The Fires of Creation

A review of the relationship between science and religion

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Introduction

I have called this book *The Fires of Creation* because it is dedicated to a mythological character from Greek legend, Prometheus, who, for daring to steal fire from the Gods, was bound to a rock at the peak of a mountain, and eternally tormented by a Vulture tearing at his liver. There have been times over the years when I have felt a bit like this over this book, sometimes it seemed that I could never finish the thing!!

It deals with Man's long childhood, bound to the rocks of superstition and religion, and the story of his slow emancipation, and discovery of himself and his world. It deals with the origins of Religion and Science, and the increasing changes in man's thought, brought about by the scientific discoveries of the past ninety or so years, specifically, chaos, relativity and quantum theory. Please do not hurriedly put this book back on the shelf at these last dreadful words. I am not a mathematician, and you will find hardly any mathematical equations in this book.

Perhaps it is a vain hope, but I have tried to encapsulate relativity and quantum theory in words which a layman can to some extent comprehend. Their concepts and insights are far too important and exciting, to remain the province of the Professor and the University.

It is written for my children and their grandchildren and for all children (aged from seven to seventy) who are curious about themselves and the world they live in. Also, (because men are incurably vain), I would like them to understand their grandfather a little, for any book says as much about the writer as about its subject.

Finally, it is unfinished, indeed it can never be finished, for life itself is unfinished, and goes on, in them, and in their children, and the wisdom of this generation may well become the foolishness of the next. There are, as I hope to show, no final answers. This is as it should be. The old Persian poet Omar Khayam said:

Myself when young, did eagerly frequent Doctor and Saint,
And heard great argument about it and about;
but evermore came out by the same Door as in I went.

This is not, however, an argument for not bothering and just getting stoned, but an argument for not thinking that anybody, or anything has the final word to say on anything. In this world people who stick their necks out tend either to get crucified, or worshiped (or both). I am not sure which, is the greatest evil. I have no intention of deliberately courting either fate. But I do believe that to ask questions, and listen and think about the answers, is vitally important. And the more complete and definite the answer, the closer should your questioning be. You never know, it could be wrong!!

Chapter 1

The Source, primitive religion.

'The cloud of unknowing'

'O let your strong imagination turn
The great wheel backward, until Troy unburn
And then unburn, and seven Troys below
Rise out of death, and dwindle and outflow
Till all have passed'
—Sir John Squire—The Birds

Mans spiritual birthplace cannot be precisely defined, but for European man at least, it can be said to lie in the valleys of south west France, where the Vezere and Dordogne rivers flow out of the massif Central. They flow though gorges cut in the

limestone plateaus. The sides of the gorges are densely wooded with beech and oak, through which great limestone bluffs push out, undercut by the rivers, to form huge shelves of rock under which many generations of mankind have sheltered and lived. One great cliff, the Roque St Christophe, has no less than five such undercut ledges, some of which are big enough to hold a small town, and archaeological and historical records tell of occupation by men for well nigh 15,000 years, from Palaeolithic to medieval times.

The climate is almost ideal, warm in summer and mild in the winter, with abundant rain from the Atlantic depressions, but with long spells of fine warm weather to ripen the crops in summer. The valley bottoms are now intensely cultivated, yielding heavy crops of tobacco and maize, but it takes little imagination to see them covered with a dense scrub of alder, and willow. Game, deer and bird life, are abundant.

Early man lived in a 'hunter gatherer' society. The tribe lived on what it could hunt or gather in the woods, moving on when the game became exhausted. They lived in crude shelters of bent wood, or under overhanging rock ledges. It is a common mistake to think of early man as cave dwellers, in general a deep cave was a thing to be avoided, dark and dangerous, as it is for us today. They preferred the open rock shelter, or at the most a shallow cave open to the sky.

The valleys of the Dordogne and Vezere offered early man an ideal environment, plentiful game to hunt, a mild and equable climate, and rock shelters in abundance. However, because of the soft limestone rock, there are also many deep caves, and early man used them, not to live in, but for something quite different. He seems to have used them for some kind of worship, fertility rite, or initiation ceremony, and they are decorated with pictures, bulls, wild horses, antelope, mammoth, drawn with astonishing technical skill with a crude palette of natural minerals and earths bound with animal fat.

These caves all share some features in common. Firstly and fore mostly they were almost certainly not art galleries, they were religious centres of some kind. There is no evidence that men lived in them, or used them for the common purposes of life. The sections which are painted are not easily accessible; to get to them you have to penetrate deep into the cave, often via a choke or labyrinth. The approach to the painted or 'sacred' area is often marked by queer patterns and dots in red ochre paint. Often in the remote end of the painted section is a sink or pit, and here you often find not the magnificent pictures of bison or auroch which precede it, but a queer matchstick figure of a man, often wounded or lying in apparent death.

There is a rock painting from the great cathedral of prehistoric art, Lascaux, in the Dordogne region of France. Preserved in incredible detail, it shows, in one magnificent frieze after another, the animals hunted by primitive man, deer, horse, and auroch (the early forebears of our present domestic cattle), loom down from the walls of the cave in great swirling pictures.

They are impressive enough in age, after many thousands of years, though disfigured by time, and calcification, viewed by modern crowds in electric light. What they must have looked like to primitive man, after the passage of the labyrinth, in fear and wonder, by the light of a flickering oil lamp, can only be guessed. As a technical and artistic achievement, they put Michelangelo and the

Sistine Chapel to shame. The one thing you can say about the men who painted them 15000 years ago, by the light of flickering oil lamps, using a primitive palette of ochre and manganese, bound by oil, is that whatever these men were, they were not savages.

On the face of it, there is no mystery, the pictures clearly show the objects and desires of primitive man, the prey hunted and eaten by our forebears. For all savage tribes worship, and have a symbiotic relationship, with the wild beasts which are their food. But on further consideration, there are a number of quite unanswerable questions, why are they painted underground? in deep and inaccessible places?, what are these stripes and dots which stand to warn the casual incomer? and what is this queer animal on the extreme left, half leopard, and half antelope, that looks for all the world like two crouched men covered by a leopard skin, with two sticks pushed out ahead of them like antlers?. Why are human beings almost never shown, or if they are, why are they painted in deep inaccessible chasms, as almost unrecognizable stick like figures? We do not know, and shall never entirely know. It is too long ago; over five hundred generations have passed between them and us. We have become too sophisticated, we know too much, In Sir John Squires words, we cannot unburn Troy.

Yet they were men and women like us, physically and mentally they must have been practically identical, for in genetic terms seven hundred generations is negligible, there is no prima facia physical or biological reason why we cannot understand them. Their brains were the same size as ours, and they almost certainly spoke a primitive language, possibly a predecessor of Basque, which is thought to be a relic of an old language of early southern France.

But to even start to understand them, we must attempt somehow to turn the wheel of time backwards, to 'unburn Troy' if you like. Perhaps the easiest way for us to do this, is to try to go back to our own childhood, before we could read or write, when the world was full of strange things, when 'grown ups' were large, strange beings, with capricious and apparently arbitrary powers. Imagine if you will, a time before we had enough language to express our feelings fully, when life was full of inexplicable things, a minefield of obstacles and problems to be overcome and understood.

For the childhood of our race is best understood in our own childhood. If we wish to 'unburn Troy', we must enter the unknowing of childhood. Darwin, in his book *The descent of Man*, describes a dog barking at sunshade blowing in the wind. The dog knows nothing of wind. It sees only a strange object moving inexplicably, and barks to warn the pack of possible danger.

Primitive man likewise, knew nothing of cause and effect. To him the natural world must have been a mysterious thing, without explanation or reason. He was a child, at the mercy of strange forces he neither understood nor controlled. Like a child, his language was rudimentary, incapable of deep or, abstract expression. But like a child with little or no language, he could nevertheless, still express himself, in pictures, or actions. A child under these circumstances may use what we now call 'sympathetic magic'. This may involve drawing a woman in dark colours with a gloomy face, to reproach his mother for scolding him, or drawing a happy face to show his joy and pleasure in his father. He may mistreat a previously loved toy to show his frustration and anger with his parents. Because

he cannot express his feelings, he transfers them to a picture or other inanimate object, and works them out on these instead. True he is not a master artist, his pictures are clumsy and uncoordinated, but this is merely a matter of physical coordination, a few years of practice will soon rectify this.

For early man, language must have been rudimentary, probably limited to sounds for the basic necessities of life, and tribal living, For abstract words, apart from simple needs, like 'want' and 'go' and 'come', he could have little use. How then could he express his basic needs, the need for good hunting, and food for the tribe, except by pictures, and painting and dance? If the hunting is poor, and the wild cattle are not in evidence, if the tribe is starving, and the weather poor, paint a picture of his needs and desire, of wild cattle in abundance, preferably pregnant, or speared. But why in a cave, and what is more, in such inaccessible places, on the walls of a cavern, two hundred feet or so underground? One reason for using a cave or rock shelter is of course that here was a readily available 'canvas', sheltered from the elements. But there must also have also been the further reason that, in some way, a cave represented the deep and mysterious earth from which all things sprang, that the deeper you got, the more powerful your magic became. For this was essentially a private magic, not to be seen by all and sundry, a mystery, to bewitch out of mother earth, her goodness, and her bounty. Dance and music, on the other hand, must have been public magic, to be seen and shared by the whole tribe, we know less about these, apart from a few remains, like the stag skull pierced for use as a head dress from Seamer Carr in North Yorkshire, and what we know of primitive dance and music from aboriginal tribes today.

The basic question they must have asked is "Why?" Why is the world like it is? Why have the deer ceased to visit this neck of the woods? Why has the old man or woman "fallen asleep"? Why has the woman grown plump, and given birth to a man child? Why do the seasons change, and the sun rise and set? Why do the stars move in the heavens? Why, What, How?

It is difficult for us, in this scientific age, to appreciate the concepts and beliefs of ancient man. When we see a car drive down the road, we do not in our wildest dreams think of opening the bonnet and looking for a horse or donkey. When we see a plane, we do not think of it as a great bird in the sky. But tribes in Borneo, whose first contact with civilization is often when the Cessna skims over the treetops, and bounces to a halt on the landing strip, think in precisely these terms. It is not illogical, if your experience is of a world where most things that move are alive, then it is entirely logical to endow the world around you with living spirits. And thinking thus, to go on and think of the great spirit that inhabits and in some way drives the earth. It is probable that the first religions were of this type, the earth mother, the heavenly father, with all their tribal attendants of earth.

Another possibly later, phenomenon, as tribes came more in contact with each other as the population increased, was 'tokenism'. Just as children in the playground play at Cowboys and Indians, so primitive man identified himself with 'Bulls' and 'Lions'. A bull must have seemed a tremendously powerful thing to early man, and to catch and kill a wild Auroch in its prime a fearful undertaking. So when the tribe first came into contact with other raiding tribes, what better

than to claim that they themselves are the 'bull' people, especially if you have a bulls horns or skin available to dress up in. So powerful indeed was the 'bull' totem, that, traces exist today, in the bull rings of Spain, and in the general admiration for the bull felt by many western societies. A possible link between the bull and the cave, linking the cave paintings of primitive man and the bull ring of today may still exist in the ancient legend of the Minotaur and the labyrinth, the bull like monster, lurking in the depths of the cave, a legend deriving from ancient Crete thousands of years ago.

Later on in Neolithic times, came the cult of the dead. As families and tribes became more settled, and spoken and oral records became the norm, tribes began to identify, not with animal totems, but with legendary ancestors, and the Chief's family became endued with more than normal powers. The tribal burial place became important, and the afterlife loomed more importantly into men's lives. When life was nomadic, impermanent, and short, as in hunter gatherer societies, the old were of necessity left behind when they became too old to move with the tribe, but as a more settled pastoral life developed, the old became more important, treasuries of information and legend, and their burial places remembered, as places of pilgrimage and worship. Southern England, the Wessex of my childhood, is littered with old barrows, commemorating old tribal leaders of the past. If you go to Wayland's Smithy on the Wiltshire downs, now little more than a heap of stones in a ring of trees, set on the downs alongside the Ridgeway on a hot summer afternoon, or to Bela's Knap on the Cotswold scarp, a largely intact long barrow with a marvellously rebuilt dry stone false entrance in the gloaming of a late summer evening, when the shadows are falling, you will get a deep sense of the mysterious nature of these monuments, built in the childhood of our race, to celebrate men long since dust and ashes. Stonehenge and Avebury, Silbury and White horse hill, stand in mute evidence of old tribes and peoples vanished in the dust of time.

But while our ancestors were building their barrows and henges, three thousand miles away in the Nile valley, an older civilization was building even vaster tombs to the memory of their dead. For Egypt was of all the ancient civilizations, typical of a settled agricultural mode of life. To a large extent this is an accident of geography, for it may be said that the Nile is Egypt, and Egypt is the Nile. A thousand miles of fertile river valley, barely ten miles wide, with nothing but desert on either side for hundreds of miles. Consider the timeless, unchanging life of the Egyptian peasant, even today. There are no real seasons in Egypt, no real changes in the weather. The sun rises each morning over the eastern desert, and sets each evening over the western escarpment, its journey through the skies ruling the blazing dusty heat of the day. Through the cool of the night it travels 'under' the earth, through the kingdoms of the dead, to rise again next morning in the east. The only season they knew was the rise of the river, and the flooding of the fields, followed by the planting of the crops in the fertile mud left by the flood. To the east, the Eastern Desert, the land of the rising sun, to the west, the Western hills, rising in dry limestone scarps where the sun set, and they buried their dead. The river rose, the river fell, the crops were planted in the fertile mud, the sun god warmed and ripened the crops, and the grain was stored ready for the next flood. For the peasant it had been so in his father's time, and his father's

father's time, and so it would be for his son and his son's sons. It was a timeless, eternal, static society. The role of the Pharaoh, and the priesthood was essentially ritual, for he, and he only, could support the sky, ensure that the river rose on time, control the fate of his people. When he died, his body was embalmed, and laid in a sumptuous painted rock tomb, where he could continue in the afterlife to look after them. Just as the days and the seasons were governed by the sun God Amun, who rose over the eastern desert, and sank to rest in the Western hills, to pass under the world, in the land of the dead, ruled by the hawk headed God Osiris, so the life of man was a journey through life, to pass on death through the western hills, to the underworld and rise with the sun in the East to eternal life. The religion of the ancient Egyptians was dominated by this obsession with the afterlife. Their tombs are full of rules to pass the underworld, their nobles and their rulers were embalmed and buried in great sarcophagi, in rock cut tombs and pyramids, with servants and utensils to serve them in the afterlife. Even a minor Pharaoh, who died at the early age of manhood, Tut-ankh-amun, was buried in a triple sarcophagus, the two inner coffins of which were solid gold. We can only guess at the wealth of the burial of major Pharaohs such as Rameses the Great whose great pyramid tomb was plundered in ancient times.

We have now come out of prehistory, into the realms of history, where written record begins. And here, what we call religion, becomes explicit. For as soon as you are worried about more than food and survival, you start asking questions - Why is the world like it is? What can I do to ensure that the river rises and my crops succeed? What happens when I die? Where does the sun go when it sets? For primitive religion was really a form of science, it is an attempt to understand and control the world around us. Often this was a desire to understand death. The afterlife was clearly an important affair to the ancient Egyptians, and they devised elaborate and complicated mythologies to explain and understand it. From the point of view of early man, death was a mystery that had to be explained, especially in a settled hierarchical society like Ancient Egypt. It is noticeable that nomadic tribes and hunter gatherer societies never felt this need, for them the old were merely an encumbrance that was left behind on the road when they could no longer travel with the tribe. It is for this reason that the Semitic concept of the afterlife is extremely nebulous, when compared with the precise delineation of the Egyptian. If the rules of the Jew and Babylonian concern life here and now, and the rules to live it, the Egyptian concept of religion concerns the afterlife and rules as how to attain it. Their theology may seem to us to be absurdly simplistic, but again we have to strip off our knowledge of the world, and try to understand the minds of people to whom it was clearly and manifestly obvious that the world was flat, and bounded by desert on one side, and desert on the other. To have suggested otherwise to an ancient Egyptian would have been an invitation to ridicule if not a charge of blasphemy. If you believe, on the clear evidence of your eyes, that the world is flat, the question of where the sun went in the night time is obviously relevant, and to say that it journeyed through the halls of Osiris, the ruler of the underworld is reasonable and sensible answer.

For the religion of a people is a reflection of their needs and their preoccupations. For early man living in a hunter gatherer society, this was primarily the hunt and the food and sustenance he got from it. For more settled,

agricultural societies, this was the seasons and their control, and the seers and patriarchs that understood and controlled them. Our religion is an expression of our society.

Chapter 2

Greek, Jew, and Roman.

Praise to the Living God
All praised be his name
Who was, and is, and is to be,
For Aye the same!

The one eternal God
Ere aught that now appears
The First, the Last, beyond all thought
His Timeless years.
—Medieval Jewish Doxology

But at the time civilization in ancient Egypt was developing fully, an altogether different mode of thought was developing, having its ultimate roots, not in the static agricultural civilization of the Nile valley, but in the nomadic trading civilizations of the Fertile Crescent of the Middle East. The Jews, originally a small offshoot of the ancient civilization of Ur and the Euphrates valley, were beginning to colonize Palestine. Always precarious, their very existence threatened by the monolithic states to their south, north, and West, they developed to a high degree, the concept of monotheism, one God, originally their own personal God, (and later the only God). Who created heaven and earth, and they his people.

They were not a philosophical people. The desert was too near, and the world too threatening for the leisured pursuit of philosophy. In a hostile world full of alien Gods, their particular forte was monotheism—One God, J.H.V.A, whose name was too sacred to be spoken or written, and how this God wanted them to behave.

Their Law, their customs, and their stories, are enshrined in the Old Testament, one of the oldest and most read books of the World. They became, above all things, the 'people of the Book'. In Prophecy, and Law they still stand supreme. God they said 'Created the heavens and the earth'. Before he created it the earth was without form and void, and darkness was upon the face of the deep; and the Spirit of God was moving over the face of the waters. And God said "Let there be light"'. They saw the world as God's creation. Beneath the clear desert skies they saw the stars in the heavens circling above them. They saw the waters raining from the heavens, and the rivers going down to the sea. They, above all people of their time, believed in one God who had made all of this. They would have nothing to do with lesser Gods, of spring and stream, mountain and dale. There was one God, and

one God only, who had made this earth and all that was in it. In the Polytheistic world of their time it was a revolutionary concept, for most other people believed in a multitude of Gods, greater and lesser. True there might be a high God, above these latter Gods, but he was not alone, more a first amongst equals.

The Jews would have none of this, there was just one God, the Lord, the God of Israel, and all other Gods were false. It was a remarkably stiff necked attitude for its time, and although it earned them a grudging respect, it also got them into a lot of trouble, for no one likes being told that their own particular God is false, especially by a small and obstinate tribe, far smaller than your own.

Their idea of the world that this God had created was basically that common to the Middle eastern tribes around them. The earth was flat, and above it the sky held up by the pillars of the mountains. Above the sky the waters of the sky, descending in the rain, and above this the starlit heavens, the abode of God, around the earth, the waters of the seas, and below the earth the abode of the dead, Sheol.

In numerical terms, however, the Jews were never very strong. Throughout their history, they have remained a separate, dedicated, and exclusive society, always under threat from larger nations around them. In part this was due to their ancient insistence on circumcision and other rituals to mark their separateness.

But in the West, another civilization was rapidly developing, the Greeks. Alongside the Semitic, Babylonian tradition of the Middle East, the western, trading, technical, maritime states of Greece were developing. The Egyptian culture was static and agricultural, the Hebrew, nomadic, of the desert, but the Greek was of the town and trade. They formed colonies and city states all over the Mediterranean, and sailed their ships to all the known world at the time, and because of their sea going expertise, and because their land which was often shaken by earthquake and tremor, they became acutely aware of the weather and the seas, and of the earth and the mountains.

About 1100 BC Greece, originally Mycenaean, was invaded by vigorous fair skinned tribes from the North. Their Gods were the original nature spirits of the mountains and woods of middle and Eastern Europe. Poseidon 'The Earth Shaker'. Zeus, of the mountain and the storm, Apollo the god of music and prophecy, Athene the goddess of wisdom. With these came a host of minor gods and goddesses. Their attitude to their Gods, even as early as 800 BC, when the Homeric poems were written, appears to have been rather casual. Although their Gods were immortal, and had superhuman powers, they appear to have been, by and large quite amoral, there is little sense of mystery or awe in Homer's attitude to them. Certainly no theology or science can be built on their antics, nor was any significant attempt made to do so by ancient Greek philosophy. The most that can be said about them is that they were convenient pegs on which to hang some of the more salient aspects of the world. In the end, by Roman times, the Classical Gods of Greece, had faded to become mere embodiments, or genii of place or person.

As against this, there seems to have developed also, in Greek religion, a strong strand of Orphic mystery religion, which remained strong and vital even into early Christian times. Bertrand Russell quotes a moving hymn from Euripides, by an Orphic Priest

Lord of Europa's Tyrian line
Zeus born, who holdest at thy feet
The hundred citadels of Crete
I seek to thee from that dim shrine
Roofed by the Quick and Carven beam
By Chalyb steel and wild bull's blood
In flawless joints of Cypress wood
Made steadfast, there is one pure stream

My days have run, thy servant I
Initiate of Idean Jove
Where midnight Zagreus roves, I rove
I have endured his thunder cry
Fulfilled his red and bleeding feasts
Held the great mother's mountain flame

I am set free and named by name
A Bacchus of the mailed priests
Robed in pure white I have borne me clean
From man's vile birth and coffined clay
And exiled from my lips always
Touch of all meat where life has been

The mention of the citadels of Crete, and the great mother not to mention the wild bull's blood, strongly suggests that this strain of Greek religion survives from Cretan and Mycenaean times, rather than the nature/spirit worship of the Achaean conquerors from the north. I mention this dual strand of Greek religion, because it is important when we come to consider their philosophy, mathematics, and science to remember that there is also a strongly mystical element in Greek religion, which lasted well down to early Christian times.

But, as I have said, above all, the Greeks developed into a trading, mercantile nation. Their city states and merchant fleets traded all over the Mediterranean. And if it be objected that the Mediterranean sea is only a small pond in a world of much vaster oceans, we should remember that in ancient times it was literally what its name implies, the centre of the known world - "Media Terra".

And because they asked questions about this world rather than the next, their philosophy and mathematics became the foundation of much of our modern scientific way of thinking.

Indeed, the first suggestion that the world was round and not flat was made by Pythagoras, admittedly for philosophical reasons, and some other Greek philosophers even suggested that the earth went round the sun, or central fire. Aristarchus around 310 BC is even thought to have advanced a reasonably complete Copernican hypothesis, and quite realistic estimates were made of the size of the earth and the moon, and the distance of the sun based on quite practical observations. Such ideas could never have occurred to a static agricultural civilization such as developed in Ancient Egypt.

Because the Greeks were essentially a building, trading, mercantile people, living in (albeit small) city states, they needed above all to count, to reckon, to measure, for unless you can do these things you cannot build, trade or barter. Fundamental to building large well proportioned buildings - The Acropolis in Athens is a classic example—is the ability to mark out and measure. The Egyptians had a simple 'set square', they knew that a triangle with sides in the ratio 3:4:5 had a right angle opposite the longest side. But the Greeks were the first to generalize this into what we know as Pythagoras's theorem. Their number system could cope with whole numbers and fractions but not decimals, and significantly they had no number zero, or negative numbers. Indeed they argued that there could be no such thing as zero, for by the very meaning of the word, 'nothing' could not exist. For the same reason, most of their philosophers denied the possibility of a vacuum, for by definition what was completely empty, could have no physical existence. But they were great geometers, the very word geometry comes from the Greek—measure of the earth. Just how great they were can be understood when you realize that the Greek geometer, Euclid's, postulates of geometry are taught in schools today, in virtually their original form. Yet it was written around 300 BC—a textbook 2300 years old, yet still sound, and still used!!

Pythagoras (circa 530 BC) was the first well known Greek philosopher. Apart from the theorem that bears his name, he is also immortalized in Pythagoras's constant Pi, the ratio of the circumference of a circle to its radius. 3.14... Now Pi is an "irrational" number, i.e. there is no way of representing it exactly, The Greeks recognized the existence of such numbers, their development of Pythagoras's theorem implicitly shows this. But Pi was a special problem to them. Some irrational numbers could be represented as fractions, i.e. 1.333333... was 4/3. But Pi could not be represented in this way, they knew that 22/7 was a good approximation, but they also knew that it was not quite right. This problem, the "squaring of the circle" was never really solved by them, or for many subsequent generations. We know now that it has no finite answer, it is a non repeating irrational decimal number, but the Greeks had no decimal notation, or calculus, and the answer was quite beyond them. Before you dismiss such ideas as mere philosophical meandering, ask yourselves how you would calculate accurately the volume of oil a cylindrical drum of given height and diameter, an essentially practical mercantile problem if there ever was one.

But before this, the Greeks had been asking questions about the nature of the World. The most important of their philosophers (philosophy means lover of wisdom) are generally thought to have been Plato (born 427 428 BC), and Aristotle (born circa 384 BC) whose influence over the way we think is still extant today, 2500 years later.

Plato and Aristotle represent the first signs of the formal split between religion and science, which was to develop further into the complete break of our own times. Plato argued that basically, when it came to perception, and ideas, there were two ways of looking at things, knowledge and opinion. Knowledge he said is certain, opinion, however is uncertain after all you may be wrong or misinformed. He argued that the physical world of the senses, was one of opinion, you could always be wrong in what you see or perceive. The aim of the philosopher or seeker after truth was knowledge or perfection, and this he said could never come from

looking at the physical world. It could only come from understanding the ideal things that underlay the visible, ephemeral, sensible world of the senses. On the one hand there was matter, which he saw as formless and inchoate, and on the other form or idea, which gave shape and expression to matter. The philosopher had to apprehend the underlying ideas or concepts of things, rather than the particular instance which lay before his eyes. He argued that when we say for example 'this is a cat', we mean something more than this particular cat, we have in mind a general concept of 'cattiness'. This concept, he said is eternal, it does not disappear when the particular cat dies. He argued that it was thus possible to have knowledge of the world by 'universals' -ideas and geometry, quite independently of vision and sensory perception. The philosopher should seek knowledge of these universal concepts, rather than concern himself with study of the ephemeral things of this world.

Plato seems to have thought that the underlying final perfection or hypostasis (hypostasis is Greek for "standing under"), was God, the prime mover, Thus, hypotheses acting on inchoate matter produced the manifold phenomena of the material world, water, air, hills, animals, people. It is important to notice that he did not believe that God created matter, only that he gave it form. In this, Plato's ideas differ from the Judaic idea of God, in which God created the world from nothing.

Plato is much more than a philosopher, he wrote books on politics, and ethics, as well as philosophy. But he thought that the best ruler would be a philosopher, or a group of philosophers, and his "Republic" is ruled by such a body of men.

His ideas were immensely influential. The government, and public school system of eighteenth and early nineteenth century England was strongly platonic. You have only to compare the Arnold's ideal public school system with Plato's ideal Republic, to see how strongly the century was influenced by him. In the same period, John Keble's well known hymn

"*Two worlds are ours, Tis only sin*
Forbids us to descry
The mystic heaven and earth within
Plain as the sea and sky"

is pure undiluted Platonism. As we shall see later, his ideas were also immensely important in the development of early Christianity.

The two things we must remember about Plato are firstly, that he tends to ignore observation, as a means of gaining knowledge, this was to him a mere 'mechanic' art, unworthy of the true philosopher, and that secondly in social terms, he was avowedly elitist and undemocratic. His proposed republic was to be ruled by an oligarchy of 'gentlemen philosophers', and he saw nothing wrong with the hereditary principle, holding that the ruling class were fit to govern, simply because, they, and only they had the leisure and time to properly educate their children.

Aristotle is much more interested in things. There is a celebrated picture (Raphael The School of Athens) which contrasts Plato and Aristotle's mode of thought.

Plato is centre left surrounded by artists and mathematicians pointing up to the heavens, Aristotle is centre right surrounded by engineers and artisans pointing a restraining hand downwards to the earth.

Aristotle argues that there are three kinds of substances. Firstly those that are sensible (i.e. those that can be perceived and felt) and perishable, (i.e. of limited duration like plants and animals.). Secondly those that are sensible and not perishable, i.e. the stars and the planets. And thirdly those that are neither sensible not perishable i.e. the soul in man and God.

God is the first cause, the unmoved mover. This concept arises from the observation that things either moved because they were pushed, or moved because they were alive. Inanimate things were moved, but could not of themselves move, Animate things moved of themselves, but could also be moved, God could not be moved, since that would imply a greater being than him, he was the 'final cause' of movement. Be careful here, the latter term, 'cause', does not mean what we would mean by cause, for Aristotle argued that there were four kinds of 'causes'. Material, formal, efficient, and final. He claims that form, or essence, exists independently of the matter of which it is comprised. When a man makes a statue he takes a previously conceived idea (form or essence), and works it onto the marble to create the statue. The material 'cause' is the marble, the formal 'cause' is the shape to be produced, the efficient 'cause' is the action of the chisel, and the final 'cause' is the statue itself. In Aristotle, God, the unmoved mover is the 'final' cause, the thing itself. He cannot be the material, formal, or efficient cause, for that would imply some greater power than himself.

When we ask questions about the world we can ask them in two ways 'how', and 'why'. When we say "Why does copper conduct electricity?" we really mean “How does copper conduct electricity”. Alternatively we can ask "Why does the dog chase the cat?", this last is a question of a quite different kind, concerned with purpose or end, and it is 'teleological' (from the Greek 'tele' or issue. Modern science is generally concerned with the first sort of question, i.e. the 'how' of things.

But the Ancient world, rarely made such a clear distinction. "Why?" is usually teleological, what it's all in aid of , rather than the original cause. In part this is because to them, there was a radical difference between the inanimate and the animate. A thing was either inanimate, i.e. having no life of it's own, acted upon only by external forces, or it was animate, having purpose and aim, and the latter seemed far more important to them.

Aristotle's science, in common with most of his compatriots, was very much preoccupied by living, animate things. Mechanics, the science of the inanimate was a very inferior art unworthy of the study of a gentleman. Physics, or 'Physis' as the Greek word had it, was to do with why nature behaved like it did in the teleological sense, rather than the 'how' the mere mechanical investigation of its working.

Matter said Aristotle is composed of 'Fire', 'Air', 'Water', and 'Earth'. These are not to be construed as elements in our modern sense of the word. They are not indestructible, but interchange, being understood more as 'qualities' than elements. This concept, which was quite reasonable given the state of knowledge at his time, developed in the Middle ages, to the pseudo science of the Alchemist,

where all sort of nostrums and magic were employed in the attempt to transmute base metals into gold.

Aristotle's cosmogony, is simple. The Earth is spherical, and is the centre of the universe. Around it move the moon and the planets, and the sun and stars, in perfect circles. Anything below the orbit of the moon (i.e. sublunary), is corruptible, and changing, being composed of the four elements and their combinations, fire, air, water, and earth. The moon and everything beyond it are incorruptible, and unchanging, being composed of a fifth element or quintessence.

Virtually all of this is now known to be untrue. It may seem rather surprising that it held and gained credence as much as it did for nearly 1500 years. However it must always be remembered that experimental science or observation, was regarded by the Greeks as beneath the dignity of a true philosopher, in general they believed that anything worth knowing could be obtained by deduction alone from general principles.

Throughout both ancient and medieval times, the underlying Pythagorean principle that perfection was to be found in eternal, perfect mathematical forms, of which the circle was the supreme example, was often both implicitly, and explicitly held. (If this seems odd remember that even today modern particle physicists classify and understand subatomic particles in terms of symmetry, a purely mathematical and geometric construct).

Given the knowledge of his times, Aristotle is really quite advanced. After all, most people of his time, if they thought at all, would have said that the world was flat, even 1500 years later, Columbus's seamen feared they would fall off the edge of the world. It is not illogical to postulate a world surrounded by some kind of crystal spheres, in which the sun and the planets and the fixed stars rotated. If he had suggested instead, a Copernican system, (or even worse, our finite but bounded time space continuum!!), he would have not gained much credence, nor would he have had the mathematical knowledge or the observational data to support it. The trouble with Aristotle, was not that he was wrong for his time, but that he was too successful in codifying and setting down the knowledge of his time, and in doing so set it in 'tablets of stone', to the detriment of successive generations, as observational science improved.

For the free thought and inspiration of Greek philosophy and science, had all too short a life. The City states of Athens, Corinth, and Sparta, dissipated their energies in internecine squabbles, and the advent of the Macedonian empire of Alexander swept them into irrelevance. It is salutary to learn that Aristotle was in fact Alexander's tutor in his youth, and presumably taught him Plato's principles of the ideal republic, ruled by the philosopher king. What Alexander thought of the old pedagogue can only be surmised. Then came the Roman and his legions. As a military organization, the Roman Army was unique in the known world at that time. For the first time an army existed that had discipline and structure, one that could stay in the field indefinitely, instead of having to break off to get the harvest in. Roman discipline and arms were triumphant throughout the western world, and much of the Middle East.

But the Roman was practical and organizational, In cultural and religious terms he was a thug, he had no real religion of his own, and merely took over the fading Greek Pantheon, added his own tribal idols Romulus and Remus, and later mixed

it with the Egyptian Gods and a mishmash of Middle East and Persian Gods and Goddesses. Finally, in an attempt to impose some sort of order he added the cult of the Emperor and his family.

In the later Empire, literally anything went, as long as you formally acknowledged the Emperor's deity (or genius, Latin for spirit). This is not to say there was no real religious feeling. Patriotism, and a feeling for their household Gods, their 'Lares and Penates' was real and strong in the older patrician Roman. Soothsaying and prophecy at the shrine of Apollo, or on the altars of the many temples was widely believed. The primitive Orphic mystery religions of the Earth Mother Demeter, of Bacchus, and Pan, still held many in thrall. From Persia, Zoroastrian and Mithraic beliefs were prevalent, especially in the army. But in religious terms the early Roman empire was a huge melting pot, in which all the religions of the Western world, and many of the East were stirred together and boiled up to form one vast and rather indigestible stew.

A man could believe, in anything (as long as he paid his respects to the Genius or Spirit of the Emperor), and that means essentially believing and explaining nothing, for when there were so many different religions, and so many different explanations, they all in the end cancelled each other out. In these terms the parallel between the late Empire and our modern times is quite strong, both are times of relative material prosperity, but weak spiritually, few people believed anything very much, but most believed vaguely in something.

Only Judaism, stuck out against the tide. By this time the Jews had become widely dispersed in the Empire. There were large colonies in most of the cities of the Middle east, especially in Alexandria. Of all the religions of the time, the Jewish faith with its distinctive monotheism, and rejection of all other faiths stuck out like a sore thumb. The Romans regarded the Jews with increasing irritation and annoyance. Judea was increasingly ruled with a harsh hand after the initial attempt to Hellenize it under Herod, and finally under Vespasian, Jerusalem and the zealots were finally and irrevocably crushed by the legions, and the 2000 year Diaspora of the Jews had begun.

Into this mishmash, came the first stirrings of what was to become the dominant religion of the West—Christianity. For over a hundred and fifty years after the birth of Christ in the time of the Emperor Augustus, Christianity remained an obscure and somewhat troublesome minority sect, obscure because few people had heard of it, and troublesome because it's adherents, like their progenitors, the Jews, refused to acknowledge the supremacy and divinity of the Emperor. But in the late Empire it offered a combination of things that few other religions of that time could supply. A real and historical figurehead, Paul’s great letters and the early gospels, a relatively simple theology, and a simple and coherent explanation of the nature of life and death in terms everyone was familiar with.

There is an old story of the King who chose to be converted because only the Christian point of view could explain where he had come from and where he was going. Here, at last, was a sensible, and reasonable (for its time) explanation of the world. Mithraism, with its appeal to the military class of the Roman Empire gave it a run for its money, but as the Roman Empire collapsed, Christianity in effect took over, to survive the dark ages, and become the primary religion of the West. To

modern man, the theology of the Nicene creed, which has been the basis of the faith for nearly two thousand years, may seem absurdly anthropomorphic. But to the men of those times, knowing little or no science, and assailed by many and diverse religions and philosophies, it's simplicity and strength was outstanding, and in the collapsing civilization of the time, as the Vandal battered down the gates of Rome, it took over the mantle of the Roman empire, as the only hope of civilization in the darkness of the collapse.

We have now come to the end of the second chapter of this book. I have attempted to sketch, in very broad brush strokes, the origins of Western religion and science, from prehistorical times to the decline and fall of the Roman Empire. We have seen how primitive man's desire to understand and control his world, has led to the first stirrings of primitive religion and science. How he has progressed from primitive nature worship, and ancestor worship, to more refined forms of religion, and the first glimmerings of science and mathematics. How the foundations of rational, reasoned thought were laid down by Greek philosophers and geometers over 2000 years ago, and still form the basic elements of our geometry, and to a lesser extent our science and mathematics. How man's desire for comfort in a strange and often hostile world led him to seek inspiration in mystery religions, and mystic communion with others of the same mind. All these strands of thought were inextricably mixed up in the turmoil of the collapsing Roman Empire, and lead finally to the triumph of the early Christian Church.

Chapter 3

Theology, the queen of all the sciences.

