Chapter 2 DARWIN AND THE AFTERMATH

Science and Faith in the 19th and the 20th Centuries

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CONTENTS – CHAPTER 2

2.1 INTRODUCTION

2.1.1 Darwin and The Origin Of Species

Darwin and *The Origin of Species* dominates the science/faith debate in the 19th Century. *The Origin of Species* was published in 1859 after a long gestation period. The Huxley, Wilberforce debate at the British Association meeting was held on June 30th 1860 in Oxford.

These two events are commonly perceived as a simple contest between enlightened science and outdated religion. The truth is much more complex as recent historical evidence has made clear. They need to be seen in a broader context therefore, in relation to the social, political and religious scene in 19th C Victorian England.

2.1.2 Darwin and the aftermath

Darwin's theory of natural selection was variously received as an affront to creation — a new "world view", or alternatively as an evidence of God's sovereignty over nature. Its basic scientific tenets were however largely ignored by many scientists particularly by prominent Christian physical scientists such as Kelvin and Clerk Maxwell and also by many prominent religious spokesmen such as Spurgeon.

The June 30th 1860 debate was not reported in the press at the time and has taken on a life of it's own in the hands of those who were engaged in a struggle for hegemony in 19th C England. There was neither universal acceptance of Darwinism by the scientific community in the late 19th C nor universal rejection by the theological community, but rather a range of views expressed on both sides. Darwinism however, was often exploited by those with a variety of political and social reform ideas — ideas as diverse as Marxism, exploitative capitalism and liberal humanism. Such promotion was often carried out without the blessing of Darwin himself. It is necessary therefore to examine the historical context for the arrival of Darwin's theory on the world stage and also the variety of perceptions and reactions that resulted from it.

2.2 BACKGROUND TO DARWIN

2.2.1 18th Century Geology and the Age of the Earth

Archbishop Ussher and a Young Earth

Ussher, who was Archbishop of Armagh and a notable scholar, had arrived at an estimate for the age of the earth and of a date for creation, by appropriate "scientific" and literary research. His views were almost universally accepted in the 17th C. They represented the best of 17th C scholarship and his dates were enshrined in the margin of many editions of the King James Bible. Creation was considered to occur in 4004 B.C and there was no reason to doubt this on the basis of the contemporary science.

18th Century Developments in Geology

The 18th C. however saw a revolution in understanding of the age of the earth, brought about by the activity of a variety of earth scientists (Buffon, Hutton, Lyell and others), who established from both fossil and rock strata evidence that the earth was of much greater antiquity and that the processes involved were the result of progressive changes resulting from processes that could be observed today (uniformitarian geology). These findings are described more fully in Chapter 1.

The result of these developments was a general acceptance of the concept of an old earth with a long history that made evolutionary development feasible. Lyell's Uniformitarian Geology became the basis for geology in the 19thC and his *Principles of Geology* (1830-33), first published in 1830, the standard geological work and also the valued companion of Darwin on his historic "Beagle Journey".

2.2.2 Early 19th Century Background

19thC Establishment

The early 19thC saw a growing professionalism in science with geology and later biology becoming independent scientific disciplines. Ecclesiastical control of science, and education generally, was however in the hands of an Anglican establishment most of whom had a classical non scientific background and training. Non-Anglicans were excluded from the Universities. This hegemony was resented by many non-conformist professionals who saw established religion as inhibiting scientific development. The prevailing theology was natural theology - using science to prove God.

Early 19thC Theology

This was dominated by William Paley (1743-1806) and Natural Theology. His book, *Natural Theology - Evidences for the Existence and Attributes of the Deity* first published in 1802 and repeatedly republished throughout the 19thC, set the scene. The argument from Design envisaged God as the divine watchmaker and every variation in nature was exploited as an evidence of design and of special creation by a beneficent Creator. The earth was envisaged as a static unchanging earth with each element and species owing its creation to a special act of God. Darwinism changed all that and the struggle was therefore often determined by a resistance to changing concepts of nature not so much to a changing concept of a creating God.

