

## CHAPTER II

# THE MIDDLE AGES

The Middle Ages—The Fathers of the Church—The Dark Ages—The Reconstruction of Europe—The Arabian School of Learning—The Revival of Learning in Europe—The Thirteenth Century—Thomas Aquinas—Roger Bacon—The Decay of Scholasticism.

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UNTIL recent times the term "Middle Ages" was applied to the whole long interval of a thousand years between the fall of the ancient civilization and the rise of the Italian Renaissance. But the revival of interest in the history, art and religion of the thirteenth and fourteenth centuries has led to a clear recognition of the fact that by then a new civilization had arisen, and there is now a growing tendency to restrict the name "mediaeval" to the four hundred years between the "Dark Ages" and the Renaissance.

Nevertheless, to the historian of science there are advantages in the older classification. The "Dark Ages" of Western Europe coincided with the beginning of a remarkable growth of learning in those Asiatic countries which were soon afterwards conquered by the Arabs. The Persian and Arabic school originally based its teaching on translations from Greek authors, but at a later time it added appreciable contributions of its own to natural knowledge. Europe gained much from the Arabs, whose learning was in its prime from 800 to 1100 A.D. But afterwards science became chiefly a European activity, and the thirteenth century showed a real intellectual advance, helped by the recovery of complete Greek texts, especially those of Aristotle. But it was not till the period of the Renaissance that the western world began to examine Greek philosophy critically, and endeavour to find its own way in the new experimental method. Thus the period from the year 1100 onward, like the dark age that preceded it, is to the historian of science but a time of preparation. The two divisions are part of the same whole, and may well be treated together, though for the historian of politics, literature or art they are distinct and separable. To us, then, the Middle Ages have their old significance—the thousand years that passed between the fall of the ancient learning

<sup>1</sup> For a general account of mediaeval thought see (1) H. F. Stewart, "Thought and Ideas", in *Cambridge Mediaeval History*, vol. 1, ch. 20; (2) H. O. Taylor, *The Mediaeval Mind*, 2 vols., New York and London, 1911 and 1914. For facts and references down to the year A.D. 1300 see G. Sarton, *Introduction to the History of Science*, vols. 1, II, Baltimore, 1927, 1931.

and the rise of that of the Renaissance: the dark valley across which mankind, after descending from the heights of Greek thought and Roman dominion, had to struggle towards the upward slopes of modern knowledge. In religion, and in social and political structure, we are still akin to the Middle Ages from which we have so recently emerged; but in science we are nearer to the ancient world. As we look back across the mist-filled hollow, we see the hills behind more clearly than the nearer intervening ground.

In order to appreciate the causes which produced the great failure of Europe to increase the stores of natural knowledge in the Middle Ages, it is necessary to trace the development of the mediaeval mind. We must first realize the general outlines of the theology of Christian faith and ethics framed by the early Fathers in terms of Hebrew Scripture, Greek philosophy, the mystery religions and the underlying primitive rites. Next, we must follow the changes in the resultant doctrines as they were moulded by each succeeding age into instruments of controversy with pagan or heretic. We shall then understand why Patristic and early mediaeval Christianity was inimical in spirit to secular learning; why philosophy became the handmaid of theology, and natural science vanished from the earth.

The older Greek philosophies were frankly founded on observation of the visible world. With Socrates and Plato the enquiry took a deeper turn, and moved from questions of phenomena to those of underlying reality, from natural to metaphysical philosophy of an idealistic and mystical tendency. "The Greek mind became entranced with its own creations." To Plato, external facts, whether of nature or of human life and history, only became real when apprehended by the mind. Their true meaning must lie in that aspect of them which accords with the mind's consistent scheme of concepts, for thus alone can the facts be thought of, and thus alone can they be. The inconceivable is in truth the impossible.

Such a philosophy clearly could not foster accurate and unprejudiced observation of nature or of history. The structure of the Universe had to conform to the ideas of Platonic philosophy; history was in its essence a means of vivifying argument or of pointing illustration.

Aristotle was more interested in the observation of nature than was Plato, though even Aristotle's greatest strength lay in metaphysics and logic rather than in science, and as regards the latter in biology rather than in physics. He created the subject of logic, and in biology, at all events, he showed the true method of detached observation. His physics were not objective like those of Democritus, who sought

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the ultimate nature of things in atoms and a void. To Aristotle, the concepts by which nature must be interpreted were substance, essence, matter, form, quantity, quality—categories developed in an attempt to express man's direct sense-perception of the world in terms of ideas natural to his mind. At the beginning of the Dark Ages, the works of Aristotle in imperfect form were the most scientific of the Greek sources available, but his influence, great though it was, gradually ceased to be dominant. By the sixth century his writings had passed out of fashion, and for seven hundred years almost all that survived were commentaries on his book on Logic.

The philosophy of the Stoics, best known to some of us in the writings of Marcus Aurelius, was especially suited to the Roman mind, and must not be overlooked in any estimate of the different streams of thought on which the Patristic theologians floated their ark. For the Stoic, the central reality was the human will. Metaphysics and a knowledge of the natural world were only of importance when they subserved the ends of his philosophy as guides of life and conduct. Stoicism was essentially a scheme of ethics, and it diverted physical science from truthful observation in order to secure conformity with the preconceptions of morals.

The modes of thought inaugurated by Plato were wafted into even more super-rational heights by the Neo-Platonists, whose philosophy was the last product of late paganism. From the time of Plotinus the Alexandrian (d. A.D. 270) to Porphyry (d. 300) and Iamblichus (d. c. 330) philosophy became less and less physical and experimental, and more and more concerned with mystical ideas. Plotinus lived in a pure region of "metaphysics warmed with occasional ecstasy", and to him the highest good was the super-rational contemplation of the Absolute. In the writings of Porphyry, and still more in those of Iamblichus, these mystical views were brought down to practical life, and their application thereto led to greater credulity in magic and sorcery. The soul needs the aid of god, angel, demon; the divine is essentially miraculous, and magic is the path to the divine. Thus Neo-Platonism countenanced and absorbed every popular superstition, every development of sorcery and astrology, and every morbid craving for asceticism, of which a decadent age was prodigal. The life of Iamblichus, as told by a Neo-Platonic biographer, is as full of miracle as Athanasius's contemporary life of Saint Anthony.

This mystical philosophic atmosphere contained currents of eastern faiths such as Mithraism and Manichaeism, the latter of which enunciated a dualism of the powers of good and evil, destined to

reappear again and again. Mithraism, which disputed with Christianity the possession of the Roman Empire, was a Persian example of the mystery religions, which, as we have said, took the place in Hellenic times of the Olympian mythology when that picturesque faith decayed towards the end of the classical period. Our knowledge of these mystery religions is far from complete.<sup>1</sup> Their ritual involved secret rites of initiation and communion; their beliefs were expressed in sacred legends of the gods peculiar to each cult, legends which were accepted by the people literally, and by the educated as symbolical of the mystery of life and death. Beneath the rites and legends primitive nature-worship appears—sun gods and moon gods and the celebration in imagery of the drama of the year: the full life of nature in the summer, its death in winter, and its joyous resurrection in each new spring.

Modern anthropology has thrown much additional light on the origins of primitive ideas such as those which underlie the mystery religions, and of their ritual, which is itself derived from even more primitive rites based on the idea that nature can be coerced by sympathetic magic and witchcraft.<sup>2</sup> Such rites and the more advanced ritual which may develop from them are prior to and much more persistent than any definite system of religious dogma. It is clear that, in the first few centuries of our era, besides the formal religions and philosophies which appear in literature, there existed a deep and pervading undercurrent of these more primitive magic rites and beliefs. In them may be traced ideas of initiation, sacrifice, and communion with the divine powers, ideas which appear in more complex shape in the mystery religions, and later in some forms of Christian dogma, especially in the Catholic theory of the Mass. The effect on the origins of Christianity of these primitive rites and more developed mystery religions has at all times been a subject of discussion among historians and theologians, a discussion which has varied in the light of the knowledge available to each succeeding generation.

Saint Paul saved Christianity from settling down as a Jewish sect doomed to early extinction, and preached it as a world religion. When it grew and spread, it came in touch with Greek philosophy, and the chief work of the early Fathers of the Church lay in combining that philosophy with Christian doctrines.

Foremost in this work was Origen (c. A.D. 185–c. 254), who pro-

<sup>1</sup> For short accounts see Percy Gardner, in Hastings' *Encyclopaedia of Religion and Ethics* and also in *Modern Churchman*, vol. XVI, 1926, p. 310.

<sup>2</sup> Sir J. G. Frazer, *The Golden Bough*, 3rd ed. See especially Part v, "Spirits of the Corn and Wild", vol. II, p. 167. B. Malinowski, *Foundations of Faith and Morals*, Oxford, 1936.

claimed the conformity of ancient learning, especially Alexandrian science, with the Christian faith, and did more than anyone else to win adherents among the educated and intelligent. In his day doctrine was still fluid, and alternative ideas, over which the succeeding ages quarrelled to the death, are found peacefully side by side in his writings.

Origen's most fundamental tenet is the unchangeableness of God. This involves the eternity both of the Logos and of the world, and the pre-existence of souls. It reduces the importance of the historical aspect of Christianity, and thus allows a more critical examination of the Old and New Testaments, and a more liberal-minded outlook than was afterwards orthodox. But Origen's theology became less and less acceptable, and was finally condemned by the Council of Constantinople in 553.

Of the Latin Fathers, it was Saint Augustine (354-430) who exerted the deepest and most prolonged influence on Christian thought; the *Confessions* and the *City of God* are among the greatest of Christian classics. He was successively a Manichaean, a Neo-Platonist and a Christian, and his combination of Platonic philosophy with the teaching of the Pauline Epistles formed the basis of the first great Christian synthesis of knowledge, which persisted in the background as an alternative mode of thought even through the dominance of Aristotle and Thomas Aquinas in the later Middle Ages. His controversies, like those of Saint Athanasius, illustrate the way in which Catholic doctrine was formulated by dispute, and show why it is that our Creeds are not only statements of belief, but "paeanes of triumph over defeated heretics and heathen". As Gibbon says, "the appellation of heretic has always been applied to the less numerous party".

