time stressing the observational status of General Relativity because of the remarkable cosmological corollaries.

An Expanding Universe

When Einstein contemplated his rather complex equations which expressed the basic relationship which holds between time, space and matter, if the known gravitational and inertial properties of the latter are to be adequately formulated, he found an astonishing thing. He considered for the sake of simplicity a somewhat idealised Universe in which the effect of matter is averaged by thinking of it as spread out uniformly instead of clumped in galaxies, stars and planets and he found that his equations in their simplest form had no stationary solution. Put starkly that implies that the Universe has to be either expanding or contracting. Then Einstein made what he later called the biggest blunder of his life; not that it violated any rules of mathematics or principles of good science, rather the reverse. He realised that his equations might still be an accurate description of local space-time and gravity, that is of the cosmos as he knew it, if they were slightly modified by adding an additional term, a constant of integration, the so-called cosmological constant. This constant represented an unknown but entirely plausible force significant only over huge distances far greater than the average distance between galaxies. It is given to few great scientists to make their biggest scientific mistake simply as a result of "sitting down before fact" in a thoroughly open minded way. After all, who, before Hubble's observations would have dreamt that the Universe was expanding and have chosen to take that as the solution implied by Einstein's equations rather than the equally valid idea of a new, as yet unobserved, force acting on a cosmic scale. In a sense Einstein was very proper. Mathematically the term should be there in his equations. Only now in the light of the evidence for the expansion of the Universe and the absence of any direct evidence for such a force we set it to zero. If Einstein had been a little less honest with himself he might have made literally the greatest scientific prediction of all time — that the Universe is expanding. No doubt he would soon have been pounced upon by theorists who would correctly have pointed out that that conclusion is not inevitable. Only sitting before the facts, so soon to be observed by Hubble, would have resolved the matter. In any case, it turns out that the value of the cosmological constant is irrelevant to the picture General Relativity gives of the big bang once the expansion of the universe has been recognised. At that epoch the Universe was too small and the gravitational forces too large for an unknown but finite cosmological force to affect the picture.

What sort of picture then does General Relativity suggest for those early moments?

It will be a blurred picture in which the detail of any broad structure in the distribution of matter is smeared out. That, after all was how Einstein first evaluated the cosmic implications of his theory. Later we must think about detail on the scale of individual particles.

The equations portray a Universe that is expanding; we cannot quite say from a time $t = 0$ at which, extrapolating its present motion backwards, its volume would have been zero, because ideas associated with Heisenberg's Uncertainty Principle and Quantum physics generally imply that times shorter than a certain amount (10^{-43} seconds) are meaningless. In practice the limitation to our backward vision is much more severe because of inadequacies in our present knowledge of the basic physics, even assuming the laws have not changed with time. The picture presented by extrapolating from what we know today back to within a millisecond (10^{-3} second) of t = 0 is plausible and some inkling of events back to within about a microsecond (10^{-6} second) seems possible.

This picture is of space with a temperature approaching 10^{14} K having already expanded to a volume three hundred metres in diameter but containing all the mass/energy the Universe contains now. In order to get an idea of what we mean by a temperature of 10^{14} K we need to recognise that temperature is a measure of the average energy of motion per particle of an assembly of particles. Although the temperature of radiation can be thought of analogously it is perhaps better to think of it as related to its wavelength or colour. Thus the microwave radiation which pervades space has predominant wavelengths of a millimeter or so and corresponds to the radiation from a body at a very low temperature only about 3 degrees above absolute zero or -270^{o}C. As the wavelength gets shorter and shorter, corresponding to higher and higher energies or temperatures, the particle-like behaviour becomes more and more pronounced. Thus the wavelength of a gamma-ray is comparable to the size of an atomic nucleus so quite an extensive train or packet of such waves could still be of only atomic dimensions. We call a well defined packet of light a photon and a continuous beam of such packets can be thought of as a succession of photons. It is an intriguing and highly unclassical aspect of quantum physics that energy carried by an individual photon is accurately proportional to its frequency (that is inversely proportional to its wavelength). Gamma-ray photons are very energetic (corresponding to a temperature of billions of degrees), X-rays correspond to a somewhat lower energy (millions of degrees), visible light still less energy (thousands of degrees) and the individual photons of microwaves are very unenergetic (just a few degrees). In thus firmly associating temperature with particle (photon) energy we must remind ourselves that temperature is a description of an average energy of a statistical assembly of particles and cannot properly be applied to individuals.

Having considered the meaning of temperature as applied to both particles of matter and photons of light we are now in a position to consider the implications of a big bang fireball at a temperature approaching 10^{14} K. The average kinetic energy of a particle at this temperature is greatly in excess of the energy associated with its rest mass.

To be able to grasp the implications of the huge amount of energy associated with individual particles and photons we need to introduce a suitable 'yardstick'. Such a unit of energy is that necessary to create an electron and its associated antiparticle, a positron. This process, having been predicted by Dirac, was first discovered when the energy of cosmic rays entering the laboratory was found to give rise spontaneously to an electron-positron pair. The photon energy required, although large for those days (1932), is small compared to that given to individual particles and photons in modern high energy accelerators. We must emphasise that although this unit of energy is enough to make two particles we cannot create an electron by itself. It always comes with its antiparticle which has the same mass but opposite electrical charge so that no net charge has been created. This unit of energy is approximately 1 MeV on the electron-volt scale. The mean particle kinetic energy at 10^{14} K is sufficient to create about ten thousand electron-positron pairs. It corresponds to 10^4 MeV.

Because the fireball initially occupied a very small volume the density was huge, particles and photons were continually colliding so their temperature was the same. A typical photon would therefore be a gamma-ray with sufficient energy to create 10^4 electron-positron pairs. Now the mass of protons or neutrons (from which the nuclei of the chemical elements are built up) is less than 2000 times that of the electron so these particles also would be created in abundance from the kinetic energy of the particles and the photon energy of the gamma-rays.

If this was all that was going on we would simply have a Universe in which a great deal of primordial energy gave rise to equal quantities of matter and antimatter. (Every particle kind has its antiparticle). But two other important things were happening. The whole system was expanding, of which more later, and particle annihilation — the reverse of creation of particle pairs was taking place. This too is a familiar process in the laboratory and it explains on the one hand why we do not find antimatter lying around today and on the other, sets us one of the biggest puzzles about the big bang scenario.

The Presuppositions of Cosmology

The justification for the scientific process is the ability it gives to interpret an indefinitely large number of highly complex phenomena in terms of relatively few, possibly unfamiliar and startling, ideas. The early history of the Universe is no exception, but how far back can we hope to probe? In suggesting earlier that there is a limit, perhaps 10^{-43} seconds after time zero beyond which the Uncertainty Principle makes the situation undefinable in principle, and in further suggesting that before an age of a millisecond the model becomes increasingly obscure, we have introduced two limitations. The first is concerned with the basic meaninglessness of statements about existence over almost infinitesimal periods. The second arises from inadequacy in knowledge that we can at least hope and work to remedy. But even extrapolating back to a millisecond is a good deal further than we can see, remembering that seeing to great distances is seeing to earlier epochs because of the travel time of the light. The earliest phenomenon we can see is the (nearly) isotropic (i.e. uniform in all directions) microwave radiation flowing in a Universe already ten thousand years old. It must therefore be re-iterated that extrapolation depends on certain assumptions, but that is not just science, it is life. My trust that tomorrow will be another day, whether I am here to see it or not, is no less an aspect of my belief in the Principle of Uniformity than is my belief that I can extrapolate into the past. Only, the longer the extrapolation the greater degree of uncertainty I must be prepared to entertain while recognising that a blurred and distant view is far better than no view at all. To the basic science postulate of the Uniformity of Nature we add two other beliefs of a more specifically astronomical kind. They are the belief in the homogeneity of the Cosmos and belief in its isotropy. These beliefs do justice to the situation as we see it now and they mediate understanding, enabling us to make sense of what seems to have been in the past. Belief in the homogeneity of the Universe is sometimes called the Copernican Principle as it amounts simply to applying to any other hypothetical observer the insight of Copernicus, that we do not occupy any specially significant place in the physical Universe. To put it another way the Universe has the same gross appearance from every point in it. The Isotropy Principle extends this to the view that not only does the Universe look broadly the same in every direction from here and now but that it would do so from everywhere else in time and space. Taken together these two Principles constitute what is known as the narrow Cosmological Principle. A wide Cosmological Principle took it that the gross features of the Universe were not only the same as seen from every point in space but also as seen from every point in time. It has been rejected by almost everybody because it leads logically to the continuous creation or Steady State Theory. Any principle that leads by logic alone, rather than by sitting before the facts, to meaningful statements about nature has to be treated with great caution. This was the great error of Greek science. It is evidence of the caution with which basic presuppositions are tested that the wide Principle was never generally accepted by cosmologists and has now largely been set aside.

Events in the Fireball

The simplest way to understand what we think went on in the fireball and why we think it is to consider the history the Universe would appear to retrace if time were to reverse now. Many details which can be filled in will be overlooked for the present. We would see the distant galaxies retrace their flight and start to approach one another. Since, according to Hubble's (observational) law their velocities are related to their distances they would head to coalesce at t = 0 in around fifteen billion years. However since galaxies are at present separated on the average by distances about one hundred times their average diameter, it is clear that before the time when the Universe was a hundred times smaller in diameter than it is now, matter was not distributed in galaxies. This corresponds to an age of the Universe of around 10^8 years, and shows that the ages of the galaxies, about which we can learn by direct observation of their contents may be not much less than the age of the Universe. Before that time the blobiness that we associate with galaxies and stars must have been very much less, these having condensed from a relatively much more uniform distribution of matter. We know from spectroscopic studies of very old stars that that matter must have been mostly hydrogen with about 25% by weight of helium.

At this point it will be helpful if we think of an analogy to help us understand the idea of an expanding or contracting Universe. From a purely philological point of view we can note that it is the Universe, the whole, that we are talking about. All the space-time there is is expanding. It is not expanding into more space and taking time about it. It is just growing. From a more scientific point of view we see that if this were not so the cosmological principle would be violated. If it were a case of matter expanding into unoccupied space then there would be a centre and a boundary and the view from them would be quite different. Since the Universe is changing in size it is finite, but homogeneity and isotropy require that it is unbounded. Einstein's curved space-time provides the mathematical key but not a complete mental image, for we can picture a curved line on a plane and we can picture a curved surface in space but we cannot picture a curved space in some hyperspace. Instead we restrict ourselves to representing three dimensional space by a surface; the surface of a sphere — a rubber balloon — for example, although since time and space are so closely related we must recognise a four dimensional continuum, curved in an unimaginable hyperspace. For the moment, however, let us picture the Universe by the surface of a balloon and the galaxies as paper discs randomly distributed on it. The view from any one galaxy is broadly the same as that from any other, but we must not think that we can see right round this closed curved space for it is expanding at a velocity near that of light.

