

## Introduction

Today we stand on the threshold of one of the greatest social revolutions since the one that was triggered 3,000 years ago by the alphabet. In the coming decade, information technology, potentially capable of delivering the sum of human knowledge to everybody, everywhere, will literally change the world, because at any time, the world we live in, our view of it and the values we attach to it, is shaped by what we know. And when what we know changes, the world changes with it, everything.

History is full of pivotal moments, when our perceptions are altered by new data. We move from version to version, confident that the latest is the most complete and accurate description of the world so far. This in itself is the expression of a new attitude. It did not exist before the late 19th century, when change in one limited area of knowledge altered our view of everything (7).

New knowledge often causes so much social damage that it can sometimes bring an entirely new view of knowledge itself (8).

Ever since Bacon and Descartes, we live with the expectation that knowledge will continue to change and with it the beliefs and values by which we live. This book examines 8 moments in history when that happened. Its purpose is to show that when the moment of change came, new institutions and modes of thought were generated and would persist to become part of our modern view (8-9).

Change is now the only constant and, as was said after the publication of the Copernican view of the solar system, "the new philosophy calls all in doubt." How we live with the new view is the matter of this book and the purpose of the chapters that examine previous, similar episodes when everything changed. The final chapter asks the question: if all knowledge is relative, constrained by its contemporary circumstance, to be negated by the next development, then is there any truth to seek? Or is it we who, in manufacturing knowledge, make the universe what it is, each time (9)?

This book examines what happened at particular points in history when man applied such a rational approach to nature. It looks at the ways in which a questioning system

of thought brought us to today's world, in which change is only constant. Above all, it seeks to show how the attitudes of Western culture, and the institutions which accompany these attitudes, are generated at times when major changes occur in the way society sees itself, as a result of advances in the body of knowledge (17).

## **1: The Way We Are**

### **Man as the Eternal Cartographer**

*Man is the eternal cartographer. He is defined by his perpetual simplification of complex phenomenon into simpler intellectual forms or typifications. "The factual world of our experience," as Schutz explains, "is experienced from the outset as a typical one" and "every empirical idea of the general has the character of an open concept to be rectified or corroborated by supervening experience" (116-117).*

We abhor complexity, and seek to simplify things whenever we can by whatever means we have at hand. We need to have an overall explanation of what the universe is and how it functions. To achieve this overall view we develop explanatory theories which will give structure to natural phenomena: we classify nature into a coherent system which appears to do what we say it does.

The view of the universe permeates all aspects of our life. All communities in all places at all times manifest their own view of reality in what they do. The entire culture reflects the contemporary model of reality. We are what we know and when the body of knowledge changes, so do we.

Each change brings with it new attitudes and institutions created by new knowledge. These novel systems then either oust or coexist with the structures and attitudes held prior to the change. Our modern view is thus a mixture of present knowledge and past viewpoints which have stood the test of time and, for one reason or another, remain valuable in new circumstances.

In looking at the historical circumstances which gave birth to these apparently anachronistic elements, which this book will attempt to do, it will be seen that at each stage of knowledge, the general agreement of what the universe is supposed to be takes the form of a shorthand code which is

shared by everyone. These forms primarily take the shape of rituals (11).

### **Rituals**

Rituals are condensed forms of experience which convey meanings and values not necessarily immediately obvious or consciously understood by people performing them.

*"The social world into which man is born and within which he has to find his bearing is experienced by him as a tight knit web of social relationships, of systems of signs and symbols with their particular meaning structure, of institutionalized forms of social organization, of systems of status and prestige, etc. The meaning of all these elements of the social world in all its diversity and stratification, as well as the pattern of its texture itself, is by those living within it just taken for granted. The sum total of the relative natural aspect of the social world has for those living within it constitutes the folkways of the in-group, which are socially accepted as the good ways and the right ways for coming to terms with things and fellow men. They are taken for granted because they have stood the test so far, and, being socially approved, are held as requiring neither an explanation nor a justification" (Schutz, 80).*

Rituals which are performed widely and generally enough become institutionalized. These institutions are staffed by members of the society who are given authority and responsibility for social acts which are considered vital to the continued security and operation of the community (12).

### **Institutions, Language & Education**

One of the principal aims of the institutions is that they free the majority of the group to do other things considered necessary for the welfare of all, such as the production of wealth, the maintenance of physical well-being and, above all, the inculcation of the community's view of life in the young. Humanity is unique in the length of time its offspring spend learning before they begin to take on adult responsibilities. Language gives us the unique ability to pass on information from one generation to another in the form of education (13).

*"Only a very small part of my knowledge of the world originates within my personal experience. The greater part is socially derived, handed down to me by friends, parents, my teachers and the teachers of my teachers. I am not only taught how to define the environment (that is, the typical features of the relative natural aspect of the world prevailing in the in-group as the unquestioned but always questionable sum total of things taken for granted until further notice), but also how typical constructs have to be formed in accordance with the system of relevances accepted from the anonymous unified point of view of the in-group. The typifying medium par excellence by which socially derived knowledge is transmitted is the vocabulary and syntax of everyday language. The vernacular of everyday life is primarily a language of names things and events, and any name includes a typification and generalization referring to the relevance system prevailing in the linguistic in-group which found the named thing significant enough to provide a separate term for it" (Schutz, 96).*

The content of this kind of instruction indicates the social priorities of the group concerned, reveals in what terms it regards the world around it, and to a certain extent illustrates the direction in which a community considers that its own development should go (13).

Education in the West consists of providing intellectual tools to be used for discovery. We encourage novelty, and this attitude is reflected in our educational curricula. Apparent anachronisms such as the titles of qualifications and of the teachers, as well as the conferring of formal accouterments on the graduating student, recall the medieval origins of the organization and at the same time show the importance our society attaches to standardized education (13).

Education in the West today is geared round the production of modern technology and science oriented towards service and information systems. The most significant point about these sources of modern technology in the West is that they are entirely directed towards the production of the means of constant change. Whereas other societies in the past adopted the same social structures as we do in order to ensure their stability, and others in contemporary world still do so, we use those structures to alter our society unceasingly (14).

This extraordinary, dynamic way of life is the product of a particular rational way of thought that had its origins in the eastern Mediterranean nearly 3,000 years ago (14).

### **Origins of Modern Thought in the West**

1000 BC mainland Greeks begin emigrating eastwards to Ionia and settle on the islands and the Aegean coastline of Asia Minor. The new arrivals were pragmatic pioneers.

Conditions in Ionia were difficult. Backed by inhospitable mountain ranges that blocked all exits hinterland, the Ionians turned to the sea for survival. They began to travel all over the eastern Mediterranean and discovered almost immediately the Babylonian and Egyptian empires. Both these ancient river-valley cultures had been the first, almost simultaneous examples of urban civilization. Their societies were theocratic and introspective. There had been little scientific/technological novelty due to the extreme regularity of their physical environment and rigidity of their social structures.

Building upon their dynamic, pragmatic perspective, the Ionians rejected theocratic tradition and adopted Babylonian and Egyptian technology for practical purposes. Whereas Babylonian astronomy had aided priests to make magic predictions, it now served the Ionians as an aid to maritime navigation. The major advance represented by the use of the Little Bear as an accurate positional aid is attributed to one of the early Ionians, Thales of Miletus, who flourished at the end of the 6th century BC. He may have been instrumental in introducing Egyptian geometry to Ionia and reputed to have been able to use Babylonian astronomical techniques to predict eclipses.

Thales and the 2 generations of students that followed him are credited with the invention of philosophy. These Ionians began to ask fundamental questions about how the universe worked. Whereas older cultures relied on custom, edict, and priestly authority, the Ionians looked to naturalistic explanations for the origin of the world and everything in it. They began to explore nature to explain and control it and better ensure their survival (15).

The Ionians' interest in practical answers to empirical questions led to the first, crude attempts to find mechanisms responsible for natural phenomena. Their simple

analyses of phenomena and the observation of the presence of opposites in nature combined with the political and economic structure of the Ionian society to produce the dominant intellectual structure in Western civilization.

Geometry became the basic instrument for measuring all things. All natural phenomena including light and sound, as well as those of astronomy, existed and could be measured in exclusively geometrical space. Geometry rendered the cosmos accessible to examination according to a common, standard, quantitative scale. Together with the concept of pairs of opposites, geometry was to become the foundation for a rational system of philosophy that would underpin Western culture for thousands of years. The systems of Plato and Aristotle, the apotheosis of Greek thought at the end of the 4th century BC, were based on the use of opposites in argument and the self-evident nature of geometric forms.

Rational discussion followed a new logical technique, the syllogism, developed by Aristotle, which provided an intellectual structure for the reconciliation of opposing views. The self-evident axioms of geometry could lead via deduction to the development of more complex theorems. When this technique was applied to rational thought it enhanced the scope of intellectual speculation (16).

In this way Aristotle produced a system of thought that would guide men from the limited observations of personal experience to more general truths about nature. Plato examined the difference between the untrustworthy and changing world of the senses and that of the permanent truths which were only to be found through rational thought. The unchanging elements of geometry were the measures of this ideal, permanent thought-world with which the transitory world of everyday existence could be identified, and against which it might be assessed. This union of logic with geometry laid the foundations of the Western way of life (16-17).

## **Chapter 2: in the light of the above**

### **The Importance of Law**

The rule of law regulates every social event and transaction from international trade and the running of a country to handling private property, planning a career and

having children, and in doing so it guarantees social stability.

Because the rule of law exists, and above all because it encourages and protects acts of innovation with patent legislation, we in the modern world expect that tomorrow will be better than today. Our view of the universe is essentially optimistic because of the marriage between law and innovation.

### **Origins of Laws**

In many ways the purpose of European law has changed little since the system was first established, even though the society for which it was developed has changed beyond all recognition. Modern Western law and the institutions that came with it sprang from a society totally different from ours, with a view of the universe alien to us in almost every way.

### **the fall of rome & the middle ages**

The emergency of law and of the desire to innovate peculiar to Western society began with 2 men who lived in the 5th century in the same Roman city, both with very different reactions to what they regarded as the imminent end of the world.

One of the men, a teacher who had turned Christian, was Augustine, Bishop of Hippo, in North Africa. The other was a Roman public official, the lawyer proconsul Martianus Capella. The city in which they both lived was Carthage, capital of the Roman province of Africa (19).

#### ***Fall of Rome***

The Carthaginians reacted with horror to the news of the sack of Rome in AD 410 at the hands of Alaric the Goth. It seemed that only a matter of time before Roman civilization would fall apart and take everybody down with it. Darkness and death seemed inevitable.

#### ***Augustine***

Augustine's reaction was to offer a way of escape. At the time, the Christian Church was much influenced by the thinking of Neoplatonists, based on the writings of Plato.

His philosophy was attractive to a new religious sect accustomed to persecution by the state, because it made suffering easier to accept. Plato's philosophy drew a distinction between reality and appearance as well as opinion and knowledge. The empirical world was only a shadow of a pure, unintelligible reality. By implication, everything in the daily life of the Neoplatonist Christian was a shadow of the truth. Augustine combined these views with the teachings of the Scriptures in a book called the *City of God*. The work offered a complete set of rules for living and an integrated structure for Christian society that would influence Christian thinking for a thousand years (20).

Augustine offered escape to a spiritual life in the monasteries. If the world was not worth study, deserting it for a life of contemplation could only be for the good. Belief was more important than earthly knowledge. *Credo ut intelligam* (understanding comes only through belief) was the creed which would see the monasteries through the Dark Ages that lay ahead (20).

### **Capella**

The reaction of the Carthaginian proconsul Martianus Capella to the fall of Rome was more pragmatic. He saw the expansive, public life of the Empire was gone for good. If the Romans were to survive at all, it would be in a very different world, with everything on a much smaller scale (20). Without the centralizing influence of Rome, the Empire would be fragmented into tiny states and cities that would have to exist autonomously on limited resources. They would need condensed forms of Roman knowledge to help them (21).

In 9 volumes Capella packaged the imperial school curriculum dividing it into 2 sections: (1) primary subjects of rhetoric, grammar, and argument and (2) music, geometry, arithmetic and astronomy. His work was to become standard reference for education for the next 6 centuries (22).

As Rome fell, society divided into isolated communities which would loosely connect into the manorial system: autonomous entities seldom covering more than a few square miles (23). Knowledge at this time, including Capella's work, was cloistered within the monasteries. Guardians of

the past, the monks shared their learning among their own kind as centuries passed.

### ***Charlemagne & Isidore of Seville***

In the 8th century the barbarian invasions halted for a short while and Europe made a cultural recovery under the emperor Charlemagne. He standardized religious practice and established schools among the monasteries under Capella's work. From the middle of the 8th century onwards the liberal arts of were taught all over Europe (24-25).

The materials available to teachers of the arts was limited. The main source of general knowledge was the work of Isidore of Seville. Like Capella, Isidore gathered together all he knew into 20 texts and produced his *Etymologies*. The *Etymologies* were massive, rambling and confused. Everything had a hidden meaning because, according to Augustine's teaching, nature's true meaning was not made visible by God. Nothing, therefore, was what it seemed. The "Book of Nature" was a cryptogram that had to be decoded by the faithful (27-28). The world described in these books was a world of shadows (28). But this weird, mystic interpretation of reality was driven back inside the monasteries when new invasions and the break up of Charlemagne's Empire after his death in the 9th century brought Europe into chaos once more (28).

### **Peace, Commerce & the Medieval Mind**

After a century of Scandinavian violence, the Norsemen settled in northern France, and peace returned. Slowly people began to emerge from hiding and commerce began. But the philosophical viewpoint at the time of the resurgence of the cities in the 10th and 11th centuries left their citizens ill-prepared for the new problems now demanding solution. There was no concept of progress. In the early Middle Ages men were aware only of the greatness that had been lost (29).