Climate of Dissent

There was also a climate of dissent arising from the enlightenment. *Vestiges of the Natural History of Creation* was published anonymously by Robert Chambers in 1844 and was met by a shocked, but nevertheless popular reaction. Chambers used progressionist geology and evolutionary biology (which did not arise with Darwin) to provide a naturalistic explanation for the origin of the earth and the evolution of life including man. It preceded the *Origin of Species* and set the tone for the reception of Darwinism (and also for some of Darwin's hesitancy to publish). The Romantic movement sought to promote nature, not as a mechanism but as an organism — Mother nature — bringing in pantheistic naturalistic overtones.

Pre Darwinian Evolution

It needs to be realised that Darwin did not originate the concept of evolution. What he did was to provide evidence for a feasible mechanism — Natural selection.

Erasmus Darwin

Darwin's grandfather Erasmus Darwin in the 18thC. had suggested evolution, a concept of progressive change, as a possible process to explain living things.

Lamarck

Lamarck, the French Biologist, had also promoted evolution and suggested as a possible mechanism the inheritance of acquired characteristics. Unlike Darwin however he was unable to sustain his ideas by experimental evidence.

2.3 EARLY DARWIN AND THE ORIGIN OF SPECIES

2.3.1 Background and training

Darwin was born in 1809 into a well known and well endowed family. He was the son of Robert Darwin a rich Shrewsbury doctor and related by both marriage and descent to the Wedgewoods. His early intentions to enter medicine were truncated by his departure from Edinburgh University after seeing only two operations, and his training for the Anglican ministry at Cambridge was thwarted by his consuming interest and diversion into natural history. Although he found Paley's "Natural Theology" fascinating, his interests lay more in collecting biological specimens and in field trips with Adam Sedgwick the Professor of Geology and Henslow the Professor of Botany. Henslow suggested that Darwin join HMS Beagle—which was about to sail on a survey mission in 1831—as a companion to its Captain, Robert Fitzroy.

2.3.2 The Beagle Journey 1831-1836

The Beagle journey lasted five years, not two as originally planned, and was the turning point in Darwin's career. Darwin collected specimens that depicted the enormous diversity of living things. He was fascinated by the diversity of species that existed in geographically separated areas such as the Galapagos Islands. He saw no validation of special creation, but rather of a process that promoted diversity in separated communities.

2.3.3 Malthus and Population Control

In 1838 shortly after returning home Darwin read Thomas Malthus's controversial book *Essays on Population Control.* It was a picture of the survival of the fittest in a world faced with a population explosion. The population was increasing more rapidly than was the ability of the environment to support it. The resultant struggle for existence against the enemies of famine and disease etc. formed both a basis for the competitive industrial society and the embryo mechanism for Darwin's Natural Selection.

2.3.4 Alfred Wallace

Darwin however delayed publishing his conclusions. He recognised that they would not receive a good response in the theological climate (and scientific climate) of natural theology with its concept of a static creation and of special creation of individual species. His delay was also conditioned by his struggle with the implications for naturalism that his theory clearly had, as well as for the religious sensibility of his wife, Emma, who was a devout Christian. He was eventually forced into publication by the very similar conclusions regarding "natural selection" arrived at by Alfred Wallace in 1858. This finally goaded him into publication, firstly in a joint paper with Wallace and then in the *Origin of Species* which appeared in 1859. It sold out the first day.

