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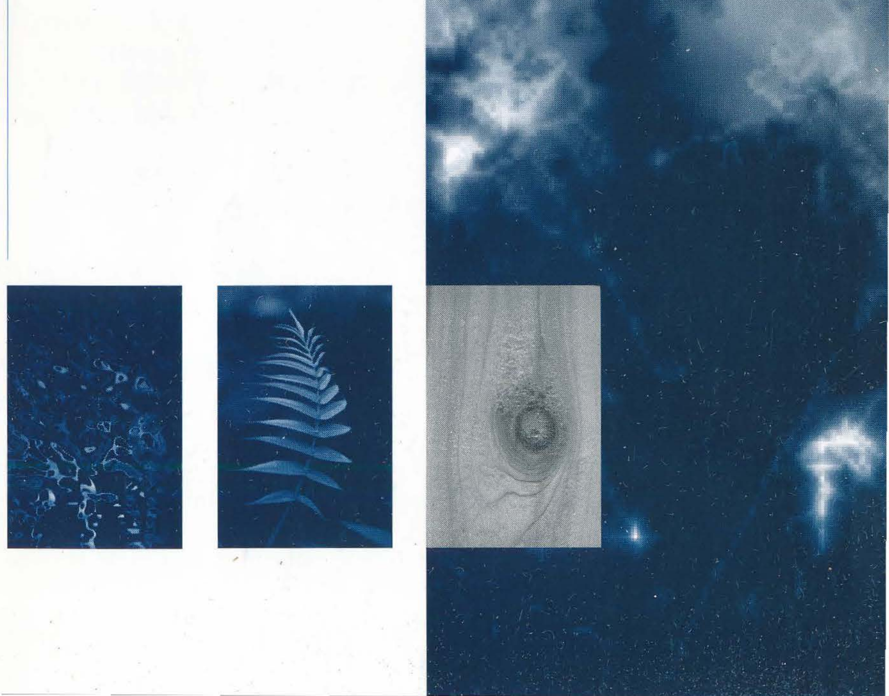

FAITH and THOUGHT

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Editorial

We greatly regret to have to report the death of Sir Robert Boyd, one of our vice-presidents, and a very valued member of the Institute over many years. The obituary in this issue is published with very grateful thanks to the *Daily Telegraph* in which it appeared.

One of our earlier presidents was Sir Ambrose Fleming, and it is a delight to publish an account of his life and work by Brian Bowers.

We also give notice of a forthcoming conference on Biblical Archaeology to be held in October. It is some years since the Institute held a day conference, and we commend this to you.

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Obituary - Sir Robert Boyd

Physicist who helped launch the first British satellite in 1962 and worked closely with Nasa on space research

Sir Robert Boyd, who has died aged 81, was Professor of Physics in the University of London from 1962 to 1983 and one of Britain's foremost space research scientists.

The Second World War had left two alarming scientific legacies in the atom bomb and the ballistic missile. But to small groups of physicists and mathematicians, rockets, when turned to peaceful ends, held the promise of a new gateway into the realm of space research.

At last theoretical speculation and laboratory experiment could move into actual probing, if only the money and means could be found. In America there was buoyant optimism, money and captured V2 rockets, with which scientists and engineers in US Navy and Army research laboratories forged ahead.

In Britain, government laboratories had more pressing matters to attend to, but academics freshly back from war work picked up their old interests, set up their laboratory apparatus and waited for the tide to turn.

Notable among them was a group newly released from the Admiralty Mining Establishment. Its director, Harrie Massey, a leading mathematical physicist, returned to University College London (UCL) and began to build there one of the biggest physics research and teaching departments. One of those who came with him was the young experimental officer, Robert Boyd.

Robert Lewis Fullarton Boyd was born on October 19 1922 at Saltcoats, Ayrshire, the son of a scientist. He was educated at Whitgift School and at Imperial College, where he read Engineering, an interest engendered by his father's tuition at the work-bench; as a boy he had built a working steam engine using only hand tools.

As a research physicist working with Massey after the war, Boyd studied the measurement of the ionospheric plasma created by solar radiation in the high upper atmosphere. He soon learned that a laboratory is no place in which to simulate the space environment, and that if measurements are to succeed they must be made in space itself from a rocket or, better still, a satellite.

In 1954 an opportunity presented itself that Boyd was quick to take up - a joint programme of high altitude research arranged between the Royal Society and the then Ministry of Supply, using a sounding rocket developed and built at the Royal Aircraft Establishment, Farnborough.

Boyd, aided by special government funding, built up a team of physicists, engineers, technicians and research students at UCL. Over the next 20 years this team, jointly with others from British universities, shared space on a succession of sounding-rocket launches, mostly made from Australia's Weapons' Research Establishment at Woomera.

In March 1959 a second opportunity arose when the newly-created American National Aeronautics and Space Administration (Nasa) announced that it would, without charge, be prepared to launch in satellites scientific equipment of scientists of other countries. That offer led to the launching of a series of American and British Ariel satellites.

The first, launched in April 1962 from Cape Canaveral, carried instruments built by three British universities, among them Boyd's group, the spacecraft itself having been built for them at Nasa's Goddard Space Flight Center. The project was not only highly successful but it cemented a close, mutual confidence with Nasa scientists. Boyd and his colleague A.P. Willmore were invited to propose instruments for flight on a succession of Nasa research satellites over many years ahead.

Whilst these activities were developing, moves were afoot for creation of a European co-operative space programme using rockets and satellites. The European Space Research Organisation, later renamed the European Space Agency, came into being in 1964. Boyd was a member of a small advisory programme committee that proposed its first rocket programme with which, as it emerged, British scientists, including the UCL group were much involved. That same committee gave high priority to the creation of a programme of satellite launchings in 1968; it was the first of several to which the UCL group again contributed.

With so much to be done and with new staff being recruited, there was, by the early 1960s, a pressing need for extra accommodation at UCL, but in Gower Street, central London, there was none to be had. In 1965 the electronics firm Mullard donated £65,000 to allow UCL to purchase a Victorian mansion high above Holmbury St. Mary in the Surrey hills. The resulting Mullard Space Science Laboratory opened in 1967 with Sir Robert Boyd as director.

He became a Fellow of the Royal Society in 1969, was appointed CBE in 1972 and knighted on retirement in 1982. By then his laboratory had grown in size and strength; it remains a major contributor to research in the fields of astronomy and astrophysics, space plasma physics, solar physics and remote sensing.

Boyd's publications included *The Upper Atmosphere* (with H.S.W. Massey, 1958), *Space Research by Rocket and Satellite* (1960), and *Space Physics* (1975).

He was chairman of the board of governors of the London Bible College. Throughout his life he was a man of strong religious faith that was entirely rational and committed; he saw no incompatibility between the honest pursuit of scientific truth and the claims of the Christian Gospel.

He married Mary Higgins in 1949; she died in 1996. He later married Betty Robinson (née Chelmsford), who survives him, along with two sons and a daughter by his first marriage. He died on February 5.

(Printed from the Daily Telegraph with permission.)

Molecular Biology in the Twentieth Century

A Meeting took place at the Royal Instution, London on 28th-29th April, 2003 under the above title to mark the fiftieth anniversary of the *Nature* paper which announced the structure for DNA proposed by Watson and Crick. Baroness Susan Greenfield, the Director of the RI welcomed attendees, and was accompanied in this by representatives of the Rockefeller Archive Center of Rockefeller University, and of the Wellcome Trust Centre, University College, London. These two were joint sponsors of the meeting.

The papers given varied widely in their remit, from 50-year overviews to matters of finance, law and national perspectives, cultural impacts and medical applications. It should be noted that this gathering at the RI had been preceded by meetings in Cambridge and at the Royal Society. This prompted the first speaker, Rob Olby, to comment on the danger of 'over exposure' of the subject, especially during this year. He claimed that we needed a broader time-scale, and went on to review much of the early work of Astbury in Leeds, who was a pioneer in the structure of proteins. At one time it was thought that DNA was the 'midwife' during protein development, and only later recognised as the genetic material. However, its omnipotency was rejected in favour of the all-important proteins, and genetics was only really connected with DNA in the 1970's and 1980's. Thus, in studies on the effects of radiation on tissues, DNA was not at first the putative target. The Atomic Energy Authority and the Medical Reseearch Council became involved in the post-war years of atom-bomb testing; radiation protection was investigated, as was also the clinical use of radiation.

Geneticists in the USA were working with laboratory mice, whereas UK scientists were employing rabbits. John Cockcroft asked the MRC for a facility at Harwell where Mellanby came after working with Waddington in Edinburgh, as did Müller also. It was proposed to use large numbers of mice (150,000!) to study mutagenesis and answer the question 'is there a safe threshold for radiation?' In 1956 a report stressed the need for more research on genetic hazards - about the time that the Campaign for Nuclear Disarmament was initiated. However DNA did not figure in this report, *per se*, somehow being regarded as irrelevant, even though chromosome breakage was obviously important. The unit at Hammersmith Hospital was involved at this time. Initially only male mice were used (spermatogenesis) but studies were later enlarged to encompass female mice also. In all, some 5 million animals were involved in these studies. The AEA and the MRC diverged politically in their outlook. It is interesting to note that it was not until 1958 that the human chromosome number was settled at 46. In retrospect one could say that Harwell may have understood the importance of the molecular level in genetics, but even then DNA was not implicated.