Neo-Platonism and early Christian theology grew up together and acted and reacted upon each other—indeed each accused the other of plagiarism. Christianity, like Neo-Platonism, is based on the fundamental assumption that the ultimate reality of the Universe is spirit, and, in the Patristic Age, it accepted the Neo-Platonic super-rational attitude. In the writings of the early Fathers the highest super-rationalism, the love of God and the apprehension of the Risen Christ, passed down through every step to the lowest form of credulity held in common with the pagan populace and the Neo-Platonic philosophers. Plotinus, the early Neo-Platonic pagan, and Augustine, the Christian theologian, laid little stress on divination and magic, and the Latin Father, Hippolytus, exposed the folly of pagan magic and astrology. But two generations later, Porphyry and Iamblichus

on the one side, and in the next centuries, Jerome and Gregory of Tours on the other, revelled in the daemonic and the miraculous.

Symbolism, which had shown itself in Neo-Platonism, was extended and developed by the Fathers in their efforts to co-ordinate the Old Testament with the New, and both with the prevalent modes of thought. What in the Scriptures or in the world of nature conforms to the Christian scheme, as interpreted by each Father, may be received as fact; what does not so agree is to be accepted only in a symbolic sense.

Finally, to understand the Patristic and through it the mediaeval mind, it is necessary to appreciate the overwhelming motive introduced by the Christian conception of sin, the hopes and fears of heaven and hell, mediation to obtain salvation in the one, and to avoid damnation in the flames of the other.

The pagan world itself had become less confident. Mankind had moved far from the bright Greek spirit of life, and the stern Roman joy in home and State. The mystery religions had brought Oriental ideas to Europe. Men were beginning to rely more on authority; they were seized with unrest and vague fears for their safety in this world and the next. The phase recurs at various epochs of history. Even before the ministry of Christ, in Palestine and wherever Jewish influence was felt, eyes were looking for a catastrophic coming of the Kingdom of God, a conception which made the Christian faith of the Apostolic Age largely a matter of eschatology, and its rule of life but an *Interims Ethik*, a short preparation for the triumphant Second Coming. Perhaps in the Patristic Age the end of the world had receded a little into the future; but the day of judgment was still very near, and to each man death was an effective door into the mystery of the next world and the horror of the Shade. Darkness was covering the civilization of the ancient lands, and gross darkness the spirit of mankind, almost obscuring the one transcendent ray of Christ's message of hope and reconciliation.

With such an outlook on life and such a prospect in death, it is no wonder that the Fathers showed small interest in secular knowledge for its own sake. "To discuss the nature and position of the earth", says Saint Ambrose, "does not help us in our hope of the life to come." Christian thought became antagonistic to secular learning, identifying it with the heathenism which Christians had set out to conquer. A branch of the Library of Alexandria was destroyed about the year 390 by Bishop Theophilus, and, in general, ignorance was exalted as a virtue. When Christianity became the religion of the people, this

attitude grew more brutal. We have an illustration of this result in the year 415, when Hypatia, the last mathematician of Alexandria, daughter of the astronomer Theon, was murdered with revolting cruelty by a Christian mob, which, according to the common opinion, was instigated to the deed by the Patriarch Cyril.

The Emperor Julian (331-363) tried to revive pagan religion and philosophy, but the last great philosopher of Athens was Proclus (411-485), who made the final synthesis of Neo-Platonism, and gave it "that form in which it was transferred to Christianity and Islam in the Middle Ages".<sup>1</sup> Proclus formed a link with Plato and Aristotle, and partly created and nourished mediaeval mysticism.

Gradually the desire and the power to investigate nature with an open mind passed away. With the Greeks natural science became merged in metaphysics; with the Roman Stoics it faded into the need to support the morality of the human will. So in the early Christian atmosphere natural knowledge was valued only as a means of edification, or as an illustration of the doctrines of the Church or the passages of Scripture. Critical power soon ceased to exist, and anything was believed if it accorded with Scripture as interpreted by the Fathers. The contemporary knowledge of natural history, for instance, was represented by a second-century compilation called *Physiologus*, or the *Bestiary*, in which the subjects and the accounts of them, originally Christian allegories with imagery taken from the animal world, were frankly ruled by doctrinal considerations. For example, it is stated seriously that the cubs of the lioness are born dead, but that on the third day the lion breathes between their eyes, and they wake to life, thus typifying the Resurrection of our Lord, the Lion of Judah.

In their views of history and biography, the pagan historians were always ready to modify their accounts to serve the rhetorical fitness of the occasion, and the Church writers carried this tendency to greater lengths. In their hands history became a branch of Christian apologetics, and the lives of the saints, the characteristic form of early mediaeval literature, became simply a means of edification. Any legend which accorded with the author's conception of the holiness of his subject was received unhesitatingly.

The power of Patristic theology was strengthened by the ecclesiastical organization which grew up to enshrine it. And when, with the conversion of the Empire to Christianity, that organization could rely on the still overwhelming though decaying strength of Roman tradition, it became irresistible. The Roman Empire died, but its soul

<sup>1</sup> Zeller, quoted in "Neo-Platonism", *Enc. Brit.* 9th ed.

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lived on in the Catholic Church, which took over its framework and its universalist ideals. The Bishop of Rome found it immeasurably easier to acquire the Primacy of the world, and gradually to tighten the bands of uniformity, because even barbarians had come to look to Rome as their metropolis, their Holy City, and to Caesar as their semi-divine ruler. Philosophically the Catholic Church was the last creative achievement of Hellenistic civilization; politically and organically it was the offspring and heir of the autocratic Roman Empire.

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Such was the intellectual position in Europe when the last gleams of sunset of the ancient civilization were fading away into the dark night of the sixth and seventh centuries. And such was the nature of the ideals to which the succeeding ages looked back as they emerged into the feeble light of a new morn, looked back as to a brighter day whose glorious noon culminated in God's crowning revelation by His Son, and whose resplendent eve was illuminated by the inspired writings of the Fathers of the Church. It is small wonder that the men of the new time took all that came to them from across the darkness as endowed with supernatural sanction, and that they viewed it with no critical insight.

Almost the only traces of secular learning which in the West survived the seventh century were the works of Boëthius, a Roman of noble birth, who was put to death in 524. It seems now to be agreed, after a long controversy, that Boëthius was a Christian and even a martyr. However that may be, he was certainly the last in direct descent to show the true spirit of ancient philosophy. He wrote compendiums and commentaries on Aristotle and Plato, and treatises, founded on the writings of the Greeks, on the four mathematical subjects which he called the quadrivium: arithmetic, geometry, music and astronomy. These manuals were used as schoolbooks in the Middle Ages, in the earlier part of which the only knowledge of Aristotle was derived almost entirely from Boëthius' commentaries.

Dr H. F. Stewart, the biographer of Boëthius, gives me the following note:

Boëthius was the last of the Romans; but he was also the first of the Schoolmen in virtue of the classification of the sciences for which he supplied material. The uniform distribution of knowledge into natural sciences, mathematics and theology which he recommended was adopted by his successors and finally accepted and defended by Thomas Aquinas. His definition of *persona* as *naturae rationalis individua substantia* held the field till the end of the scholastic period.

After Boëthius and his younger contemporary Cassiodorus, the classical spirit vanished from the earth. The schools of philosophy

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founded by Plato at Athens, which by this time were teaching a mystical, half-Christian Neo-Platonism, were closed in the year 529 by order of the Emperor Justinian, partly in order to destroy the last vestiges of the teaching of heathen philosophy, and partly to prevent competition with the official Christian schools.

Yet the Byzantine Empire maintained a background of civilization through the worst times of barbarism in the west of Europe. Its armies cleared Italy from the Goths, and its lawyers codified Roman law in the *Institutes* of Justinian. Founded on definite principles, those of the Stoics, Roman law gave an ideal of rational order, which survived the times of chaos, and helped to form both the Canons of the Universalist Church, the heir of the Roman Empire, and later on the intellectual synthesis of Scholasticism. Again, the knowledge which survived in Byzantium from classical times, even in its decay, shone as a torch amid the darkness of Europe, to light the way to a revival of Western learning. Before the light failed altogether, that revival had begun.

But meanwhile in the West the break with the past was much more complete than was necessarily involved by the mere fall of Greece as a civilizing influence and of Rome as a world power. Not only were Athens and Rome destroyed as political States and social structures, but both the race of the Greeks, the artists and philosophers, and the race of the Romans, the lawyers and administrators, had ceased to be.

The beginning of the decline of Rome has been assigned to many causes. One important factor, often overlooked, is traced by the historian Alison to the economic disturbance caused by a shortage of currency.<sup>1</sup> The gold and silver mines of Spain and Greece began to fail, and the treasure of the Empire available for money, estimated at the equivalent of £380,000,000 in the time of Augustus, had shrunk to about £80,000,000 in that of Justinian. In spite of occasional debasements of the currency,<sup>2</sup> it is fair to assume that internal prices within the Empire fell, that is the value of money measured in goods and services rose, and all the evils inevitable in times of deflation must have followed. Productive industry and agriculture ceased to be remunerative; taxes became oppressive; imports from countries like Egypt and Libya, outside the area of monetary disturbance, were stimulated, and Roman land went out of cultivation, as did land in England from similar causes from 1873 to 1900 and again from 1921 to 1928.

<sup>1</sup> Sir Archibald Alison, *History of Europe*, vol. 1, Edinburgh and London, 1853, p. 31.

<sup>2</sup> A. R. Burns, *Money and Monetary Policy in Early Times*, London, 1927.

With the failure of cultivation, and the neglect of the old systems of drainage in town and country, vast tracts were rendered uninhabitable by malaria<sup>1</sup>, while it is probable that the fall in the birth-rate among the nobler and abler stocks, together with the constant drain of incessant wars and—among the Romans—of foreign administration, not only killed off many of the best in each generation, but also, by the survival of the unfittest, lowered the average quality of the nations. Doubtless the obvious military and other causes, usually blamed, had much to do with the catastrophe, but economic and racial factors must not be overlooked. We may perhaps say that the overthrow of Rome by the Northern invaders was not so much a destruction of civilization by barbarians, as the clearing away of a doomed and crumbling ruin, in preparation for future rebuilding.

