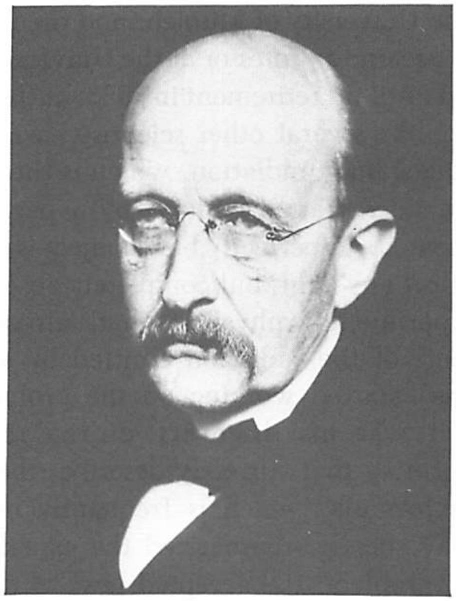

59 MAX PLANCK

1858-1947

In December 1900, the German physicist Max Planck startled the scientific world with his bold hypothesis that radiant energy (that is, the energy of light waves) is not emitted in a continuous flow, but rather consists of small chunks or lumps, which he called *quanta.* Planck's hypothesis, which conflicted with the classical theories of light and electromagnetism, provided the starting point for the quantum theories which have since revolutionized physics and provided us with a deeper understanding of the nature of matter and radiation.

Planck was born in 1858, in Kiel, Germany. He studied in the Universities of Berlin and Munich, and received his doctor's degree in physics *(summa cum laude)* from the University of Munich when he was twenty-one years old. For a while he taught at the University of Munich, and then at Kiel University. In 1889, he became a professor at the University of Berlin, where he remained until his retirement in 1928, at the age of seventy.

Planck, like several other scientists, was interested in the subject of black body radiation, which is the name given to the electromagnetic radiation emitted by a perfectly black object when it is heated. (A perfectly black object is defined as one that does not reflect any light, but completely absorbs all light falling on it.) Experimental physicists had already made careful measurements of the radiation emitted by such objects, even before Planck started working on the problem. Planck's first achievement was his discovery of the fairly complicated algebraic formula that correctly describes the black body radiation. This formula, which is frequently used in theoretical physics today, neatly summarized the experimental data. But there was a problem: the accepted laws of physics predicted a quite different formula.

Planck pondered deeply on this problem and finally came up with a radically new theory: radiant energy is only emitted in exact multiples of an elementary unit that Planck called the *quantum*. According to Planck's theory, the magnitude of a quantum of light depends on the frequency of the light (i.e., on its color), and is also proportional to a physical quantity that Planck abbreviated h, but that is now called Planck's constant. Planck's hypothesis was quite contrary to the then prevalent concepts of physics; however, by using it he was able to find an exact theoretical derivation of the correct formula for black body radiation.

Planck's hypothesis was so revolutionary that it doubtless would have been dismissed as a crackpot idea, had not Planck been well-known as a solid, conservative physicist. Although the hypothesis sounded very strange, in this particular case it did lead to the correct formula.

At first, most physicists (including Planck himself) regarded his hypothesis as no more than a convenient mathematical fiction. After a few years, though, it turned out that Planck's concept of the quantum could be applied to various physical phenomena other than black body radiation. Einstein used the concept in 1905 to explain the photoelectric effect, and Niels Bohr used it in 1913 in his theory of atomic structure. By 1918, when Planck was awarded the Nobel Prize, it was clear that his hypothesis was basically correct, and that it was of fundamental importance in physical theory.

Planck's strong anti-Nazi views placed him in considerable danger during the Hitler era. His younger son was executed in early 1945 for his role in the unsuccessful officers' plot to assassinate Hitler. Planck himself died in 1947, at the age of eighty-nine.

The development of quantum mechanics is probably the most important scientific development of the twentieth century, more important even than Einstein's theories of relativity. Planck's constant, *h*, plays a vital role in physical theory, and is now recognized as one of the two or three most fundamental physical constants. It appears in the theory of atomic structure, in Heisenberg's uncertainty principle, in radiation theory, and in many scientific formulas. Planck's original estimate of its numerical value was within 2 percent of the figure accepted today.

Planck is generally considered to be the father of quantum mechanics. Although he played little part in the later development of the theory, it would be a mistake to rank Planck too low. The initial breakthrough which he provided was very important. It freed men's minds from their earlier misconceptions, and it thereby enabled his successors to construct the far more elegant theory we have today.