Returning now to our time reversed history of the Universe we have seen that the reversed evolution of the galactic paper discs would have shown them dissolving as their matter became smeared over a sphere now only one hundredth of its size today. As we watch the contraction further the density continues to rise and with it the temperature. This is no more mysterious than the rise in temperature of the gas in a diesel engine cylinder as it is compressed and its reverse, in the actually expanding Universe, is a cooling like that produced in certain refrigeration cycles. There is, however, a subtle difference. The Universe is full of microwave radiation and as we compress this in our time reversed model its wavelength gets shorter. This, as we have seen is equivalent to increasing its energy. Its temperature rises. If we change the radius of our model Universe by a factor of a thousand we change the wavelength of the photons by the same factor and their energy in inverse proportion. Because of the change in volume the energy density (if we neglect particles) changes by 10^{12}. So when the Universe was only one thousandth of its present day radius the microwave radiation was no longer microwave but red or even yellow hot, corresponding to a temperature of 3000K. Now the matter in a Universe full of light, like that in an oven whose walls are incandescent tungsten, cannot be unaffected by the situation. At this temperature hydrogen atoms — the most abundant stuff of the cosmos — are torn apart into protons and electrons. Such a gas is called a plasma and because electrons, being charged particles, interact very strongly with electromagnetic radiation (c.f. the electrons in a radio aerial) no photon can travel far without being scattered. The sun like other stars, although gaseous, is opaque in this way and in just this way at that epoch the whole Universe too will have looked like a fireball. But the only viewpoints are in space-time, that is to say inside the ball. It is, to reverse the argument and restore time's arrow, just this fireball which we see everywhere with the radiation Doppler shifted by the expansion of the Universe to the microwave region of the spectrum. The reality of the fireball can hardly be in doubt; we can see it with our microwave telescopes. But just because we can see it we cannot see beyond it. For earlier epochs we must rest more heavily on the Cosmological Principle, Uniformity and well tried theory.

We have now seen that the microwave radiation points to, we can even say is, the fireball, and that the ages of the galaxies fit the big bang picture. The remaining main piece of evidence is the 25% helium to hydrogen ratio in the Cosmos and this takes us back to events in the first minute or so of the life of the Universe.

Helium

If we continue the technique of watching the action replay of the Universe in reverse we shall realise that the ever decreasing volume of "india rubber" space will see an ever increasing temperature due both to doppler shift in the radiation and to compression of the gas. The process of nuclear fusion to make heavier elements from hydrogen is humanity's hope as an energy source for the 21st Century. It is also well understood as the process by which normal stars stoke their fires and so shine almost unchanged for millions of years. One might expect that conditions in the first second of life of the primordial fireball were not dissimilar to those in the deep interior of a star. Computations based on the time reversed compression idea show, however, that the temperature was higher and the density lower at t = 1 second than is typical of stellar interiors. This has a profound consequence. At the huge temperatures of the first second, after which the fireball has cooled to 10^{10} K no chemical elements other than hydrogen could exist undisrupted by the turmoil. Not only would they have been stripped of their electrons, even at much lower temperatures, but the atomic nuclei themselves, built up of their basic components, protons and neutrons, could not endure. Indeed even protons themselves, the elementary nuclei of hydrogen could not retain their identity during the first few seconds, but would dissolve to a sea of quarks. During that period, therefore, no enduring nuclear synthesis of elements could occur. But as the seconds ticked by towards the first minute neutrons and protons would stabilise and colliding would give rise to the heavy isotope of hydrogen, deuterium. Deuterium nuclei colliding produce a rare variety of helium the light isotope which soon absorbs a neutron to become normal helium — an element so stable that it is shot intact out of a radio-actively decaying heavy element and so earned the name α-particle as if it were an elementary nuclear constituent like the proton and neutron. We shall see later that even these are not unstructured. It is because of its great stability that the helium concentration could build up to quite high levels. Once formed it is not easily destroyed. Later as the density and temperature fell little more would be produced until once again high temperatures and densities were available in the deep interiors of stars. It turns out that calculations of the relative amount of helium formed in a cooling fireball of hydrogen, at the temperatures and densities backward extrapolation points to are not very sensitive to the accuracy of the extrapolation. The figure of 25% by mass is in astonishingly good agreement with what we find today for the Universe as a whole.

We have now traced the history of the Universe back to the point at which the third pillar of evidence on which the contemporary evolutionary picture of the Universe primarily rests is seen to be well founded. The time is not long after t = 1 second. At this point as we peer back further it is, perhaps, worth digressing briefly to relate the exercise to an important and unfortunately sometimes heated discussion that took place in the latter years of the last century.

The Omphalos Question

Omphalos is the Greek word for navel though it is derivatively used for central point, hub or perhaps even the crux of an argument. The question debated, sometimes in its exact form, but more often in terms of its more general philosophical implications was "Did Adam have a navel?". An analogous question is "Did the trees in the Garden of Eden have rings?". The philosophical meaning of the argument is quite unrelated to one's view on biblical interpretations and the early chapters of Genesis. Put baldly the crux is, if Adam had no navel then he was (at least in that respect) not a real man — the argument can, of course, be extended to every other property which in a real man relates him to his mother (and father), his heredity written in his genes, his memory, his psychology and so on. Similar questions were posed about Eden's trees, and a parallel debate went on in geology. This is, probably, the central (*omphalos*) problem for a narrow unbiblical creationism. I say unbiblical because the Genesis record does not suggest creation from nothing but says rather "let the seas bring forth", "let the earth bring forth" and Adam is singled out as formed from the dust of the ground like the creatures of Psalm 104. The whole issue can be sharpened by bringing it up to the present and asking myself how I know that I and all my surroundings have not just been created complete with my memories of a never experienced past and the remains in my digestive system of a never eaten meal? It cannot be denied that God could create a being or a whole Universe with an apparent past and it may be thought impious to ask if He would. But even to assume that He did is not to bring science to a halt, for providing the apparent past He creates shows all the fundamental characteristics of the world I take to be real today I can continue to study it as if real. At any point in the past, therefore an *ex nihilo* creationist can suppose the past I am describing is only apparent and not real and I cannot refute him. Equally he cannot call a halt to my exploration. That halt, as we have pointed out, may well be called by the nature of science soon after $t = 0$. At $t = 0$ itself all pattern and structure is gone and all trace of any former history would seem to be lost in the mathematical singularity. Any effort to look beyond, at the most, mirrors what I see on this side of the beginning and who shall say that mirror is not real?

Encouraged therefore to assume that neither God nor the Devil puts fossils in the rocks to test or tempt Christians let us look back beyond $t = 1$ second and see what we can descry.

The First Moments

Looking back towards the earliest moments of the Universe is closely related to researching deeper and deeper into the nature of matter. Modern elementary particle physics started with the search for the basic building blocks of the Universe. As everyone knows the Greeks had a word for such blocks, *atomos*, and in the last century it was realised that there were several score different elemental atoms. Even then it had been suggested that these atoms were really made up of hydrogen — a hypothesis which is correct in essence since although the hydrogen nucleus contains only a proton, carrying one atomic unit of positive charge, and other elements contain also neutrons having about the same mass but no charge, we now know how protons and neutrons transmute into one another with the aid of electrons (or their antiparticles) and some further mysterious and elusive particles known as neutrinos. The structure of atomic nuclei is studied by examing the effects of an impact from a high energy subatomic projectile such as an electron or a gamma-ray photon. The main function of the projectile is to supply energy to the system under study so as to break it down into its constituents, but here we encounter a problem. Energy can create new particles and as higher and higher energy projectiles become available from huge particle accelerators so a bewildering spectrum of known and unknown particles materialised at the points of impact. Increasingly over the last two decades order has been introduced into this chaos by the demonstration that even the neutron and proton, and indeed the transient pion (π-meson) which binds them together, have a structure. The components that constitute them are called quarks and these are helpfully conceived as bound together by transient gluons.

This is not the place to dwell at length on the beauty and symmetry of modern elementary particle physics but firstly to draw the parallel that as we approach either $t = 0$ or sub-protonic space we find a world in which Heisenberg's Uncertainty reigns in its most creative and positive role and in which particles come and go in a way that must shatter any simplistic or grossly materialistic ideas and secondly to note that whatever particles may exist at the heart of such basic atomic constituents as neutrons and protons or may materialise when electromagnetic radiation interacts with matter, we can expect to find also in the early moments of existence in what was formerly called the primordial atom. Thirdly and more mysteriously and uncertainly we can note that while twenty years ago or less it would have been claimed that there are four fundamental forces of nature — electromagnetic, the weak nuclear force of radioactivity, the strong nuclear force which binds the nucleus of atoms and gravity which rules the Cosmos — today the first two of these are seen as aspects of a single type of process unified by a single theory. Symmetry ideas suggest that the six basic elementary particles with their six antiparticles (they are called leptons) which interact, as described by this unified theory, have counterparts in six types of quark (with their antiquarks) which account for the strong nuclear force. These quarks, only five of them have been discovered, at the time of writing seem to come in three different kinds called colours for want of a better name; hence the name of the theory Quantum Chromo-dynamics. The symmetry between the leptons and quarks points strongly to a basic, as yet undiscovered unity, and already there are hints that gravity, the fourth fundamental force may be brought into the fold.

In a situation where even the most elementary particles can change into others (quarks can decay radioactively for example; indeed this is the basic event of beta radioactivity), where they can annihilate or materialise with their antiparticles and where the intense gravity (space curvature) of the early Universe may itself create particle pairs as the intense electromagnetic fields of gamma-rays do it is important to enquire what, if anything, is conserved. Conservation laws in fact are amongst the most important in physics.

Our understanding of the Universe so far, which is the eating which proves the pudding, suggests that total energy is conserved (remembering $E = mc^2$) in elementary particle interactions, in the Universe as a whole and in everything in between. Electric charge is similarly conserved and so, it would appear is the mysterious colour of quarks. A charged particle is never found to come or go without its antiparticle keeping the net change in charge zero. Momentum and angular momentum are also conserved.

As we address the earliest moments we will abandon the reversed action replay approach and simply suppose that all the energy of the Universe at a time very close to $t = 0$ was an enormously rapidly varying, unimaginably intense electromagnetic field. That is a description of light of all wavelengths, far beyond the visible spectrum. Whatever the writer of Genesis 1.2 understood by his words and whatever God meant him to teach no big bang cosmologist could quarrel on cosmological grounds with an exegisis that applied "And God said let there be light" to a time close to $t = 10^{-43}$ second Before that perhaps we should invoke the wholly unclassical quantum gravitational soup described by Hawking as a "foam of constantly exploding and reforming mini black holes". Now, as we have seen, Quantum Physics recognises electromagnetic radiation not only as varying electric and magnetic fields but complementarily as individual photons (quanta) each with an energy defined by the frequency of the variations in the field. These photons when sufficiency energetic, and as we have seen at 10^{14} K most of them are, can create pairs of particles.