A new civilization had to be evolved from chaos; nations with definite ideals and well-marked characteristics had to be formed out of the medley of races comprised in the decadent universalist Empire; and those nations had to advance far in the reconstruction of social order and the determination and specialization of intellectual attributes before they could form a suitable seed-bed for the germination and growth of a new science and scientific philosophy.

Here and there in Europe, through the gloom of the Dark Ages, we see tiny plants of knowledge struggling to the light. It is probable that in Italy some of the secular schools maintained their continuity in the large towns throughout the times of turmoil and confusion. But the rise of the monasteries gave the first chance of a secure and leisured life, and, consequently, it is in the cloister that the first signs of the new growth of learning are to be seen.

In view of the character of the Gospel story, it was impossible for the Fathers of the Church to despise the art of healing as they despised or ignored other secular knowledge. Hence the tending of the sick remained a Christian duty, and medicine was the earliest science to revive. Monastic medicine was at first a mixture of magic with a faint tincture of ancient science. In the sixth century the Benedictines began to study compendiums on the works of Hippocrates and Galen, and they gradually spread a knowledge of these writings throughout the West. The monks were also practical farmers, who kept alive some knowledge of the art of agriculture.

The first new secular home of learning appears in the schools of Salerno, a city to the south of Naples, on the Bay of Paestum, and

<sup>1</sup> Angelo Celli, *Malaria*, Eng. trans., London, 1901; W. H. S. Jones, *Malaria, a Neglected Factor in the History of Greece and Rome*, Cambridge, 1909.

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from this centre proceeded many compilations founded on the writings of Hippocrates and Galen. In the ninth century Salernian physicians were already famous; in the eleventh they began to read translations from Arabic works; and their schools continued to flourish till the twelfth century, when they were overshadowed by the general spread of Arab medicine in Europe. Since Salerno is known to have been first a Greek colony, and then a Roman health resort, and since the traditions of Greek medicine seem never to have been entirely interrupted in Southern Italy, it is possible that here a direct and unbroken link existed between the learning of the ancient and that of the modern world.

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It should be noted, however, that countries at a distance from Rome were among the first to show signs of a new and distinctive spirit. The literary and artistic development of Ireland, Scotland and the north of England, beginning with Irish sagas full of poetic extravagance, was quickened by the absorption of Christian teachings. In the fervour of its missionary zeal, that culture was carried with some of its secular learning into more southern lands by such men as Willibrord and Boniface. This northern development culminated in the works of the Anglo-Saxon monk, Bede of Jarrow (673-735), who incorporated into his writings all the knowledge then available in Western Europe. His science was founded chiefly on Pliny's *Natural History*, though he added something on his own account, such, for instance as a few observations on the tides. He stands between the Latin commentators Boëthius, Cassiodorus, Gregory, and Isidore of Seville, who caught the last direct echoes of the classical or Patristic learning, and the scholars of the abbey schools founded by Charlemagne. Chief among these latter was Alcuin of York, who did much to overcome the prevalent idea that secular learning was opposed to godliness, and carried the tradition of classical knowledge into definitely mediaeval times. Bede wrote in Latin, mainly for monks; but one hundred and fifty years later culture had so broadened that Alfred the Great (849-901) translated or caused to be translated many Latin books into Anglo-Saxon, and the influence of Latin literature began to pass into native languages.

By this time mediaeval Europe was taking shape. Nations had crystallized out from the mixture of the Romanized Gauls with the vigorous Teutonic tribes that overran the Roman provinces. Northern lands that had never seen the Roman eagles, or from which the Romans had retreated, were developing a culture and even a literature of their own, on which Roman ideals and Roman civilization only acted as external and foreign influences.

While European learning was at its lowest ebb, a considerable amount of culture of mixed Greek, Roman and Jewish origin survived in the Byzantine Imperial Court at Constantinople, and in the countries which stretch from Syria to the Persian Gulf. One of its earliest centres was the Persian school of Jundishapūr, which gave refuge to Nestorian Christians<sup>2</sup> in 489, and to the Neo-Platonists who left Athens when Plato's Academy was closed in 529. Here translations, especially of Plato and Aristotle, brought Greek philosophy into touch with that of India, Syria and Persia, and led to the growth of a school of medicine, which survived till the tenth century, despite its comparative isolation.

Between 620 and 650, under the stimulus of Muhammad, the Arabs conquered Arabia, Syria, Persia and Egypt. A hundred and fifty years later, Hārūn-al-Rashid, the most famous of the Abbāsīd Calīphs, encouraged translations from Greek authors, and thus helped to initiate the great period of Arab learning. At first the advance was slow, for new terms and constructions, suitable for the expression of philosophic and scientific thought, had to be formed and incorporated into the Syriac and Arabic languages. As in the analogous revival of learning which took place in Europe in the later Middle Ages, the first task of the Arabs, and of the races under their influence, was to recover the hidden and forgotten stores of Greek knowledge; then to incorporate what they recovered in their own languages and culture; and finally to add to it their own contributions.

For two centuries after the death of Muhammad, there was intense theological activity in Islam. The atomic system of Epicurus, and the problems of time and space raised by the paradoxes of Zeno, stimulated the Muslim mind, which may possibly have been influenced also by the Buddhist atomism of India.<sup>3</sup>

According to the Korān, Allah created and uphold's the world, which has only a secondary existence in His absolute existence. This orthodox view was modified by Greek philosophy, Neo-Platonic and Aristotelian, as well as by another Islamic school of thought. The latter added to the implied unilateral pantheism of Muhammad the Neo-Platonic endless chain of existence, and the Aristotelian idea of the Cosmos. Thus it arrived at the complementary view that

<sup>1</sup> See especially G. Sarton, *Introduction to the History of Science*, vols. I, II, Baltimore, 1927, 1931.

<sup>2</sup> Followers of Nestor, declared to be heretics.

<sup>3</sup> See chap. I, p. 8 above; also D. B. Macdonald, in *Isis*, No. 30, 1927, p. 327; arts. "Atomic Theory (Indian)", by H. Jacobi, and "Muhammadan", by De Boer, in *Hastings, Encyclopaedia of Religion and Ethics*.

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conversely the Cosmos is God. A third group, trying to explain nature in orthodox Muhammadan terms, reached a theory of time, similar to, if not derived from, the Buddhist atomic philosophy of India. The world is made of atoms all exactly alike, which Allah creates anew from moment to moment. Space too is atomic, and time is composed of indivisible "nows". The qualities of things are accidents, which belong to the atoms and are created and re-created with them by Allah. If Allah were to cease re-creating from moment to moment, the Universe would vanish like a dream. Matter only exists by Allah's continued will, and man is but a kinematographic automaton. Thus the apparently godless system of Epicurus is converted into an intense monotheism.

By the side of these theological interests there became manifest a curiosity concerning that nature to which the theologians denied permanence or reality. Islamic science grew while that of Christendom was decaying, and by the second half of the eighth century the lead had definitely passed from Europe to the Near East. In the ninth century the Arabic schools of medicine were improved by the study of translations of Galen, and new and striking work was achieved in that primitive chemistry which underlay alchemy.

The earliest practical chemistry is concerned with the arts of life such as metal-working on the one hand, and with the preparation of drugs on the other. The speculations of the Greeks in classical times about the nature of matter, with their ideas of atoms and primary elements, are too much divorced from observational or experimental facts to be classed as chemistry. The Alexandrian alchemists of the first century may be considered to have been the first who realized and attacked chemical problems. Little was done after their day till, six hundred years later, the Arabs took up their work.

It is true that, misunderstanding the origins of the art in Alexandria, the later alchemists set before themselves two great aims, both of which proved impossible of attainment—the material transmutation of baser metals into gold, and the preparation of an *elixir vitae* that would cure all human ills. Their search was doomed to failure, yet, by their way, they acquired much sound chemical knowledge and discovered many useful remedies.

The Arabic alchemists obtained their initial knowledge from two sources, the Persian school mentioned above, and the writings of the Greeks of Alexandria, partly through Syriac intermediaries and partly by means of direct translations. The Arabic-speaking people studied alchemy for seven hundred years, the chief centres of their labours

being first in Irak and later on in Spain. In the hands of these men, alchemy developed into chemistry, and from them, chiefly through the Spanish Moors, the European chemistry of the later Middle Ages was derived. While some Arabic writers and their European followers thus passed from alchemy to chemistry, others, not understanding the technical knowledge and philosophic outlook of the Alexandrian alchemists, and unable to take the newer, more scientific view, degraded their work into a sordid search for gold, or a background for magic based on chicanery or self-delusion.

The most famous Arabian alchemist and chemist was Abu-Musa-Jābir-ibn-Haiyān, who flourished about 776, and is thought to have been the original author of many writings which appeared later in Latin, and were assigned to a shadowy "Geber" of uncertain date. The problem of their origin is not yet solved.<sup>1</sup> From an examination of new translations of some of the Arabic manuscripts, Berthelot<sup>2</sup> concluded in 1893 that the knowledge of Jābir was much less than that of the Latin "Geber". But Holmyard<sup>3</sup> and Sarton<sup>4</sup> state that other Arabic works, still untranslated, show that Jābir was a much better chemist than Berthelot thought. He seems to have prepared (to use the modern nomenclature) lead carbonate, and separated arsenic and antimony from their sulphides; he gave accounts of the refinement of metals, the preparation of steel, the dyeing of cloth and leather, and the distillation of vinegar to yield concentrated acetic acid. He held that the six known metals differed because of the different proportions of sulphur and mercury in them. But Jābir's place in history cannot be assigned till a critical study of all his Arabic works has been made, and a comparison effected with those of "Geber".

In the history of chemistry, the idea that the principles of sulphur or fire and mercury or liquidity are primary elements is of great importance. It seems to have arisen from the discovery that mercury and sulphur combine to give a brilliant red sulphide. As silver is white and gold is yellow, red must be made of something even more noble and fundamental than gold. To sulphur and mercury, salt was afterwards added to represent earth or solidity. The theory that salt, sulphur and mercury were the primary principles of things lasted as an alternative to the four elements of Empedocles and Aristotle till the days of Robert Boyle's *Sceptical Chymist*, published in 1661.