To the early medieval mind, the universe of Augustine was static and unchanging. The world had been made for the edification of man to bring him closer to God. It had no other purpose. Nature was inscrutable and there was nothing to be gained from its study. Objects of everyday reality were meaningless except as symbols of God's incomprehensible design (30).

Into this backward-looking, ritualistic, rigidly structured life, the growing economic forces at work in the new towns brought stress. As the trade in surplus goods increased, merchants found that the raw materials they needed were controlled by feudal lords who neither understood nor cared about commerce. Transportation of goods through their lands was both dangerous and costly. Alternative sites for commerce had to be found and the towns seemed to offer the best alternative (31).

### ***Changing Social Structure***

The townspeople, with their economic strength and their craftsmen supported by the general surplus, began to demand from kings and emperors those statutes which would reinforce their freedom in law. Merchants who had no place in the feudal pyramid of serf, knight, priests and king now had the money to buy social status. As the aristocrats began to commute their serfs' dues from service to cash, money began to weaken the old social structure (31).

The new supply of cash brought a critical change in the position of the monarch. It strengthened the king's position, enabling him to raise taxes whenever he chose without upsetting the old land and service contact.

Money also made longer journeys possible. As the forest roads became more secure craftsman and especially builders were encouraged to travel.

### ***The Abacus***

The abacus, introduced in the 11th century by Gerbet of Aurillac (later Pope Sylvester II in 999), boosted the secular business community.

### ***Law***

With all the urban growth, the population increase brought economic improvement, and the secularization of much social power through the effect of money, the earlier, apathetic view of the world began to change. The old ways were no longer adequate. This was most acutely felt with regard to the lack of good law and of people qualified to administer it (33).

The problem was not lack of law, but too much law. With papal and royal codices, verbal laws, local customs, remnants and modifications of Roman and Germanic law, there was no single system which could be used to enforce unambiguous obedience throughout Europe.

### ***The Digest***

In 1076 a liberal arts teacher called Irnerius found a copy of the *Digest*, (the key to the great compendium of Roman law, *Corpus Juris Civilis*) in Ravenna, close to Bologna where he lived (34). The discovery of the *Digest* and the subsequent use which Irnerius and his successors made of it (glossing) was of major importance in Western European history, because it put all Roman law into the hands of both the Church and the citizen (34).

Irnerius made the *Digest* easier to use by glossing it. Glossing was a technique already in use which involved the addition of notes, analyses and commentaries to the margin of manuscript. These glosses were generally used as lecture notes by teachers interpreting the text for their students. At the monastery of St. Stephen, Irnerius expounded his system. The aim was to elucidate the literal meaning of every sentence and to give coherence to the subject-matter as a whole. The novelty of this approach cannot be overestimated (34). To approach jurisprudence in a rational and analytical way was a tremendous step forward (36).

The means available to the curious were pitifully few and the medieval mind was still weighed down by centuries of superstition, still fearful of new thought, and still totally obedient to the Church and its Augustinian rejection of nature. They lacked a system for investigation, a tool with which to ask questions and, above all, they lacked the knowledge once possessed by the Greeks, of which medieval Europe had heard, but which had been lost (36)

## **ARAB CULTURE & THE NEW INTELLECTUALISM**

### ***Toledo, Spain***

In 1085 the Arab citadel of Toledo in Spain fell, and the victorious Christian troops found a treasure beyond anything they could have dreamed of. In the libraries of Toledo there existed the rich intellectual heritage of Arab

culture. The central library of Cordoba alone contained 400,000 titles. (36-39).

The intellectual plunder of Toledo brought the scholars of northern Europe like moths to a candle. The scholars came in a steady flood. Some stayed, some translated the text they were looking for and returned to the north. The intellectual community which the scholars found in Spain was so far superior to what they had at home that it left a lasting jealousy of Arab culture which was to color Western opinion for centuries (41).

### ***Adelard***

One of the first scholars to arrive and to take back what he discovered was an Englishman from Bath. His name was Adelard, and his prime interest was in astronomy. But it was his exposition of the new method of thought he found exemplified in the Arab texts that made the greatest impact on his European contemporaries: rationalism and the secular, investigative approach typical of Arab natural sciences. Adelard's new insight convinced him of the power of reasoning, rather than the blind respect for all past authority that he had left in Latin Europe. This kind of approach was not in itself, the stuff of revolution, but together what else was coming from Spain, it was explosive (41).

### ***Content***

The translators dealt with every subject known to the Arabs at the time, almost all of the knowledge culled from Greek sources and new to Latin Europe. The subjects covered by the texts included medicine, astrology, astronomy, pharmacology, psychology, physiology, zoology, biology, botany, mineralogy, optics, chemistry, physics, mathematics, algebra, geometry, trigonometry, music, meteorology, geography, mechanics, hydrostatics, navigation and history.

### ***Aristotle Rediscovered***

What caused the intellectual bombshell to explode, however, was the philosophy that came with it. This included Aristotle's system of nature and the logic of argument. Through Aristotle, philosophy was given equal status with religion in explaining the cosmos. Through these

translations the West also learned the power of argument by syllogism, induction, and deduction (42-44).

Aristotle's system used these techniques to examine nature and the cosmos and arrive at infallible truths. What was revolutionary about this was Aristotle's suggestion that nature could be systematized so as to make it amenable to syllogistic analysis (44).

In an influential and controversial work called *Sic et Non* Abelard analyzed 168 statements from the Bible and showed that there were inconsistencies in the interpretation. Though he claimed that his attack on authority aimed only at finding the truth, the Church did not approve. When he said "by doubting we come to inquiry; by inquiring we perceive the truth," Rome heard the voice of a revolutionary (44).

### ***Logic and Law***

In 1140 the great Bolognese jurist Gratian produced his *Decretum*, a lawyer's textbook embodying the techniques of logic. Heavily influenced by Abelard's *Sic et Non*, it used Aristotle's rules of argument and deduction to deal with conflicting arguments about law itself (46).

The work of Irnerius and Gratian made Bologna the home of law, and Abelard made Paris that of theology and dialectic. Soon a university system formed in Bologna. While the new learning stimulated the creation of universities, it posed fundamental problems for the Church. The difficulty for Rome lay in the fact that Aristotle advocated logic and empirical investigation which was antimonious to the Church's Augustinian teaching. In 1210 Aristotle was banned in Paris. This ban was ignored (49).

From 1130 until the end of the 12th century, Greek and Arab science and logic flooded into Europe. The texts made available the exploitation of Greek naturalism and rationalism. Nature was no longer a closed book to be understood only by initiates: it was as much a functioning part of the universe as man himself, and was open to man to explore.

In the early 12th century came one last shock: the commentaries on Aristotle by the Arab philosopher Ibn Rushd, known to the West as Averroes. This gave the West

the clearest analysis yet of pure Aristotle. Averroes submitted all but divinely revealed truth to the cold light of reason. He claimed that the act of Creation had taken place before the beginning of time and that once the act had been performed certain events inevitably followed. Beyond this point God could no longer intervene. This posed one more major problem for the Church, concerning the relationship between free will and Providence. Augustine had said that man could not be saved except by divine grace, but if there were no free will, man could not help sinning. And if no intervention by God were possible, no grace could be given. God had been given limitations (50).

### ***Thomas Aquinas***

On 3/19/1255, the Church caved in and permitted all Aristotelian work on to the curriculum. Full heterodox Aristotelianism was now let loose. It took one of the supreme Church intellects to tame it. Thomas Aquinas, in his great *Summa Theologica*, was to reconcile the dual modes of thought by approving a kind of double standard. There would be areas of truth that related to revelation, which would be the province of theology. As for the natural world, reason could handle that. Philosophy was finally granted independence (50). Even the great Aquinas bowed to the inevitability of mathematical rationalism. In a list of things God could not do, among such limitations as "change Himself," "forget anything" and "commit sins," Aquinas included; "God cannot make the sum of the internal angles of a triangle add up to more than 2 right angles (50)."

### ***Architecture & the Church***

The new humanist self-confidence was monumentally expressed in architecture. Communities of craftsmen and professionals, using money and logic, increasingly aware of how nature might be controlled, with the ambition and expectation that tomorrow would be better than today, changed the style of building in which they worshipped God. Gothic architecture may have been principally a technical advance due to the Islamic knowledge, but it also gave people in the late Middle Ages the chance to express their new-found power. Between 1140 and 1220 they build cathedrals in Sens, Oyon, Senlis, Paris, Laon, Chartres, Reims, Amiens and Beauvais (50-51).

In church activities too, the life of this world began to make itself felt. At the end of the 12th century Christ was brought to the worshipper in a new way. The new cult of the Eucharist, the elevation of the Host, the dogma of transubstantiation and the Feast of Corpus Christi, inaugurated in 1264, all manifested the new desire to "see and touch." The brief dramatic interludes in the liturgy which had appeared in the 10th century moved out of the church into the porch, where they took the form of public plays (52).

### ***Light & Rational Investigation***

The concern with the metaphysical properties of light brought to its logical conclusion the change in European thought begun by Aristotle and the Muslim philosophers. During the 1st half of the 13th century Bishop Grosseteste suggested comparison of repeated observations as the best method of verifying or disproving the true cause of his ideas concerning optics. He suggested that to understand what caused something to happen it was necessary to go beyond what was revealed by observation to the mechanism of the phenomenon itself (52). His younger contemporary Roger Bacon tried to solve the problem by the use of mathematics, arguing that the truth could only be found through experimentation.

Where men had once said "*Credo ut intelligam*" (understanding can only come through belief), they now said "*Intelligo ut credam*" (belief can only come through understanding). In 1277, Bacon was imprisoned for an indefinite period for holding these opinions. Free and rational investigation was to come hard in the clash between reason and faith which would echo down to our time (53).

### **Chapter 3: Point of View**

Much of the disquiet expressed today about the social effects of information technology relates to what it might do to the individual's right of privacy. We defend this right jealously and regard with growing concern the possibility that while new services such as electronic shopping or computerized medical histories may enhance the quality of our physical lives, the same data might be used to model us. Concern for privacy is a major determinant in

the way we live. We allow government many prerogatives, but never to invade or detract from our rights as individuals.

Most of us regard these rights as primarily political, sprung from the great democratic reforms of the 18th century. But those reforms might not have been possible without an intellectual revolution in thinking which occurred 300 years earlier, in northern Italy. It was a revolution based on 2 events: the greatest holocaust the West has ever known and a new way of painting.

### **The Plague**

In summer of 1347 a merchant ship returning from the Black Sea entered the Sicilian port of Messina bringing with it the horrifying disease that came to be known as the Black Death. It struck rapidly. Within 24 hours of infection and the appearance of the first small black pustule, came an agonizing death. The effect of the Black Death was appalling. In less than 20 years half the population of Europe had been killed, the countryside was devastated, and a period of optimism and growing economic welfare had been brought to a sudden and catastrophic end (55).

After it was over, towards the end of the 14th century there was a new air abroad, a feeling of reckless joy at being alive. The survivors were rich, having inherited what the dead had left, so they went on a gigantic spending spree in an effort to wipe out the memory of those horrific years (56).

But it was the change in the status of labor that had the greatest effect. The Black Death had killed 1/2 the workforce, and those that remained were desperately needed if enough food and raw materials were to be produced to help Europe recover. Their entire condition of life was altered. No longer helpless bonded serfs, the farm-workers became a commodity that could command any price for its efforts. All over the Continent the workers flexed their industrial muscle, in displays of political insurrection that would have been unthinkable a generation before. With the general breakdown of authority came heresies (57).

Of all the countries ravaged by the Black Death, Italy made the fastest recovery. In an attempt to stem the tide of revolution and hold down the trouble the Franciscan friars preached a new, individual form of salvation (57).

This society—numerate, superstitious, emotional, cruel and egotistic—was ideally placed to recover fastest from the economic devastation of the plague. Italy was situated exactly between northern Europe and the Near East. By the end of the 14th century the great Italian maritime republics of Genoa, Venice, Pisa and Livorno had bases all over the eastern Mediterranean, and there were regular departures to the Baltic (60).

What helped to give the Italians and in particular the Florentines, control over these vast amounts of money and goods was their monopoly of the latest accounting system. Leonardo Fibonacci, a Pisan who had been brought up in North Africa in what is now Algiers, had introduced the full range of Arab and Indian decimal calculation. In the 14th century Fibonacci's double-entry system made a tentative appearance, first in Genoa and then in Venice. But it was the Florentines who were to take the most advantage of the system (60-61).

In 1397 the Medici family started lending money on an international scale. But by the end of the 14th century the general economic recovery from the effects of the plague was demanding more flexible financial systems. The Medics opened banks throughout Europe, providing a stable exchange rate, a regularity of service based on their branch managers' ability to take independent decisions, and their efficient double entry book keeping methods. The Medicis dominated the money market in Europe because they could balance their books (61).

Although the rest of Europe was beginning to share in the boom—manifested in an unprecedented scale of building projects—it was in Italy that the recovery was most spectacular (63).

This was the time of the entrepreneur, as new trading opportunities brought new families into positions of power hitherto the prerogative of aristocrats. Florence was republican by the mid-14th century, and the power of the state was growing mightily (63).

Opportunities in the city were so attractive that many landed magnates, powerful in their local country villages, changed their names and became franchised urban commoners. As the climate became more egalitarian, state control grew until it dominated every aspect of life (64).

Money had become the key. The Florentines were shareholders in the first giant corporate state in Western history. The backbone of this new community, half democratic, half totalitarian, was the middle class (65).

Religion was relegated to being a private matter. Perfection can only be attained by the community. Dignity and stability were the new accolades. Labor and wealth were sanctified because of their public value. These new attitudes were vital to a burgher class that with the disappearance of the guilds, had lost the protection it had enjoyed during the Middle Ages (66).