'Haec est domum Die et porta Coelia'
(Here is the house of God and the gate of heaven)

To an open House in the evening
Home shall men come
To an older place than Eden
And a taller town than Rome.
To the end of the way of the wandering star
To the things that cannot be and are
To the place where God was homeless
And all men are at home.
—The house of Christmas by G.K Chesterton

At the start of this book I described the vast overhanging limestone bluffs of the Dordogne valley, below which primitive man sheltered from the elements. To most of us in the West, whether we are Christians or not, and in spite of our now largely secular society, Christian beliefs and customs still dominate us like those huge

overhanging limestone bluffs dominated early man. We have only recently crawled out from underneath their shelter, and some of us have still not got far enough away from it to see it as a whole. It overhangs our lives, from early childhood, and we have great difficulty in viewing it impartially. We tend to be either sympathetic or (conversely) violently anti like Richard Dawkins!!

The purpose of this chapter is to describe how Christian belief came to be like it was, how it was formed in the chaos and destruction of the declining Roman empire, and how it was shaped by the culture of the time, until finally it attained it's apogee in the teachings of Thomas Aquinas, the 'divine doctor' of the high middle ages.

Christianity started with one man, Jesus of Nazareth, an itinerant preacher in Judea. Some have suggested that he never really existed, but this seems to be pushing scepticism to extremes. True the Gospels, and the letters of the Early Church, incorporate much that is miraculous and incredible to modern thought, but when you strip out all that is superstition, and obvious interpolation, you are left with a core that is almost certainly historical and which cannot be merely dismissed as myth.

Modern Biblical Criticism, whilst not being able to identify the basic corpus of historical evidence exactly, does in general agree that Mark is probably the earliest of the synoptic Gospels, written around fifty years after the crucifixion and that Matthew and Luke were probably written rather later. They were almost certainly not written by the Apostles themselves (it was usual in those days to claim some eminent author for quite miscellaneous writings), but almost certainly incorporate memories and traditions of what these Apostles had seen and said. That said, there are significant differences between them, Mark, the earliest, covers only the last three years of his ministry, and ends abruptly at the empty tomb with only a small later emendation, Luke adds on a narrative of his birth, and more post resurrection stories, whilst Matthew adds a specifically Jewish element in the form of a detailed genealogy (from Abraham himself!), and frequent references along the line of “and this took place to fulfil what the Lord had spoken by the prophet” to tie in the New testament narrative with the Old testament. The Gospel according to St John is generally thought to be written later again, although some dispute this, and whilst very important in the development of Christian Doctrine, differs greatly in style and approach to that of the synoptic Gospels.

Much of Acts and most of the letters of Paul are almost certainly genuine, Paul’s letters are the earliest, probably written about twenty years after the crucifixion, and Acts a little later about twenty to thirty years after the Crucifixion… There is a suggestion, but it is not certain, that the synoptic Gospels draw on an earlier vanished source 'Q', which contains elements common to all three.

Another thing that can be said of the earliest teaching of the Church, is that it was not much concerned with doctrine (that came later), it was basically messianic (He who is to come), and eschatological (The coming of the End of the World). The primary claim of Acts is that "Jesus is Lord", ie the Messiah, the one who is to come or the anointed one, and of the imminent Parousia—the approach of the 'Kingdom' or rule of God at the end of the world. Peter in Acts 2 quotes directly from the Messianic verses of Joel "In the Last days, I will pour out my spirit upon all flesh… And I will show wonders in the heavens above, and signs on

the earth beneath... And it shall be that whoever calls upon the name of the Lord shall be saved".

There is little or nothing in Acts and the synoptic Gospels of the more complicated Trinitarian doctrines of the later Church, no teaching of Christ as pre existing history and time (that is only found in John), no Athanasian or Nicene Creeds. Even the nature of Christ himself is confused and contradictory, in one breath spoken as a miraculous birth via the Holy Spirit, and in the other simply as a descent from King David via Joseph. The birth stories are hopelessly self contradictory, and the core material deals only with the last two or three years of Jesus' ministry.

In spite of all these caveats, this core material, dealing with Jesus' ministry and death by crucifixion, is almost certainly historical, based on eyewitness accounts, and not to be lightly discarded however incredible the resurrection story is to modern man. The Messianic element, looking for a leader who is to come, was common to much Jewish thought of the time. Ever since the prophecies of Deutero-Isaiah, and the exile to Babylon, the Jews had looked for a Messiah, to lead his people out of exile, and restore the glory of his people Israel. The Zealots remembered the short lived Maccabean dynasty, and looked for another such to throw off the Roman yoke. There is little doubt that Jesus himself shared this viewpoint, and increasingly, both he and his disciples became engrossed in it.

It must also be said that the resurrection element is central to early Christianity, incredible though it may be to this modern age. In its defence it must be said that it was a credulous age, and there was nothing very unusual in such a claim. Many of the Orphic mystery religions of the middle east of the time had a similar, if not identical theme. The tradition of Orpheus descending to the underworld to redeem Persephone, has its roots deep in the nature worship of mankind, as any perusal of Fraser's *The Golden Bough* will demonstrate.

Just how it arose in the case of Christianity is a matter of debate. That Jesus was crucified, can hardly be the point at issue, the question is what happened afterwards. The Gospels are specific, the tomb was found to be empty, and Jesus (or someone the disciples thought to be Jesus) appeared to his disciples on several occasions after wards. That the crucifixion, by some accounts, occurred on the Friday, just before the Jewish Sabbath, and that the soldiers and the crowd were in a hurry and anxious to be done and away, may be of relevance, but nothing certain can be said of the matter on historical evidence alone. It must be said however that most modern opinion is that the subsequent Ascension stories are almost certainly latter additions. It seems to me that there is little doubt that the historical record is probably correct, and that the tomb was found to be empty. The interpretation of this is a matter of personal inclination, although few scientifically minded people would accept a literal 'resurrection' from the dead.

Sir James George Frazer in *The Golden Bough*, first pointed out how prevalent the ideas of divine kingly sacrifice and resurrection were in primitive religion. It is probable that the combination of this with the Jewish messianic vision was a very potent mix, especially in the disturbance and ferment accompanying the decline and fall of the Roman Empire.

The point is that Christianity, in those days, had a great deal going for it. The idea of rebirth, and resurrection, was common in all the Orphic mystery religions

of the time, and indeed goes back to the earliest of Man's historical religions. Couple this with the strength and simplicity of Jewish monotheism and the promise of personal salvation by the Messiah, and a better life hereafter when the Kingdom of God had justified all believers, and you have an almost unbeatable combination.

You cannot understand the strength of the early Church unless you understand the people to whom it spoke. They were a people to whom the idea of a God (or God's) controlling and directing their fate, on sea and land, was familiar, even though they might be gods of terror, rather than love. They were used to offering sacrifice to appease these Gods. They celebrated their death each autumn, and their rebirth, each spring. Their pagan festivals were the winter solstice, and the fertility festival of the spring. They believed implicitly in magic, the raising of spirits to control their world by incantation and spell. How else could they interpret and understand the world in which they lived. Roman altars scattered all over the empire attest to this belief. One of the most common inscriptions was 'To the Genius (or Spirit) of this place'. To their way of thinking all natural phenomena resulted from the action of gods, if the spring dried up it was because the spirit of the spring was displeased, and sacrifice or appeasement of this spirit was required, if the river rose and flooded the land, the spirit of the river was responsible, and appeasement was required here also.

But by the time of the late Empire, there were just too many Spirits and Gods. The Roman world, by fusing all the ancient religions into a mishmash of Gods and Goddesses had debased the coinage, until even the most simple could see that there was no reality behind the claims. When an obviously mortal and frequently all too human emperor could claim divine rights even during his lifetime, there was little to recommend divinity. Into this chaos, the monotheistic teachings of Christianity and Judaism brought order and sanity.

A developing factor must have been the nature of the society that developed out of the takeover of the late Roman Empire by the barbarians. The claim of the Romans that they ruled under the authority of the Senate and People of Rome (S.P.Q.R), had long since been eroded by the Emperors, and the late Roman Empire was essentially monarchical and dictatorial. When the Barbarians overran the Empire during the fifth century, society became essentially feudal in nature, owing allegiance to the local warlord, and he in his turn to the local King. In this turbulent, warlike society, democracy as we know it could survive only in the local sense of the village moot, neither the mechanism nor the will existed for democracy in the wider sense. All men, save the outlaw, knew their place, the serf under his chief, the chief under the local lord, the lord under the King. Justice was arbitrary, and summary, dependent on gaining the ear and the help of your local suzerain, and often unfair and discriminatory.

Into this rude, arbitrary, and often brutal, society the teachings of the Early Church came as a breath of summer in the wild winter of life. A Vision of One God and above all one Lord who gave his life for his people. The Atonement, the teaching that God's son gave his life to atone for the sins of his people, before a demanding God, may strike little spark in modern man, but to a people living in a hard, feudal society, it made much sense. You can sense this devotion in one of the greatest crucifixes of the middle ages, Gero’s crucifix in Cologne Cathedral.

After all, they had little cause to trust or rely on the dispassionate goodwill of their Kings and Chiefs, like them God was also remote, all powerful, arbitrary in his works in providence and the world; they had little reason to expect him to listen to them. But that God's Son should become human, and live their life, and intercede for them was both believable and understandable. They were not troubled by doubts about the Virgin birth, or the resurrection. In a world so inexplicable, where even the simplest things were ascribed to spirits, why should they quibble about such things? It all made sense to them, and more than sense, it made common cause with their desires and their needs.

When such a faith was backed up by a real historical origin, and by preachers who risked fire and torture in a prejudiced and turbulent society it became unstoppable. When people looked back to the golden age of the Empire and the current turbulence of their times, and heard preachers talking of a new and eternal empire of God and his Son, it was small wonder that the Word swept it's way through the Mediterranean and beyond. The early church has been rightly described as the ghost of the Old Roman Empire rising in triumph over its ashes.

The first teaching of the Apostles was little more than Christ the Messiah, the Son of God, crucified and risen again. Doctrine was minimal, and subordinated to the primary message of Gods rule. Paul says simply 'We preach Christ, and him Crucified', and in this context 'Christ' is not merely another name for Jesus of Nazareth, but a specific claim for the Messiah, God himself, come to Earth. In such troubled and dangerous times, an eschatological religion such as this, foretelling the final end of things was a natural and normal outcome. There is much evidence that Jesus himself looked forward to this imminent parousia, and Paul certainly saw the end of things as coming in his time.

But as time went on, and the early expectation of the Last Judgment receded, and different interpretations of Christ's nature developed, doctrine became necessary to define the canon of the Church's teaching. The strands of thought rapidly developed into two directions, one arguing that Christ was really divine and only covered up as it were his divinity by humanity. The second argued that Christ was really human, but became divine as it were by adoption. The first line of thought fitted well with the Messianic outlook so predominant at the time, and increasingly, under the influence of Middle East mystery cults, began to assert itself in Gnosticism and Docetism, the former claiming that Christ was wholly divine, and the latter which claimed that Christ was divine, and adopted as a guise as it were, the human character. The last of the Gospels, the Gospel according to St John, was strongly influenced by this line of thought, and took, from prophetic writings, the idea of Christ having pre existed his earthly life, in the form of the 'Logos' or 'Word', only in the fullness of time being made flesh in Jesus. The second line of thought, which is to our ears, more commonsense developed into Pelagianism, and was at first popular especially in the West, but ultimately came to be regarded as heretical.

By the time of Constantine, who officially adopted the Faith as the official religion of the later Empire, Christianity had long since left it's early, simple origins, and begun to take on board the philosophical background of the time. More and more, the able administrators of the time became the servants of the Church, rather than the Empire. But in order to attract able, intelligent men, you

require not only inspiration, but an intelligent, philosophical framework of belief. Fortunately such a framework was available in an offshoot of Platonism. This was Neo-Platonism, taught by Plotinus in Alexandria around 300 AD. Plotinus argued that since God was perfect and embraced the nature of all things, he could not be 'self aware', and to solve this problem introduced 'nous' and 'soul' into the Platonic scheme of things. Nous, is the light by which God sees and is seen, i.e. his self awareness. Soul is the individual spirit within man which sees and is seen by God. This philosophy had great influence on the earliest of the Christian Fathers Origen, Plotinus's contemporary, who seems to have thought of Christ as Nous, or Logos, the light by which God sees and is seen, and the Holy Spirit as Soul, the animating spirit of Christianity.

Another factor which had great, indeed overriding influence on the early Christian Fathers was the need to reconcile the Old Testament with the New, and with the Church's developing teaching about the nature of Christ. The early Fathers of the Church went to ludicrous efforts (to our eyes) to do this. The old prophetic scriptures were scanned, and scanned again, to find texts which would justify the developing doctrinal views of Christ. A notorious, and widely recognized, error arose from the use of the Septuagint's translation of Isaiah "Behold a Virgin shall conceive" to justify the Virgin Birth, because it was felt that God could not possibly be involved in the messy and unrespectable business of human reproduction and birth. But in fact, it was recognized even from St Jerome's times that this was a mistranslation of the original Hebrew text "Behold a young woman shall conceive".

Having settled, to most people's satisfaction, the divine nature of Christ, a further issue arose, what was the nature of the Trinity? To the early Christian fathers, it was axiomatic that there was God, the Father, Jesus the Son, and the God the Holy Spirit (in philosophical neo Platonist terms God, Nous, and Soul). But how did they relate to each other? As usual in those times, everyone sought proof of their own particular viewpoint in the Scriptures and spent much effort culling texts ancient and new to prove their point. The problem was that no one was prepared to give up the essentially Jewish monotheistic view of God, yet at the same time no one, except a few heretics, were prepared to deny the divinity of Christ, or the inspiration of the Holy Spirit. They had to keep the one, but philosophically and doctrinally, they had to have three. What then was the relationship of the Three to the One?

The difficulty was that neither could be completely accepted without negating the other, and the early Church had to retain both points of view, for both could be justified by appealing to scripture. It solved the Gordian knot, in the best administrative fashion by clouting both sides on the head, and condemning them both as heretical, and then dumping them together in one pot. At Chalcedon, the issue was resolved by a form of words which could accommodate all parties. God was to be one but three, undivided but co-substantial.

The result the Nicene Creed, has been the cornerstone of institutional Christianity ever since, and must be quoted in full for us to appreciate its full splendour and emphasis (far too many people only know it in the watered down version found in the modern service books).

“We believe in one God, The Father Almighty. Maker of all things visible and invisible; and in one Lord, Jesus Christ, the Son of God, begotten of the Father, only-begotten that is to say from the essence (ousia) of the Father. God from God, Light from Light, True God from True God, begotten not made, of the same essence (homousos) as the Father; by whom all things were made, both in Heaven and in Earth; who for us men and out salvation came down, and was incarnate; was made man; suffered and rose again on the third day; and ascended into heaven, and is coming to judge the living and the dead. And in the Holy Spirit. And those who say that he was not, and before his generation he was not, and that he came into being out of nothing, or those who claim that the Son of God is of other substance or essence, or created, or alterable, or mutable; the Catholic Church anathematizes. Notice particularly in the final paragraph, the anathema (i.e. those ideas that are specifically repudiated), since these comprise the major heresies of the day, on the one hand those who saw Christ as man, who somehow became God—the Arian Heresy, and on the other hand those who said that Christ was not really human at all but of other substance—the Docetic Heresy.

To modern eyes the Creed is not a very logical document. It attempts to pull together a number of mutually irreconcilable ideas, Christ is on the one hand the son (begotten) of the Father, and at the same time of one substance with the Father. He is clearly human on the one hand, and yet Divine on the other. He was born (to an earthly mother), and lived as a man on earth, and yet is said to be pre existent (in the Father). To modern eyes it seems like an attempt to both have your cake and eat it. It has all the marks of a modern day government communication, in which different viewpoints are summed together in a form of words which will satisfy all the major participants, and gloss over their differences.

It is easy to mock, but less easy to see what else they could have done. The times were dangerous, civilization under the threat from the Vandal and the Goth. To divide would be folly, they had to hold together, and they could only do so by adopting an eclectic form of words, even it was intrinsically illogical.

From about 400–500 AD onwards, the Roman empire in the west had basically ceased to exist, and in the East, it never again had the strength to really fight back against the barbarian. The only bastion of civilization, of learning, or reason, in the West, was the Church and the monasteries. Civilization survived, but only just. From the time of the sack of Rome, by Alaric in 410, until the year 1000, the dark ages descended on the West. Civilization did survive, but only as Kenneth Clark has said, “by the skin of its teeth”. For most life was brutal and short, Vandal, Goth and Norsemen, plundered and ravaged at will. Only in the scattered monasteries, and in the enclave of Byzantium, increasingly fossilized and hierophantic, did any form of knowledge and civilization survive. For 500 years the papacy clung on by a thread, rent by schism, and simony, for much of the time dependent on surrounding petty kingships, and a residual and largely nominal respect for Rome and it's bishopric, honoured more in the breach than the observance. But, no matter how much they resented it the barbarian chiefs and kings needed scribes and accountants, administrators, and clerks, and these could only come from the Church.

The old civilization of Greece and Rome died because it was exhausted, and the new rulers of the West, nearly went down in the crash. The Church was the only

thing that held civilization together, and we should not mock its determination, enshrined in the creed, to hold things together. If the dark ages, preserved anything of the old Graeco-Roman civilization through to the renaissance, it is almost totally due to the Church and the Monasteries, and their refusal to split into a confused mass of heretical sects.

Nevertheless, we should not overemphasize the civilization of the early Church. Whilst it had many men of genius, and administrative skill, the vast bulk of its people were grossly ignorant and superstitious. It is doubtful whether many of the clergy or priesthood were more than barely literate, and the laity were in general wholly ignorant. They lived in a world where horizons barely went beyond their own village, where life was rough, harsh, and brutish. The woods stretching for miles around their clearings were peopled with hobs, and hobgoblins, God the father, ruled above, in the heavens, and hell was only just down below. Their Gods and Spirits of the wood and cave, had been promoted to the saints and angels, or demoted to fiends and devils lurking in the woods and rocks.

They knew nothing of hygiene, or medicine. Plague and Cholera, Dysentery, and Fever carried them off in their thousands, especially in their cramped and unsanitary towns and villages, with no drainage, and bad water. Our modern word Loo, comes directly from the time when chamber pots were emptied out of bedroom windows, with a cry of "Gardez 1'eau", only to drain down the cobbled lane into the stream at the end, which in turn led to the river from which they hauled their water. Of modern Science and technology there was none. A jealously guarded mystery or craft of smith and iron founder, mason and builder was all the technology they had, whilst their nobles were almost entirely preoccupied with war and power.

Pitifully little had survived from ancient times. A little of Plato, less of Aristotle, a few of the Greek playwrights, a little Cicero, and Tacitus, Caesar's commentaries, but most had been lost, (irretrievably many thought). There was always of course the Bible, basically the Septuagint, and St Jerome's translation of it into Latin the Vulgate, The New Testament, and the writings of the Church Fathers Origen, Augustine, Chrysostom Out of this meagre hoard, the scholars started to rebuild. They were, almost without exception, Churchmen, outside the church there was nothing, 'ex cathedra nihilo', and they naturally sought to develop a church based knowledge or schema—Theology—the science of God. Above the courtyard of the Bodleian library in Oxford you can still see their threefold classification of human knowledge—the 'arts' of Mathematics, Language, and Theology. Theology they called the queen of the sciences. Their textbooks were the Bible, and the Church Fathers, together with what remained of the literature of the Ancient world.

But with the reviving confidence of the West, and the knowledge imported from their increasing contacts with the Arab world, they began to rediscover the ancient writers, Plato, and above all, Aristotle. It is difficult to know now whether Aristotle's dominance was fortuitous or not, it may have been due to the fact that alone amongst the Greek philosophers, a large corpus of his work had become available from the Arabs. Certainly the Greek Atomist philosophers, Lucretius, Democritus, and Leucippus were little known or understood. to the medieval school men, Aristotle was supreme. As further knowledge from the Arabic world

filtered back from the Crusades, the writings of the late Greek astronomer Ptolemy were incorporated into their schema. Ptolemy, in his turn influenced by Euclid described the Universe, the motions of the stars and the planets, by a system of cycles and epicycles (an epicycle is another smaller circular motion imposed on a large circle) around the earth, which was of course at the centre!! (After all why not!! where else could the centre be??).

The early Middle Ages were a time of extraordinary religious and intellectual ferment. The Papacy was weak and new sects, imported from the East swept through Southern Europe, amongst them the Cathars or Bulgars, from their origin in the Balkans. With this new freedom of thought and religion came many surprisingly modern ideas. Anselm, Archbishop of Canterbury (1033-1109) was the first 'father of scholasticism', the new knowledge. He stands with his feet in both camps, both the old, and the new. He first spelt out the ontological 'proof' of God, as ‘a perfect being - so great, nothing greater could be conceived'. In formal logic the 'proof' miscarries, since it is not necessarily true that being able to think of something greater and more perfect means it has to exist, it is basically a platonic idea. I may think of a suspension bridge 200 miles long, but that does not necessarily imply its reality.

None the less, we should not misunderstand the strength of his arguments within his context and his times. Anselm's concept of God was much more than merely verbal; it embraced all human experience of God within his times and his people. He believed that Faith was necessary that men may understand. "*Credo ut intelligam*" ('I believe that I may understand'). And he believed that God had created man as a rational being.

But in the next generation, this serene confidence was blown wide open. The division is best characterized by two completely dissimilar men, both in type and social class, Bernard of Clairvaux, and Abelard. St Bernard stands for the power of Faith and the Heart, Abelard for the power of Reason and Logic. St Bernard was of the ruling class, tall red headed, blue eyed, the son of a Burgundian nobleman He was only 21 when he entered the Cistercian order. Three years later he became Abbot of Clairvaux, an office in which he dominated the Papacy and the religious orders of the time. By his preaching he set in motion the Crusade of 1147, and under his influence the Cistercians founded numerous religious houses throughout Western Europe. The keynote of his preaching and his thought was austerity and discipline, dominated by an intense personal fervour. If in this world man was to be saved, it could only be by Faith and Rule, and this springs from deep personal desire for Christ. We still sing his songs in our Churches today

Jesu thou joy of Loving hearts
Thou fount of Joy, thou light of Men
From the best bliss that earth imparts
We turn unfilled to the again.

St Bernard, believed intensely in education, he felt that the only hope for the world lay in teaching this faith to the youth of his time. For it was a time of youth. Europe was awaking, and its intelligent young men were flocking to the new universities or Schools of Paris, Bologna, and Oxford. The grim battle in which

Bernard overthrew Abelard can perhaps only be really understood against this background. For Abelard was the opposite of Bernard in almost every way. a small, dark haired, sensitive Breton, a man of the people, a freelance teacher in the University of Paris, who drew crowds wherever he taught. Unlike Bernard, Abelard stood for the primacy of reason over faith. He said "By doubting we come to questioning, and by questioning we come to the truth". Anselm's "I believe that I may understand", was turned completely in its head. Abelard used his subtle intellect and teaching skills to question the deepest obscurities and contradictions of the 'authorities'—the Fathers of the Church, the canon law, the Bible itself. He attacked the fundamental teaching of the medieval Church, which saw guilt and sin and expiation as a legal transaction made with a stern God.

St Bernard and the authorities were horrified. Abelard was branded a corrupter of youth, attacked and castrated by thugs, and condemned as a heretic, and banished to a monastery, his books burnt. He died in humility and silence in 1142, having seemingly lost his life's work, his manhood, and his love. His letters to Heloise survive. But perhaps he had the last laugh, his thought in the end proved far more important than the devout piety and anger of St Bernard.

As I have said, it was a time of extraordinary freedom of thought and ideas. The very fact that Abelard was allowed to live out his life in obscurity and (relative) peace after condemnation as a heretic points to this freedom. A hundred years later he would have been burnt at the stake. The freedom of the age is expressed uniquely in its buildings. The Churches of Charlemagne's day are squat solid and dour, but with the new freedom of thought and idea's came a new architecture. Their Churches are soaring buildings of tension and light. Vezelay, and Chartres are living monuments to light and form. Vezelay is a supreme aid to worship and contemplation, whilst the great west door of Chartres Cathedral is one of the most stupendous things in western Christendom.

The scholars of the 12th and 13th century benefited enormously from the Crusades. The returning knights and clerks brought back from the Middle East many of the lost treasures of Antiquity. From the Arabs, they rediscovered the works of Plato and Aristotle, free from the commentaries and distortions of the Fathers. The works of the Arab philosophers Avicenna and Averroes were widely read, and they developed a world centred philosophy and a rational scientific mode of thought which threatened both orthodox Christian and Islamic thought alike. Amaury, Clarembald, and Siger taught an earth bound humanism which has been the hallmark of humanism ever since. Indeed David of Dinant, whose works were condemned with Amaury's seems to have taught an out and out pantheism. “God is matter, and no reality exists outside matter, outside God” he said. For a short time the orthodox viewpoint taught by the Church seemed to be tottering, until the greatest of the medieval School men Thomas Aquinas arrived on the scene.

Amongst the medieval scholastics, Thomas Aquinas, the "Divine Doctor" of the School men, stands supreme. An immensely fat and corpulent man (he was called the Sicilian Ox by his brother friars), he managed almost single handed to reconcile the newly recovered knowledge of Aristotle with the teachings of the Church. As Aristotle had summarized and codified the knowledge of the Ancient world, Thomas Aquinas summarized and codified the knowledge and philosophy of the middle ages, and reconciled it to Church teaching so thoroughly, that his

system of thought and Philosophy is still taught in Catholic universities today as the only correct viewpoint. It was probably the last time that science and philosophy were ever to be in such complete agreement with religion.

Thomas Aquinas's thought is summarized in two of his major works *Summa contra Gentiles—Arguments against Non believers* and *Summa Theologica—Theological Arguments*. The first deals with the logical case for Christianity, and is concerned to demonstrate the truth of Christian doctrine as far as possible without relying on divine revelation. The second summarizes the Theology of the time, but relies more on Divine Revelation as given in the Scriptures and the teaching of the medieval Church. He was the first Christian philosopher to make a clear distinction between faith and reason, and although he tries to demonstrate that reason results in nothing contradictory to the Catholic faith, he clearly recognizes that not all faith is demonstrable by reason, but that doctrines such as the Trinity must rely on Divine revelation. His thought is important, because it still forms the mainstream of Christian ideas of God, even today, and because, even for unbelievers, his ideas are still subconsciously powerful.

Aquinas was deeply sensitive to the ultimate mystery of the Faith, seeing clearly that God must always remain to some extent mysterious. He argues that the things we can logically know about God are all in a sense negative. God is eternal since he is not moved. He is unchanging because he cannot change. He is indivisible since he is not compounded of many parts. He is his own essence, since otherwise he would be compounded of essence and existence. He cannot be defined, since he embraces all types. God created the World out of nothing, contrary to the opinions of the Ancients. He cannot be a body, or fail or tire, or anything an animate body may be, i.e. weary, forget, repent, or be angry or sad. He cannot do the logically impossible, i.e. make the sum of a triangle less than or greater than two right angles, or undo the past, or sin, (or make a man have no soul!!). The soul is the form of the body, i.e. the thing which gives it essence. The intellect is part of the soul. All things tend to God, who is the purpose of all things (the final cause). Evil is unintentional. Divine providence does not exclude evil and chance and luck. Evil is an accident, not an essence, resulting not from intent, but from imperfection. Sin, predestination, and election, are basically as in St Augustine. No man can be freed from sin except by Grace, which is Gods Gift. God is not the cause of Sin, but some he leaves in sin, whilst others he delivers from it, we cannot argue that this is unfair, because we are all unworthy.

In general philosophy, Aquinas agrees with Aristotle, his merits lie in his adaptation of Aristotle to Christian Doctrine. Together with this the Christian Church took over Aristotle's view of the physical world.

God, the prime mover, had created the earth at the centre of the world, above were the heavens, visualized as concentric crystal spheres containing respectively the moon, the planets, and the fixed stars. Anything below the moon was sublunary, and changeable, being composed of fire, air, water, and earth. Anything above and including the moon was celestial, and unchanging. Above all this was Heaven, the abode of the blessed, below all this was Hell, ruled by the devil and his fiends. God sent his son Jesus, to save the human race from Hell, and the Holy Spirit to inspire them, and would at some time to come raise up all

men at the last trump, when the heavens and the earth would pass away, and the souls of all men would be judged and apportioned to Heaven or Hell.

It may seem a dreadfully simplistic system to us, but it was really remarkably powerful. After all it explained, in its own fashion, most of the observable world. The heavens, and as far as they could determine the motions of the stars, the cycles of the day and of the year, the material the earth was made of, the passage of the seasons, life and death, the hierarchical nature of society, God above, here on Earth the King, his Earls, the peasants, below, the devil. Man could see, and interpret such a world in his terms, and in distress or trouble could request the intercession of God's son Jesus, and his mother, the blessed Virgin, and the saints, against the machinations and attacks of the evil one. By the twelfth century, when St Thomas Aquinas, the divine doctor, codified and summarized it all in his Summa Theologica, everything seemed to have been settled. Theology was triumphant, and king, and priest, merchant and peasant, knew their place in a world. which if not the best of all possible worlds, was at least explicable and reasonably logical.

The achievement of the medieval scholars is the more remarkable when you look, as we now can, at the rest of the world. True, Islam was rampant in the middle East, but apart from it's insistence on the uniqueness of God, and Sufi philosophy and astronomy, basically Greek in derivation, had little to add as yet. Its main contribution was yet to come in the thirteenth and fourteenth century, when it passed its mathematics and its chemistry back to the West. In the far East and, India and Japan, Buddhism had failed to clean the Augean stables of the Hindu pantheon. Only in China, was a comparable civilization extant, and that failed to develop fully simply because it had no logical foundation of mathematics and science, and in spite of all it's excellence, was already slipping to decline and decay. The Triumph of the West was to come, but its foundations, in law and jurisprudence, in logic, and science were already laid.

However complete and magnificent Thomas Aquinas's edifice was, even as he built it small cracks were appearing in the foundations. Even as early as the twelfth century Abelard was arguing for critical examination of the faith, "by doubting we come to questioning, and by questioning we come to the truth". Roger Bacon was making his first forays into experimental science, "that despised mechanic art", and Duns Scotus was tossing intellectual time bombs into the complacency of the medieval scholastic world. Thomas Aquinas had built a great structure of faith and doctrine, which together with Plato and Aristotle still has influence today, and we have dealt in this chapter with its foundation and architecture. Its strength is in its coherence and logic, and its close bonding of the faith with the observable world. But its very completeness, is its fundamental weakness, for more and more as time wore on, it was found to be inadequate. Like cracks in the foundation of a building, small and apparently minor discrepancies, grew more and more serious, until by the time of Galileo, the whole edifice of Medieval science and theology was looking distinctly shaky.

Chapter 4

Reformation and the age of reason.

What though in solemn silence all
Move round this dark terrestrial ball
What though no real voice nor sound
Amid their radiant orbs be found.
In reasons ear they all rejoice
And utter forth a glorious voice
For ever singing as they shine
The hand that made us is divine.
—Addison

"*Eppur, si muove*" (Nonetheless, it moves)
—Galileo

At first the cracks in the foundation of the medieval philosophy and science seemed quite small and trivial. For example Aristotle, and following him Aquinas, held the comets to be sub lunar, (they could not be outside the moon's orbit since the heavens were perfect and changeless). But as astronomical observations became more careful and sophisticated, it became apparent that they were from outer space, and not sub lunar at all. Also there was the little matter of the irregularities of the orbits of the planets, Mars, Mercury, and Venus. It had long been known that their movements in the heavens were sometimes retrograde, and additional epicycles had to be added to the Geocentric system to accommodate this. But as more detailed observations were made with better instruments, it became apparent that such an earth centred system could only accommodate the measurements by piling epicycle on epicycle. Finally, in Sweden, Copernicus, after a lifetime of patient observation, dared to advance a new and revolutionary hypothesis, instead of the sun and the planets going round the earth in a complicated system of cycles and epicycles, both the planets and the earth went round the sun, and the apparent retrograde motions of the planets were due to the earth catching them up and then leaving them behind.

Copernicus knew that this would incur the censure of the Church, and advanced it very cautiously and did not commit himself to print until the very end of his life. Even then it was advanced only as a hypothesis, not necessarily fatal to the geocentric view held by the Church, that the earth was the centre of the universe. In fairness to the men of the time the Copernican hypothesis is by no means immediately obvious to the casual observer. After all if the earth really is spinning on its axis once every twenty four hours, and turning round the sun once a year, what is holding things on to its surface, and why do we not fly off into space. But as more and better measurements were made of the heavenly motions, more and more the Ptolemaic hypothesis began to look unduly complicated, and

the Copernican system more attractive. However, to the Church, the geocentric hypothesis was essential. Oddly enough, this was not so much because of Scripture, (the story of the Sun standing still in the Book of Joshua is really a very minor part of the picture), but fundamentally because they felt that if the earth was not the centre of the universe, then mankind cannot that important after all, and this strikes straight at the heart of the Church's teaching that God so loved the world that he sent his only Son to redeem mankind. For if man is not in the centre of the world, why did God bother? We must give the Church authorities of the time credit for seeing the essential point; it is after all arguable that even modern Church leaders have not really understood the point at issue. However, for the moment, the Copernican hypothesis, remained just that, an academic proposition talked about in the universities, but not pushed vigorously as a real explanation of the celestial motions.

But in 1608 some Flemish spectacle makers invented a primitive form of telescope, and the news filtered through to a Venetian scientist and mathematician called Galileo. Curious, he made a telescope of his own, with a magnification of about three times, and used it to demonstrate to the merchants of Venice that it was possible to identify a ship well out to sea from the top of the Campanile tower, hours before a casual observer could see it with the naked eye, (this could be worth a lot of money on the stock exchanges of the day). A little further work produced a telescope with a magnification of about thirty, vastly superior to anything that had been produced before that time. Galileo turned it to the heavens. Thus when he first saw the phases of Venus as it turned around the sun, and the moons of Jupiter orbiting their giant world, the effect was like a detonation in the intellectual world of the time. For arguments amongst scholars about heliocentric hypotheses are one thing, seeing for yourself the orbits of the moons and the planets is another. For if Venus orbited the sun and moons could orbit a planet, then the earth could surely orbit the Sun. and if this were so, then Holy Scripture was wrong, and the teaching of Holy Church in grave danger. Even that most worldly of Ambassadors, Sir Henry Wotton, took notice, writing home to his mistress, Queen Elizabeth the first "The mathematical professor of Padua hath discovered four new planets rolling around the sphere of Jupiter... The author runneth a fortune to be either exceeding famous or exceedingly ridiculous", and he promised to "send one of these new instruments home to England", for examination. But the Church was aghast, so extreme was the reaction that many churchmen refused even to look through this 'device of the devil', lest they be drawn into error and sin. It is difficult for us, at this space of time, to appreciate the shock and horror of the Church and churchmen of the time. At first they refused to believe it, hoping that this awkward and devilish observation would simply go away. Finally they seem to have decided to ignore it. But the observation had been made, and it demonstrated clearly that the Copernican hypothesis was probably true, and that the Ptolemaic theory was far too complicated and probably wrong.

In spite of the deep disapproval of the Church, Galileo persisted in demonstrating and teaching the Copernican hypothesis, braving the reproaches of the Cardinals and the Pope. He seems to have believed that he had got permission to teach it, merely as a hypothesis, if not as the truth. But eventually he went too

far, he wrote a book "Dialogue on the Great World Systems", in which the arguments for the heliocentric system were cogently put, and the opposite arguments for the Geocentric Ptolemaic system were put into the mouth of a simpleton—'in bocca di sciocco'. The Pope of the time Urban VIII was outraged. Galileo, as an old man was hauled before the Inquisition, and persuaded under threat of torture to abjure, and recant. It is said that as he signed the document he muttered under his breath "Eppur, si muove"—nonetheless it (the earth) moves. No doubt his inquisitors, unwilling to press the matter, and create a martyr, turned a deaf ear to this whimper of protest, after all they had what they wanted, a signed recantation. The documents of his trial and his recantation "*I Galileo Galilei., have abjured, sworn, and bound myself as above*" lies today gathering dust in a locked safe in the Vatican Archives.

But few heeded his abjuration any longer, for the control of scientific and technical advance had irrevocably passed out of the hands of the Church. In the protestant countries of the North, free from the dead hand of the papacy, scholars and scientists were pressing on. Kepler took another look at Copernicus's data, and showed that the planets moved round the sun, not in circles but ellipses, and that their velocity was inversely proportional to their distance from the sun. For the moment this was merely an empirical observation. It took a man of supreme genius to show the reason why it should be so. Isaac Newton (born in 1642, the year Galileo died). Like most insights of genius, the reason was to be found in a simple and elegant demonstration to be found not in the heavens but here on earth.

Aristotle had taught that heavy bodies fall faster than light ones. This of course is a matter of simple observation—a cannon ball falls faster than a balloon. But Galileo (again) had actually thought about it, and recognizing that the resistance of the air would have a larger proportional effect on a lighter body, arranged to eliminate the air resistance by using two balls of the same diameter, but different weight, and rolling them down an inclined plane to slow them down so that the primitive timepieces of the age could be used effectively. Lo and behold!! they rolled down at exactly the same rate, arriving at the bottom at exactly the same time. So Aristotle was wrong (again)! Fundamentally Aristotle had been wrong because he had confused velocity with acceleration. He was right in saying that things move because they are pushed but thought you had to keep on pushing to keep them moving, but in fact, in the absence of friction, you don't need to keep pushing, things will just carry on along at whatever velocity and direction they had in the first place.