During the brief millisecond while the expanding Universe cooled from 10^{14} to 10^{12} K we can imagine literally all kinds of elementary particles being created and, colliding again because of the great density with its twin or another antiparticle, annihilating in a fresh burst of gamma-radiation. At this time those mysterious leptons, the neutrinos, would leave the game but not the field. Neutrinos are mysterious because they hardly react with matter at all. Those generated (and there are many) deep in the Sun have little difficulty in passing out and on reaching the Earth, for example, for the most to part pass right through totally unaffected. It is just because a neutrino can go so far in dense matter without any interaction that I say that at about t = 10^{-3} seconds they leave the game. They just do not play any more part in the mêlée of interactions which is going on. But I mention them because they may still be important for at least two reasons. First since they are so unreactive they are still in the field, still around in huge quantities and may contribute to the unobservable (at present) mass of the Universe. Secondly because few of them have interacted with anything since t = 10^{-3} seconds. If we ever find a way of observing them we will be directly observing right back to the end of the first millisecond of the Universe.

At the moment the important question of whether they have a rest mass is being vigorously pursued, firstly because it bears on the whole question of our understanding of the relationships between fundamental particles. It is an intriguing point that the properties of these mysterious barely observable particles may hold the clue to such questions as to why the Universe is not all radiation or at any rate not matter and antimatter in equal quantities, whether the Universe is closed, that it will eventually contract to a Big Crunch. They relate also to the question of the finite life of all gross matter — the half life of a proton may be (only!) 10^{30} years. Neutrinos, like photons outnumber other particles by 10^8 to 10^9. Even a rest mass of 10 eV would point to a final event. But that is another story.

Reason, Design and Form

Such then is God's workshop, an expanding space in whose initial chaos randomness and order are indistinguishable, where in a "light that no man can approach unto" He set out His bench, assembled His tools, collected His materials and prepared as He evolved the Universe to pursue His creative craft. And "those whom He foreknew He also predestined to be conformed to the image of His Son."

J.H. JOHN PEET

CHEMICAL EVOLUTION – SOME DIFFICULTIES

Dr Peet, who is the Head of Science Section & Science Coordinator, Guildford County College of Technology, examines the theories which have been advanced to explain the origin of life from inorganic matter. He shows that the difficulties are far greater than often supposed.

As the study of biology has shifted to the realm of the molecular, it has required an understanding of, and an explanation in terms of, chemistry.

In approaching the subject, it would be helpful to clarify certain assumptions and principles behind my reasoning. First of all, I am concerned to identify the facts on which the prebiotic evolutionary theory is based. On these we will agree. Then, we must be clear on our extrapolations from facts into theories. The scientist is wary of far-reaching extrapolation, yet this is common, in evolutionary theory. Limited range extrapolation is of course permissible – without it observable facts can rarely be tied together to give a coherent picture. Science is based on the assumption that such a coherent pattern exists; we have no quarrel with this. But, theories of unification may start with differing sets of presuppositions, and these can cause us to link facts in different ways.

In this paper, I am asking whether the path used by the materialistic evolutionist to link chemical observations is valid and in accord with his own rules. We will test his claims and examine their relevance to the debate on the origin of life. In contrast to the Biblical claim, "In the beginning God created..." (Gen.1:1), Prof. Fox has said, "In the beginning, life assembled itself."[1] Does the evidence – experimental and theoretical – give any substance to that claim?

We shall consider amino acids and proteins in detail. This is primarily because this is the area which has been the most extensively evaluated by the chemical evolutionist. Other biochemical systems will be examined as we progress but, as we shall see, the evidence is even weaker for these.

Two evolutionists have recently set the stage for us. Prof. M. Eigen has said, that the origin of life "never can be repeated by us, but we could ask proper questions, knowing the problem."[2] Prof. Ponnamperuma writes: "To the chemist, prebiotic synthesis appears as a two-part problem:

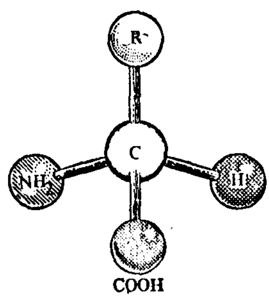
(i) to make small molecules necessary for life;

(ii) to combine the small molecules under similar conditions into the polymers, the polypeptides and oligonucleotides, which are the precursors of nucleic acids and proteins."[3]

We have no quarrel with these statements; have these colleagues, or others, found a reasonable answer?

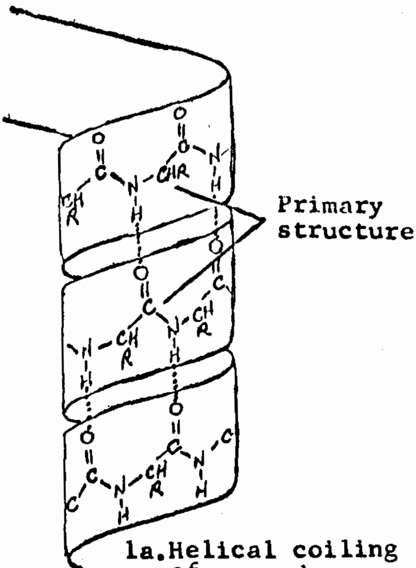
Amino acids — their Nature and Occurrence

Most extensively studied, in terms of prebiotic synthesis, are the proteins. We will consider these in detail, knowing that the problems for other compounds (e.g. carbohydrates, nucleic acids, etc.) are probably even greater. Proteins are important to life — they are the basis of structural materials (hair, muscles, wool, skin, nails etc.) and of enzymes. They are produced by the polymerisation of α-amino acids, of general structure:

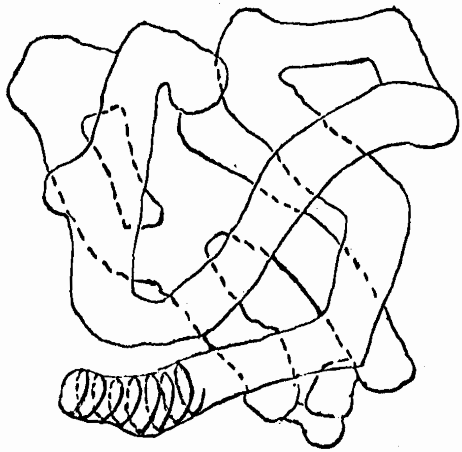


There are about twenty amino acids known in nature which form the building blocks of proteins. The order in which these are linked in proteins is known as the primary structure (figure 1a) Then part or all of the chain may coil up on itself to give the helical secondary structure (figure 1a). This then folds up on itself to give the overall tertiary structure (figure Ib). The secondary and tertiary structures are held in place by linkages (through hydrogen or sulphur) between parallel amino acids (figure Ia). The manner of folding of the chain determines the biological activity and is, in turn, determined by the nature and order of the amino acids in the primary structure.

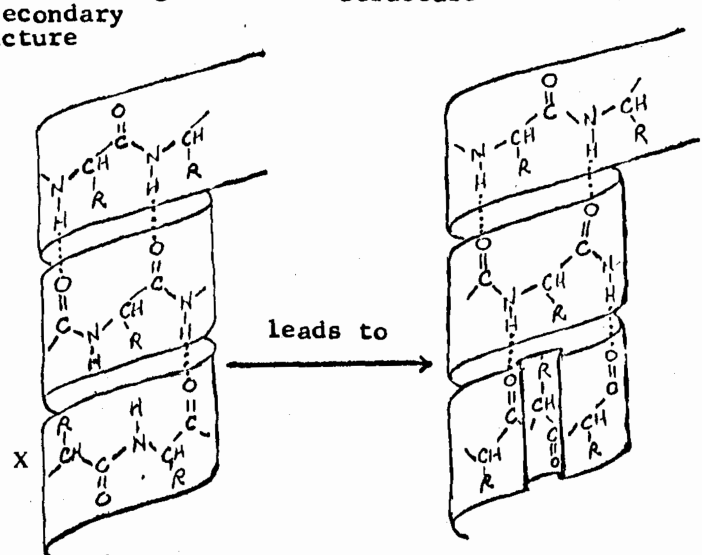
Figure 1. Protein Synthesis



1a. Helical coiling of secondary structure



1b. Folding of tertiary structure



1c. Helical distortion due to substitution of a D-amino acid in a L-chain at X

The Raw Materials of Abiotic Synthesis

In attempting any chemical synthesis, we must first ask the nature of our raw materials. Immediately we are faced with a problem: we do not know what was available. In general terms, we assume that the substances are present in simple chemical forms which were converted to more complex structures, the compounds of life. The primeval chemicals would be gaseous (being small molecules) but could be, in chemical terms, either reducing or oxidising in nature. Our present atmosphere is oxidising. But organic compounds, the "compounds of life", are chemically unstable in an oxidising atmosphere. The primitive atmosphere must be anaerobic. If oxygen were present organic compounds would simply end up in combusion[4] and so are unlikely to be found in such conditions. So, it is postulated, the primeval atmosphere would have to be a reducing one — ammonia, methane and water being proposed. A similar one — ammonia, methane, nitrogen, water and hydrogen — was originally postulated by Oparin.[5] This was based on evolutionary requirements rather than geochemical evidence.

So, Maddox has said, "After more than a decade of speculation, it's now clear that when life began the atmosphere of the earth was rich in materials such as methane, ammonia, hydrogen and water vapour."[3a] But this is either ignorance or a "burying of the head in the sand." Abelson[6] has shown that the evidence counters this and proposes an alternative model of carbon monoxide and hydrogen (by volcanic outgassing) with nitrogen and water. Walton[7], in turn, has produced evidence which shows that, rather than carbon monoxide and hydrogen, such sources produce 90% water and carbon dioxide. Furthermore, Brinkman[8] has argued that ultraviolet production of oxygen would have given an atmospheric concentration of 25% early in the earth's history, that is, long before life began, so preventing it by oxidation of the vital materials. Fyfe[9] believes that the primordial temperatures would have been too high for successful abiotic synthesis.

A detailed analysis of Precambrian rocks indicates that the atmosphere was of a similar nature to that known today, in that these rocks are also in a partly oxidised state.[10] Even the very earliest known sedimentary rocks of $4.0 - 4.1 \times 10^9$ years old show some oxidation.[9b] As Hoyle and Wickramasinghe have written.[11] "There is a disconcerting lack of evidence for any large scale nitrogenous carbonaceous deposits in the oldest sedimentary rocks ...; their absence in the geological record may be construed as evidence against the soup." A. Henderson-Sellers[12] has come to a similar conclusion by studying surface temperatures. She believes that the popular view stems "as much from ignorance of recent advances as from active opposition to them."

Furthermore, Shimizu[13] has shown that methane would last for only 1% of the time required by evolutionists. Abelson[14] found that "a quantity of ammonia equivalent to the present atmospheric nitrogen would be destroyed in about 30,000 years." An additional complication arises from the great solubility of ammonia in water, so removing a large proportion of the gaseous atmosphere. On the basis of energy sources available, "life times in the primitive environment would have ranged from seconds to many years, but few would have survived over geologically long periods."[17] Those models based on water fare no better, because the water vapour would dissociate as a result of ultraviolet radiation and so produce an oxidising atmosphere.[8] Henderson-Sellers and Schwartz[16] have sought to salvage the situation by proposing a TiO_2-catalysed fixation of nitrogen, but acknowledge the problem of photochemical destruction. So, the long times required by the evolutionary theory are disastrous to the chemicals.