Graeme Hunter entitled his talk *Before the Double Helix*, and gave a detailed elucidation of the the chemical structure of DNA from the earliest studies, with many illustrations. Referring to Miescher's work, he defined three stages in the work on nuclein, namely, the separation of protein and nucleic acid, the characterisation of the components DNA and RNA, and their relative proportions. In the time of Miescher only the relative ratios of atoms were known. For example, cysteine was only identified in 1820, synthesised in 1838, and its structure elucidated in 1902.

Analysis of nuclein showed much variation, and yeast nucleic acid-was demonstrated to be different from animal nucleic acid. By early in the twentieth century all the nucleic acid bases had been identified, Levine being a pioneer in this work. For example, purines and pyrimidines were shown to be in equimolecular proportions before 1910. Levine also proposed the mononucleotide concept, suggesting that the nucleic acids were polynucleotides. By 1914 Kossel had raised the matter of structure, and in 1923 Pavlov and

Levine established that thymus nucleic acid contained a 'new' sugar, namely deoxyribose. This was found to contain a furanose ring, and Todd later pushed this even further. Dr. Hunter's talk was illustrated with many structural diagrams, impossible to reproduce here.

Emphasis then changed to legal matters, and **P.G. Abir-Am** asked, 'who paid for DNA research, and why?' By the mid-1950's the Rockefeller Foundation was funding Randal's work in London, specifying that the money should be used for DNA research. Max Perutz, Bragg's assistant in Cambridge was also supported by Rockefeller. In 1946 Randal had been helped by funds for cell-division studies; somewhere along the line an MRC report was 'leaked', and Cambridge took up DNA research. Initially Rockefeller granted $40,000 over 3 or 4 years, which helped Franklin's X-ray studies. The Rockefeller continued to support UK research, and eventually the unit under Wilkins at King's College, London was opened. About 50% of the Rockefeller funding went on DNA research. Public and private monies were used - one could ask today whether this was a positive or a negative contribution. However there is no doubt that by combining public and private funding the results in DNA research were achieved. Without this combination there may well have been little result.

Dan Kevles presented a masterly overview of the patent situation *vis-à-vis* science and ethics in the US and the UK. According to US law, dating from Jefferson in 1793, there must be evidence of a new, or useful process or technique for a patent to be granted. This means that 'natural' products would be excluded, an edict which was tested in 1889; 'discovered materials cannot be patented though breeding of new species is possible (1930's). When DNA came along, i.e. a 'chemical', this would not be patentable - with the reservation that if it were modified under controlled conditions, then patents would be allowed. Chakrabarty applied for a patent in 1972 for a bacterial strain to digest oil-slicks, but was turned down. Later, 1979, the Supreme Court ruled by a 5 to 4 majority to allow Genentech patents - Chakrabarty's products should have been allowed as 'new' and not 'natural'. Are there now no holds barred? The 'oncomouse' is now patentable, and in 1984 patents were granted for any transgenic organism, except human. (No-one may have property rights over human beings since the abolition of slavery.)

There has been much discussion and objection, e.g. by Rifkind, farmers, clergy, conservationists and animal rights activists, who regard the whole matter as 'playing God'. Lately, human genes have been tested for patenting by Venter in the 1990's, and there is much on-going dispute. The situation in Europe is somewhat different, in that the proposed patenting of life organisms is refused on ethical grounds. The situation is tighter than in the USA, although there have been compromises, for example in Germany in 1995 jobs were considered of more importance than ethics. In 1998 all this was still under discussion, but the matter is regarded as very important in the EU ('the human genome must be free').

Robert Williamson then reviewed the early days of human molecular genetics in the UK, reminding the audience that in the 50's and 60's those scientists who were honoured were part of the mere 3% who went to University. They were in the main, male, white and middle class. The advent of the DNA 'revolution' marked a 'sea-change', in that since then we have had more *inter*-disciplinary research. Williamson remarked on how much 'fun' it was but only for the few. Biochemistry in those days was big, but Watson and Crick were outsiders in that field. Davidson and Chargraff opposed 'molecular biology' as a separate discipline in the UK. The patronage of the MRC was vital and grants were hard to acquire. The clinical genetics fraternity was 'precious', dealing with rare and frequently fatal diseases; people tended to come into genetics from other fields.

The advent of 'Southern blotting' technique changed everything, and information was rapidly exchanged for the next 10 years. A meeting in Asilomar led to a moratorium on cloning, but Brenner *et al* side-stepped that issue, claiming that cloned DNA is person-specific. Clinical geneticists resisted a molecular approach, for example in cystic fibrosis, muscular dystrophy and Huntingdon's disease. With the coming of the human genome project (1982/3) research became 'less fun' (*sic*). And what about today? Are we not brave enough, are there too many of us, is greed corrupting science? (Or, one might ask, is the speaker being cynical, or too nostalgic?). Is medicine a career rather than a life? We must learn from the past, and encourage fresh minds, and young people to be iconoclasts.

Ton van Helvoort reviewed the situation in the Netherlands, especially asking whether patenting and secrecy were inevitable today, and therefore does University life suffer? In 1945 the Dutch government was discouraged from limiting academic freedom, and universities attempted to follow the Rockefeller Foundation. However, equipment was very expensive for universities, and thus research institutes were set up. Salaries were low and universities themselves were still organised by disciplines, even up to the 1960's and 1970's. Molecular biology was thus an ideal boundary area for research institutes to pursue, i.e. applied research since the institutes were 'society based'. One formed the impression that Holland's experience has not been a happy or fruitful one, and lessons are still being learned.

The evening of the first day of this conference concluded with an address by **Sydney Brenner**, Nobel Laureate, entitled *Adventures with DNA*. The talk was quite philosophical, and the speaker challenged the audience to consider the role of information theory in molecular biology. He claimed that biological systems are T-machines, in which one looks up the answer to a problem, rather than P-machines which calculate and the store the result. Hence biological systems are more open-ended. With regard to the current discussion on cloning, we must always remember that even 'copies' are persons with rights - we are more than our genes. Another question is how the genome maps on to the phenotype. Perhaps an aphorism would be 'life is polygenic, death is monogenic'. The scientist Jim Watson has been criticised for his emphasis on 'big labs', whereas Brenner claimed that science advances via communities, and interaction is essential. Fifty years ago the community of molecular biology was initiated; now we need competition and communication. Whither the next fifty years? One of the recent challenges is the idea of continuous development - a theory of organisation. There must be flexibility in development - i.e. not determinism. The final point made was the fact that humanity itself is now open to study. All in all the talk was overtly optimistic regarding the future.

The second day of the conference continued the theme along the lines of national perspectives, commencing with the Italian experience, unfortunately missed by the reviewer. Then **Michel Morange** gave an outstanding overview of the story in France, much of which he has published recently. In 1965 Jacob, Monod and Lwoff received the Nobel Prize, and 1970 saw the publication of *Chance and Necessity* by Monod. Then in 2001 France joined the contributors to the human genome project. The speaker conceded that in the early days maybe France relied too much upon past successes. Lamarckism inhibited progress, and whereas in the 1930's Lwoff was head of a laboratory, it was only later that Jacob and Monod joined him. At this time the main work was concerned with the UV-irradiation of bacteria. Lwoff was a true Darwinian who published his last paper in 1990. Some of the early work by Bertrand suggested that the metal component of co-enzymes was of more importance than the protein. There was a step forward when the Institut de Physique Chimie et Biochimie was established in the rue Pierre Curie quite early in the century. Was this the first such institute in the world? The advent of World War II proved disruptive of research, and moreover, anti-semitism was rife. The famous Institut Pasteur was regarded as too 'vitalist', and molecular biology was held back there. However three positive characteristics of the Pasteur were the phage group (where US techniques were assimilated), a realistic attitude to study (phage was not regarded as a mysterious 'black box'), and thirdly the political element in the society around. In 1948 Monod was a communist who found it hard philosophically to work on species adaptation. Then in 1958 de Gaulle created the environment for molecular biology; the impact of this was strong in France. The 1965 Nobel Prize was a landmark, but Monod's book *Chance and Necessity* aroused much opposition in the literature. The main controversy was over chance and Darwinism. People such as Monod were opposed to Teilhard de Chardin who was a priest. Monod became isolated from the intellectual scene because of his outlook. Much study of development was considered 'tedious' (*sic*). However today the French, although opposing GM foods, give strong support to gene sequencing, and have a 'global' outlook.