2.3.5 The Origin of Species - 1859

The *Origin of Species* presented the data Darwin had collected, both in his voyage on the Beagle, and in his researches since, in support of his theory of the mechanism of evolution — natural selection. It is important to point out that Darwin's theory was not the theory of evolution — that had been previously suggested. His genius however was to present a feasible mechanism to support evolution as a concept. He demonstrated the capacity for both overpopulation and of variation in biological species and also of the survival of those variants that were best fitted to survive in hostile and competitive environments. This was his theory of "Survival of the fittest" although it was not Darwin who labeled it as

such. He recognised and considered many of the objections to his theory and discussed them fully in the "Origin". He had no mechanism to account for either the generation of variation or of its fixation in succeeding generations. That was to await the arrival of Mendel and genetics. He also had no concept of the time span now known to be involved. This was to await the radioactive dating of the mid 20thC. Thus many of the objections foreseen by Darwin have been eliminated by subsequent work. His contribution is therefore all the more remarkable.

2.4 RESPONSES TO DARWIN

The responses to Darwin need to be seen in the light of the context of the times. It was not a debate between progressive science and outdated religion as commonly perceived. Darwin's theory was exploited by those like Huxley who wished to use it to attack the ruling ecclesiastical establishment, or by Spencer who wished to promote a social theory of human progress, long since debunked. It did however have naturalistic overtones that were recognised and debated and needed to be taken seriously, but it also could be seen as it was by many Christians, particularly by Calvinist conservatives, as an example of God's activity and sovereignty in the world.

2.4.1 The British Association Debate 1860

It was not surprising that the establishment theologians should react to the attack on natural theology implicit in Darwin's theory. Samuel Wilberforce, Bishop of Oxford, a High Churchman and a Paley "natural theologian", who was by no means ignorant of current science, was an early opponent. He was prompted by Cambridge anatomist, Robert Owen, a notable special creationist and also a member of the ruling culture. They were prize targets for Huxley, a rising biologist excluded from church based Universities and espousing naturalistic views. It was seen as a chance to oppose and destroy the church's grip on science. Darwin was caught up in this politicking but was a very reluctant contributor. Huxley was portrayed as "Darwin's Bulldog".

The debate took place on June 30th 1860 at the British Association meeting in Oxford. It was not reported in the press and the commonly reported view is that published by Huxley some years after the event. It is one of complete humiliation of the "ignorant and bigoted" Wilberforce at the hands of the enlightened scientist Huxley. It is from this report that the widely known jibe about "rather having an ape for a grandfather than an ignorant and bigoted bishop" is drawn. All good publicity stuff for Huxley's campaign against the church's hegemony. There are reasons to believe that the events were somewhat different, that Wilberforce presented a much more intellectual case, prompted by Owen and that Huxley's prominence was not as he indicated. Hooker claims himself as the major contender, while the supposed main event itself seems to have been only a small component of the proceedings. Draper (who was later to write the influential polemic history against the Roman Church and science) was a preliminary and very boring prelude to the Huxley/Wilberforce exchange.

The whole reporting of the Debate was part of a very effective publicity campaign waged by the scientist agnostics against ecclesiastical control of the universities and culminating in the publication of J.W.Draper's *History of the Conflict between Religion and Science* (1875) and Cornell University's founder A D White's *A History of the Warfare of Science with Theology in Christendom* (1895). Both of these histories are now discredited. Huxley and his companions used the Darwin issue to discredit the church and to promote their agenda. This was further served by their imitation of the church in the development of a "church scientific", in the events of the X Club and even in the use of Darwin's funeral in Westminster Abbey against the wishes of the family as the final assault (See Russell 1995).

2.4.2 Scientific Responses

As indicated above, Darwin recognised that there were many scientific objections to Natural Selection. Nevertheless his theory received good support from scientists. However there were some natural scientists who were not convinced. It was only with the 20thC. and the development of Neo Darwinism that scientific support for natural selection became part of scientific dogma. It was not easy to dissociate the overtones of naturalism from Darwinism and this is still the case today in both the scientific and theological responses.

Regarding science and faith in the !9th and 20th Centuries, see Russell (1989).