Synthesis of the Biochemical Building Blocks

Let us assume though, that these problems are trivial and ultimately resolvable, in spite of the contrary evidence. We must now expose the supposed reducing gases of the early atmosphere to a high energy source to make them react.

In 1951, Calvin[17] irradiated a mixture of carbon dioxide and water in a cyclotron and produced a number of organic compounds. More famous is the work of Miller and Urey[18] who subjected a mixture of methane, ammonia and water to an electric discharge and obtained a number of amino acids. Other significant biochemical species have also been detected. (Table I). Palm and Calvin[19], using their electron bombardment technique, also obtained hydrogen cyanide, to the significance of which we shall return. Groth[20], using Miller's mixture and ultraviolet radiation, obtained traces of only two amino acids: glycine and alanine. Even in the most successful work, that of Miller, using idealised conditions, only small amounts of amino acids etc. were obtained. On this basis, the edifice of chemical evolution has been built.

AMMONIA — METHANE — WATER

Formaldehyde	Amino acids	HCN
Sugars	Peptides	Nitrogen bases
Polysaccharides	Proteins	ATP/RNA/DNA

Table I. Products in Miller's electric discharge experiment.

SUBSTANCE*	YIELD/MICROMOLES PER MOLE METHANE
Formic acid	40,000
Glycine	10,700
Glycollic acid	9,500
Alanine	5,800
Lactic acid	5,250
β-alanine	2,500
Acetic acid	2,500
Propionic acid	2,200
Iminodiacetic acid	930
Sarcosine	850
α-aminobutanoic acid	850
α-hydroxybutanoic acid	850
Succinic acid	680
Urea	340
N-methylurea	250
Iminoaceticpropionic acid	250
N-methylalanine	170
Glutamic acid	100
Aspartic acid	70
α-aminoisobutyric acid	20

(*Yields of compounds associated with the origins of life in the experiments of Miller and Urey In addition there was a larger amount of tar; only four of the commonly occurring amino acids were identified.)

Miller's experiments represent an unrealistic situation, one not available on the primitive earth, namely the use of a cold trap. The compounds can be isolated only because of its presence; without it, no detectable quantity of the product would ever have been produced. Furthermore, to have removed the chemicals from this high energy source would hinder subsequent reactions and so facilitate degradation.

Let us look more closely at this primeval soup that has been postulated. Firstly, if *all* the atmospheric nitrogen were converted to a single nitrogenous compound (e.g. glycine), its concentration would be only 0.2 molar. In fact, this must be divided, not only between the twenty amino acids, but also between such species as the nucleotides and porphyrins.

But, this is unrealistic. Hull[21] examined the most favourable reaction: that for the equilibrium production of glycine —

$$2CH_4 + NH_3 + 2H_2O \rightleftharpoons H_2N\cdot CH_2COOH + 5H_2$$

The proportions of products and reactants present at equilibrium is given by the relationship,

$$K = \frac{p(gly)\cdot p(H_2)^5}{p(CH_4)^2 \cdot p(NH_3)\cdot p(H_2O)^2}$$

where p(A) represents the partial pressure of A. For this reaction, K has the value 2×10^{-40}. Substitution of the appropriate values for the pressures of the reactants in the primeval atmosphere shows that glycine would have a maximum concentration of 10^{-27} mol.dm^{-3} (i.e. one molecule in ten thousand litres). Even then, the glycine is so unstable to ultraviolet radiation (photodecomposition being 10^4 - 10^5 times more efficient than the photosynthesis), that 97% of this glycine would decompose before it reached the earth's surface.

In an alternative, kinetic calculation, Hull deduces that the amount of glycine might reach a maximum of 10^{-12}mol.dm^{-3}. (This is equivalent to 0.2 mg in a swimming pool). The amount is far too small to achieve any significant amount of subsequent reaction, since this concentration would adversely affect both the equilibrium yield and the rate of formation of subsequent compounds.

And this is the situation for the most favoured compound! And we have seen that the fact that a compound has been obtained in the laboratory is no real indication that it was present in significant quantities in the prebiotic soup.[15] Unbelievably, Eigen speaks of this as "a rich soup!"[22] Hull, reasonably, says that "the conclusion from these arguments presents the most serious obstacle, if indeed it is not fatal, to the theory of spontaneous generation."[21] Sillen claims[23] that the concentrations are so low "that the concept of a prebiotic soup (is) an entire myth."

Bernal[28] has suggested mechanisms that might have concentrated the organic molecules in the sea. (A basic problem is that there must be sufficient molecules of the right type in the first place!) Again, considering the amino acids, we note that, including their stereo-isomers, there would be thirty-nine α-amino acids corresponding to the twenty naturally-occurring ones, and there would also be β- and γ- isomers formed in the prebiotic soup. And, once the amino acids and carbohydrates reach the required concentration, at the pH of the ocean they would react.[10] Abelson has shown[6] that even at 0° C amino acids and carbohydrates are incompatible. He and Hare[29] found that for all the amino acids they tested, substantial yields of humic acids or kerogens were formed by reaction with carbohydrates. In fact, since the amino acid concentration would have greatly exceeded carbohydrate concentrations (as shown below), there would be no sugars at all in the soup!

Kinetically, the problems are just as great. Under the conditions of the proposed synthesis, the rate of decomposition exceeds the rate of production by a factor of 10^4.[21] Reaction rates are affected by concentration, temperature and catalysis. They are low, very low, at low concentrations even for thermodynamically favoured processes. At the concentrations described, even geological times are too short. Increases in temperature accelerate reactions; but this means all reactions, including the degradation of the essential prebiological intermediates.[15] Some surfaces (e.g. rocks and clays) might absorb the reactants and so catalyse the process. But, as Hulett emphasises,[15] to argue for the importance of catalytic surfaces only increases the rate at which these poor yields are reached.

Hulett summarises the problem[15] when he writes, "It is, in fact, hard to reconcile the thermodynamic and kinetic characteristics of these compounds with the postulated pathways for chemical evolution in the primitive environment."

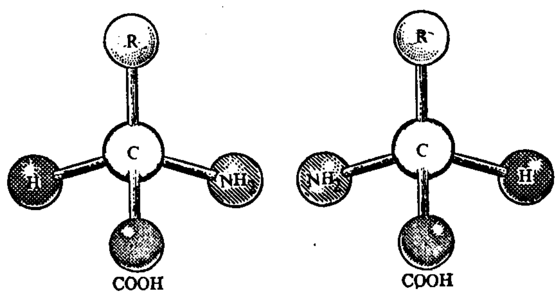
Matthews and Moser[26] have suggested that polyamino acids, and other nitrogenous materials, might be obtained by the polymerisation of hydrogen cyanide. This compound also is produced when suitable gaseous mixtures are subjected to electrical discharge.[27] This compound polymerises to a black solid, which undergoes hydrolysis in an acidic medium to generate fourteen amino acids. It is proposed that iminoacetonitrile was the intermediate.

$$\mathrm{HCN} \rightarrow \cdot\mathrm{HN{=}CH{\cdot}CN} \leftrightarrow \mathrm{H_2N{\cdot}\overset{+}{C}{=}C{=}\overset{-}{N}} \rightarrow (\!-\underset{\mathrm{NH_2}}{\mathrm{C}}{=}\mathrm{C}{=}\mathrm{N}-\!)_n \rightarrow \text{polypeptides}$$

Experimental work has been based on *high* concentrations of hydrogen cyanide. It has been suggested by Sanchez[28] that these might be achieved by freezing. Intermediates are apparently formed more readily under these conditions. However, polypeptides have yet to be isolated from this reaction medium. In addition, as R.E.D.Clark has pointed out, if hydrogen cyanide had been present on the earth in early times, the iron-cyanide complex, Prussian Blue, should be present as a mineral; yet it does not appear to occur at all.[29]

Stereoselectivity

Even if these massive problems could be overcome, there is still a problem to which no successful explanation has been given — why do we get only one stereochemical isomer of each of the amino acids?



In experiments such as those of Miller, both enantiomers are formed. Yet, in nature, almost exclusively, the L-form occurs. Even in the very rare situations in which the D-isomer is found,[30] the occurrence is highly specific and our arguments would still apply. Indeed, Bodansky and Perlman[31] were able to show that the D-amino acids in antibiotics arose from the L-forms; the D-forms are not incorporated directly!

The main differences between these two isomers occur in two areas. One is their effect on optical activity; the other distinction is a biological one. If a chain is constructed from the L-acids, and then one of the units is replaced by a D-acid, it breaks the symmetry of the helix, since the functional groups are in the wrong positions (figure 1c). This distortion of the helix destroys the tertiary structure and activity of the protein.

A number of attempts have been made to explain this selectivity, either by stereospecific synthesis or by selective destruction of one isomer, without experimental success. Yet, the importance of this topic cannot be over estimated. J.D. Bernal stated that this is "the key unsolved problem of detailed biogenesis."[32] W.E. Elias, in a well-balanced review on this subject, has said that "acceptable theories must provide answers to at least five important question."[33] These he gives as follows:

"(1) Were single isomers created by asymmetric synthesis, or did they appear as racemic pairs, one isomer of which was preferentially eliminated?

(2) If asymmetric synthesis or decomposition is postulated, what was the asymmetric agent?

(3) Was the production of an optically-active compound... an oft-repeated event or one of single occurrence?

(4) Are the rotation of compounds the result of chance...?

(5) Was the asymmetry introduced at an early or late stage of chemical evolution, or was it delayed until the appearance of inchoate life...?"

The chemical synthesis of an optically active compound always generates an equal mixture of the D- and L- forms, unless another chiral compound is used in the process. Several recent reviews[34,84] indicate the difficulty the chemist has in preparing "optically pure" products. One can summarize these efforts by saying that, in order to achieve a stereospecific synthesis, one must use an optically pure reagent, catalyst or solvent. Fortunately, for the chemist, methods are also available for the resolution (separation) of D and L forms. But, what about the natural synthesis of the L-amino acids? Currently, biological cells achieve this by the use of enzymes. But, how did the optically pure enzymes originate? Here is the crux of the problem. A number of models have been suggested and abandoned as unacceptable (table II).

1. *Polarised electrons.* When beta radiation is slowed down, it becomes polarised. In an experiment, Garay[35] showed that a mixture of D- and L- tyrosine, in alkaline medium, exposed to this bremsstrahlung for eighteen months experienced a significantly greater destruction of the D- isomer than of the L- isomer. The implication is, of course, that from a synthetic mixture of the two forms in the "primeval soup," the D- isomers would be selectively destroyed. Hodge *et al*[36] have tested this method and have concluded, "we observed no single case of preferential decomposition of the enantiomers... on irradiation with polarised electrons."

Table II. Proposed models for the origin of asymmetry.