The more wealthy Florence became the more she began to compare herself with the classical republican Rome. The more they looked at pre-Christian classical thought, the more the Florentines found what they wanted: the civic glorification of the community conscious individual. The Romans and Greeks were not to be regarded as paragons of knowledge, but as paragons of excellence. At the core of their writings, in the rhetoric, education, poetry, morals and philosophy, the central figure was not Christ, not the transient, worthless figure of mankind as described by the medieval theologians, but man— independent, intelligent, adventurous, capable (68).

This concentration on the human rather than the divine, an attitude that became known as humanist, was to characterize the next hundred years of Florentine and European thought. The new type of man lived a life that was positive, a life full of the beauty and dignity inherent in the natural world (68).

However advanced this humanist outlook may seem, it must be remembered that there were still few tools with which to give concrete expression to the new-found confidence of Florence (69).

### **A New Way of Painting**

Brunelleschi provided the first example of perspective painting. It had an extraordinary effect on people accustomed to the non-perspective representational styles of the period (72-73).

What had been achieved as a revolution in the way people looked at the world, not just in terms of visual

representation but from a philosophical point of view. Following the discovery of perspective geometry, the position of man in the cosmos altered. The new technique permitted the world to be measured through proportional comparison. With the aid of the new geometry the relative sizes of different object could be assessed at a distance for the first time. Distant objects could be reproduced with fidelity or created to exact specifications in any position in space and then manipulated mathematically. The implications were tremendous. Aristotelian thought had endowed all objects with essence, an indivisible, incomparable uniqueness. The position of these objects was, therefore, not to be compared with that of other objects, but only with God, who stood at the center of the universe. Now at a stroke the special relationship between God and every separate object was removed to be replaced by direct human control over the objects existing in the same measurable space (76-77).

Man, with this new geometrical tool, was the measure of all things. The world was now available to standardization. Everything could be related to the same scale and described in terms of mathematical function instead of merely its philosophical quality. Meanwhile, the confidence that the discovery must have raised in the Florentines began to make itself evident. If man were the measure of all things, then all things must surely relate to the measure of man: his experiences, observations, and perspectives (77).

In literature, as with painting, writers began to express themselves more personally. But the most obvious example of the change in attitude was seen in architecture. Building were now to be constructed with man as their focal point (78-80). The rules for the building of cities were equally concerned with proportion. Cities were to be the mirror of a harmonious universe, with building arranged according to function (83). Parallel with these developments ran a series of events that started where the original use of perspective had begun—with cartography (84).

One such cartographer was Toscanelli. Using geometry, Toscanelli gave his maps metric coherence through the gridding method and wrote maps to find an alternative to the West African route to the Spice Islands. With Toscanelli's map stuck to the flyleaf of his atlas, a captain set sail for Japan. He was never to arrive. On the way west to Japan Captain Columbus discovered America (89).

## Chapter 4: Matter of Fact

We are trained today to accept the facts of science and technology no matter how frequently the same science and technology renders them obsolete. Yet the concept of the generally accepted facts is a relatively new one.

In the world that existed before this occurrence, contemporary references reveal the people of the time to have been excitable, easily led to tears or rage, volatile in mood. Much of their life was led in a kind of perpetual present: their knowledge of the past was limited to memories of personal experience, and they had little interest in the future. Time as we know it had no meaning. They ate and slept when they felt like it and spent long hours on simple, mindless tasks without appearing to suffer boredom.

The medieval adult was in no way less intelligent than his modern counterpart, however. He merely lived in a different world, which made different demands on him. His was a world without facts. Indeed, the modern concept of a fact would have been an incomprehensible one. Medieval people relied for day to day information solely on what they themselves or someone they knew had observed or experienced in the world immediately around them. Their lives were regular, repetitive and unchanging (91).

For the illiterate dialect-speaking villager, the church was the main source of information. In communities that had for centuries been isolated and self-sufficient, the social structure was feudal. There were 3 classes: noble, priest, and peasant. The noble fought for all. The peasant worked for all. The priest prayed for all (92).

Manuscripts were rare. They were little more than marks of doubtful significance on dead animal skins. To the illiterate, documents were worthless as proof because they were easy to forge (92).

In the 15th century it took 18 months for the news of Joan of Arc's death to reach Constantinople. The news of the city's fall in 1453 took a month to get to Venice, twice as long to Rome, and 3 months to reach the rest of Europe. Later, the perception of the distance traveled by Columbus was colored by the fact that the news of his landfall

across the Atlantic had taken as long to reach the streets of Portugal as did news from Poland (97).

In a world where few could read or write, a good memory was essential. It was for this reason that rhyme, a useful aide-memoire, was the prevalent form of literature at the time. Up to the 14th century almost everything except legal documents was written in rhyme. French merchants used a poem made up of 137 rhyming couplets which contained all the rules of commercial arithmetic.

### memory

Given the cost of writing materials, a trained memory was a necessity for the scholar as much as for the merchant. For more specific tasks than day to day recall, medieval professionals used a learning aid which had originally been composed in late classical times. The text they learned from was called Ad Herennium, the major mnemonic reference work of the Middle Ages. It provided a technique for recalling vast quantities of material by means of the use of memory theaters (99).

As painting and sculpture began to appear in churches the same techniques for recall were applied. Church imagery took the form of memory agent (101). Cathedrals became enormous memory theaters built to aid the worshippers to recall the details of heaven and hell (102).

It was this oral habit which separated reading from writing. The former used the voice, the latter the hand and eye. All writing held a kind of magic quality for the reader, most of all that of the holy texts. Books were in a sense miraculous objects. After the growth of the European economy in the early 15th century, demand grew steadily for these wonder-working texts. Such writing was for God's eyes, not for communicating everyday things to common men (104-106).

The problem with these great works, whose creation involved immense, time-consuming acts of worship, was that not only were they filled with errors, but very often the entire texts were irretrievably lost because there was no way of finding them once they had been written and placed in the monastery or church. There was no filing system (107).

### Fact & history

For this reason there was no concept of history: there were only chivalrous romances and chronicles based on widely differing monastic views of what had happened in the world beyond the community's walls. There was no geography, natural history, or science, because there could be no such confirmation of the data upon which such subjects would rely. This absence of proven fact bothered few people. Life was depicted by the medieval Christian Church as ephemeral and irrelevant to salvation. The only true reality lay in the mind of God, who knew all that needed to be known and whose reasons were inscrutable.

Into this alien world of memorizing, hearsay, and fantasy, the pressure for rational, factual information began to come first from traders (108). Pressure for access to information also came from the growing numbers of universities and grammar and church schools, whose students were entering an increasingly commercial world. The kings and princes of Europe also needed ever-larger bureaucracies to handle the increasing responsibilities devolving on them as the feudal system gave way to centralized tax collecting monarchies. In fairs all over Europe, from the 14th century on, international trade had been stimulated by the use of Arab mathematics which made documenting easier than with the old-fashioned abacus and the Roman numerals of earlier times (108).

### **Paper**

The greatest pressure of all for literacy, however, was caused by the sudden availability of paper. Originally a Chinese invention, paper had been discovered by the Arabs when they overran Samarakand in the 8th century. By the 14th century new water powered technology was pounding linen rags as fast as they could be collected by the rag and bone man and turning them into cheap, durable paper. In Bologna at the end of the 14th century the price of paper had dropped 400%. It was much cheaper than parchment, though there was still some opposition to use it (109).

As the paper mills spread, so too did the spirit of religious reform. The Church had long been criticized for simony and equivocal practices, and in the late Middle Ages came the birth of a reforming movement led by the Brothers of the Common Life who preached a simpler, purer form of Christianity. Their devotio moderna attracted many of the scholars of the day, including eminent men such as Erasmus.

Above all their schools and others like them began to turn out relatively large numbers of literate clerics. These men rapidly found employment in the scriptoria or writing shops which were springing up all over the continent to meet the demand for documentation from traders and governments, as well as from the lawyers and notaries who formed the single largest and fastest-growing professional body in Europe (109-110).

The insoluble problem which bedeviled Europe at this time was that there were far too few scribes to handle the business being generated and their fees were astronomically high. Economic development appeared blocked (110).

### printing press

At some time in the 1450s came the answer to the problem, and with it a turning-point in Western civilization. The event occurred in a mining area of southern Germany. These cities were also centers for the manufacture of astronomical and navigational instruments, the source of the first engraving techniques, and the home of some of the best watch and clock makers on the Continent. The region also held many men highly experienced in working of soft metals.

It was probably one of these metal-workers who recognized that the goldsmith's hallmark punch could be used to strike the shape of a letter in a soft metal mold. This would be filled with a hot tin-antimony alloy which when cooled, formed the first interchangeable typeface which could be used in a printing press. The press itself was a modified linen press that had been in use for centuries; it was now adapted to push paper down on to an inked matrix of upturned letters, each one of which was close enough in dimension to its neighbor to fit into standard hold in the matrix base. The technique would not have worked with parchment because it was not porous enough to take the ink (111).

The man who is credited with inventing the process was Johannes Gansfleisch zur Laden zum Gutenberg. His new press destroyed the oral society. Printing was to bring about the most radical alternation ever made in Western intellectual history, and its effects were to be felt in every area of human activity (112). The innovation was not in fact new.

There had been an even earlier attempt in China and Korea (112).

The reason for the late appearance of the technique in the West may be related to the number of developments which had to take place before printing could succeed. These included advances in metallurgy, new experiments with inks and oils, the production of paper, and the availability of eye-glasses. Also significant would have been the mounting economic pressure for more written material and dissatisfaction with the over-costly scriptoria, as well as the generally rising standards of education which accompanied economic recovery after the Black Death (112).

Once introduced, however, the speed with which printing propagated itself throughout Europe suggests a market ready and willing to use it. From Mainz it reached Cologne in 1464, Basel in 1466, Rome in 1467, Venice in 1469, Paris, Nuremberg and Utrecht 1470, Milan, Naples, and Florence 1471, Augsburg 1472, Lyons, Valencia and Budapest 1473, Cracow and Bruges 1474, Lubeck and Breslau 1475, Westminster and Rostok 1476, Geneva, Palermo and Messina 1478, London 1480, Antwerp and Leipzig 1481, and Stockholm 1483.

It should be noted that almost without exception these were not university cities. They were centers of business, the sites of royal courts or the headquarters of banking organizations. By the end of the 15th century there were 73 presses in Italy, 51 in Germany, 39 in France, 25 in Spain, 15 in the Low Countries and 8 in Switzerland. In the first 50 years 8 million books were printed (113).

The new printing shops have been described as a mixture of sweatshop, boarding house, and research institute. They brought together members of society strange to each other. The craftsman rubbed shoulders with the academic and businessman. Besides attracting scholars and artists, the shops were sanctuaries for foreign translators, emigres, and refugees in general who came to offer their esoteric talents.

### ***Cultural Exchange***

Printing shops were above all centers for a new kind of intellectual and cultural exchange. Existing outside the framework of the guild system, they were free of its

restrictive practices. The new printers thought of themselves as the inheritors of the scribal tradition, and used the word scriptor to describe themselves rather than the more accurate impressor.

The print shop was one of the first truly capitalist ventures. The printer or his partner was often a successful merchant who was responsible for finding investors, organizing supplies and labor, setting up production schedules, coping with strikes, hiring academically qualified assistants and analyzing the market for printed texts. He was also in intense competition with others who were doing the same, and was obliged to risk capital on expensive equipment (114). These men also pioneered the skills of advertising (115).

### ***Impact***

Almost immediately after its invention print began to affect the lives of Europeans in the 15th century. The effect was not always for the better. Along with the proliferation of knowledge came the diffusion of many of the old scriptural inaccuracies. The principal effect of printing, however, was on the contents of the texts themselves. The press reduced the likelihood of textual corruption. The concept of authorship also emerged. For the first time a writer could be sure of reaching a wide readership which would hold him personally responsible for what he had written. Printing made possible new forms of cross-cultural exchange without the need for physical communication. New ways were developed to present, arrange and illustrate books. It became feasible to collect books systematically, by author or subject. But the most immediately evident effect of printing lay simply in the production of many more copies of existing manuscript texts (116).

### ***Religion: Luther & the Catholic Church***

A prime example of the proliferation of an already established text was the use of the press by the Church to reproduce thousands of printed indulgences. The widespread cynicism which greeted this ecclesiastical involvement with the world of technology was undoubtedly a contributing factor to the rebellion of the Augustinian friar of Wittenberg, Martin Luther, which sparked off the Reformation. Luther (1517) reacted by producing 95

criticisms of the Church which he nailed to a notice board in his church in Wittenberg. Luther's expectations of quite, scholarly discussion of his grievances among his friends were rudely shattered when copies were printed and distributed. Within a fortnight the theses were being read throughout Germany. Within a month they were all over Europe. Luther found himself at the head of a rebellious army he had never thought to command. The only way to make the rebellion effective was to use the same weapon that had started it: the press. 3 years later 300,000 copies of Luther's work were on the market. "Print," Luther said, "is the best of God's inventions." The first propaganda war had been won (116-117).

The new power to disseminate opinion was seized eagerly by anybody with a desire to influence others. The printers themselves had shown the way with their advertisements. Now the broadsheet radically changed the ability to communicate. Broadsheets were pinned up everywhere, stimulating the demand for education and literacy by those who could not read them. Public opinion was being molded for the first time, fueled by anonymous appeals to emotion and the belief that what was printed was true. Centralized monarchies used the press to enhance their control over the people and to keep them informed of new ordinances and tax collections (118).

The corollary was that dissidence now also had a louder voice. The persecution of religious wars that ravaged Europe in the 16th century were given fresh and continuing impetus by the press, as each side used propaganda to whip up the frenzy of its supporters (119).