Isaac Newton in Cambridge, England, around 1666, showed why this should be so by developing his two laws of motion, Firstly, that a body undisturbed by any other forces, carries on at whatever velocity it originally had in a straight line, Secondly, that when a force is applied to such a body it results in a change of the body's momentum in the direction of the applied force, (momentum is the product of its mass and its acceleration). Thus two bodies of different mass acted on by the same force; accelerate at the same rate, since the effect of their mass cancels out.

But Newton's real genius lies in his putting this to the test not on earth but in the heavens, i.e. applying observations made on earth to the motions of celestial bodies. He seems to have said to himself, if the moon goes round the earth, it

must be because the force of gravity is continually pulling her down from the straight (tangential) line she would pursue if left to her own devices. How fast then, he must have asked himself, must she have to go to a) avoid falling back to earth and b) avoid flying off into space? Using the known acceleration of gravity (measured on earth), and assuming that the force of gravity varied as the square of the distance, he calculated a velocity using his new method of fluxions (which we now call the calculus), and came up with an orbital period which turned out to be very close to the twenty seven and a quarter days of the lunar month.

Now by itself this is not so tremendous an achievement. Most first year Physics students could make the calculation on the back of an envelope. But for its time, it was literally world shaking. For it was a clear demonstration that a simple measurement of the force of gravity with which the earth acts on an apple, could be applied throughout the heavens, not just to the moon but also to the planets, (and by implication, the stars themselves). In other words a simple measurement of the gravitational constant made on earth can be used throughout the whole universe. For the first time, man held the keys to the heavens in his hand.

Perhaps the real mystery is why he did not publish such a remarkable and fundamental discovery immediately. In fact it was only twenty years later in 1684, during a discussion with Hooke and Halley about Kepler's observations, that Newton casually said that 'the orbits of the planets around the sun had to be elliptical'. When pressed for the proof, he casually said that he had 'lost the calculations!!' Pressed, he did proceed to publish in full his results in the *Principia Mathematica*. It turns out that the calculation of the moons orbital period only works if you can treat the heavenly bodies as point sources for the purposes of gravitational attraction and assume a simple two body calculation, and assume that gravity falls off as the inverse square of the distance. If you do this, the orbits of the planets turn out, in general to be ellipses, with the sun at one of the two principal focii. Kepler's empirical observation now at last had a sound mathematical basis. To the universal astonishment of the whole scientific world, the problems of celestial mechanics turned out to have been solved, and solved so conclusively that for all intents and purposes, no modification was needed for over 200 years. Even today Newtonian dynamics can predict the movements of the heavenly bodies to an extremely high degree of accuracy in spite of vast improvements to the observational techniques. Small wonder that his contemporaries said in astonishment "God said 'Let Newton be', and all was light"

However there was a rub, which Newton rather glossed over. Up to this time it had been tacitly taken for granted that 'action at a distance', i.e. two bodies acting on each other without coming into contact, was impossible, (for something to be moved, it was surely obvious that actual contact with another moving body was necessary). But Newton’s 'force' of gravity was 'action at a distance'. and as such deemed impossible. When pressed on such questions, Newton always answered "I do not make hypothesis", meaning in effect that he did not deal in metaphysical speculation, but merely laid down a rule and derived phenomena from it. Now as Bronowski has pointed out, if Newton had been a plain, dull, uninteresting sort of man, that would have been quite understandable. But Newton was in fact a most extraordinary, and subtle character. Wordsworth says of him "Newton with his prism and silent face". For this foremost of scientists, pre eminent in his age, not

only worked out the secrets of the heavenly machinery, the first science of optics, the laws of motion, and the first primitive form of the calculus, but also, in secret practiced alchemy, and wrote an immense (unpublished) treatise on the book of Revelation. Incidentally he was also Master of the Queens mint, President of the Royal Society, and knighted by Queen Anne in 1705. His most famous saying "If I have seen more than most people it is because I have been able to stand on the shoulders of giants", is not quite what it seems, since it occurs in letters he wrote disputing the priority of his ideas with another scientist of the age, Hooke, who incidentally was a very short man!!

In many ways, Newton's achievement was to set the pattern of the age. The old emphasis on divine revelation was in retreat everywhere, the universe seemed more and more like majestic clockwork, with God relegated to the master clockmaker, who having made the mechanism, had just wound it up and started it off and left it to its own devices. In this respect it must also be remembered that the clockmaker's of the day were the aristocrats amongst workmen, much as the mason had been in the middle ages. For the eighteenth century was the age of discovery and navigation. To navigate the oceans of the world you need above all an accurate method of determining latitude and longitude. The former was easily done by sighting the maximum elevation of the sun above the horizon using a sextant. But to determine the latter requires a very accurate knowledge of the passage of time since the voyage began, since it is done by comparing the time of midday recorded on a chronometer set at Greenwich time with the actual time of midday observed on board the ship, a feat which was quite beyond early mechanical clocks. Chronometers, accurate to half a second on a voyage of up to six weeks, which could stand the movements and shocks of the shipboard life, were essential. Indeed the British Government of the day offered a prize of 20,000 pounds (a fortune in its day) to the maker of such a machine.

The London clock maker John Harrison built a number of clocks capable of this degree of accuracy, incorporating several pendulums, so that between them they could compensate for the lurch and sway of the ship. It was an age in which all were fascinated by machinery just as we are fascinated by the computer. In philosophy too, this emphasis on a mechanical determinism, held sway. For, although Newton in public claimed that he did not practice metaphysical speculation, others had no such inhibitions.

Although throughout the Middle ages, philosophy had been basically a religious exercise, this was no longer true. In the protestant countries of Holland, and Germany, free from the restraint and domination of the Papacy, a new school of philosophers arose. The most important of these were Descartes, Spinoza, and Leibnitz.

Descartes, a Frenchman of independent means, was the first of these. Although he developed a strictly deterministic philosophy, he never entirely broke free from the Catholic Church and the authority of the schoolmen, remaining a practicing and devout Catholic throughout his life. Spinoza was a poor optical lens grinder, a renegade Jew, who brought his own magnificent monotheistic outlook into determinism. Leibnitz, a minor official in an obscure German state, whilst a very much less sympathetic character, (he was satirized by Voltaire as Dr Pangloss—

“all is for the best in the best of all possible worlds”), must be counted one of the deepest of deterministic philosophers.

Descartes, famous for his dictum "Cogito, ergo sum"—I think therefore I am, although still inhibited by Aristotle's thought, was the first scientific philosopher, who attempted to base his thought on strictly logical grounds. He is famous in mathematics for his development of co-ordinate geometry. His metaphysics is strictly deterministic and mechanical. The physical world, in Cartesian terms is like a mechanical clock, everything is determined and preordained. God may have set the system up and given it the first push, but thereafter everything that happens is preordained and inevitable. Living organisms, he said, like inanimate matter, were entirely governed by the laws of physics. He did, it is true, allow a soul in man, but animals were to be regarded entirely as automata. Descartes himself argued that in man, the soul could affect the body through the 'vital spirits' whatever this is! and thus have a degree of free will. However, his disciples were forced to abandon this when the laws of mechanics became fully understood, and had to have recourse to a fantastic and incredible theory of two synchronous clocks, one controlling the body subject to strictly deterministic physical laws, the other controlling the mind, and somehow synchronized with the first. Free will, in fact was only apparent, rather than real. Mind and body, in Cartesian terms are completely separate, and cannot act on each other. Although Descartes philosophy is apparently entirely deterministic, it is in reality highly subjective, the mind is the only final arbiter of reality, 'I think, therefore I am'. He allowed only three substances, God, mind, and matter, and allowed the mind only to influence matter under the control of God, who presumably set up and synchronized the clocks!

Descartes exhibits an unresolved dualism between the scholastic world of his early teaching, and the scientific developments of his time. His separation of God, mind and matter is so absolute, that he takes the Platonic 'otherness' of God and the soul to extremes. But in much of his work he exhibits the great virtue of logical rigorous thought, unaffected by preconceived religious ideas. His value should be judged on his mathematics and his logic, not on his ideas of the physical world.

Whereas Descartes divides the world into God, mind, and matter Spinoza will have none of this, for him both mind and matter are extensions of God. He is just as deterministic as Descartes, indeed more so, for in his philosophy, there is no place at all for free will. Everything is determined by an absolute logical necessity. Good and evil are both willed by God. But then we are on the horns of a dilemma, for if all things are willed by God, then God is responsible for evil as well as good. Spinoza argues that if we could see things from God's timeless, eternal stance, then even the evil in the world is the product of God's goodness. Although this teaching, in one form or another, has been implicitly implied through the ages by most mystics, it is obviously cannot be reconciled with most people's idea of good and evil. Any form of individuality, whether of soul or matter, is purely adjectival, body and soul are not things, but aspects of God are being. Free will, and chance, does not exist, everything that happens is a manifestation of God's nature, and it is logically impossible that they should be otherwise.

Spinoza's philosophy is splendid, and utterly consistent. But he is far beyond most people, and he was condemned on all sides. All who knew him personally seem to have loved him, and he seems to have lived his austere ethics and

philosophy to perfection. But his philosophy is logical monism carried to extremes, and is not easily reconciled with modern logic and scientific method. He suffers from the disadvantage that his major published work the 'Ethics' is written in the form of a long sequence of logical axioms and theorems, and is unreadable for modern users.

Leibnitz is a far less sympathetic character, a minor functionary in the court of the Elector of Hanover. He was a distinguished mathematician, and is credited with the development of the calculus, (indeed we use his notation, rather than Newton's), Like Descartes he based his philosophy on a deterministic view, and on the separation of mind and matter. But for him 'extension' could not be a property of matter. He argued that extension involved plurality, and therefore must involve an aggregate of entities. These individual entities he called 'monads'. His theory of non interacting 'windowless' monads is somewhat fantastic to modern thought. He seems to have thought of each monad as a 'soul' or a 'mind'. His system seemed to him to restore the possibility of free will. He agrees with Aquinas that God cannot act contrary to the laws of logic, but he can decree whatever is logical, giving him considerable freedom of choice. Leibnitz develops the four metaphysical proofs of God to their final form. Ontological, the argument that for the most perfect possible being, essence does imply existence. Cosmic, the argument for a necessary first cause. Eternal Truth, which turns out to be a form of the Cosmic argument, and Pre-established harmony, which depends on all the 'clocks' for an infinite number of monads being in harmony. The last argument is frankly fantastic, but can be developed more generally into an argument from divine design.

Russell argues that much of Leibnitz's published philosophy, is the by product of private thinking that he did not dare publish openly for fear of censure. Leibnitz was a firm believer in the importance of reason. He did work on mathematical logic which would have been immensely important had it been published. He based his philosophy on the concept of analytical propositions and uses them to justify many arguments. He is the supreme example of a philosopher who draws inferences from syntax to the real world, a mode of thought which has now largely fallen into disuse. One very interesting unpublished paper however apparently sets out a very novel idea as to why some things exist, and others do not. According to this view, everything that does not exist struggles to exist, but not all possibilities may exist because they may contradict each other. That which exists is what belongs to the largest group of possible things. On this basis there is no need of God as a 'Deus ex Machina' or First Cause, since in theory logic can determine which group of possibilities is the largest, and this group in consequence will exist.

Leibnitz, was not the first to see that if matter was not continuous it must be discrete. A primitive 'atomic' theory had been first postulated by Leucippus and Democritus in the fifth century BC, and later by Epicurus in the third century BC. But, to ancient eyes, such a theory suffered from the fatal flaw that if matter was discontinuous, then there must of necessity be 'nothing' in between the atoms. And in the verbal logic of classic Aristotelian philosophy 'nothing', could not possibly exist, since this would be a logical contradiction in terms. Besides if there

was nothing between the atoms, how could they interact, since action at a distance was inconceivable?

But in England, far from all this metaphysical speculation, the practical sciences were beginning to make the running, and take over from the theoreticians. Boyle had recently discovered that the volume of a gas is inversely proportional to the pressure and Newton offered a theoretical explanation of this in his Principia, by assuming that in a gas there are mutually repelling particles, where the forces are reciprocally proportional to their distance apart (action at a distance again!!). However, the full development of the atomic theory of matter had to wait until much later, 1808, when a rather humdrum Quaker schoolmaster, John Dalton, published his book *A new system of Chemical philosophy*.

Dalton epitomizes the humbler origins of chemistry, as distinct from the other Sciences. He really seems to have been a very ordinary sort of person. He was a man of very regular and dull habits, for fifty seven years he walked out of Manchester every day to measure the rainfall and the temperature at his meteorological station. From this mass of data, nothing really useful came at all. But this illustrates his lifelong preoccupation, the preoccupation of a tradesman—how much? For he above all people of his time, saw that this very question lay at the root of chemistry. A fixed weight of oxygen always reacts with a fixed weight of hydrogen, or carbon, and he made the instinctive jump from this very ordinary fact, to the idea that one or more bits of oxygen always combine with one or more bits of hydrogen or carbon. In his book he advanced the hypothesis that all matter is composed of extremely small, indestructible particles called atoms. "Thou knowest that no man can split the atom" he said—words that were to prove tragically wrong. Each element had its own distinctive kind of atom. Compounds are formed by the combination of these elemental atoms, and the ultimate particles of these compounds are composed of small whole numbers of these atoms. It does not detract from his achievement, that he then went on to calculate a set of completely incorrect atomic weights for the elements. At the time Dalton had no means of determining the actual numbers of atoms in even simple compounds like water, although the latter was known to be comprised only of hydrogen and oxygen. Accordingly Dalton took the simplest possible hypothesis and assumed water to be formed from one atom of hydrogen and one atom of oxygen, or HO. From this, and other similar assumptions he derived a set of incorrect relative weights (or atomic weights as we would now call them).

But, at the same time as Dalton published his work, a Frenchman, Gay-Lussac found that when gases combined they did so in volumes which bore a simple relation to each other, and with the volume of the product (provided this also was gaseous). Berzelius tentatively advanced the hypothesis that equal volumes of gases, must therefore contain equal numbers of atoms or molecules. The trouble was that it could be shown that one volume of oxygen reacted with two volumes of hydrogen to give two volumes of water vapour. If Berzelius was right, this meant that one atom of oxygen reacted with two atoms of hydrogen to give two molecules of water i.e. 0 + 2H = 2HO, which is clearly impossible (remember Dalton had said that water was HO). It could also be shown that one volume of hydrogen reacted with one volume of chlorine to give two volumes of Hydrogen chloride, and on Berzelius's theory that meant H + Cl = 2HCl, also impossible if the law of

conservation of matter was to be observed. However the real reason soon became apparent and Avogadro in 1811 supplied the explanation. Elemental Hydrogen and Oxygen (and indeed most elemental gases) were not atomic but molecular, Gaseous Oxygen, Nitrogen and Chlorine was not monatomic but diatomic. Under this rule two atoms of oxygen react with four atoms of hydrogen to give 2 molecules of water—which agrees with Berzelius. The atomic weights of Hydrogen, Oxygen, and Chlorine then came out as 1, 16, and 35, in line with modern accepted values. From this date on, modern chemistry had a sound physical basis, and the next century saw major advances in inorganic and organic chemistry. The contrast between the hesitant, fumbling, development of the fundamentals of chemistry, and the brilliant clear incisive work of Newton in physics, can hardly be more marked. In general this often seems to be true between the two sciences, physics advancing by clean, spectacular leaps, and chemistry by slow plodding progress, with frequent backtracking and error.

We see then, that by the turn of the eighteenth century, or shortly thereafter, the foundations of our modern scientific world had been laid. Newton's celestial mechanics had solved the problems of the heavens, and linked them to the mechanics of the earth, and Dalton, Gay-Lussac, and Avogadro had laid the basic foundations of modern inorganic and organic chemistry.

Basically all these advances were the result of a major revolution in men's thinking. Up to the close of the sixteenth and seventeenth century, the ancient scholastic and religious modes of thinking had been dominant. Truth was to be discovered by deduction, i.e. the drawing of a particular truth from general truths, previously known or revealed, working from a few basic premises of geometry and mathematics, or from Holy Scripture and the canon of the Church. Induction, the drawing of general truths from a set of individual observed facts was felt to be a mere mechanic art, unworthy of the study of a scholar and gentleman. This attitude, at heart, derives from Plato's argument that the world of the senses, because it is always changing and impermanent, was less important, and hence less worthy of study, than the 'universals' that lay behind them.

But with the freedom of the Reformation, and the invention of better means of observation, and measurement, and the skills of the toolmaker, optical grinder, and the clockmaker, men began to look more closely at the physical world about them, and as they looked, it became apparent that much of the ancient knowledge, so carefully saved and garnered from the past, was deeply flawed. Freed by the Reformation from the dead hand of the Church and Inquisition, empirical observation and induction replaced logical deduction. Even in that most theoretical of occupations, Philosophy, the influence of empiricism is to been seen. Locke, Berkeley, and Hume, are all representatives of this new and revolutionary trend.

Locke (1632-1704) is the father of modern empirical philosophy, and the first philosopher with which the modern age can relate with ease. Unlike Descartes and his school, he does not set up a logically consistent system from a few first principles, but seeks to show that all human knowledge (with the possible exception of logic and mathematics) is derived from human experience. To us, this seems commonplace, but at the time it was revolutionary, refuting the ancient philosophers, and Descartes and his school, who argued that ideas and principles

are innate, not acquired, and derive from some other higher principle or being. He is contemptuous of metaphysics, of some speculation of Leibniz, he writes to a friend "You and I have had enough of this kind of fiddling". To him perception is the first step towards knowledge. This seems obvious to us in this modern day and age, but in his time when men were supposed to know all sorts of things 'a priori', it was a new and disturbing doctrine, going directly against the father of all philosophy Plato, who thought that true knowledge could not be got by these means. In Scholastic terms he is an out and out Nominalist. To him all things that exist are particular things, and the names we give to universals or classes of things, i.e. Man, for mankind in general, are merely a general idea to which we attach a word.

In general, Locke says little with which a modern man would disagree, He makes no wide ranging claims for his philosophy, and rarely takes up a controversial or extreme position. The same cannot be said for his disciples Berkeley (1685-1753) and Hume (1711-76) who carried his subjective line of thought to extreme. Berkeley argues that since we can only be certain of anything when we see it, when we do not see it we cannot be certain that it exists. He maintains, essentially, that material objects exist only because we perceive them. To the objection that in that case a tree, for example, would cease to exist if no one could see it, he replies that God always perceives everything, and that it is only because of this that things do not have a discontinuous existence. Well it is certainly a novel view of reality, but although consistent, it is certainly open to a degree of ridicule. You may know the limerick by Ronald Knox

> There was a young man who said 'God
> Must think it exceedingly odd
> If he finds that this tree
> Continues to be
> When there's no one about in the Quad.

And the reply

> Dear Sir
> Your astonishment's odd
> I am always about in the Quad
> And that's why this tree
> Will continue to be
> Since observed by Yours Faithfully
> God

Oddly enough, as we shall see, when we come to look at modern Quantum theory, there is in fact a grain of truth in this approach, although few nowadays would take it to the extremes of Berkeley and his disciples.

Hume developed the empiricism of Locke to its logical extremes, and, as Russell says, thereby rendered it incredible. Hume argues that because all perception is basically subjective, we cannot be absolutely certain either of substance or cause and effect. As Russell says, his philosophy represents the ultimate bankruptcy of

eighteenth century rationalism. He starts out like Locke, with the intention of being sensible and empirical, taking nothing on trust, but seeking whatever can be gained from experience and observation. But being more rigorous than Locke, he arrives at the disastrous conclusion that from reason and experience nothing is to be learnt with certainty. There can, on his philosophy be no such thing as rational belief. All new ideas and thought, however well they are accepted by the age, ultimately go too far, and generate counter ideas and methods of thinking.

We have dealt in this chapter with the 'Age of reason', when man first broke out of the bonds of religion, and ventured out of his shelter into the wide plains of reason and observation. By the close of the eighteenth century, Newton the intellectual giant of the century had established the mechanism of the heavens, and Dalton and Avogadro had laid the foundations of modern chemistry. Civilized men looked forward to a steady and continuous progress towards an ever more reasonable Universe. God was relegated to the status of the Divine Clockmaker, who had built the marvellous mechanism, and set it into motion. Addison's verse, quoted at the beginning of the chapter sums up the views of all reasonable educated men of the time.

But men are rarely entirely reasonable, and a backlash of one kind or another was inevitable. Hume had shown the limits of strictly empirical philosophy, and his scepticism fuelled the inevitable reaction against reason. The next chapter deals with this backlash, the revolt against reason and science, which occurred in both philosophy and religion. It is fortunate for us, that owing to the destruction of the power of the Catholic Church in the Reformation, and the rise of the modern secular state, that this backlash was never powerful enough to stifle the progress of science.

Chapter 5

Romanticism and the Evangelical revival.

Lame as I am, I take the prey
Hell, earth, and sin with ease o'ercome
I leap for joy, pursue my way
And as a bounding hart fly home
Through all eternity to prove
Thy nature and thy name is love
—Charles Wesley

"*The heart has its reasons the mind does not know of*"
—Blaise Pascal

The renaissance of the fifteenth and sixteenth centuries had, however, a much wider influence than a purely scientific one. This is because it was accompanied

and perhaps caused by a revolution which is comparable to the communications revolution of today, i.e. the printing press.

For the invention of printing meant that the written word could be reproduced and disseminated cheaply, just as we can now phone each other cheaply. Books, which had been the province of the monastery and court, copied by hand, and absurdly expensive, became available to all. And the printers printed mainly one book The Bible, indeed you needed a license from the Lord Chamberlain's office to print anything else!! So when a child was taught to read he was taught from the Bible. It was literally “The Word of God” and regarded much as a devout Muslim regards the Koran.

Even Newton the greatest scientist of the age, although probably basically a Unitarian, had a deep belief in the Bible as the Word of God, as written by men who were inspired. It is not commonly realized that he studied and wrote on the Bible extensively, and a huge tome was published after his death “Observations upon the Prophecies of Daniel and the Apocalypse of St John” which has now largely vanished into obscurity.

But by the end of the seventeenth century, there were already signs of a revolt against the scientific rationalism of the age, a revolt which encompassed both manners, morals, and philosophy. Perhaps it is hardly surprising, after all, the fine gentlemanly world of the educated scientist or philosopher, was really only a polite crust on top of a seething pit of ignorance and cruelty. Hogarth's cartoons of the Rakes Progress, illustrate this aspect of eighteenth century life very well, his fine ladies and gentlemen hover on the verge of drunkenness, and destitution, Gin alley is only just round the corner. For underneath that elegant facade there was an ignorant, primitive world, which the rich and secure resolutely persist in ignoring until they in their turn by misfortune or recklessness are dragged down into the pit. Sooner or later, men were bound to revolt against this elegant, polite, and artificial world.

Rousseau in France, was the forerunner of this revolt, which we now call the Romantic movement. It affected all sections of society, and its influence still prevalent today, especially in the arts and in religion. In the arts it produced a sea change in human perception and attitudes. Before the romantic revolution, moor, mountain and wilderness, were an abhorrent desolation’s, to be avoided at all costs by men of sense and prudence. Boswell and Johnson when they journeyed to the Hebrides have nothing good to say of the wild and beautiful scenery of those parts. But the Lakeland poets, Coleridge and Wordsworth, a few years later, found the mountains of the Lake district sublime and magnificent, and soon the fashionable world flocked to see them and admire their grandeur. At the same time the humble peasant who lived in the valleys, previously considered an ignorant yokel, suddenly became an object of romantic approval. Feeling and 'sensibility' are all, reason and logic hardly get a look in. Although the romantic movement of the late eighteenth century was far from being particularly ethical, its attitudes indirectly influenced the evangelical revivals of the eighteenth and nineteenth century in its appeal to the heart rather than to reason. For since the romantic revolution, the vast majority of protestant theologians have appealed, not to reason, but to faith, as the evidence of their belief.

Rousseau (1712-1778) was not a very sympathetic character in himself. Burke said of him "He entertained no principle, either to influence his heart, or guide his understanding, but vanity". Despite his claim of a warm and sensitive heart, he never seems to have let this hinder him from being pretty unpleasant even to his best friends. Even his children were abandoned to the local Foundling Hospital, because he and his common law wife would not, or could not look after them. Despite this, his writings and thought had immense influence on the time. People were turning away from the logical, mechanical world of Descartes and Newtonian mechanics, to a greater admiration of what in France was called "La sensibilitie", which meant a susceptibility to sympathy and feeling. Rousseau's first literary success was an essay for the Academy of Dijon, on the question of whether the arts and sciences had benefited mankind. He argued that in fact they had not, that they had enslaved mankind. He claimed to admire what he calls the 'noble savage', by which he means man living in a state of complete ignorance of science or technology, and claimed that everything that distinguishes civilized man from the savage is evil, Astronomy has its origins in superstition, geometry from avarice, and physics from vain curiosity. He followed this up with an essay on 'Inequality', claiming that man is naturally good, and that only the institutions of the state have made him bad (he does not object to natural inequality, but only to inequality resulting from privileges established by convention). Rousseau sent the latter essay to Voltaire, who replied sardonically "One longs, on reading your book, to walk on all fours. But as I have lost the habit for more than sixty years, I feel unhappily the impossibility of resuming it".

Rousseau wrote several books, *Emile*—a treatise on education, *Julie* or the new *Heloise*—a precursor of the romantic novel of today, and two very important books *The Social Contract*, and a *Discourse on Inequality* which strongly influenced modern political thought. His autobiographical writing introduced the eighteenth century movement known as the Age of Sensibility.

Although in general Rousseau's philosophy, such as it is, is perhaps intentionally outrageous, the romantic revival which it fostered, resulted in a major innovation in theology, which has now been accepted by the majority of Protestant theologians. Up to his time, anyone questioned on belief in God would have made use of at least some intellectual arguments, i.e. the ontological argument, or the argument from first and final causes. We may not now find these arguments very convincing, unless we believe in God's existence anyway, but they were acceptable to most, and not without strengths. But, as Russell remarks, modern Protestant theologians, in the main despise the old 'proofs', and base their belief on some aspect of human nature, awe and mystery, right and wrong, inspiration etc. This way of defending religious belief was first put forward by Rousseau, and is now so familiar to the modern reader, that he may not realize its full originality at the time.

As Russell says, this rejection of reason in favour of the heart, is not much of an advance. Indeed no one thought of it as long as reason could be invoked to defend religious belief, it was only when reason appeared to deny or water down religion, that it became intellectually respectable to defend it from the heart only. However unappealing Rousseau's life may have been, his philosophy of life has been a deep and lasting influence on the west since his day. Such diverse movements as the

romantic poetry of the late eighteenth century, the romantic novel, the worship of nature in all it's forms, the romantic devotion of so many people to a country cottage, even perhaps the nature conservation movement of modern day times, all owe their root to his thought and philosophy, that nature is more noble than civilization, the heart is more important than the head. Of course the 'noble savage' as conceived of by Rousseau is a figment of his imagination, and is in reality just as self seeking and corruptible as his civilized cousin, and life in nature is in reality often brutal and short. Nonetheless, Rousseau is a necessary antidote to the deterministic universe of Newton and Descartes.

The antinomy between 'revealed religion' and 'natural science', between the religious and the logical modes of thought begins to sharpen from this time on. It probably always existed to a degree, even in Ancient Greece, as between the 'orphic' mystery religions, and the more logical reasoned thought of the ancient philosophers. The Catholic synthesis of Thomas Aquinas, brought the two modes of thought into harmony for a short time, but the synthesis proved ultimately to be unstable. Although the Catholic church has in general held on to it, even up to the present time, the Protestant Churches, with their inherent tendency to schism, have largely abandoned it.

Pre eminent in England by the end of the eighteenth century was the Methodist Revival led by John and Charles Wesley(1725–1795). There are many strands to the England of the late eighteenth century, and without understanding them we cannot understand the evangelical revival, and its climax in the nineteenth century. England in Wesley's day was a nation, outwardly calm and civilized and prosperous under the Georges, but inwardly full of fears and suppressed passions. Barely a hundred years before, she had only just survived the sectarianism and disorder of the civil war between the Puritans and the Round heads, followed by the unstable interregnum of the Commonwealth, and Restoration, and the subsequent (largely peaceable) revolution of 1688. Within living memory the Stuart revolt of the forties had threatened even London itself, and been put down by Cumberland's butchery.

The scars run deep in English society. I remember a story told of two villages in the depths of rural England, A reporter in the local pub in one village, asked the landlord why, in the general election, there were so many posters for the local Labour candidate, whilst only half a mile away in the other village, the posters were for the Conservative. "*Arrgh*" said the landlord "Well yur see sur, in the Civil war we was fur Cromwell, and they was fur the King"!. It may be apocryphal, but it has the ring of truth—old attitudes die hard. In Georgian England, anything that threatened the existing order and prosperity was regarded with fear and loathing by the upper educated classes. On the surface society was elegant, mannered and rational. But to be an 'enthusiast', i.e. one who followed some errant or wild religious creed was highly suspect. Underneath the veneer one suspects, was a maelstrom of civil, religious, and social fears.

The infant industrial revolution was pulling men and women out of the timeless, hierarchical world of the village and the squire, into the growing towns and cities. There, bereft of leadership, and tradition, a new urban poor was developing, hungry for something to believe in, and a society to belong to. To these people, the majestic clockwork of Newton, and the logical determinism of Descartes had

nothing to offer. They would not have understood it even if they had been told about it. To the working class men and women of the time, John Wesley, with his teaching of pure universal love and salvation, came like an angel from heaven. For the Wesley's were 'Arminians'. Not for them, the predestination of the Elect, or the ritual of the High Church. They preached salvation for all, and conviction of it now, in this world, and they preached it to high and low, to peasant and squire. From the late seventies of the century Methodism spread like wildfire, assisted it must be said by the failure of the Church of England to tackle the problems of the urban society developing in the towns. There is a close similarity between the primitive Orphic mystery religions of classical Greece, and the attitudes of the Revival. Both were inspired by a real and powerful personal devotion, in the one case Bacchus, in the other Christ. Before you revolt against this statement, go back and read the strangely moving hymn quoted earlier in this book.

"My days have run,
Thy servant I
Initiate of Idaean Jove.
Where midnight Zagreus roves, I rove
I have endured his thunder cry
Robed in pure white I have borne me clean
From man's vile birth and coffined clay
And exiled from my lips away
Touch of all meat where life has been"

And compare it with Charles Wesleys great conversion hymn

Contented now, apon my thigh
I halt, till life's short journey end.
All helplessness, all weakness I
On thee alone for strength depend
Lame as I am, I take the prey,
Hell, earth, and sin with ease o'ercome
I leap for joy, pursue my way
And as a bounding hart fly home
Through all eternity to prove
Thy nature, and thy name is Love.

John Wesley himself was not an unreasonable man, he was extremely well read by the standards of his time, but generally he was sceptical of the science of his time. He notes in his diary "I read Mr Huygen's Conjectures on the Planetary World. He surprised me. I think he clearly proves the moon is not habitable; I know the earth is. Of the rest I know nothing." Of Dr Wilson's tract on circulation of the blood, he exclaims "What are we sure about, except the Bible!". Indeed he describes himself (not entirely fairly) as "A man of one Book—the Bible". He judged everything he read by the Bible, and would have been shocked to the core by modern attitudes to it.

Indeed, the comment stands for the whole of the Evangelical movement which swept England in subsequent years. For the Bible was their Beginning, their Rule, and their End. In part this was due to the lasting effect of the Reformation upon thought in the protestant north. For though the rule of the Saints, and the tyranny of the Sects had been defeated, the Bible remained, a revered and sacred book to Round head and Cavalier alike. Also, it is easy to forget, in these days of ready availability of books, that for generations, the Bible was not just 'The Book', it was the only book available for most people, and served not only as holy writ, but also as dictionary and primer. Most children learnt to read from the Bible itself, some even being set a chapter of the King James version to read each week, a feat which few modern children could compass. If the 'Good Book' was nursery primer, catechism, and lectionary, read morning and night, day in day out, it is hardly surprising that it was imprinted on the minds and hearts those generations, in much the same way that the Koran is imprinted into the hearts of Muslims today for much the same reason. I have not forgotten the fashionable and educated Muslim lady who being told that there were several different translations of the Bible available in English, indignantly accused my wife "But you have altered your Book!!", for her Book, the Koran, was sacred, the word of Allah, it had to be read in Arabic, in which it was originally written, or not at all, and could in no way be altered or translated. This devotion to a uniquely inspired scripture is common both to present day Islam, and to fundamental Christianity .

Much good came from this personal religion. Under the influence of the dissenters and the evangelical revival, many of the abuses and evils of eighteenth century England were slowly ameliorated. Wilberforce almost single handed, abolished slavery, Lord Shaftesbury abolished slave labour in the factories and mines. Peel set up the first efficient and non corrupt police force. If England was saved from revolution in the 1820's when the Chartist movement threatened both Monarchy and State, it is probably due in no small account to the restraining influence of the Evangelical revival, whose influence spread upwards in society, until by the 1850's, even the nobility were affected. Even in a modern secular society, we should not underestimate the power of religion, both for good and evil, and in the late eighteenth century, and the early nineteenth century its influence was almost entirely to the good. It was essentially a personal religion, and unlike the later Papacy of Galileo's time it made no real attempt to restrict or control the science of the time. Indeed, one of the oddest things about the nineteenth century scene is the way in which advances in scientific knowledge, went hand in hand with the increasing power of religion in men's lives, until almost the end of the century.

This was due to two reasons. On the one hand the churches no longer had to defend the dead hand of the Middle ages philosophy and science. After that one dreadful episode with Galileo, even the Catholic church no longer seriously intervened in scientific matters. The reformation, did not prohibit scientific inquiry, and was essentially an attempt, spurred by nationalism, to return to an earlier purer, more primitive form of Christianity, which was essentially bible based. And the Bible has never been, or ever claimed to be, a scientific textbook. On the other hand while the scientific world was developing rapidly in technology, chemistry, smelting, metallurgy, electricity, and magnetism, these matters had

very little impact on Christian belief. It was an age of practical discovery, devoted largely to the rapidly developing worlds of Chemistry, Electricity, and Technology, subjects about which the Bible says nothing. So that provided you can ignore a few passages about the sun standing still in the book of Joshua, you could get by quite happily in your factory or laboratory in the week, and go to church without qualms on Sunday. Indeed Clerk Maxwell one of the greatest physicists of the nineteenth century was a practicing and devout Christian.

The conflict when it came, was not was not about a scientific observation, as was the case with Galileo, but about the Bible itself, and the role of divine revelation in the Bible. For Christianity, almost from the beginning, insisted, as all proselytizing religions do, on the divine origin of its scriptures. Most people nowadays, unless they are religious fundamentalists, view the bible as a sort of religious 'copybook', containing myth, legend, poetry, history, and moral teaching, collected over several thousand years or so. But such a view would have been anathema to out forefathers. For them the 'Good Book' was, literally, divinely inspired. From the early days of the Church, when the Septuagint was said to have been translated from the Hebrew by seventy scholars, who were all inspired to produce identical translations, God was felt to have had a direct and formative hand in its compilation. It was quite literally the 'Word of God'. They scanned its pages to prove or disprove their actions, they believed everything it said, explicit or implicit, and if it was in any way inconsistent or self contradictory, it was to be interpreted allegorically or if that did not serve, put aside as a mystery. Even Newton, sane and logical as he was, spent many years attempting to interpret the book of Revelation.

The problems did not start until the middle of the nineteenth century, when advances in geological science made it clear to the most prejudiced observer that the earth was many millions of years older than the 6000 odd years implied by the chronology of the Old Testament.

Then in the 1850's Darwin and Wallace independently advanced the theory of Natural Selection, arguing that species had differentiated by a process of natural selection, over many millions of years, and that by implication Man himself, must have descended from the family of the apes. The impact on the world was as startling and eventful as Galileo’s discovery of the moons of Jupiter 300 years before. The Established Church was outraged. Thomas Huxley and Bishop Wilberforce engaged in a fierce public debate which culminated in Huxley being asked sarcastically whether he was descended from the apes on his father’s or his mother’s side. For to a public used to being assured from the pulpit that man was special in the eyes of God, and had been created in his image, to be told that he was in fact only a descendant of an ape, was outrageous. Furthermore, to be told that the mode of selection was by the law of the jungle, the survival of the fittest, was the last straw. From that day to this, the theory of evolution has been rejected by many well meaning Christians, especially those of a fundamentalist persuasion.

Part of the problem, is that unlike Galileo's demonstration of the moons of Jupiter, which can been shown to anybody willing to look through a telescope, there has never been any very dramatic demonstration of Evolution, and indeed in view of the timescale required of any such experiment, there probably never will be. Also, when it was first put forward, no mechanism was known to explain the

biological mechanism involved. Furthermore the argument as to whether natural selection was Darwinian, i.e. by weeding out the unfit, or Lamarckian, i.e. by inheritance of acquired characteristics, was to plague biologists for some generations yet.

In a way, the whole of the period 1750-1914, is a tale of two cultures, neither of which paid any regard to the other. Reading the Christian writers of the age, one is struck, time and time again, by their total ignorance, and disregard of the scientific world which was developing under their very eyes. Even Cardinal Newman, who intellectually was by no means negligible, seems never to have considered the scientific evidence which was shortly to blow his world sky high.