1. Polarised electrons
2. Circularly polarised light
3. Adsorption on quartz and clay
4. Spontaneous crystallization
5. Statistical variation
6. Autocatalysis
7. Contamination from space

A similar principle is implied in the use of *circularly polarised light.* A number of workers have attempted to induce stereoselective disintegrations and synthesis by irradiating mixtures with polarised light. It is suggested that the polarised light might originate through the influence of the earth's magnetic field.[37] The best result obtained using reasonable concentrations is 20% optical activity.

Harada[37] has suggested that optical activity may be related to the non-conservation of parity. That is, the existence of the L-amino acids is pre-determined because of the inherent dissymmetric nature of matter. We must ask the source and reason for this dissymmetry. But, as we have seen, the experimental evidence does not lend support to the hypothesis anyway.

2. The most popular idea is that this selective synthesis might be achieved by the *selective adsorption* of the L-amino acids and D-glucose on clays or quartz.[38] This has recently been challenged by Youatt and Brown.[39] Quartz occurs in nature in its two optical enantiomorphs. Reactions occurring through adsorption on one of these forms are often selective, resulting in asymmetric synthesis of disintegrations. Akabori[40] proposed that adsorption of an initial unit on clay would result in an alignment of molecules to produce a specific conformation. Ponnamperuma has found that these claims cannot be substantiated.[41] Terentev and Klabunovskii[42] claim to have brought "about a number of asymmetric syntheses with different catalysts on quartz crystals under many variable conditions." Even though quartz has two crystalline forms, these seem to be unable to distinguish between the amino acids according to other research.[43]

3. Other workers have tried to explain the selective synthesis by proposing a mechanism of *spontaneous crystallisation.* Eliel[41] says, "If, in a solution of a racemic modification supersaturated

with respect to the enantiomers, a nucleus of one of the enantiomeric crystals begins to form spontaneously and fortuitously, this nucleus is apt to grow by the addition of molecules of its own configuration, and it is quite possible that a macroscopic crystal of this particular enantiomer results before any other enantiomer crystallises. If, through some accident, the mother liquor is at this point separated from the crystal, a partial resolution of the material... will have been affected." Note the importance of chance here. In fact, it requires an impossible situation — a highly concentrated solution ("supersaturated"); we have seen that the concentration is infinitesimal anyway!

Fox[45] predicted that preferential crystallisation might be induced by "seeding" the solution with an L-crystal, which might have originated from a meteorite. Prof. Burke referred to the concept of contamination from space and said,[46] "Since the production of L-amino acids is associated with living cells... it is clear that these amino acids are formed by chemical processes, possibly catalytically on the surface of a meteorite." However, as he also reported, so far only mixtures of D + L have been found from these sources.

To attempt to account for the selectivity by seeding or contamination is to push the problem back one step.

The suggestion that one form might crystallise selectively from a mixture of the two is challenged by Fox *et al*,[45] who stated that "any one DL- amino acid is thermodynamically more stable as the racemate than as either the L- or D- enantiomorph." The spontaneous process is not resolution but racemization.

Statistical variation[47] is a simple model that has been invented to account for selective crystallisation. While, on the average, a racemate will contain equal quantities of the two isomers, it is statistically possible for a racemate to crystallize out with a predominance of one form. Such a possibility has been shown to be experimentally viable. However, it only happens in a minority of cases and then still gives both isomers. There is no statistical bias for one isomer over the other.

Terentev and Klabunorskii[42] dismiss this mechanism, (of preferential crystallisation), by saying that it "need hardly be taken into account in connection with the complicated substances of colloidal structure which undoubtedly played the essential part in the building up of the primeval protoplasm."

4. *Autocatalysis*. According to this hypothesis, once one isomer has been produced selectively, the rest of the process is self-catalysed in that the L- isomer will show preference for reaction with other L- isomers over that with the D- form. As we have seen,

the preliminary selectivity is an unsubstantiated hypothesis. There is, however, no basis for confidence here either. While it is true that a protein formed from a solution containing only the L forms grows longer and faster than a protein produced from a mixed medium, there is no evidence that it would be formed exclusive to the formation of the mixed form or to the protein based on the D- isomers. The formation of an optically homogeneous protein can only be described as being faster than that for the heterogeneous form. In fact, Steinman found that the experimental evidence failed to substantiate this hypothesis at all: "These results suggest that the synthesis of stereohomogeneous polypeptides would have to depend on chance associations at the simple peptide level and then on stabilisation of homopolymers by the α-helix at higher degrees of polymerisation."[48] It has been shown that the large helical polymers required for information storage do not form spontaneously unless optically pure monomers are used; racemates yield shorter polymers and these don't form helices.[49]

The hypothesis also proposes that, since the two forms exist in equilibrium, the removal of the L- isomer would cause a shift in the equilibrium to replenish, so re-establishing equilibrium and causing an overall shift in favour of the L- isomer. For such a mechanism to occur, the initial selection would be necessary and the maintenance of the optical purity (over against racemization) must be preserved.

Eigen, recognising that this optical selectivity is a characteristic of a self-replicating system, concludes that it was only a matter of time before natural selection isolated the one form. But this position is tautological[50] because the natural selection would have to operate on the initial racemic system and this contradicts the first part of his hypothesis, that is, that a natural system is dependent on optical purity.

Resolution is a teleonomic process: it requires knowledge as well as the enantiomer and energy. Most of the proposed techniques, in so far as they can be demonstrated to have any validity at all, generate an enantiomeric excess (rather than optical purity),[51] and fail to explain why the same isomer should be selected on each occasion that the amino acid is synthesised. For example, *if* the surface characteristics of the levorotatory quartz favoured the formation of the L- amino acid, this does not account for the failure of dextrorotatory quartz generating a parallel system based on the D- isomer.

The only successful synthetic route is one that involves enzymes. But these need our L- amino acids for their own synthesis and so assume the answer to the problem!

Harada[37] has come to the conclusion that "the origin of optical activity might not be a single process. Several individual or cooperative processes could constitute the origin of optical activity."

We posed a set of questions postulated by Elias. We quote him again, "This... does not obviate the fact that not one of the five questions posed... can be answered!... It also appears unlikely that experiments can be designed to provide the desired definitive evidence, for chemical evolution cannot be duplicated." We must concur with Wald, that the selection of one enantiomer may be the *result* of life rather than its *prerequisite*.[52] Brown[53] has said, "Questions such as... how optical activity arose are points of current controversy where persuasive evidence is hard to find." No wonder Elias concludes, "Only speculations on this subject are possible at the present time." It is our belief that the concept under investigation lacks substance, not only experimentally, but in terms of the underlying scientific laws.

All these methods fail in that they do not, in the final analysis produce exclusively the L- isomer. So, what happened to the D- forms? There is another related problem. The enantiomers undergo a process of racemisation. We must ask why we do not find extensive deposits involving complete racemisation. A period of approximately six half-lifes (of the order of ten million years) should be sufficient for this condition. So, if the synthesis of life along these hypothetical lines had been successful so many million years ago, we would be faced with another problem: the amino acids should be thoroughly mixed in D- and L- forms now; but they are not. Kvenvolden[54] has found that Fig Chert contains only the L- amino acids, yet it is supposedly 3,000 million years old.

Polymerization

We have identified a series of problems (table III). Let us be generous and assume that these barriers can be overcome. What happens next? The amino acids must join together to form proteins; we call this polymerization.

Let us first see this process as the evolutionist views it. Horne writes[55] "Once in hand the building blocks (amino acids, etc) must be put together. The putting together was a long and delicate sequence and each step was highly improbable. Fortunately the time span allotted to the beginnings of life was exceedingly long, perhaps billions of years, so that the improbable was not necessarily the impossible. Biogenesis is pushed further into the realm of possibility if there were mechanisms operative for the

Table III. Problems in the prebiotic synthesis of amino acids

A. *The atmosphere*

1. Requirement: absence of oxygen — evidence opposes this.

2. Instability of a reducing atmosphere — would last only tens of thousands of years.

B. *The reaction*

3. Conditions are unrealistic — the use of a cold trap.

4. Yields negligible even for the most favoured compounds.

5. Reactions between the products at higher concentrations.

C. *Their stereochemistry*

6. There is only one kind: L-amino acids — chemical synthesis gives a racemate and selective degradation cannot be substantiated.

7. Geological ages would result in racemization.

concentration of the pieces. Let us imagine then the proto-biological substances being absorbed on bubble surfaces, transported upwards to the sea's surface and joined with other materials absorbed there, then tossed up by the waves and carried by the seaspray up to the beaches and estuarine mud, where in the richer warmer waters the pieces began to react and aggregates to grow." Is Horne being unnecessarily pessimistic when he says that each step was highly improbable? Not at all. First of all, monomers do not polymerise spontaneously. Energy must be supplied. This is very definitely true of protein formation. The reverse reaction, hydrolysis, occurs much more readily. A study of body processes will show this. Proteins in our food are rapidly broken down to amino acids in the duodenum; their synthesis in the body's cells are complex processes by comparison.

Consider a polypeptide of one hundred amino acids, and so 99 peptide bonds. The free energy change for the formation of a peptide bond is +2.09 $kJ.mol^{-1}$.[56] So, 99 bonds require 206.9 $kJ.mol^{-1}$. Therefore, at 300K, $\log_{10}K = 36$. So, the equilibrium constant for the polymerization reaction is 10^{-36}. So,

$$K = \frac{[peptide]}{[aa]^{100}} = 10^{-36}$$

We have shown that if all the atmospheric nitrogen were converted to one amino acid, the concentration would be less than 0.2 $mol.dm^{-3}$.

$$\text{So, } [protein] = 10^{-36}.(0.2)^{100}$$

$$\approx 10^{-106} mol.dm^{-3}$$

In the cell, the condensation requires activation by ATP and a specific enzyme and specific t-RNA for each amino acid. These were not produced in Miller's synthesis. It is only by a mechanism such as this that polymerization can be achieved. Furthermore, a mixture of the amino acids with other carboxylic acids, amines and carboxaldehydes (which must be present in the proposed prebiotic soup) would prevent polymerization.

The thermodynamic barrier to spontaneous polymerisation is not easily overcome. Matthews and Moser say[57] "Since the thermodynamic barrier to spontaneous α-amino acid polymerisation is not easily overcome, and indeed seems impossible by any reasonable condensation mechanism, a completely different sequence of events leading to polypeptide formation has been postulated..." So, where can we find such a generous energy source? Sidney Fox[58] felt that he had found the answer and confidently entitled a paper "In the beginning...... life assembled itself." He heated a mixture of amino acids at 175° C for six hours. Leaching of the mixture with water showed that some substances related to proteins had been produced. These were called "proteinoids." He suggested that a natural equivalent of this laboratory reaction would have been the rims of volcanoes, and that rain would have leached out the proteins. How realistic is this claim?

