As the nineteenth century came to a close, physicists were in an upbeat mood. The discoveries of Roentgen, Becquerel, and the Curies—x-rays, penetrating radiation, and the transmutation of elements—had capped a triumphant century in the laboratory. On the theory side, Hamilton, Jacobi, and others had solved the problems of rigid bodies and constrained motions, completing Newton’s program in mechanics. Faraday and Maxwell had unified electricity, magnetism, and optics at one stroke in their continuum theory of the “aether.” True, these two great edifices were somewhat askew at the join, and the building labeled “atomic structure” remained an empty shell. But only a few physicists worried about that.

A senior scientist judged the result, remarking that since all the basic theories were known, the primary task of physicists in the future would be to make ever-more refined measurements of the fundamental constants. Yet a mere five years would pass before a clerk at a Swiss patent office mailed papers to a German journal suggesting that neither house of nineteenth-century theoretical physics rested on firm foundations. As for atomic structure, hopes for a quick solution would be dashed almost
before physicists had completed their year-end salutations and gone back to the laboratories.

In 1899, the English physicist J. J. Thomson demonstrated that certain rays seen in electric discharges were actually streams of minute corpuscles, each carrying the identical amount of negative electric charge. A term proposed earlier by the Irish physicist George Stoney for a hypothetical discrete unit of charge, the “electron,” was adopted for the new particle. (The obscurity of this scientific field at the time is perfectly captured by the toast once offered in Cambridge: “The electron—may it never be of any use to anyone!”) Theorists immediately speculated that the atom was made up of electrons. This was only natural, but as atoms are normally found in an electrically neutral state, positive electricity had also to reside somewhere in the atom. Thomson favored a uniform background of positive charge in which the electrons swam like minnows in a pond; others proposed that another particle, not yet discovered, carried the positive charge. There was even speculation, anticipating Rutherford by a decade, that the atom was a miniature solar system, with a positively charged central “sun” around which the negatively charged “planets” (electrons) revolved.

These proposals had to surmount two obstacles to atomic modeling—one theoretical and one experimental. The theoretical difficulty concerned stability. Before treating any of the transformations to which atoms are prone, theorists had first to explain the relative permanence of atoms. (By way of analogy, a historian who sets out to explain why an empire of a thousand years finally collapsed should explain first why it survived for so long.) A theorem from electrostatics stated that no system of stationary charged particles could be stable. Therefore, the electrons had to move. Obviously they could not move in straight lines, since the atom would fly apart. So their trajectories must be curved, but now Maxwell’s theory of the electromagnetic field caused headaches. A particle moving in a curved orbit is accelerated (according to Newton) and, if charged, must continuously radiate electromagnetic waves (according to Maxwell). But electrons in atoms did nothing of the sort: atoms were observed to persist in stable states, without radiating, for indefinite periods.