For in spite of Darwin's 'Evolution of the Species', and the geological discoveries which completely overturned the chronology of the Old Testament, the Churches, both on the Evangelical wing and the Catholic wing, went calmly about their way, sublimely unconscious of the gulf yawning at their feet. Indeed, in the late 1870's there was a swing back towards medievalism and Platonic philosophy in the Anglo Catholic Oxford movement. The membership of the Churches, both Dissenting and Anglican, peaked in England at around 1890. In modern America, religious observance is still very high, even at the present date. A modern religious phenomenon is the Charismatic and Jesus movements of the nineteen seventies and eighties. In part these, with their appeal to emotion and 'Jesus is Lord', and their use of guitar and gospel music, are a reaction to the increasing formality and 'spiritual deadness' perceived , rightly or wrongly, in the older established churches. But in terms of doctrine, they are essentially primitive. I suspect that many charismatic and evangelical adherents would deny this, and perhaps it is a rather sweeping statement. But certainly the average attendee at a charismatic service today is almost totally uninterested in doctrine. Mention the trinity to him and his eyes will immediately glaze over, God to him is merely another name for Jesus. It seems that Christianity has finally stripped itself down to its bare essentials. The sole remaining cry is "Jesus is Lord". It may perhaps, to some extent be scriptural, it is undeniably emotionally powerful, but one wonders what Jesus himself, an entirely orthodox Jew, would have made of it!!.

It seems that any attempt by the churches to incorporate more logical religious thought (if that is not a contradiction in terms) automatically produces an emotional swing in the opposite direction. This is a phenomenon which started over two hundred and fifty years ago in the Evangelical Revival, and still has power to move and sway our thought today. It seems that man, in spite of the logical power of his brain, is not really a very a logical creature. Blaise Pascal observed, over two hundred years ago that "The heart has its reasons the mind does not know of", and I think he was wiser than he knew. For Man needs both emotional experience and reason. In essence we want more than logic or a 'divine clockmaker', we need also to wonder, worship, and adore. Perhaps this is linked with the structure of our brains themselves, with a right side dealing with words and logic, and a left side dealing with emotion and drive.

If we are to attain a new synthesis of religion and science, we shall have to take this dichotomy into account. It may be that the attempt is doomed to failure. Nonetheless I believe that it must be attempted. Mankind cannot live in two separate worlds at once and remain sane. The 'cult of unreason' in our modern

world, the proliferation of sect after sect, believing in ever wilder fantasies, is a sign of this insanity, and is a danger to us all.

Chapter 6

The Triumph of Nineteenth Century Science.

"*To myself I seem to have been only like a boy, playing on the sea shore, and diverting myself now and again finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all before me*"

—Isaac Newton

By the end of the eighteenth century, the scene was set for what many people of the time thought was the final triumph of Science over Religion. By the beginning of the century Newton had established the laws of gravitation and applied them to the heavens and by the end of the century Dalton and Avogadro had established the fundamentals of Chemistry, and the way was open for the advances in Astronomy, Physics, Chemistry, 'and Mineralogy which were to occupy most of the nineteenth century.

To cover so vast a field in a single chapter is impossible, if you have had a scientific education you will know it anyway, and if you have not, you could not hope to pick up much of it in so short a space. Nonetheless, certain key points have to be picked out, if you are to understand the arguments in the succeeding chapters of this book. Those of you with a scientific education may pass over this chapter, but for those who have not been so fortunate (or unfortunate!!) it is, I am afraid, necessary reading. I propose to deal with some of the major advances in physics, chemistry, geology, and biology during the nineteenth century, and their impact of the attitudes and thought of the western world.

Let us begin by going back to Isaac Newton's ideas about gravitation, as exemplified by the way in which the moon orbits the earth. Newton showed quite clearly that this could be explained extremely very accurately by postulating a gravitational force between the earth and the moon which was proportional to the product of their masses and inversely proportional to the square of their separation. At the time there was much criticism of this force as implying some sort of spooky 'action at a distance' (after all, it was objected, there was no rope, as it were, tethering the moon to the earth!!).

Nowadays we are happier with the idea of action at a distance, we call it a 'field' . A field is simply a description of the strength and direction of the forces which surround an object. A gravitational field surrounds the earth which decreases with the square of the distance.

You can easily visualize the magnetic field around a bar magnet or a coil carrying electric current by scattering iron filings over a sheet of card placed above

the magnet or coil. The filings line up along the field around the magnet to show the direction and intensity of the magnetic field.

Similarly an electric field forms around a charged body. Charges may be positive or negative, like charges repel each other unlike charges attract each other. As with a gravitational field the intensity of the charge decreases with the square of the distance

Magnetic fields and electric fields are closely connected, a moving electric field generates a magnetic field and a moving magnetic field generates an electric field In the early nineteenth century Faraday constructed the first electric motor based on this principle using the repulsion of the magnetic field generated by a moving coil carrying electricity, by a permanent magnet.

A field occupies space, and it has energy and momentum, in practice however most known fields (gravitational, magnetic, electric etc) diminish with distance to the point of being undetectable.

Because electric and magnetic fields interact, (the one causes the other and vice versa), a disturbance in an electromagnetic field can propagate through space. Such a disturbance is called an electromagnetic wave and because it is not subject to attenuation it can travel through a vacuum almost indefinitely.

Light is a form of electromagnetic radiation, which covers the whole spectrum from X rays to radio waves, including heat radiation, and the visible spectrum.

Visible light was first studied properly by Newton, who showed that white light from the sun could be split by a prism into the light of different colours called the chromatic spectrum. Newton seems to have thought of light as corpuscles, or small particles, travelling in straight lines, unless they were bent or refracted by a prism. However this viewpoint was later challenged by Young, who showed that monochromatic light, i.e. light of one single colour or wavelength, could be diffracted by a finely ruled grating or slits, and that an 'interference' pattern resulted analogous to that which resulted if waves on the surface of a liquid interfere with one another.

Such interference patterns can be shown to occur not just with light but with a wide range of radiation, ranging from X-rays, through ultra violet radiation and the visible spectrum and infra red radiation, to radio waves. Increasingly therefore as time went on, light was seen as merely part of a whole range of radiation and was thought to be basically 'wave like' in nature.

The full theory of this 'electromagnetic radiation' as it came to be called, and its relation to electricity and magnetism was first worked out by Clerk Maxwell (1831-1879) in 1862, who showed that light could be interpreted as a transverse wave in an ‘electromagnetic' field. He calculated that the velocity of such waves in a perfectly elastic medium would be the ratio of the electromagnetic and the and electrostatic units of charge, which comes out at 186,000 miles per second in a vacuum—almost exactly the measured astronomical speed of light!!. Clerk Maxwell's theory worked, and worked brilliantly, not only with visible light, but also with the whole range of the electromagnetic spectrum from very short X-rays, to very long radio waves. In 1888 Hertz demonstrated that periodic interruption of a current at a spark gap, generated very long electromagnetic waves which could travel over extreme distances. Marconi subsequently used these 'radio' waves to

transmit messages over many miles, and subsequently over the Atlantic. Modern 'Wireless', television, and radar all use this phenomenon.

Magnetic fields, electrostatic fields, and electromagnetic waves are all 'electromagnetic fields', the only difference between them being that the first two are stationary, whilst the last is moving.

A field is a force of some kind, and is defined only by its intensity and direction at any point. Later on we shall meet other kinds of fields. The concept of a field is extremely important in modern physics and astronomy.

In Chemistry, by the end of the nineteenth century, patient work had largely elucidated most of the known elements and their compounds, and sufficient was known for a young Russian chemist Mendeleev in 1871, to make one of the guesses by which science sometimes proceeds. He possessed an almost inspired feeling for the elements, and their properties. Looking for relationships between the elements, he noticed that if he ignored hydrogen, and listed the rest of the known elements in order of their atomic weights, they could be grouped in seven columns or groups, such that each column contained elements of very similar properties.

Evidently there was something in the sequence of the atomic weights that is not accidental but systematic. The trouble was that not all the elements were available, only sixty three out of the total of ninety two were then known, and after the first two columns, serious discrepancies occurred in Mendeleev's scheme. Most sensible men would have given up at this point, and said that there was something wrong with the whole idea. Mendeleev however was so convinced that he was right, that he boldly skipped an element or elements where necessary, predicting that in this or that gap, an element with such and such properties would be found. For example he predicted that an element which he called eka-caesium would be found, which would lie between Gallium and Arsenic, have an atomic weight of about 72, and a density of about 5.5. It would have a refractory dioxide with a density of 4.7 which was feebly basic. It would have a fluoride, which would be a liquid, boiling below 100 degrees C, and a density of 1.9. This element, now called Germanium, was in fact not discovered until 1890, and its properties almost exactly matched those predicted by Mendeleev. The whole theory was brilliantly verified in 1894 when Rayleigh and Ramsay discovered a whole new series of elements, the rare gases, Helium, Neon, Argon, and Krypton and Xenon, by fractional distillation of liquid air. The whole series slotted in neatly as Group 0, just before the Alkali metals Group 1.

It seems that the underlying pattern of the chemical elements is numerical in some way. The true reason for all this was not discovered until 1897 when J J Thompson, experimenting with vacuum discharge tubes, discovered the electron, and its counterpart the positive discharge, made up of atoms from which one or more electrons had been stripped.

It was realised that the atom is not in fact, as Dalton had thought, indivisible, it has its constituent parts—a nucleus containing positively charged protons, and an surrounding cloud of electrons, the overall charge being zero, the number of electrons balancing the charge of the protons in the nucleus. The meaning of Mendeleev's periodic table now became clear, the electrons formed, as it were 'shells' around the nucleus, a single electron in the outer shell, resulting in the

monovalent Alkali metals, Lithium, Sodium, Potassium, Rubidium, Caesium, two electrons in the outer shell giving the divalent alkali metals Beryllium, Magnesium, Calcium, Strontium, Barium and so on. Complete shells of eight electrons resulted in, the inert elements Helium, Neon, Argon, Krypton, and Xenon.

The modern theory of valence was now established. Chemists found that they could explain the reactions of the elements, and their compounds with comparative ease, and systematise what had, until that time been a vast and largely empirical body of knowledge.

Moving on, the science of thermodynamics, the quantitative relationships of heat and work, developed out of the engineer's attempts to understand and improve the steam engine, that typical product of the Victorian age. Joule first measured accurately the mechanical equivalent of heat, i.e. how much heat could be generated by a given amount of work. The first and second laws of thermodynamics were developed. The first law says briefly that heat and work are equivalent and can be converted into each other. The second says, more fundamentally, that the process of conversion of heat into work, is always more or less inefficient, that the entropy (or disorder) of the total system always tends to a maximum with time, (or in Helmholtz's stately phrase “Die entropie der welt steht un maximum zu” he disorder of the world tends always to a maximum).

In effect there is always a finite limit on the efficiency of any thermodynamic process, since waste heat always has to be thrown away to the outside world as friction or waste heat. This apparently common sense conclusion, finally put paid to attempts to develop 'perpetual motion' machines. More significantly it is the first fundamental physical law which explicitly invokes 'the arrow of time'. For Newtonian mechanics, whilst invoking time, do not state in which direction time must go. Whether an apple falls or is thrown upwards the same laws apply. But the second law of thermodynamics explicitly states that physical time can only go in one direction, the direction of increasing disorder. It is to this law that we owe both our finite lifespan of three score years and ten, and the finite lifespan of our planet, measured though it is in millions of years, (ultimately the sun itself will 'blow up' to become a white dwarf). The second law of thermodynamics is probably the one law of science which no one ever argues about!!. You may put forward the most preposterous theories, and might even get some crazy obscure Journal to publish them, but attempt to argue about this, and absolutely no one will listen to you!!

In Geology, man's exploration of the earth, was at last bearing fruit. The difference between sedimentary, igneous, and metamorphic rocks altered by the heat of volcanic action, had been established and the study of fossils and geological strata was well under way. It was beginning to dawn upon men that in geological time they were dealing with something quite different in scale to the 6000 or so years suggested by Biblical Chronology, and that there was just no way that the rocks of the earth could have been laid down in that time. The time scale had to be many many millions of years rather than a few thousands.

But it was in Biology that the real crisis for the religion of the time exploded. In 1831 a young biologist Darwin went on a five year voyage round the world in the survey ship HMS BEAGLE. He left England, a careful systematic observer of plant

an animal life in his own land. He came back fascinated by the variety and differences he had found in South America, utterly convinced that in some way species evolve in different directions when they are isolated in different ·environments. He wrote a very entertaining book about his journeys *The voyage of the BEAGLE*, which is still well worth reading. Two years later, reading Malthus, he hit upon the idea of natural selection—the survival of the fittest—acting upon the natural variability of species and their offspring. Although Darwin wrote his ideas up, he was most reluctant to publish it, for it went clean against the prevailing religious culture and beliefs of the time, and he might well never have done so, if another biologist, Wallace, had not had the same idea in 1858, over twenty years later, and knowing he was interested in the subject, sent him a draft of a paper on the subject.

Darwin's friends thereupon persuaded him to publish his work. In 1859 he wrote *The Origin of the Species*. It was an instant best seller. It was followed in 1871 with “The Descent of Man”, which opened the floodgates of controversy. For to Victorian England, used to being told, Sunday after Sunday, that they were the children of God, to find out that they were, in fact the children of monkeys, was to say the least, a trifle upsetting. One of Darwin's supporters, T.H. Huxley, in a heated debate with Bishop Wilberforce, was sarcastically asked whether he was descended form a monkey on his mothers or his father's side!!. One suspects that the good bishop had lost his cool by this time, since abuse is ever the resort of those who have lost a reasoned argument.

The heart of the problem, was the mechanism proposed, 'natural selection', or the survival of the fittest, which was disliked by many people on moral grounds. One suspects that most would have preferred Lamarck's idea, that the species were modified by the offspring inheriting their parent’s acquired characteristics, rather than by the survival of the fittest, with the weakest going to the wall. Indeed, only 50 years ago, Communist Russia almost wrecked its efforts to improve agricultural production by supporting a biologist, Lysenko, who thought Lamarck was correct, purely for reasons of party doctrine.

The clue to the mechanism of inheritance forms one of the most fascinating stories of scientific history, for in fact the modern science of genetics was founded at practically the same time as Darwin's publication of *The Origin of the Species*. It was first published by Gregor Mendel in 1866, in a very obscure provincial Austrian Journal. Understood by nobody, it was instantly forgotten, and ignored for over forty years, only to be rediscovered at the turn of the century, when its true significance was recognized, nearly 40 years after his death.

Gregor Mendel was a farmer's son, and remained throughout his life a farm boy in the plodding way he went about his work. He had become a monk to get an education, and joined a teaching order. His abbot sent him to the University of Vienna to get a teaching diploma, but his examiner failed him with the comment “he lacks insight and the requisite clarity of knowledge”!!. Disgraced he returned to the monastery at Brno and started work in the kitchen gardens. What is fascinating about his experiments, is that he must have known more or less what he was going to find, even before he started to look for it. For plant breeding experiments are not like normal experimental work, the time scale is years not

days, and a proper scheme of experimental work must be set out before you commence.

Mendel chose the common pea for his studies, and selected seven varieties which had bred true for shape of seed, colour of seed, etc... finishing with tall versus short. He found that when he crossed tall varieties with short for example, all the offspring were tall. Crossing these offspring to get the third generation however he found that approximately one plant in four is short, and the rest are tall. Why should this be? The conventional view at the time was simply that the second and third generations should just have been intermediate in some random fashion. Mendel guessed the correct explanation, the characteristic (or gene) for tall was dominant over the characteristic'(or gene) for short, hence the second generation were all tall. But half of this second generation carried the recessive short gene as well as the tall gene, and crosses of these gave half short and half tall. The characteristics for short and tall are paired in some way. Why paired?, remember this is generations before anyone knew anything about genes or Chromosomes, on which the pairing can be plainly seen under the ultra violet microscope. We can only surmise that this humble farmers son knew instinctively that sex involved two partners, and that one partner or other was dominant, a fact which might well have escaped a scholar or an academic!.

Confirmation that Mendel guessed before he started, what he was looking for, has come from an unlikely source, statistical examination of his results has shown that either he was phenomenally lucky, or biased—the results are just too good to be statistically likely!!. Note carefully, I did not say that they are wrong, they are just rather too good to be true!!. Did he fake them? No one really believes that he did, but there is little doubt that he knew what he was looking for, and unconsciously weeded out the doubtful results!!

But at the time no one understood his work, and not a soul took any notice. The paper gathered dust on the library shelf for almost a lifetime. Two years later, the monks made him Abbot of the monastery, and he seems to have abandoned his plant breeding experiments and spent the rest of his life doing the monastery accounts with commendable zeal, and a little too much fussiness. When he died the new Abbot burnt all his papers, and only chance preserved the original research paper in the obscure Journal of the Brno Natural History Society, to be rediscovered long after his death!!

The concluding part of our tale, is the story of the discovery of Isotopes and Radioactivity. In part this is the final conclusion of Mendeleev's discovery of the Periodic table. For there are two problems with the periodic table, firstly some elements have fractional atomic weights. If the nucleus is made up of protons only, and the lightest (reference) element, hydrogen has one proton only in its nucleus, then it is difficult to see why some elements, e.g. Chlorine (35.457) have atomic weights so far removed from a simple numerical sequence. The second problem is that there is no obvious reason why Uranium should be the final element in the table, or why the abundance of the elements varies as widely as it does. The first problem was solved in 1900 by Moseley and Aston, who following on J J Thompson's work on vacuum discharge tubes, developed the mass spectrograph and showed that most elements were in fact mixtures of nuclei of different atomic weights, chlorine for example containing the isotopes of mass

number 35 and 37, in proportions giving an overall atomic weight of 35.47. An isotope is at atom of an element which has all the properties of that element but a slightly different atomic weight to the norm, due to an excess or deficit of uncharged particles called neutrons in its nucleus. Separation of these isotopes in any quantity by physical and chemical means is extremely difficult, and has only been effectively solved in recent years, by sophisticated diffusion and centrifuge technology.

In 1896 Bequerel, showed that certain compounds of Uranium emitted radiation which blackened a photographic plate, and ionised the surrounding air. Marie Curie showed that this was, in fact, a property of the uranium atom, since it depended only on the uranium content of the compound. However certain uranium ores, pitchblende in particular, had a much higher radioactivity than could be accounted for by its uranium content, and she surmised that it contained another more radioactive element hitherto unknown. How much more radioactive, she could never have guessed. Radium when finally isolated, proved to be so radioactive that it glowed in the dark, and generated appreciable amounts of heat, over a hundred calories of heat per gram of radium per hour. Even more remarkable, was the fact that the heat evolution was completely independent of the temperature, over a range of 250 to 1000 degrees centigrade, and apparently virtually inexhaustible, facts which preclude any thought of a chemical process of any ordinary type.

Radioactivity is in fact, the spontaneous, and random, disintegration of the nucleus into simpler nuclei. It is completely independent of any outside pressure or temperature conditions, and the 'half life' of any radioactive isotope, i.e. the time taken for it to decay to half its original value, is completely characteristic of that particular isotope. Radium was found to be composed of several isotopes, whose half life varied between 22 years and a few minutes. Uranium on the other hand was composed of three isotopes, 234, 235, and 238, only the 235 isotope being significantly radioactive. Marie Curie became famous for her work, and the subsequent use of radium compounds to treat cancerous conditions. Ironically, she herself died at a relatively early age, largely due to the heavy dosage of radiation she had received over the course of a life devoted to the study of radioactivity and its elements.

We have now come to the end of an admittedly sketchy and incomplete review of nineteenth century science, the age of classical physics and chemistry. By the end of 1910 most of the major problems seemed to have been sorted out. The chemists had largely solved the problems of their material world, The periodic table had been developed, and the place of the elements in it largely defined. The classical picture of the atom had emerged, of a nucleus composed of one or more protons associated with approximately the same number of neutrons, surrounded by orbiting electrons in shells around the nucleus, the outer shell largely controlling the chemical properties of the element.

The electromagnetic theories of Maxwell had largely solved the problems of electricity and magnetism. Radio waves had been discovered and the first radio messages had been sent across the Atlantic. Radioactivity was just an interesting phenomenon, of a few unusual elements and isotopes, with little practical application apart from the treatment of cancer . There seemed no reason why in a

few more years, most of the remaining problems should not have been sorted out, and mankind could settle down to a calm and dignified golden age of scientific prosperity and optimism.

But it was not to be. The next chapter deals with 'the ghost in the machine', the demonstration that within this admirably logical system, the ghosts of chaos and uncertainty were lurking. That time and space themselves were far from the sensible, certain things they first appeared. That the 'solid globe' of nineteenth century science and materialism was about to collapse, 'like an insubstantial pageant, and leave not a wrack behind'. The next chapter covers the fundamental reappraisal of space and time brought about by Einstein's theory of relativity, and the next the breakdown of classical physics and chemistry, brought about by quantum theory.

Chapter 7

Relativity, a new look at the heavens.

God said "*Let Newton Be and all was light*"
Twas not to be
The Devil shouting "*Ho!! Let Einstein be*"
restored the status quo.

There is a story told of the celebrated lawyer and wit Sydney Smith, that one day, walking down a narrow street in Edinburgh he heard two women quarrelling across the road from two opposite houses. Turning to his companion he said "They will never agree, they are arguing from different premises". If you keep this in mind, you cannot go far wrong when trying to understand relativity, which basically says that two observers moving at different speeds will not agree on either the distance or time—because they are looking at them from different premises or 'frames of reference'.

Einstein's major contribution to Physics, his theory of relativity, was to point out that just as there is no 'absolute' distance between two events, neither is there any 'absolute' time between them, both the observed distance and the observed time depend on the relative velocities of the observer and the event. The only thing that links them is the maximum speed at which information can pass between them, i.e. the velocity of light.

Relativity is closely connected with the speed of light, since this is the maximum speed at which any information may be transmitted between observers and events. When Clerk Maxwell developed the theory of electromagnetic radiation in 1867, his equations described light as being transmitted in the form of transverse (up and down) electromagnetic waves, rather like those which form when you throw a pebble into a pond of water.

When the Clerk Maxwell's theory was first put forward, some physicists thought that there must be some infinitely rarefied elastic medium—the 'ether'—pervading

all space, in which the waves travelled. The difficulty was to conceive what this 'ether' actually was. The idea was not new, Descartes had proposed a similar rarefied form of matter in his development of the vortex theory of the cosmos. Most physicists however did not think of it as having any real physical existence at all.

But when we talk of the velocity of light surely we must refer it to something!! After all there is no such thing as an 'absolute' velocity, all velocities must be relative to something or other. It was therefore tacitly assumed that in some way, the velocity of light must be relative to this medium, the 'ether', and that normal Newtonian laws would apply, i.e. the velocity of light would vary with the speed of the light source through the ether.

In 1891 Michelson attempted to measure this difference by setting up an experimental system in which the velocity of light could be measured very accurately. By setting up the apparatus firstly parallel to the earth's motion round the sun, i.e. EW, and then perpendicular to the motion, i.e. N-S, he expected to find a very small difference in the velocity of light, corresponding to the velocity of the earth through the ether. To his astonishment no difference was found, whichever way he set up the apparatus, north-south, or east-west, or whatever time of the year the tests were done. The experiment was repeated more accurately a few years later, but still no difference could be found. It is now known that within the best measurements of error, the velocity of light is a constant, irrespective of the speed or direction of either the source or the observer, a result which contradicts both common sense and Newton’s Laws of motion. After all if a light source is moving at high velocity towards you, you would expect the observed velocity of the emitted light waves to be increased, and if it were moving away from you, you would expect their velocity to be diminished.

But for light, no such effect can be found, all observers measure the same speed, no matter how fast, they or the source of the light, are moving. This oddly humdrum, yet vitally important fact was to prove the first crack in the edifice of classical science. (strange when you think about it!, normally it is disagreement that sparks off controversy, but in this case it is agreement that upsets the apple cart:)

To illustrate just how odd this is, think of trying to catch up with a beam of light. As you move faster and faster, common sense tells you that the apparent speed of the beam you are chasing should diminish and that you could ultimately reduce it to zero. But that is just what Michelson's experiment showed does not happen, no matter how fast you go, it would still appear to you to be receding away from you at 186,000 miles per second! But a stationary observer would see it quite differently, he would see both you and the light beam receding into the distance at the speed of light 186000 miles per second.

Then which observer right, surely one or the other must be correct. Surely they cannot both be right!!.

In 1905 in a paper entitled *The Electrodynamics of Moving Bodies* Albert Einstein showed conclusively that both observers are right, they are just looking at it from different premises or frames of reference.

At the time that Michelson made his experiments Albert Einstein was not very distinguished student at university, (His university tutor described him as 'inattentive, and somewhat mediocre'). He took a not very distinguished degree and

went on to work as a clerk in the Patent office in Berne, where he spent some years perusing some equally mediocre patent applications. But at the same time he must have been thinking about Michelson's experiment, and the oddly constant velocity of light. And, as Bronowski says, one of the questions he must have asked himself was “What would happen if I rode on a beam of light?”. And the conclusion he came to was really quite simple—time would stop!!. In some ways this is not too surprising, after all in such a case you are riding on the very beam which conveys information from the external world—looking back at a clock at your starting point it would appear to be frozen at the time of departure. Note however that it is only your external time that stops, your internal time, the watch that travels with you, is unaffected).

Einstein pointed out that each observers experience of the world was relative, and depended on his relative velocity (Hence the theory of relativity!!). In the case quoted above of the observer chasing the beam of light, and the observer left behind on earth, both observers were right, they are just looking at the world from different frames of reference. For the space traveller, time and space are different from the time and space experienced by the observer left behind on earth. For the space traveller, his observation of external time, the time he is leaving behind, slows down (and ultimately stops when he reaches the speed of light). It is important to note that his observation of internal time is unaffected, as far as he is concerned everything is normal, only everything outside is slowing down for him. From his point of view it is the external world which is slowing down. But for an external observer the reverse is true, for him it is the space traveller's time which is slowing down, his own time is passing normally!! This is the origin of the 'time traveller's paradox', a traveller at or near the speed of light apparently ages less rapidly than his counterpart on earth.

Although Einstein's theory involves some pretty complicated mathematics, it is basically quite simple. If you are moving at the speed of light, time (external time anyway) has frozen, stopped, finished, as far as you are concerned, if you look back at a clock on earth, its hands will appear fixed, eternally, at the time of your departure.

Einstein was able to show that not only time will slow down, but that space will contract, for the fundamental requirement that the velocity of light remains constant for all observers, implies that if time expands, distance (in the direction of motion), must also apparently shrink, ultimately to zero, to hold the speed of light constant. The effect is reciprocal, the observer on earth sees distances shrink for the space traveller, and the time traveller sees distances shrink for the observer on earth.

Bronowski has described the effect quite graphically in terms of two observers, one on the pavement, and the other travelling past in a tram at a speed close to the speed of light. The observer on the pavement will see the moving tram as very tall and thin, (there will also be colour changes due to the doppler effect, the approaching tram looks bluer, and the receding tram looks redder—but this is not a relativistic effect) . Conversely the observer inside the tram will see the outside world through similarly distorted perspective, everything outside would look very tall and thin, and he will see more of the street from his window than he could when stationary, with the forward view bluer, and the rearward view redder.

The essential point is that each observer has his own local time and space, the man on the pavement has one (we would say the 'normal' one), the man on the tram another, they will not in general agree. But they will agree, they must agree, on the speed of light, for this velocity, as Michelson and Morley have shown is constant under all circumstances. This distortion of space and time at relativistic speeds applies not only to distance, but also to mass, objects become heavier as they approach the speed of light, and at the speed of light their mass becomes infinite—one very good reason why light has no mass and relativistic space travel is impossible, the energy required to accelerate any material object to the speed of light would be infinite!!.

In an appendix to his great paper of 1905, Einstein published a simple formula expressing this relationship between mass and energy, energy equals the mass of an object times the square of the speed of light

Energy = Mass times the square of the velocity of light (E = MxC^2)

At the time this was merely a theoretical equation in an academic journal, but gradually over the succeeding years it dawned on people that it implied that if you could convert one teaspoonful of matter into energy, it would yield the energy equivalent of many million tons of coal!! It is this transformation of a small amount of matter into a large amount of energy that is responsible for the seemingly inexhaustible energy of radioactivity, and the frightening power of atomic weapons, for in both cases disintegration of an element into lighter elements occurs and mass is converted into energy.

Why is the speed of light of such fundamental importance? Fundamentally it is because it is the maximum speed at which information can be passed between two events. For it is now a cardinal principle of physics that nothing can travel faster than the speed of light in vacuum. Indeed by Einstein's theory, if it could, causality itself would be broken you would be like Miss Bright who:

“Could travel much faster than light. She went off one day, in a relative way, And came back the previous night.”

As far as we understand it at the moment, this limit is fundamental to the world we live in. It is true that hypothetical faster than light particles called 'tachyons' have been predicted by some atomic theories, but they have never been observed, and there are cogent reasons for thinking that they are merely a mathematical fiction. Likewise time travel in the usual sense of the world is prohibited since it violates causality. Recently there has been some speculation that time travel might be possible through 'worm holes' in space, but the possibility seems remote since it has been shown that even in this case you cannot violate causality.

This special theory of relativity, as it is now called, has proved to be extraordinarily successful, but problems remained in bringing gravitational forces into the picture, since under Newton's theory, gravitational forces were transmitted instantaneously (he was much criticised for this so called 'action at a distance' at the time), and thus violated this fundamental limit of the speed of light. Einstein spent some years trying to resolve this problem, and finally in 1915 published his second paper, on what is now called the general (as distinct from the special) theory of relativity. In it he proposed that gravity could be regarded as a

geometrical property of what he called space-time. This needs a little explanation. Space is usually thought of as Cartesian (three axes at right angles i.e. up/down, left/right, forwards backwards). But Space-time is four dimensional, three dimensions in space, and one in time.

The problem is that for most people visualizing things in four dimensions is impossible (although mathematically it is relatively trivial). But if we ignore one spatial dimension and represent three dimensional space as two dimensional (i.e. a thin sheet), with time as the third dimension, it becomes quite simple to visualize.

Consider the moon orbiting the earth. By Newton's theory it is held in its orbit by the gravitational pull of the earth, which balances the centrifugal force which would otherwise throw it off into space. By Einstein's theory, the earth distorts space time around it, like a massive ball resting in a depression in an elastic sheet, and the moon, moves in a geodesic in space time around it, (a geodesic is a the shortest possible path between two points) .

Indeed there is a deeply significant relationship between relativity and geometry. In 1908 Minkowski pointed out that such odd relativistic effects like length contraction and time dilation, don't appear so strange if we view them as a 'geometrical rotation' in space time. From the observer on earth's point of view the space traveller's dimensions have been 'rotated' so that he appears to become thinner and loses time. I mention this because the connection between geometry, specifically geometric symmetry rotations, and space-time is extremely important, as will be seen later when we come to deal with Quantum physics.

Both the special and the general theory of relativity have now been conclusively proved by experimental observations. Indeed the time and mass dilation effect of relativity can be directly observed in beams of atomic particles accelerated to near the speed of light in cyclotrons. Particles that only have a life of nanoseconds at lower speeds, have much longer life spans when accelerated to relativistic velocities, and electrons circulating in the huge underground cyclotron at Berne, at near relativistic speeds appear to be much heavier than electrons at lower speeds. With the development of ultra accurate atomic clocks, it is also now possible to demonstrate the time dilation effect by spinning two clocks on a flat disc, one in the centre, and the other on the periphery. The clock on the periphery runs slower than the one in the centre, and the retardation is exactly proportional to the circumferential velocity. General relativity has been confirmed by small but significant deviations from Newton’s laws in the precession of the perihelion of the orbit of Mercury, and in the bending of light under the gravitational effect of the sun, measured during solar eclipses.

Perhaps the most telling observation has been the recent astronomical discovery of a star system near the constellation of Sagitarius, which is believed to be composed of two extremely dense neutron stars orbiting each other in close proximity at relativistic speeds. We can measure the spin of one of the stars because it is a pulsar, i.e. it emits regular pulses of radio waves, and we can measure its orbital velocity round its partner because of the doppler shift of the radio waves it is emitting. Common sense suggests that as the star alternately swings towards and away from us at relativistic speeds as it orbits its partner, it signals should speed up and slow down, and that over the vast distances between

the earth and the binary system, these signals should be all 'mixed up' as they traverse the distance between us and them. But nothing of the sort occurs, the pulsar signals are unaffected by the orbital velocity, and everything is easily decipherable. Prior to 1905, such observations would have been greeted with incredulity. Now they are accepted as perfectly normal.

Very recently, the last of Einstein's predictions have been confirmed, the existence of gravitational waves in space time produced when massive objects merge, LIGO has detected very weak distortions of space and time from the merging of two black holes many thousands of light years away.

One of the most important effects of the General theory for astronomy and Cosmogony, was the prediction that space and time were distorted by mass. As Einstein saw it the reason why the moon orbits the earth, is not because of gravitational attraction, but because space time is bent around the earth, so that though the moon follows a direct path in space time, we observe its path as a curved trajectory in three dimensional space, just as the direct path for an aircraft from New York to Tokyo, is a great circle route on the globe.

But this has implications for the Universe itself. If Einstein's theory is correct, and we have no reason to think it is not, then the overall mass of the universe should result in an overall curvature of the space time continuum it occupies. We can only conjecture as to the total mass of the Universe, at the moment the 'observed' matter is only one tenth of that necessary to 'close' the equations, but mathematically it turns out that there are three general solutions, one open, one closed, and one boundary solution poised in between the two. In the first case the total mass of the universe is sufficient to 'close' it, space is curved positively like a ball, and is in effect finite but unbounded. In the second case there is insufficient matter in the universe to 'close' the system, and space is curved negatively like a hyperbola, and is infinite and unbounded, In the third case, the boundary solution, space is flat, and infinite.

It is now generally thought that space is either 'closed', and thus finite and unbounded or near to the boundary condition. The concept of space being finite and unbounded is difficult concept to understand, but it means exactly what it says, space time does not go on for ever, but it has no edge, it bends round to meet itself again. An explanation is at hand again in the two dimensional world on the surface of a sphere. To an ant on the surface of a globe, the world is finite, .but unbounded, if he sets off in any direction, he will eventually get back to where he started, there is no edge he can drop off. Similarly in the closed case the universe is finite but unbounded, if we had time, we would in setting off in a particular direction, eventually return to our starting point. (Actually, like the ant, we do not have time, even if we travelled at the speed of light, it would take longer than probable life of the universe to make the journey!!).

This idea, the idea of the curvature of space time has now been experimentally confirmed by the observation of what is called the red shift of remote galaxies. Astronomers measuring the spectra from the Galaxies have found that the further they were away, the greater the doppler red-shift in the absorption spectra of the light gathered from them. Now the only sensible interpretation of this red shift, is that the galaxies are receding away from us, and the further away they are the faster they are receding. The most distant galaxies have now been calculated to be

receding at half the speed of light!!. This red shift could of course be just a coincidence, but it seems most unlikely, since no significant blue-shift in a galaxy has ever been observed. The only conclusion that can be drawn is that the universe is expanding evenly, in all directions, like the surface of a balloon being steadily inflated. So, in present terms, we now think that the universe is curved in space time, and expanding, and depending on whether the curvature is hyperbolic and open, or spherical and closed it will either continue to expand for ever, or its expansion will eventually cease, and it will begin to contract again. But if the universe is expanding evenly in all directions, by implication it must at some time in the past have started from some inconceivable point, or singularity. From the known rate of expansion of the universe we can calculate approximately when this was, (about ten to fifteen billion years ago). This point is what is popularly known as the 'Big Bang'. Experimental confirmation of this has recently been obtained from observations of the remnants of the radiation from this 'big bang' in the form of microwave radiation, coming at us from all directions from outer space, which although now only at a temperature of approx four degrees absolute, represents the ghostly remnant of the primeval fireball.

We have come a long way from the fixed space and time of our ancestors. Three hundred years ago, Galileo shocked his contemporaries by showing that the earth was not fixed in space, but rotated around the sun. Newton, a hundred years later, in effect showed that space was not absolute, but depended on the viewpoint of the observer, i.e. was no fixed reference point. Einstein completed the process by showing that neither time nor space were absolute, both depended on the viewpoint of the observer. Absolute space and time have disappeared, vanished into thin air, to be replaced by a space-time continuum, in which the only rule is that nothing, but nothing, can travel faster than the speed of light, without violating causality. The universe described by this continuum, is curved (in space-time), and had a beginning some ten to fifteen million years ago in some big bang or singularity. We do not yet know whether it will continue to expand indefinitely, or whether it will ultimately stop expanding and collapse back into another singularity.

The nature of this beginning is the subject of another chapter and can only be understood by a complete change of scale. In this chapter we have been dealing with immense dimensions of both space and time. We have travelled vast distances in time and space, to explore the universe. It is time now to explore the infinitely small world of the atom and its constituents for these will prove to be equally strange and as unexpected as space time itself.

Chapter 8

Quantum Physics—the Nature of Reality.