Pro Darwin

Huxley and his colleagues of the X Club saw Darwinism as a clear example of naturalism. Their espousal went well beyond the scientific aspects of natural selection. They adopted a positivist view of science and saw Darwinism as an alternative explanation of Creation, denying any role for a Creator. Thus, for Huxley etc., Darwinism moved from science to metaphysics. As indicated above this stance also had political aspects in their struggle for hegemony in Mid 19thC England. Asa Gray was the most prominent biologist in North America in the mid 19thC, Professor of Botany at Harvard and a friend and advisor of Darwin, and he was also an evangelical Christian. He saw no threat to Christian theism from the theory of natural selection and wrote frequently about both the scientific and Christian aspects of Darwinism. He was a correspondent and supporter of Darwin from before the publication of the "Origins".

Anti Darwin

Louis Agassiz (1806-1873) was a French Protestant geologist and zoologist who came to the USA in 1846. He brought a natural history that was based on catastrophism and a series of separate creations. He persistently opposed Darwinism in the USA. His stance was seen by his popular churchgoing audience as a defence of Biblical as well as scientific creationism. He was not however influenced by theological presuppositions and was never associated with organised religion. His reactionary views on racism and slavery made many orthodox Christians uneasy. Although he was a gifted teacher his many students failed to follow his anti Darwin position. William Dawson (1807-1899) was a Canadian Presbyterian and a highly acclaimed geologist at McGill University in Montreal. He occupied the Geology Chair at McGill and was one of the developers of that university as both a scientific and secular institution. He carried his objections to Darwinism throughout his career and was frequently quoted by antievolutionists.

Physical Scientists

Far from being agnostic many of the most prominent physical scientists of the late 19th Century were devout Christians. They included Faraday, Joule, Clerk Maxwell and Lord Kelvin. They had little to say about Darwinism. They were certainly not part of any anti-Christian science movement that promoted a conflict approach based on science.

2.4.3 Theological Responses

There was certainly no united opposition to Darwinism amongst theological opinion on either side of the Atlantic. Some like Hodge saw Darwinism as naturalism and as atheism. Others like McCosh, also from Princeton, espoused Darwinism as an example of God's activity in Creation.

Pro Darwin

The pro-Darwin stance taken by many Christians often came from those with widely different theology. In Victorian England liberal and moderate spokesmen were prominent in their support. Charles Kingsley the author and Anglican clergyman wrote in support of Darwinism glorifying a Creator *"who made things make themselves".* He was a correspondent of both Darwin and Huxley. Frederick Temple who later became Archbishop of Canterbury spoke positively of evolution in his university sermon on the day following the June 30th, 1860 debate. More liberal theologians often exploited Darwinism to include Spencer's social Darwinism and to support a view of humanity that included social progress. On the other hand many conservatives in both Scotland and the USA found in Darwinism an example of God's hand that denied the prevailing deism and semi-deism and asserted a Calvinistic view of God's sovereignty and activity in creation. These included prominent spokesmen such as George Wright of Oberlin College and James McCosh of Princeton, as well as influential Scottish theologians such as Iverach. See Moore (1979). The theological reaction to Darwinism was far from the universal rejection suggested by the popular press.

Anti Darwin

Apart from the emotive reaction of a variety of biblical literalists there was an informed and concerned response from a number of influential conservative theologians. The most effective of these was Charles Hodge, Principal of Princeton and perhaps the most influential conservative theologian in the USA. His closely argued book *What is Darwinism* concludes that "it is atheism". Hodge distinguished three aspects of evolution: the concept of evolution, the scientific concept of natural selection itself and the concept of natural selection without design. He had no argument to make against the first two but only about the third. His opposition was therefore against naturalism which he saw to be represented by Darwinism as it was promoted.