Under the title *Cultural Impacts* **Jan Witowski** reviewed the way genetics has been portrayed in the newspapers, in particular by cartoon. People are interested, but the cartoons must be humorous in order to carry the message. The speaker cited several aspects which are of interest to the population at large. Two of these are, for example, the possible existence of a gene for obesity, and a deficiency of the enzyme monoamine oxidase, which may be linked to aggression. All of this has to be carefully handled, since such connections to genes may lead to 'excusable' behaviour or 'What can we do about it?' The issue of cloning is very much a popular topic, but we need to remember that even clones show differences, e.g. identical twins. We do have different personalities, and people need to realise this. Above all we must not ignore popular culture - cartoons may well influence perceptions, be they ironic or factual.

Bettyann Kevles also addressed the cultural aspect, reviewing the visual arts and representation of DNA. There has been an anti-science backlash in the past, and people are afraid of technology and anti-faith movement. In 1963 Salvador Dali used DNA as *Homage to Watson and Crick*, and by the 1980's DNA was seen as an icon, likewise the human genome project. (In fact in 2000 an art exhibition was mounted in the USA on the genome project.) In general artists view the DNA phenomenon with optimism, there are pessimists, and others are obviously angry. (Illustrations of these viewpoints were given by the speaker.)

The next section of the conference focused upon the medical applications. Although many examples could surely have been given, in fact only two papers were presented. The proposed speaker on the subject of *Immunology in the 1950's and 1960's* was to have been **Elena Aronova**. In her absence the paper was read by **Janet Browne**, Reader in the History of Science. The development of immunology from 1934 onwards was reviewed, and since that time there has been a paradigm shift towards the molecularisation of the science. In earlier days at the Rockefeller Institute, the main concern was with immunogenetics. Then in 1950 a big jump was made since the structure of proteins was starting to be revealed. The dawn of nuclear energy gave a boost to this. The first meeting at Gatlinburg, Tennessee in 1957 focused upon bone marrow transplantation, and a year later a similar conference in Texas was addressed by Lederberg, and Medaway. An article in *Science* by Lederberg in 1959, June, p. 1650, was seminal in the field. Antibody formation was an important issue, and nine propositions were formulated, which led to many other workers in the field focusing upon antibody structure and function. Then in the late 1950's attention was directed more to higher organisms, which led to investigation of the chemical structure of antibodies. Thus in the 1960's, e.g. in the Cold Spring Harbor Conference, antibodies were paramount (1967). The 'operon' model was suggested in 1964 (Finch, *Nature*, 1964), though it gradually became less prominent. However, 'instructive' theories still hung on for a while. These 1960's meetings saw the enhancement of the introduction of molecular biology into the field of genetics.

Viviane Quirke then reviewed the area of drug design between the 1940's and 1970's. The modern tendency is to employ computer imaging to predict new drugs, but the word 'design' was extant in the 1950's, as also the word 'rational'. One could ask how companies developed new drugs prior to the discovery of the DNA structure. But even in 1925 Burroughs Wellcome in New York founded a drug group, and George Hitchings started work on the pyrimidines as a thesis topic, since nucleic acids were believed to be at the core of life, this being ten years before Watson and Crick.

The discovery of the sulphonamide antibacterials gave a boost to the studies when it was realised that they were antagonists of p-aminobenzoic acid, a folic acid precursor. They were effective against bacteria since these require p-ABA, whereas the human host does not. A large amount of the drug design was rationally based in this way. Other examples are the use of lactobacillus casei as a system which led to the development of 6-mercaptopurine, septron, imuran, zovirax, etc. The years 1947-1957 were a 'rich' period, but it was not until the 1980's that AZT and acyclovir were developed. The possibility of 'intercalation' of drugs into the DNA helix had been suggested in 1961 - but was there a previous 'incarnation' in 1949 (B.J.Pharm, 3, 298) and the antimalarials along the way?

In 1978 DNA was viewed as a drug 'receptor' with binding in the wide groove, which seems a long time after the nucleic acid studies which dated back to the 1940's. By the 1970's work slowed down due to problems of drug resistance. More research on DNA structure could possibly resolve this impasse. Also there was a tightening of regulations, and it became necessary to show how drugs 'worked'. But eventually drug design and the DNA 'receptor' concept came together, and led to further development.

The final session of the conference was devoted to the work of Rosalind Franklin. **Brenda Maddox** gave an overview of this work, which led at one point to the Watson and Crick hypothesis. The speaker has outlined Rosalind's work in her book *Rosalind Frankin - the Dark Lady of DNA*. Since this is very accessible, it will not be referred to further, save to say that it is a fascinating work, well-recommended, and now a prize-winner. Rosalind's main study in her all-too-short career was on viruses and in particular tobacco mosiac virus. **Angela**

Creager and **Gregory Morgan** from Princeton University described this work. TMV was the first virus to be identified in 1935, when it was found to be not entirely made up of protein. Many theories were proposed as to its structure (were 'rods' merely an artefact? An aggregate?). It was known to contain many sub-units and Wilkins and many others worked on TMV in 1954. A core of RNA was proposed by the X-ray evidence. Franklin worked in Wilkins' department on the diffraction patterns produced by TMV, and Aaron Klug joined her later in this work. Watson and Crick were also involved in collaboration. Even in the 1950's Franklin suggested a model with strong protein-nucleic acid association. Caspar joined the team and suggested a sub-unit structure using radioactive counting techniques. The work was published in the CIBA symposium of 1957. By the following year a model was shown at the Brussells Fair. It must be remembered that in Rosalind's scientific life, the transition from DNA to TMV was not a break, but a continuation of her study on viruses, and that 1953 was also more of a gradual acceptance of DNA structure rather than a milestone. Finally, contrary to what is sometimes said about her, she was not afraid to speculate (the paper in 1955 witnesses to this).

The Editor

Professor Sir John Ambrose Fleming MA DSc FRS

President of the Victoria Institute 1927 - 1942

Brian Bowers PhD CEng FIEE

1. Introduction

At the start of the twentieth century two leading modern technologies were electric lighting and radio. Fleming was involved in both, and his most important contribution to radio came from his work on lighting.

Electric arc lamps were first used in the 1870s for lighting streets and large buildings such as railway stations. Practical filament lamps suitable for domestic use were developed by several inventors in the late 1870s. The English Edison Company opened a power station at Holborn Viaduct, London in 1882, and engaged Fleming as Scientific Adviser.

Early in the nineteenth century Michael Faraday and James Clerk Maxwell had developed theoretical ideas that led to radio. In 1886 Heinrich Hertz demonstrated for the first time the production and detection of radio waves. Radio as a means of commuication began with the work of Guglielmo Marconi, son of an Italian father and an Irish mother.

In 1901, Marconi showed that radio could cross the Atlantic. For that he needed a powerful source of high frequency electricity, and he engaged Fleming to design the necessary generator. The greater technical problem, however, was detecting radio waves when the signals were very faint. Marconi had been using the 'coherer', invented by Edouard Branly, but he needed something more sensitive. Fleming's great contribution was the realisation that he could develop the filament lamp into a very sensitive detector of radio waves: the 'valve' or thermionic diode.

So, who was Fleming?

2. Family and Background

Fleming came from quite a remarkable family. He was born at Lancaster on 29 November 1849, the eldest child of the Revd James Fleming, minister of High Street Congregational Church there. A brother, Howard, was born in 1851, and two years later the family moved to London were James became minister of Kentish Town Congregational Church where he remained until his death in 1879.[1] James Fleming was a prominent figure in Congregationalism. In 1857 he contributed to a volume in the Rivulet controversy. This was a major theological dispute among Congregationalists, prompted by a hymn book published by T.T. Lynch in 1855. The hymn book was called *The Rivulet: Hymns for Heart and Voice*, and Lynch explained that 'Christian poetry is indeed a river of the water of life, and to this river my rivulet brings its contribution'. Lynch's hymns were rather different from the hymns then in fashion, and tended to wax eloquent on the beauties of nature. A reviewer of the book, in a morning paper, condemned it as 'utterly opposed, in spirit and teaching, to the Gospel of Jesus Christ'. Fifteen Congregational ministers in London, who knew Lynch, protested at the 'spirit and charges' of the critic.[2] James subsequently published eight other theological books, and received a DD from Adrian College, Michigan, in 1877.

Fleming's mother, Mary Ann, was the daughter of John Bazley White, one of the pioneers of the Portland cement industry. The principal raw materials for Portland Cement are chalk and clay, both found in abundance in north west Kent where White had bought Frost's cement works at Swanscombe in 1834. As a boy Ambrose spent some of his time at the cement works. In 1900 a number of firms including White's merged to form the Associated Portland Cement Manufacturers Ltd., which later became Blue Circle Cement. After extracting chalk for more than a century they left a large hole in north west Kent, surrounded by fifty-metre high chalk cliffs, part of which is now occupied by the Bluewater Shopping Centre.[3]

His mother's elder sister, Ellen Henrietta (1810-1879) married Benjamin Ranyard in 1839. From 1857 they lived in Hunter Street, Brunswick Square, London. As a teenager Ellen went visiting the sick poor with a friend, and in one visit they both caught a fever from which the friend died. When she moved back to London Ellen devoted most of her life to providing Bibles, basic education and nursing care in some of the poorest parts of London, and she eventually had more than 200 women drawn from the poorer classes working in her 'London Bible and Domestic Female Mission', usually known as 'The Ranyard Mission'.

