14 EUCLID *fl. c.* 300 B.C.

Few persons on this list have earned such enduring fame as the great Greek geometer, Euclid. Although in their lifetimes such figures as Napoleon, Alexander the Great, and Martin Luther were much better known than Euclid, in the long run his fame will probably well outlast theirs.

Despite his reknown, almost none of the details of Euclid's life are known. We do know that he was active as a teacher in Alexandria, Egypt, in about 300 B.C. However, his dates of birth and death are uncertain, and we do not even know on which continent he was born, much less in which city. Although he wrote

several other books, some of which survive, his place in history rests primarily upon his great textbook of geometry, the *Elements*.

The importance of the *Elements* does not lie in any one of the individual theorems it demonstrates. Almost all of the theorems in the book had been known before Euclid, and a good many of the proofs as well. Euclid's great contribution was his arrangement of the material, and his formulation of the overall plan of the book. This involved, in the first place, the selection of a suitable set of axioms and postulates. (This was a very difficult task, requiring extraordinary judgment and great insight.) He then carefully arranged the theorems so that each followed logically from its predecessors. Where necessary, he supplied missing steps and developed missing proofs. It is worth noting that the *Elements*, while primarily a development of plane and solid geometry, also contains large sections on algebra and number theory.

The *Elements* has been used as a textbook for more than two thousand years, and is unquestionably the most successful textbook ever written. So superbly did Euclid do his work, that with the appearance of his book all prior geometry textbooks were superseded and promptly forgotten. Originally written in Greek, the *Elements* has since been translated into many other languages. The first printed edition appeared as early as 1482, only about thirty years after Gutenberg's invention of printing. Since then, over a *thousand* different editions have been published.

As an agent for training men's minds in the nature of logical reasoning, the *Elements* has been far more influential than any of Aristotle's treatises on logic. It is the outstanding example of a complete deductive structure, and as such has fascinated thinkers ever since its creation.

It is fair to say that Euclid's book was a major factor in the rise of modern science. Science is more than just a collection of accurate observations and shrewd generalizations. The great achievements of modern science come from a combination of empiricism and experimentation on the one hand, and careful analysis and deductive reasoning on the other.

We are not certain just why science arose in Europe rather than in China or Japan, but it is safe to say that it was not merely

by chance. Certainly, the roles played by such brilliant figures as Newton, Galileo, Copernicus, and Kepler were of tremendous importance. However, it seems likely that there were underlying reasons why men such as these flourished in Europe, rather than the Orient. Perhaps the most obvious historical factor predisposing western Europe to science was Greek rationalism, along with the mathematical knowledge that the Greeks had bequeathed.

To the Europeans, the idea that there were a few basic physical principles from which everything else could be deduced seemed quite natural, for they had the example of Euclid before them. (In general, Europeans did not consider the geometry of Euclid to be merely an abstract system: they believed that Euclid's postulates—and therefore his theorems—were actually true of the real world.)

All of the men just mentioned were steeped in the Euclidean tradition. Indeed, each of them had carefully studied the *Elements*, and it formed the basis of their mathematical knowledge. The influence of Euclid on Isaac Newton is particularly obvious, since Newton wrote his great book, the *Principia*, in a "geometric" form, similar to that of the *Elements*. Since then, many other Western scientists have emulated Euclid, by showing how their conclusions could all be logically derived from a small number of initial assumptions; so have many mathematicans, such as Bertrand Russell and Alfred North Whitehead; and philosophers, such as Spinoza.

The contrast with China is particularly striking. For centuries, its technology was more advanced than that of Europe. But there was never any Chinese mathematician corresponding to Euclid, and consequently the Chinese never possessed the theoretical structure of mathematics that the West did. (The Chinese had a good knowledge of practical geometry, but their geometric knowledge was never reformulated into a deductive scheme.) Euclid was not translated into Chinese until about 1600 A.D., and it took a few centuries for his conception of a deductive scheme of geometry to become widely known among educated Chinese. Until that happened, the Chinese did no serious work in science.

Similar statements might be made about Japan, where Euclid's work was unknown until the eighteenth century, and even

then not appreciated for a good many years. Though there are many excellent scientists in Japan today, there were none there before Euclid became known. One cannot help wondering whether the Europeans would have been able to create modern science had Euclid not prepared the way!

Today, mathematicians have come to understand that Euclid's geometry is not the only self-consistent geometrical system which can be devised; and during the past 150 years many non-Euclidean geometries have been constructed. Indeed, since Einstein's general theory of relativity has been accepted, scientists have realized that Euclidean geometry does not always hold true in the real universe. In the vicinity of black holes and neutron stars, for example, where the gravitational fields are extremely intense, Euclid's geometry does not give an accurate picture of the world. However, these cases are rather special; in most cases Euclid's geometry provides a very close approximation of reality.

These recent advances in human knowledge, in any case, do not detract from Euclid's intellectual achievement. Nor do they detract from his historical importance in the development of mathematics and in the establishment of the logical framework necessary for the growth of modern science.

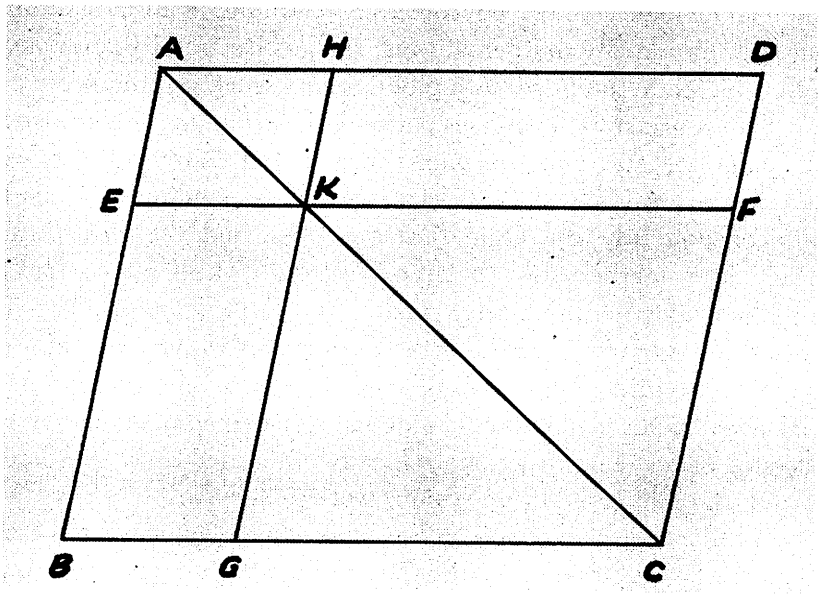

Diagram from a Euclidian geometric theorem.