### ***Politics***

In the political arena printing provided new weapons for state control. As men became more literate, they could be expected to read and sign articles of loyalty. The simple oath was no longer sufficient, and in any case a man could deny it. He could not deny the signature at the foot of a clearly printed text. This represented the first appearance of the modern contract, and with it came the centralization of the power of the state.

Through the press the monarch had direct access to the people. He no longer had to worry about the barons and

their network of local allegiance. Proclamations and manifestoes were issued to be read from every pulpit.

### ***Lifesyttles***

With the new press came a new, vicarious form of living and thinking. For the first time it was easy to learn of events and people in distant countries. Europe became more aware of its regional differences than ever before. As Latin gave way to the vernacular languages encouraged by local presses, these differences became more obvious. Printing also set international fashions not only in clothes but in manners, art, architecture, music and every other aspect of living (118).

With the spread of printing came loss of memory. As learning became increasingly text-oriented, the memory theater technique fell into disuse. Prose appeared more frequently as the mnemonic value of poetry became less important (119).

One major result of printing was the emergence of a more efficient system of filing. With more than a thousand editions produced from the same original, book collecting became fashionable. These collections needed to be catalogued. Also, printers had begun to identify their books by title, as well as author, so it was easier to know what the book was about (120).

Cataloguing involved another new ability. People began to learn the alphabet, which until the advent of printing had had little use. Early printers found their books sold better if they included an index (120).

The new availability of data and the novel concept of information as a science in itself made the collation and use of data easier than before. The principal contribution to knowledge by the presses, however, lay in the establishment of accurate reproduction. When books came to be written by men whose identity was known, writers became more painstaking. Also, each writer could now build on the work of a previous expert in his field. Scholarship benefited from not having to return to first principles every time, so ideas progressed and proliferated.

Texts could be compared and corrected by readers with specialized or local knowledge. Information became more

trustworthy. More books encouraged more inter-disciplinary activity, new combinations of knowledge and new disciplines. Now the world was open to analysis by the community at large. The mystery of essence and intangible God given substance gave way to realistic drawings which took advantage of the new science of perspective to measure and describe nature mathematically. Not only was the world measurable, it could be held in one's hand in the knowledge that the same experience was being shared by others. New natural sciences sprang up, born of this ability to standardize the image and description of the world (121).

Printing changed the entire backward looking view of society with its stultifying respect for the achievements of the past, to one that looked forward to progress and improvement. The Protestant ethic, broadcast by the presses extolled the virtues of hard work and thrift and encouraged material success. Printing underlined this attitude. If knowledge could now be picked up from a book, the age of unquestioned authority was over (123).

The cult of youth had begun. As young men began to make their way in the new scientific disciplines made possible by standardization of textual information, it was natural for them to explore new areas of thought. Thus was born the specialization which is the lifeblood of the modern world. The presses made it possible for specialists to talk to specialists and enhance their work through a pooling of resources. Knowledge became something to be tested on an agreed scale. What was proved, and agreed, became a fact (123).

## **Chapter 5: Infinitely Reasonable**

We accept with equanimity the immensity and complexity of the universe, because we also accept man's ability to investigate it and to understand what he discovers. We are the children of science, self-reliant, confident, masters of our destiny. We are capable of tremendous feats, and we take them for granted.

The same is true of our acceptance of novelty. We live with such a high rate of change that we have come to expect obsolescence. We build it into our economy, and we adopt the same attitude to all other aspects of living. Transience is the mode. The only constant is change. This temporary quality is an integral part of scientific

progress. While working with immense accuracy and precision, scientists seek above all to find flaws in their theories (125).

This ability to regard all phenomena as obeying universal laws, as much applicable on earth as they are in the center of a star, is at the root of science. The ability was developed 400 years ago for reasons that had nothing to do with scientific research (125).

### **The Council of Trent**

On 12/13/1545, in the northern Italian town of Trento a group of eminent churchmen were summoned by Pope Paul III as representatives of the Catholic Church. They had come to Trento to deal with the greatest crisis ever to face the Church. The results of their deliberations would change the face of Europe. The crisis had erupted 30 years before when Martin Luther had nailed up in his church in Wittenberg a piece of paper on which were written 95 demands for reform. One of these called the organization of the Church superfluous and appealed to Germans to reform the liturgy (126).

Luther's message of revolt spread through Germany like wildfire. The aristocracy joined him against Rome because they hoped a break with the Pope might place valuable Church property in their hands. Inside the Church itself Luther's desire for reform was shared by many. The ecclesiastical organization had long been in need of overhaul. But Luther's aim was reform, not destruction, and when the German peasants rose in armed support he denounced them. His denunciation came too late. In spite of his protestations, Luther found himself running a new Church, independent of Rome and bearing his name. The German princes offered him protection, because it was in their political interests to do so (127).

At the time Europe was in turmoil for other reasons, the principal one being the attempt of the Emperor Charles V to realize his dream of the restoration of the Holy Roman Empire which met serious opposition and ultimately failed. Intellectual life was also in ferment as the Italian humanists spread their secular doctrine throughout the Continent and their questioning attitude combined with the early Renaissance contacts between craftsmen and scholars threatened established authority in almost every field. The

Portuguese had circumnavigated the globe and returned unscathed through regions south of the Equator which theology had decreed to be incandescent. Common sailors refuted the teachings of Rome. The discovery of the New World had unbalanced the economy due to the inflation which American silver was already bringing to the market-place. The very discovery itself created problems for the Church. If America had not figured in early Christian teaching, which had been taken to be comprehensive, what more might be waiting to be revealed for which the Church had not prepared (128).

The Council of Trent met all these threats with vigor. The meetings continued for over 30 years, with increasingly large congregations of clerks who hammered out a new policy of tighter control. While some reforms of malpractice were instituted, the Council approved decrees which exacerbated German objections. The real presence of body and blood in the Eucharist was declared dogma. The Mass was promulgated as the only true and proper liturgical service (128).

For the peasants the Council had other plans which were to change the face of worship. It was time to make the Church and her activities more attractive. In order to counter the libertarian promises of the Protestants, the Catholic Church should come to represent Heaven on Earth (128).

The new style appealed to the ordinary passions. An increased emphasis on the lives of the saints, aimed at bring religion closer to everyday life, meant that the inhabitants of heaven were soon to be seen in any church. The decor and the general design was aimed at taking the eye up into extravagant gyrations of color and embellishment in the painted dome, which represented heaven (130).

### **Copernicus & the calendar**

In 1514 the secretary to the Pope asked a relatively unknown mathematician, also a Canon of Frombrok in Poland, to look at the problem of calendar reform. The priest, called Niklas Koppernigk, replied that nothing could be done about the calendar until the matter of the relations between the sun and moon had been resolved.

Koppernigk had attended the university of Cracow and had then visited Italy, where he had studied at Padua and

Bologna. His principal aim was to explain the apparent anomalies in the motions of the planets with a simpler version of events than was currently held, closer in conception to the original, circular plan adopted by Aristotle. Copernicus came to the conclusion that there was a better explanation of the anomalies in planetary motion. On 5/1/1514 Copernicus the name by which he is better known today circulated a manuscript called *The Little Commentary* which questioned the entire Aristotelian system and suggested a sun-centered system with a moving earth. The fully developed heliocentric argument was not published until Copernicus died in 1543.

His scheme met the requirements of philosophical and theological belief in circular motion. In every other aspect, however, Copernicus struck at the heart of Aristotelian and Christian belief. He removed the earth from the center of the universe and so from the focus of God's purpose. In the new scheme man was no longer the creature for whose use and elucidation the cosmos had been created. His system also placed the earth in the heavens and in doing so removed the barrier separating the incorruptible from the corruptible (135).

For 20 years before Copernicus's theory was published it was discussed all over Europe. Ironically, the earliest attacks came from the Protestants (135).

Copernicus had satisfied everybody's demand that the hypotheses be as simple as possible and that they should save the appearances or account for what heavenly phenomena appear to be, as exactly as possible. A fictional orbiting earth would do so. The scheme was taken up without demerit and used to reform the calendar in 1582 (137).

### Gunpowder

Gunpowder had been in general use for only 100 years. It had proved an immensely popular discovery with the princes of Europe, who had merely to indicate that they were passing a rebel town with artillery for that town to surrender (138). All over Europe engineers and gunners began looking for ways to fire more accurately. It was at this point that one of Copernicus's minor heresies—placing the earth among the planets and blurring the separation between celestial and terrestrial conditions—was to become a vital element of momentous change. The problem involved

in analyzing the movement of a cannon-ball was that there were confused ideas about what happened to the ball in the air. Aristotelian laws said that the natural state of all earthly objects was to be at rest. Since all heavy bodies had a natural desire to be close to the center of the earth they tended to remain static at the lowest position they could find (138). The flaws in this argument were obvious even to the would-be faithful. Projectiles did not fall straight to earth, but followed a curved path (139).

## Galileo

Galileo brought about an intellectual revolution by proposing that phycists should dispense with Aristotelian essences. His view was that the only way to find out what was happening was to observe and experiment; that in experiment one should look for the nearest cause for a phenomenon, and for events or behavior that were regular in occurrence, which could be repeatedly observed; that the universe could be reliably observed by the senses; and that everything should be reduced, if possible, to mathematics (144).

Galileo's speculations concerning the heavens were guesswork until mathematical speculation could be replaced by proof that they were not as the Church described them. This was a matter that was about to engage Galileo's rapt attention and turn him from a math professor with a comfortable though obscure position into a household name throughout the Continent. The event, when it happened, would also confirm the fears of his friends that when he had gone to Florence in 1610 it had been to a place where the authority of the friends of the Jesuits counts heavily.

### ***The Telescope***

It was there that Galileo wrote the 24 pages which were to being his downfall. In the previous year he had heard of a new looker invented by a Dutchman called Lippershey. By mid-year he had developed it to the point where his looker-telescope would magnify 1000 times and make things appear 30 times closer (147).

On 1/7/1610 was looking at Jupiter with his best telescope when he notice 3 new stars he had not seen there before, 2 to the east and one to the west of the planet. The next night they were all to the west, in a line. Jupiter's

movement at the time was such that if these were starts, Jupiter should have moved against them and revealed them all to the east of the planet. Through the winter Galileo observed these tiny stars and became convinced that they were Jovian satellites (147).

### ***The Starry Messenger***

Galileo propounded his theories in a brief paper called *The Starry Messenger* in 1610. Then in 1613 Galileo published again. This time it was to explain the sunspots reported by various people. He said that these were imperfections on the sun, because the mathematics of optics showed that they were on its surface. He also noted that the sun rotated: 2 more blows to the Aristotelian system.

Then Galileo wrote a letter to the Tuscan Grand Duchess Christina, in which he referred to criticisms of his work and argued that he was not imputing scientific error to the Bible because the Bible was not a scientific text. He gave a detailed defense of the independence of scientific investigation and of his preference for the evidence of the senses. This was a dangerous move, since it took Galileo into the arena of the theologians (148).

In 1642 Galileo went to Rome to argue for more freedom. If he could prove the action of the tides to be due to the earth's moving and not because of some magic effect of the moon, would that, for instance, be acceptable? He was told to take care that his hypothetical arguments should be explained slowly and carefully over a period of time so as not to cause Catholics to lose their faith in the Scriptures for the wrong reasons. Galileo insisted on total freedom.

### ***The Dialogue on the Two Chief Systems of the World***

In 1632 he published *The Dialogue on the Two Chief Systems of the World*. It caused a sensation. The book showed the opponents of the Copernican system to be simpletons, which was seen to be a full-blooded attack on the Church. In 1633 Galileo was condemned to house arrest, where he remained, in Arcetri, near Florence, until he died in 1642. His book was placed in the Index of Prohibited Books until 1835.

Galileo's trial virtually ended scientific work in Italy and changed the nature of scientific investigation permitted by the Church. After his efforts the Church insisted that hypotheses should relate to reality and not to convenient fictions. They must be compatible with the principles of physics, but at the same time they could not contradict the Scriptures in any way. Two conditions were imposed on any hypothesis: it must not be *falsa in philosophia*, or *erronea in fide*. Galileo's *Dialogue* had broken both rules by presenting physical evidence which validated Copernicus's theory in support of a heretical view. No more such hypotheses were to be permitted in Italy or anywhere else under Rome's authority.

### Kepler

It was in the north, where Roman writ ran less effectively, that the work continued, thanks to one of Galileo's German contemporaries who had avoided trouble because he couched his form of heresy in Pythagorean terms and because he lived in a well protected Protestant part of Austria near the town of Lize. Johannes Kepler had been born in 1571, one year before the great nova (149).

Kepler, working with Tycho Brahe, realized that something was wrong with the motion of Mars. Its path around the sun was unequal, without the symmetry to be expected from a circular, Aristotelian orbit. The planet's path was 8 minutes of arc longer on one side of the sun than the other. The discovery of this discrepancy was to revolutionize astronomy. After completing 900 pages of calculation during 4 years study of data, Kepler discovered that the orbit was not circular but elliptical (149-150).

Kepler's laws removed the planets from the community of celestial bodies. They also revealed a solar system in which the various parts were mathematically related to each other. The system worked as Kepler had wanted it to: like clockwork. The only problem remaining was the mathematics. Even with Kepler's new geometrical technique, calculation was dauntingly difficult and time-consuming.

### Economy

Throughout this period the center of activity in almost every field was shifting steadily north, away from the Mediterranean. With the major metal industries now in

Protestant Germany and the Portuguese spice imports going to northern Europe where the most profitable markets were, Antwerp had become a center for international trade by the middle of the 16th century. The Low countries had held a pre-eminent position in the economy of the north since the Middle Ages, when their textile industry had been the key factor in the recovery of the European economy after the Black Death. It was in Holland that Portuguese spices were finally exchanged for German precious metal (145).