Firstly, these "proteinoids" are not proteins. His product is no more than a peptide chain. Proteins, as shown earlier, are much more complex. Also, in contrast to the large variety found in nature, only a few polypeptides are synthesised by Fox. The sequence of the acids in Fox's peptides have no apparent significance either. Miller and Orgel[59] commented that "the degree of non-randomness in thermal polypeptides so far demonstrated is minute compared with the non-randomness in proteins. It is deceptive, then, to suggest that thermal polypeptides are similar to proteins in their non-randomness." For a protein of a hundred units, made up from twenty amino acids (assuming only the L-forms are available) the chances are 10^{70} : 1 against a meaningful combination. Mathematicians would write it off; only evolutionists would try to make something out of it.

Furthermore, the reaction mixture consists of the pure, anhydrous acids — water or other chemicals interfere. Volcano gases consist of 70% water and this would result in depolymerisation. Then, the reaction conditions are specific — heating for more than six hours would lead to destruction. The rain had to fall right on time! This would result in the hydrolysis of the proteins as well, though, of course, the rate of this reaction could be low. Also, the volcano temperature is much greater than 175° and this would lead to racemization. Hulett agrees that volcanism might have provided an environment conducive to dehydration, but acknowledges that it also favours the degradation of most prebiological molecules. Miller and Orgel[59] put it like this: "Another way of examining this problem is by asking whether there are places on the earth today where we could drop, say, 10 grams of a mixture of amino acids, and obtain a significant yield of polypeptides.......We cannot think of a single such place."

Fox found that either aspartic acid or glutamic acid must be present in excess with lysine.[60] But this is very different from the proportions found in nature. (Nor is it compatible with Miller's experiment). In addition, threonine and serine are destroyed in this reaction; yet they are very prominent in proteins, making up 10-20% of the total amino acid content.

Miller and Orgel state that "we doubt that.....biological polymerisation could have taken place except in an aqueous environment."[59a] Oro and Guidry[61] produced a peptide of up to eighteen units of glycine by heating the monomer in aqueous ammonia solution at 160°C. But, the aqueous medium is unsuitable for extensive polymerisation as the reaction is reversible and the water would aid hydrolysis of the peptide. So, the ocean is practically the last place for the spontaneous formation of life. It has been suggested that warm lava would cause evaporation and so aid the condensation reaction; but this would lead to denaturation. Ponnamperuma and Peterson,[62] Calvin *et al*[63] and Schramm *et al*[64] have suggested alternative dehydration routes, but these are irrelevant in that the reagents proposed have no apparent natural significance.[65]

Recognising the difficulty, Eigen proposed that some peptides have the capacity to condense some amino acides into a chain;

other peptides would join these peptides. A contribution from chance is then needed to set up a cycle in which the newly made protein is, for practical purposes, the same as one of the proteins contributing to its manufacture, thus creating a reproductive cycle. Eigen thinks it would occur often enough in aggregations amongst the vast numbers of molecules in the soup.[22a] But, where are these vast numbers of molecules; we have seen how dilute the solution is!

Wald[4] has said that "one of the most difficult problems is to attempt to understand how such unit structures combined with one another and polymerised against thermodynamic gradients that tended rather towards hydrolysis...apart from the precise activating mechanisms that guide and provide the energy for such syntheses in cells." In other words, we need the result (modern proteins) before we can get the result!

Carbohydrates

It has been shown that, in the presence of calcium carbonate, methanal (formaldehyde) polymerises to give ribose, but only as a minor product.[66] A 0.5 molar solution at pH 8.5 gave a 40% conversion to sugars after an induction period. A 0.01 molar solution gives sugars, but they are not produced from 0.001 molar solutions. Crabel and Ponnamperuma[67] got similar results using alumina rather than calcium carbonate. However, these latter writers conclude that "We do not believe that the formose reaction .....is a plausible model for prebiotic accumulation of sugars." Reid and Orgel[68] consider that the conditions are too extreme for primitive earth because the formaldehyde concentrations were too high. Also, the sugars undergo rapid decomposition in an aqueous environment. Hullett[15] examined the likely maximum yield of formaldehyde by photo-chemical irradiation of the proposed reducing atmosphere. Hull[21] showed that the equilibrium yield of glucose would be 10^{-134} moles per litre. This is a non-sensical amount — it means a concentration of one molecule in 10^{111} litres. Since the volume of the observable universe is of the order of 10^{80} litres, this one molecule would be in a volume 10^{30} times that of the universe!

Nucleotides

The abiotic synthesis of these presents a major problem. The most likely route seems to be via hydrogen cyanide. Hullett[15] examined its rate of synthesis (10^{-6}mol.cm^{-2}.y^{-1}) and stability. It is photochemically reasonably stable, but is hydrolysed by water

(3% p.a. at 25°C at pH of the oceans). This gives it a half-life of thirty years at this temperature, but of hundreds of years at 0°C. So Hullett estimated a maximum concentration of 10^{-6}mol.dm^{-3}.

The most promising route to adenine required the concentration of cyanide by eutectic freezing at about -10°C.[69] Besides its polymerisation to amino acids, hydrogen cyanide can be conceived as the precursor of these nitrogen bases. Calvin[70] describes a 3% yield of a nucleoside (base and sugar) by condensation of the components with phenyl polyphosphates (but no experimental evidence is presented), which is analogous to a supposed primitive environment, for their condensation or polymerisation.

But, if the nucleic acids had been formed by some yet-to-be-discovered method, they would have been very susceptible to ultra-violet radiation damage. Also they would be unstable to water – the only medium that could offer them any protection (ten metres or more down) from UV. Similarly ATP has a half-life of only a few years at 25°C.

An important component of the nucleotides is the phosphate group. Surely there is no difficulty in obtaining this? But there is. In the presence of calcium ions, the phosphate ion is precipitated out leaving a solution 10^{-6} molar.

Primitive cells

Oparin suggested that the first "cells" would have consisted of coacervates.[5] These are colloidal particles formed by the association of macro-molecules of different types. This association results from physical or chemical properties of the macromolecules and is non-selective, is not self-organising and is unstable.

Fox[71] claimed that his peptides formed microspherical proteins and that these would be a step towards a living cell. We have seen that his peptides are not proteins. But then, cells are significantly more than proteins anyway. His claims[72] to have found that they have enzyme-like properties display either a desperate hope or an ignorance of both enzyme action and that of the catalytic properties of histidine[73] which was a key amino acid unit in his peptide. More recently,[74] he has produced lysine-rich peptides which, *with ATP*, catalyse the formation of other polypeptides. Even so, one enzyme would have been meaningless without the others still needed. For example, besides the one needed to produce the substrate, another will be required to utilise the product. Without these complementary enzymes, the single enzyme activity would not only be useless, but destructive.

Fox admits that his microspheres are rather unstable — they are dissolved when the microscope slides, on which they are examined, are warmed. Also, they dissolve on dilution — and we know how much water there is on the earth! His claim that the polymers are not completely random and contain identical structures are unsubstantiated. Fox has also described the multiplication of these primitive cells by a process related to cell division. In fact, the two mechanisms are unrelated. In the case observed, the division is due to physicochemical effects as in the division of soap bubbles; there is no reproduction or replication.

The cell is a (the?) most complex machine. Whenever in history did a machine arise spontaneously from matter? Potter has said that the simplest form of life requires not less than a thousand molecules, "but whether it is 3,000 or 10,000 or greater is anyone's guess."[75] Morowitz estimates that the simplest conceivable cell requires 124 different protein molecules plus the sugars, lipids, nucleic acids, etc.. The free energy of formation for the average microorganism from a solution of its monomer units is 326 $J.g^{-1}$. From this it can be shown that the probability of its spontaneous formation is 10^{-10^8}.[76]

Information coding

Even if we are able to form our polypeptides by random processes, there is still a big jump from these to the specific properties required for biological activity. These properties are coded into the molecule by the sequence of amino acids. In living systems, this is generated from the nucleic acids with their specific sequence of nucleotides which is a code in itself. How big a problem is this? This question is crucial. If the problem is trivial, the solution is relatively easy.

Let us consider the production of an abiogenetic enzyme and of the corresponding DNA molecule required to code it. We consider a relatively simple system of one hundred units. Since these 100 units are made up from twenty amino acids, the enzyme has $20^{100}(=10^{130})$ different combinations. The probability of obtaining a specific structure is therefore 10^{-130}. But experience shows that some variation is possible without loss of activity. For example, of the 101 residues in cytochrome c, 27 are invariant and a few positions can have up to ten different acid units.[77] If we allow an average of five variations per position (which is considerably more than yet observed), then the number of acceptable structures will be $5^{100}(=10^{70})$. The probability of getting an active enzyme is, then, $10^{70}/10^{130} = 10^{-60}$. This probability only becomes significant if the time factor is very large so as to allow sufficient trials.

But are we really being realistic with this option? If 1% of the atmospheric nitrogen was fixed into one hundred residue proteins, it would give 10^{40} such molecules (450 $kg.m^{-2}$ of the earth's surface!). If such a yield was obtained every year of the earth's history, it would give us the chance of finding a viable protein as 10^{-11}.

Now we also want to get the right DNA — protein interaction for our scenario. If the polynucleotides formed as readily as the proteins so that we had 10^{40} molecules of each, and they collided 10^{10} times a second, no collision repeated, we would have 10^{66} collisions in the period under consideration. From this, we can show that the chance of a successful pairing would be 10^{-55}.[77] The significance of this should become apparent shortly.

Eigen realised that there was a large jump from the chemical flask to a living cell, and so has set himself the task of determining the minimum assemblage of molecules needed for this leap.[22] His approach was to apply "the Darwinian logic"[2b] to the inanimate material. Since the primordial soup contained a mixture of chemicals, there had to be a selection process acting on the molecules now known to be essential to life, and yet the system had to tolerate the biologically unacceptable compounds too.[78] Maddox described these as "evolving molecules."[2] Eigen refers to the "fittest molecular assemblies."[78] But this is not a meaningful description — we are talking about chemical fitness, not life; there is no chemical distinction between one protein assembly and another. As Eigen sees it, in order to achieve some selection, "certain forms of cooperation were essential." An expansion of the information system in a molecule required double feedback loops known as hypercycles.

The hypercycles are cyclic pathways in which polynucleotides first arose by chance and then coded for the first protein. But, we can immediately make two comments. The abiogenesis of these polymers is more problematic than for proteins; it also avoids the question of the origin of the code translation system required to produce the proteins.

However, in spite of the failure to produce the required starting materials, Eigen supposes that there was an endless supply of activated RNA monomers and that the lifetimes of the RNA's were infinite.[78a] Of course, initially the RNA sequences were random. But, since the continued existence of RNA is against the rules of thermodynamics, then some kinds of molecules should be preferred over others. Which? Those strands with stable structures (for example, resistance to hydrolysis) survive and are the only ones capable of stable self-replication. Some mutants would be copied more rapidly than others or would be less susceptible to errors in copying and so their concentration would increase more rapidly. Sooner or later these faster-growing mutants would take over.[78a] The maximum gene lengths in a prebiotic system for stable self-replication is found to be less than a hundred nucleotides (in the absence of enzymes). This is confirmed by experimental tests on copying fidelity. Such a polynucleotide would give a peptide of about thirty units. To extend beyond this, we need the production of enzymes: non-self-reproducing proteins. So, neither can be optimized without the other; interaction is needed. A second, linked hypercycle was needed to produce these proteins.[22]

Ultimately, Eigen sees these cycles as possessing the ability to wrap themselves "up in small packets...escaped poisoning...and scattering its key products."[22a]

Smith has pointed out that there is no experimental justification for the concept.[79] The arguments "...raise more problems than they solve." As Calder admits, "The hypercycle is, of course, nothing but a theory..... The only test is plausibility."[22a] The neodarwinian concept of the chance origin of the code is without experimental basis and contrary to the second law.