Neutral Responses

Many in Victorian England were content to ignore Darwinism and to oppose only its exploitation by social theorists etc., no comment being made about the merits of Darwinism as a scientific theory. The most popular preacher of the late 19thC. was Charles Spurgeon, whose London congregation exceeded 12,000 each Sunday, and whose sermons were speeded across the Atlantic and published in the secular press in the USA the following week. He rarely commented on Darwinism and when he did it was to address theories derived from it, not the theory of natural selection itself. He was content to let the scientists decide their matters on scientific grounds. It was a wise approach that could well be emulated today by many of his contemporary admirers. It is apparent that the dispute about Darwinism in the late 19thC was a debate about opposing world views, not about a conflict between science and faith. Many saw Darwinism from a positivist perspective, as more than science, and used Darwin's theory to promote a naturalistic world view. This was rightly opposed by theological opinion that espoused a theistic world view with God as Creator and Sustainer. Other theological opinion could see Darwinism as consistent and indeed supportive of a theistic world view and had no problem with embracing its strictly scientific claims (see Moore, 1979).

2.5 DARWIN'S 20TH CENTURY LEGACY

The embers of the 19thC. debate about Darwinism are still glowing, and in some quarters bursting into flame, but the issues are still the same. There is a need to distinguish between the debate about differing world views, which is not a scientific debate and the debate about the merits of Darwinism as a scientific mechanism to explain biology. What has changed in the 20thC however is the mounting evidence in support of Neo-Darwinism

and the universal acceptance of the theory by the 20thC. professional biological community. Amongst this community however, are the "descendants" of Huxley, who still wish to use Darwinism with its convincing scientific credentials to promote an agnostic or atheistic world view. Richard Dawkins is perhaps the most outspoken and widely known contemporary exponent. His unquestioned communication skills and excellent description of the scientific picture of evolution hide his confusion of science with metaphysics and his promotion not so much of evolution as science, but of a naturalistic world view. Amongst the professional scientific community are also those who have no problem with holding both a theistic world view and an acceptance of evolution as "theistic evolution"[1]. They see evolution and neo Darwinism as the most convincing mechanism to explain God's activity in nature. Despite this there is still an active anti evolution movement which has emerged in the late 20thC. as the Creation Science Movement. While contending for a creationist world view they see this as inconsistent with any acceptance of scientific evolution. A better understanding of the 19thC debate helps to put this in context. In many respects the issues have been addressed and can helpfully be reviewed if Christianity is not to be considered anti science and obscurantist.

2.6 ANTI-EVOLUTION MOVEMENTS IN THE 20TH Century

2.6.1 Fundamentalism and its 20thC History

Conservative Christianity was not only affected in the 19thC by the scientific naturalism debate but also saw the biblical criticism movement as an increasing threat to biblical authority and supernatural Christianity. As indicated above, the reaction to Darwinism was somewhat mixed in the USA, but by the end of the 19thC and until the mid 1920's it was not a large issue. In any case Darwinism as a mechanism was having its struggles in the scientific realm until the genetic basis for variation and hereditary etc. was determined and later evidence brought about its general acceptance.

The fundamentalist movement was a specifically American phenomenon set up in the first two decades of the 20thC. It was concerned to preserve the essentials, the fundamentals, of orthodox Christianity and numbered among its founders and supporters many of the important conservative theologians of North America including the influential Princeton School. Their concern was to maintain the essential doctrines of the deity of Christ, the Incarnation, the Resurrection and of Biblical Authority in the face of liberal assaults. Special Creation was never a tenet of the early founders. In fact, some of the leaders of the Fundamentalist movement accepted Darwinian evolution as an acceptable method of Creation, e.g. B.B. Warfield, the Princeton theologian, who championed Biblical inerrancy in his theological writing. Even those who had anti-evolution views (and these became more vocal in the 1920's) accepted an old earth and some form of "Scriptural geology". Thus although many of the early fundamentalists were unable to accept evolution as a method of creation, few had any difficulty with an old Earth and uniformitarian geology. This remained the case until the strict biblical literalism of the Creation Science Movement appeared in 1961 and came to dominate the anti-evolution agenda (see Berry, 1988).

