and a scheme of natural knowledge built up in a consistent manner, so that metaphysical ideas, though they may underlie the foundation of the ultimate conceptions, do not intrude between the parts of the building. Hence Aristotle’s explanations often turn directly on metaphysical ideas such as form, cause, substance, terms which do not occur (in the Aristotelian sense) in modern scientific terminology.

A century later than the time of Aristotle, Archimedes of Syracuse (287 to 212 B.C.) formulated the fundamental concep­tions of hydrostatics and took what may be regarded as the first step in the exact science of mechanics. The use of the lever must have been discovered at a very early date, and Archimedes set to work to in­vestigate its quantitative laws by the application of principles learnt from the geometers. He begins by laying down two axioms: (1) Equal weights placed at equal distances from the point of support of a bar will balance: (2) Equal weights placed at unequal distances do not balance, but that which hangs at the greater distance descends. The ancient philosophers based such axioms as the first of these two on the “ principle of sufficient reason.” No motion can take place, because, from the symmetry of the system, there is no reason why the balance should descend on one side more than the other. Even if we grant the theoretical validity of this principle, it is impossible to make sure without trial that the system in any given case is really symmetrical. Electrification of the bar, for instance, though imperceptible to our senses, would cause one end to descend if an oppositely electrified body were placed near that end; we cannot assume without trial that the position of the sun, or the colour of the arms, will not affect the result. Archimedes based the second axiom on the sounder ground of direct experience. On these two axioms he proceeded to construct an elaborate deductive proof of the numerical law of the lever, but, in the course of it, he assumed as known the principle of the centre of gravity. In reality, this principle is identical with that of the lever, and assuming one, implicitly we assume the other. Nevertheless, Archimedes’ proof is of use and interest. On the assumptions made, it shows the connexion between the general case of the lever with unequal arms, and the special and more familiar case when the arms are equal. Indeed, if we also treat the principle of the centre of gravity as an axiom known by experience, Archimedes’ proof is a true type of all scientific “ explanations ’’; it reduces an unfamiliar phenomenon to others already well known to our minds, which, creatures of habit as they are, regard the familiar cases as in ho need of explanation. Nowadays we should treat the law of the lever of unequal arms as one that is verified by direct and familiar experiment, and use it, in its

turn, as the starting point for further deduction.

Thus before the intellectual activity of Greece was absorbed by the utilitarianism of Rome, which, in its turn, was lost in the dark ages following the barbarian conquests, the seeds were sown which, germinating after the lapse of centuries, developed in the more fruitful soil of the age of experiment. But for a time they were buried, and only remembered by compendiums written just before the ancient light was wholly lost. During the dark ages, the contents of secular learning, based on those compendiums, settled down into the elementary “ trivium,” consisting of grammar, rhetoric and dialectic, and the more advanced “ quadrivium ’’ music, arithmetic, geometry and astronomy. Music included a half- mystical doctrine of numbers and the rules of plainsong; geo­metry consisted of a selection of the propositions of Euclid without the demonstrations; while arithmetic and astronomy were cultivated chiefly because they taught the means of finding Easter. Meanwhile, the early alchemists of Alexandria, by the aid of mystical analogies with the conceptions of astrology, were making primitive experiments on the transformations of various substances. It was probably from them that the “ sacred science” passed to the Arabs, among whom Geber (c. a.d. 750)

discovered many new chemical reactions and compounds.

With the intellectual revival which began in the 11th century, and the gradual recovery of some of the lost works of the ancient

writers, we turn a new page. The controversy between Plato and Aristotle upon the doctrine of ideas fascinated the minds of the middle ages, saturated as they were with the logical subtleties of dialectic. This controversy originated the long debate on the reality of universals, which absorbed the intellectual energies of many generations of men. Did reality belong only to the idea or universal—to the class rather than to the individual—to the common humanity of mankind, for instance, rather than to each isolated being? Or were the individuals the reality, and the universals mere names? In this question, trivial, almost meaningless, as it seems at first sight, logical analysis disclosed to the medieval mind the whole theory of the universe. Either answer contained danger to theological orthodoxy as then understood; hence the fervour with which it was debated. But, as communication with the East was reopened early in the 13th century, Latin translations of Aristotle’s works gradually were recovered; the whole of Aristotle’s philosophy was reimported into the schools of Europe, and reconciled and adopted by Christian theology. For three hundred years Aristotle reigned supreme in European thought, and exponents of the scholastic philosophy, ignoring their master’s teaching on the need of experiment, settled questions of fact as well as those of opinion by an appeal to his books. But outside the academic schools of the newly founded universities, experiment was kept alive by the labours of the alchemists, who, early in the 13th century, caught their ideas from the Arabs, and began to search for an *elixir vitae* and for a means of transmuting baser metals into gold. But alchemy never quite squared its account with orthodox theology, and the “ sacred science ” of the Alexandrians became associated in the medieval mind with the “ black art ” of witchcraft. Even a man like Roger Bacon, who, with some astrological mysticism, had a more modem idea of experiment both in chemical and physical problems, did not escape condemnation.

We now reach the period in the history of the world known as the Renaissance, when many converging streams of thought were given room to join by the increased material prosperity and improved political stability of the 15th and 16th centuries. The Renaissance was not, as it is sometimes represented, a sudden break with medievalism and a birth of the modem world. But a number of conditions favourable to rapid development happened to coincide, and, in the course of a century, men’s outlook on themselves and on nature became profoundly modified. The recovery of the Greek language, the voyages of Columbus, the decay of the Western and the passing of the Eastern empire, the temporary diminution in power of the papacy, the invention of printing, all tended to produce new ideas and to prepare men’s minds to accept the more human and naturalistic view of the universe which had been current among the Greeks, in place of the mystical aspect which it wore to the medieval schoolmen and ecclesiastics. At first the tendency was to substitute the authority of the ancients for the authority of the schoolmen, but gradually more independence of thought was secured; men like Leonardo da Vinci (1452-1519) began to experiment and to record their results; Nicolaus Copernicus (1473-1543) revived the heliocentric theory, and showed how the accumulated mass of astronomical observations could be interpreted by its means; and anatomy began again to be studied in the schools of medicine, gradually making its way in face of the prejudice against mutilating the human body.

The philosophy of the new experimental methods was first studied deeply by Francis Bacon (1561-1626). Sensible of the confused and disjointed information which then con­stituted the only scientific knowledge, Bacon set himself to describe a new method by which definite knowledge might be acquired with certainty. Warned by the failure of the scholastic methods, Bacon laid exclusive stress on experimental research, and it was perhaps natural that he should incline to the other extreme and ignore almost entirely the use of hypothesis and the deductive method. To arrive at the underlying causes, said Bacon, we must study the