These our actors,
As I foretold you, were all spirits,

and are melted into air, into thin air
And like the baseless fabric of this vision
The cloud capped towers, the gorgeous palaces
The solemn temples, the great globe itself
Yea, all which it inherits, shall dissolve
And like this insubstantial pageant faded
Leave not a wrack behind.
—Shakespeare, the Tempest

As I have said, by a little after the end of the nineteenth century, the classical model of the atom had been largely established. The atomic nucleus was thought to be made up of protons and neutrons, of almost identical mass (1840 times the mass of the electron), the only difference between them being that the former carried a positive charge to balance that of the electron, whilst the latter was uncharged and electrically neutral. Orbiting this nucleus were the electrons in their shells, to balance the charge on the protons, the outer shell largely controlling the chemical properties of the element concerned. Isotopes resulted when the nucleus had an excess or deficit of neutrons, since the latter were uncharged, the number of electrons, and hence the chemical properties of the element concerned, were unaffected, the only difference between isotopes of the same element being small difference due to the slightly different atomic weights (this is why isotopes are so difficult to separate). Radioactivity was the result of unstable nuclei, which spontaneously disintegrated to form lighter elements.

But then, Rutherford and his students did a very simple experiment, they studied the scattering of a beam of highly energetic alpha particles (nuclei of charged helium atoms) when passed through a very thin sheet of gold. Not unexpectedly most (99,9%) of the alpha particles went straight through the sheet without any scattering (after all alpha particles are moving very fast). But a very small fraction of the alpha particles bounced straight back towards the source. As Rutherford said, this was quite extra ordinary, equivalent to firing a twelve inch shell at a piece of paper, and having it bounce straight back at you!!

Rutherford argued from this, that the atom must be almost entirely empty space, (if the nucleus were the size of an orange, then the orbiting electrons were forty feet away!!). This was the first intimation that these so called solid atoms were not what they seemed.

Indeed, there are two major problems with the old classical picture of the atom. Firstly what holds the electrons in their shells?, for the analogy with gravitation implied by the term 'orbiting electrons' is totally incorrect, gravitation is an extremely weak force, and could have no effect on the atomic nucleus and its electrons, the charge difference between the electrons and the nucleus should make the electrons spiral rapidly down into the nucleus emitting radiation as they did so. But this is clearly not so, atoms are, in general extremely long lived and stable, radioactivity being the exception rather than the rule.

There was also a second less obvious puzzle, things radiate heat when hot, (their atoms radiate energy)—a hot poker radiates red light and invisible heat waves from its tip. This radiation peaks at a particular wavelength, the peaks

shifting to higher wavelengths as the body gets hotter, as the tip of the poker gets hotter the visible light from its tip gets whiter. However Maxwell's laws implied that this radiation should occur all wavelengths up to infinity, and should therefore be infinitely great (since there are an infinite number of possible wavelengths), whereas it was clear that in fact it dropped off effectively to zero at shorter wavelengths.

In order to explain this Max Planck very reluctantly suggested in 1900, that radiation could only be emitted in small packets, which he called quanta, and that at shorter wavelengths the energy of these quanta became such, that the chances of an atom gaining this amount of energy, became almost zero. This explanation satisfied the 'black body' radiation problem very nicely, and also explained why electrons were locked into shells around the atom, they could only be knocked out of place by absorbing or emitting a finite quanta of energy.

The full implications of this 'quantum' effect were not realised until Werner Heisenberg formulated his famous uncertainty principle in 1926. He pointed out that in order to completely predict the future position and velocity of a particle you have to accurately measure its present position and momentum. To do this you have to 'observe' it by some means, but to observe it you need to use at least one quantum, be it light or any other form of radiation. But in so doing you inevitably disturb the particle, and hence change its momentum in a way that cannot be predicted. The more accurately you try to measure its position, i.e. by using a shorter wavelength of light or other radiation, the greater the change in its momentum.

Heisenberg showed that the product of this uncertainty can never be less than a certain quantity which is known as Planck's constant, and that this is a fundamental property of the atomic world. Basically Heisenberg's principle says that you can either measure the position of an atomic particle accurately, but in that case you will be unsure of its momentum, or you can measure its momentum accurately, but in that case you will be unsure of its position.

In effect there is a fundamental fuzziness about atomic particles.

The philosophical implications of this simple inescapable fact are so immense that they have not yet been fully appreciated, for it finally and comprehensively demolishes dreams (or nightmares) of a completely deterministic world. Ever since Newton, scientists and philosophers had tended to agree with Laplace that if you knew the initial state of the universe, then you could completely predict its future course. No one ever contemplated being able to do so of course, but nonetheless presumably God could, and therefore He would know the future outcome of his creation in entirety.

Heisenberg's uncertainty principle completely demolishes this argument, for if uncertainty lies at the heart of the atomic world, then sooner or later it must and will spill over into the physical world of observation.

In the 1920's Heisenberg, Schrödinger, and Dirac, reformulated particle mechanics to fit in with this quantum effect. This new theory of 'quantum mechanics' says in effect that a subatomic particle, like an electron or a photon, cannot simultaneously have a well defined position and velocity, instead its state can only be described by its 'wave function', the square of which defines the probability of finding it in a particular position (or velocity).

For normal purposes of course, we can define the position of most objects, for example, a ping pong ball, with all the accuracy we chose, but for a very small elementary particle like an electron, this is no longer true, we can only know the probability of finding it at a certain point (as given by its 'wave function'). This leads to the celebrated 'wave/particle' dilemma—is the electron a 'particle' i.e. an entity occupying a certain well defined space, or is it a 'wave', i.e. having properties akin to electromagnetic radiation?

This aspect of reality deserves more consideration, and is best covered by considering the simplest particle of all, the photon, the quantum particle of light itself. Light, as Clerk Maxwell had conclusively shown, can be regarded as an electromagnetic wave propagating at a constant speed of 186000 miles per second in vacuo. The wave nature of light has been understood for a long time, ever since Young first demonstrated interference effects in monochromatic light. Interference is the phenomenon observed when waves interact with each other. It can be seen quite clearly in the ripples which spread out from two dripping taps in a bath half full of still water. The waves spreading out from each source interfering with each other, to either cancel each other out or to reinforce each other.

On the other hand, the photo electric effect, the action of light upon metals which causes electrons to be 'knocked' out of a metallic surface when illuminated by a beam of light, can only be explained by assuming that light comes as a particle. So what is light, is it a particle or a wave?

You will remember the diffraction experiment first observed by Young in the nineteenth century. It is worth looking at this experiment more closely, and to perform a simple 'thought experiment' on it.

A point source of monochromatic light (light of one single wavelength) is set up on one side of a screen in which are cut two parallel slots very close together. On the other side of the screen we place a white card. Young observed that under these circumstances, we obtain a diffraction pattern on the card, a series of alternating dark and light bands, caused by the interference of the light waves coming from each slit. You can show a precisely similar interference pattern from waves in a pond under similar circumstances.

Now replace the card with a light sensitive photographic plate. Every time a particle of light hits the emulsion, the silver halide at the point of impact is sensitised, and on reduction shows as a grain of reduced silver (The graininess of the emulsion can be clearly seen under the microscope). Obviously, nothing has really changed, you will now get a photographic record of the diffraction pattern—a series of light and dark bands on the plate.

But if you think about it a bit, this is quite extraordinary, think of reducing the intensity of the source until you only get (say) one particle per second. So, one photon leaves the source—which slit does it go through? The right slit or the left slit? The common sense view is that it must go through one or the other. Let us say it goes through the left slit, and impinges on the film to produce a dot on the left. Then a second later another photon leaves the source, let us say it goes through the right slit this time, to produce a dot on the right. Carry on like this for as long as you like—you could never get a diffraction pattern, just a fuzzy image of two slits—separate events in time can't interfere with one another!! But in fact they do!!, you do eventually build up a diffraction pattern!! somehow each particle

of light 'knows' that there is another slit, and an interference pattern develops. It goes through both slits at once!!.

In fact when light travels from A to B it behaves like a wave, i.e. it passes through both slits at the same time, when it reacts with the emulsion it behaves like a particle, i.e. it reacts with the film at a particular point. You may argue that the quantisation of light as photons is merely a figment of mathematics, after all light has no mass, and what reality can be given to a mass less particle. But this argument is demolished by a similar experiment which shows that electrons, which are definitely particles with a known mass, also produce diffraction effects, indeed any subatomic particle can be used or even atoms or molecules.

So what is a photon or an electron or an atom, is it a wave or a particle? Well… Frankly it depends on the way you look at it!. Yes, I know, Its crazy!! Indeed Niels Bohr, the founder of modern quantum theory once said “those who are not shocked when they first come across quantum theory cannot possibly have understood it!!”

Einstein himself never really accepted quantum theory. He once commented that the more you studied it, the sillier it became!!

The truth of the matter is that at the subatomic level we have entered a world where the normal vocabulary of human perception is inadequate, and only mathematics can really express the observations. We have moved from a deterministic world where common sense applies, to a probabilistic world where probabilities replace certainty. Atomic particles are both 'wave like', and 'particle like'. All we can know about them is encapsulated in their wave function which tells us the probability of finding them in any given position!!

After all why should we assume, as we so often implicitly do, that a proton or an electron is just like a very small billiard ball, it really would be most surprising if it were. Perhaps our common sense thinking introduces impossible distinctions that need not be made.

Modern physicists now tend to regard the fundamental entity as the field, and say that 'particles' are seen when the field is quantized. Radiation, including light, is an electromagnetic field, when it is quantised and interacts with matter a 'particle' or photon appears. Likewise the fundamental entity of charge is the electric field, when it is quantised and interacts with matter the electron appears. How particles interact is controlled by their quantised fields or wave function. Another way of looking at the wave function of a particle, is to treat it as the probability of finding the 'particle' at any given point. The diffraction pattern of two slits is then the probability of finding the particle at that point on the film.

Fundamentally quantisation is about information. The classic example of this is the story known to all physics undergraduates as *Schrödinger's cat*. Consider a totally light proof and sound proof black box, in which we place a small amount of a weakly radioactive source, and a cat. Alongside the radioactive source we place a detector, set up in such a way that when an alpha particle from a radioactive decay is observed, a cyanide pill is dropped into a bath of acid and the hydrocyanic produced kills the cat—tough on pussy!!

Now radioactive decay is a totally random quantised event, expressed by a wave function, or probability function, and until we open the box we cannot know for certain whether a decay has occurred. Obviously until the box is opened we

cannot know whether the cat has survived or not. In wave mechanics terms, the box also has a wave function or probability function associated with it, which is resolved only when the box is opened. Only then does the probability wave collapse to the dead or alive state. (of course the cat knows, and so would you if you were inside the box, but the point is that neither the cat nor you have passed on the information—the information has not entered the outside world) .

It has been argued on these grounds that the 'observer' somehow influences the event when he opens the box, but this is surely wrong, the 'observer' merely receives the information, when he opens the box, the probability function collapses, and fixes the event into the real world. Indeed the 'observer' need not be animate at all!!, anything that senses a change in the cat's condition 'observes' as it were the cat's state, and fixes it in the real world. The observation does not influence the outcome in any way. Nevertheless I would remind you of the limerick by the undergraduate about the 'tree in the quad', and Bishop Berkeley's argument that it only exists whilst somebody is looking at it!!. In the subatomic world we can certainly say that only when an event is observed can we be sure of its reality!!.

Just how queer this aspect of the quantum theory is brought out by a particular thought experiment, called the Einstein, Posen, Rosenberg (EPR) paradox. Certain particle decays observed in experiments with particle accelerators, result in the creation of an electron/positron pair. (A positron is a positively charged electron). Because they are oppositely charged they are ejected from the collision in opposite directions, and because 'spin' must be conserved, the electron and positron must 'spin' in opposite directions, if the electron is spinning clockwise, the positron is spinning anti clockwise and vice versa. Now quantum theory says that until you make the observation, the system is indeterminate (the wave or probability function for the event expresses this ambiguity). Only when you, or someone or something else, observes the spin of the electron (or positron), will the spin of the other positron (or electron be 'determined'. But in fact the other positron (or electron) could be half way across the universe by then!!, how on earth can an observation of the spin of the electron on the one hand, instantaneously 'collapse' the spin of the positron on the other, when the latter may be light years away?. Einstein objected that this violated the principle that nothing can travel faster than light, and that quantum theory was therefore if not wrong, at least incomplete.

In fact however quantum theory has been validated even in this case, there is a theorem called Bell's inequality, which can be used to show that the EPR paradox is in fact true, it is not just a matter of not knowing the state of the system, it really is indeterminate until observed.

In recent years modern particle accelerators have vastly advanced our knowledge of the atom. A particle accelerator is merely a large scale version of the old cathode ray television screen. In the tube of a television set electrons emitted from a hot wire are accelerated and deflected to scan and excite the phosphor coating on the front of the screen to produce a picture. A modern particle accelerator is merely a very large and sophisticated version of this. Particles, are accelerated to very large velocities in huge vacuum rings underground, guided round the ring with large superconducting magnets. Ultimately they are 'smashed'

together and the resultant shower of subatomic particles analysed in a cloud chamber or similar detector. The basic idea is to smash subatomic particles like electrons or protons together at such high energies that the nucleus breaks up, and reveals its fundamental structure. It is not an unreasonable approach. (After all if you were a giant and too clumsy to take a watch to pieces, one way would be to hit it and see what bits and pieces came out!!.) At first, during the 20's and 30's many hundreds of subatomic particles were observed, and it was very difficult for physicists to make any sense of them. Admittedly most of them were very short lived, but nonetheless, they existed, even if only for nanoseconds. The problem was that it isn't as simple as just hitting the atom to see what came out. You don't in general expect more things to come out than went in, if you fire a bullet at a target, say a watch, you don't expect to get bits from three and a half watches to come out!!. But this is what happens in a modern particle accelerator because of the large energies involved. You will remember that Einstein's theory of relativity showed that Energy = Mass x the square of the velocity of light. Turn that on its head and you will see that Mass equals Energy divided by the square of the velocity of light. The energy of the collision is so great that more particles come out than were put into the collision!!. At first physicists had great problems understanding the results. One is reported to have said that he was a physicist not a botanist!! hundreds of subatomic particles was just too many!!

In 1920 Dirac formulated what has now become known as relativistic quantum theory, which was ultimately to make sense of these observations. Basically, quantum theory on its own places no great restrictions on the number and type of possible subatomic particles. But Dirac showed that by combining quantum theory with the relativistic Einstein/Minkowski symmetry transformations, it was possible to greatly restrict the number of possible elementary particles, and specify their properties quite exactly.

Symmetry is, in the mathematical sense, an operation which restores the identity of something (for example rotating a square by 90 degrees, ¼ of a full rotation , restores it to the original condition, hence we say a square has four fold symmetry). It is vital to an understanding of particle physics, since it implies that something is conserved i.e. it implies a quantum number of some kind (spin is a quantum number). Indeed it is probably the only way in which meaningful statements can be made about point like particles. Application of the mathematical symmetry operations to points together with Einstein's relativity theory (which is itself basically a symmetry operation) leads to a relatively simple 'standard model' of atomic particles.

It is now thought that all the fundamental particles may be classified into two types—particles that make up 'matter'—Fermions, and particles that carry force—Bosons.

Quantum particles are indistinguishable because particles of the same type are strictly identical, and cannot be labelled. Consequently the square of the wave function (the probability) for two particles cannot change if they are interchanged. This implies that the wave function itself could have either a positive or negative value (the square of a negative value is the same as the square of a positive value). If, in the exchange, the sign of the wave function is unchanged, the particles obey what is known as Bose Einstein statistics and are defined as Bosons. If in the

exchange, the sign of the wave function reverses, the particles obey Fermi Dirac statistics and are defined as Fermions.

The difference between the two is fundamental, Two Fermions cannot occupy the same quantum state (the Fermi exclusion principle—which underpins all Chemistry), whereas two or more Bosons can.

The fundamental 'matter' particles are Fermions because they follow a set of rules called Fermi-Dirac Statistics. All Fermions possess half integer spin, what this means is that no two identical fermions may occupy the same quantum state simultaneously. This is the so called Pauli exclusion principle. There are two different types of Fermions—Leptons and Quarks.

Currently we know of six Leptons, the negatively (or positively) charged electron, and its neutral equivalent the neutrino, and four others, the muon and its neutral equivalent, and the tau and its neutral equivalent (the last four are basically unstable short lived heavier versions of the electron and neutrino).

Quarks are much odder particles, in that they have never been observed, and indeed can never be observed as isolated particles, their existence can only be inferred from scattering patterns from particle colliders such as CERN. Like the leptons there are six quarks grouped in three sets of two, with each successive group just a heavier version of the previous group, but unlike the leptons here are no neutral quarks, and their charges come in fractions of one third. The lightest pair are Up (charge 2/3), and Down (charge -1/3). the next heaviest Charm(charge 2/3) and Strange (charge -1/3), and the heaviest pair Top (charge 2/3) and Bottom (charge -1/3).

Quarks are only observed in groups, called Hadrons. Two quarks together give Mesons, unstable particles observed in particle collisions, that rapidly decay to stable particles. Three quarks together give Baryons, which include protons and neutrons. A proton is made up of three quarks, two up, one down, a neutron of three quarks, two down one up. Various combinations of the other quarks, the strange, charmed, bottom and top!!, produce the other hadrons but they decay rapidly into neutrons and protons. All Hadrons have mass, and a symmetry or spin of either half or one. They may be charged or uncharged.

The particles that carry force—Bosons, are perhaps better understood as the fields which enable other particles to interact. For electromagnetism the force carrier is the photon, if an electron gets near another electron it emits a virtual photon which is absorbed by the other electron, and causes it to move away. Another way to view electromagnetic waves is to regard them as the probability of encountering a photon at any particular point in space.

For the strong nuclear force which holds the nucleus together the Boson is the gluon, it has zero rest mass, and zero charge, but comes in different 'colours'

For the weak nuclear force which is responsible for radioactivity there appear to be three Bosons W+, W- and Z. None of these are mass less.

For Gravity, the hypothetical Boson is the graviton, thought to have zero rest mass and zero charge. It has not yet been discovered.

Particle physics, deserves a closer look in passing, because it brings out the essential queerness of the basic nature of reality in a way we could never appreciate if we did not delve a little deeper. We have discussed the duality of position and momentum in subatomic particles, and our inability to resolve one,

without losing the other. What is less well appreciated is this duality also applies to energy and time. We can only fix the energy of a 'particle' by information about its wavelength, but in order to measure its wavelength we have to observe it for a minimum period of time. Over periods of time less than this we cannot be certain of its energy This leads to the bizarre effect known as quantum tunnelling. Over extremely short time scales, the energy (and hence the mass) of a subatomic particle is subject to quantum fluctuation, and it therefore has for a very short time, the potential to borrow excess energy, and escape from situations in which it would normally be confined by energy barriers. An example is the escape of an alpha particle (a charged helium atom) from a radioactive nucleus. Normally it would have insufficient energy to escape, but by 'borrowing' as it were, energy via the quantum tunnelling effect for a mere million-billion-billionth of a second, which is all it takes the alpha particle to travel the ten-millionth-millionth of a centimetre through the nuclear surface it tunnels through the surface and is ejected at enormous velocity.

An even more bizarre effect is the association of 'virtual' particles with the 'real' particles of ordinary space and time. For example an electron has associated with it a cloud of 'virtual' photons, flashing in and out of existence around it. None of these particles lives long enough, to have any independent existence, they are almost immediately re adsorbed by their parent particle. They are not normally understood as representing 'real' particles, but 'potential' particles which could if circumstances permitted it attain an independent existence of their own. For example, if the electron meets its corresponding anti particle, the positron, annihilation results and sufficient energy is liberated to enable some of the virtual particles to become promoted as it were to reality, their energy loan having been paid off as it were—a phenomenon which has actually been observed in the modern cloud chamber!!

The ghostly nature of reality at the subatomic level should now be becoming very clear. It is a world where the old certainties of position and momentum, of mass and energy, have become blurred and lost in a shifting kaleidoscope of possible and potential, real and virtual Indeed “these our actors are melted into thin air... and like this insubstantial pageant faded, leave not a wrack behind”. Well, not quite, there are still very strict rules, mass and energy, spin (or symmetry) and charge are still conserved, and as Weinberg has pointed out the combination of relativity and quantum theory is quite restrictive as to what a 'particle' may be and do. What should by now have become clear is the importance of symmetry—translation, rotation, geometrical operations, in the classification of subatomic particles—a property of space/time which seems to have universal application.

We have now come a long way from the cool, classical, world of the early 1900's, and we have travelled some strange roads. Our concepts of three dimensional space and the arrow of time have fused to become a strange four dimensional space time continuum.. Newton’s stately laws guiding the planets in their courses have degenerated to a property of space and time itself. At the atomic level, the solid atoms of Dalton and the nineteenth century chemists, have vanished, and become mere wave/particles unimaginable and almost incomprehensible in their dance and their diversity.

The old stable, certain, world of our forefathers has vanished; the universe is no longer seen as a machine proceeding inexorably on its predestined way. We know now that when the universe came into being it was subject, from its outcome, to uncertainty, and that this uncertainty pervades the very fabric of space and time. To some such a world may be horrifying and frightening. To me however, it gives a glimpse of freedom. For freedom is the possibility of something other than being subject to an inexorable machine. The working out of this freedom is the subject of the next chapter.

Chapter 9

Darwinism, the new Biology.

Created half to rise, and half to fall
Great Lord of all things, yet a prey to all
The Glory Jest and riddle of this world.
—Pope

Evolutionary upstart one!!
The web-footed beasts have been (dear beasts!) and gone,
being part of some yet wider plan Perhaps in His infinite mercy
God will remove this man
—Edward Carpenter

Up until around 1850, few people doubted that the natural world was designed, or created by some intelligent agency of one kind or another. Their argument has been compellingly expressed by Archbishop Paley. Imagine, he said walking over a stony plain, and accidentally tripping up over something, If on picking it up, we saw a stone, we might reasonably conclude that it was purely accidental, and simply a product of nature. But if, picking it up, we observed it more closely, and found that it was a watch, we would obviously conclude that some intelligent agent had made it. Anybody in their right senses, he said, would conclude that it was a product of intelligent design, even if they had never seen a watch before, and did not know what it was for. Human beings, he said were like that, it was inconceivable that they could have arisen by accident, they must be a product of intelligent design.

The achievement of Darwin and Wallace, was to suggest an alternative to this viewpoint—evolution. That life could in fact have arisen from very primitive beginnings by a series of many small random changes, selected under pressure from the surrounding environment, and that there was indeed an alternative to the argument of intelligent design.

Since Darwin's time, advances in geology and palaeontology, have modified and extended his theory to some extent, but basically it is still largely unchallenged. (It

must be clearly said from the outset that the pseudo religious alternative—Creationism, is not accepted by any reputable scientist, and is regarded, by the scientific community in general, as a last ditch attempt by religious fundamentalists to roll back the thrust of scientific advance). The major changes that have been made to evolutionary theory relate to firstly the major extinctions which are now known to have occurred, probably due to major global climatic shifts, caused by asteroid impact, or extensive volcanic eruptions, and secondly to the demonstration of extensive decimation of early forms of life following the 'Permian' diversification. The first is now thought to have caused the extinction of the dinosaurs in the late Cretaceous period, and the second has recently been demonstrated by re-examination of fossils of early soft bodied animals found in the Burgess shale in Western Canada, laid down in the early Permian period.

It is a common mistake to think of evolution as 'progress' (to some higher or more sophisticated organism). Often we think of evolution as a 'ladder'—from ape to man, or early eohippus to our modern horse, or alternatively as a 'cone' of increasing diversity from some simple primitive ancestral stock to the incredible diversity of modern life. But both of these pictures are false. The so called 'ladder' of evolution is merely an illusion resulting from the fact that often collateral branches have just died out!! The modern horse is at the top of the equestrian stakes simply because it is the only one to have survived time and chance, it is not 'better' than its siblings, just more fortunate!! The same comment could equally justly be made of man, Homo Sapiens is not top of the ladder of creation, he is just a fortunate survivor of many other simian types that just didn't make it, due to local circumstances of environment and climate. When Ecclesiastes says that the race is not necessarily to the swift or victory to the strong, but that time and chance happen to them all, it is stating no more than the plain truth.

Similarly the idea of a increasing cone of diversity from early primitive stock has been blown sky high by recent re-examination on the Burgess shale's, which indicate that the early Permian world was a time of incredible and bizarre diversity in marine life, much of which was decimated in the later Permian era.

The first traces of life in the geological record appears in the Ediacara sandstones of the Flinders Range in Australia laid down some 570 million years ago, and the first detailed record of these early soft bodied organisms is to be found in the Burgess Shale in Western Canada laid down about 500 million years ago. Some of the species found in the Burgess shale's are so weird that they cannot be placed in any class or Phyla at all. One of them is even called Hallucogenia, because no one in their right senses could have conceived anything like it, it resembles nothing less than something put together by a blind drunkard.

It is now recognized that the tree of life is not a stately oak tree branching out from a few primitive worms to the great canopy of species in this modern day, but rather a very straggly and storm swept shrub, broken and torn by the storms and accidents of time and circumstance.

In the current century, biology, the study of living things, has been revolutionised by the insights given by evolution. From being a purely observational science, it has begun to be a predictive one, with ramifications throughout the social and medical world. The most traumatic change has been the displacement of man from being the crown of God's creation, to merely one part of

many in the scheme of things. There is no automatic and stately progress from amoeba to man. If man is now master of this planet it is not because of 'progress' or destiny. Time and time again man and his precursors have survived by the skin of their teeth. If his ultimate ancestor, the humble notochord Pikaea had not survived the late Permian extinctions we might never have existed. Similarly if the Dinosaurs had not been wiped out by the Cretaceous extinction, or if Neanderthal man had been a little more intelligent or fortunate, life might have taken a very different course. Man is now no longer seen in Pope's words as great Lord of all, but part of nature, and all too conscious of his somewhat fragile hold on creation.

Edward Carpenter's little verse at the head of this chapter, reminds us that the little blue flower insulted by the name of Squinancy Wort, has grown on the Downs for millennia, long before man arrived on the scene, and will probably be there long after man has left the scene. God removed the Dinosaurs, and may also remove this man, (if man does not first remove himself!) .

But before this happens, we ought to look at ourselves, Homo Sapiens, and how we got here. We have plumbed the depths of space, we have (almost) solved the riddle of the atom. We rule this world, to our profit and our loss. And yet, we are basically no more than an intelligent ape, and time and time again our heredity betrays us.

The first question we have to ask is what is life and how did it begin on this planet. At the same time we can ask ourselves whether it could begin anywhere else in the universe, whether in all the firmament there is anywhere else where life could exist, and what are the chances of finding it. We can then go on to ask how, from the first simple unicellular organisms, what forces stabilise it, and what forces tend to its destruction. We can then consider consciousness, what it is, and whether It can be said to occur elsewhere in the animal kingdom. Finally we can ask ourselves what are the limits to conscious life, and whether such a thing as the soul can sensibly be said to exist.

We must start with chemistry and thermodynamics, for unless we understand these, we cannot make sense of the chemistry of living things. For in the thermodynamic sense we are 'order' created out of 'disorder', and we now know that this can only occur in a system which is far from equilibrium, and where substantial reserves of energy are available. We must look therefore, for a chemistry which provides for a reasonably accessible form of energy, from abundant materials, at a state far from equilibrium. Such an energy source is available in an aqueous environment—the reaction of hydrogen with carbon dioxide to yield carbohydrates. The main problem is where to get the hydrogen from, but this can be solved if hydrogen can be obtained in an 'active' state by the reduction of simple hydrogen containing materials, such as H2S and H20, the former being easily split into hydrogen and sulphur, the latter being split (with more difficulty) by photochemical reaction with light. Primitive bacteria exist which can effect both these reactions, the first being easily effected even in the dark, the latter being effected by means of the green plant colouring material chlorophyll. It is probable that the first forms of life formed in the deep oceans, around subterranean vents spewing hydrogen sulphide and carbon dioxide, and that later bacteria and simple algae developed which could split water to give hydrogen and oxygen by photosynthesis.

Gradually these blue green algae colonised the oceans, and began to liberate free oxygen into the primitive planetary atmosphere. But before even this could be done, stable, self replicating molecules must have been formed. We know what this self replicating molecule was like because it, and its derivatives form the basis of all living life on earth. It is deoxyribose nucleic acid, or DNA for short, Its composition has been known for some time, it is composed of sugars and phosphates, and four small molecules or bases, thymine, cytosine, guanine, and adenine. Its structure was first worked out in 1968 by Crick and Watson, and takes the form of a double helix the backbone of which is composed of sugars and phosphates, and attached to this backbone are sequences of bases sticking out from the axis. But what holds the two helixes together? Crick and Watson had the fundamental insight that the shape of the adenine-thymine pair, held together by weak hydrogen bonds, was identical with the shape of the guanine-cytosine pair. So the base pairs, set at 36 degree angles, form a ladder, the treads of a spiral staircase, a spiral in which each tread is the same size, at the same distance from the next, and turning at the same rate, 36 degrees, between successive treads. And the sequence of base pairs on the treads forms a code, which may be as long as we like, and carry as message as complex as we like. The secret lies in the coding, the sequence of the bases on the helix, and in the ease with which the weak bond between the base pairs can be broken and reformed. Hydrogen bonding like this, is predominant in liquid water, and only in liquid water can the reactions described here take place. All life requires the presence of liquid water, without it life as we know it is impossible.

Where did the sugars and the phosphates and the amino acid bases come from in the first case. Oddly enough that is relatively simple, it has been shown that they are formed by passing UV light and an electrical discharge though a dilute 'soup' of water and inorganic phosphates, under a primitive 'planetary' atmosphere composed of hydrogen, nitrogen, carbon monoxide, carbon dioxide, and methane. After a few days the water turns brown and we can demonstrate the presence of complex amino acids, sugars, and phosphates in the soup. What we cannot do in such an experiment is demonstrate the presence of self replicating DNA molecules, for this to occur, we would have to run the experiment for a very long time, many millions of years.

But time is just what the earth had, time in abundance. Richard Attenborough has illustrated this very nicely by taking a time scale in which one day represents ten million years. On such a time scale, life started well before 3000 million years ago, say a year. The first bacteria probably appeared fairly early on but have left no fossil record. The first fossils of primitive algae colonies, the stromatolites, then first occur in August. The first fishes, in November, the first lizard in mid December, and the first man, late in the evening of the 31st December!! Evolutionary upstart indeed. It is a sobering thought that man has been around for only an hour or two, and that the whole of the history of mankind only occupies a few minutes of the calendar of life.

The uniqueness of the first self replicating molecule is indicated by the observation that all amino acids found in the nature are asymmetric and left handed, whilst all the sugars are right handed. This asymmetry is characteristic of all naturally occurring amino acids and sugars, whereas synthetic amino acids

and sugars are 50% mixtures of right and left handed forms. It would seem that the first self replicating molecule, just happened to be built up in this way, (it could just as easily been the opposite way round), but it proved so successful, that its configuration was passed on to all successive generations.

It has been argued that the probability of random chemical reactions in the primitive a biotic soup of the primitive oceans, producing a self replicating molecule, is so small, that it effectively becomes impossible. But this ignores the vast time scale available, and the evolutionary advantage accorded to even just one such molecule. We now know that self replication can occur even in very simple systems, given sufficient time. There is a simple computer game called 'Life' which has extremely simple rules, and which can yet, given time, develop quite extraordinarily complex patterns. More significantly, there is a particular fairly stable pattern which can replicate itself for quite long periods of time at a stretch, in what is quite an eerie simulacrum of life itself.

This takes us on to the next point, Is life unique to this planet or is there anywhere else in the universe that it could have developed, and if so would it be anything like ourselves. I think the answer is that it probably could, and that it would probably take a similar form of development. It would appear that the prerequisite for life to develop from a primitive planetary environment is time, and liquid water in abundance, and that this is unique to this planet in our solar system. However, since it is now known that most stars have planetary systems of some kind, it is highly likely that somewhere else in the universe there are other planets similar to the earth on which life could have developed, and there are good grounds for thinking that these life forms would in general be based on carbon, oxygen, and hydrogen, and probably have developed from DNA helix structures. This is not to say that such 'life' would be anything like us—as I have just pointed out the path is strewn with too many pitfalls to be sure of that!!

However, to say that life probably occurs elsewhere in the universe, is not to say we are likely to come into contact with it. As Sagan has shown, that depends critically on the effective lifetime of a technical civilisation, and the probability that within the possible ranges of radio or other electromagnetic wave communication, another such civilisation is in being and listening. The actual probabilities appear to be very low. Not low enough to completely rule it out, but low enough to expect to have to wait a pretty long time. Furthermore, even if mutual comprehension were possible, any conversations would be limited by the speed of light, and we would probably have to wait many years for a reply to any question, which would render interactive communication somewhat tedious!!

We have seen that, the development of simple, self replicating molecules in the primitive ocean of the earth is possible given enough time, and the right conditions. But it is a far cry from a simple bacteria, to a complex organism like animals or man.

The first step in this development is the ability to change, to mutate, and pass the change on to our offspring, so that the environment can select as it were, the successful adaptation and weed out the unsuccessful. The only way the primitive bacteria could do this, was as the result of random errors creeping in to their coding sequence when their DNA replicated. Some of these errors will prove beneficial; most will prove deleterious or even lethal. The beneficial changes will be

small and will be passed on to their descendants, and such strains will preferentially survive and gradually oust their siblings. Non beneficial strains will simply die out. This was the only way life could change and adapt for the first 2,000,000 years or so that life existed on earth. Change must necessarily have been slow and faltering.

The critical point came with the development of sex (Hooray!!), for sex requires sperm and egg, and produces diversity by the random mixing of the genes of the two sexes, and this diversity permits natural selection to proceed much faster. The first organisms to utilize sexual reproduction were the protozoa. These first appeared about 1,000,000 years ago, in September of the evolutionary year. Like bacteria they reproduce by splitting into two, but because their cells are more complex, they split in several different ways. One way is basically the formation of a large relatively immobile thing—an egg, and a much smaller active one with a flagellum—a sperm, which then merge. This greatly increases the diversity of the resultant daughter cells, and also greatly accelerates the rate at which the protozoa can adapt to changes in the environment. However, there are strict limits to the size to which a unicellular organism can grow, due to the simple diffusion process by which raw materials may enter the cell, and waste products be rejected. The next phase in evolution was association. The protozoa associated to form colonies, the sponges, and about the same time, in October of the evolutionary year, the first true multi cellular organisms appeared, the jellyfish, the first organisms to have a distinct nervous system.

From this time on the tree of life grows rapidly, through the fish, the early amphibians, the reptiles and the dinosaurs, and the early primates, and a full—description of its progress belongs to other books. Suffice to say that eventually (but not necessarily finally), Man arrived on the scene, an offshoot of the primitive Apes.

It must, and should be said, that evolution in the Darwinian sense, of selection by natural forces, is now almost universally accepted in the Biological Sciences. This is not to deny that there are many dark corners in the subject, some of which are only just now beginning to be cleared up, like the mass extinctions of past ages, whilst others may never be entirely understood. But by and large no other adequate explanation of the development of life on earth appears to be possible in scientific terms. There are some people who still oppose it, usually for religious reasons, and they sometimes make an apparently plausible case. One common argument is that structures as complex as the human eye, could never have arisen by chance. But this is to forget the vast age of time over which such an organ could develop from the primitive light sensitive cells of the nematodes, to the sophisticated eyes of present day mammals. For whilst change may be to some extent random, the natural selection process which weeds out the unfit and the maimed is certainly not. It ensures that at any given time, the fittest survive, and the weak go to the wall.

But there are two common misunderstandings of Darwinian Evolution which must be dealt with. The first is that it is completely pointless and random. The second is the assumption that it always produces the 'best' solution.

To the first misunderstanding the biologist answers that whilst the mechanism—genetic mutation—may be random, the selection—survival of the

fittest—is emphatically not, it is efficient, sharp and entirely to the point—adapt or die.

To the second misunderstanding, he replies not so, natural selection can only modify it cannot create from new. A case in point is that incredibly complex and functionally efficient organ the human eye. It has one peculiar quirk, the cells in the retina which detect the light are 'reversed', they lie behind the network of nerves which collect and carry the signals to the brain, rather than, as efficiency would demand, in front. This odd feature may well be a product of the past, when man's precursors were small furry rodents who had to hunt by night, and had an efficient 'tapetum', a reflective layer behind the retina, to concentrate what light there was. The point is that nature selects from the available store, it does not start afresh each time. The wheel is undoubtedly a very efficient form of transport, but natural selection has never, (and probably never could) develop it, because it is so completely foreign to the evolutionary process.

But, we may ask the pertinent question of evolution, fittest for what? A good question. There is no doubt that Tyrannosaurus Rex was a supremely fit and able predator. When man's primitive ancestors, the small blooded marsupials were cowering in the undergrowth, Tyrannosaurus Rex was lord of all he surveyed. But the dinosaurs suffered from one major defect, they were too big, and too vulnerable, and when the climate changed, whether by the periodic climatic changes to which the earth is subject, or some catastrophic meteoric impact, they could not adapt, and died out,' whilst the small furry warm blooded rodent in the undergrowth, could take shelter and survive the holocaust. It is clear that in a fickle and dangerous world the survival of a species depends critically on the adaptive ability of the organism. In general those species that have survived, are those which can best adapt to the changing circumstances of their environment. In the main the primitive organisms have remained in the sea, where the environment has remained essentially unchanged for millennia. On land the picture is entirely different. Here the environment is much more variable, and life faces many more difficult and various problems. Modern climatic research and planetary studies, are only now beginning to show us just how chaotic and unstable the climate can be, and this is beginning to throw some light on some of the mass extinctions of land life, which are shown in the fossil record.