After the first world war the social, moral and political position in the USA was blamed on the theory of evolution. Now the anti-evolution stance became a mark of the fundamentalist movement and political activism to prevent its propagation was involved. William Jennings Bryan was the high profile leader of this political

[1] Bishop Antje Jackelen, Lutheran Bishop of Lund in Sweden, in *Theology and Science* Vol 5 (2), July 2007, p. 151, argues against using the term *theistic evolution* and instead encourages the development of a theology of evolution.

movement. Three times presidential candidate and an outspoken fundamentalist, he led the legal battle to prevent the teaching of evolution in schools.

2.6.2 1925 Scopes trial Tennessee

In 1925, the law in Tennessee, as well as in a number of other Southern States, prohibited the teaching of evolution in schools. A challenge was mounted by civil liberties contenders and Scopes, the deliberately offending teacher, was charged and convicted under the anti evolution statutes. However the case was made into a national event with Bryan acting for the prosecution and Clive Darrow, a prominent civil liberties lawyer, for the defence. Although the case was lost, the battle for removal of the restrictive statute was not. Bryan and the anti evolution case was ridiculed and eventually the anti evolution statutes prohibiting the teaching of evolution were removed. There was, however, continued silent pressure for removing offending material from textbooks and sanitizing, as it were, the teaching of biology. Thus while evolution was permitted, it was actively opposed and covertly restricted in a conservative USA.

2.6.3 Popularisation of antievolution in USA

There was considerable support in the USA for a campaign against evolution. This was mounted in the public arena by two self styled scientist preachers, Harry Rimmer who had a considerable fundamentalist following in the 1930's, and George McCready Price. Rimmer adopted an old earth anti evolution, without a strict biblical literalism as did most of the anti evolutionists of his day. McCready Price on the other hand, resorted to a strict biblical literalism and a flood geology that arose initially from a vision to Ellen White the founder of Seventh Day Adventism, from which tradition Price emerged. He supported his interpretation and his science by a somewhat bizarre geology that returned in part to the diluvialism that had been discarded by the scientific community 100-150 years before. He was not taken seriously by the geological community, but his 'Creation Science' has persisted in the Creation Science Movement founded by Henry Morris in the 1960's.

2.6.4 1957 Sputnik and its effect on US education

The humiliating defeat of the USA by the Soviets in the space race, marked by the successful launch of the first manned satellite, goaded US education into a rethink of science education policy. This resulted in a much more aggressive approach to modern biology in schools. Evolution was now taught actively in schools, with non-sanitized text books instead of the half hearted compromise that had prevailed.

2.6.5 1961, Morris and Whitcomb — The Genesis Flood

A reaction to this action was the publication of a book that was to galvanise the antievolution sentiment in the USA and elsewhere. It was the much reprinted *Genesis Flood* by two anti evolutionists — Henry Morris, a hydraulics engineer, and John Whitcomb an Old Testament teacher at a small conservative college. They used the young earth flood geology of George McCready Price to present and document a strict literalist interpretation of Genesis and to launch a so called "creation science" to support this interpretation. The movement has been extremely successful in convincing over 40% of the US population of the truth of their views, despite the clear testimony of the professional scientific community. The movement, as early 20thC movements before it, has been active in seeking to establish its position by legal means, calling for the mandatory teaching of Creation Science in schools as an alternative to evolution.

2.6.6 1982 Act Defining Creation Science as religion

Statutes were enacted in several US States mandating the teaching of "Creation Science" along with evolution in state schools. The Arkansas State Act 590 was contested and overturned in a celebrated case in 1982. Creation Science was judged to be a religion and not science and therefore inadmissible in the US Education System for science classes. Legal action in relation to the teaching of evolution in schools continues to be pursued actively in the US Southern states. In 2000 in Kansas laws were enacted to make it non obligatory to examine evolution in biology examinations. Other States are pursuing similar actions. As in the 19thC debates, the issues have been confused. As was evident in the Darwin debate of 100 years ago there was a failure by many of those rightly seeking to maintain a theistic world view to recognize that creationism is not opposed to the scientific theory of natural selection; or of failing to understand that the truth of any scientific theory needs to be decided on criteria that are acceptable on scientific grounds and not on any presupposition based on a biblical interpretation. The conflict between science and religion suggested by the long evolution debate does not represent any intrinsic conflict between science and faith but simply a conflict between differing interpretations of the Genesis record.

