The personal and professional lives of these two discoverers of the quantum were intertwined, yet their personalities and political philosophies could scarcely have been more different. To understand Planck, said his younger colleague Max Born, one must know about his ancestry of “excellent, reliable, incorruptible, idealistic, and generous men, devoted to the service of Church and (Prussian) State.” Disciplined, orderly, formal, and deeply patriotic, he worked at a stand-up desk, yet he was kind to students and friends. Planck had considered careers in classical philology and musical composition but eventually settled on physics. He moved by the conventional steps of a German academic career to become Professor of Physics in Berlin, where, from 1894 on, he concentrated on the problem of the interaction of radiation with matter. In the fall of 1900 he made his great discovery of quantization of energy. As he was walking in the woods with his son, he said, “Today I have made a discovery as important as that of Newton.”

Einstein, in contrast, rebelled against authoritarianism in both education and government. He was a citizen of the world but not a patriot of any country; he was fond of mankind in general, but not strongly attached to people around him. Though a prodigy in physics and mathematics, he left his school in Munich without a certificate, apparently because of his resentment of the regimentation of the education. At the age of 16 he passed the entrance exams of the Swiss Federal Polytechnic School (ETH) in Zurich, and embarked upon a four-year college course in physics (1896–1900). That same year he officially renounced his German nationality, thereby becoming a stateless person until he received Swiss citizenship seven years later. He graduated from the ETH, but was the one man in his class to fail to secure an academic post in physics, again apparently because of his independent attitudes. Through the help of one of his teachers he became a patent examiner at the Swiss Patent Office in Bern, work which allowed him to study physics in his spare time over the next five years. He published a few papers on statistical mechanics, and these earned him a Ph.D. from the University of Zurich in 1905. In this same year he wrote three major papers, each of which opened an entire area of physics. One was on the explanation of the photoelectric effect in terms of the quantitation of light. A second was his special theory of relativity, with the celebrated equation $E = mc^2$. A third was an explanation of Brownian motion in terms of atomic movements.

Planck and the rest of the physics establishment were quick to recognize Einstein’s genius, and soon he was invited to take up professorships at the University of Zurich (1909), Prague (1911), and the ETH in Zurich (1912). Then, in 1913 Planck and Nernst traveled to Zurich to implore Einstein to accept the position as Director of the Kaiser Wilhelm Institute of Physics in Berlin. Though this entailed
membership in the Prussian Academy of Sciences, and presumably Prussian citizenship, Einstein accepted.

Einstein's creativity continued in Berlin. He published his general theory of relativity in 1915, and its prediction that starlight is bent as it passes by the sun was dramatically confirmed during the solar eclipse in 1919. His paper on spontaneous emission of radiation in 1917 laid the theoretical groundwork of the laser. By the time he received the Nobel Prize in 1921 he was known beyond scientific circles. Indeed, the Nobel Prize was such a forgone conclusion that his first wife had asked for the prize money as a divorce settlement, even though the divorce occurred several years before the prize was awarded. In Berlin, Einstein met frequently with Planck on scientific matters, and the two also played chamber music with Planck at the piano and Einstein at the violin.

The responses to World War I of Planck and Einstein were entirely different. Planck signed the "Manifesto of the 93," disclaiming Germany's war guilt in the invasion of Belgium and stating that "were it not for German militarism, German culture would have been wiped off the face of the earth." In contrast, Einstein turned increasingly towards pacifism, and he worked for the establishment of a republic in Germany. His request to Planck to sign a statement calling for abdication of the Kaiser was rejected.

As anti-Semitism increased in Germany in the 1920s and early 1930s, Einstein identified himself with his Jewish ancestry, and worked increasingly for Jewish and Zionist causes. With the rise of the Nazis, Einstein became an object for abuse, and Professor Lennard, himself a Nobel Prize winner for his discovery of the photoelectric effect, led the attack. (One example: "...the dangerous influence of Jewish circles on the study of nature has been provided by Herr Ein-stein with his mathematically botched-up theories consisting of some ancient knowledge and a few arbitrary additions." ) When Hitler was voted into power in 1933, Einstein's bank account was seized, his apartment and summer house were confiscated, and a book was published with his portrait and the words underneath, "Not yet hanged."

Planck as President of the Kaiser Wilhelm Society attempted to intercede with Hitler on behalf of the great German chemist Fritz Haber, who, like other academics of Jewish ancestry, had been dismissed from his job. Planck reminded Hitler that Haber had saved the German First World War effort with his process for nitrogen fixation from the air. This provided nitrates for fertilizer and explosives when imports were cut off. But Hitler's reaction was a violent outburst against Jews in general. Planck withdrew, probably deciding he must keep peace with the powers to save German science and learning from complete destruction. At the annual meeting of the Kaiser Wilhelm Society in 1933 he read a message sent by the Society to Chancellor Hitler, "The Kaiser Wilhelm Society for the Advancement of the Sciences begs leave to tender reverential greetings to the Chancellor and its solemn pledge that German science is also ready to cooperate joyously in the reconstruction of the new national state."

Einstein and his family took refuge first in Belgium and then the United States, where he worked at the Institute for Advanced Study in Princeton. Undoubtedly his most far-reaching act was to persuade President Roosevelt to initiate an American effort to build an atomic bomb (see the sketches on Oppenheimer in Chapter 11 and Szilard in Chapter 14). Einstein's motivation was the fear that German scientists were on the way to a similar development. Einstein later told Linus Pauling, "I made one great mistake in my life—when I signed the letter to President Roosevelt."
Planck suffered much during the Second World War. His younger son, who held a high government post, was implicated in the July, 1944 plot on Hitler’s life and was murdered by the Nazis. His older son had been killed in the First World War. His house in Berlin was destroyed in an air raid on Berlin, and he lost everything, including his library.

When in 1947 Einstein learned of Planck’s death, he wrote to Mrs. Planck, “Your husband has come to the end of his days after doing great things and suffering bitterly. It was a beautiful and fruitful period that I was allowed to live through with him. His gaze was directed on eternal truths, yet he played an active part in all that concerned humanity and the world around him. . . . The hours which I was allowed to spend in your house, and the many close conversations which I had with your dear husband, will remain among my happiest memories for the rest of my life. Nothing can alter the fact that a tragic event has affected us both. . . . From this distant place I share your grief and greet you with all the former affection.”

**Bohr Explained the Spectrum of the Hydrogen Atom**

Planck’s success with a radical approach to the blackbody radiation problem established the precedent that physicists can allow themselves a limited number of ad hoc or unfounded assumptions if these lead to solution of a problem that has not been explained by classical methods. In 1913 Niels Bohr explained the spectrum of light emitted by hydrogen atoms. The problem he faced, and his explanation of it, are sketched in Figure 10-6. Rydberg had

![Diagram of Bohr's model of the hydrogen atom](image)

**Figure 10-6**

(a) The light emitted by the hydrogen atom occurs at discrete wavelengths (λ), which can be described by the equation $1/\lambda = R_0\left(1/n_e^2 - 1/n_i^2\right)$, in which $R_0$ is the Rydberg constant, and $n_i$ and $n_e$ are integers (1, 2, 3, . . .). (b) Bohr’s model for the hydrogen atom. An electron of mass $m$ and charge $-e$ travels in a circular orbit around a heavy nucleus of charge $+e$. Quantization of the angular momentum, $L = mvr = nh/2\pi$, leads to the emission lines observed in (a).