One thing is very certain, man's success in dominating this planet, is extremely recent (we arrived at the ball very late on the evening of the 31st December!!). There is still a big question as to our ability to adapt to a rapidly changing world, some of whose changes, like climatic warming, are probably caused by man himself. We do not know enough about the factors controlling the climate of the earth. It may be only a small increase of global atmospheric temperatures, but it may equally be a catastrophic step change to temperatures which could effectively wipe out life on earth. Our sister planet Venus, stands as a warning to us, of what can happen if the greenhouse effect gets out of control. But the characteristic of Man which have given him a vast global advantage over other species, is the development of a highly complex nervous system, culminating in a brain five or six times as big (in relation to body weight) as any other living organism. Man is master of this world because he can think and plan ahead, and manipulate his environment to suit his own needs.

Until the present time, Natural selection in the Darwinian sense, has ruled the world. As species changed via random mutation, and sexual selection, the weak dropped out, and only the fittest survived to breed. But now a new force has been unleashed on the world, an old idea has been resurrected. For Society passes on its advances by the inheritance of learning, and culture, and knowledge, from father to son, and mother to daughter. In the end Lamarck has the last laugh—we really can now inherit acquired characteristics!!. Evolution in human society is now social and Lamarkian, rather than Darwinian. Indeed much effort now is devoted in the medical world to ensuring the survival of babies which nature would have long abandoned as unfit. We can afford to do this, simply because our evolutionary pattern is now Lamarkian, not Darwinian. Whether our mechanisms of social evolution are adequate to ensure our survival as a species, and replace the law of the Jungle, is a moot point, and the Jury is still out. One thing seems very certain, that our anarchic system of nation states, jealously guarding their independence, will not be adequate to deal with the global problems of population, pollution, food supplies, and climatic change we are likely to face in the next hundred years.

But still, man can think, and that is important, even if he is still not very good at thinking collectively. The human brain, is however a product of evolution, as much as any other part of the body. The first sign of anything resembling a brain as such is the anterior lobe in fishes, a small portion of the nervous system at the front of the body, which is devoted mainly, if not exclusively, to olfactory purposes. Indeed the vertebrate fishes may be said to be our first real ancestors. From the fish man inherited a single canal for balance, teeth, liver, pancreas, spleen, two kidneys, ribs, thyroid, spinal cord, a bony skull, and a brain. It has been said that the growth and development of a species, mirrors the evolution of his kind. The human foetus starts life as a primitive group of cells bathed in the water of the womb, which gradually differentiate as the cells divide to form first a primitive nervous system, and then a more distinct head and body, fish like in character, and finally a recognizably human baby. But the really significant difference between man and his nearest relatives the apes, is the size of the brain, and especially the size of the cerebrum, the fore brain.

The size of a chimpanzee's brain is about 400 ml, a gorilla's is 500 ml, and the first Australopithecine brain about 450 ml. Homo habilis had a 750 ml brain, and Homo erectus, about one and a half million years ago, and a tool maker and fire user, about 1000 ml. The average size of mans brain today is about 1300 ml, though some individuals have more and others less. Strangely enough however in individual human beings there is no obvious correlation between intelligence (whatever that is). It is not often realised that this greatly increased brain size in as compared with the apes is not in fact present at birth. The brain of our closest living relative the chimpanzee is about 350 ml at birth, after a gestation period of 7.5 months, its brain is essentially the size it will be in adulthood, indeed there is no room for it to grow much further since the bones of the fontanel have essentially fused at birth. It reaches adulthood at around nine years of age. By comparison, the human child's brain, although about the same size initially, continues to grow until the bones of the fontanel knit together at between seven and fourteen years of age. Indeed the human brain triples in size between birth

and the age of three or four, although it grows more slowly thereafter. We may owe our development as Homo Sapiens (wise man???), simply to this fact of delayed fusion of the fontanel, which could well be the result of a minor genetic change in the genes which control foetal development.

Almost certainly the development of the cerebrum, is associated with the development of manual dexterity and some form of primitive speech about one million years ago, but since the development of language leaves no fossil traces, the matter must remain pure speculation.

Whatever it's precise origin, the brain of Homo sapiens is a quite remarkable organ. There are about 10-15 thousand million nerve cells in it, and the number of synapses, or nerve cell connections is about one hundred million million. Small wonder that we are still largely in ignorance about its precise mode of functioning. Nevertheless, we must follow this line of discussion, if we are to usefully deal with man and his place in the universe, for unless we know ourselves, we cannot understand out place in this strange and improbable world we find ourselves in.

Chapter 10

Mind, matter, and soul.

I summon'd Nature; peirced through all her store
Broke up some seales, which none had touched before
Her wombe, her bosome, and her head
Where all her secrets lay abed,
I rifled quite, and having past
Through all the creatures, came at last
To search myself, where I did find
Traces and sounds of a strange kind.
—Henry Vaughan

Having now explored the natural world, we must go on to explore the brain itself, and the more philosophical problems of mind, consciousness, memory, and soul. Clearly we must distinguish between the brain, which is the physical thing – the 'grey matter' and its structure; and mind, which is the action or behaviour of the brain, as shown in thought, memory, consciousness, and intelligence.

The physical entity – the brain in man, is an assembly of several billion nerve cells interconnected in a myriad ways via complex neural networks. We can dissect it in detail, and, using modern medical techniques, study it in action in a general, and sometimes, quite particular sort of way. Brain cells are almost unique in the body in both their degree of interconnection and in their longevity. After the first hectic growth in the first few years of life they are no longer renewed to any great extent. All other tissues of the body are periodically rebuilt as new cells replace the old. This does not occur in the brain, and from puberty onwards we

lose millions of brain cells by death each month, the fact that this is not noticeable until old age, gives a pointer to the amazing flexibility and degree of redundancy built into the structure of the brain.

The degree of interconnectivity is extraordinary. A single neuron from the hippo campus of a rats brain has been carefully stained and dissected to show thousands of branches or dendrites, linking up to many other neurons of different kinds.

Neurologists tend to regard the brain as a 'biochemical computer'. Like the transistor the neuron is essentially a 'on/off' device. When sufficient stimulus is applied to one of the dendrites feeding into the nucleoli the cell 'fires' and a periodic potential wave moves down the axon at a speed of several hundred feet per second to stimulate other dendrites, which in turn stimulate other cells. The action of some the major nerve channels in the brain has been extensively studied and we are now able to 'map' onto the brain and its convolutions, the functions that that particular portion of the brain deals with, to a quite detailed extent.

We know for example that the optic nerve bundles come from the eyes, cross over, and concentrate in the occipital lobe at the back of the brain, and that the right and left visual fields of each eye can be 'mapped' onto specific areas of this lobe and that damage to these specific areas results in loss of the visual field, the left field of each eye being lost if the right area is damaged, the right field if the left area is damaged.

What we do not clearly understand is the form of further processing that goes on, when the information is passed on for interpretation to the rest of the brain. After all the amount of information in the visual field of each eye is enormous, if we had to process all of it we would be overwhelmed with information, most of it quite irrelevant to the task in hand. In some way the brain filters out the irrelevant information, and only passes on that which is relevant. The complexity of the picture is indicated by the fact that if the occipital lobe is destroyed, people, although functionally 'blind', can still sometimes 'sense' movement in his visual field via alternative subsidiary nerve channels which bypass the occipital lobe completely, these channels are more clearly dominant in the rudimentary brains of a fish, and the phenomenon has been described as 'blind sight', and may be an evolutionary residue from the days when our ancestors swam in the oceans!!.

Again hearing is known to be processed in two areas in the left hemisphere of the brain. Damage to Broca's area as it is called causes failure to string words together properly, resulting in 'broken' stilted speech. Damage to another adjacent area—Wernicke's area, on the other hand, results in fluent but unsemantic speech, where words are strung together correctly, but the wrong word is used.

This 'mapping' onto specific areas of the brain, is true of virtually all our input and output functions, speech, sight, and movement. These 'pre-processor' areas are well defined, and a quite small amount of damage to them produces quite specific effects.

On the other hand damage to the frontal lobes of the brain can be huge, with hardly any direct effect at all. One famous case concerns a man who was severely injured by a six foot tamping iron blown out of a shot hole by a premature explosion, which passed beneath his left eye and out through the top of his head.

Thirteen pounds of steel rod straight through a man's fore brain, and he walks away alive!!. The only change was from a genial happy go lucky character, to a capricious ne'er-do-well. Physically he was essentially unharmed. A number of other similar cases are extant. A small nick in the spinal cord can put a man in a wheelchair for the rest of his life, a massive bar through his fore brain, and he can walk out of hospital a few days later with only minor?? personality changes!!. (although minor is perhaps not the word to use, as the social effects can be pretty catastrophic)

The point is further made, by the operation known as lobotomy, once used to mitigate the effects of severe and uncontrollable epilepsy and depression. Here the two hemispheres of the brain are completely severed, by cutting through the massive bundle of nerves which connect them, the corpus callosum. This seems to ameliorate the epileptic fits by suppressing the disturbance and confining it to one half of the brain. You might expect such a massive operation to have a major effect, but in fact the changes are quite subtle. In effect, the person becomes split brained, being apparently unaware of things seen or heard by the opposite side. For example objects presented only to the left visual field of the eyes, cannot be verbally described because the speech centres are in the opposite side of the brain, and thus have no knowledge of them. But the subject can pick the object up when asked even if he cannot name or describe it!! It seems that such subjects function (comparatively effectively) as two persons, the left hand quite literally not knowing what the right hand is doing and vice versa.

Why should minor damage to a particular area be so specific and obvious, yet major damage to the frontal lobes be so apparently innocuous. Part of the reason must be that the frontal lobes have a much different function to the rest of the brain. Remember, these are the areas that have expanded greatly in the last million years of man's time on earth, and appear to be connected with his social and technical achievements as a social and co-operative being. Obviously as an individual, he can function well enough without them, but as a social and co-operative animal, he seems be at loss if they are damaged. We do not know enough to say more than this, but one can only suspect that reason, imagination, and foresight are manipulated in the frontal lobes in ways that at present, we can barely more than speculate.

Memory is one of the big conundrums of the brain/mind system. There appears to be no specific site in the brain for memories. There is no particular area of the brain in which the memory of your grandmother is located. A man may suffer extensive damage to his fore brain, with no significant loss of memory. It seems to be a property of the system as a whole, rather than a specific location, although we know that destruction of the hippo campus, a small region in the centre of the brain, will result in failure to establish fresh memories. There certainly seems to be a distinction between short term memory and long term memories. You can remember a phone number for a few minutes while you dial it up, but five minutes later you will have forgotten it completely (just as well really!!). On the other hand long term memories are permanently stored, and even apparent loss, seems to be a matter of retrieval failure, rather than actual permanent loss. (We say “It has fallen off the shelf”. This suggests that short term memory is a matter of a local temporary circuit, whilst long term memory has somehow been 'burnt in' to the

circuitry. Recall of long term memories seems to be akin to following an 'association trace' until we locate the information we are looking for.

The difference between brain and mind is somewhat analogous to the difference between a computer's hardware (its motherboard, interfaces etc), and its operating system (Unix, or Windows or any other proprietary system). The brain is the physical machine in which the process operates, whilst the operating system, the mind, is the process of information handling and processing itself.

But whilst the brain—the physical medium of thought, can be anatomically described quite accurately, mind i.e. the way it behaves, is quite another matter. In part this is because no two human minds are programmed in the same way, quite apart from differences in the 'hard wiring' resulting from different inheritances. For each of us can be said to be programmed from birth by our environment. We each of us, as it were have different operating systems!! True our common culture, imposes some things in common, a common language, and a common experience of life, leading to common appreciations of space and logic and number. But essentially we are each of us different, programmed by differently by life and inheritance.

The analogy between brain and mind on the one hand, and computer hardware and software on the other hand can appear to be remarkably close. The reason for this is a matter of some argument. Some say that it is because computers and computer programmes are themselves the product of human thought, and therefore mimic their creators. This argument is somewhat weakened by the rather obvious fact that a computer is really very different from the human brain, and its software in many ways very different to the processes of the mind. The one is an array of transistor chips linked in circuitry, to a keyboard and a screen, working via step changes in voltage at incredibly high speeds measured in nanoseconds, the other a neural network of incredible and little understood complexity, working at much slower though still respectable speeds, via periodic discharges of a few millivolts, transmitted via the neurones of the brain, and the 'bus' of the nervous system to the muscles of the body.

In the case of the electronic computer the operating system and programmes are in general logical step by step instructions, whilst in the case of the mind we seem to have a weaving shuttle of impressions and memory and consciousness, operating both in parallel and in series, and capable of making 'fuzzy' judgements at a speed which the computer is quite unable of matching. It is worth noting that the 'simple' task of recognizing a familiar face, can be done by the human mind, in a fraction of a second with almost unerring accuracy, but such a task is a major problem for a computer, it is beginning to be solved, but it is still not very satisfactory.

Nevertheless, we in general use many common terms when describing the action of a computer, and the action of your minds. Why should this be? It seems likely that the resemblance between the computer and the mind, arises because the external requirements driving both are the same. A computer has to have a central processor or processors, input and output devices, short and long term memory store, and a database of information from which it can work. Similarly the mind has to have a central processor or processors (the brain itself), sensory input from hand and eye and ear (via the nervous system), and output to voice and hand

and muscle. It also requires a short term and long term memory store and a database of acquired information or memories to work with. There is good reason to believe that these functions or something like them are a necessary foundation of any 'intelligent' device whether mind or computer. But the similarity ends there, in terms of mechanism they are very different beasts. The computer is a programmable device, the brain is a learning device. The computer does basically what it is programmed to do, and nothing else (unless of course you have a 'wild pointer' in your program, and then God help you!!). The brain is programmed by nature to learn, and adapt to its environment.

A fundamental difference between the mind and a computer operating system, is that the mind is able to alter the hardware, (the wiring system), whereas a computer operating system cannot do this (at present anyway). One shudders to think of dealing with a computer which could do this. It is bad enough dealing with programming languages which can corrupt the operating system (like C for example). A pointer error in C, can crash the operating system in an entirely random way, which can be quite difficult, if not impossible, to pin down. A computer which could modify its hard wiring under the command of its own operating system would be a nightmare!

It is true that attempts have been made to build computer circuits which mimic the neural circuits which occur in the brain, and which can to some extent adapt themselves to external stimulus, and a limited degree of success in pattern recognition has been achieved, but in general the results have been disappointing, they. are slow, clumsy, need excessive computing power, and not well understood.

Can computers ever replace the human mind? Well that is a moot question. In some aspects the computer is far superior to the human brain (i.e. in numerical processing), but in others (intelligence, association, pattern recognition) it is very inferior.

Alan Turing first proposed a test for artificial intelligence. He argued that if a human observer communicating with a machine only by means of a terminal via a process of question and answer, were to be unable to distinguish between a computer and a human being on the other end of the line, then the machine could be said to be intelligent. We are nowhere near that point yet, and perhaps we never shall be.

Consider the difficulty of interpreting the different meanings of the phrases 'Time flies like an arrow' and 'Fruit flies like a banana', Do Time flies exist?, why do they like arrows?, if it comes to that why does a fruit fly like a banana?, and what is an arrow or a banana anyhow?!!. The problems of interpretation of syntax are bad enough, but the knowledge database which would have to be loaded into the machine to deal with general problems of understanding like this is so large, and the access problems involved in searching such a database so big, that the problems involved in making a machine understand general (as distinct from specific) human conversation may well be insoluble.

True some programmes can mimic human behaviour to some extent, 'Eliza', and 'Parry', to quote two in particular, the one mimicking a psychologist always reflecting a question back on the questioner, and the other mimicking an acutely paranoid individual who misinterprets everything he hears as a personal attack.

Also Chess playing programmes are now so sophisticated that they can rival a human Grand Master. But this is a very restricted scenario, and success has been achieved by brute force, look ahead, computation, rather than by any novel computing techniques.

Whilst it is possible that a computer could in principle replace a human being, it is probable that in practice, such a computer, even if we could build it, would have to undergo as long and as testing a period of education and adolescence as any human child, and would furthermore, because of its complexity be equally error prone and as neurotic as any human being.

Arthur C Clarke, in his prescient work of fiction Odyssey 2001, described such a computer 'Hal', and his analysis of its behaviour and problems is highly illuminating. Hal has been taught and programmed to preserve and look after the astronauts in the spacecraft, and also to repair himself. He has also in his store, instructions which even the astronauts do not know of. The ensuing breakdown when these instructions conflict, causes the computer to malfunction, and eventually the sole survivor disables it by pulling out its circuit boards one by one. The pathetic, and progressive disablement of the computer as this is done, is highly memorable.

We come now to consider Consciousness, which may be defined as 'being aware of oneself as a distinct entity, separate from other people or things in ones environment'. It is sometimes claimed, to be an exclusively human quality. Descartes denied that animals were conscious, choosing to regard them purely as automata. Nowadays, few would agree with him in this matter. Most of us would not deny animals, a degree of consciousness and self awareness, we are only too aware now of our own roots in the animal kingdom. Even the humble earthworm reacts to the spade that digs it up, and seeks to bury itself again in the earth. In general medical terms, consciousness is defined as reaction to external stimulus. The medical test for brain death, i.e. death of the higher regions of the brain, is to test for the automatic reaction of the pupil to bright light. If this is absent, brain death is suspected, and when confirmed by ECG or other test, life support may be terminated. Sleep or unconsciousness, is certainly a lack of consciousness, but (hopefully) a temporary one.

It may be argued that self consciousness is not just the ability to react to stimuli as described above, but something more. This may well be so, but I find it difficult to agree with those who argue that it is quantitatively different, rather it seems to me to be a further development of consciousness resulting from the higher degree of organisation inherent in the higher animals.

Jonathan Miller in 'The body in Question' makes some interesting points in this connection. He points out that our perceptions of ourselves differ considerably from our actual physical proportions. The mouth cavity for example seems huge to us, and feeling a hole in our teeth with our tongue, is like probing a large hole in the pavement!!. The mouth is an extremely important organ in man, and so too is the hand.

Presumably, for a dog, the nose would dominate, since the canine world seems to be very much dominated by smell!!. I think it is important to emphasize this. We commonly describe man as 'higher' than the animal kingdom, and use the word 'subhuman' to describe other species. But a dog might well feel otherwise, and

describe our abysmal sense of smell as a pitiful sub canine shortcoming!!. The difference between man and dog is that we have specialised in speech and verbal communication, and the dog has specialised in smell and olfactory communication, To describe animals as lower in some way than humans, and say that they are not self conscious or aware is hubris of the highest order.

Montaigne quite rightly points out that “It is by the vanity of this same imagination that man attributes to himself divine qualities, withdraws and separates himself from the crowd of other creatures and cuts out the shares of animals his fellows and companions How does he know, by the strength of his understanding, the secret and internal motions of animals . When I play with my cat, who knows whether I do not make her more sport than she makes me… If I have my hour to begin or to refuse, she also has hers.”

In essence self consciousness, is what we are aware of in ourselves and our surroundings. It may be argued that it is more than this, and it is true that it is more than just sensory input. Even when our sensory inputs are cut down to the minimum possible we are still self aware, we can process our internal memories and imagination, (unless of course we are asleep). It is this feeling that *'I know that I, am I'* that lies I think at the root of Descartes *'I think, therefore I am'*, and the reason that he denied this to animals, was that he was not prepared to allow an animal such self knowledge.

Few people now would agree with him on the latter, but in any case the question is largely academic, since we cannot talk in any very meaningful terms with the animal kingdom, we cannot know whether they would claim any self awareness. I am inclined to think that any organism which is sufficiently developed as to be able to describe itself, to itself, in whatever terms, may claim to be self aware, and that it is largely a matter of organisation and function, rather than any basic structural or physical quality.

The question of whether a computer can be said to be conscious is another matter, it certainly reacts to its environment, but self awareness is perhaps debatable. It may be argued that a large multi operating system, provided it is sufficiently sophisticated, approaches this level with its reliance on multilevel interrupts to handle several programmes at once, and a sophisticated operating system can certainly be said to be self aware, if by self awareness you mean an ability to monitor its own performance. But basically we do not build computers to scream if they malfunction, or croon if they are happy!!. I think really this is a matter of semantics rather than a real question, the operating mechanisms and purposes of a computer and the human mind are so different, that it probably makes little sense to ask whether a computer is self conscious, or can feel emotion, they were just never designed to do this. Incidentally Sherrington, over 40 years ago built simple but fascinating electromechanical analogues of simple reflex neural circuits that certainly showed many of the attributes of self consciousness.

The third attribute of the human being, the soul, is a different issue. It has its philosophical roots, in Platonic philosophy. Aristotle defined the soul as the 'form' or essence of the body, i.e. that which distinguished one person from another. He claimed that this form or essence was immortal, and did not cease to be when the body died. Religious thought throughout the ages has likewise asserted the

immortality of the soul in one form or another. The question for us now, knowing what we do about the brain, and the mind (little though that is), is whether soul means anything more than mind? Rather than take Aristotle's reasoning, many would now argue that the thing which distinguishes one person from another is his mind, the way he thinks and behaves, and that this is, if you like, his own particular 'operating system', the result of his heredity and upbringing.

In what sense then, can we talk about an immortal soul, Using the analogy with the computer, you can ask if an operating system can survive the demise of the hardware on which it operates? Obviously it can, if it is stored somewhere else, either on disk or tape or written form, or even in someone else's mind. Whether this can be said to be true of the individual 'operating system' (i.e. his mind) which we call self is not clear, for though it might be in principle possible to copy a man's mind onto another storage medium, no mechanism currently exists, and is barely conceivable at our current levels of knowledge, (outside the realms of science fiction).

I suspect that most medically trained people would say that 'mind' ceases with the death of the brain, and disclaim any expertise as to 'soul', saying that this was a philosophical or religious term. There is also the problem of damaged brains, when the mind and consciousness is diminished by stroke or other damage, where then, has this lost ability gone? We can die in stages as well as in one catastrophic event. It may be possible to envisage some transference of a man's 'operating system' or mind, to some other medium on death, it is surely stretching the imagination too far to think of this occurring with every minor 'death' of individual brain cells, which in fact occur throughout our life. John Masefield, wrote of man

> 'Water and saltness held together
> To tread the dust and stand the weather
> And plough the field and stretch the tether…
> Prove in the lifeless granites,
> Scan the stars for hope, for guide, for plan
> Fasten to lover or to friend
> Until the heart break at the end
> The break of death that cannot mend
> Since moons decay and suns decline
> How else should end this life of mine
> Water and saltness are not wine.

Well, I am afraid that I agree with him, water and saltness are not wine. The only immortality I can see at present lies in the genes I have handed on to my children, and even those are subject to the inevitable whim of time and chance.

The point I would like to make here is that as human knowledge advances, terms and concepts which used to be very important can lose their significance. The old mind/matter duality which so bothered the old philosophers (how could immaterial mind produce material movement and vice versa) no longer appears to be an issue with our modern knowledge of neurology, since mind is now seen as a function of neural processing in the brain, and there is no problem in seeing how this may produce a 'voluntary' movement of the arm or leg. Likewise the concept of

'soul' as distinct from 'mind', and being indestructible and having immortality seems very unlikely, knowing what we now do about the brain/mind relationship. I am not saying that it is impossible, it just seems to me to be very unlikely—although as Hugo Gryn has said 'I may be pleasantly surprised!'

Some may find these conclusions depressing, but for myself I cannot agree. Rather the alternative, eternal life, or immortality, is thoroughly depressing. It is change and happenstance that makes life interesting, an eternity of 'casting down our crowns beside a glassy sea' is too awful to contemplate!!!

Chapter 11

Cosmogeny, the beginning of things.

Space is big. You just won't believe how vastly, hugely, mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to space.

—Douglas Adams, the Hitchhikers' guide to the Galaxy

Cosmogony is a not very handsome word for the study of the origins and development of the Universe. This may seem a rather theoretical study, since it may be objected that one can hardly observe the beginning and development of the Universe, and verify your conclusions experimentally. But in fact you can!!, it is a very practical and experimental science, which is rapidly expanding its domain with modern telescopes, radio astronomy, and space flight.

As a science, its beginnings lie way back in the mists of time, with the first nomads gazing at the stars from their desert camp sites. It is no accident that many of the brighter stars have Arabic names—Aldebaran, Betelgeuse, Altair, Rigel etc. Astronomy took its first steps into an experimental science when Galileo turned his first primitive telescope onto the moons of Jupiter, and progressed with increasing speed throughout the eighteenth and nineteenth centuries as optical telescopes were improved and refined. But however large you make an earth bound telescope, in the end 'you are limited by the distortions of the thermal motion of the earth's atmosphere, and the narrow window of radiation covered by visible light. Atmospheric perturbation means that you cannot, except under extraordinarily good atmospheric conditions, get a clear view of, for example Mars, for more that a second or so; the image fluctuates and quivers continually with the thermal currents of the intervening atmosphere, and, because of the instinctive tendency of the human brain to try to make sense of what you see, you tend to read into a hazy and fluctuating image, details which are not there at all. An amusing, and famous example of this are the so called canals of Mars, popularised by the Astronomer Perceval Lowell at the end of the last century partly because of a misunderstanding of the meaning of the Italian word 'Canali' (grooves) used by an early observer of Mars, Schiaparelli. The idea of water bearing canals on Mars

became fixed in popular mythology, and Lowell became convinced that he could actually see such canals during periods of good visibility, although, because of the fluctuating nature of the image, photographic evidence could never be produced.

In fact it is now known that no artificial canals exist on Mars. The so called canals were merely optical illusions, the product of human imagination. That this human imagination also produced the novels of Edgar Rice Burroughs and C.S Lewis' *Perelandra*, is a fortunate? bonus.

The second problem, that of the limited 'window' of visible light, means that effectively an earth bound observer is blind to vast areas of the electromagnetic spectrum ranging from the radio and far infra red region down to the ultraviolet to X-ray region.

Taken together, it is rather as if we could only observe a garden through frosted blue glasses and a heat haze at a distance of several hundred yards!! Much of the detail and colour of the universe is just inaccessible to visual earthbound observers.

Until a few years ago, all Astronomers were very much in this position, despite all the size and sophistication of their instruments, they were essentially limited to earth bound observations using visible light. All this is now changing rapidly, radio astronomy, and space based telescopes, infra-red, X-ray, and visual are now giving us vastly more information and improved images of the remotest Galaxies and stars.

But you will say, surely, even then, you can only see the universe as it is now, you cannot look back in time, and see it as it was ten or fifteen billion years ago? But in fact, that is what you do see, because the light coming from the most remote galaxies and quasars (quasi stellar objects), has been travelling for up to ten billion years, (at 186,000 miles per second!!) and what we see now on earth is what they were like not now, but ten billion years ago, long before the earth was formed!! Similarly we can see stars in the Galaxies which were very young when their light left them to travel to us, although by now they may well be old and dying. So for the Astronomer, time travel of a sort is indeed possible (as long as it is backwards!) .

What then do we see, with modern technology of the Universe we live in. Let us take a journey out into space, and back into time.

We will deal firstly our own solar system, the system of planets and their moons orbiting the sun, our knowledge of these has been vastly extended by two magnificently successful space probes, Voyager I and Voyager 11, and the Hubble orbiting telescope.

The sun first, what is it, how old is it, and what is its fate, and how did the planets come to be formed? In Stellar terms our sun is a common, mid term, normal sized star, which condensed out of the primordial dust and matter of the Galaxy (our 'home' galaxy – the Milky Way), about ten billion years ago. It gets its energy from the nuclear fusion of hydrogen to helium, and subsequently further nuclear reactions of helium via what is known as the 'carbon' cycle to form higher elements, a sequence of nuclear reactions, which result in a small loss of mass, and the corresponding release of vast quantities of energy. It has now finished its formative stage, and is currently on what is called the 'main sequence' of stellar

evolution, and will remain in this sequence for many billions of years, finally burning out, to form a red or brown dwarf star.

During the initial formative stages, as the primordial dust of the galaxy, condensed, the contraction triggered off a swirling motion of matter around the proto star, (analogous to the increasing momentum of an ice skater as she folds her arms inwards in a spin). Out of this accreting disk of infilling matter, the planets and their moons began to condense. The early solar system must have been a time of incredible meteoric bombardment for the surviving planets, some of whom, the dead planets and moons, Mercury and the Moon, still bear on their surface the marks of the innumerable craters of this early stage. Not all the planets bear these marks however, those with an appreciable atmosphere and an active tectonic core, the Earth, and to a lesser extent Venus and Mars, have largely eroded such craters away, although some remnants remain of a few later crater impacts even on earth. The outer planets, Jupiter, Saturn, and Uranus, retained such extensive hydrogen and helium atmospheres due to their distance from the sun, and their size, that the are effectively giant gas planets, and hence cannot be marked by tectonic impact. Indeed the largest of the planets Jupiter, only just failed to become a star in its own right, even today a fair proportion of its energy comes from nuclear reactions in its core, as distinct from radiation energy from the sun.

It is a salutary reminder to those who condemn all nuclear energy, to realise that the very sun itself, so welcome and sustaining all life on earth, is a nuclear reactor. When we look at the sun we are looking into the fires of creation, an unshielded nuclear reactor so big, that the earth would be swallowed up in it without even a hiccup. Indeed this will be the final fate of the earth, for as the sun enters its last stage of burning before it collapses into a white dwarf, it will expand to a red giant, which will eat up the earth and all the inner planets in its wrath.

The Voyager space craft have vastly expanded our knowledge of the solar system. We have learnt more in the past fifteen years, than in all the many centuries of patient observation before. Some of the discoveries have been largely expected. Mercury is a dead shell of rock always turning one face to the sun. Venus is blanketed by a thick impenetrable atmosphere, and a searingly hot interior, as hot as molten lead. Even the Earth has yielded surprises, in plate tectonics and atmospheric circulation patterns are emerging.

Mars has proven surprising in some ways, although a dry cold planet, with a very thin atmosphere of carbon dioxide, it does appear to have been more active and welcoming in the past. There is much more water in the polar icecaps and tundra than we had expected, and evidence of water in the past in winding valleys which could only have been formed aeons ago by liquid flow.

Jupiter, Saturn and Uranus, the giant gas planets, continue to awe by their size and activity, but apart form vast convection patterns nothing permanent can be seen on their surfaces. All the 'gas giants' have planetoidal rings, rings of ice and rocky debris 'shepherded' by their inner moons, and magnetic fields generated by convection currents in their metallic cores. But the real surprises of the Voyager discoveries have been the diversity of the moons of the outer planets.

Jupiter has twelve, Saturn nine, Uranus five, and Neptune two, some as small as four kilometres diameter, others almost as large as the inner planets

themselves. Their diversity has been entirely surprising, what had been expected to be rocky barren airless worlds, turn out to be completely unexpected in their variety, from the volcanic world of Jupiter's satellite Io, powered by the gravitational stresses of its giant neighbour, to the icy chaos of Enceladus, One of the satellites of Saturn even has geysers of boiling nitrogen erupting through a thick methane ice cap over a shallow sea of liquid nitrogen and argon!!. One satellite of Saturn is tumbling in a completely random fashion in its orbit, belying the conventional view of Newtonian order in the heavenly bodies - one of the latest examples of windows of chaos in apparently fixed and orderly systems.

But Life? apparently not, most of the other planets and their moons are either too hot or too cold for liquid water to exist, although Enceladus may have a briny ocean below an icy crust.whilst Mars may at one time have had liquid water on its surface, and it is not beyond possibility that it may be colonised, and 'terraformed' to have liquid water again, whilst Jupiter undoubtedly has organic matter, if not living organisms, in its immensely thick atmosphere.

And the solar system is only one of billions of normal stars in our 'local' home Galaxy, (and there are billions of galaxies in the universe as a whole.) As far as we can see most normal stars will have planets associated with them, and there is a good possibility that one or more of these planets may be habitable. If life is not a complete and utter fluke, the chances of life occurring at some time elsewhere in the universe are not just good, they are almost certain. However the chance of communication with other life forms, during the lifetimes of their 'civilisations' over the distances of interstellar space are quite another matter, although it cannot be completely ruled out.

It must be remembered that not only must two civilisations be coterminous with each other, but they must also be listening for each other, and ultimately able to understand each other. Sagan has estimated the probability of such a civilisation within 100 light years of us as being barely one in ten, and this may well be a gross overestimate. Nevertheless a long term project of seeking such civilisations is under way at present, and may eventually be successful. If it is, it will effect as big, if not bigger, a revolution, as the discovery of America to our forefathers.

Our sun, is as we have said, a fairly normal star. In about eight billion years its nuclear fuels will be exhausted, and it will expand to be a 'red giant' for a few hundred million years before exploding as a nova before slowly cooling as a white dwarf to extinction.

But stars larger than our sun, burn their fuel more vigorously, and have a shorter lifetime. They also exit the stage more vigorously in an explosion called a supernova. In this case the gravitational force is so large that the electrons of the atoms in the core are forced into the nucleus to form an tiny incredibly dense neutron star only a few miles in radius, and the rest of the material is ejected in a truly titanic explosion. On average we would expect one supernovae in our home galaxy every few hundred years or so. As it happens one is overdue, for one probably occurred in 1054, and was observed by Chinese astronomers as a 'Guest star' which suddenly appeared in the constellation Taurus, and remained visible for several months before gradually fading. Although 3000 light years away, on the other side of the Galaxy, at its peak it was brighter than any of the planets, and was exceeded only by the moon in brightness.

It is visible now only through telescopes as the 'Crab nebula', and shows an expanding shell of gas moving at 1000 kilometres per second, out from a very powerful radio source seen only as a very dim optical object. All supernovae remnants (others have been observed in other galaxies), are without exception very powerful polarised radio sources, their radiation being characteristic of the synchrotron radiation given out by electrons accelerated by powerful magnetic fields. The energy of the explosion is almost unbelievable. A Supernovae near to the earth (and there must have been several during its 5 billion year history, would indeed be spectacular. It would be visible during the day, and as bright as the moon at night - bright enough to cast an appreciable shadow. It radiation would cause a significant increase in the cosmic ray radiation on earth, and severe difficulties with radio transmissions. Such an event in the past might well have resulted in a drastic climatic change and destruction of the ozone layer, possibly causing some of the periodic mass extinctions of life which have occurred in geological history.

It is now thought that the remnant from such an explosion is a 'neutron' star, a star so dense that the remaining material is a completely new form of matter, the orbital electrons of the atom having been compressed down into the nucleus, and the constituent protons thereby converted to neutrons. Such a material is unimaginably dense, a cubic inch of such a material weighs ten billion tons!!. The resultant star is extremely rigid, and only a few miles in circumference, spinning at very high velocities and its resultant magnetic field is so strong that electrons spiralling down to its surface emit intense directional synchrotron radiation out into space in a sort of cosmic beacon. Hydrogen accreting onto the surface of such a star, accumulates on its surface until sufficient is on the surface for periodic nuclear explosions. The density of such a star is almost unimaginable, relativistic effects occur, clocks run two or three per cent slower on its surface, and light has appreciable difficulty in escaping.

If the collapsing star is larger again, say ten solar masses, the resultant remnant is so dense and so massive that light cannot escape from its surface at all!. It becomes a 'Black hole'. The word is apt, since it really does become a 'hole', for not only can no radiation escape from it, nothing can escape from it, it is indeed, an end to all things. For it is axiomatic that nothing can travel faster than light, and if light is trapped, so is all information. A Spacecraft falling into a black hole (assuming it could escape destruction by the gravitational stresses involved) would be accelerated up to the speed of light!!. In the doubtful event of any observer surviving such a cataclysm, on returning from such a 'journey he would find all time finished in his home galaxy!!

Observation of such an entity is somewhat problematic, since by definition it cannot of itself be observable except by its intense gravitational field and its weak Hawking radiation. However candidates do exist, notably as massive companions of orbiting binary star systems, and hidden in the cores of the galactic centres, obscured by dust and radiation from observation, although they have not been identified with certainty as yet.

Stars are always associated into galaxies, groups of many billions of stars forming globular or disk shaped accretions in space, many millions of which are now known to exist. Our local Galaxy, seen in the night sky as a band of

luminosity overhead in the plane of the ecliptic, is merely one of many typical galaxies, each containing themselves many billions of stars. The nearest the Andromeda galaxy, seen as a small blur by the naked eye in the belt of the constellation of Orion is a typical spiral galaxy several millions of light years away.

It is salutary to remind ourselves, that at the time the light we now see this galaxy left its sources, there were no men on earth!! We are looking back in time as well as space. And with the farthest galaxies we are looking back to a time when the earth and the solar system had not yet been formed from the dust of space, back over ten billion years to the dawn of the universe.

Galactic development is a major issue with Astronomers at present. It is now thought that Galaxies are associated into super galaxies, and that the distribution of such Galactic structures is not random but possibly filamentary. Generally the farther away (and the older) a Galaxy is, as observed by its red shift, the more energetic it becomes. The picture is not as you might expect, one of gradual condensation of galaxies from cold interstellar matter, but of gradual cooling down of incredibly violent and tumultuous clouds of galactic matter. For at these distances and time, almost two thirds away across the Universe, and in the early days of the Cosmos, a subtle observational change is occurring, the furthest objects out telescopes can see are no longer galaxies, but so distant and so energetic that we are not at all sure what they are, all we know is that the represent something awesome at the beginning of time. They are known as 'Quasars'—quasi stellar objects. One of the most distant 3C-9, is receding from us at half the speed of light, and is reckoned to be about a hundred times as luminous as a normal galaxy. It is now thought that these are the first signs of the beginning of all things, the big bang.