A recent historical overview of the situation has been provided by Frame (2009, Chaps 10 & 11).

2.6.7 Intelligent Design(ID)

Frame (2009, Chap. 12) covers the recent development of intelligent design (ID) and the legal ramifications within the USA. The issue came to a head in 2005 in the much publicised court case in Pennsylvania, *Kitzmiller et al versus the Dover School District.*

> The legal action originated in a decision of the School Board to direct Year 9 biology teachers to question the scientific basis of evolution… Teachers were told to explain that *'the theory [of evolution] is not a fact…..Intelligent design is an explanation of the origin of life that differs from Darwin's view…*' After a six-week hearing, United States District Court Judge John Jones III ruled in December 2005 that Intelligent Design was a religious concept and that it could not be taught in science classes as an alternative to the theory of evolution. While noting that Darwin's theory was imperfect, Judge Jones went on to say: *"the fact that a scientific theory cannot yet render an explanation on every point should not be used as a pretext to thrust an untestable hypothesis grounded in religion into the school classroom".* (Frame, 2009, p. 201).

In an article in *The Melbourne Anglican* (Day, Sept. 2005, p. 15), the author explains why ID is flawed scientifically, philosophically and theologically. It is flawed philosophically because it confuses metaphysics (religious belief) with science. It is flawed scientifically because it proposes a 'secondary cause' that cannot be tested scientifically. Finally, it is flawed theologically because the god of ID is a 'god of the gaps', not the Christian God of the bible or of the creeds. It sells God short – a God who gets smaller with every advance of science.

2.7 THE NEW PHYSICS[2]

At the end of the 19th century, Newtonian physics with its deterministic universe was the dogma of physics. The created universe was thought to be deterministic and predictable. But quantum physics changes this. The physical world had become relative,

[2] See Chapter 6 for more detailed discussion of the 'New' Physics.

unpredictable, holistic. It marked a "quantum shift" in the way the world of nature could be viewed.

2.7.1 Einstein and Relativity

The speed of light was found to be a constant, not changing with the speed of the light source. From this starting point, Einstein showed that there is no universal time scale. Different observers measure time differently. However, the term "relativity" can mislead, since Einstein's theory is completely deterministic. His later "general relativity" extended these ideas to accelerated bodies, and interpreted gravitation as a distortion of the framework of space and time near massive bodies.

2.7.2 Bohr and Complementarity

Radioactive atoms decay at random times, though the rate of decay is characteristic of the element concerned. While light travels as a wave motion, its interaction with matter happens in discrete amounts called "quanta", whose size depends on the frequency of the light, as e.g. in Einstein's description of the photoelectric effect. Particles of matter also have observed wave properties. Both wave and particle descriptions seem unavoidable. Bohr proposed that wave and particle descriptions are "complementary", each being appropriate in its domain.

2.7.3 Indeterminacy

Since "particles" have wave properties, the position and velocity of a "particle" cannot both be measured with complete precision. If one is measured precisely, then the other cannot be measured at all. Heisenberg's Indeterminacy principle formulates this. However, the usual "Copenhagen interpretation" of these effects follows the "positivist" philosophy in asserting that an electron has no defined velocity unless it has been measured (which it often cannot be). This viewpoint seems to make the existence of the external world depend somehow on an observer. However, this is an interpretation of the observations, and is not compelled by them. The observed randomness seems to contradict any deterministic view of the world. Bohm proposed a deterministic theory, involving particles and "guiding waves", but his approach has not won acceptance.