Ellen Ranyard's son, Ambrose Fleming's cousin, the astronomer Arthur Cowper Ranyard (1845-1894) was educated at University College London, as was Ambrose. In 1865 Arthur Ranyard read the first paper to the newly-formed University College Mathematical Society, which later became the London Mathematical Society. He had a particular interest in solar eclipses, and took part in expeditions to observe and photograph them in Sicily in 1870, Colorado in 1878, and Egypt in 1882. He carried out photographic research with Lord Lindsay; studying the relationship between brightness of an object, length of exposure, and the resulting photographic image.

So Fleming was born into an enterprising family, but his immediate family was not wealthy and on three occasions young Ambrose had to leave his college studies for a while and find paid employment.

3. Education and early work

Ambrose was educated at a private school from the age of ten, where he particularly enjoyed geometrical drawing, and then at University College School in Gower Street from the age of fourteen (1863). The headmaster, Thomas Hewitt Key, a linguist, believed that any boy who could reach a certain standard in mathematics should also join the corresponding class in Latin. Consequently Ambrose was bottom of every Latin class in turn. As a boy he exhibited scientific and technical interests. He made model engines and ships, and took up photography, using the collodion process.

His ambition was to be an engineer, but at that time the only way to come a professional engineer was to start as a premium pupil to a practising engineer. Unable to afford this, he decided to become a science teacher. He entered University College London in 1866, intending to obtain a BSc, but had to leave after two years for lack of money.

He took a job copying drawings for a firm of shipbuilders near Dublin, but left that after four months to take a post in a stock jobbers' office in London. The work there was easy, and only occupied him from 10.30 in the morning till 4.00 in the afternoon, so after hours he returned to his degree studies and obtained his BSc, with first class honours, in 1870.[4]

A friend of his father was Edward (later Sir Edward) Frankland (1825-1899), a fellow Lancastrian who had become Professor of Chemistry at the Royal College of Chemistry in South Kensington. His main work was in organic chemistry and in water analysis and purification. After consulting Frankland, Fleming obtained the post of Science Master at Rossall School, Lancashire in 1871 but returned to London the following year to become a student again, this time in South Kensington. He studied under both Frankland and Frederick Guthrie (1833-1886), Professor of Chemistry at the Normal School of Science, South Kensington,[5] whose students 'included large numbers of the "certificated science teachers" of this country, and for them he devised a very practical mode of teaching physics, by which the learner constructs his own apparatus'.

Needing paid employment again, he obtained the post of Science Master at Cheltenham College in 1874, at a salary of £400 per year - a good salary at that time. While at Cheltenham he began to do his own scientific research. He obtained a copy of Faraday's *Experimental Researches in Electricity*. After discovering that electricity was induced in a conductor moving in a magnetic field, Faraday reasoned that electricity should be induced in the River Thames because of the earth's magnetic field, but he was unable to demonstrate it. Fleming arranged an experiment in which acidulated water flowed down a glass tube arranged between the poles of an electromagnet, and showed that an emf was produced.[6]

After three years he had saved a year's salary and he sat for an open science exhibition at St. John's College, Cambridge which he entered in October 1877. Among the lecturers was James Clerk Maxwell, to whom he listened avidly although he found him difficult to follow. In the Cavendish Laboratory Fleming was given the task of comparing the various standards of resistance, and devised an apparatus for the purpose, based on Carey Foster's method of using the Wheatstone Bridge. Maxwell called the apparatus 'Fleming's Banjo'.[7]

When Fleming's father died in November 1879 he had to leave full-time studies so took a post as demonstrator of mechanism at Cambridge in order to help the family. After a year of teaching at Cambridge, during which time he had obtained a DSc degree from London and a first class in the Cambridge Natural Science Tripos, he was appointed the first Professor of Physics and Mathematics at the new University College, Nottingham. In 1882 he was elected a Fellow of St. John's, and was then offered consulting work in London. The prospect of dealing with the applications of science rather than just pure science attracted him, and he resigned his post at Nottingham.[8]

4. Consulting Engineer

A cousin of Fleming's, Arnold White, was secretary of the Edison Telephone Company, formed in 1879 to promote Edison's telephones in Britain. He engaged Ambrose Fleming as scientific adviser to the company. There was also a Bell Telephone Company, but after the High Court ruled that the state monopoly of telegraphs included telephones, the Edison and Bell Telephone companies merged as the National Telephone Company. Fleming was actively involved in the litigation and became scientific adviser to the merged company.[9]

From March 1882 Fleming was also scientific adviser, and White secretary, to the Edison Electric Light Company, formed a little later than the telephone company to promote Edison's electric lighting in Britain. That company built a power station at Holborn Viaduct, which began supplying electricity in January 1882. Their largest single customer was the City Temple, the large Congregational church on Holborn Viaduct. Fleming had technical responsibilities at Holborn Viaduct and also a general responsibility to promote Edison's electric lighting.

Edison's London agent, Edward H. Johnson, organised an exhibit at the Crystal Palace electrical exhibition in 1882. Johnson had photographs of the Holborn Viaduct station and other Edison equipment on display. Fleming was in attendance most days to explain things to delegations from town councils around the country, and to encourage them to visit Holborn Viaduct.[10]

From November 1881 Edison also had the services of another consulting engineer, John Hopkinson, who subsequently became professor at King's College London. He was consulted generally about the operation of the Holborn Viaduct station and distribution arrangements for electricity supply, especially the 'three-wire' system, and about machine design.[11]

Hopkinson's major interest was in electrical machines. There was an electrically-driven hoist at Holborn Viaduct. Hopkinson thought it important to have an electric machine visibly at work. He reported that the hoist was working satisfactorily and had been handed over to Dr. Fleming.

Fleming tried to interest Edison in an insulating material on which he had been working. He said that the material, which he called 'insulite', was made by compressing fine wood flour and a resinous hydrocarbon. In June 1882 he sent a box containing various pieces of insulite, including some telegraph insulators made from the material, to Johnson for passing on to Edison.[12] It would seem that Edison did not take up the invention, but Fleming had more success the following year selling his idea in Australia.

Early in September 1882 there was a serious generator failure at Holborn Viaduct. Fleming dismantled the machine and found the commutator insulation defective. He arranged repairs, had the machine put together again, and reported that is was satisfactory. Hopkinson inspected it all and wrote a report expressing agreement with Fleming - adding the cheeky comment, 'Edison should test each engine before despatch'.

While Fleming was working at Holborn Viaduct a strange phenomenon was being noticed in some electric lamps.

Everyone today is familiar with the ordinary light bulb - the filament lamp, which was the principal source of light in most of our homes in the twentieth century. The filament inside the glass bulb is a tungsten wire made white hot by the electricity passing through it. Usually it works at full efficiency until, suddenly, the filament breaks. Often there is a flash as it breaks, but then nothing. Before the First World War most filament lamps had a filament not of metal but of carbon. Carbon filament lamps behave differently. In use, carbon particles sputter off the filament and collect on the inside of the bulb, blackening the glass and reducing the light output. There comes a point where, although the lamp still works, it makes sense to throw it away and have a new one.

Occasionally a srange effect was noticed in the blackening. When the filament was a simple loop, and supplied with direct current electricity, a line on the glass remained clear. This line was in the plane of the filament, but on one side only. It looked as if carbon had sputtered off one side of the filament, and the other side had stopped particles reaching the glass, leaving a clear 'shadow'. The phenomenon became known as the 'Edison Effect'.

Edison tried to make use of the effect, without much success, and for several years it remained a scientific curiosity with no practical application. Fleming does not seem to have been involved at that stage - but he was clearly a very busy man.

5. Professor at University College London

In 1884 Fleming was invited to give a course of lectures at University College London on electrical technology, and the following year he was appointed the first professor of electrical engineering in the college, a post he was to hold until his retirement in 1926.[13]

All the equipment he had initially was a piece of chalk and a blackboard, but he pressed the college authorities for more and obtained a grant of £150 and the use of a small room as a laboratory. He bought various measuring instruments and set up a photometric laboratory. His photometric work was important for the new electric lighting industry, and he also developed some 'standard' lamps which were essentially 'aged' filaments mounted in a very large glass bulb. His students worked in the photometric laboratory, and were compensated for the lack of other laboratory facilities by various industrial visits. They also assisted Fleming in the preparation of lighing schemes: Fleming was engaged in designing schemes for a number of municipalities.[14]

When Sir John Pender, the submarine telegraph pioneer, died in 1896 a fund was raised in his memory and the Pender Memorial committee gave £5,000 to the college to endow an electrical laboratory.