<sup>1</sup> *The Arabic Works of Jābir-ibn-Haiyān*, ed. by E. J. Holmyard, 1, Paris, 1928; *The Works of Geber*, R. Russell, 1678, ed. by E. J. Holmyard, London, 1928.

<sup>2</sup> *La Chimie au Moyen Âge*, Paris, 1893.

<sup>3</sup> E. J. Holmyard, in *Isis*, No. 19, 1924, p. 479.

<sup>4</sup> *Introduction to the History of Science*, vol. 1, p. 532.

*The Arabian  
School*

The increasing importance of scientific chemistry is shown by a controversy, which began in the ninth century, concerning the real value of alchemy. At this time also translations into Arabic were made of Euclid's *Elements* and Ptolemy's work on astronomy, which thus acquired its best known name of *Almagest*. In this way Greek geometry and astronomy were brought into the Muslim world. The Hindu numerals were perhaps invented in Greece, but they passed to India and then, in an early form, reached the Arabs, who modified them into a type (called Ghubar) more like our own.<sup>1</sup> Muslim trade was widespread; through its agency these convenient symbols became known to the world as Arabic, and, after some centuries, displaced the clumsy Roman notation. The earliest Latin example of the use of the new system seems to be found in a manuscript written in Spain about 976, but the zero sign was not universally adopted until a somewhat later date.

The renown attaching to the works of the Greeks was used by some Arabic authors to gain acceptance for their own writings. For instance, an Arabic or Syriac compilation of folklore and magic, known as the *Secretum Secretorum*, was popular in mediaeval Europe as a translated work of Aristotle. About 817 Job of Edessa wrote an encyclopaedia of philosophical and natural sciences as taught in Baghdad. The Syriac text was edited and translated lately by Mingana.<sup>2</sup>

The translation of Ptolemy's book stimulated Muslim astronomers. From his observatory at Antioch Muhammad al-Batani (c. 850) recalculated the precession of the equinoxes and drew up a new set of astronomical tables. He was followed by others of less eminence, and about the year 1000 advances in trigonometry were made and observations on solar and lunar eclipses were placed on record at Cairo by Ibn Junis, or Yūnus, who was perhaps the greatest of all the Muslim astronomers. He was encouraged in his work by al-Hakim, the ruler of Egypt, who founded at Cairo an academy of learning.

The classical period of Arabian science may be said to date from the tenth century, beginning with the medical work of the Persian Abu Bakr al-Rāzi, known to Europe either as Bubachar or Rhazes, who practised in Baghdad and compiled many encyclopaedic textbooks, including a famous treatise on measles and smallpox. He is held to be the greatest physician of Islam, indeed of the whole world during the Middle Ages. He also applied chemistry to medicine, and used the hydrostatic balance to measure specific gravities.

<sup>1</sup> S. Gandz, *Isis*, Nov. 1931, No. 49, p. 393.

<sup>2</sup> Cambridge, 1935; *Isis*, No. 69, 1936, p. 141.

The most eminent Muslim physicist was Ibn-al-Haitham (965–1020), who also worked in Egypt under al-Hakim. His chief work was done in optics, and showed a great advance in experimental method. He used spherical and parabolic mirrors, and studied spherical aberration, the magnifying power of lenses, and atmospheric refraction. He improved knowledge of the eye and of the process of vision, and solved problems in geometrical optics by capable mathematics. The Latin translation of his work on optics exerted considerable influence on the development of Western science, especially through Roger Bacon and Kepler. About the same time the physician and philosopher Ibn Sinā, or Avicenna (980–1037), a native of Bokhara, wandered from court to court among the rulers of Central Asia, vainly seeking some place of settlement where he could find an opening for his talents and carry on his literary and scientific labours. He wrote on all the sciences then known. Sarton states that in alchemy he disbelieved in the transmutation of metals, regarding the differences between them as too deep-seated to be overcome by changes of colour. His *Canon*, or compendium of medicine, “a codification of the whole of ancient and Muslim knowledge”, represents one of the highest achievements of Arabic culture. It afterwards became the textbook of medical study in the European Universities; until the year 1650 it was used in the schools of Louvain and Montpellier, and till lately was said to be still the chief medical authority in Muhammadan countries.

A contemporary, less well known but not less great in mind, was al-Birūni, philosopher, astronomer and geographer, who lived from 973 to 1048. He carried out geodetic measurements, and determined latitudes and longitudes with some accuracy. He measured the specific gravity of precious stones, and explained natural springs and artesian wells on the principle of water finding its own level in communicating channels. He wrote a clear account of parts of India and their people, and also the best mediaeval treatise on Hindu numerals.

At this time Arabic had become the acknowledged classical language of learning, and everything written in Arabic carried the prestige that in earlier (and again in later) ages was accorded to Greek. The first systematic translator of Arabic texts into Latin was Constantine the African, who worked at Monte Cassino from about 1060 till his death in 1087. He visited Salerno, and his work had much influence on the Salernian School, stimulating, both there and elsewhere, the absorption of Arabic knowledge by the Latin nations.

Nevertheless the highest point of Arabic learning had been reached. In the eleventh century appeared the important algebraic work of the Persian poet Omar Khayyam, and the theological writings of al-Ghazzāli, who did for Muhammadanism the philosophic and synthetic work that Thomas Aquinas did for Christianity. But by the close of the century the decline of Arabic and Muslim learning had set in, and thenceforward science was chiefly a European activity.

Politically also any prospect of a stable Arabian Empire had been put to an end by the internal quarrels of the Muhammadan princes and generals, and by the gradual disintegration and destruction of the gifted, noble and old-established Arab families, which had provided the necessary governors, soldiers and administrators. The distant provinces, one after another, separated themselves from the weak overgrown and heterogeneous Empire, re-created their native characters, and reasserted their political independence.

It was in Spain, the farthest province of the Muhammadan conquest, that the best results of the intercourse of Arabian, Jewish and Christian civilizations became apparent. For three centuries, from 418 to 711, a West Gothic kingdom, which had established itself in Spain, maintained law and order from its capital at Toulouse. The Sephardim Jews, originally deported from Palestine to Spain under Titus, had preserved traditions of Alexandrian learning, amassed wealth, and kept open communications with the East. This continued after the Muhammadan conquest of Spain in A.D. 711. The tolerance of thought accorded by the Arabs, as long as their supremacy remained unquestioned, allowed the establishment of schools and colleges which, however, owed their continued existence, not to the support of the people as a whole, but to the occasional and spasmodic patronage of a liberal-minded or free-thinking ruler.

The course of Spanish-Arabian philosophy developed on much the same lines as that of the Christian schools which followed it a hundred years later. There was the same attempt to harmonize the sacred literature of the nation with the teachings of Greek philosophy, and an analogous contest between those theologians who relied on reason and rational conclusions, and those who put their trust either uncritically in revelation, or in mystic religious experiences, and in both cases denied the validity of human reason in matters of faith.

Orthodox Muslim Scholasticism with its rational philosophic theology was chiefly founded by the Persian al-Ghazzāli, who flourished at Baghdad. Similar views were prevalent in Spain, but the real fame of the Spanish-Arabian school of thought is due to the

work of Averroes, who was born at Cordova in 1126. While showing a profound reverence for the teachings of Aristotlé, Averroes nevertheless introduced a new conception into the relations between religion and philosophy. According to him, religion is not a branch of knowledge that can be reduced to propositions and systems of dogma, but a personal and inward power, distinct from the generalities of "demonstrative" or experimental science. Theology, the mixture of the two, he regarded as a source of evil to both, fostering on the one hand a false impression of the hostility between religion and philosophy, and, on the other, corrupting religion by a pseudo-science.

It is not surprising that the teaching of Averroes came into fierce conflict with that of the orthodox Christian theologians, but, in spite of opposition, especially from the great Dominican school of thought, his words fell upon willing ears. By the thirteenth century, Averroes had become a recognized authority in the Universities of South Italy, Paris and Oxford, worthy, according to Roger Bacon and Duns Scotus, to be placed by Aristotle as a master of the science of proof.

Another great Cordovan of this period was Maimonides (1135–1204), a Jewish physician, mathematician, astronomer and philosopher, whose chief work was the construction of a Jewish system of Scholasticism, comparable with the Muslim Scholasticism of al-Ghazālī, and the Christian Scholasticism soon afterwards completed by Thomas Aquinas. Maimonides sought to reconcile Jewish theology with Greek philosophy, especially with that of Aristotle. His work had much influence in the later Middle Ages, when some of his followers pressed his views so far as to regard the whole of Biblical history as symbolic, a theory which naturally aroused controversy.<sup>1</sup>

In the Europe which received and slowly absorbed this stream of Arabic knowledge, the apparatus of learning had made appreciable progress. In the Eastern Empire at Constantinople a definite revival of knowledge took place in the ninth and tenth centuries, when Constantine VII patronized art and learning, and ordered the compilation of a number of encyclopaedic treatises. From Constantinople too, Russia was converted to Christianity, mainly by the irresistible persuasion of Vladimir, Duke of Kiev, and Russian art, directly derived from that of Byzantium, began at the end of the tenth century. To this Byzantine Renaissance we also owe the reproduction and preservation of many Greek manuscripts.

<sup>1</sup> For Jewish mediaeval philosophy, see H. A. Wolfson, *The Philosophy of Spinoza*, Harvard, 1934; *Isis*, No. 64, 1935, p. 543.