2.7.4 Quantum Theory

These phenomena have been described mathematically by wave equations (by Schrödinger and Dirac), and "quantum field theory" which gives more emphasis on particle aspects. These apparently disparate theories are mathematically consistent, though a conceptual picture is hard to obtain. It has been truly said that "what the physicist believes is a mathematical formula". But the formulas describe, and predict, observations to an astonishing precision, and not only on an atomic scale. (Devices such as lasers depend on quantum effects.) There are also serious difficulties. A measurement of a quantum effect is supposed to be by a "classical" (Newtonian) apparatus — but why is this not part of the quantum world? Also, quantum theory and general relativity are incompatible, so gravitation does not fit with quantum theory.

2.7.5 Chaos

While computing a model concerning weather prediction, Lorenz found that extremely small changes in initial conditions made a great difference to the result. The computed path moves into a region, called a "strange attractor", whose location is known, but where it is within this region is not predictable, unless the initial conditions are known to an impossible precision. This phenomenon is called "chaos" (not related to "random"), and it has been found in

various models described by nonlinear equations. Even if we live in a deterministic world (and we do not know this), it is a much less predictable world than was previously supposed.

2.7.6 Cosmology

The color of the light from distant galaxies is shifted toward the red end of the spectrum. In the usual interpretation, this "red shift" results from the galaxies moving away; the universe is expanding, so must have begun from a small beginning at some definite past time. This "Big Bang" theory is supported by observations of microwave radiation, by observed abundances of chemical elements, and by theoretical considerations from general relativity. A rival theory of "continuous creation" of matter, with no starting time, does not agree with some of the mentioned observations. There are also difficulties with the "Big Bang". Not all redshifts are easily interpreted by receding motion; the degree of uniformity over great distances is explained by "inflation" of the early universe (but how was it caused?); and the discrepancy between redshift distances and gravitation has led to the postulate that most of the mass of the universe is unobserved (perhaps unobservable) "dark matter". So it may be premature to tie one's philosophy to the Big Bang. Nevertheless in spite of some of the difficulties mentioned above, there is a strong consensus that the age of the universe is 13.7 billion years.

2.7.7 New Natural Theology

Calculations of how various chemical elements may have been made namely those elements necessary for our life and other carbon-based life, show that various details (energy levels in atomic nuclei) had to be set with extreme precision, otherwise these elements (and we) would never have existed. A similar comment apples to other physical details, such as the peculiar properties of water, and the astonishing chemistry of carbon. These facts have suggested various versions of the "anthropic principle", according to which the extraordinary precision of these physical properties was somehow put there to enable life to exist. Of course, this is a "God of the gaps" theory. But it is hard indeed to see how these physical properties might have evolved. However, sceptics have postulated an infinite number of other (unobservable) universes, having different physical constants, and our universe as some sort of random selection.

2.8 NEW AGE RELATIVISM

The end of the 20th century has seen some disillusionment with a scientific world objectively described by science. Many people, though dependent on technology, blame science for many problems of the modern world, especially environmental problems. Many have rejected a scientific world picture, and replaced it by a "new age" relativism. There is no uniformity in these views; however common ingredients are: A world view that is subjective (true for me, maybe not true for you) instead of objective (one truth out there to be found); Mysticism and holistic "alternative science" (often with no great concern for evidence); aspects of Hindu religion (especially belief in reincarnation).

Some of the views held are as follows:

Monist - "All is One".

The world and God are regarded as the same.

Pantheist - "All is God".

Often there is belief in "Mother Nature", or "green theology". The "Gaia" theory, that the whole biota behaves, in some ways, as a feedback system, may be extended to almost deify the earth.

Autonomy of human beings.

Individuals are thought to have great potential to help themselves.

Relativism.

It is asserted that there is no absolute truth in science and religion. (This assertion becomes the only absolute truth!) Of course, these various views are in conflict. But "new age" is not a consistent system. There have been attempts (e.g. by Capra and Tipler) to synthesize science and faith into a holistic system drawing on eastern religions and a mistaken understanding of the new physics. Indeed, some post-modern writers have extensively quoted terms from mathematics and physics, but misunderstanding their meanings, so as to produce nonsense!

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