The new Professor gave lectures in other places. In the winter of 1885-6 his friend R.E.B. Crompton invited Fleming to give a series of lectures to the pupils and workmen associated with his firm. These lectures were published later in 1886 as a very successful book, *Short Lectures to Electrical Artisans*. A second edition was published sixteen months later,[15] and Fleming published another thirty books on scientific and technical topics over the following 56 years.

In 1887 Fleming married Miss Clara Ripley Pratt. Professor J.T. MacGregor-Morris, who had been a student of Fleming's and then his assistant, wrote 'she was not often seen at College, and rarely, if ever, were senior students or research workers invited to their home in Hampstead. She did not appear to be strong.'[16] A rare glimpse into their home life is provided by the Census for 1901 which records that John A. Fleming aged 51 and his wife Clara, who had been born in Wiltshire and was then 43, lived at 212 Finchley Road, Hampstead, NW, with two domestic servants. They had a cook, Agnes Buxton aged 30, and a Housemaid, Alice M. Buxton aged 16. The Flemings had no children, and Clara died in 1917 when she would have been 59.

6. Continuing research and consultancy

Professor Fleming continued to be an active researcher and consultant. He was active in the Institution of Electrical Engineers, of which he become a Member in 1882 when it was the Society of Telegraph Engineers and Electricians. He served on its Council several times and was Vice-president from 1903 to 1905. He read many papers to the Institution and joined frequently in its discussions. In 1888, for example, we find him contributing to the discussion on a paper by Arthur Cockburn on fuses, papers by Gisbert Kapp and J.T. Mackenzie on transformers and AC distribution systems, and by Sir William Thomson on measurements. In talking about fuses Fleming also discussed the insulating properties of various kinds of slate, used for switchboards, and was clearly drawing on his own practical experience.[17]

The Edison power station at Holborn Viaduct was a direct current system, but alternating current systems were coming ito use and had their own special problems. Fleming first met AC systems at the Inventions Exhibition at South Kensington in 1885 when the Hungarian inventor Zipernowsky exhibited his transformers and the proposal to transmit alternating current over a distance at high voltage, and then transform it down to the required working voltage. In London Sebastian Ziani de Ferranti was then developing his proposal for transmitting electricity at high voltage into central London from a power station at Deptford. Unexpected problems arose, such as arcing at the switchboards, and Fleming was consulted. He traced the problems to inductive effects and suggested remedies. The results of this work were embodied in his book *The Alternating Current Transformer*, which was a standard textbook for several years.[18]

In 1896 the Irish-Italian Guglielmo Marconi brought his radio apparatus to England. One of the leading particpants in a company formed to manufacture and operate Marconi's apparatus was Fleming's friend Major Flood Page, and in 1899 he invited Fleming to be scientific adviser. At the time Marconi's apparatus could receive Morse code signals over about forty miles. Marconi wanted to extend the range, and transmit signals across the Atlantic. His transmitting apparatus was a spark gap and an oscillatory circuit energised by a Rhumkorff Coil. His receiver was a coherer, a relay and a Morse printer.

Fleming's first task for the Marconi Company was to design a twenty-five horsepower generator to feed a Tesla high-frequency transformer for the transmitter. This was done during 1900, and the equipment installed at Marconi's transmitting station at Poldhu, Cornwall, in 1901. In December of that year signals were detected 1800 miles away in Newfoundland. But the received signals were very weak, and it was clear that something better than the coherer was needed. In October 1904 Fleming had an idea that solved the problem, but this idea canot be understood without explaining some earlier developments.

The 'Edison Effect' - a clear line in the blackening of carbon filament lamps - has already been mentioned. Edison fixed an additional metal plate in a lamp. It was insulated from the filament but connected by another wire passing through the glass. It was found that when the lamp was hot a small current flowed to the plate as if it was connected to the positive side of the filament, thus showing that the plate was in some way collecting negative electricity. Shortly afterwards Elster and Geitel connected a battery in the plate circuit and found that an increased, but still unidirectional, current could be obtained. In 1903 Wehnelt discovered that coating the filament with certain metal oxides increased the effect.

After a time Fleming also studied this phenomenon, but for several years it remained a scientific curiosity of no practical value.[19] Everyone realised that thermionic emission led to a rectifying effect, but nobody saw a use for it. There was no obvious benefit in a rectifying device that needed a relatively high current in the filament to yield a very small rectified current. For practical rectification a closely-related device, the mercury arc rectifier, had been developed by Cooper Hewitt and was in use by 1903.

In October 1904 Fleming realised that the rectifying effect could have a practical value: it could rectify frequency signals and enable a radio receiver to operate a telegraph receiver. He patented the idea. In his patent specification he described only a circuit using the simple Edison connection, not the Elster-Geitel connection nor the use of the coated filament. Nevertheless, he had described the first radio valve, and paved the way for the development of the valve by Lee de Forest and others in the following years.

Radio was not Fleming's only research interest at this time. He worked on the idea of 'repulsion motors', which had the advantage of working on an alternating current supply, and he gave a Royal Institution Discourse on them in 1891. He collaborated with James Dewar on low-temperature research at the Royal Institution. Dewar's main interest was in very low temperatures, and he invented the vacuum flask in the course of that work. Together the two men studied the electrical behaviour of metals at very low temperatures, and showed that the electrical resistance of a metal approached zero as its temperature approached absolute zero. He also worked with Crompton on electrical measurements, desiging a potentiometer arrangement for measuring voltage easily and accurately. The instrument was manufactured by Crompton, and led Sir James Swinburne to dub Fleming 'The Apostle of the Potentiometer'.[20]

7. Educator and communicator

Fleming was undoubtedly master of the scientific theory behind his work but he was a down-to-earth practical engineer and he had a gift for explaining techical matters to working people and to the general public as well as to his students. There is no record of his views on teaching students, but he had definite views on school teaching.

> It is useless to lecture to boys as one would do to adults. They simply do not listen. The main purpose of science teaching in schools should be to train the boys' powers of observation and inference. Hence such teaching should consist largely in performing experiments, and making the boys note what takes place. I found it to be a good plan to do one or more experiments in complete silence, and then set the boys in a line in class, and cross-examine them as to what they had see and what they had inferred, and let them take places for good answers.[21]

His lectures were described as 'triumphs of lucidity, compression and skilful demonstration'.[22] Arthur Blok remarked that Fleming 'hated slackness and all kinds of superficiality and he spared no effort to eliminate them by act and example. I remember hearing him turn the career of one student from mediocrity to success by the pungent observation "There is all the difference in the world Mr. So-and-so between knowing a thing and knowing about a thing" ... To the keen student he was an inspiration, but to the slacker or dullard he was a devastation and a despair'.[23] Fleming's students - or at least the successful ones - seem to have retained a high regard and some affection for their professor. I met Arthur Blok in 1974, when he was in his nineties, and he still retained happy memories of his time with Fleming which had clearly been a highlight of his career.

One mnemonic which Fleming used in teaching is known to almost every electrical engineer and physicist today, and was first published in Fleming's book *Short*

Lectures to Electrical Artisans mentioned above. His Right Hand Rule, for remembering the direction of the current induced in a conductor moving in a magnetic field, and its converse, the Left Hand Rule, for working out the direction in which a current-carrying conductor moves in a magnetic field. In Fleming's Rules the thumb, forefinger and middle finger are held mutually at right angles. The thu**M**b represents the direction of motion of the conductor, the **F**orefinger points in the direction of the magnetic field and the m**I**ddle finger points in the direction of the current, 'I' being used conventionally for electric current. Most people who learnt physics at school remember these rules even if they know nothing of Fleming and have forgotten nearly everything else learned in the physics class.

Outside the university, Fleming was a highly acceptable public lecturer on scientific topics. He gave the Gilchrist Lectures to audiences totalling several thousand. In an autobiographical note he said that he 'was also greatly interested in popular education and for many years as a Gilchrist Lecturer addressed large audiences of working people in all parts of the country'.[24]

These lectures attracted quite lengthy and enthusiastic reports in local newspapers. He usually said that his aim in the lecture was to explain the principles of magnetism and electricity, and how the magnet and the electric current were made. He could not hope to tell them what magnetism was or what an electric current was, for the simple reason that he did not know nor neither did he know anyone who did know. But a great deal was known about their properties, and what they were capable of producing.[25]

In 1902 Fleming was 'Departmental Editor for all the Electrical articles' in a supplement to the *Encyclopaedia Britannica*. He wrote to Oliver Heaviside inviting him to contribute an article of not more than three pages, which would be a maximum of 5,000 words, on recent advances in the theory of signalling along cables. The fee proposed was £9, though Fleming said he was sure it could be increased to £10. Six weeks later another letter from Fleming begins, 'Dear Mr. Heaviside, I thank you for your M.S. which however I must return to ask you to kindly shorten it and bring it within the space allotted.' Heaviside had written 8,000 words. The correspondence does not all survive, but there was apparently some argument about the length and the proprietors of the encyclopaedia were persuaded to accept a longer article. In a letter accompanying a proof of the typeset article Fleming comments, 'I think it reads very well and as you will see it extends to about five and a half pages'.[26]

It is interesting to see that the last mentioned letter is typewritten, all Fleming's earlier correspondence being written by hand.