As we have seen, a centre of secular studies, and especially of medicine, had existed since a very early date at Salerno, and, in Northern Europe, the encouragement bestowed on scholars by Charlemagne and Alfred had given an impetus to teaching generally. Gerbert, the learned French educator and mathematician, taught at Rheims, and elsewhere, from 972 till 999, when he was elected Pope, taking the name of Sylvester II. In his writings he dealt with the Hindu numerals, the abacus, a simple form of calculating machine, and the astrolabe, a graduated metal circle with a limb pivoted at the centre, which gave the zenith distance. And, earlier in the tenth century, Arabic learning became known in Liège and other cities of Lorraine, whence it spread to France, Germany and England.<sup>1</sup> About 1180 a centre of Arabic learning appears under Roger of Hereford.<sup>2</sup>

The effect of the increasing demand for teaching was that the monastic and cathedral schools were found insufficient to meet the growing needs, and new secular schools began to assume their modern form of Universities.<sup>3</sup> A revival of legal studies took place in Bologna about the year 1000, and, in the twelfth century, schools of medicine and philosophy were added to that of law. A Students' Guild, or *Universitas*, was formed for the mutual protection, at first of the foreign students, who were at the mercy of the inhabitants, and later of all students, whether native or foreign. These guilds hired their own teachers, and the University of Bologna, even in later years, continued to be a students' University, in which the governing power was held by the learners.

On the other hand, a school of dialectic at Paris in the first decade of the twelfth century was organized by the teachers, and shortly afterwards a community, or *Universitas*, of teachers in that city set the constitutional model to most of the Universities of Northern Europe, including England. Thus it is that at Oxford and Cambridge the governing power has always rested with the teachers instead of with the students as at Bologna and in Scotland, where the election of the Rector shows a surviving trace of undergraduate control.

As early as the Carolingian period, the academic subjects of study had settled down into an elementary trivium, comprising grammar, rhetoric and dialectic, three subjects which dealt with words, and a more advanced quadrivium, music, arithmetic, geometry and astronomy, which four were supposed, at all events, to deal with

<sup>1</sup> J. W. Thompson, *Isis*, No. 38, 1929, p. 184.

<sup>2</sup> J. C. Russell, *Isis*, No. 52, July 1932.

<sup>3</sup> H. Rashdall, *The Universities of Europe in the Middle Ages*, Oxford, 1895.

things. Music contained a half mystical doctrine of numbers, geometry merely a series of Euclid's propositions without the proofs, while arithmetic and astronomy were esteemed chiefly because they taught the means of fixing the date of Easter. All were treated as a preparation for the study of the sacred science of theology. Throughout the Middle Ages, this division of subjects held good for the elements of academic learning, and, as interest grew in philosophy, that study was merely added as a more advanced part of the simpler logical dialectic.

The old controversy between Plato and Aristotle on the nature of "intelligible forms" or "universals" found its way into the writings of Porphyry and the commentaries of Boëthius, and so reached the mediaeval mind as the problem of classification. Why is it that we are able to classify? Are individuals the only realities, classes or universals existing merely as mental concepts or names, as the nominalists maintain, or have they a certain independent reality, existing in and with the objects of sense as the essence of those objects, as Aristotle taught? Or, on the other hand, have the ideas or universals a quite separate existence and a reality apart from the phenomena or the isolated beings, as Plato held in his idealist philosophy, which had come to be called realism? For instance are Democritus and Socrates realities, and humanity only a name? Or is man a species with a reality of its own, receiving here and there certain forms which make it Democritus or Socrates, accidents of the real substance, humanity? Are we to say *universalia ante rem* with Plato, *universalia in re* with Aristotle, or *universalia post rem* with the nominalists?

To our scientific minds, more at home with Archimedes than with either Aristotle or Plato, this controversy seems both foolish and tiresome. Yet it is necessary to study it if we are to unearth the buried seeds of modern science which germinated at the Renaissance. In its effect on the theory of knowledge, even to the Greeks it was of great importance, and in it the mediaevalists eventually discovered the whole problem of Christian dogma, the only difficulty being to determine on which side persecuting orthodoxy was to take its stand.

In the ninth century Erigena, or John Scot, a disciple of Origen, propounded a mystical theory, based on the idea that the divine is the only reality. The theory contained the first great mediaeval, as contrasted with Patristic, synthesis of Christian faith with Greek philosophy, in this case the philosophy of the Neo-Platonic school. To Erigena true philosophy is true religion, and true religion true philosophy. Reason leads to a system which coincides with Scripture properly interpreted. Erigena was a realist, but his realism shows

a fusion of Platonic and Aristotelian views, and the discussion between realism and nominalism only became acute later. In the eleventh century critical reasoning was applied to theology and the issues at stake began to be seen. Nominalism made its appearance in the writings of Berengarius of Tours (999-1088), who criticized the doctrine of transubstantiation, holding that a change of substance could not take place in the bread and wine with no corresponding change in the accidents of appearance and taste. Nominalism appeared also in Roscellinus (d. c. 1125), who held that the individual is the sole reality, and thus reached a Tritheistic conception of the Trinity. This at once crystallized the opposing realism, especially in William of Champeaux and Anselm of Canterbury, and established it as the orthodox view for several centuries.

But the inherent difficulties of the theory of realism led to many varieties of it; an interminable discussion raged in the schools and employed the philosophic acumen of the scholastic dialecticians for two hundred years. Abelard, a Breton (1079-1142), attacked his master William of Champeaux, and taught a modified doctrine verging on nominalism, though it was a nominalism not so consistent as that of Roscellinus. In Abelard the doctrine of the Trinity was reduced to the conception of three aspects of the One Divine Being. Abelard showed signs of independence from the dogmatic frame within which the mediaeval mind was accustomed to work. He made the pregnant statements that "doubt is the road to enquiry", that "by enquiry we perceive the truth", and that "it is necessary to understand in order to believe", a saying which may well be compared with the *credo quia impossibile* of the Patristic Tertullian, and the *credo ut intelligam* of Anselm. Abelard was called to account by Saint Bernard, who held in abhorrence the wisdom of this world, and did much to foster ecclesiastical suspicion which saw heresy everywhere. But for a time the speculative spirit was exhausted, and the middle of the twelfth century marks the beginning of a pause of fifty years in logical and philosophical dialectic, and the return to a passing interest in classical literature, an interest which centred in John of Salisbury and his school at Chartres.

If the philosophic discussions of the mediaevalists are still of living interest to some modern metaphysicians, their general conception of the physical Universe appears to us strange, unreal and confused. For the most part no distinction was drawn between natural events, moral truths and spiritual experiences. Doubtless ultimate reality contains all three, but history shows that natural events, at any rate, need to be

viewed in isolation if our knowledge of their interrelations is to be increased.

The mediæval mind was fascinated by a supposed analogy between the nature of the Godhead, the astronomical constitution of the Cosmos, or macrocosm, and the anatomical, physiological and psychological structure of man, the microcosm. The whole Cosmos is usually imagined as permeated and bound together by a living spirit, the *voûs* or world spirit of Neo-Platonism, which in its turn is pervaded and controlled by the Godhead. Thus primordial matter, the principle of death and dissolution, is held in subjection.

The idea of the macrocosm and microcosm is set forth in Plato's *Timæus*, and can be traced back to Alcmaeon and to the Pythagoreans, but it was attributed by some mediæval authors to Hermes, the somewhat doubtful Alexandrian figure to whom so many alchemical writings are referred and who probably represents the Egyptian god Thoth. The theory reappears in simple form in the works of Isidore of Seville, and of the alchemist "Geber". It was developed later by Bernard Sylvestris of Tours (c. 1150), and by the Abbess Hildegard of Bingen (c. 1170).<sup>1</sup> It is constantly to be seen represented allegorically in mediæval art.

In other illustrations, which represent only the physical Cosmos, we see some such picture as the following. The Earth is imagined as a central sphere, in which the four elements, originally in harmonious order, are in confusion since Adam's fall. The Earth is surrounded by concentric zones of air, aether and fire, containing stars, Sun and planets, all kept in motion by the four winds of heaven, which are related to the four elements of Earth and the four humours of man. Heaven is the empyrean space beyond the zone of fire, and hell is within the sphere of Earth under the feet of men.

The conception of the essential similarity of macrocosm and microcosm held throughout the Middle Ages. It survived the Renaissance, and persisted in literature into almost modern days. The idea of the Universe as composed of concentric spheres or zones was developed and made classical in mediæval times: perhaps it reached its culmination in the Vision of Dante. Copernicus destroyed its rational basis, but did not uproot the popular tradition. Indeed, drawings clearly derived from these confused imaginings of the ancient world and the Middle Ages may still be seen decorating the covers of certain almanacs which circulate among the ignorant of all classes even now.

<sup>1</sup> *Studies in the History and Method of Science*, ed. by Charles Singer, Oxford, 1917, "St Hildegard", p. 1.

*The Revival  
of Learning  
in Europe*

Somewhat similar notions are found in the system of Jewish theosophy known as the Caballa, which, professing to set forth esoteric truths revealed by God to Adam and carried down the ages by tradition, afterwards came to exert a considerable influence on Christianity.

It is impossible here to trace a tithe of the enormous and intertwined tangle of astrology, alchemy, magic and theosophy which enmeshed the Middle Ages, and is so difficult for us to understand or even to read with patience. But it must not be forgotten that such ideas were essentially characteristic of the mediaeval mind, which in them felt at home. Scientific thought, of which in those times we find rare examples, was quite foreign to the prevailing mental outlook. The scattered seedlings of science had to grow in a vast and confused jungle which was always threatening to choke them, and not in the open healthy prairie of ignorance which seems to be envisaged by some historians of science. If agricultural land be left uncultivated, in a few years the jungle returns, and signs are not lacking that a similar danger is always lying in wait for the fields of thought, which, by the labour of three hundred years, have been cleared and brought into cultivation by men of science. The destruction of a very small percentage of the population would suffice to annihilate scientific knowledge, and lead us back to almost universal belief in magic, witchcraft and astrology.

*The  
Thirteenth  
Century*

If the intellectual task of the Dark Ages was to save what it could out of the wreck of ancient learning, that of the first succeeding centuries was to master and absorb what had been recovered. The chief intellectual achievement of the early mediaeval period was the welding together of the remains of ancient classical knowledge, as preserved by the writers of Latin compendiums, with the Christian faith, as interpreted by the early Fathers in the light of Neo-Platonism. From the ninth century onward we may watch this process at work, and there the constructive period of the Middle Ages may be said to begin.