On this latter point, Eigen postulates a mechanism which is inherent in his hypercycles but not in matter. It requires a mechanism to receive and store reduced entropy locally. A mechanism or machine is essential for storage; without it, the second law of thermodynamics forbids autoorganisation. Neither existed in the prebiotic world because both constitute expressions of teleonomy which is not a property of inorganic matter but of life.

But, does a decrease in entropy correspond to information generation?[80] Systems of decreased entropy, for example the Morse Code, are available for the transmission of information because the accidental production of such systems is improbable and they will not appear everywhere instantaneously and simultaneously. So, information can be inserted into them. Information and concepts are *inserted* by human conventions onto reduced entropy systems, but the system is not the same as the information it carries.[81] All experimental work in the realm of biogenesis involves matter + energy + teleonomy; evolutionary theory substitutes chance for intelligence.

Chance, however, is not adequate. It does not develop new information nor does it form an information storage system; it can only modify a pre-existent system. It is contrary to the tenets of information theory to attribute the origins of coded programmes to chance and autoorganisation of inorganic material. Increased order, decreased entropy, does not necessarily carry meaningful information. The meaning of a sequence is not inherent in that sequence. The random selection of the letters A-N-D in "Scrabble" is chance, but its meaning is not the result of chance; its meaning is the result of human convention not chance. So, A-N-D has no significance to the Frenchman, German, Dutchman, etc.. Similarly, identical sequences can have different meanings to different people; for example, T-E-E has different significances to the English golfer and to the German housewife. To Eigen, that meaning and information appears only in the translation. And how was the translation apparatus obtained? By chance! However, this translation machine must produce both the information and the concepts. Better than any man-made computer!

Molecular movements do not produce increasing genetic information. For an increase in order, "rectified energy" must be supplied, that is, the product of a machine. Living cells are programmed genetically and so can direct non-directional energy. The biological cell has no apparent mechanism to generate *new* information. The energy is utilised for replication, not for new information. If this is not possible in biological systems, what hope is there in the original inorganic ones?

The synthetic protenoids of Fox *et al* exhibit normal molecular architecture, not that required for physiology. The informational code is developed from the chemical order. Wilder-Smith[50a] uses the illustration of ink on paper. The dried ink has a molecular structure. Over and above this, we have the information those marks carry. A mutation would occur if it was splashed with water! The mutation modifies or destroys; it does not create. A living organism is a hybrid between the two types of order. But the first type of order cannot spontaneously provide for the second by chance. So Yockey says, "The (chemical evolutionary) scenario does not generate even one molecule of the biopolymers of reasonable specificity from which the non-linear processes of evolution considered by Eigen *et al* could start."[82]

Other points that have been made against this theory include the fact that Eigen's hypothesis is based on a non-equilibrium system, which is highly improbable in view of the time-scale involved. The concept of the generation of information by these means ignores the fact that the laws of nature provide a basis for function, not genesis. The laws of nature never bring forth a machine spontaneously. Eigen's reference to natural selection and its application to molecules[78] not only involves the unscientific principle of extrapolation into the unknown, but seeks to apply at the molecular level a concept which is even questioned at the organic. The concepts behind all organisms and their inter-relationships require (a) a knowledge of the laws of nature providing the functioning basis, and (b) the know-how in order to transform such knowledge into practice and apply it. Eigen has not succeeded at these points.

Conclusion

We have cast our net wide over this subject in order to see if there is any plausible mechanism of chemical evolution. To Calder, the "astounding coincidence" becomes possible "given enough time."[22a] However, we have sought to show that chance is an inadequate tool for the production of life.

We have also to conclude that there is no satisfactory synthesis for half of the amino acids even in the laboratory. Similarly, the fatty acids, sugars and nucleotides are lacking in the proposed primeval soup. What is more, under the proposed prebiotic conditions, they are incompatible. Even when they have been synthesised, these biochemicals have to face up to conditions which guarantee their destruction within short life-times. As Miller and Orgel have pointed out,[69a] the ocean will lead to the depurination of nucleic acids, the hydrolysis of the polymers and decomposition of sugars — unless, of course, we can drop the temperature to -10/-20 degrees Celsius. Aside from the difficulty of deriving such conditions, they would have adverse effects on the reaction rates. Once formed, we have still to select out a limited number of amino acids etc. from the soup.

A study of the early atmospheric conditions has shown that biochemists are looking at artificial conditions that have no reality in practice. Future work must at least be based on the proven oxidising conditions known to have existed. Furthermore, Vallentyne[83] has pointed out that "the results obtained from experiments run over a few hours may bear no relation whatever to the actual state of affairs resulting after a period of thousands or millions of years." Additionally, we would hardly describe the laboratory experiments as primitive conditions. Another problem is that the work done generally assumes different — if not, inconsistent — conditions for the various classes of compound required. According to Bernal, "....the principles of experimental science do not apply to discussions on the origins of life, and indeed cannot apply to any problem of origin."[69b] They cannot, because they are devastating. We would be surprised if intelligent chemists did not find ways of solving many individual steps; but would that not prove the importance of intelligence?

Clearly, the results obtained in simulation studies can only be as accurate as the model they seek to represent. The evidence for what did happen is not available. Asked by Maddox, "Do you think it will ever be possible to reconstruct with fidelity..... the course of this evolutionary process — in detail?", Eigen replied: "No..... I don't think in detail.... but we want only to see that it's a possible process."[2b]

So, we have seen that the evolutionary theory must stand on chemical principles. We have followed the path of the proposed evolutionary synthesis and polymerisation of one chemical family: the amino acids. There is not one step in the sequence that can be justified in terms of a prebiotic synthesis. We have seen that the theory is both unable to explain consistently and coherently the origin of life, and is, in fact, flatly contradicted by basic chemical laws, both thermodynamic and kinetic. Hull has wisely concluded[23] that "the physical chemist, guided by the proved principles of chemical thermodynamics and kinetics, cannot offer any encouragement to the biochemist, who needs an ocean full of organic compounds to form even lifeless coacervates." Wilder-Smith has concluded[50b] that the theory of evolution (spontaneous biogenesis and spontaneous automatic transformism) is dead at its roots. Certainly in the area covered in this paper, it still has to prove its case.

Of course, we cannot prove a negative position completely. Each new piece of research must be assessed on its own terms. But, equally, success in synthesising any of the chemicals of life in the laboratory does not confirm what happened originally. Merely its feasibility as a mechanism. However, we can assess the improbability of such a position. That we have sought to do.

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REVIEWS

Francis Hitching, *The Neck of the Giraffe or Where Darwin Went Wrong*, Pan Books, 1982, PB, 288pp, £2-50.

1982 is the centenary year of Charles Darwin's death and Francis Hitching here takes a long, hard look at modern Darwinian evolutionary theory and some of its alternatives. Although the style is 'popular', the book is not superficial and is well referenced.

Part I is a masterly summary of many of the unsolved problems of Darwinism, and the doubts being expressed by more and more scientists from a variety of disciplines as to the essential correctness of natural selection by gradual accumulation of small (genetic) changes.

Part 2 considers various alternatives to orthodox neo-Darwinism. For example, the writer gives a balanced, objective view of (mainly American) creationism, and lists some of the gains, albeit modest ones, it has brought in text-book evolutionary teaching. He adds, "The greatest service which the creationist movement may yet perform is to spur on a basic re-evaluation of the laws underlying evolution." Insight into some of these laws may have been gained through the 'catastrophe theory' of the French mathematician, René Thom, whose work seems to show that there are basic rules which govern, not only preferred forms, but preferred changes of form, in fundamental physical and chemical processes. "Instead of (random) mutations determining the variation of form, the change is, in a way, automatic: the new form was implicit in the old one." Such a view is, of course, the antithesis of Darwinian variation due to chance.

Part 3 contains a summary of the development of Darwin's thought and its legacy to science, reminding the reader of the unfortunate influence of Darwinian dogma on the interpretation of fossil evidence. The writer discusses the recent controversy over cladism (which avoids ancestral relationships and seeks to systematize on a basis of observable common features).

The book is written in an interesting manner, with varieties of style. It covers pretty well everything, from pre-Cambrian fossils to punctuated equilibria; from artificial evolution to Velikovskyism. Odd facts are mentioned, such as the formation of anthracite in the wooden piles of a German bridge in the late nineteenth century, and even odder speculations, such as a recent suggestion (with mathematical support) by a British physicist that reversal of the earth's magnetic field may have been due to the earth turning upside down! Altogether a fascinating survey. There are seven pages of references, a list of books cited in the text (some as recent as 1981), a list of suitable introductory reading for each chapter, and an index. A few minor misprints were noted; none should interfere with comprehension of the text.

D.A. BURGESS

Michael Wadsworth (ed), *Ways of Reading the Bible*, Brighton: Harvester Press, 1981. £18.95. viii + 224 pages.

The question to which this book addresses itself is a familiar one to followers of modern theological debate. A hundred and fifty years ago the question, 'How should you read the Bible?' was being answered by rationalist critics and historians by the assertion that the Bible is to be read the same way as you would read any other book. But the intervening century and a half has shown only too clearly how difficult that is. Critical scholarship has certainly got rid of the unthinking literalism of earlier generations, but it is not unusual for Biblical scholars to be accused of having done so only by introducing their own esoteric and subjective modes of interpretation, and thereby *not* reading the Bible as if it were 'any other book'.

This collection of essays, emanating from the University of Sussex, tries to correct the balance. The editor sets the tone of much of the book in his introduction, where he describes modern Biblical scholarship as "an intellectual discipline possessed of its own laws and vocabulary, its own methodology and self-authenticating rituals." Naturally, it is implied that if the methodology set forth in this book is employed, then one can read the Bible in a way that, by contrast, is open, objective, and meaningful.

In the event, this is a disappointing collection of essays. Of course there are some high points, especially Kenneth Cragg's essay on "Literacy and Revelation", and Ulrich Simon's on "Samson and the Heroic". But much of the rest leaves one wondering whether the authors have actually read the material they are supposed to be writing about. One of them actually boasts about having "a truly barbarous ignorance of the Bible" and then suggests that this is a distinct advantage in writing about it! (A.D. Nuttall, p.41). Others display a similar ignorance of its contents and its intention. Stephen Prickett, for example, complains that modern versions of the Bible have 'demystified' its message, making it plain for all to see — as if there was some sort of virtue in obscurity. For some religions, there is — but not the religion of the Bible. And when this same author tries to justify his opinion by a series of specious (and quite untrue) observations about the Hebrew text of the story of Elijah, it is difficult to take him seriously.