He gave a number of radio broadcasts, starting with a talk on 'The Origination of the Valve and How it works', broadcast on 2LO on 16 February 1923. Two months later he was on the air again with a talk about Sir James Dewar, who died in March 1923. A broadcast in March 1924 on 'Wireless for the Deaf' was printed in full in *Radio Times*. Fleming, who was himself extremely deaf, explained that even a slight deficiency in hearing cut one off from other people, from pleasures such as music, and from lectures. He explained the physiological causes of deafness, and that in many cases deaf people could hear speech or music transmitted through a headphone. 'Let no deaf persons, therefore, consider themselves as permanently isolated ... Science comes to the aid of human infirmity'.

He gave several further broadcast talks in retirement, mainly looking back on the history of radio and the benefits it had brought. The last was in 1944.[27]

Because of the secular basis of University College, the religious beliefs, or lack of belief, of both staff and students were not generally known. Fleming had throughout his whole life a deep Christian faith acquired in childhood. It came as a surprise to many of his colleagues when, in 1931, he preached a sermon at St. Martin's in the Fields church in London. His subject was the evidence for the resurrection, and he argued that Christianity was based on actual historical facts.

Fleming wrote a number of books on questions of science and religion. In reading his text one can hear the professor challenging students who have not thought things through. His first such publication was *The Evidence of Things Not Seen*, published in 1904. In 1917 he published *Science and Miracles*. In the year he retired, 1926, he published *Evolution and Revelation*, described as a 'vindication of the divine origin of the Bible'. An address he gave in 1932 at the Fifth National Bible Day, entitled *The Bible and Modern Evolutionary Theory*, was published as a 24-page pamphlet costing two pence. Other books, mainly relating to the theory of evolution, followed.[28]

It was a time of widespread debate between those who accepted literally the account of the creation given in *Genesis* and those who would explain the natural world through evolution, meaning, as Fleming puts it, 'a self-acting agency or operative cause which has brought about the gradual perfection of existing things, living and non-living, without assistance or guidance by Thought or Mind'.

He observes that in the case of human inventions, such as the steam engine, the sewing machine, wireless, and others, perfection is never reached at one jump. The word 'Evolution' can appropriately be used to describe a process of gradual improvement by the mental operations of many men, but we recognise that at every stage the inventive and constructive thought of human minds has been the real operative cause of the advance. We should reject with scorn the suggestion that any of these human inventions had been the result of fortuitous concourse of atoms or the spontaneous agglomeration of masses of different materials'.[29]

'The more we study the development of the physical Universe and its relations to living organisms,' wrote Fleming, 'the more we see that purposive Thought, and not accident or any self-adjustment, must be at the bottom of it all.' He added, 'Thought implies a Thinker, and a Thinker must have individuality and therefore be a Person.'[30] He did not believe that random chance provided an adequate explanation.

8. Retirement

Fleming retired to Sidmouth in 1926 at the age of 77. He had a house built to his own design which he called 'Greenfield' after the house in which he was born. He lived there with two of his sisters. He was knighted in 1929. In 1933 he married Miss Olive Franks of Bristol, a singer, well known in the West Country, and she lived on at 'Greenfield' until 1978. They worshipped regularly at Sidmouth Parish Church, and after his death Lady Fleming presented the church with a 'finely carved Litany Desk' in his memory.[31]

It was an active retirement, in which he continued to write and lecture, and he was President of two organisations. One was the Television Society (now the Royal Television Society), founded in 1927, the year after he retired. In 1928 he gave a lecture on television to the Sidmouth Literary Society. The local newspaper reporting the lecture says it was 'highly interesting', but the only actual information reported is that in response to the 'question of how long it would be before it would be possible to see pictures from distant places of such events as the Lord Mayor's Show, or the King opening Parliament, the professor said it was a matter of evolution. He had no doubt whatever that it would eventually be possible'.[32] Five years later he gave a lecture in Sidmouth on the history of the thermionic valve.[33]

Fleming's deafness has been mentioned above. A surviving letter that he wrote to Llewelyn Atkinson, another electrical engineer living in Devon, described the deaf aids he and his sister used. His measured 9 x 6 x 5 inches. His sister, who was not so deaf as him, found that she could hear well with hers in public meetings and in church. He urged Atkinson not to buy any deaf aid without trying it out first.[34]

Although he was never a member of Sidmouth Congregational Church he was consulted by them in 1936 when they had problems with amplifying equipment. Just before that Lady Fleming had been invited to open the Annual Bazaar, and in 1939 'Lady Fleming and the choir' gave a Sacred Concert in the church.[35]

Before his retirement Fleming was not a member of the Victoria Institute or Philiosophical Society of Great Britain, formed in 1865. He might well have been, for its objects would have appealed to him. Their first object is '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'. The Very Rev. H. Wace. Dean of Canterbury, was President of the Victoria Institute until his death in 1923. In March 1926 the Council reported to the Annual General Meeting that they 'regret that up to the present they have not found a suitable successor to the late Dean of Canterbury, but the matter is under consideration'. At the 1927 AGM the Council proposed Fleming, who was then elected into membership. He was an active President, and gave twenty addresses to the Institute between 1926 and 1942 on topics including 'Evolution and Revelation'. 'Some recent Scientific Discoveries and Theories', 'On Beauty in Nature as a supplement to the Argument from Design', 'On some Methods of Determining the Age of the Earth and their Assumptions', and 'The Visions of Nebuchadnezzar'.[36]

Many honours and awards came to him in retirement. He had been a Fellow of the Royal Society since 1892 and recipient of the Royal Society's Hughes medal in 1910 and the Royal Society of Arts' Albert Medal in 1921. He received the Faraday medal of the Institution of Electrical Engineers in 1928 and the Duddell Medal of the Physical Society in 1931. He did not receive a Nobel prize, though he was nominated for the Nobel Prize for Physics in 1927.[37]

In 1935 he was awarded the Kelvin Medal, a distinction which is given only every three years by the senior Engineering Institutions. When the award was announced Crompton wrote to Fleming expressing his hearty congratulations, 'for there is no man who has done work of such huge importance, and to my mind quite insufficiently acknowledged'.[38] That seems a fair comment on a man who is little known today but whose work had such an impact on modern life.

10. Acknowledgements

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Evangelical Engineering

Bob Allaway

Examples of scientists motivated by their Christian faith are legion. Well-known Christian engineers are rarer. This gives added importance to Pilgram Marpeck, who was not only a leading light of the continental Radical Reformation, but also a precursor of the modern Civil and Municipal Engineer.

He was an important and wealthy local official in Rattenberg, a mining town in Austria. As 'mining magistrate', it was his job, amongst other things, to settle disputes about ownership, collect taxes and see that the mines were safe and the miners and their families provided for in the event of death or injury.

An Anabaptist called Leonhard Schiemer came to town. He spoke of the inward change that the spirit will work in the true believer, and called on those who believed to be baptised in obedience to Christ. Many of the miners accepted Schiemer's message and were baptised as believers. This worried the Catholic authorities, who arrested and tortured him. Pilgram was asked to report any Anabaptist miners, who would face similar treatment. He objected that his job was to watch over the miners' working conditions, not their religion, but he was then *ordered* to report them. For a time, he sought to stay on in his job, but without reporting anyone. (Indeed, it is possible that he had already been baptised himself, but he was always vague about the exact circumstances of his baptism as a believer, possibly for security reasons.)

When, in 1528, Schiemer was executed, within 200 yards of Pilgram's house*, his example made Pilgram obey his conscience. Having entrusted his children to guardians and made provision for them, he resigned his job, and publicly declared himself one of the 're-baptised'. This made him a hunted outlaw, with all his goods confiscated by the state. At this time he was probably in his thirties. He now became (with his wife) a travelling evangelist, earning his living by the civil engineering he had learnt in the mines.

The next we know of him was that he became a citizen of Strasbourg in September of that year. Presumably, he had arrived there not long after departing Austria. At this time, the more tolerant 'free cities', such as Strasbourg, were overcrowded with refugees from persecution. This made the price of firewood high in winter, so the poor were in danger of freezing. Marpeck drew up plans for canals, to help bring cheaper wood to Strasbourg from distant forests, and oversaw their construction. It is a testimony to his widely acknowledged moral uprightness that the City Council was prepared to entrust large sums of money him for this project.