For the universe had a beginning, of that there is not much doubt. It must be clearly understood that it was not a beginning in time and space, but a beginning of time and space. It is pointless to ask what there was before the big bang. Neither time nor space existed. This idea of an initial singularity, or 'big bang' is inherent in Einstein' theory of general relativity, and the curvature of space-time by matter, and the observed expansion of the universe, and it has received unexpected experimental confirmation by observations of a universal background radiation which pervades all space, in the form of microwave radiation at only just above absolute zero, corresponding to the intensely hot radiation from the initial 'big bang' which has cooled over the aeons to a very low temperature of 4 degrees above absolute zero. The study of the early universe and its origins in 'the big bang' is Cosmogony, and is a subject of intense interest to many astronomers and theoretical physicists today.

Why theoretical physicists? well because at this point, the high energy physics, the nature of matter, and the origins of space and time itself become, fused, in the initial singularity, and in attempts to formulate one relatively simple theory—the so called Theory of Everything. For if the universe started as a singularity or point, Quantum theory, the theory of the unimaginably small, starts to take over, and modern mathematical physics starts to have a vital input. It may seem far fetched that understanding the atom may lead us to an understanding of the origins of the universe, but oddly enough, it is possible to calculate more about the first few seconds of the Universe than we can about the succeeding billions of years!! For it

seems that the beginning may well be remarkably simple, since the complexities of the galactic development and the wheeling star systems of the present time do not have to be considered.

Physicists now think that the original singularity or 'big bang' was responsible for synthesising the primeval elements Hydrogen and Helium, (the rest of the elements were synthesised in the stars, and their evolution via novae and supernovae is fairly well understood). The 'standard' theory of the 'big bang' envisages the initial singularity as a sort of primeval 'atom,' a soup of 'quarks', unbelievably dense, unbelievably hot, and about the size of a grapefruit!!. Only as space-time expanded, did things begin to cool enough for the symmetry breaking field (The Higg's field) to differentiate this 'soup' into the more complex forms of matter we know today. The problem with the standard theory however, is that although it explains very well the relative abundance of the primeval elements Hydrogen, Helium, and Deuterium in the early universe, it raises a number of problems, particularly the 'lumpiness' of the universe that subsequently developed. If the universe did in fact arise from such a simple primeval 'atom' it should not be as 'lumpy' as it is. There were other problems with this model, why for example if the initial expansion were so close to the speed of light, did all parts of the observed universe cool down to more or less the same temperature, and where are the 'magnetic monopoles' which calculations suggested should have been formed, and why is the mass and hence the curvature of the universe so close to the critical 'closure' point.

But in late 1979 Alan Guth suggested that instead of starting out as a grapefruit sized primitive 'atom' of quarks, the universe could instead have started out simply as a 'quantum fluctuation'. The idea is that a quantum fluctuation in what is essentially nothing, of effectively zero dimensions (less than a billion times smaller than the nucleus of the hydrogen atom), could have resulted in an almost instantaneous expansion of space from effectively zero to about 10 to the power ninety times greater. Matter and energy cannot expand this fast, and the initial almost instantaneous expansion forms a 'false vacuum' into which the subsequent matter and energy expands in the big bang proper.

But where did all this matter and energy come from? Normally in our almost flat space time, such quantum fluctuations produce only virtual particles which are rapidly reabsorbed, due to the lack of energy to ensure their continued existence, but in the highly energetic curved space of the initial singularity, this restriction no longer applies, and in effect something can come out of nothing. In effect it is at least possible that the Universe is in fact a 'Free Lunch'. The idea attracts many scientists, and whilst far from proven, does explain many otherwise inexplicable features of the early universe.

In Dante's the *Divine Comedy*, which tells how Dante, accompanied by Beatrice (the beloved guide), is granted a vision of the Divine essence.

"A point I saw that darted light so sharp, no lid unclosing may bear up against its keenness".

In fact Dante is referring to a famous passage from Aristotle's Metaphysics—"From that principle (the Prime mover), depend Heaven and all nature". It would 'be quite wrong to imply that Dante, in this passage is foreseeing modern

developments in cosmology. In platonic philosophy the prime mover existed as an origin of prime reality, of which the transient, material world was merely a copy.

Nevertheless, it is now possible to say with some degree of confidence that there was, in reality, a 'prime movent', a beginning of all things, and from that point 'depend the heavens and all nature'.

Some physicists are now talking seriously of a possible Grand Unified Theory (G.U.T). The idea is of a set of mathematical equations, which would fundamentally model all the primary forces of the Universe, from Gravitation to Quantum mechanics. In a sense this would represent the final end (in the Teleological sense) of theoretical physics. If complete, there would be nothing more to learn, only the extended development of these equations with time, to model the complexity of the actual world. Whether this is ever possible, remains to be seen. It is not inconceivable that such a system could be developed. If it is, we could really say that the Universe, this solemn Temple, the great Globe itself, like an Insubstantial pageant has faded, leaving only a set of mathematical equations!!!.

But things are not quite as simple as this. For one thing, why (if we ever get such a system of equations) are the they set up in the way they are, who wrote the equations as it were?

It is worth thinking a bit more deeply about this. Firstly it is really a very down to earth question, for so many constants have to be 'fixed' before the equations that model the initial singularity produce sensible results. Take the gravitational constant, the acceleration due to gravity of unit mass, or the speed of light 186,000 miles per second, or the charge on the electron. All of these have to be set into the equations, and if they differed from the accepted values by even a very small percentage, the universe would be very different, if indeed it could exist at all. Did God have any choice in this matter? Could he, did he, does he, have created or create other worlds, in which other creatures could have existed? Indeed did he create an infinity of worlds, and ours just one of them? After all if the beginning was just a quantum fluctuation in nothingness, why this world in particular.

There is an argument—'the weak anthropological argument', which says simply 'Well if he did create other such worlds, we could not have been there to observe it - this is the only world we could exist in!!" which is undeniably true, but somehow highly unsatisfying. Another argument was put forward by Leibnitz, who said that whilst God could have created any number of possible worlds, this is the best world he could have created, but this again begs the question of 'best' for whom?—us or the starving peasant in Angola!! Indeed Leibnitz's philosophy has been mocked on this account. Voltaire caricatured him as Dr Pangloss, who assured everybody that everything was for the best in the best of all possible worlds!!.

However in his unpublished writings he appears to have been thinking of the creation of a Universe which maximises possibilities. and there is certainly a suggestive idea here. Perhaps God is a God of possibilities, and selected (or had to select by his own nature), the only Universe that could by its duration and development, include many possibilities (including you and me)..

However, if our current views of the beginning (and end) of the Universe are correct, then we may well have come to a finally unanswerable question, a sort of mathematical singularity beyond which we cannot go. There is nothing odd or

strange about this. Kurt Godel showed in 1932 that in any sufficiently powerful self referential system of mathematics, there will always be at least one theorem which we cannot answer or resolve. It is conceivable that a similar argument may apply here, certainly man's thought can be regarded as a 'sufficiently powerful self referential system'. We know from computer studies that there are certain classes of problems which although soluble in principle, cannot in practice, be solved, because they cannot be guaranteed to terminate in a finite time. Perhaps we are at this point in the theoretical physics of the Big Bang. This is not to say that speculation is forbidden, just to say that there may eventually be no way in which a definitive answer may be given.

Einstein once said of the beginning of the universe 'The question is, did God have any choice in making the world like he did?'. It is an interesting comment, since it raises questions about the nature of God, for what sort of God is it which “has no choice in making the universe as he did'? If 'He' had no choice, then surely he is in fact powerless!! a being if you like in the grip of himself, compelled by his own essence. One suspects that this may be the reason why Leibnitz, discouraged by the Jansenist Arnauld, never published his ideas on 'compossibility' as he called it.

In Primitive times 'God' or 'Gods' was understood as the activating spirit of whatever thing you were talking about. The Roman would have called it the 'genius' of the thing. The Goddess Coventina was the genius or spirit of the well at Carrawburgh, the Goddess 'Sulis' was the genius of the hot wells at Bath—*Aquae Sulis*. The God Mars was the genius of war, Athena the genius of wisdom and learning and so on. If you wanted victory in war you sacrificed to Mars, if the well dried up you sacrificed to Coventina. This was largely because, quite sensibly, no one in the ancient world could conceive of change or movement without the intervention of some 'genius' or spirit. If an ancient Roman could see a modern motor car, his reaction would not be 'How does it work?' or 'where does it get its energy from?', but what 'genius' or spirit was driving it, and hence what sacrifices do you have to make to appease this spirit and control it!!

We do not now think like this, as regards the lesser Gods of home and hearth and country. We know why the well rises or falls, and why the springs of Bath are hot. But explanation need not take away wonder. Properly taught an intelligent child can be as thrilled by Archimedes as by Arsenal. The sheer logic and strength of scientific and mathematical reasoning can still thrill us, and a good teacher or lecturer can still inspire his students.

But all our explanations, all our science, all our mathematics, still come down to this 'Why is the world like it is?', and even if in the end we can reduce the beginning of the universe to a simple formula, and all its incredible complexity, to a time development of this formula, we are still faced with the ultimate questions of firstly, why are the rules set up in this way,

From this point onwards this book will be discussing, not so much the basic science of the world we live in, as the limits to reason and logic inherent in us, and the nature of time, order, chaos, and uncertainty. The next chapter covers these topics.

Chapter 12

Time, chaos, and uncertainty.

The moving finger writes, and having writ
Nor all thy piety, nor all thy wit
Can lure it back to cancel half a line
—The Rubaiyat of Omar Khayam

Oh I was young and easy in the mercy of his means,
Time held me green and dying
Though I sang in my chains like the sea.
—Under Milk Wood, by Dylan Thomas

Few things are so obvious, and so unheeded as the passage of time. We live forever in a fleeting moment, the past only memory, the future to be guessed at and unknown. The present moment is evanescent, as soon as we attempt to hold on to it, it has slipped from our grasp to become the past. Time indeed holds us, and all creation, 'green and dying though we sing in our chains like the sea'.

We have seen that Einstein showed that time can be regarded as another dimension another way of identifying not only 'where', but 'when'—an extension as it were of our normal conception of space—up and down, right and left, and in and out. But we know, instinctively, that time is not really just this, another dimension like up and down, forward and back, in and out. Time, unlike the other dimensions has only one direction—forward, you cannot go back.

Indeed the prohibition is so absolute that even to consider it as a hypothesis leads to glaring contradictions. If you could go back in time, you could for example quarrel with (and shoot!!) one of your parents before you were born!! a contradiction in any terms. Of course, it is possible to envisage different futures in your life. You could for example marry Jane instead of Mary, and go to live in London rather than New York, there is nothing implausible, or impossible, in these alternative scenarios. But what is not possible is that they could both be true, you cannot be in New York and London simultaneously. J.B Priestley has written an interesting play *Time and the Conway's*, on the contradictions that arise when two such divergent scenarios interact. But in practice such a thing is logically impossible, you cannot be in two places at the same time (unless of course you are an atomic particle like a an electron or photon—and they of course are identical—you cannot distinguish one electron from another!!)

Oddly enough, nothing in Einstein's or Newton's theories of gravitation or quantum mechanics, despite having everything to do with 'dynamics'—the way thing change with time, i.e. the change of position and velocity with time, say anything about the direction of time as such. The equations for a bouncing ball, or the orbit of a comet are entirely reversible, the ball may fall or rise, the comet may come or go. As far as Einstein's or Newton's theory is concerned, time has no fixed

direction, any more than the spatial dimensions, up and down, forward and back, to and fro. There is only one science which is concerned with time's direction—the dismal science of heat and work—Thermodynamics. For the second law of Thermodynamics says in effect that the entropy (i.e. the disorder), of a 'closed' system tends always to a maximum with the passage of time.

The nineteenth century German Physicist, Boltzmann, put it succinctly in a phase I still remember from my student days—“Die Entropy der Welt steht un maximum zu” (The entropy of the world tends always to a maximum).

There is something deadly and inexorable about the German phrase, with the leaden emphasis on the final 'zu', which has always fascinated me. Perhaps it is just due to the guttural nature of the German language, and the grammatical structure which insists on piling up nouns and adjectives and terminating the whole pile with the final definitive verb. But whatever the reason, nothing, in the long run can escape this law, the final 'to' is inevitable, time has only one direction, towards increasing disorder.

The Second law of thermodynamics is universal, it controls the maximum efficiency of all machinery, making perpetual motion impossible, and steam locomotives inefficient, power stations need cooling towers. It limits human life to approximately three score years and ten, and the lifetime of our sun to 5 billion years or so. Everything, it says, must eventually run down and die.

Why should this be? Well basically because whenever anything moves, it moves with some inefficiency, and the loss of efficiency results in an increased disorder in the greater system of which it is a part. Consider the case of a train running freely down a track which ultimately bottoms out and rises again to the same altitude. If the wheels of the train were frictionless, and the air resistance nil, the train would career down the slope reach its maximum velocity at the bottom, and continue onwards and upwards at decreasing velocity until it reaches its original height, and then reverse back and repeat the process ad infinitum. But in practice, the train would slow down on each pass, and ultimately come to rest at the bottom of the dip, its energy dissipated in friction as low grade heat to the rails and the atmosphere.

The key to understanding the arrow of time is to understand that no process is entirely reversible, all processes degrade higher grade energy to heat. Indeed many processes in the real world are almost totally irreversible. A world in which the broken pieces of a cup suddenly leap off the floor and gather themselves together to form an intact cup in your hands, is not just impossible, it is inconceivable!!. The reason for this is basically statistical, there are an infinite number of ways in which the cup may break, but only one way it can be put together. Thermodynamics is statistics in action. Thermodynamics is the science of chaos, the science of lots of things, atoms, nuts and bolts, gases, cars, steam engines moving in a random fashion.

Until a few years ago, thermodynamics meant only 'equilibrium' thermodynamics. People thought of the arrow of time going steadily and remorselessly in one direction. However that is not quite true, it applies only to the system as a whole (technically a 'closed' system). But recently we have begun to realise that within the system, if the driving forces are large enough (i.e. non-

equilibrium), transient pockets of 'order' may arise as the system degrades, which may persist for a greater or lesser extent, although overall the arrow of time is remorselessly downwards. This new branch of thermodynamics is called non-equilibrium thermodynamics, and is closely bound up with new studies of chaos itself.

There is indeed a science of disorder, we are increasingly coming to understand that within the most apparently orderly of systems, the seeds of chaos lurk, and that this chaos is in itself subject to order, and that all the really interesting things happen in this half way house. After all if you picked up the phone and you heard a message which was just a single word repeated ad infinitum, you would not find it very interesting. Equally if you heard only a random sequence of words you would be equally bored. The really interesting messages are sequences of different words (which may convey a meaning). The first is a completely ordered system, the second a completely disordered system. The mixture of the two is the interesting bit.

Until a few years ago, chaos or disorder, was the 'bête noir' of mathematics. Equations were supposed to 'behave' themselves and give reproducible results, and if they did not, mathematicians regarded them as 'monsters' and hastily tucked back into the cupboard. But we now know that many equations, often very simple ones, can give chaotic results We ought not to be surprised at this, after all even the simple enumeration 1,2,3,4..., has the seeds of chaos embedded in it. If you don't believe me try to predict when in the series the next prime number will emerge!

One of the most illuminating chaotic equations is a simple equation often used by biologists for predicting the future population of a closed system, ultimately subject, as it always must be, to constraints such as food and space. Initially with a small population the numbers increase exponentially, but ultimately, the rate of increase will be limited by the food, space, or whatever, available. These limiting factors will be proportional to the size of the population, being zero when the population is small, and inhibiting growth massively when the population is large. Ultimately, at high rates of increase, the succeeding generation is so large, that disaster sets in, the food/space is exhausted in one generation and (in theory) the population collapses to zero. For a long time everybody assumed that the equation was well behaved, and nobody bothered to look beyond this point at what would happen with higher reproduction rates than the disaster scenario when the population collapses.

In retrospect, this is odd, since violently fluctuating populations are often observed in nature especially in insect and rodent populations. But in 1971 it was shown that at very high reproduction rates this equation shows firstly a rise toward a maximum population, followed by a bifurcation (splitting) into two possible levels, followed by a further splitting into four and eight possible levels, and then increasing periods of complete chaos, when it was impossible to predict the population level at all, interspersed with regions of comparatively orderly behaviour.

A similar situation occurs in the prediction of global weather conditions. The equations governing the motion of heated columns of air in the atmosphere, and the dynamics of wind forces and the earth' rotation, have been known for many

years, and can be written down, and in principle solved, given sufficiently powerful computers. With the advent of the supercomputer in the sixties and seventies, the weather forecasters thought that they would soon be able to predict global weather patterns weeks or months in advance. But in 1961 Edward Lorentz was working in this field, and developed a model that appeared at first to predict future weather patterns fairly well. But one day he wanted to go back and pick up from the middle of a run he had done the previous day, to examine the predictions in greater detail. He typed in the intermediate results and started the run off again from an intermediate point. To his dismay the new run began to diverge at ever increasing speed from the previous days results. Lorentz satisfied himself that this was due not, as he originally thought to a data error, or computer malfunction, but due to the fact that he had typed in the intermediate results to only three decimal places, whereas the original run had used data stored to six decimal places. Thinking about it he realised that this was very bad news for long range weather forecasters, for if over a period of weeks weather patterns could be entirely different due to differences in the fourth or higher decimal places of the input data, then there was little possibility that better data collection or improved computing facilities would improve long range weather forecasting.

We now know that the dynamic equations used in weather modelling are a mixture of both order and chaos, called 'strange attractors'. When developed over time, they take the form of families of curves that increasingly diverge from each other with the progress of time. Whatever the accuracy to which the input data is specified, the final outcome cannot be completely predicted.

At this point I would like to look again at two apparently totally unrelated ideas. The first is the 'collapse' of the quantum field by an observer, as exemplified by the story of Schrödinger's cat, and the second the Darwinian thesis of descent of species. Both are 'time sequences' i.e. the development of a system with the passage of time, and both say something quite important about the world we live in.

You remember that the unfortunate cat was put inside a sealed box with a small portion of radioactive material set up in such a way that a radioactive decay, a purely random quantum event, triggered the release of a cyanide pellet which would kill the cat. The question was what was the state of the cat the moment before the box was opened? Common sense says that the cat is either alive or dead, it cannot be both. But Von Neuman showed that in strict quantum mechanical terms, it is logically both!!, for not until the box is opened and the probability function for the system 'cat in a box' collapsed, is the actual state of the cat resolved. Sane people of course revolt at this conclusion, and indeed it can be shown that an extension to two independent observers when each has the power to 'collapse' the probability function, leads to a number of logical absurdities. Quantum theory, although undeniably powerful when dealing with atomic and subatomic phenomena, clearly breaks down when dealing with large scale macroscopic phenomena like 'cats in boxes'!! Nevertheless, it cannot; be denied that quantum processes at subatomic and atomic levels must underlie reality as we know it in the macroscopic world, so we must ask ourselves what causes this breakdown as we progress from the subatomic level to the macroscopic level?

I believe that explanation must lie in the multiple interactions which occur in the real world, which function as 'observers' of the event and 'lock' or 'freeze' the quantum probabilities as they progress in time, so that the real macroscopic world is classical rather than quantised in its behaviour. In essence Quantum mechanics says that until an event (whatever that event may be) is 'observed' i.e. has affected the world around it, it is essentially indeterminate. Only when an interaction with the 'external' world has occurred, is the indeterminacy resolved.

You will remember the conundrum posed by the decay of a particle into a positron/electron pair, ejected in opposite directions, and spinning in opposite senses, and the point made that observation of the direction of the spin of one partner determines the direction of the spin of the other partner, even though they may be separated by half the universe!!. Here we have the point made with the utmost force, the positron/electron system is indeterminate until it interacts (is observed) with the external world, however far apart the partners are. Observation then 'freezes' the total system. The nearest analogy I can think of is the process of crystallisation of a supersaturated solution when a seed is placed into the melt. As soon as this is done, a crystal grows out from the seed, and within a few seconds the whole melt has solidified. The initial process must be quantised, and subject to quantum rules, and the uncertainty that implies. Once started however the multiple nucleating surfaces spreading out from the original seed, lock the process, and it proceeds rapidly and irreversibly to completion.

After all this irreversibility is inherent in the real world, when you go out of your front door into the street, you may turn right or left, the choice is yours, but once you have done so, the world has irreversibly frozen your act, you cannot go back and do something different.

Exactly the same thing occurs in Darwinian evolution. Random changes in species, some small, some large, over time, are weeded out by the environment at any time, and some lines of species survive, and others die out. Natural selection, is by no means necessarily for the 'best' species in the long run, only for the best species at that particular time. Often pure luck plays a part. If an Asteroid had not hit the earth during the early Cretaceous era (if that really was the cause), the Dinosaurs might not have been wiped out, and man might never have become the dominant species on earth!! The race is not necessarily to the swift, nor victory to the strong, time and chance happen to them all. But, and this is the important point, the process is irreversible, once time and chance have had their say, evolution is locked into that particular course. The Dinosaurs are dead, and nothing (notwithstanding *Jurassic park*) can bring them back.

Time then, is basically our experience of change, and all change is basically more or less irreversible, indeed it may be said that time is irreversibility.

But, in that case, we may ask, is there a beginning and an end to time? And the answer it seems is yes. For a beginning the Cosmological evidence is now overwhelming. For an end, Thermodynamics points a remorseless finger. Both space and time started about 10 to 15 billion years ago, in what is popularly known as 'The big bang'. It is important to understand that not only did the universe of matter come into being in the big bang but also space and time. It is meaningless to ask what there was 'before' the big bang, neither space nor time have any meaning before that moment.

But time must have an end also this is the 'heat death' of the universe, in which the temperature driving forces, which activate all processes, have vanished, although long before that has occurred we may well have been sucked by the ever persuasive force of gravity into the sink of a 'black hole'. In terms of time a black hole is the ultimate end, for if anyone could return form a black hole, he would find the universe had ended when he returned!! But of course nothing could, for nothing, no light, no radiation, no information could escape from a black hole. The end of the Universe may well be bound up with this phenomenon. If the earth itself escapes being drawn into a local black hole in some future age, the Universe itself will probably collapse back into one almighty black hole, or singularity. Big bang to Big hole if you like!!

Increasingly then, it is beginning to look as if the universe itself mirrors a time development, from an initial singularity, to a final collapse. The complexity of the real world arises not from any complexity as such, but from its development with the passage of time.

There is an intriguing game called 'Life' developed by Conway, which illustrates this point very neatly. 'Life' is played on a squared board, in theory of infinite dimensions. You start by colouring some of the cells at random. The rules state that if a vacant cell has three coloured or 'live' members, then the vacant cell is coloured, and becomes live. If a living cell has two or three living neighbours then is stays alive. If it has more than three living neighbours it dies through overcrowding, and if it has fewer than two living neighbours it 'dies' through loneliness. The game is best played on a computer, with each pixel of the screen switched on or off with each transformation. If the sequence is run rapidly, at say sixty times a second, the screen becomes a hive of activity. Dots race around, form worms, crawling around the screen, colliding and eating one another. Some patterns, which Conway calls glider guns, seem to be semi stable, and pump out endless streams of 'gliders'. Some patterns even seem to able to reproduce themselves. Games such as 'Life' are examples of 'cellular automata'. The rules are very simple, but the consequences of their development with time are very complex and unpredictable.

Mathematics, chaos, and time itself, have come together in recent years to produce the science of 'Fractals', now widely used in computer graphics, to simulate natural scenes and processes. The idea of a fractal was developed by Benoit Mandelbrot in the early seventies. We are used to describing things in terms of dimensions. A line is one dimensional, a surface is two dimensional, a solid three dimensional.

Mandelbrot showed that it was possible to conceive of figures that had, for example, dimensions greater than one or less than two. Consider for example a equilateral triangle which is 'developed' by introducing a kink in each side at its mid point, and then introducing another kink in each of the resultant sides and so on, ad infinitum. What do you get then? You get what is called a 'Koch snow flake'. Its perimeter is infinitely long, but it bounds a finite area!! It is a perfectly self similar curve of infinite length that bounds a complex shape of area eight fifths of the original triangle. The curve itself is so fuzzy that one can no longer think of it as a one dimensional line, instead it can be said to have a fractal dimension of 1.2168 .

If you think this is nonsensical, ask yourself how long the east coastline of the United States is? The only valid answer is that it depends how closely you measure it. If you measure it on a world atlas, it comes out at about 2000 miles. On a large scale map it will appear much jagged, and you will come out with about 5000 miles. If you walked it yourself, always staying within one foot of the high tide mark, it would come out at perhaps 15,000 miles. If a determined ant walked it staying within one tenth of an inch of the high water mark, it would come out at around 40,000 miles. Where do you stop?? The coastline is a natural example of a fractal, a curve that the closer you look at the longer it becomes.

Fractal curves can develop pictures of infinite complexity and beauty. Julia sets (named after the mathematician who first investigated them) are sets of curves based on a quite simple function. Mandelbrot discovered a way of mapping this equation, from which particular Julia sets can be selected. A feature of these curves is the way in which particular figures keep recurring, however deep you go into the mappings. It seems that however chaotic and varied the patterns that develop are, deep within them they 'remember' the basic patters that form them, which recur at intervals, however deeply you probe. Such Fractal curves can be developed to model natural forms surprisingly closely.

What has all this to do with our overall theme, the nature of the world, and the universe we live in? Simply this, that it begins to look as if the rules that constrain our world, the 'Theory of Everything' if you like, might well prove in the end to be comparatively simple compared to the complexity they generate with time. Indeed it is possible that our world is really a sort of fractal. Basically simple, but developing an incredible complexity and beauty with time.

The initial singularity or 'Big Bang' seems to have been very highly ordered. As time and chance progressed a simple singularity flashed into existence, expanded many million fold, and formed our universe. The beauty and chaos of our world mirrors the development of a fractal, a world in which chaos and order an inextricably mixed, in which recurrent patterns occur, time and time again, yet with infinite variation. Perhaps indeed the 'mind of God' may be mirrored in some mathematical equation at the beginning of time and space, but this equation, or 'system', call it what you will, is not deterministic, but is capable of developing in infinitely many ways, to be investigated and described, and in which clues are to be found at whatever level we look.

Joachim Neander at the end of the fifteenth century, wrote a lovely hymn, which I would like to quote here

Splendour, light, and life attend him
Beauty springeth out of naught
Evermore
from thy store
New born worlds rise and adore.

The words still ring out through the ages—“Evermore, from thy store, new born worlds rise and adore.

Chapter 13

The limits of reason.

There are more things in Heaven and Earth Horatio
Than are dreamt of in your philosophy
—William Shakespeare, Hamlet

Logic is undoubtedly a very powerful tool, and in mathematics it reigns supreme. To calculate and measure, compute and deduce, has been the foundation of science and mathematics from the outset. But it is by no means the end of the story, for in recent times mathematicians have increasingly begun to realise that there are limits to logic, and even more remarkably, that no logical system can completely describe the real world. In the real world one you may observe something that appears to be true, but be unable to explain it in completely logical terms, and that this inability to explain something is not just due to the fact that at the present time you do not completely understand it, but is inherent in the limitations of your logical system.

At the turn of the century, it was commonly thought that given a sufficiently powerful set of simple and obvious axioms (basic premises), all known mathematics could be deduced by the application of the laws of logic. Indeed Russell and Whitehead produced what was thought to be the definitive textbook of mathematics based on these principles—the *Principia Mathematica*, published in 1902.

But in the 1920's a young mathematics student, Kurt Godel, used their own tools to prove them wrong. Godel's Theorem appears as proposition VI in his 1931 paper *On Formally Undecidable Propositions in Principia Mathematica and related systems*. It says—'To every w—consistent recursive class k of formulae there correspond recursive class—signs r, such that neither v Gen r nor Neg (v Gen r) belongs to Flg(k) (where v is the free variable of r)—actually it is written in German as well, and as Hofstadter says might as well be in double Dutch, for all the sense it makes to most of us!!

But in plain English it says something like this—'All consistent axiomatic formulations of Number Theory (for example the Principia Mathematica) include Undecidable propositions'.

The proof is far to complex to be included here, and only a trained mathematician could understand it. But suffice to say that it drives a coach and horses through any attempts to develop a rigidly formal mathematical number system, and indeed through any attempt to develop a rigidly formal logical system to describe anything, including the Universe itself!!.

Basically this is because you cannot, in logical terms, put a limit on the number of true statements an axiomatic system may generate. Truth is in this sense infinite. Godel seems to have been led to this conclusion by a consideration of

Epimenides paradox, the ancient paradox of the liar. In its simplest form this says—“This sentence is not true”.

Think about this a moment. It is validly formed sentence, which at first sight is quite simple. It refers to itself, and then says that 'it' (i.e. this statement) is untrue. But if that is the case it must be true (the opposite of not true is true), but conversely if it is true, it is untrue, and so on and so on ad infinitum! In practice, of course, it is Undecidable. There is no terminating answer.

Why should this be so? What is it about this simple sentence that makes it so perplexing. At first sight it may be thought to be its inherent 'self reference'. Perhaps any sentence that refers to itself is Undecidable? But there is nothing wrong with “This sentence is short” that is self referential. And in any case recursion, (which is only another name for self reference), is not an invalid mathematical technique, provided it can 'bottom out' somewhere. The problem is that this sentence cannot bottom out.

Godel was able to show, that 'self reference' was not the problem, by coding up the sentence in a special sort of way, so that the self referential element can be simply dealt with. What is in fact wrong is the fact that it cannot bottom out. Think about it a moment—the number of possibly true (or untrue) things is after all infinite. Truth has no finite mathematical description.

This is not to say that Truth is a meaningless concept, for the known facts of the world are finite, and consistent. It merely says that you cannot prove everything—the ocean of truth is infinite, and our knowledge but an island or rather an archipelago, floating in a boundless ocean of possibilities.

You can look at it in this way if you like. Think of the rules of mathematics as a 'seed' in 'logical space' i.e. the multidimensional space of all possible logical truths. Now develop this seed using the rules of logic, to explore this logical space, marking the bits you traverse in white or black according to whether they are found to be true or false. Godel's Theorem says that no matter how you chose your seed, there will always remain some grey areas that never get turned white or black. Indeed the proof is in fact a set of instructions for finding an area that in fact stays grey, i.e. is formally Undecidable!!

There is an interesting analogy here with the idea of 'tessellations' or ways of tiling an area. There are only three regular polyhedrons you can use to tile an area using only one of a kind, the equilateral triangle, the square, and the hexagon. There are an infinite number of other regular polyhedra, pentagons, heptagons, octagons, etc, but you cannot cover an area completely with them, they do not fit together completely. If you regard a logical system as a sort of regular shape, and impose the condition that it must be sufficiently multifaceted (powerful) to describe itself, then ipso facto, it cannot cover the whole of the logical space available.

Since the nineteen thirties, much work has been done on exploring the limits of mathematical logic. Alonzo Church used Godel's methods to show that there is no finite way to look at a statement and prove that it follows automatically from a given theorem (you can only prove the statement by showing that it is one of the results which can be output, (technically 'listable') by the theorem, not vice versa (and this could take an infinite length of time!!).

Similarly Turing has shown that there is no logical way of predicting that a given computer program will terminate in a finite time.

In general logical problems may be classified as computable, listable, or prospective. A computable problem can be set up on any computer and can be guaranteed to give a definite result. A listable problem can be set up on a computer, but a definite result cannot be guaranteed in a finite time, A prospective problem is neither computable nor listable, i.e. it can neither be programmed onto a machine, nor can a result be guaranteed.

The term prospective is taken from a paper by Myhill written in 1952, which explores the philosophical implications of mathematical logic, and is illustrated by the following analogy. Consider a page of print. Deciding if this page is grammatical English is a computable problem. You can write a program to check whether the all the words occur in an English dictionary, and whether the syntax accords with commonly accepted English grammar.

But this is not to say that the page will make sense, it could be gibberish, or it could just be above your head, like a page of abstruse mathematics (cf Godel's theorem as originally stated above). It may with time and study, become meaningful to you, but there is no a priori way of telling this from the text. Its meaning is listable, but not computable.

But when we come to its higher properties, beauty, truth, virtue, then these properties of the text are prospective. They are not 'computable', you cannot write a program to decide whether the text is beautiful, nor is it 'listable', there is no program which can generate all the possible true or beautiful texts which may exist, and on the way be guaranteed to produce this particular text.

Basically, mathematics and science, are logical systems, and they have the strict limitations of all logical systems. They can define some truths, but not all truths. Some truths are computable, like the orbit of the earth round the sun, or the trajectory of a cannon ball. Some truths are listable, but not computable. A classic example of a listable, but not computable problem, is Goldbach's conjecture, which says that every even number is the sum of two prime numbers. This has been checked right up to one hundred million, and no exception has been found. But no general proof is available, so far the problem is listable but not computable.

Higher conjectures again, like truth, beauty, virtue may not be provable at all, in the logical sense. We recognize this implicitly in ordinary life by saying that they are not entirely 'objective' facts. They could be true (for some people) they could be false (for others) they are subjective, i.e. dependent on the observer, what is beauty to one man may be ugly to another. They are not any the less important for this, just not computable or listable by scientific, logical thinking.

But care is necessary here, or else we fall into the rationalist trap of saying that nothing can be said with conviction as regards these higher entities. But this would be absurd. Life is beautiful to most people, and illness ugly to most people—though there may of course be individual exceptions. Communication would be impossible if we could not make meaningful statements about these things. What Godel's theorem says is that we cannot specify all of them, not that we cannot specify any of them. There will always be something more to say about them.

I would like to return here to Leibnitz, and his unpublished theory of 'compossibles'. According to this theory, everything that does not exist struggles to exist, but not all possibilities exist, because they are not all 'compossible'. It may be possible that 'A' could exist, and also possible that 'B' could exist, but not possible that both 'A' and 'B' could co-exist, because one logically excludes the other, i.e. they are not 'compossible'. The ocean of possibilities is infinite, but, as time goes on, one thing or another happens, and the real world of facts, reality, grows, like a sandbank in the sea, but can never completely fill the infinite ocean of possibilities.

But is this not precisely what modern physics and cosmogony suggest? As the primitive 'soup' of quarks in the early cosmos cooled, the Higg's field broke the symmetry, and the atomic particles we now know, appear. Subatomic processes may be probabilistic, i.e. not entirely determinate, but once they have interacted with other processes, their wave function has collapsed and the process becomes frozen into reality. The number of possible particles may be infinite, but once the symmetry field has broken, only certain particles are possible. The number of possible universes may have been infinite, but once this universe crystallised out in the first moments of time, no other universe became possible.

There is nothing really strange about this, every moment of our lives we are interacting with the world around us and limiting the future, we marry A instead of B, we turn left instead of right, once we have done so the universe has irrevocably frozen along this path, the moving finger writes, and neither all your piety nor all your wit will move it back to cancel half a line!!

And 'this', as Rudi Drucker says, is reality. You can't define it. It just is… this!! You can explore its logic, its history, you can speculate on where it is going. It is not indeterminate, there are strict rules of logic and causality which determine it at any given moment, but equally it is not completely determinate, you can influence it and the future by what you do. Science, mathematics, and logic may describe it and control it, but they cannot predict the future, they are not the dead, logical, determinate things the layman fears.

Reality is bound up with our view of the world and we ourselves are part of the picture we draw. In fact, a sort of 'strange loop' is involved. There is a famous drawing by Escher which illustrates this. What we see is a picture of a hand drawing a hand!. Hold on a minute!! We are back at the same level where we began, though all logic dictates that we cannot be'. Such 'strange loops' are an inherent part of many of our concepts of the world. Escher is famous for pictures of this type, and many of them involve similar 'strange loops' which can only be comprehended by 'jumping' out of the paper as it were, into three dimensions.

We are trying to draw a picture of reality, yet we ourselves are part of that reality. We cannot make sense of the picture unless we are prepared to jump out of this strange loop into a further dimension of some kind.

We have now come to the end of the historical review that forms the major part of this book, we have surveyed the sources of religion and science, the philosophy, and religion of our forefathers. We have explored the development of scientific understanding of the world, of Chemistry, and Physics, and Biology. We have looked at the revolutionary ideas of Darwinism, Relativity, and Quantum theory which have destroyed for good the old ideas of Creationism and Determinism. We

have explored ourselves, and the Universe we live in. We have looked at the nature of time and chaos and uncertainty, and the limits of mathematical logic.

If you have stayed on board so far, we can now proceed to the nub of the matter, 'What is it that makes us like we are, both religious and scientific, both heart and head. How do we tie these two sides of our nature together. What is the nature of reality.

The final two Chapters of this book in effect make this jump, they are no longer strictly scientific in approach. Indeed they are inevitably more personal and social. Up to now I have carefully avoided anything of this kind, and said nothing that any scientist of probity could really disagree with. But I am not just a scientist, I am also a man, indeed I would claim to be a religious man (albeit in my own terms). Like many people I have a deep desire to understand the world I live in, and I cannot do this just on a scientific basis. We shall therefore have to shift our ground and vocabulary somewhat. I hope that in doing this, I have done nothing that violates my scientific upbringing, or the tenets of modern science. The next chapter deals with modern trends in Religious thought, the problems raised by it, and the attempts by modern theologians to deal with these problems.