By the twelfth century the dual heritage from the past had been surveyed and mapped out, absorbed and transformed by the mediaeval mind. Then came a pause in the work of philosophic theology, during which we see the culmination of mediaeval appreciation of classical writings as literature. None of the more advanced works of Aristotle were known in a complete form; and thus no scientific book had come to hand to disturb the literary outlook of those scholars who cared for the classics as a bypath of study, or as a means of under-

standing better the language of Scripture and the writings of the Fathers. In spite of the indirect influence of Aristotle, exerted through commentaries, the predominant theological attitude was still Platonic or Neo-Platonic and Augustinian, idealistic and mystical rather than rational and philosophical.

But in the thirteenth century a great change of outlook took place, coincident and perhaps connected with the humanizing movement associated with the coming of the friars. An increasing desire for secular knowledge was satisfied by the rendering of Greek authors into Latin, firstly by retranslation from the Arabic, and later by direct translation from the Greek. The complete story has not yet been worked out, for our knowledge of Arabic scientific literature, even of that part of it which is extant, is still so fragmentary that it is impossible to specify exactly what additions the Arabs made to Greek science.

The most active work in translation from Arabic to Latin went on in Spain, where a succession of translators, busy with many subjects, can be traced from about 1125 to about 1280. "To them we owe texts of Aristotle, Ptolemy, Euclid and the Greek physicians, Avicenna, Averroes, and the Arabic astronomers and mathematicians, a great mass of astrology, apparently also a certain amount of alchemy."<sup>1</sup>

Next to Spain in importance were Southern Italy and Sicily, whence came translations both from Arabic and from Greek, made possible by the presence of resident Arabs and Greeks, and by diplomatic and commercial relations with Constantinople. From this source were obtained medical works, a geographical treatise and map, and Ptolemy's *Optics*. Of scattered or unknown origin are translations of Aristotle's *On Animals*, *Metaphysics* and *Physics*, and other less important works which appeared in the West from 1200 onwards.

The current language of scientific literature was Arabic, and translations from the Arabic, even of Greek authors, were highly valued. The Arabic-speaking races and the Jews living among them had at this time a real interest in science, and it was by contact with Muhammadan countries that mediæval Europe passed from its earlier outlook to a more rationalist habit of mind.

The greatest change was produced by the rediscovery of Aristotle. Between 1200 and 1225 his complete works were recovered and rendered into Latin, like those of other authors, first from Arabic versions and then by direct translations from the Greek. In this latter work one of the foremost of scholars was Robert Grosseteste, Chancellor of Oxford, and Bishop of Lincoln, who himself wrote on comets

<sup>1</sup> C. H. Haskins, in *Isis*, No. 23, 1925, p. 478.

and their causes. Grosseteste invited Greeks to England and imported Greek books, while his pupil, Roger Bacon, a Franciscan friar, wrote a grammar of the Greek language. Their aim was not literary but theological and philosophical, to unlock the original tongue of Scripture and of Aristotle.

The new knowledge soon produced an effect on the current controversies. Realism survived, but it became less thorough and less Platonic. It was seen that Aristotle's modified realism might be formulated in psychological terms which brought it nearer to nominalism. But in wider questions Aristotle opened up a new world of thought to the mediaeval mind. His general outlook, at once more rational and more scientific, was quite different from Neo-Platonism, which had hitherto chiefly represented ancient philosophy. His range of knowledge, both in philosophy and in the science of nature, was far greater than anything else then available. It was a heavy task to absorb and adapt the new material to mediaeval Christian thought, and the work was not effected without misgiving. Men were convinced of the intellectual supremacy of the Church as the recipient and interpreter of all revelation and of the conformity therewith of the mystical Neo-Platonism which represented secular learning. Hence it needed a real and courageous intellectual effort to accept the newly recovered works of Aristotle, with all the scientific or quasi-scientific knowledge those works contained, and to undertake the task of reconciling that knowledge with Christian dogma, and it is not surprising that the early study of Aristotle aroused alarm. At first the Arabic channels by which his books reached the West mingled his philosophy with Averroist leanings, and mystical heresies were the result. Aristotle's works were condemned by a Provincial Council at Paris in 1209, and again later. But in 1225 the University of Paris formally placed Aristotle's works upon the list of books to be studied.

The chief of the scholars who interpreted Aristotle at this time was the Dominican Albertus Magnus of Cologne (1206–1280), perhaps the most scientific mind of the Middle Ages. He interwove Aristotelian, Arabian and Jewish elements into a whole which included all contemporary knowledge of astronomy, geography, botany, zoology and medicine, in which Albertus himself, and some of his contemporaries like Rufinus the botanist, made definite progress.<sup>1</sup>

The prevalent trend of thought may be illustrated by the developments which followed Albertus's teaching of Aristotle's embryology. Aristotle held that in generation the female contributed substance

<sup>1</sup> E. Michael, *Geschichte d. deutschen Volkes vom 13 Jahrh.*, vol. v, part III, 1903, p. 445 *et seq.*

and the male form. The mediaeval mind with its desire for values made the male element the more noble, and later on developed a theological embryology, in which the moment of entry of a soul into the embryo became the problem of supreme importance.

The work of Albertus on one side shows affinity with his younger contemporaries, the Oxford Franciscans, Grosseteste and Bacon, and on another led directly to the more systematic philosophy of his famous pupil Saint Thomas Aquinas. Though his mind was cast in a less scientific mould than that of Albertus, the importance of Aquinas in the history of philosophy and of the origins of science is great. By carrying on Albertus's work of rationalizing the existing stores of knowledge, both sacred and profane, he stimulated intellectual interests and made the Universe seem intelligible.

Albertus Magnus and Thomas Aquinas together produced a revolution in thought, especially in religious thought. From Plato through Neo-Platonism to Saint Augustine, man was held to be a mixture of thinking soul and living body, each a complete entity in itself. In every soul God implants innate ideas, including some idea of the Divine. This scheme is easily reconciled with Christian doctrines such as individual survival and direct knowledge of God.

But Aristotle put forward a quite different theory of man and knowledge. Neither body nor soul is a complete entity in itself, and man is a compound of the two. Ideas are not innate, but built up from sense-data by some few self-evident principles such as causation. Apprehension of God is not innate but has to be reached by rational and laborious inference. In spite of its religious difficulties, Aristotle's scheme led to a better account of the external world, and for that reason Albertus and Aquinas accepted it, and Thomas courageously and skilfully set to work to reconcile it with Christian doctrines.

But Aristotle's philosophy, more scientific than that of Plato, was still discordant with the new knowledge of the Renaissance, so, when his writings had been accepted and become authoritative, they delayed for many years the liberation of scientific thought from the trammels of theology, for to Saint Thomas's Aristotelianism was mainly due the predominantly hostile attitude both of academic secular learning and of the Roman Church towards the initial development of modern science.

Thomas was the son of a Count of Aquinum and was born about 1225 in Southern Italy. At the age of eighteen he joined the Dominican Order. He studied at Cologne under Albertus Magnus, taught at Paris and Rome, and, after a life of incessant activity, died in 1274 at the age of forty-nine.

Thomas  
Aquinas

His greatest works, the *Summa Theologiae* and the *Summa Philosophica contra Gentiles*, the setting forth of Christian knowledge for the ignorant, recognize two sources of knowledge: the mysteries of the Christian faith as transmitted through the channels of Scripture, of the Fathers and of Christian tradition, and the truths of human reason—not the fallible individual reason, but the fount of natural truth of which the chief exponents were Plato and Aristotle. The two sources cannot be opposed, since they both flow from God as the one source. Hence philosophy and theology must be compatible, and a *Summa Theologiae* should contain the whole of knowledge; even the existence of God can be demonstrated by reason. But here Thomas Aquinas parts company with those who went before him. Erigena and Anselm, under the more mystical Neo-Platonism, sought to prove the highest mysteries of the Trinity and the Incarnation. But Thomas, under the influence of Aristotle and his Arabic commentators, held that these mysteries could not be proved by reason, though they can be examined and apprehended thereby. These doctrines, accordingly, are henceforth detached from the sphere of philosophic theology, and transferred to that of faith.

Throughout his work Aquinas's interests are intellectual. Perfect beatitude of any created rational being lies in the action of the intelligence directed to the contemplation of God. Faith and revelation are belief in a proposition and presentment of truth. It is an entire fallacy to suppose that Scholasticism and the later orthodox Roman theology which is derived from it are opposed to, or belittle, human reason. That was the attitude in early days, when, for instance, Anselm feared the use of reason by the nominalists of his time. But the later Scholastics did not decry it. On the contrary, they regarded human reason as formed for the purpose of apprehending and examining both God and nature. They profess to give a rational account of the whole scheme of existence, though to us their premises may be doubtful.

Aquinas's scheme was framed in accordance with Aristotle's logic and science. His logic, known already through compendiums, acquired a wider influence when a rational synthesis of knowledge was attempted. Based on the syllogism, it professed to give rigorous proof from accepted premises. It led naturally to the idea of knowledge derived from intuitive axioms on the one side, and authority—that of the Catholic Church—on the other. It was singularly ill adapted to lead men to, or guide them in, the experimental investigation of nature.

Aquinas also took over from Aristotle and from the Christian doctrine of the day the assumption that man is the centre and object of creation, and that the world is to be described in terms of human sensation and human psychology. Aristotle's physics, his weakest scientific subject, made all this possible. A striking anticipation of more modern physical views was contributed by Democritus when he said: "According to convention there is a sweet and a bitter, a hot and a cold, and according to convention there is colour. In truth there are atoms and a void." This theory is that of modern objective physics, which seek to get behind crude sensation and discover the workings of nature irrespective of man. But, as we know, Aristotle rejected it all, and would have none of the atomic concepts. To him a material body was not, as to Democritus, a collection of atoms, or, as to us, something which has to be conceived as possessing mass or inertia, and other definite physical, chemical and perhaps physiological properties. It was a subject or an entity about which can be said things which fall into certain categories. First it is substance, "that which is not asserted of a subject but of which everything else is asserted"; for example, man, bread, stone; though Aristotle was not thinking of a concrete thing but of an essential nature. Then it has qualities, heaviness, hotness, whiteness; and, of less importance, it can be said to have existed in some place and at some time. These are all accidents, less fundamental than substance, but an integral part of the subject at any given moment.