While at Strasbourg, he was seen as a leader of the Anabaptist fellowship there, and was drawn into debate with Martin Bucer, the leading theologian of the city's mainstream Reformed Church. This led Marpeck to articulate a more carefully thought out theology, but also led Bucer to more radical positions than those of other mainstream reformers. This means that Marpeck had an indirect influence on the English Reformation, since Bucer later moved to that land and advised Cranmer. (It was Bucer's influence that led to the direction, in the Second Prayer Book of Edward VI, that communion should be celebrated in the round, with 'the Table' moved to the centre of the church.)

Equally important for Marpeck's theology was the need to counter heretical opinions among his fellow Anabaptist refugees. I will say more about these in a moment.

The presence of such a notorious Anabaptist leader in their city was evidently an embarrassment to the City Council. In December 1531, following a debate with Bucer, they ordered Marpeck to leave the city, if he was not prepared to change his opinions. Nevertheless, they happily accepted various requests from him to put off enforcing this, and it was not until January 1532 that he finally left.

His movements in the next twelve years are unclear, but at some point he evidently did some civil engineering around St. Gall, in Switzerland. Testimony to this work was later given to the Council in Augsburg. The latter was another 'free city', where Marpeck settled from 1544 till the end of his life, and was employed as what we would now call a Municipal Engineer.

Like Strasbourg, Augsburg was overcrowded with refugees. Such overcrowding endangered health, without plentiful clean water. Marpeck built a dam and waterworks that gave Augsburg such a good supply, some houses even had piped water on tap - something almost unheard of in those days. So valuable were his services that he remained untouched, even though the city was under alternating Catholic and mainstream Protestant control. From time to time, the Council warned him to desist from his Anabaptist ways, but continued to pay his salary. He died of natural causes in 1556.

So much for the bare facts of Pilgram Marpeck's life. Undoubtedly, his skill as an engineer assisted his Christian activities, by making him too valuable to persecute. Is this its only value, though? Was it, perhaps, also an outworking of his theology?

Boyd argues that he had a concern for the poor as an expression of the gospel, pointing, for example, to the way tht Marpeck sees the commission in Isaiah 61:1f, that Christ applies to himself in Luke 4:14f, as applying also to all servants of Christ. However, this occurs in a letter to the Swiss Brethren {Klassen, p 438}, whom Marpeck considered to be excessively legalistic, so he may be wanting to draw attention more to the need to 'bind up the wounded' and 'comfort those who mourn'. Either way, the key point is that we are called to take Christ as our model.

A common heresy amongst Marpeck's fellow Anabaptists, especially those in the Netherlands, with whom he had most dealings in Strasbourg, was belief in 'the celestial flesh of Christ' - that Christ did not take flesh from the Virgin Mary, but brought it with him from heaven. This Marpeck rightly repudiated. Christ was truly 'one of us', not only because only thus could he save us, but also because only thus could he serve as a model for us.

Another of his theological opponents was Caspar Schwenckfeld, who stressed the glorified nature of the resurrected Christ and the spiritual nature of the church. This led him to reject outward things like sacraments. Marpeck, by contrast, stresses the importance of the material world and the church as the body of Christ, which should be as involved in that world as Christ was. He compares those who despise the visible church and its practices, composed of ordinary people, with those who rejected Christ because they thought him 'a carpenter's son'. We are called to follow Christ in his physical humanity and fellowship with the humble.

Seen in this light, Marpeck's 'down to earth' concern for the practical application of knowledge in the service of the masses was a reflection of the'down to earth' Christ whom he preached. Many Christians see their jobs as a useful source of money to put in the church offering and of contacts to be evangelised, just as Marpeck's job helped give him the freedom to evangelise. We can learn from him also, though, the value of seeing how our jobs can in themselves be an outworking of our faith. In this sense, he was not only an evangelical engineer, but one who practised evangelical engineering!

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William Klassen and Walter Klassen (eds), *The Writings of Pilgram Marpeck*, Eugene (OR): Wipf and Stock publishers, 1999

* Boyd, p. 23. Klassen & Klassen, p.18, talk of 'Hans Schlaffer and Leonard Schiemer' being beheaded the next month in Schwaz, but the latter is a misprint for Leonhard Frick.

Science and Faith in Pastoral Context

The Third Theological Consultation: '**Baptists Doing Theology in Context**' was held at Regent's Park College, Oxford from 26-29 August 2003. These gatherings are for papers prepared by pastors, not 'professional', academic theologians, although the Baptist College Principals attend as convenors. Certain unifying themes emerged when the programme was published. One series of papers was on *Following Jesus in a Violent World*. Another was on worship. A smaller group, reviewed here, was on science and faith issues.

The Revd Dr John Weaver is Principal of the Cardiff College, a former geologist and a Vice President of *Faith and Thought*. He spoke on the process of *making moral decisions about new technologies*, using genetic engineering as an example. (His book *Earthshaping, Earthkeeping*, London: SPCK, 1999 is reviewed in *Science and Christian Belief*, **12** (2000), 188.)

The Revd Dr Richard Kidd is Principal of the Northern (Manchester) College and a former physicist. He gave an illustrated talk on *colour perception*, showing how skilful artists could cause the eye to see colours other than those that a digital analysis might register, (Jointly with Graham Sparkes, he has now published *God and the Art of Seeing*, Oxford: Regents' Park College, 2003.)

The Revd Prof. Michael Humphries is a former physicist and an honorary Professor of Architecture. He spoke on *Research into Evolutionary Psychology and Consciousness: its Impact on Faith and Preaching* and entertained us with a story in which 'virtual widgets' in a computer evolved consciousness. How would they consider the programmer, if at all, and how would he regard them?

It was unfortunate that this paper clashed with one by the Revd Dr Anthony Thacker (author of *A Closer Look at Science Fiction*, Eastbourne: Kingsway, 2001) entitled *Holodeck Dialogues: Sci-Fi and Christian Faith*. Just about everyone at Prof. Humphries' paper would have liked to have gone to this, also, and *vice versa*.

Finally, Revd Dr Robert Allaway, a former Chemist and a member of *Faith and Thought* council, read a paper, *What is the Mind? Some pastoral implications*. Over the course of his ministry, he had frequently been led to provide pastoral care to the clinically depressed, which had been appreciated. Sadly, he had come across many cases where fellow ministers and other Christians have been less than sympathetic to such conditions, sometimes making folk feel guilty for being down. He suspected that an over-spiritual view of what the mind is could be one reason for this. He argued that a 'physicalist' view of the mind was more Biblical as well as more scientific, and did not detract from a Christian view of Man's origins or moral reposnsibility.

It seemed appropriate that, like God's creation, a consultation that began with 'Nothingness' (in a talk by the Principal of Spurgeon's College) concluded with the Human Mind!

It is hoped that papers read at the Consultation will be published in electronic form.

Symposium on Biblical Archaeology

To be held at the Quaker International Centre,
1-3 Byng Place, London WC1

on

Saturday October 2nd 2004

- On the Reliability of the Old Testament — Professor Kenneth Kitchen
- Archaeology of the Bible - Friends or Foes? — Professor Alan Millard
- The Exodus - What Really Happened? — Professor Colin Humphreys
- Using Ancient Words to Date the Old Testament — Mr. Terence Mitchell
- Archaeological Evidence for the Brother of Jesus? — Dr. John Kane

This meeting is open to all who are interested. The cost is £10.00 including tea and coffee (Full Time Students £5.00). Anyone joining the Institute at the day of the meeting will have their fee refunded. Lunch will be available at extra cost.

Bookings: Mr. R.S. Luhman, 110 Flemming Avenue, Leigh-on-Sea, Essex SS9 3AX.

Correspondence

Dear Editor,

Following my letter of 28 November and our subsequent telephone conversation, I did write to Duncan asking if he would be willing to deal with questions affecting the biblical doctrine of creation arising from the address he gave last May, published in *F&TB* 34. This is because I reckon there must be readers like me who do not understand the language of science. Very few of our target audience will have acquired a full understanding in secondary education. CiS exists for scientists, VI does not.

I asked whether recent experiments proved that entropy was reversible: development instead of degeneration.

I acknowledged that I had no knowledge of the Quantum theory and was unable to make sense of the paragraph at the top of page 11 in that Bulletin.

I added, it was understood to be impossible for different species to interbreed. That being so I enquired how this impacted on the theory of evolution.

Yours,

Brian H.T. Weller

Reply to Brian Weller

Dear Brian,

Thank you for your letter of the 10th with its three questions; I'll do my best!

Q.1
Yes, you are right; it used to be thought that pattern and structure in nature can only be lost as entities of all kinds degerate, and that lost entropy cannot be regained spontaneously. This has now been shown to be untrue. Structures can arise via random forces, and given circumstances which conserve complexity can persist. The clearest account of this with examples is by Kauffman. He includes the chemistry of our genetic material in his argument with natural selection as the conservator of adaptive complexity. His research group has been concerned with this for many years; a major part of it has been to use the mathematical logic which applies to switches and switching to show how self-regulating and self-modifying systems may arise, even some which show elements of self-maintaining constancy.