Chapter 14

Modern trends in religion.

The Heart has its reasons the mind cannot comprehend
—Blaise Pascal

Now at this birth season of decease
Let the Infant, the still unspeaking and unspoken Word
Grant Israel's consolation
To one who has eighty years and no tomorrow
—T.S. Elliot, A song for Simeon.

For over five hundred years, Science and Religion have been drawing apart—increasingly the scientific and the religious views of the world have been diverging and there is now virtually no contact between them at either the practical or the organisational level. The chasm is now virtually unbridgeable, and any attempts to cross it hazardous in the extreme.

Some years ago Stephen Hawking was in Rome attending a scientific congress. The Roman Catholic Church has always approved of the idea of a 'big bang' (since it fits in with the Christian teaching of creation 'ab nihilo'), and recognizing Hawking's contribution, awarded him an audience and a medal from the Pope. But in fact it was a meeting of two opposites. Hawking like most scientists, is not a believer, and has little in common with the Pope and the Vatican. It was merely a polite nod and acknowledgement in each other's direction, a matter of slight

amusement and curiosity on Hawking's part, and a matter of polity and politeness on the Church's part.

I have been a professional industrial chemist all my working life, and a communicating Christian for over seventy years, (indeed I was a Methodist local preacher for almost forty years). On the rare occasions when I had cause to disclose my religious affiliations to my professional colleagues at work, I have encountered in the main an embarrassed silence, people are in general too good mannered to query, but the unstated question 'Why?', always hung as it were, in the air.

On the other hand, when I have attempted to discuss the implications of scientific advances in biology and cosmology with my religious affiliates, I have (with honourable exceptions) been greeted with either incomprehension, or uncomfortable indifference. In general it is 'not done' to introduce religious ideas into science, or press disturbing scientific ideas onto an increasingly beleaguered religious establishment. I have never forgotten in my first year at university going to an SCM meeting and challenging the speaker's assumption of a miraculous event in the Gospels, and being greeted only with an embarrassed titter form the audience.

But increasingly I have come to feel that while the sciences have been forging onwards, extending their realm to the point where much of the physical and biological world is explicable in scientific terms, the religious world has by and large, retreated into a 'holy huddle', its synods and convocations, and concerns itself only with its own affairs, its arguments about church organisation, the ordination of women, and the role of homosexuals in the ministry. Its attempts to provide moral and spiritual leadership to an alienated world, have been increasingly frustrated, by a widespread disbelief in its doctrine.

It may be objected that this is unfair, and it is true that there have been some brave attempts to face this issue. Bultmann, Tillich, Bonhoeffer, Robinson, and Cupitt, have all attempted to challenge conventional religious thought to a greater or lesser extent. Bultmann in his attempt to 'demythologise' the creeds, Tillich to redefine the nature of our ideas of God, Bonhoeffer to develop a theology of suffering, Robinson to make people face up to the problems of belief in a scientific world, and Cupitt to define a 'Sea of Faith' as a cultural icon. Indeed I attempted myself, during my years as a Methodist local preacher, to change the attitudes and thinking of my congregations as far as I was able.

But, if you go into any church in the land on Sunday morning, you will find that the total effect of all these efforts over the last fifty years or so, has been, by and large, negligible. The inertia of the faith has been dominant. The same creeds, the same biblically based sermons are trotted out as if the old world of God 'up there' still existed, eternal, unchanging. In general we either still sing the old hymns, and say the old creeds or beat out the new songs to guitar and drums, and congratulate ourselves on new versions and interpretations of the creed. Even if, by any chance, you have ventured into the 'happy clappy' world of the charismatic's, you will still find the same refusal to face the fact that the old religious formulae of the creeds, and the gospels, have been blown sky high by modern scientific knowledge.

In fact few believers really believe what they often say (and sing). If the 'living Christ' walked into the Church and shook hands with them they would be first to question their own sanity. If God Almighty suddenly 'descended from the heavens' to put the world to rights they would running for the shelter in the crypt with the rest of us. They don't really believe in it in any real sense.

Some will say, in excuse, that it is all a matter of language, but language is not unimportant, for it governs how we think. The Medium is all too often the Message. I can understand religious language, I know what the average believer means when he says 'Christ is alive', and when he talks about the last Judgement. But I have to translate it all the time into more sensible terms, and more and more I question the language we use. There is a tremendous hymn of Charles Wesley's

Lo he comes with clouds descending.
Once for favoured sinners slain.
Thousand, thousand saints attending
Swell the triumph of his train.
Alleluia, Alleluia
God appears on earth to reign

Every eye shall now behold him
Robed in dreadful majesty
Those who set at nought and sold him
Pierced and wailing to the tree
Deeply wailing, Deeply Wailing
Shall the true Messiah see.

Which I have heard many times sung at Easter, by a fervent congregation to a pealing organ. It is magnificent poetry, and a magnificent tune, but what does it mean? Are people really saying that they expect all this to happen, the clouds to break, and God descend to earth? Of course not!!. It's a magnificent piece of poetic imagery, but it is not going to happen!!. It is emotional indulgence. The outside world neither understands nor accepts this imagery any longer. I feel about it as I feel about the Charge of the Light Brigade at Balaclava—“C’est magnifique, mais Il n’est pas la Guerre”.

Emotional highs' may be necessary for religion, but they are not sufficient. It is high time, in this modern world, that we faced the fact that our creeds, our hymns and songs,, and our preaching, are based on a world view that is five hundred years out of date, and increasingly irrelevant to a technological society.

Does one any longer have to believe in the Immaculate Conception, a physical Resurrection, the Ascension, the Miracles, the Trinitarian doctrine, a pre existent Logos etc in order to be a Christian, and believe in the Christian way of life? I find myself in complete agreement with Don Cupitt writing in a recent article in the *Guardian* entitled Escape to the real world. He says 'One does indeed feel acutely embarrassed and ashamed to be stuck with a medieval world view in an increasingly technological culture. Why has it become obligatory for Christians to be silly? Where in the Bible does it say *Thou shalt be 400 years out of date?*'

For my own part, I can honestly say, that in some ways my own Christian faith is as strong as it ever was. I really do believe that Christ's moral teaching and example, I really do believe that redemption is possible, and that in Tolkien's words "The Christian has still to work, with mind as well as body, to suffer, hope, and die: but he may now perceive that all his bents and faculties have a purpose, which can be redeemed". But I no longer believe, if I ever did, in much of the conventional doctrine of the Church, in a physical resurrection, a pre exiting logos, in an immaculate conception, it is philosophical baggage from a pre scientific age, it just does not make sense in the modern world. The strength of the Christian teaching is not in its creeds or doctrine, but in its idea of 'God Immanuel'—God with us'. This is why Christmas is such a popular and moving festival, celebrated by believer and unbeliever alike, whilst the other major festivals of the Church, Easter and Ascension, are now observed only by a dwindling band of the faithful.

In the Western world, the result of this schism between science and religion is a form of corporate schizophrenia, on the one hand people see science as a cold, logical, amoral, unfeeling activity, unable to cater for any of their social, emotional and psychological needs, whilst on the other hand conventional religion is regarded with increasing scepticism and indifference, its doctrines and metaphysics seeming to most people, increasingly irrelevant and absurd. Because of this dehumanisation of science, and the increasing alienation of people from conventional religion, we have seen in recent years a vast increase in cult belief, the belief by ideas and concepts which are grounded neither in the traditional teaching of the Church, nor in any reasonable logical mode of thinking.

Just look at the fringe cults that have arisen in the last hundred years or so—Mormonism with its ridiculous story of Joseph Smith reading the book of Mormon with special spectacles on golden plates behind a curtain!! Or even crazier, Scientology, the cynical creation of science fiction writer Ron L Hubbard, with its gibberish of Thetan's and it its use of Dianetics as a diagnostic tool.

Men and women, by their very biological make up and inheritance, are social animals, and the search for meaning and significance, in whatever form it takes, mathematics, science, music, dance, ecstasy, mysticism, plays a large part in their make-up. And if they cannot believe in God, they will, I am afraid, believe in the Devil, not literally of course (that Devil has long been a pantomime figure of fun), but in some cult or superstition.

I remember reading once, in the *Guardian*, a detailed article on the health page discussing 'alternative therapy'. The author was detailing the use of various crystals, amethyst, quartz, etc, as healing agents. She believed that these crystals had healing properties for various illnesses. It was suggested that bathing with these crystals in the bathwater was beneficial, that they gave off 'emanations', and that the 'waves' from these could revitalize the spirit and body of the bather. There was a detailed and serious discussion of the merits of variously shaped crystals of different colours, the implication being that once you found one that was 'tuned' to your wavelength, the healing effects were both marked and effectual.

What was remarkable about the article was not the so much the pseudo scientific balderdash, but the total failure of both the writer (and the editor?) to even question any evidence that the so called emanations existed, that the

procedure was effective in any way, or that there was any basis at all for the script. It was quite simply nonsense from start to finish. I am afraid that this sort of non-sense is very much on the upturn these days from Scientology to Mormonism, and all the present day cults which have proliferated in America . The example quoted above was pretty harmless of course, but what are we to say of 'The cult of the Solar Temple' and such like cults, which have resulted in many futile and stupid deaths of many young and able people?

Perhaps, there will always be some who believe in nonsense. But nonsense is exactly what it says 'non-sense' and is of its very nature, fundamentally pernicious. The only thing that really distinguishes us from our close cousins the apes, is our capacity to reason and think. If we abandon this we may as well go back to the jungle.

In his day Aquinas managed a superb concordance between the science of his day (as embodied in Aristotle) and Christianity. It was so successful, that within its own terms of reference, no one has ever been able to shake it, and it is still today the official teaching of the Roman Catholic church. In Aquinas's time there was nothing unreasonable in 'Heaven up there' and 'Hell down there'. To medieval man this was both obvious and accepted. But we can no longer take such a simple faith for granted. We have got by until now by making the tacit assumption that science has nothing to say on human nature and ethics, and that religion has nothing to say on scientific subjects. Whilst such a stand off may be tenable in the short term, it must be recognized that in the long term it is essentially self defeating. As scientific knowledge and ways of thinking increase, it leads remorselessly to the marginalisation of religion, a supernatural God becomes not the centre of things, but a sort of cosmic ‘Cheshire cat’ lurking in the undergrowth. It is no longer possible to say, as they said in the seventeenth and eighteenth century, that the current norm of the Christian faith is a reasonable faith for men of good sense.

In much the same way philosophy and science were once barely distinguishable in ancient Greece, but are now separate, it is arguable that Philosophy has similarly been marginalised with the advance of science, and has degenerated now to mere arguments about the meaning of words.

Nor can Religion any longer appeal to its Scriptures for authority. Increasingly it is clear that the Bible is not a single divinely inspired book, but rather a collection of many ancient, and not so ancient, religious texts, of greater or lesser importance. John Wesley (not a poorly read man) could say in his time 'What are we sure of but the Bible!!', but few today would take so certain a line. Not only is Scripture inconsistent in itself (witness the stark contradiction between the claim for divine parentage for Christ in Mark, Luke, and John, and the factual (if legendary) descent of Christ via Joseph given in Matthew, it is to a large extent inconsistent with a modern view of the world. Even an allegorical reading of scripture, which in Wesley's time would have been acceptable, now presents so many problems to a reasonable man, that it has been largely abandoned even by the theologians. It is increasingly accepted that even the Gospels and the New Testament, whilst dealing with historical events are not, first hand, reliable records. This is not to deny the importance of the Bible (or indeed the sacred

scriptures of other religions). But in general modern man can no longer take its literal authority for granted.

Modern Theology has tended to take three different viewpoints in defence of the Faith, one, conservative, pointing back to the past, and insisting (against all the odds) on the fundamental truths of the Christian creed, another, liberal, attempting to demythologise Christianity to a greater or lesser extent, to bring its teaching more into line with modern thought, and a third, Christocentric, view which really says 'A Plague on both your houses, we hold Christ and him crucified' .

As an example of the first, defensive, approach we may take the dogmatic theology of the Catholic Church, it is magnificent, and impressive, but smacks more and more of a 'closed schema', an attempt to return to the theology of the Church Fathers, ignoring modern thought and knowledge. It is possible, as D H Lawrence has said, “to shut yourself in the bathroom, paint the ceiling blue, and say you are in heaven”, but it does not seem to me to be an option for modern man.

As an example of the second, modernist, approach we may take Liberal Theology based on the critical analysis of Biblical texts, which attempts, from textual and historical evidence to separate, and identify the source material, and locate textual additions by later scribes. Implicitly, this approach assumes that the Bible is a text like any other text, and subject to the same rules of textual analysis. A modern example of this approach is the book by E P Sanders—*The Historical Figure of Jesus* which is well worth reading. I find myself sympathetic to this approach, but inevitably a lot of the charisma and strength of Christianity is lost.

As an example of the third, 'a plague on both your houses' approach we may cite the modern Charismatic movement, spearheaded originally in England, by David Watson. This is basically an attempt to bypass the controversy between conservative and liberal theology, and return to the simple message of the early Apostles. Its theological message is minimal, little more than the statement 'Jesus is Lord'. When pressed its adherents tend to a fundamentalist approach to the Bible, but basically they are not interested in theology. Rather its attraction lies in its use of new, more informal forms of Worship and Music, and a renewed sense of community and fellowship. Very nice and cosy, but it hasn't answered the question.

There can be little doubt that the defensive approach of the conservatives, is the 'safest' option in one sense. It is far easier to retreat into the bunker, than to go out into the world. Indeed this approach is not confined to the Catholics, the religious orders, and the elderly conservative, it is also characteristic of the some of the modern fundamental evangelical movements of our time, especially in America, which have attracted a not insignificant number of youngsters.

But modern Charismatic Christianity, as presented to the young has little intellectual or theological content. By and large it is content to develop new and undoubtedly attractive ways of presenting 'Christology' to the outside world. Its motto is 'Jesus is Lord', and its tool the guitar and the chorus. Of serious discussion of what these statements mean there seems to me to be little of significance, except a throwback to a fundamentalist conservative theology of the past. This is not to belittle it, and its achievements, it has had a profound effect for

the good on many young people today. But to me, I must confess, despite all its good points, it is seriously flawed. It may provide an attractive background beat, but it does not carry long term intellectual conviction.

Despite all claims to the contrary, the seemingly inexorable decline in religious belief and observance in the West has continued for over seventy years or more. Huxley's comment in 1927, is as pertinent now as it was when it was written almost seventy years ago. 'It will soon be impossible for an intelligent, educated man to believe in a God as it is now to believe that the earth is flat... God's will doubtless survive, sometimes under the protection of vested interests, or in the shelter of lazy minds, or as puppets used by politicians, or as refuges for unhappy and ignorant souls... But are we to fall upon one or two unhappy people in their weakest moment and force upon them a sort of religious coercion?'

But that was written before World War two, and Huxley's alternative dream of 'Evolutionary Humanism' and the possibilities of Man, has faded to a rather facile optimism, when confronted with the reality of Auschwitz and Nagasaki. Evil is not susceptible to a facile humanism.

In 1943-44, Pastor Dietrich Bonhoeffer, a German opponent of Hitler wrote a series of Letters from Prison, in which he started to develop the idea of 'Living without God', writing that 'God has allowed himself to be edged out of this world, and that this is exactly the way, and the only way, in which he can be with us and help us. For Bonhoeffer, abandoned by his church, facing death, in the concentration camp, it seemed that God had abandoned him, and that all he could celebrate was a suffering, powerless God, with them in their distress. He was to be proved tragically correct. He was hanged in Flossenberg concentration camp, a few weeks before it was liberated by the Americans in late 1944. You cannot understand the theology he was developing, unless you also understand the terrible situation he was in.

About forty years ago John Robinson, the Bishop of Woolwich, wrote a little book 'Honest to God' which caused quite a stir at the time. In it he comments that the Gospel imagery of God and heaven 'Up there', the earth 'down here' and Hell 'down below' was entirely natural to its writers, and caused no comment. People had no inkling of modern astronomy and science. That the earth was flat (down here), and the heavens were above (up there), was so obvious that no one questioned it. But with the advent of Copernicus and Newton, and the development of the telescope, people began to make a subtle but important distinction. Realising that God was not 'Up there', they began to think of God being not 'Up there' but 'out there', whilst hell and the devil, 'down there' merely faded away to become pantomime characters. Robinson argues that in general the modern religious man still makes this (now largely automatic) translation 'For in place of a God who is literally or physically 'Up there' we have accepted as part of our mental furniture a God who is spiritually or metaphysically 'out there'. So while our hymns still sing 'There's a home for little children, above the bright blue sky', the adults at any rate, make an automatic translation from 'up there' to 'out there'. But, in general, modern man now sees no need for even this, and goes his own sweet (or not so sweet) way. Some more gullible, or less secure, seek an answer to their doubts and problems in the latest 'Guru' or fad from the east. Some revert to belief in pseudo-scientific cults such as Scientology. Some seek the

reassurance of the fringe Christian faiths. But the decline of faith is seemingly inexorable.

But we live in the world, and our knowledge of it (and ourselves) is steadily increasing. We may if we wish add to this knowledge, but we cannot ignore it, to do so leads to the 'cult of unreason'. Religion cannot ignore science for that way lies delusion and marginalisation, but nor can science ignore religion for that way lies dehumanisation and sterility. In chapter ten, I spoke about the dual nature of the human brain, and the subtle but devastating effects of pre frontal lobotomy, in which the connection between the two sides of the human brain, the 'corpus callosum' was severed, with the result that the subject acts literally as if the either side of his brain did not know what the other was doing. In the same way we cannot permanently sever the 'corpus callosum' between religion and science, as we have been doing over the last two hundred years or so, the results in society, like that on the human brain will be both subtle and devastating. This is not to say that that religion and science are the same, any more than the two sides of the human brain are the same, but they must be connected, they must talk to each other, and as far as possible understand each other, and they must act in concert. There are few things as pathetic as a Jehovah's Witness with a transistor radio, happily ignorant that his beliefs and religion are totally inconsistent with the device which he so proudly carries in his hand!!

At the start of this book I said that the religions of the World started as an attempt to explain and control the world. This was perhaps not entirely fair. There is more, much more to religion than this. Worship is much more than primitive science or magic—the incantation of spells to a particular end. It is also emotion, music, ritual, catharsis. For man, is as I have said, a familial, and social animal, and he needs elements of all these things in his religion.

Kenneth Clark, at the end of his book 'Civilisation', makes the point that it is lack of confidence, more than anything else that kills a civilisation. We can destroy ourselves by cynicism and disillusion, just as effectively as by bombs. He quotes W.B Yeats

Things fall apart, the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood dimmed tide is loosed,
and everywhere The ceremony of innocence is drowned;
The best lack all conviction,
while the worst are full of passionate intensity.

He says that this was certainly true between the wars, and nearly destroyed us. Is it true today? Not quite, because good people have convictions, although perhaps rather too many of them. But there is still no centre. I believe that there will not be such a centre until religion and science come together again, and are again joined together in a common framework of philosophy and belief. The centre is and must be, in a new Theology. Whether this can be worked out, depends on the willingness of the Church to change and adapt, and upon its acceptance not of a supernatural God 'up there' but a natural God 'down here'.

For me, personally, the clue lies in Dietrich Bonhoeffer. In his letters from prison he writes

"God as a working hypothesis in morals, politics, or science, has been surmounted and abolished; and the same thing has happened in philosophy and religion . For the sake of intellectual honesty, that working hypothesis should be dropped, or as far as possible eliminated. Anxious souls will ask what room there is left for God now; and as they know of no answer to the question, they condemn the whole development that has brought them to such straits. I wrote to you before about the various emergency exits that have been contrived; and we ought to add to them the salto mortale [death- leap] back into the Middle Ages. i.e. a counsel of despair, and it would be at the cost of intellectual honesty. There is no such way—at any rate not if it means deliberately abandoning our mental integrity; the only way is through repentance, through ultimate honesty. And we cannot be honest unless we recognise that we have to live in the world "etsi deus non daretur".

This passage has been widely understood as saying that we now have to live "without God". I'm not sure that this is quite what he means. The Latin phrase (from Grotius) does not quite mean "as if there were no God" it means "as if God were not a given fact", (Grotius was a lawyer and he uses it to say that there is a natural law which does not need the sanction of God for it to be valid).

I think what Bonhoeffer is saying is that we now have to live our lives (Christians and Non Christians alike) without relying on a supernatural God to get us out of trouble, just as we no longer rely on the idea of a supernatural God to explain or do science. (In a way he is saying "Look, you've grown up!! you no longer need Daddy to tell you what to do!!")

The religions of the world may have started as primitive magic, as an attempt to explain and control the world. But they almost immediately became much more, they became cultural institutions, of great benefit and significance. But like all human institutions, they can suffer from hardening of the arteries, and as they age they become more and more concerned with dogma and culture, and their own survival. Sometimes I think that Christ, were he alive today, would spare his church none of the criticism he gave the Pharisees and the Sadducees. We do him little credit when we make his love too narrow, by false limits of our own.

For much of the formal doctrine and dogma of the Christian church did not originate with Jesus, but from the letters of Paul, and the philosophy of the time, and is a cultural and philosophical accretion. It may express valid religious concepts, but it can no longer be seen by any thinking scientist as true in any rational sense. Even more importantly religion cannot just ignore scientific knowledge, or, even worse, pretend that it does not exist. To me it seems that this puts off many people who ask intelligent questions of the faith, and makes many churchmen unwilling or unable to face up to modern scientific understanding of the world. Well, if history teaches anything, it teaches that if you cannot adapt, you will die, and the stage of human history is littered with dead religions. I do not wish to see a dead religion, for, I believe most men need a religious outlook of some kind or other, and also that this outlook is crucial in forming and guiding society. Science, on its own is not enough, you cannot worship knowledge, you

can only use it. And how you use it depends on your religion and your culture, and the latter is basically only an offshoot of the former.

Chapter 15

Wrapping it all up, advice to my children and grandchildren.

Out of the earth to rest or range
Perpetual in perpetual change,
The unknown passing through the strange.
—John Masefield, The passing strange

On the wall of our living room above the fireplace, there is hung (and has hung for may years) a reproduction of The elder Brueghel's *Peasant Dance*. It was painted about 500 years ago and depicts a group of villagers dancing in a small village street in the Low Countries. In the foreground a middle aged peasant and his wife are entering the dance. They are not rich, they are dressed in coarse homespun clothes. The man, crudely shaven, with rotten teeth, with a large knife at his belt, the woman, cleaner but with a none too clean linen wimple on her head.

But they are real recognizable people, (unlike the courtly pictures of the time), we can relate to them, they were men and women like ourselves. Like us they struggled to survive, earn a living, and understand the world around them. It was a simpler life then, their world was bounded by their village, their farms, and their church. When they did go to Church they would be taught a simple faith, in which they implicitly believed.

We are still the same people as they were, we still need food, homes, clothes, companionship, and love. But our world is very different, and the old simple faiths for our fathers are no longer sufficient.

Above all we need a new understanding of God.

I may have given the impression in the preceding chapters that the scientists have all the answers and the religions of the world are all outdated and irrelevant. If I have, then I must clearly apologize, nothing of the sort is implied!! The scientists do not have all the answers! Our models of the world are no more than that, models, and with all their strengths, they are full of problems, some of which may be ultimately unanswerable.

Quantum physics works and works brilliantly, but is still basically a crazy. It works only with a steady erosion of common sense. Nobody really understands why it works.

The fundamental entities of the ‘standard model’ - quarks, are problematical, we describe particles as being ‘quantised’ fields (whatever that may mean!!), but the field surrounding a quark is nothing like the field surrounding a normal particle

like an electron - electrons repel each other as they get closer and closer together. The opposite is true of quarks—quarks attract each other more strongly as they get closer and closer together. In other words they cannot exist as separate particles except at extremely high energies and are never actually observed. What you are supposed to make of a particle which does not exist as a separate particle (except at the temperature of the big bang), heaven only knows!! It seems better to regard them as structures within the atom rather than separate particles.

Cosmogony is full of riddles, Gravity should be quantised, but gravitons have not yet been observed. Gravity, over vast distances, does not explain the formation of galaxies, they should not be stable, and Astronomers have had to postulate some exotic form of 'dark matter'—WIMPS—Weakly Interacting Massive Particles—to explain this—and nobody has the faintest idea what WIMPS are!! Current theories hold that most of the material in the universe is 'dark energy', and 'dark matter', and only five per cent is the kind of matter we know of!!. In other words we can only explain five per cent of the observable world!!

No theory uniting relativity and quantum theory has yet been developed. We still do not understand the massive 'inflation' which must have occurred in the early instant of the 'big bang' to iron out the fluctuations and render the observable universe so similar in all directions.

And why, oh why, do so many constants have to be 'written' into our models, to make them work, when we have absolutely no idea where these numbers came from—did God write them in??

Much effort recently has been put into attempts to develop a "theory of everything". The standard model of quantum mechanics has been extended by a 'string' theory where the fundamental particles are regarded as incredibly small closed loops, vibrating a different frequencies, and more recently by a more mathematically abstract 'M' theory. These theories have proved mathematically engrossing, but up to the present time they involve many extra dimensions, and energies which are currently completely unattainable (and will almost certainly remain so!!)., They are speculative, indeed so speculative that these models have been rather caustically described as 'not even wrong'

It may be that the Large Hadron Collider, which has recently restarted at full design energy, may give us some indication as to whether these theories are true or false, but I wouldn't like to bet too much on it.

So, no! Science does not have all the answers, and probably never will!! And even if it could it would almost certainly involve a time development in which complex structures evolve to an almost infinite variety

Conversely Religion is a far stronger thing than many scientists will allow. J R R Tolkien in a little monograph says-

"Redeemed Man is still man. Story, fantasy still go on. The Evangelium has not abrogated legends, it has hallowed them, especially the 'happy ending'. The Christian still has to work, with mind as well as body, to suffer, hope, and die, but he may perceive that all his bents and faculties may have a purpose, which may be redeemed".

But, (and it is a big 'But'), the philosophical background and underpinning of the Faith has crumbled, and crumbled irreversibly.

When the scientific community uses the word God they are not thinking of a supernatural God. Paul Erdos, a Hungarian born mathematician, famous for his brilliantly elegant proofs of seemingly unsolvable mathematical problems, was an agnostic, but one of his favourite sayings when he heard of a new proof was “That's straight out of God's book”. I believe that when scientists invoke 'God' it is this 'God' they mean. For them the 'word' is the book of life itself, not any scripture written by man. God is in nature itself, and revelation is by its study and understanding. And in the nature of things there will always be more things to discover and understand.

The one thing all of us can agree on is that we exist (Descartes ‘I think therefore I am’). But that must necessarily imply that there is an external world that we exist in. What we call this external world is of course up to us. But this, as Rudi Drucker says, is reality. You can't define it. It just is… this!!. You can explore its logic, its history, you can speculate on where it is going. It is not indeterminate, there are strict rules of logic and causality which determine it at any given moment, but equally it is not completely determinate, you can influence it and the future by what you do. Science, mathematics, and logic may describe it and control it, but they cannot predict the future, they are not the dead, logical, determinate things the layman fears.

For me this… this external reality, is ‘God’ . Admittedly there is a real problem here, since the word ‘God‘ carries a tremendous amount of baggage. Not only is there a problem of names, there is a real (and illuminating) problem of what pronoun to use. Traditionally, in English we say 'He' when referring to 'God' thus implying the male sex. Arabic does a little better, the Koran uses the royal 'We'. But the problem is still there, any pronoun or name we give carries connotations, excess baggage, as it were.

There is a Japanese Koan which illustrates this nicely.

Shuzan held out his short staff and said “If you call this a short staff you oppose its reality. If you do not call it a short staff, you ignore the fact. Now what do you wish to call this?” and Mumon's commentary “It cannot be expressed with words, and it cannot be expressed without words. Now say quickly what it is”

Nowhere is this more true than with the word 'God'. As soon as you say it you unleash a maelstrom of meanings… be very careful!! Too often the medium is the message!!. It is far too easy to slip into the old anthropomorphic ways of thinking that bedevilled our ancestors.

The problem is a real one and should not be ignored. Nonetheless, this… external reality, has to have a name, and ‘God’ is as good a name as any. I don’t think Thomas Aquinas would have disagreed, he came precious near to an identical definition himself!!

I do not know if Christianity can take this leap, from belief in a supernatural ‘God’ to a natural ‘God’, It is an almost insuperable leap, which would demand a widespread revision of its doctrine, and almost total recasting of its liturgy and hymns and worship. But I suspect that its founder, whilst he might be a bit puzzled, would not altogether disapprove. He was hardly conventional himself!!

When I first started out local preaching, an old minister told me that the secret of a good sermon was:

Tell 'em what you're going to tell 'em

Tell 'em
Tell 'em what you've told 'em!!

We're at the ‘tell 'em what you've told em’ phase now, and the first thing I'm going to say is this. The idea of a supernatural God controlling and directing our destinies is dead, dead as a dodo!! He's been a long time dying, but it is now time to declare the final obsequies. The idea of an all powerful, all seeing, all seeing, omnipotent deity, up there, or out there, is no longer credible. It is a medieval concept which is totally a variance with modern thought and knowledge!!

I'm not the first to say this of course, Nietzsche said so over a hundred years ago. His parable of the madman is worth quoting again for those who may be unfamiliar with it.

"Have you not heard of that madman who lit a lantern in the bright morning hours, ran to the market place, and cried incessantly: "I seek God! I seek God!"—As many of those who did not believe in God were standing around just then, he provoked much laughter. Has he got lost? asked one. Did he lose his way like a child? asked another. Or is he hiding? Is he afraid of us? Has he gone on a voyage? emigrated?—Thus they yelled and laughed.

The madman jumped into their midst and pierced them with his eyes. "Whither is God?" he cried; "I will tell you. We have killed him -- you and I. All of us are his murderers. But how did we do this? How could we drink up the sea? Who gave us the sponge to wipe away the entire horizon? What were we doing when we unchained this earth from its sun? Whither is it moving now? Whither are we moving? Away from all suns? Are we not plunging continually? Backward, sideward, forward, in all directions? Is there still any up or down? Are we not straying, as through an infinite nothing? Do we not feel the breath of empty space? Has it not become colder? Is not night continually closing in on us? Do we not need to light lanterns in the morning? Do we hear nothing as yet of the noise of the gravediggers who are burying God? Do we smell nothing as yet of the divine decomposition? Gods, too, decompose. God is dead. God remains dead. And we have killed him.

"How shall we comfort ourselves, the murderers of all murderers? What was holiest and mightiest of all that the world has yet owned has bled to death under our knives: who will wipe this blood off us? What water is there for us to clean ourselves? What festivals of atonement, what sacred games shall we have to invent? Is not the greatness of this deed too great for us? Must we ourselves not become gods simply to appear worthy of it? There has never been a greater deed; and whoever is born after us—for the sake of this deed he will belong to a higher history than all history hitherto."

Here the madman fell silent and looked again at his listeners; and they, too, were silent and stared at him in astonishment. At last he threw his lantern on the ground, and it broke into pieces and went out. "I have come too early," he said then; "my time is not yet. This tremendous event is still on its way, still wandering; it has not yet reached the ears of men. Lightning and thunder require time; the light of the stars requires time; deeds, though done, still require time to be seen and heard. This deed

is still more distant from them than most distant stars—and yet they have done it themselves.

Of course Nietzsche, has had an unfavourable reputation since his theories of the 'Ubermensch' got taken up by the Nazi's in the early part of the last century before the second world war, and indeed he was more than a bit crazy. Nonetheless his parable is a powerful statement of the theological conundrum we face even today.

Indeed for me, God died on the Cross 2000 years ago!!. What I am saying here is that the very crucifixion gives the lie to the idea of a benevolent omnipotent supernatural God. (I cannot emphasize too strongly that the old ugly primitive Doctrine of Atonement—the appeasement of an angry Deity by his son's death, is pure superstition, derived from the Old Testament story of Abraham's attempted sacrifice of Isaac his son.)

Spinoza back in the sixteenth century, came up with possibly the only concept of God which would be acceptable to modern scientific man, as “Deus sive Natura” (God, or in other words nature). To Spinoza the natural world was God, and he developed an entire and specific system of thought on this basis. He was, as has been said a “Gott betrunkener mann” (A God drunken man).

But Spinoza was a man of his time, his 'God' had to be omnipotent!! everything had to be ruled by absolute logical necessity, there could be no such thing as free will or chance. Everything that happens he said, is a manifestation of God's nature, and it is impossible that events could be other than what they were. If we observe something as evil, that is because we cannot see the whole picture, only God can see the whole, and to him it must be good.

But we would not now see it like this, the world as we know it is inherently chancy, you cannot be sure of the future. Indeed God cannot see the future!!.

We can agree with Spinoza's *Deus sive Natura* i.e. all the natural world is God, and indeed most scientists would be entirely happy with this, when Erdos said of a new mathematical theorem “That's out of God's book”, that is precisely the sense in which they are using the word 'God'.

But Spinoza was wrong is saying there is no such thing as chance—chance is inherent in the nature of things. In this sense God is not omnipotent, God cannot see the future!! I don't think this idea of God having limitations is that novel, indeed Thomas Aquinas, the medieval 'divine doctor', argued that God could not violate his own nature. i.e. he could not make two plus two equal five for example.

Many religious people (perhaps most) will say that this is outrageous!!, but I can only say to them that it is easy to 'shut yourself in the bathroom, paint the ceiling blue, and say you're in heaven', but it is not a way I can chose. The world is just inherently a chancy place, and any concept of God must reflect this. To me God is, well, this, the world around me. The past was God, the future will be God, (and fraught with possibilities), and the present, God also, a point , a ‘phase change’ if you like, where the future solidifies.

This does not rule out a religious interpretation of God, such a God is not necessarily inconsistent with the Gospels provided you discount the obvious interpolations and glosses, and the miraculous elements of the Gospel story, and recognize that its founder was 'a man of his time'. Even the Trinity begins to make

some sense, for at least it modifies the soppy idea so often heard in the pulpit that “God is Love".

The Communion Service in particular is almost completely unaffected; the idea of a God with us (Immanuel) is still credible.

I believe God is in a sense Immanuel, he is part of my experience. I am an individual in a world which is full of possibilities. If things go wrong, there is still a possibility of putting it right. No I shan't live for ever, and no, God will not necessarily guard me from evil, I have to take my chance with the rest of us. It's a chancy world, but it is a free world. There is a modern development of theology (Process Theology) that explores this idea further, although few conventional approaches endorse it.

A final word to my grandchildren and great grand children!! (it was written for you after all!!)

You are growing up in a world where the old certainties of creed and culture are no longer valid. Christianity is no longer the only, or even the major creed of the West. China and India and the East are beginning to challenge the hegemony of the West. Islam is now a major contender for hearts and minds even in Britain.

I am not against religion, I have been attending church all my life, (although some might call my vision of God as described here as contrary to most religious thought.) We are only human, and being human means being vulnerable. Religion provides comfort and inspiration in an uncertain world. It has been and continues to be of immense cultural and spiritual importance.

But religions usually carry an immense amount of baggage, and because we do not stop to think what we are saying we can sometimes be very silly indeed. Thomas Aquinas was quite right when he said that you can only define 'God' by what he is not!!. I can happily. for example, say that God is not evil, or not malicious. But I cannot say what he is, because he is without limit. But what I can say to you is that he is not supernatural.

Inevitably, you will look for certainty. New prophets may beckon you this way and that. But all Scriptures, whether the Bible or the Koran or the Vedas, are human creations, historical, human, documents. They were conceived, written, and transcribed by human beings. They are of immense importance in the West and the Middle East and India. All have much to say of the human condition which is as valid now as it was when it was written. But their originators were men, not gods, men of their times and they had the prejudices of their times. It is we, ourselves, who have made them gods!!, (or at least elevated their words to a divine status)

Take nothing as ‘Gospel’ truth, examine everything, Always ask questions, and if you are not satisfied walk away. Your religion (if any!) is your choice, and your choice only. But be careful—and do not be silly!! Nonsense is just that non sense, you should have grown out of that!! The world is a very queer place, probably as someone has said, queerer than we can imagine. But it is not a silly place.

I do not know whether this will ever be published, probably not!!. But I have put down all that I can to guide you. Go with my love, and be careful!!

References

This book has been over twenty years in the writing, and I am indebted to many writers for the ideas herein. It is not an academic treatise, and I have not included a formal Bibliography. However I must acknowledge my debt to the following writers, from some of which I have quoted extensively. If I have misquoted or misunderstood them, the fault is entirely mine and |I apologize unreservedly.

Bertrand Russell—*History of Western Philosophy*
Kenneth Clark—*Civilization*
Bronowski—*The Ascent of Man*
Bonhoeffer—*Letters and papers from Prison*
John l Casti—*Searching for Certainty*
Peter Coveney and Roger Highfield—*The Arrow of Time*
Marcus Chown—*The Magic Furnace*
Heinz R Pagels—*Perfect Symmetry*
Richard Feynman—*QED The Strange theory of Light and Matter*
Douglas R Hofstadter—*Godel Escher Bach, an eternal golden braid.*
E P Sanders—*the Historical Figure of Jesus*
And many others!!