The Italian banking representatives were also in Holland, where a sophisticated credit system was slowly developing. Above all, in mid-century the heavy-handed rule of the distant Spanish king, Phillip II, was increasingly resisted by the Protestants in the northern part of the Low Countries. Guerrilla warfare finally broke into full-blooded conflict in 1586 when the rebellious Dutch, under William of Orange, began to take the country from the Spaniards (145).

### ***Holland***

Holland was fast becoming one of the richest countries in Europe. As a result of the flight of talent from Antwerp in the previous century, Amsterdam was not the economic capital of the West. The Dutch East India Company had been founded in 1602 to beat the Portuguese at their own game in trade with the Far East. To promote the development of the economy the government had founded the Amsterdam Bank in 1609. The bank offered long-term credit, issued bills of exchange and banknotes, and generally facilitated mercantile expansion as the Dutch fleets brought the riches of East and West to Europe to be re-exported in the famous *fluytschip*, the extraordinary short-haul cargo vessel invented by Dutch shipbuilders. The ship and the bank together made Holland the import-export capital of Europe (153).

Although the country was nominally Calvinist, the Dutch took the attitude that as long as people did not attempt to interfere in how the country was run they could do, say and print what they chose. Whereas the Catholic countries with their repressive, centralized, absolute monarchies continued to build baroque extravaganzas to dominate their cities as reminders of the power of the throne and the Vatican, in Holland the architects built small, cool

elegant houses for wealthy merchants along the banks of the Amsterdam canals (153).

The Dutch accepted any refugee who sought asylum. Rene Descartes was such a refugee (154).

### **Descartes**

In Holland in 1637 Descartes published a work that was to influence the course of science for a hundred years and lay the foundations of modern thought. Descartes shared the opinion of other scientists of his time that it was pointless to engage in battles with the Church over whether such things as celestial spheres existed, or whether the Bible was literally true. Instead, the increasing mass of scientific and technical knowledge should be placed in the hands of practical men such as navigators, engineers, builders, mathematicians, entrepreneurs and the new capitalists in mining. In the preface to his book Descartes said: "Philosophy allows you to go on apparently in truth about everything. And it impresses the stupid . . . philosophy itself needs reforming."

#### ***The Discourse on Method***

Descartes book was called *The Discourse on Method* and just as Aristotelian logic had revolutionized the form of European argument 400 years earlier, so now did Descartes' Method. The book exhorted the reader to doubt everything. It advised him to take as false what was probable, to take as probably what was called certain, and to reject all else. The free-thinker should believe that it was possible to know everything and should relinquish doubt only on proof. The senses were to be doubted, initially, because they were also the source of hallucination. Even mathematics might be doubted, since God might make a man believe that 2 and 2 made 5 (154-155).

The only thing that was certain was thought. The fact that a man thought, whether falsely, madly or truthfully proved that he existed as expressed in the famous dictum, "I think, therefore I am." Knowledge based on experience might be alterable, only the mind could be trusted because all things that we conceive of very clearly and distinctly are true (155).

#### ***The Principles of Philosophy***

Thought in the form of critical doubt was the only tool that the scientist could trust. In solving problems, the simplest possible solution should be examined first and after that the more complex. Descartes applied his Cartesian doubt to the behavior of the universe. In 1640 he wrote *The Principles of Philosophy* (155).

Descartes' universe was a cold, empty, mechanical place. He devised a system of exact coordination to locate phenomena. The graph did away with the need for Kepler's cumbersome geometrical drawings. Its importance in the history of science cannot be overestimated. It permitted any series of positions along any line to be described in terms of its coordinates. Any trajectory could be described by its y and x values, which would alter according to its movement in either axis. The new analytical geometry permitted all forms of motion to be analyzed theoretically. Now the principal need was to be able to make more precise measurements of the data to be so manipulated (156).

### **Advances**

By the middle of the 17th century such developments were already well under way. In 1628 William Harvey demonstrated the circulation of blood. Jan Baptista van Helmont discovered the existence of gases some time before 1644. In 1646 Evangelista Torricelli produced a vacuum, as a result of which barometric pressure was able to be accurately measured by 1648. Otto von Guericke developed the vacuum pump. In England Robert Hooke and Robert Boyle examined the compressibility, elasticity and weight of air and showed it to be vital for respiration. In 1661 Boyle led the way to modern chemistry when he dispenses with the Aristotelian theory that all substances were made up of the 4 elements.

The rate of change was equally rapid in the development of scientific instruments, particularly precision instruments. By the last quarter of the century there were telescopes, pendulum clocks, screw micrometers, air and vacuum pumps, barometers and chronometers, bubble levels and, above all, microscopes. From 1660 on the microscope seemed to underline the mechanical nature of the universe as it revealed more and more minute forms of life and inorganic structures which evidently operated on mechanical principles. Experimental science was immensely stimulated by these advances (157).

In 1685 the last of the inventive middle-class French Protestant Huguenots left France for England, to settle in Norwich, Southampton, Bristol and London. They also went to Holland. While France employed all her capital resources to support Europe's largest army, and in so doing crippled the economy, Holland became the only nation at peace on the Continent. England meanwhile had passed first through Civil War, then Restoration, finally offering the English crown to the Dutch sovereigns William and Mary, who became joint monarchs of both England and Holland in 1688.

### ***Spinoza***

In each of these northern countries two men were looking towards the logical end of what Benedetti and Galileo had begun when they tried to bring the sky down to earth for experimental examination. In Holland the man was a quite lens-polisher and philosopher whose father had come to Holland to escape persecution as a Spanish Jew. Baruch Spinoza was excommunicated by the Jews, attacked by the Christians and tolerated by the Dutch state. From 1663 he published his views, exalting the powers of reason, applying Cartesian theory to philosophy and ethics. Spinoza replaced Descartes' dictum, "Obey and respect religion," with "Love your neighbor and perfect your reason." For Spinoza, in a mechanical universe which operated according to natural laws there was no need for religious direction regarding the sacredness of life (158).

### ***Newton***

In England another thinker was to turn this desire for a rationally operating universe into physical reality. His name was Isaac Newton and in 1665, at 23, he had just taken his degree at Cambridge where he was the prot+g+ of the Lucasian Professor of Mathematics, Isaac Barrow. When the plague struck later that year Newton, like others, went to the country to escape contagion, returning to his birthplace in Woolsthorp, Licolnshire.

In the 2 years he remained there Newton discovered how the universe worked. He only began to write his theory down, however, 20 years later, in 1685. It was published in 1687 under the title *Principia Mathematica*. The *Principia* provided such an all-embracing cosmological system that it stunned science into virtual inactivity for nearly a century (159).

Newton developed 2 kinds of calculus. Differential calculus measured the difference in behavior which showed as the effect of rate of change. Integral calculus showed how the rates of change varied one with the other and showed them as a ratio of one to the other (159).

Newton agreed with Kepler that the mutual attraction operated in relation to the distance between the planetary bodies. He theorized that the force would work at a ratio inversely proportional to their separation. In the case of the moon, at a distance of 60 times the earth's radius, the strength of the attraction of the earth should be 1/602 of the attraction, which Galileo had shown to be 16 feet per second.

In the *Principia* Newton went on to explain how to use these calculations to derive the masses of all the planets from their orbital behavior. He demonstrated that the irregularities of the moon's behavior were due to the pull of the sun, that the moon does indeed cause tides, that comets are part of the solar system with calculable orbits, and that the earth tilts on its axis by 66.5 degrees to the plane of its orbit (160).

In his statement, "Every body attract every other with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them, "Newton gave man a tool with which all planetary behavior could be analyzed.

With the theory of universal gravity Newton destroyed the medieval picture of the world as a structure moved by the unseen but ever-present hand of God. Man was no longer at the center of a system created for his edification by the Almighty; the earth was merely a small planet in an incomprehensibly vast and inanimate universe which behaved according to laws that could be calculated (161).

## **Chapter 6: Credit Where It's Due**

Our lives are no longer controlled by nature. We control nature with power far beyond what it can muster against us. This power, and the world today which it created, is a relatively recent acquisition. Throughout the entire history of man until 1720, the number of people alive at any time in any society was ultimately dictated by the weather. In good weather and full harvest, people ate more

and were healthier. they produced more children, because they expected them to be able to survive in the clement temperature. When the population became too big for the land to support, either more land was cleared and planted, or the food supply became marginal. Whichever the case, the next time the weather turned bad, the fall in crop levels would cause widespread famine and death. In turn the succeeding generation married later and had fewer children, so there were fewer mouths to feed. Fewer people would work the land and the output would fall again, until the return of good weather (163).

### **England**

This cycle repeated itself endlessly, with occasional outbreaks of plague worsening the situation. Dependence on the land was virtually total: the entire economy was geared to agriculture. In 1720, in England, of the estimated 5.5 million population, 4.25 million lived in country villages. That year came the hottest summer in living memory. It was to be the forerunner of 3 decades of fine weather, with hot summers and mild winters. What historians call the mini ice age and ended after 200 years (164).

#### ***The Rat***

Moreover, at almost exactly the same time, the black rat, the bringer of plague, was supplanted in England by the brown rat. The major difference between the types was that whereas the black rat carried fleas which wandered, those of the brown rat nested. The carriers of plague remained with their hosts and the plague virtually disappeared.

Outside England the new weather conditions had little effect on the cyclical nature of social conditions. In England they were to bring massive change that would alter the nature of Western society through the unique English social structure (164).

#### ***The Golden Age: A Myth***

It was above all a remarkably stable society. 60 years before, the only home-grown revolution the country experienced had ended, and although with the crowning of Charles II the monarchy was restored to power after 20 years of republican government under Cromwell, the old ways were gone for good. The new England was no longer feudal.

The Crown was subject to the sovereignty of Parliament. The King might appoint ministers, but their actions had to have Parliament's approval (164-165).

Unlike his opposite number on the Continent the English farm-worker was no landless peasant. Nearly 2 million agricultural workers were wage-paying tenant farmers, living on the estates of the aristocracy. These farmers in turn employed over 2.5 million farm laborers who were accustomed to fluctuating employment, as the seasonal nature of farm work made for periods of high intensity followed by stretches of inactivity.

This was the England of the so-called Golden Age, with small country villages and happy under the fair skies, as depicted in Constable paintings, with a close-knit community cared for by the parson and ruled by the benevolent hand of the squire, with games of cricket played on the village green and apple-cheeked children running laughing in the fields, while their fathers rested over the scythe with a pot of ale and a loaf of freshly baked bread.

### ***The Golden Age: Reality***

Reality was a good deal less pleasant. The Acts of Settlement of the mid 17th century had made the village a virtual prison. No man could move to another place without a certificate of movement issued by the Justice of the Peace (JP), who was often the squire. These certificates were used to restrict the movement of out of work or politically active laborers. The Poor Laws already provided for the less fortunate in the parish and no village wanted to have to support vagrants out of the public purse (165).

The aim of legislation was to serve the best interests of the land and to immobilize and divide the working population so as to keep it out of London. The certificates of movement were mainly issued to single, male Irish and Scots who could most easily be moved on in the event of trouble (165).

### ***Land***

Furthermore, common lands were enclosed by the landowners recouping their losses from Cromwell's land redistribution. Fencing permitted controlled experimentation on improving yields of both crops and animals and limited the spread of

disease by wandering animals. Towards the end of the 17th century, enclosure put the value of improved land up by as much as 3 fold (166).

### ***Trade***

The growth of the amount of money in circulation during this period came principally from increased trade. During the republic, the great Navigation Acts of 1651 had paved the way for England's mercantile expansion. Described by Adam Smith as "perhaps the wisest of all the commercial regulations of England," the acts made all colonies subordinate to Parliament. All trade with them was to be in English ship. The aim was to deny foreign fleets, particularly the Dutch, the benefits of trade with the needy foreign markets (167).

The immediate effect was to double the tonnage of English shipping by the end of the century and to quadruple the amount of import and export trade, of which fully 15% was with the colonies. The hegemony of the Dutch over international trade was broken in a series of wars between 1652 and 1674, after they refused an English offer of political union (168).

The English now began to reap the full benefit of importing and re-exporting tobacco, cod, sugar and furs to the rest of Europe. Trading became increasingly centered in London. By the end of the century trade was also opened with the Baltic, Africa, Russia and Newfoundland. The Dutch colony of New Amsterdam was out-traded and then annexed to be renamed New York. From the East Indies came spices, coffee and tea. For the West Indies came sugar, rum and molasses, and from America, tobacco (168).

### ***Banking***

As the flood of goods increased, men became more aware of the need for regulatory legislation and everything seemed amenable to mechanical application.

Dudley North demonstrated the relationship between trade and the availability of money. These were novel thoughts, but they rapidly caught on. As the 17th century closed, there were calls for ways to ease the development of trade.

Holland had an extensive credit and banking system since the foundation of the Bank of Amsterdam in 1609. The Bank was authorized to accept and transfer deposits, exchange coin, buy metal and non-current coin for use in the mint and act as a clearing house for notes of exchange. Above all, it gave credit to certain major institutions such as the City of Amsterdam and the Dutch East India Company. A Scotsman called William Paterson suggested the establishment of a similar institution for England (171). On 7/27/1694 the Bank of England charter was sealed (172).

### ***Save From Slaughter***

The most urgent need at this time was to find a way to avoid slaughtering farm animals in winter because they could not be fed. The English introduced a technique for producing more hay to feed animals by the use of water meadows. Originally, hay had come either from uplands or from wet bottom-lands. From 1635 these lands were deliberately flooded by damming of streams. The grass was kept covered throughout winter, protected from frosts and snow, and by mid-March was 6 inches high. The quality was high and a floated meadow gave 4 times more hay than a dry one. Sometimes second and even third crops could be produced through rewatering. By the end of the 17th century this method was in used throughout England and most of the new crops produced at the time were for winter feed (172).