In the nineteenth century all this would have seemed futile and almost meaningless, though we are able to recast it in more modern form nowadays. But points of view held in the nineteenth or twentieth century would have been equally foreign to men of the Middle Ages, and their attitude of mind had important historical consequences. If heaviness is a natural quality opposed to lightness, it is easy to see how Aristotle arrived at his doctrine of natural places, according to which heavy bodies tend downward and light ones upward, so that the heavier a body the faster it falls. On this point the Scholastics quarrelled with Stevin and Galileo. Furthermore, Aristotle's distinction of the underlying substance from the appearances, accidents or species made the doctrine of transubstantiation, an article of faith since 1215, seem natural to the mediaeval mind, even when mystical Neo-Platonism had been replaced by rational Aristotelian Thomism.

Aquinas accepted the Ptolemaic system of astronomy, but it is a remarkable fact that he regarded it merely as a working hypothesis—

Thomas  
Aquinas

“*non est demonstratio sed suppositio quaedam*”.<sup>1</sup> But Saint Thomas’s caution was overlooked, and the geocentric theory became part of the Thomist philosophy. As man was the object of creation, so the Earth was the centre of the Universe, and round it revolved concentric spheres of air, aether and fire—“the flaming walls of the world”—which carried the Sun, stars and planets. Mediaeval pictures of the Day of Judgment show how naturally this view led to the vision of heaven localized above the sky, and hell beneath the ground. Within the premises given by contemporary Christian dogma and Aristotelian philosophy, the scheme was worked out with subtlety and skill, and, accepting the premises, it all held together in a consistent and convincing whole.

Aristotle’s doctrine of the eternity of the world was rejected as irreconcilable with an act of creation in time, but in other respects even the details of Aristotle’s science were brought into line. From the idea that all motion implies a continual exertion of force, Aquinas deduced results in accordance with the theology of his age, such as *Movetur igitur corpus celeste a substantia intellectuali*. The deductions being regarded as verified, the premises became strengthened, and thus the whole of natural knowledge was welded with theology into one rigid structure, the parts of which were believed to be interdependent, so that an attack on Aristotelian philosophy or science became an attack on the Christian faith.

In the Thomist philosophy, both body and mind are realities, but there is none of the sharp antithesis between them first formulated by Descartes and so familiar in later ages. Aquinas was not troubled by such modern metaphysical difficulties as the relation between these two apparently incommensurable entities, or the allied problem of how natural knowledge comes to be possible to the mind of man. There was as yet no need for this analysis; it only became necessary four centuries later, when Galileo had shown that, from the dynamical point of view, the Aristotelian concept of substance with its qualities had to be replaced by the idea of matter in motion, and that accidents like colour, sound and taste were not inherent qualities of the substance, but mere sensations in the mind of the recipient. In the thirteenth century these ideas would have been incomprehensible, and the difficulties involved in them would have been meaningless.

In Saint Thomas Aquinas, Scholasticism reached its highest level. Its grip on the human mind was intense and prolonged. Though the surviving Scholastics opposed the new experimental science after the

*Lib. Physicorum*, I, cap. 2, lect. III, 7.

Thomas  
Aquinas

Renaissance, it was the thorough rationalism of their system that formed the intellectual atmosphere in which modern science was born. In one sense, science was a revolt against this rationalism, an appeal to brute facts whether conformable to a preconceived rational scheme or not. But underlying it is the necessary assumption of the regularity and uniformity of nature. As Dr Whitehead has pointed out,<sup>1</sup> the idea of an inevitable fate—the central theme of Greek tragedy—passed down through the Stoic philosophy to Roman Law, which was based on the moral principles of that philosophy. In spite of the anarchy which followed the fall of the Empire, the sense of legal order always survived, and the Roman Church upheld the universalist traditions of imperial rule. The philosophic rationalism of the Schoolmen arose from and fitted into a general ordered scheme of thought, and prepared for science the belief that “every detailed occurrence can be correlated with its antecedents in a perfectly definite manner, exemplifying general principles. Without this belief the incredible labours of scientists would be without hope”. “The habit remained after the (scholastic) philosophy had been repudiated, the priceless habit of looking for an exact point and of sticking to it when found. Galileo owes more to Aristotle than appears on the surface. . . he owes to him his clear head and his analytic mind.” And “the pilgrim fathers of the scientific imagination as it exists to-day, are the great tragedians of ancient Athens, Aeschylus, Sophocles, Euripides. Their vision of fate remorseless and indifferent, urging a tragic incident to its inevitable issue, is the vision possessed by science”.

The thirteenth century saw the triumphant and applauded work of Thomas Aquinas, the greatest exponent of the scholastic philosophy, and it saw also the tragic life of Roger Bacon, the only man in Europe throughout the Middle Ages, as far as records have reached us, who approaches in spirit either the great Arabians who preceded him or the men of science of the Renaissance who followed. The tragedy of Bacon's life was as much internal as external, as much due to the necessary limitations of his modes of thought in the existing intellectual environment, as to the persecutions of ecclesiastical authority.

Roger Bacon<sup>2</sup>

Roger Bacon was born about the year 1210, near Ilchester, in the Somerset fens. His family seem to have been people of position and considerable wealth. Roger studied at Oxford, where he came under the influence of two men, both East Anglians, Adam Marsh, the

<sup>1</sup> A. N. Whitehead, *Science and the Modern World*, Cambridge, 1927, pp. 11-15.

<sup>2</sup> E. Charles, *Roger Bacon, sa Vie, ses Ouvrages, ses Doctrines*, Paris, 1861; *The Opus Majus of Roger Bacon*, translated by R. B. Burton, Philadelphia, 1928; G. Sarton, *Introduction to the History of Science*, vol. II, p. 952.

*Roger Bacon* mathematician, and Robert Grosseteste, Chancellor of Oxford, and afterwards Bishop of Lincoln. "But one alone knows the sciences, the Bishop of Lincoln", said Bacon; and again, "In our days Lord Robert, lately Bishop of Lincoln, and brother Adam Marsh were perfect in all knowledge".

Grosseteste seems to have been the first in England, perhaps in Western Europe, to invite Greeks to come from the East as instructors in the ancient form of their language, which was still read at Constantinople. Bacon himself was equally impressed with the importance of the study of the original language of Aristotle and the New Testament, and put together a book on Greek grammar. He was never tired of insisting that the prevailing ignorance of the original tongues was the cause of the failure in theology and philosophy of which he accused the doctors of the time. In anticipation of modern textual criticism, he pointed out how the Fathers adapted their translations to the prejudices of their age, and how subsequent corruptions must have crept in through carelessness and ignorance, or by that tampering with the text which had gone on, especially among the Dominicans. Bacon himself, be it observed, was a Franciscan.

But that which marked Bacon out from among the other philosophers of his time—indeed of the whole of the European Middle Ages—was his clear understanding that experimental methods alone give certainty in science. This was a revolutionary change in mental attitude, only to be appreciated after a course of study of the other writings of his day. Bacon read all the authors he could reach, Arabic (probably in Latin translations) as well as Greek, but instead of accepting the facts and inferences of natural knowledge from Scripture, the Fathers, the Arabians, or Aristotle, Bacon told the world that the only way to verify their statements was to observe and experiment. Here again was an anticipation, this time of the doctrine of his more famous namesake, Francis Bacon, Lord Chancellor of England, who lived three hundred and fifty years later, and seems to have made use of some of his predecessor's ideas. This comes out especially in his analysis of the causes of human error. These are taken by Roger to be: Undue Regard to Authority; Habit; Prejudice; False Conceit of Knowledge: an analysis to which Francis's four *Idola* bear too great a likeness to be accidental.

In spite of his writing, Roger does not appear to have done much experimenting himself except in optics, on which he spent a considerable sum of money, though the results he obtained seem to be meagre. After spending some years in Paris, where he was made a

doctor, he returned to Oxford. The growing suspicion of his labours, however, soon caused him to be sent back to Paris, apparently for more strict supervision by his Order, and he was forbidden to write or to teach his doctrines. But now came the chance of Roger Bacon's lifetime.

Guy de Foulques, an open-minded jurist, warrior and statesman, who had become interested in Bacon's work at Paris, was elected Pope, taking the name of Clement IV. Bacon wrote to him, and in reply Clement sent a letter to *Dilecto filio, Fratri Rogerio dicto Bacon, Ordinis Fratrum Minorum*, commanding him, notwithstanding the prohibition of any prelate or the constitution of his Order, to write out the work for which he had formally asked permission. For some unknown reason, the Pope added an injunction of secrecy, which increased Brother Roger's difficulties. As a friar he was pledged to poverty, but, by borrowing from friends, he got together enough to provide materials, and in 1267, after some fifteen or eighteen months, he despatched three books to Clement: an *Opus Majus*, containing his views at length; an *Opus Minor*, or epitome; and an *Opus Tertium*, sent after the others for fear of miscarriage. From these books we chiefly know his work, though some still remains in manuscript.<sup>1</sup>

Clement died soon after, and Bacon, deprived of his protection, suffered without redress a sentence of imprisonment passed in 1277 by Jerome of Ascoli, General of the Franciscans, who became Pope Nicholas IV. It is probable that Bacon was not released until the death of Nicholas in 1292. In that year he wrote a tract called *Compendium Theologiae*, and thereafter we hear no more of the great friar.

Bacon, for all his comparatively advanced outlook, accepted most of the mediaeval attitude of mind. No man can do more than advance a little way in front of the ranks of that contemporary army of thought to which, whether he will or no, he belongs. Naturally Bacon pictured the Universe as bounded by the sphere of the fixed stars with the Earth at the centre. He accepted the absolute authority of Scripture, could the pure text be recovered, and the entire frame of dogmatic theology in which Christianity was presented to that age. A more hampering preconception was his agreement with the scholastic view, which in other ways he assailed vehemently, that the end of all science and philosophy was to elucidate and adorn their queen, theology. Hence came some of the confusion and the inconsistencies which at every turn are seen in his writings, mixed with originality

<sup>1</sup> S. H. Thomson, *Isis*, No. 74, Aug. 1937, p. 219.

Roger Bacon

and insight far beyond his time and even in advance of the next three centuries. Struggle as he might, he never cast off the mediaeval habit of mind.