However, though the mathematics is fairly persuasive, the work is decidedly short on actual examples and is indeed ingeniously speculative. As with all such reasoning, even if it shows how biological entities may have originated it does not show how it actually took place. Examples of spontaneous natural order include chemical mixtures which show balanced alternation of reaction and diffusion and the iron silicate outgrowths which so intrigued Isaac Newton ('chemical gardens'). Evidence for spontaneous order in nature is pursued avidly by those who believe, *a priori*, that there is no divine agency in the natural world.

Q.2
Quantum Theory: Here I must disclaim any physical expertise; I can only state some of the ideas at a popular level. However, on your immediate question I must make it clear that the aspect of quantum wave theory which I wrote about

was not the Heisenberg uncertainty principle but the quantum field potential. The Heisenberg principle concerns the inevitably probabilistic nature of the wave equation such that the more closely an observer defines a particle's position the less closely can its momentum be ascertained, and vice versa.

The quantum field potential is shown most simply by the two slit experiment; if a stream of particles is directed to a barrier perforated by two slits, and their numbers are reduced until only one particle is crossing through a slit at any brief time, then if one slit is closed the particles follow a simple beam. But if the two slits are open the particles follow an interference pattern past the barrier similar to that seen when a distant light is viewed through a fine net curtain. Even if only one particle traverses a slit in the brief time it behaves differently from that of a particle when only one slit is open.

The equation which describes this behaviour has four terms which equate to zero. The first two terms describe the wave function, its phase and the square of the gradient of this. The third term is the electrical potential. But there is a fourth term, Q, the quantum potential which involves R, the squared gradient of the root of the probability density, both in its numerator and denominator as well as the particle mass and Planck's constant. This term is minute compared with the others if the wavelength is small compared to the wavefront, so it has been ignored in a frequently used approximation. But Bohm has argued that Q is a signal to which charged particles respond as well as to the expected electrical potential, V, an energy transfer which though minute is highly significant.

Also, since R occurs both above and beneath the fraction in Q, the particle response depends not on the size of the signal Q but upon its form. He calls this 'active information' which evokes a response in the particle's trajectory.

The significance of this is that at the level of fundamental particles nature is not governed solely by mechanical or electrical forces as was supposed by physical determinists from Newton through Laplace and many others to the scientists of Darwin's day. What is more the Q signal is 'perceived' by particles at immense distances, including the quantum field of each particle itself. The universe is not shut in to mechano-electrical laws but is 'open' to 'active information' from wheresoever it may come.

Q.3

Breeding across species boundaries is not impossible (cf. ligers and tigons and carnations); species are weakly defined. Evolutionaty changes occur primarily with genetic variation which gives rise to reproductive success. Colonies of similar individuals then form a species, which is best seen as an evolutionarily independent biological unit. Once formed, species then interact at the macroscopic level as competitors, coinhabitors, predators and prey, symbiotes and so on. They are affected by genetic variation, but also by environment, isolation, adaptation and other factors. The old fashioned idea of species was based solely on mating ability; now the idea of common ancestry is added to the definition. But most species are inherently unstable, hence there is no restriction on evolution unless one accepts a definition of species as fixed or determined in some way. Many species have now been observed to evolve; the only problem with observation is that in general evolution happens so slowly that no one lives long enough to follow the changes through, unless one is a microbiologist.

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Yours sincerely,

Duncan Vere

Book Review

Peter J. Bowler, *Reconciling Science and Religion (The Debate in Early Twentieth Century Britian)*, Chicago/London: University of Chicago Press, 2001. 479pp. hb. £28.00
ISBN 0-226-06858-7

Peter Bowler is a professor of the history of science at Queens University in Belfast who has, in the past, specialised in the history of evolution. He has produced a study on Charles Darwin as well as works relating to the development in evolutionary theories in the late nineteenth and early twentieth century. This book is a logical outcome of his interest in this field. As he points out in his preface, "If the theme of this book seems rather widely removed from my usual research in the history of evolutionism, it is fairly easy to show how I was led into this new territory. I have long been interested in early-twentieth-century evolutionary theory, and had been vaguely aware that the controversies over the religious implications of the theory did not simply die away as the Victorian era ended." (xi)

Bowler challenges the long-held assumption that in Britain, as opposed to the U.S.A., where creationsim flourished, the great scientific debates of the nineteenth century just fizzled out. This was due to the neglect of this area by historians. In fact, even at the end of the nineteenth century, there was a strong reaction against mechanistic biology and a preference for non-Darwinian evolutionary modes of evolution. There was a strong diversity in both scientific and religious beliefs. T.H. Huxley's use of the conflict metaphor to oppose the subservience of science to religion fails to do justice to the fact that many scientists, at that time, were deeply religious. However there was a popular decline in church attendance in the country, as a whole, and a general indifference to organised religion.

Bowler divides the book into three sections dealing respectively with Science and Religion, the Churches and Science and the wider debate. There is inevitably a good deal of repetition as similar topics and characters are dealt with in each section and his tendency to give an overview of the material followed by a detailed consideration of important topics and leading characters.

In the first section the author looks at the changing patterns of belief and how scientists related to superstition, rationalism and Marxism and how new scientific theories and discoveries altered the perspective on the science and religion debate. Popular science, in the early part of the twentieth century, was dominated by scientists, who had been educated in the previous century, but were largely out of touch with how science was progressing. In the 1920s attempts were made to try and convince the public that science had turned its back on materialism and that religion was more open to change. Neither was completely true. Scientific naturalism, in the form of determinism and materialism and an agnosticism towards the existence of God was actively promoted by the Rationalist Press Association, who ran a campaign to base knowledge on empirical science. Religious thinkers were inclined to be ignorant of what was actually going on in science and became wedded to the popular views of outdated scientists, whose works appealed to them, even when the majority of scientists in their own fields were either hostile or indifferent to their views. The consensus fell apart in the 1930s as a result of a number of factors. Scientifically there was the final abandoning of obsolete ideas in science like Lamarkianism, the belief in an ethereal substance and vitalism and an adoption of the new insights of biology and psychology. Secondly the harsh economic conditions and the rise of fascism led to the abandonment of the nineteenth century faith in progress. Finally the religious compromise of Modernism was abandoned as a total emasculation of Christianity.

In the second section Bowler surveys the prominent figures in the Free, Anglican, Evangelical and Roman Catholic churches respectively and gives an overview of their respective positions. In an attempt to reconcile science and religion and to halt the decline in church membership modernists within the churches tried to make Christianity compatible with science and modern thought. They did this by abandoning traditional doctrines like belief in miracles, sin and redemption. Christianity was to be seen as the final stage of human evolution. Christ was the highest product of evolution sent to teach us how to overcome our baser instincts and fulfil the supreme expression fo God's will on earth. For many modernists this also involved them in supporting the eugenic dream of the elimination of the stupid, weak or unfit. Traditionalists, both Roman Catholic and Evangelicals, finally won the day. Few people saw any point in preserving a church that was no longer Christian. Also there was a resurgence of neo-orthodoxy associated particularly with Karl Barth and a group of Christian intellectual authors who successfully popularised Christianity and, in the eyes of ordinary people, answered both modernists and atheistic evolutionists. Among these authors were C.S. Lewis, G.K. Chesterton, Hilaire Belloc, C.E. M. Joad and D.L. Sayers.

In his final section of the wider debate the author shows how writers were able to use popular appeal to get their message across. He cites Huxley, Jeans, Eddington and H.G. Wells as examples of this. Often, as with Wells, they used obsolete scientific ideas to advocate their views. Wells argued for a society transformed by biological materialism and Bernard Shaw saw creative evolution as an alternative religion. He ends his study on a positive note by commenting on the work of Polanyi on the involvement on the observer in the creation of knowledge and by commending the work of Charles Coulson on complementarity in science and religion.

The book is not easy to read, because it is encyclopaedic in scope and a mine of knowledge. It is a veritable *Tour de force.* We are treated to detailed summaries of the work of hundreds of authors and the bibliography, which runs into forty-two pages, lists not only major works and articles but also papers and letters. There is a helpful set of biographical notes of major authors, which includes Sir Ambrose Fleming, a past President of the Victoria Institute. He includes sixteen black and white photographs. The author is even handed in his treatment of the topics, and this is particularly commendable as he admits he is not a religious person. He says, "I have done my best to understand the principles underlying the various theological and philosophical positions taken up by those whose commentaries I was reading. I am sure that I have to some extent over-simplified, but I have tried to approach these religious beliefs as sympathetically as possible" (xi-xii). I could only wish that many Christian writers had the same humility.

Here is a book for those interested in the complex relationship between science and religion and for those who wish to see how the history of science should be written. It is to be highly recommended.

Reg Luhman

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It is published by The Victoria Institute and mailed free to all Institute members, along with *Science and Christian Belief.*

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