### ***The Turnip***

But the wonder crop of the 17th century was the turnip. This vegetable had been introduced from the Continent decades before but had hitherto only been grown in market gardens. The widespread use of turnips as fodder began in north Suffolk. As soon as the corn had been harvested the land would be plowed and turnips sown. By autumn they were ready for storage or left in the ground. If milking cows were fed turnip together with hay or straw they would give milk all winter. Turnips also served to fatten bullocks through the colder months; the crop might last as long as March.

### ***Clover***

Another plant was to prove equally important to the economic growth of the country. By the last quarter of the 17th century clover was being grown as an alternative to

peas and beans. The idea had originally come from Holland where clover was used for land reclamation. With the use of these crops, and artificial grasses like ryegrass, it became possible to turn heath into arable land in a relatively short time

By 1720 the new agricultural crops had changed the way land was used. The multiple crop system was introduced in Norfolk. Any field under the shift system could always be brought under regular crop cultivation on occasions when there was danger of general crop failure. The system was flexible. Crop rotation was applied to the whole farm and consisted of changes from arable to grass in sequence such as turnip, barley, clover, and wheat followed by turnip, oats, clover and wheat followed by fallow, turnip, wheat and clover followed by wheat, barley, turnips and clover (173).

### **Profit in Land & the distribution of wealth**

This revolution in agriculture increased interest in making land profitable. It also provided the farm-workers with a diet that stands up well to modern comparison. At the end of the 17th century it is reckoned that compared with the modern poor in times of depression, the farm-worker availed himself of 10 times the iron and calcium, 5 times the Vitamin B complex, 6 times the Vitamin C, more D and adequate E. He also consumed more fat and calories (173).

The change in the weather and subsequent increase in the yields of corn and money, also helped the poor. Higher yields brought down prices and that meant an effective rise in real wages. Laborers began to have considerably more surplus cash to spend. Much of it went at the village store, an innovation dating from the early 18th century. Demand was such that the stores soon needed more than the basic supplies of tobacco, shoes and clothes (175).

The good weather and cheaper corn increased the peasants disposable income, leading to a rise in spending which beckoned the would-be industrialist to a market which grew with the growing population. New foods such as tea, coffee, sugar and cheaper spices entered the diet, already improved by the presence on the market of better meat and fresh vegetables. Cash was now available to buy whiter bread, darker beer, tobacco and potatoes. Potatoes, the new root vegetable from America, would feed twice the number of

people from the same area of soil used for any other crop (178).

The better diet and improved living conditions encouraged earlier marriages. In the first half of the 18th century the average age of marriage fell to 27. Birth control was practiced less because times were more prosperous. The general improvement in health meant fewer miscarriages, so more babies were born and being better fed, survived. In 1720, after centuries of little or no population growth, rates of increase grew by 3, 5, and then 10% every decade. The good weather held and the growing market and richer harvests created demand for more labor and higher wages (178-179).

By 1740 control of the sea lanes by the British as well as military successes against the French and Dutch spurred economic and imperialist successes. The British took Canada, India, Guadeloupe and Senegal from France. Trade with the American colonies increased by 25% in the first 30 years of the century.

### ***Slave Trade***

Some of the richest profits were made in slave trade. Slavery was essential to the Navigation Acts which had earlier promoted it and given the monopoly to the Royal African Company. The slave trade followed a regular pattern. Textiles and goods went to Africa to buy slaves which were transported to the West Indies, where they would work in the sugar plantations in return for sugar. This was brought back to Europe or taken to the American colonists to pay for tobacco which had a ready and profitable market in Europe. Profits from this triangular trade were enormous. A slave could be sold in the West Indies for 5 times the price paid in Africa. Even if a 5th of the human cargo were lost in transit, a common occurrence, the slaves remaining still constituted a handsome profit (178).

### ***France***

Growth in trade and industry was stimulated by new developments in finance. From the early years of the century the number of banks in London had been steadily increasing; by 1770 there were 50.

By 1770, with surplus finance, new fuel sources, expanding credit systems and a highly motivated business class, Britain was poised for the great leap. The final spur came from India. The increasing amount of cotton imports from that country were beginning to worry the English textile manufacturers. In mid century fighting broke out on the subcontinent and buyers switched to the Caribbean and the southern colonies of America. The raw cotton came through Liverpool and went to the hills of Lancashire to be spun in the cottages beside the sheepfolds (185).

### **Locke**

England at this time was firmly in the grip of the philosophy of Locke. Seldom can a philosopher have had greater power than that enjoyed by John Locke, the so called apostle of the revolution which had brought William III to England and reason to government.

### ***Essay Concerning Human Understanding, Letter Concerning Toleration & Two Treatises on Government***

He wrote several philosophical and political works that were to have profound influence on the whole 18th century Europe. His *Essay Concerning Human Understanding* was finished in Utrecht in 1684. After his return to England he published the controversial *Letter Concerning Toleration* and a year later *Two Treatises on Government*. A number of basic tenets of government still held today were set out in these publications. Locke thought it was essential to remove the right of the king to grant monopolies. He also wanted taxation to be the right of Parliament, to provide for liberty of religious worship, to free judges of royal pressure, to end arbitrary arrest, and to ensure regular sessions of Parliament (175-176).

Locke believed that men were fundamentally driven by self-interest and that to enable them to lay the "foundation of all liberty." He called the "natural state" that of living together in pursuit of happiness and banding together according to reason so as to ensure the highest personal community interest. For Locke, the most important aspect of self-interest was the safeguarding of personal possessions. The ultimate goal of all societies, he felt, was to preserve the property rights of the individual (176).

### ***Citizen & Government***

Locke saw the relation between citizen and government in business terms, as a social contract. The government might put a man to death but it might not deprive him or his family of his property without his consent, "the preservation of property being the end of government." To this contract Locke added a rider which is echoed in modern government: that the legislative power in all the state must not be in the same hands as those holding executive power. The social contract would only work if this condition were met, because without separation of powers tyranny was possible. Locke compared the business relationship with that between king and country. The government was primarily interested in fostering both so tax laws made investment attractive (176).

### **Watt's steam engine**

In 1765 Watt obtained a patent for "A New Method of Lessening the Consumption of Steam and Fuel in Fire Engines." It used the technology of a separate condenser and produced more power with a consequent saving in fuel costs, using one third the fuel burned in any other engine. Everybody wanted one (189-190). The system worked well in draining mines (190).

In 1781 one of Watt's assistants, William Murdock, developed a gearing system, known as the sun and planet, which enabled the steam engine to be used to run factory machinery and could power the same machinery that had been driven by the waterwheel. One year after the 1781 patent for the sun and planet system, every graph on the British economy begins a sharp upward curve (190).

### **the cotton industry & the industrial revolution**

Other machines were developed to handle almost every part of the process of making cotton. The cotton industry may be said to have made the Industrial Revolution the great force for change that it was. The cotton industry itself was a new phenomenon, so there were no prejudices and practices to stifle innovation. Rising imports of cheap cotton from American and the West Indies and the use of the new machinery increased production phenomenally (192).

The new steam engines needed coal for fuel. Transportation and coal mining improved to meet the demand. The coal was used to make more iron to meet the needs of transportation

and machinery. As more iron was produced, more engines and machines were made, and production went up, increasing demand for the raw materials and their transportation. And so the cycle continued.

The greatest effect of steam, however, was that it enabled manufacturers to move their factories near to the coalfields and the textile industry to be closer to its markets. Water power was no longer vital, so industries moved away from the hills and the streams and down to the plains where transportation of goods and raw materials was easier.

The overall change is perhaps best shown by the change in factory activity. Some years after the beginning of the 19th century it was noted that a factory using one 100 hp steam engine did the work equal to 800 men. It ran 50,000 spindles, employed 750 workers and produced 226 times more than it had done before the introduction of steam. The increase was also in part due to the introduction, in the first decade of the 19th century, of the new French Argand lamp, which was capable of generating 10 times more light from the same wick. This made shift work possible. Round the clock production began (192).

As people flooded into the new towns they came to a way of life very different from that of the village they had left behind. The towns themselves were not much better serviced than the villages. There were no cesspools and sewage disposal was very primitive. People threw garbage into the streets as they had always done. The major problem, however, was the inability to cope with the accelerating increase in urban population (192).

### **cities & the urban worker**

To the newcomer the cities were strange, lonely places. The workers began to band together in clubs and friendly societies and eventually in unions, both for comfort and protection. Life in the factory was not much different from the way it had been in the day of the cottage industries. Then, too, people had worked long hours in terrible conditions. But in the factory the regimentation enforced by the machine system changed people's attitude to work. Now there was no longer personal freedom to work or stop as you chose. The new discipline aroused animosity and a sense of servitude (193).

Nevertheless, the new urban workers were better off than they had been in the country. Even in times of depression they did not return to their villages. Wages were paid more punctually than in the country, although the money as often as not went to company shops charging exorbitant prices. The new worker could no longer go out to the fields and find what he needed to heat and dress and feed himself with. He had become a consumer, cut off from the source of production and dependent on cash for the first time. Money now defined working relationships (193).

Together with the Industrial Revolution came the modern expectation of progress and a better standard of living made possible by men's skills and the machines they invented. So too came the basic skills which the modern businessman uses to find market opportunities, increase sales through the use of advertising and the sales force, make enough goods to meet demand, solve technical problems of production, maintain standards of quality, ensure adequate supplies of raw materials, organize the administration, teach the workforce how to handle the technology and make enough profit to plow back into the system to make it even more productive.

### ***Socialism***

The Industrial Revolution also gave birth to socialism, and the social separation of society through the division of labor. It brought science and industry together in a new and dynamic relationship. It radically altered the shape and the country and the behavior of its citizens. And it made modern urban society dependent on mass-production techniques without which we cannot now survive (193).

### **Chapter 7: What the Doctor Ordered**

The miracle of industrial nations is that with rising populations they have not suffered from a major epidemic, until AIDS, since the last century. The modern world supports millions who come into close contact with each other every day. Each one is a potential source of wholesale death, but through medicine and pharmacology the spread of most contagious diseases is stopped before it begins (195).

Only 200 years ago the view of disease was radically different. Then, each individual's illness was a unique

condition, to be treated as the patient's situation demanded. Medical theory at the time had advanced little beyond the system worked out by the second century Alexandrian, Galen (195).

Disease was viewed as a generalized condition of the whole body deriving from a lack of balance among the essential elements of the human constitution, the four humors: blood, phlegm, choler, and black bile. The remedies for diseases were at best idiosyncratic and at worse dangerous (196).

However, as the 18th century ended, various factors combined to bring about improvement in medical science. To begin with, the new political fashion was to regard England, with its rising population, burgeoning industrialization and urban growth, as the ideal model. In a strongly mercantilist atmosphere it was felt that national strength lay in numbers. The bigger the population, the wealthier the country. In emerging nations the emphasis began to switch to health. If the population were to be capable of working productively in the new factories, "then the health of a nation was the wealth of a nation (199)."

### **Knowledge & experience**

By the late 18th century European philosophy was dominated by the views of John Locke. According to Locke knowledge had no source but that of experience. This experience would be either external or internal. Locke's rational system of analysis gave birth to an intellectual movement which became known as the Enlightenment. One of the great Enlightenment thinkers in France, Etienne Condillac, took Locke's ideas further. He said that the only way to understand the world was to regard sensations as the primary data of cognition. After his death, in 1780, Immanuel Kant popularized the system through Europe. In Germany his philosophy appealed too physicians keen to reduce medical practice to a simpler, more certain system (200-201).

### ***The Germans***

Building upon the philosophy of Kant, who postulated that understanding of the world could come only because there were certain concepts already embedded in the mind: time, space and causality, the Germans reasoned there must be a

few simple, basic laws which could be derived from observation and which would determine what was the fundamental life force. The dream of discovering the force spurred German medicine to concentrate unsuccessfully on microscopic phenomena for the next 40 years, to the detriment of all other fields of research (201).

### ***The French***

The French were attracted the more practical application of the theory, though stopping short of the German obsession with investigating the secret of the universe at the expense of the patient. Their research therefore took a different route, concentrating on careful observation and analysis of the kind of data available the senses. This approach was due in the main to the medical, social and intellectual changes brought about by the unique events of 1789, the beginning of the French Revolution. Up to this time French physicians had been no different from all the others. They were a small, powerful elite serving the aristocracy, and as such they were to suffer at the hand of the revolutionary committees. The political turbulence that ensued brought about 2 major medical changes (201).

#### ***1. Surgeons***

The first was that all medical organizations were compulsorily closed during the revolution, leaving the country in a state of medical anarchy at a time when the profession was most urgently needed. Doctors were members of the upper classes, so they were to be re-educated. But by the same revolutionary token, surgeons were craftsmen, and as such to be elevated by the new ideology.

The surgeons had enjoyed minor improvements in their social condition for some time before the storming of the Bastille. In 1743 they had been permitted to enter university, too take MA degrees and to be addressed as Doctor. This met with the greatest opposition from the physicians who did their best to see that the surgeons professional opportunities were limited strictly to those hospitals where patients were poor. The surgeons also went out into the towns and villages which were too small to provide adequate revenue for physicians. As a consequence, when the wars broke out after the revolution there were many more surgeons than physicians in France (202).