It is one of the signs of Bacon's greatness that he realized the importance of a study of mathematics both as an educational exercise and as a basis for other sciences. Mathematical treatises translated from the Arabic were becoming available. They often contained astrological applications. Astrology was a form of fatalism or determinism incompatible with the Christian doctrine of free-will, and mathematics and astrology were chiefly studied by Muhammadans and Jews. Hence both got a bad name and were associated with black arts. But Bacon, with the courage of his convictions, proclaimed that mathematics and optics, which he called perspective, must underlie other studies. Both these sciences, he says, are understood by Robert of Lincoln. Mathematical tables and instruments are necessary, though costly and liable to destruction. He pointed out the errors of the calendar, and calculated that it had gained one day in excess for each 130 years. He also gave a long description of the countries of the known world, estimated its size, and supported the theory of its sphericity. In this he influenced Columbus.

He seems to have become specially interested in light, probably through a study of the Latin version of the works of the Arabian physicist Ibn-al-Haitham. Bacon described the laws of reflection and the general phenomena of refraction. He understood mirrors and lenses and described a telescope, though he does not appear to have made one. He gave a theory of the rainbow as an example of inductive reasoning. He criticized the errors of physicians.<sup>1</sup>

He described many mechanical inventions, some actually known to him, and some as possibilities for the future, among the latter mechanically driven ships, carriages and flying machines. He considered magic mirrors, burning glasses, gunpowder, Greek fire, the magnet, artificial gold, the philosopher's stone, all in a confused mixture of fact, prediction and credulity. In the *Mirror of Alchemy* he still held the Alexandrian theory of all things striving towards improvement. "Nature", he wrote, "tries ceaselessly to reach perfection—that is, gold."

In trying to appraise the value of Bacon's work we must not forget that his fame would have rested on popular tradition of his magic had not Pope Clement commanded him to write his books. Doubtless others besides Bacon were touched by the same interests but have

<sup>1</sup> M. C. Welborn, *Isis*, No. 52, 1932, p. 26.

failed to leave direct traces. Indeed, reflections of the work of such men are found in Bacon's own writings, where he says, "There are only two perfect mathematicians, Master John of London, and Master Peter de Maharn-Cùria, a Picard". Master Peter recurs when Bacon deals with experiment.

There is one science, he says, more perfect than others, which is needed to verify the others, the science of experiment, surpassing the sciences dependent on argument, since these sciences do not bring certainty, however strong the reasoning, unless experiment be added to test their conclusions. Experimental science alone is able to ascertain what can be effected by nature, what by art, what by fraud. It alone teaches how to judge all the follies of the magicians, just as logic can be used to test argument. This method of experiment no one understands save Master Peter alone; he, indeed, is *dominus experimentorum*, but cares neither to publish his work, nor for the honours and riches (or perhaps the dangers) it would bring.

But whatever be the truth about these phantom figures which flit across Bacon's pages, it is clear that Friar Roger himself was in spirit a man of science and a scientific philosopher, born out of due time and chafing unconsciously against the limitations of his own restricted outlook, no less than against the external obstacles at which he rails so openly and so often; a true harbinger of the ages of experiment, of whom Somerset, Oxford and England may well be proud.

Roger Bacon's criticism of the Scholasticism of Aquinas, though sound from the modern point of view, was out of harmony with the prevailing spirit of the time, and consequently produced little effect.

*The Decay of  
Scholasticism*

Much more damaging were the philosophic attacks on Scholasticism which began towards the close of the century. Duns Scotus (c. 1265-1308), who taught at Oxford and Paris, enlarged the theological ground which even Aquinas had reserved as beyond the demonstration of reason. He based the leading Christian doctrines on the arbitrary Will of God, and took free-will as the primary attribute of man, placing it high above reason. Here is the beginning of a revolt against the union of philosophy and religion which the Scholastics sought, and his age believed Thomas Aquinas to have finally and conclusively achieved. A revival of dualism appears, essentially unsatisfying and incomplete, yet necessary as a stage of progress in order that philosophy may be set free from its bondage as the "handmaid of theology", free in fertile union with experiment to give birth to science. At the end of the thirteenth century and at the beginning of the fourteenth the Thomists and Scotists divided the philosophical

and theological world between them, while, on the literary side, a definite revolt against the shackles of authority appeared in Italy.

The process begun by Duns Scotus went much further in the writings of William of Occam, a native of Surrey (d. 1347), who denied that any theological doctrines were demonstrable by reason, and showed the irrational nature of many of the doctrines of the Church. He attacked the extreme theory of papal supremacy, and headed a revolt of Franciscans against the control of Pope John XXII. His writings in defence of this action led to his trial for heresy and imprisonment at Avignon. He escaped, however, and sought the protection of the Emperor Louis of Bavaria, whom he aided in a long controversy with the Pope.

This principle of the twofold nature of truth, the acceptance by faith of the doctrines of the Church, and the examination by reason of the subjects of philosophy, was bound up with the revival of nominalism, a belief in the sole reality of individual things, and the reference of universal ideas to the rank of mere names or mental concepts, a view held especially by Jean Buridon of Paris (c. 1350). In their efforts to derive the individual from the universal, the realists had been led to one abstraction after another. This complication was criticized in a statement called "Occam's razor," *Entia non sunt multiplicanda praeter necessitatem*. Here is a forecast of the modern objection to unnecessary hypotheses. By the revival of nominalism stress was laid on the objects of immediate sense perception, in a spirit that distrusted abstractions and made eventually for direct observation and experiment, for inductive research.

The new nominalism was opposed and banned by the Church, and Occam's writings condemned by the University of Paris, which tried to impose realism as late as 1473. But irresistibly the doctrine spread, and a few years afterwards the show of resistance was abandoned. Chancellors of the Universities and Cardinals of the Church became nominalists, and Martin Luther based much of his teaching on the writings of Occam. Finally Rome returned to the modified realism of Aristotle, and in 1879 an encyclical message from Pope Leo XIII re-established the Wisdom of Saint Thomas Aquinas as the official Roman philosophy.

Nevertheless, the work of Occam marked the end of the mediaeval dominance of Scholasticism. Thenceforward philosophy was more able to press home its enquiries free from the obligation to reach conclusions foreordained by theology, and, on the other side, religion was for a time detached from rationalism, and was given an opportunity

for the development of its no less important emotional and mystical aspects. Hence the fourteenth and fifteenth centuries saw the growth of a new mysticism, especially in Germany, and the appearance of many types of religious experience still known and of value.

Another prominent ecclesiastic who helped to overthrow Scholasticism was Cardinal Nicholas of Cusa (1401-1464), who maintained that all human knowledge is mere conjecture, though God can be apprehended by mystical intuition and comprehends all that is. This led Cusa to views which passed into a form of pantheism afterwards adopted by Bruno. In spite of his views about knowledge, Nicholas made notable advances in mathematics and physical science, and showed by the balance that a growing plant takes something of weight from the air. He proposed a reform of the calendar, made a good attempt to square the circle (i.e. to find a square equal in area to a given circle), and anticipated Copernicus by rejecting the Ptolemaic system and supporting the theory of the rotation of the Earth. Nicholas, Bruno and the astronomer Novara held that motion is relative and only number absolute,<sup>1</sup> thus, on the philosophic side too, preparing the way for Copernicus. Geographical knowledge was increased by Marco Polo of Venice (1254-1324) by his overland travels in Asia.

The task of the Middle Ages was accomplished; the ground was prepared for the Renaissance, with humanism, art, practical discovery, and the beginnings of natural science, as its characteristic glories. With the passing of the universal supremacy of Scholasticism we turn a new page in history.

To the historian of science mediaeval times are the seed-bed of modern growth. The Arabian school kept alive the memory of Greek learning and made considerable original contributions to our knowledge of nature. Both there and in the West the practical arts slowly made way, though with little repercussion on general thought. Distillation was practised from the twelfth century onwards, convex lenses for spectacles and other uses, mostly made in Venice, appeared about 1300, though concave lenses came two centuries later. Industry produced chemical reagents such as sulphuric and nitric acids. But systematic experiment made little progress, and it may be said that Western men of learning had no experimental science of their own till Roger Bacon wrote about it. Later some mathematicians appeared, especially Richard Swineshead (fl. 1350) and John Holbrook (d. 1437). But the interest for us of mediaeval thought in Europe is that of tracing

<sup>1</sup> L. R. Heath, *The Concept of Time*, Chicago, 1936.

the changing attitude of the human mind as it passes through states where science would have been impossible to a condition in which its rise follows naturally from the philosophic environment.

The exponents of Scholasticism took the attitude of interpreters; original experimental investigation would have been foreign to their ideas. Yet their rational intellectualism kept alive, indeed intensified, the spirit of logical analysis, while their assumption that God and the world are understandable by man implanted in the best minds of Western Europe the invaluable if unconscious belief in the regularity and uniformity of nature, without which scientific research would never be attempted. As soon as they had thrown off the shackles of scholastic authority, the men of the Renaissance used the lessons which scholastic method had taught them. They began observing in the faith that nature was consistent and intelligible, and, when they had framed hypotheses by induction to explain their observations, they deduced by logical reasoning consequences which could be tested by experiment. Scholasticism had trained them to destroy itself.

In a sense we have seen only the worst aspect of the Christian Middle Ages: they are weakest in the special department of thought necessary for scientific enquiry. We have but glanced at their work of forming and consolidating the nations of Europe. We have not touched on their wonderful achievements in literature and art. The *Chanson de Roland* is to us but a sign that culture has become national; the later romances of chivalry are outside our ken. Dante's *Divina Commedia* has for us little significance, save as the enshrinement in poetry of the concepts of Thomas Aquinas. The glories of cathedral architecture are to us but illustrations of the growth of the builder's art. Even mediaeval religion, which on its philosophic side has concerned us nearly, does not in its essence touch our enquiry. Its saving faith in its divine Founder, its spirit of humble reverence and love for all mankind, its message of salvation to suffering humanity, are hidden from our eyes. We meet Saint Bernard, the suspicious Inquisitor, but Saint Francis of Assisi, loving, joyous, simple-hearted, does not appear in our pages.