Some articles, however, do try to interact with conventional Biblical scholarship. The Jülicher-Dodd-Jeremias view of Jesus' parables comes in for particularly strong criticism from John Drury and Bernard Harrison. John Drury suggests that Jesus did indeed use allegory in his teaching. But then, many NT scholars have argued the same in recent years. Drury goes further, however, and asserts that Jesus used nothing but allegory when he taught. Indeed, his allegories were so complex that, when Luke came to use the materials handed on to him from Mark's gospel, he found it all so baffling that he was forced to introduce the sort of moral tales that most people think of as the characteristic parables of Jesus. Drury and Harrison together left the reviewer wondering why, if Jesus' teaching was so obscure, anyone would have bothered to write ti down in the first place, still less to believe it and stake their lives on it.

Overall, then, this is a disappointing collection of materials. Perhaps its main weakness is that if fails to recognise that the Bible is, above everything else, *religious* literature. As a result, it either avoids theological issues altogether or, in some cases, accepts a number of fundamental misunderstandings of what Christian theology actually is. From a religious standpoint, it is never going to be adequate just to appreciate the Bible as literature. No doubt such an approach can illuminate our understanding at various points. But the historical and critical questions asked by the theologians are ultimately the more important ones: not 'What does the Bible mean to me, as I read it today (rather than yesterday or tomorrow)?', but 'What does the Bible *mean*?' It is the lack of understanding of this that leads to some of the absurd and naive statements made by some of the authors of this book.

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Contemporary issues in Social Ethics. Edited by Ronald Sider, Vol.1, *Lifestyle in the Eighties: an Evangelical Commitment to Simple Lifestyle*, 1982, 256pp, PB, £5.80; Vol.2 *Evangelicals and Development: Towards a Theology of Social Change*, 1981, 123pp, PB, £3.40. Paternoster Press.

Evangelical Christians, throughout the world, are becoming increasingly concerned about the problems that beset our race. In March 1980 a Conference was held at High Leigh, Hoddesdon, attended by delegates from all parts of the world to discuss these matters from a Christian angle. These volumes are the result of that Conference.

The stress was put on Lifestyle, for it was felt that it is the way Christians live more than any other single factor which determines the influence they exert. Some of the Lectures are collected in Volume 1 while Volume 2 contains responses from Europe, USA and Asia.

Books of this kind are not easy to review. A list of those who spoke with a word of praise or blame concerning each would prove uninspiring, especially to those of us for whom names are just names unless we happen to have read the writings of those who bear them, seen them on TV or met them in the flesh. On the other hand a choice as to what should or should not be mentioned in a review must often seem invidious. Nevertheless, I think the second course is the wiser of the two. So here goes.

In Volume 1, Vinary Samuel and Chris Sudgen's account (Ch.2) of OT life-style is interesting. The houses of the Israelites who lived at Tirzah in the 10th century BC are of the same size and arrangement; ten centuries later, on the same site, the houses of the rich and the poor differ greatly. Old Testament laws were framed to prevent the development of great inequalities, but the Israelites failed to obey them. Another interesting chapter by T. Maruyama deals with lifestyle in church history.

I was impressed by Visgal Mangalwadi's Lecture on Cross-Bearing in India. In India, at all events, he says the bountiful Lord of creation does not want to depress our lifestyle. Visgal and his wife trust just Jesus. They share all they have and pass the word around that no one will starve in their Indian village. And the Lord never fails. But there *are* difficulties. When they visit their relatives in cities they are ashamed because their children are so poorly clothed; when they get home to their village they are ashamed because their childrens' clothes are too good! "For us to live in that tension is cross-bearing!"

Visgal hits the nail on the head. "I did not really come here to work out a theology for simple living. For our need in India is to create wealth and as such, what we need to do is to discover the dynamic of Christian theology which created wealth in the Western world."

This theme, though of vast importance, is not developed in either of the volumes. Much of the world's poverty is the direct result of tradition and false theology. Many have died in India when rice crops failed because they refused to eat wheat sent from abroad. The doctrine of reincarnation is a direct cause of hunger — if the cow in yonder field may be your grandmother, the plentiful supplies of meat which are walking around must not be eaten by the hungry! Children deserted by their parents are not adopted by

Indians (save for the occasional girl to be made into a servant) in case their caste is wrong: they are left to die unless rescued and reared for export, chiefly to America.

How different is the effect of the Christian gospel. When Christians learned to worship and pray together, they learned also to trust one another with their money and ideas. Profits were shared; industries were born; wealth was created. Without Christianity envy flourishes throughout the world: its effect on the economy of nations is devastating as Hans Schoeck has shown in his monumental work *Envy* (1969). But Schoeck is not mentioned in either volume, nor envy either, nor is there allusion to the work of great scientists and innovators who, because they asked God to guide their thinking, have been creators of wealth. What about Kelvin, Faraday, or George Washington Carver?

Another fascinating Lecture is by Graham Kerr, the Galloping Gourmet, who disposed of his millions to follow Christ.

Some excellent material notwithstanding, the constant hopping from subject to subject, the variations in style, and the occasional padding make these volumes difficult to read. One can sympathize with Ronald Sider who must have difficulty enough with the editing, but perhaps the task was too great for mortal man!

Despite occasional gems I found much of Part 2 dull, prosaic and uninspiring. The humourless style is often that of a Ph.D. thesis in the humanities. There is repetition and the language is off-putting ('perspective' is now a cliché word; "have entered into significant dialogue with"; "God's kingdom activity") while some strange words obtrude ("salvific", "conscientization"; "servanthood"). Sometimes the language seems to compete with Marxist jargon. There is a good point on p.62 against Marxists who claim to have no ideology. Challenged with the question "Why not take sides with the oppressor? It would be more comfortable", the Marxist will reply by saying that it is wrong for people to be oppressed — an idealogical value-judgment if ever there was one!

Chapter 4 (Tom Sine on *Development*) is well-written, interesting and more controversial. He blames (quite wrongly?) Francis Bacon for introducing a dualism between the words of God and the works of God and of killing the belief that God works and acts in history. John Locke is blamed for much of our hedonism and failure to find meaning and purpose in production and consumption. Sine also discusses the vast growth in the population of cities and the problems it creates.

The covers of these two volumes are extraordinarily unattractive. A man, with a look of gloom incarnates, rides his bicycle past a

multitude of super-cars: an unhappy-looking girl with bare feet carries a burden on her head. Is this what Christians can expect when they lower their life-style!

REDC

(A part of this review appeared in *Reconciliation Quarterly* **Dec. 1982).**

R.G. Clouse (ed), G.E. Ladd, H.A. Hoyt, L. Boettner and A.A. Hoekema, *The Meaning of the Millenium*, **IVP, 1982, 223pp., PB, £2.75.**

This is an excellent book, written by American representatives of the four main views held by Christians concerning the Millenium. The differences between Ladd and Hoyt seem minimal and bear chiefly on the use of the word 'dispensationalism'. Both hold that our Lord will return to earth to set up his kingdom here. Boettner thinks that the world is getting better and better, will be more or less converted eventually, and the kingdom will then be here. Hoekema takes the view of Augustine that the millenium is here already and has been ever since the church was inaugurated on earth. Each is given a chapter to marshall his views, the other three then being free to comment. The debate proceeds at a high level: there is no trace of uncharitableness, all emphasizing their agreement with the others more than their differences.

After reading this book the simple Christian will probably feel more muddled than ever unless he is prepared to work quite hard. Others will certainly be helped to clarify their ideas and will certainly learn a good deal. Except for Boettner's optimistic essay the arguments are Bible-based.

Regrettably there is no index and the binding is of that troublesome variety which all but prohibits the opening of the book without continuous effort. In desperation I opened it over a make-shift anvil and hammered the back hard with a mallet! It failed to break but there was a slight improvement.

REDC

Michael Green, *To Corinth With Love*, **Hodder and Stoughton, 1982, 175pp, PB, £1-50.**

This is a well-written little book which gives refreshing insights into a cluster of today's difficult issues by illuminating the teaching of the apostle Paul to the vigorous but somewhat immature church at Corinth.

The writer gives no detailed commentary on each verse, but selects a broad range of issues in which the apostle speaks to us today with incisiveness, clarity and authority. The section on women in the church is very illuminating, whilst that attempting to justify infant baptism uses somewhat dubious arguments. The book would serve admirably as a basis for group Bible study.

D.A. BURGESS

Peter Southwell, *Prophecy*, Hodder and Stoughton, 1982, 123pp, PB, £4-50.

Whatever else the Bible does, it certainly claims to deal with prophets and prophecy. The writer has attempted a useful analysis of the Biblical ministry and office of the prophet, from the time of ancient Israel to that of the early church, with a final chapter on prophecy today.

The usefulness of the book for reference is considerably curtailed by lack of an index and having a too-condensed typography. There is no indication of contents apart from brief chapter headings. Sub-sectional headings would have greatly facilitated quick reference and improved the somewhat forbidding appearance of most pages, liberally sprinkled as they are with scripture references.

A bibliography, too, would have been useful (a number of books is, in fact, referred to in the text).

D.A. BURGESS

Robert E.D. Clark, *Does the Bible Teach Pacifism?* Forword by J. Stafford Wright. Marshall, Morgan and Scott with Fellowship of Reconciliation, 1983, 130 pp., £1.50.

A second enlarged edition of the 1976 pamphlet. See Prof. F.T. Farmer's review, this JOURNAL, 103, 85.

Paul F. Bradshaw, *Daily Prayer in the Early Church*, S.P.C.K., 1981, 191 pp, PB, £6.95

Liturgical studies are inevitably a minority interest and this learned treatise will cater for such a minority. It is one of a series of texts published by the Alcuin Club whose main purpose is to promote the study of Christian liturgy, especially within the Anglican Church.

In the book Dr. Bradshaw examines the practice of prayer in the Early Church from its inception within Judaism to its formalised ritual in monasticism. The first two chapter are concerned with the first century and the author seeks to discover the extent to which the early Christians adopted current Jewish forms of worhsip. He believes that the relationship between the two is not so much that of parent and child but rather that of two children of the same family becoming increasingly estranged from one another. He challenges the view that there were fixed times of prayer in the second and third centuries, arguing rather that Christians were expected to pray at least five times daily but should aim for an unbroken communion. Prayer was made with upraised hands, head uncovered and eyes lowered in humility.

Later chapters concentrate on the Cathedral and Monastic Offices and Bradshaw shows how Monasticism was responsible for the frequent use of the Psalms in worship and for the use of Bible readings which he claims had a threefold function, namely to teach, to aid worship and to stimulate faith.

This is not a book for those who want a devotional study of prayer but is for the academic who desires to know how the Early Church prayed and how the liturgy evolved.

R. LUHMAN

THE VICTORIA INSTITUTE

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