## **2. Triage**

The second factor of importance in the medical situation was the numerical superiority of the surgeons at a time when they were most needed, on the battlefield, where their practical training in anatomy put them at a distinct advantage over the physicians. Whereas the physician went to war with his potions, symptom lists and bedside manner, the surgeon was equipped only with a knife and some bandages. When the physician exhausted his supply of remedies there was no available resource of replacements. Soldiers were often too shocked by their wounds to talk, let alone describe their symptoms. The surgeons, however, learned rapidly. There was a great variety of wounds to deal with. It soon became clear to the surgeons that any object left in the flesh would become a source of infection (203).

## ***Hospitals***

In 1794 all hospitals became state property and the expansion of the facilities continued. The reorganization of 1794 was to make Paris the world capital of scientific medicine, attracting visitors and students from all over Europe and America (206).

In this new tissue-oriented atmosphere medicine was free to move away from therapy to diagnosis and classification of disease. All that was needed was sufficient clinical observation to provide data on which to build statistically valid disease and treatment profiles.

## **Statistics**

In the 17th century, under the stimulus of commerce and mercantile expansion, the Englishman John Graunt had begun to investigate the use of statistical data. In 1662 he made the basic discovery that large numbers displayed regularities or patterns not evident from small numbers. Analysis of the records of births and deaths in London for a period of 50 years showed him that such data could help in prediction and diagnosis of epidemics. He also saw relationships between the chronic and regular diseases and the weather (209).

In the early 18th century the new insurance companies had begun using statistics to aid them in establishing

premiums, basing these on the actuarial analysis of probability of death. Then in the great Diderot Encyclopedia, published in France in the mid 18th century, an article on probability brought statistical analysis into the mainstream of Enlightenment thinking, particularly with regard to its potential use in social circumstances. It would, of course, also help the state to properly evaluate the size and condition of the population, which is why the term statistics probably originated in Prussia, where control of the population was most keenly sought by its absolute monarch (210).

### **Laplace**

Planning was difficult if not impossible. Counting every single person was out of the question, both financially and in terms of organization. The in 1795 the foremost French physicist, Pierre-Simon Laplace, gave a series of lectures at the Ecole Normale in Paris. His last lecture was about the calculus of probability which he had developed through his interest in games of chance. Its use in human affairs would help eliminate ignorance of the causes of error in statistical analysis, since it was possible to reason from frequency of event to probably cause. The more frequently things happened the more could be said about their constancy and regularity of repetition (210-211).

Over the next few years Laplace went on to suggest specific uses for his calculus. He showed how it could be used to guide and improve observational methods, to evaluate the reliability of experimental results, to discover underlying natural regularities or laws hidden by irregular accidental disturbances or by large observational errors, and to suggest causes. He worked out an equation that would derive the most accurate estimated total population from an extremely small sample, and in doing so invented the concept of a statistically meaningful percentage (211).

The body had been redefined as the locus of disease. The bilateral evaluation between doctor and patient had gone. The doctor was now in control. The temptation to extend that control was seductive. Already, in the 18th century, the revolutionaries had been aware of the need to improve the living conditions of the urban masses. Jean-Jacques Rousseau, in his *Discourse on the Origins of Inequality* in the mid century, had characterized illness as a feature of civilized society, attributable to the harmful effects of

unhealthy environment and incompetent medicine. Society, he suggested, was naturally pathogenic (213).

### population

For the first time, the meaning of the term population, as the mercantilists used it, took on the added implication of commonality, the non-noble classes, the laboring poor who were too ignorant to be responsible for their own well being (213-214).

While this desire to improve sewerage, water supply, ventilation, procreation, private conditions and the working environment appeared enlightened, it stemmed largely from the mercantile tendency to see welfare as a predominantly economic and political matter. 9 years later 2 events were to help bring this radical approach to public health and state intervention into common use throughout entire populations before the end of the 19th century.

The 1st was the arrival of a disease that had been traveling towards Europe from northern India at a speed of 5 miles a day for more than a decade. In 1829 it struck Europe for the first time and Austria, Poland, Germany, and Sweden learned the full horror of cholera (214).

The second event was the invention of the achromatic microscope in the same year by a London wine-merchant called Joseph Jackson Lister. From its appearance in the 17th century the microscope had suffered from 2 major problems. Rays of light coming through the outer area of the lens would bend asymmetrically and converge at different focal points, thus producing an image that was out of focus. As the rays were bent, prismatically, the different colors making up white light would also bend to different extents, causing color fringes to make the fuzzy image even less clear. These effects were known as spherical and chromatic aberration (215).

### cholera

This terrifying new plague, so different from the diseases to which Europe had become accustomed, reached Paris and took the lives of 7000 people in 18 days. 2 years later it would be in NY. Meanwhile, it took its greatest toll on Britain, the most heavily industrialized nation in the world, whose crowded cities were the perfect incubator for

the new pestilence. Cholera claimed its first English victim in Sunderland on 10/20/1831, arousing fears of riot and anarchy among the poorer members of the population. However, the plague was no respecter of persons: it hit rich and poor alike. During the 1st 2 years it killed over 22,000 people in a spectacular and devastating attack on a country which was entirely unprepared (222). In Liverpool, when cholera struck, no fewer than 60,000 people inhabited unprotected open spaces. Those who did so were only marginally worse off than the 40,000 who lived underground, sometimes 12 to a cellar in conditions of unspeakable degradation (223).

### britian

During and after the cholera epidemic of 1831, widespread riots throughout Britain woke the country to the urgent need for social change. New committees established together with the reform of Parliament turned, for recourse, to the same source of help and guidance as had the medical profession in Paris 20 years before. They turned to statistics (226).

Statistical reports showed that bad sanitation, polluted water supplies and filth shortened life-expectancy by at least a decade; that thousands of children were on the streets, begin or living as prostitutes; that the country was on the way to revolution. The average age of death among the gentry was 43. Tradesmen died at 30 and laborers could not expect to live beyond 22. For every person dying of old age or violence, 8 died from disease. In a typical industrial town like Manchester 3 times as many children under 5 died than they did in Surrey, where the population of that age group was approximately the same (229).

The problem was that there were no means of treating these problems. Even when figures showed an interesting anomaly, no action was taken (229).

Society became hypochondriac. Concern for health and fitness verged on the paranoiac. Sicknes took on a new significance in the strict God-fearing society of the time. To be ill was sinful. The surge of interest in physical fitness that followed the cholera epidemic found expression in sport, ordinarily associated only with hunting, shooting, and fishing. Games had previously been considered pastimes for children. Cholera changed all that. The health

conscious Victorians invented athletics. In 1859 the term calisthenics was coined: it meant beautiful strength (232).

By the summer of 1858 the Thames smelt so bad that all work at the Houses of Parliament had to be suspended. Members of Parliament finally acted. Legislation was hurriedly passed to renew and develop the entire London sewerage system. When it was finished, all London sewage was being piped away to outfalls in the river 11 miles downstream from the city at a point where tidal flow would take it out to sea. The cholera never returned. The sanitarians were jubilant, and science was still ignorant of the cause of the epidemic (234).

### ***Cholera Isolated***

In 1857 the contagionist argument was strengthened by the work of a professor at the university of Lille. Louis Pasteur was examining fermentation in milk and wines in order to find out what caused them to go sour. He showed that each liquid needed a specific fermentation agent (234).

Rapid discoveries followed. Koch visited India, isolated the bacillus of cholera in pure culture and showed that the disease was transferred on soiled clothing and in contaminated water. In 1879 gonorrhoea was isolated; in 1881 streptococcus, in 1883 diphtheria, in 1884 typhoid and tetanus; in 1905 syphilis (236).

### ***The Medical Revolution Complete***

The medical revolution was complete. In addition to discovering the mechanism of the transfer of disease it had generated a new concept of the role of the patient in hospital and of the individual in society. As medicine became more scientific, moving its attention from bedside to hospital to laboratory, the involvement of the patient in his diagnosis and treatment dwindled and vanished. Doctors removed themselves to a position of isolated specialization in which medical research would acquire greater social and professional status than medical practice.

The medical revolution also brought change to the world outside the hospitals. Because of their success in handling the epidemic crises of the 19th century, in terms of public

health and later of laboratory analysis, doctors began to take over the old social roles of priest and judge. Medicine became a unique repository of objective opinion where all types of social conditions were concerned. As more and more of life has since come within the province of medicine—from illness to contagion, living conditions, deviance from the norm, qualification for work, insurance and criminal guilt—social problems have become increasingly identified as involving medical aspects to be handled exclusively by doctors, who have thus become increasingly representative of the authority of the state (237).

## **Chapter 8: Fit to Rule**

The self-confidence of modern society is rooted in a belief in progress which came to us in relatively recent times. While man has always hoped that in some way the quality of life might improve, the present expectation that it will do so arose principally as a result of events at the beginning of the 19th century, when the thought first arose that God might have made a mistake at the time of creation (239).

### **Darwin**

Darwin's *On the Origin of Species* hit the world like a bombshell, because it was all too easy to apply to the human race what Darwin was saying about flora and fauna. Moreover, at the same time traces were being discovered of an early non-Adamite primitive human.

### ***Neanderthal Discovered***

In 1856 a German called Johann Karl Fuhlrott had found human remains of great antiquity in a cave near Dusseldorf; these have been named "Neanderthal" after the valley in which they had been located. In 1858 2 Englishmen, Joseph Prestwich and Hugh Falconer, found more such remains in a cave near Brixham, in Devon.

The implications of these primitive remains were far-reaching. If there had been no Adam and no Eden, man was obviously subject to the same evolutionary rules as any other organism. He was no longer a special creation made in God's image. Moreover, if this were so, of what use was the religion which taught the lie? Predictably, Darwin came under immediate attack from the clergy. The Bible was

either to be believed in its entirety, it was claimed, or not at all.

Well before that time, however, battle had been joined. At a great debate in Oxford in 1860, just after the publication of *Origin*, Bishop "Soapy Sam" Wilberforce attempted unsuccessfully to destroy Darwin's argument. Against him in the debate spoke the naturalist Thomas Henry Huxley, a professional biologist and popularizer of science. In the debate Huxley made the immortal remark: "I'd rather have an ape for an ancestor than a bishop."

Darwin was also attacked in the press, as both journalists and public confused and oversimplified the issue. It appeared to them that science was simply against religion. Darwin's naturalistic explanation of events removed the purposeful nature of the universe and with it, God's design. It left man akin to the animals.

Darwin's book stimulated a materialist movement. There was an exacerbation in the conflict between science and religion. Gradually his views came to be accepted by the more intellectual theologians. The Bible began to be regarded as primarily an allegorical work (260).

### ***The U.S.***

The reaction to Darwin was even stronger in America, where it took the form of a surge of fundamentalism and public baptism. It was not until 1925 that the trial of John Scopes, a teacher from Tennessee who was prosecuted for teaching evolution on the grounds that the theory undermined the authority of the bible, would challenge and lose the case over the ban on Darwinism, and it would be another 42 years before the relevant state law would be repealed. The Catholic Church moved faster, Catholics were permitted to discuss evolution after the publication of Pius XII's *Humani Generis* in 1951. The effects of Darwin's theories outside the sphere of religion were wide ranging. As George Bernard Shaw said, "Darwin had the luck to please anybody with an ax to grind (261).

### ***Eugenics***

Darwin's theory also gave scientific credence to eugenics. By the end of the century some eugenicists advocated such

extreme measures as preventive sterilization of imbeciles, syphilitics, tuberculosis victims and bankrupts, as well as financial aid for the parents of each child produced by persons of civic worth (261).

### ***Germany***

This was an age of turmoil and division in Germany, a country looking for an identity and soon to find it under the guidance of Bismarck. At the time the source of the greatest political and philosophical influence in Germany and indeed all over Europe was the German thinker Hegel. He taught that nothing was real but the "whole," which he called the "Absolute," that history was a series of advances towards the Absolute Idea, that things went from less to more perfect (Darwin ended *Origin* with a ringing defense of the same thought), and that the development of the spirit in man had best been represented by German achievements. For Hegel, history's great men were all German. They were Theodoric, Charlemagne, Barbarossa, Luther and Frederick the Great. These men, all "heroes," the best a nation could produce, were the finest examples of the health of a country.

In Hegel's thinking, the "whole" was represented by the state. Its purest form was the Prussian monarch, which was absolute. Hegel said "The German spirit is the spirit of the New World. Its aim is the realization of absolute truth as the unlimited self-determination of freedom—that freedom which had its own absolute form itself as its purpose." It was the duty of the individual to maintain the independence and sovereignty of his own state, if need be by means of war. Nations related to each other in a state of nature. Their relations were not, therefore, to be judged legally or morally. Their rights were what they individually willed, and the interest of the state was each state's highest law.

### ***Haeckel***

Haeckel believed in this "best of all possible states" philosophy, and when, in 1860, Darwin was published in German, Haeckel found scientific support for his views. He saw in it a way to bring together the idealism of Hegel with the German Romantic movement's search for cosmic principles which would unite man and nature.

Romanticism had been popular in Germany since the beginning of the 19th century. For the Romantics, nature was in a constant state of "becoming," developing all its forms in the Great Chain of Being. The Romantic view was that all aspects of nature were relevant to the development of society and expressed themselves in religion, art and mythology, as well as in the social structure. Through examination of this *Kultur* would come an understanding of the entire cosmos. Darwin provided a way of making this possible because he united the natural and the social world (262).

In 1862 Haeckel began lecturing on Darwin all over Germany. According to Haeckel, Darwin's theory represented no less than a new cosmic philosophy. In showing how, through evolution, man had developed from the animal, Darwin proved that inevitable change was the principal mechanism at work in the historical process and that the overthrow of tyrants who stood in the way of change was justified (262).

If Germany was, as Haeckel thought, a superior culture, it could only remain superior by ensuring the survival of what individuality it possessed. Recent philological theories of the existence of a European proto-language, called Aryan, strengthened the argument for racial purity. The mongrel languages which had developed from Aryan were the evil results of internationalism. Haeckel felt that racial differences were fundamental, there being greater differences between Germans and Hottentots than between sheep and goats. Mankind should be divided into separate groups according to color and intelligence (264).

Haeckel's use of Darwin's theories was decisive in the intellectual history of his time. It united trends already developing in Germany of racism, imperialism, romanticism, nationalism, and anti-Semitism. The unity with the group which Haeckel so strongly advocated found favor among the Volkists, a group who believed in the "blood and purity" of the German race above all others, as well as the indissoluble bond of nature and the individual (265).

A new national party would unite the community. It would function as a living example of the survival of the fittest, a hierarchy based on ability. Work would be compulsory. The state dynamic would be economic, not political. The confusion and anarchy of parliamentary procedures would disappear. The nation would become a

biological elite. Struggle would be its prime reason for existence. Underpinned by Darwin's theory of evolution, Nazism was born (266).

### ***The U.S.***

Meanwhile, across the Atlantic, Darwin was being interpreted in a totally different way. Here too he was to give credence to a view already developed before *Origin* by an Englishman, Herbert Spencer, son of a schoolmaster from Derby, a self-taught engineer working on the railways. He came close to establishing the principle of natural selectivity, and by 1859 developed his "Synthetic Philosophy" in which he drew together all knowledge under the single principle of evolution (268).

In the US, founded under a constitution that expressly discouraged government interference, Spencer's Social Darwinism took hold like wildfire. There, as Darwin seemed to demand, the government had one duty—to preserve the individual's freedom to act in his own interest (269).

In a country greatly endowed with material resources, as well as with an efficient and flexible system of production which was able to manufacture goods on a colossal scale and a fast-growing domestic market, Social Darwinism flourished, fitting well with the rugged individualism of the frontier spirit, or the exploitation of the immigrant worker, depending on the point of view. Carnegie welcomed the opportunity it brought (271).

Competition between men for available resources was right and natural. The struggle for existence on the social level was represented by man's struggle with nature to yield up subsistence. The capitalist system was the best suited to both activities. American "get up and go" had found a scientific *raison d'être*. It remains at the root of American life today (273).

### ***Marx***

Darwin was to have one last, major success in perhaps the most unexpected of quarters. When he read *Origin*, Marx wrote to Engels: "*Origin* is the natural history foundation for our views." Dialectical materialism, the basic historical process by which conflicting views were synthesized into a third, more advanced stage of

development, paralleled Darwin's mechanism of evolution. Society, like nature, improved over time (273).

Thanks to Darwin, the modern view of the human condition is essentially the same throughout the world. Arguments continue between the Left and the Right, but they are not about whether society can progress so much as they are about the methods required to bring progress about. However, both sides are equally materialistic. Humankind is now alone with the matter of its future. And as genetic manipulation advances apace, life is increasingly what we make it (273).

## **Chapter 9: Making Waves**

Newton's universe was certain, operating in absolute conditions. All events taking place in it at the same time occurred simultaneously, which is to say that everything, at any one moment, existed simultaneously. All simultaneous events on earth were also simultaneous with those on the most distant stars. Newton's universe implied an attitude to knowledge that was at once practical, optimistic and confident. The purpose of science was to investigate reality and to make definitive statements about it. Knowledge advanced certainty. The spread of knowledge was, therefore, desirable (276).

The public romance with science-which-was-technology intensified. Within 10 years of Faraday's discovery, small electric motors were being developed everywhere from the US to Italy. Principally, however, the public imagination was caught by Samuel Morse and his amazing telegraph. In 1844 a current generated in Washington to switch on and off a small magnet in Baltimore which attracted and repelled a key. The key clicked, as the current switched on and off, in a code devised by Morse and named after him. The message was, "What hath God wrought?" (284-285)

The invention of the telegraph aroused a tumult of publicity. The public began to see science as the source of amazing novelties which would make life more exciting and comfortable for all (285).

The 19th century had begun with the identification of an entirely new phenomenon, only briefly investigated before then, and as first magnetism and then electricity were analyzed their behavior seemed increasingly to disobey the

fundamental laws set out by Newton and above all to call into question the very theory of knowledge that Newtonian physics implied. Now, towards the end of the century, the universe seemed a very different place from that of a hundred years before. As the certainty of Newton vanished, the purpose of science in discovering and explaining reality also came into question (294).

This relativist view of the universe and the responsibility of science to explain it was expressed by a group of scientists and philosophers known as Positivists (294).

### **Chapter 10: Worlds Without End**

The act of mystical significance in which man uncovers yet another secret of nature is at the very heart of science. Through discovery man has broadened and deepened his control over the elements, explored the far reaches of the solar system, laid bare the forces holding together the building-blocks of existence. With each discovery the condition of the human race has changed in some way for the better, as new understanding has brought more enlightened modes of thought and action, and new techniques have enhanced the material quality of life (303).

Each step forward has been characterized by an addition or refinement to the body of knowledge which has changed the view of society regarding the universe as a whole. As the knowledge changed, so did the view (303).

With the arrival in northern Europe in the 12th century of the Green and Arab sciences and the logical system of thought contained in the writings of Aristotle, saved from the loss in the Muslim texts, the mold in which life had been cast for at least 700 years broke. Before the texts arrived man's view of life and the universe was unquestioning, mystical, passive. Nature was transient, full of decay, ephemeral, not worth investigation. The truth lay not in the world around, which decomposed, but in the sky, where the stars which wheeled in eternal perfection were the divine plan written in light. If man looked for inspiration at all he looked backwards, to the past, to the work of giants. The new Arab knowledge changed all this (304).

Whereas with St. Augustine man had said, "*Credo ut intelligam*" (I come to understanding only through belief),

he now began to say, "*Intelligo ut credam*" (belief can come only through understanding). New skills in the logical analysis of legal texts led to a rational, scholastic system of thought which subjected nature to examination.

The new logical approach encouraged empiricism. Man's individual experience of the world was now considered valuable. As the questioning grew, stimulated by the flood of information arriving from the Arab world, knowledge became institutionalized with the establishment of the European universities, where students were taught to think investigatively (304).

In the 18th century the world found a new form of energy which gave us the ability to change the physical shape of the environment and released us from reliance on the weather. Until then, all life had been dependent on agricultural output. Land was the fundamental means of exchange and source of power (305).

This self-balancing structure was radically changed by the introduction of steam power. Society became predominantly urban. Relationships were defined in terms of cash. The emergence of industrial capitalism brought the first forms of class struggle as the new means of production generated material wealth and concentrated it in the hands of the entrepreneurial few (306).

IN the light of the above we would appear to have made progress. We have advanced from magic and ritual to reason and logic; from superstitious awe to instrumental confidence; from localized ignorance to generalized knowledge; from faith to science; from subsistence to comfort; from disease to health; from mysticism to materialism; from mechanistic determinism to optimistic uncertainty (307).

The generator of this accumulation of knowledge over the centuries, science, seems at first glance to be unique among mankind's activities. It is objective, making use of methods of investigation and proof that are impartial and exacting (307).

"Which truth does science seek?" can only be, "the truth defined by the contemporary structure."

The structure represents a comprehensive view of the entire environment within which all human activity takes place. It thus directs the efforts of science in every detail. In all areas of research, from the cosmic to the sub-atomic, the structure indicates the best means of solving the puzzles which are themselves designated by the structure as being in need of solution (310).

It was for this reason that the Chinese, whose structure had no block concerning the possibility of change in the sky, made regular observations and developed sophisticated astronomy centuries before those in the West (311).

The static nature of Aristotle's universe precluded change and transformation, so the science of dynamics was unnecessary. Since each object was unique in its "essence" and desires, there could be no common forms of behavior or natural laws which applied equally to all objects.

By the middle of the 19th century a different cosmology reigned. The Anglican Church was committed to the biblical record, the Mosaic version of the history of the earth involving 6 days of creation, the garden of Eden and an extremely young planet. The church strongly opposed the new geological speculation by James Hutton and Charles Lyell regarding the extreme age of the earth. This opposition took various forms including support for a professorial chair in geology at Oxford, initially given to the diluvialist William Buckland in an effort to promote views more in tune with ecclesiastical sentiment. It was ultimately this clerical interference which was to cause a split in the geological ranks. The breakaway group, keen to remove the study of the evolutionary implications of geology from the influence of the Church, established the new and independent scientific discipline of biology (312).

Non-Euclidean geometry described what the universe would look like, for instance, to 2 dimensional beings living on the surface of a sphere. In their curved space the internal angles of a triangle would add up to more than 180 degrees. Indeed the sum of degrees would vary according to the curvature of the sphere.

Limitations were also imposed by the political structure that reigned after the French Revolution. Mathematics and physics were deemed to be too closely allied to the elitist ideologies of the pre-revolutionary Enlightenment, and were

banned. Chemistry, on the other hand, dealing as it with such things as bleaching agents, gunpowder and general technical processes, was felt to be closer to the life of the common man, and as such received encouragement and financial assistance (316).

If Aristotle were wrong in one aspect, the entire fabric of his system of nature must lie open to question. Early 17th century Catholic society rested on Aristotelian foundations. In questioning belief in the system and obedience to its concept of a hierarchy subject to the Church, Galileo was attacking the very fabric of society. The *Discourse on Floating Bodies* was politically and theologically revolutionary in its implications, and as such to be suppressed (316).

Each structure must, by definition, be a complete version of what reality, or one aspect of it, is supposed to be. It is the contemporary truth. But as has been seen, structures are replaced. Aristotle gives way to Copernicus who gives way to Newton who is replaced by Einstein. Lavoisier and Priestley destroy the concept of pneumatic chemistry and the mystery "quality," phlogiston, in order to replace it with a chemistry based on combustion. The use of perspective geometry challenges the theological rules for interaction with the intangible physical world by making it measurable. 19th century geology does away with the biblical record of history (330).

In most cases, each structure is generated by circumstances that are not directly related to the scientific field itself. Often the pressure for change will come from outside the discipline. Whatever the cause, however, it will be seen that the initial cosmological structure set the overall pattern of reality within which other structures work. They, in turn, define the areas of research to be covered. These areas demand specialist forms of investigation that then discover anomalies which the overall structure cannot accommodate, and so, change occurs. But the theories, discoveries, equations, laws, procedures, instruments, as well as the judgmental systems used to assess the results of investigation, are all defined by their context, all part of the structure (331).

The composition of our present structure is based on previous structures. Ours is the latest in a series of structural changes which has less to do with what has been

discovered of reality than how views of reality have altered from one structure to another. For scientific activity has been influenced by factors within the overall structure that may have had little to do with the supposedly autonomous activities of science (331).

During WWI, scientists in Germany looked forward to a postwar period in which science and technology would grow and prosper with increasing prestige, financial support and high social status. They expected Germany to win the war. The sudden and catastrophic defeat by the Allies, as well as the imposition of what were regarded as humiliating terms of surrender, caused a fundamental change in German thinking which was profoundly to affect one aspect of science above all (331).

German belief in order and a rational world had been shaken by the defeat. Mistakes had been made, and the nation felt a strong desire for strengthened unity to counter the general feeling of despair. Survival and recovery seemed to need a philosophy that emphasized the organic, the emotional, the irrational wellsprings of human life rather than what was seen as the cause of defeat, the "dead hand" of the old mechanistic view. Science had taken things apart, reduced them to fragments and imposed laws that were deterministic, rather than offering hope and unity. For Germany, the Newtonian view was judged responsible for failure. It was rejected (331-332).

Within a few years of the war, educational reforms brought a drastic reduction in the teaching of mathematics and physics in schools. The hostility to science was palpable. The Prussian Secretary of Education, Carl Becker, said: "the basic evil is the overvaluing of the purely intellectual . . . We must acquire again reverence for irrational." (332)

The continuing economic and political problems of the years between 1918 and 1930 brought on a sense of crisis. Feelings were intensified by the overwhelming success of Oswald Spengler's *Decline of the West*, almost universally read by German intellectuals. In the book Spengler defined the kind of knowledge Germany needed if it were to survive. Each culture, he held, was autonomous and separate, with its own forms of knowledge. There were no universal criteria by which to judge truth. A sense of destiny was essential to the health of a nation. It would provide an

irrational, inner sense of truth which should dispense with the destructive views of science, that looked to cause and effect to explain the universe. Exact science could never be objective. Causality was dangerous and destructive. It had failed Germany (332-333).

This universal hostility to the causal view permeated every aspect of German life. Those who supported it would lose financial support, grants, positions. The repudiation of causality was unique to the German sphere. It preceded the emergence of a new non-casual view in German science, which regarded the operation of the universe as a matter not of cause and effect but of chance and probability. With Erwin Schrodinger and Werner Heisenberg and the "principle of uncertainty" at the heart of quantum physics came the end of observing it. There was no causal reality to be observed.

Quantum physics might have developed elsewhere, later. The fact is that it developed in Weimar Germany in a social and intellectual environment that specifically encouraged a view of physics which did not naturally evolve out of the previous physics structure. Quantum theory is to a great extent the child of Germany's military defeat (333).

Yet myths and magic rituals and religious beliefs attempt the same task. Science produces a cosmology as a general structure to explain the major questions of existence. So do the Edda and Gilgamesh epics, and the belief in Creation and the garden of Eden. Myths provide structures which give cause-and-effect reasons for the existence of phenomena. So does science. Rituals use secret languages known only to the initiates who have passed ritual tests and who follow the strictest rules of procedure which are essential if the magic is to work. Science operates in the same way. Myths confer stability and certainty because they explain why things happen or fail to happen, as does science. The aim of the myth is to explain existence, to provide a means of control over nature, and to give to us all comfort and a sense of place in the apparent chaos of the universe. This is precisely the aim of science (336).