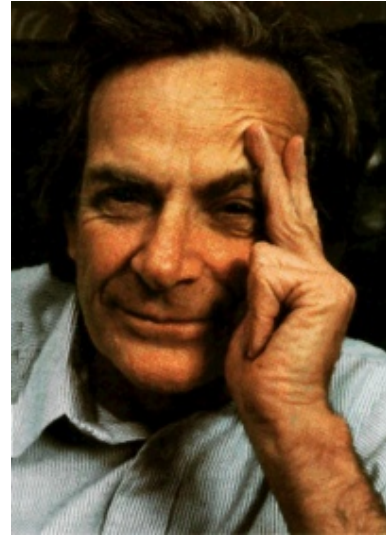


# Richard Feynman

**Richard Phillips Feynman** ([May 11, 1918](#) – [February 15, 1988](#)) ([surname](#) pronounced "fine-man") was one of the most influential [American physicists](#) of the [20th century](#), expanding greatly the theory of [quantum electrodynamics](#). As well as being an inspiring lecturer and amateur [musician](#), he helped in the development of the [atomic bomb](#) and was later a member of the panel which investigated the [Space Shuttle Challenger](#) disaster. For his work on [quantum electrodynamics](#), Feynman was one of the recipients of the [Nobel Prize in Physics](#) for [1965](#), along with [Julian Schwinger](#) and [Sin-Itiro Tomonaga](#).

He is also famous for his many adventures, detailed in the books *Surely You're Joking, Mr. Feynman!*, *What Do You Care What Other People Think?* and *Tuva Or Bust!*. Richard Feynman was, in many respects, an [eccentric](#) person and free spirit.



Richard Feynman: Nobel Prize winning physicist.

# Biography

Feynman was born in Far Rockaway, [Queens](#), New York; his parents were [Jewish](#), although they did not practice [Judaism](#) as a religion. The young Feynman was heavily influenced by his father who encouraged him to ask questions in order to challenge orthodox thinking. His mother instilled in him a powerful sense of humor which he kept all his life. As a child, he delighted in repairing radios and had a talent for engineering topics. He kept experimenting on and re-creating mathematical topics, such as the *half-derivative* (a mathematical *operator*, which when applied twice in succession, resulted in the [derivative](#) of a [function](#)), utilizing his own notation, before entering college. (Thus, even while in high school, he was developing the mathematical intuition behind his [Taylor series](#) of [mathematical operators](#).) His habit of direct characterization would sometimes disconcert more conventional thinkers; one of his questions when learning feline anatomy was "Do you have a map of the cat?". When he spoke, it was with clarity.

Feynman received a [bachelor's degree](#) from the [Massachusetts Institute of Technology](#) in [1939](#), and a [PhD](#) from [Princeton University](#) in [1942](#); his thesis advisor was [John Archibald Wheeler](#). After Feynman completed his thesis on quantum mechanics, Wheeler showed it to Einstein, but the latter was unconvinced. While researching his Ph.D, Feynman married his first wife, Arline Greenbaum, who had been diagnosed with [tuberculosis](#), a terminal illness at that time; they were careful, and Feynman never contracted TB.

At Princeton, the physicist Robert R. Wilson encouraged Feynman to participate in the [Manhattan Project](#)—the wartime [U.S. Army](#) project at [Los Alamos](#) developing the atomic bomb. He visited his wife in a sanitarium in [Santa Fe](#) on weekends, right up until her death in July [1945](#). He immersed himself in work on the project, and was present at the [Trinity](#) bomb test. Feynman claimed to be the only person to see the explosion without the dark glasses provided, looking through a truck windshield to screen out harmful [ultraviolet](#) frequencies.



Feynman worked on the top-secret [Manhattan Project](#) and witnessed the first atomic detonation at the [Trinity site](#) in [1945](#).

As a junior physicist, his work on the project was relatively removed from the major action (consisting mostly of administering the [computation](#) group of human [computers](#) in the Theoretical division, and then, with [Nicholas Metropolis](#), setting up the system for using IBM [punch cards](#) for computation). Feynman actually succeeded in solving one of the equations for the project which were posted on the blackboards.

However "They didn't do the physics right" and Feynman's solution was not used in the project.

Los Alamos was isolated; in his own words, "There wasn't anything to *do* there". Bored, Feynman found pastimes such as [picking locks](#), breaking into safes and leaving mischievous notes to prove that the security at the lab was not as good as people would like to believe; as a drummer, he would find an isolated section of the [mesa](#) to drum Indian-style; "and maybe I would dance and chant, a little". These antics did not go un-noticed, but no

one knew who the figure in the far distance was, not knowing that "Injun Joe" was actually Feynman. He became a friend of laboratory head [J. Robert Oppenheimer](#), who unsuccessfully tried to court him away from his other commitments to work at the [University of California, Berkeley](#) after the war.

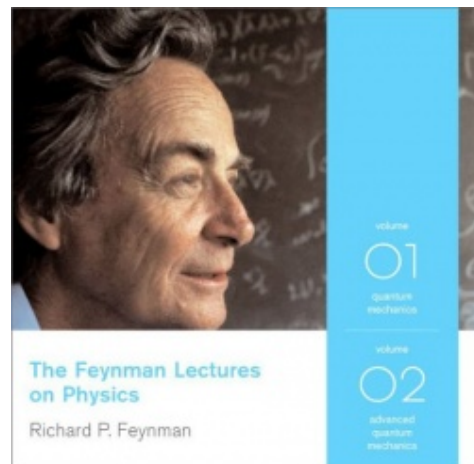
After the project, Feynman started working as a [professor](#) at [Cornell University](#), where [Hans Bethe](#), the formulator of [nuclear fusion](#) worked. However he felt uninspired there; despairing that he had burned out, he turned to more concrete problems, such as analyzing the physics of a twirling, [nutating](#) dish, as it is being balanced by a juggler. As it turned out, this work served him in future researches. He was therefore surprised to be offered professorships from competing universities, eventually choosing to work at the [California Institute of Technology](#) at [Pasadena, California](#), despite being offered a position near [Princeton](#), at the [Institute for Advanced Study](#) (which included, at that time, such distinguished faculty as [Albert Einstein](#)).

Feynman rejected the Institute on the grounds that there were no teaching duties. Feynman found his students to be a source of inspiration and also, during uncreative times, comforting. He felt that if he could not be creative, at least he could teach.

Feynman is sometimes called the 'Great Explainer'; he took great care when explaining topics to his students, making it a moral point *not* to make a topic arcane, but accessible to others. Thus *clear thinking* and *clear presentation* were fundamental prerequisites for his attention. It could be perilous to even approach him when unprepared, and he did not forget who the fools or pretenders were. On one sabbatical year, he returned to Newton's *Principia* to study it anew; what he learned from Newton, he also passed along to his students, such as Newton's attempted explanation of [diffraction](#).

Feynman did much of his best work while at Caltech, including research in:

- [Quantum electrodynamics](#). The problem for which Feynman won his [Nobel Prize](#) involved the probability of quantum states changing. He helped develop a [functional integral formulation](#) of quantum mechanics, in which every possible path from one state to the next is considered, the final path being a *sum* over the possibilities.
- Physics of the [superfluidity](#) of supercooled liquid [helium](#), where helium seems to display a lack of [viscosity](#) when flowing. Applying the [Schrödinger equation](#) to the question showed that the superfluid was displaying quantum mechanical behavior observable on a macroscopic scale. This helped enormously with the problem of [superconductivity](#).



Feynman the 'Great Explainer': *The Feynman Lectures on Physics* found an appreciative audience beyond the undergraduate community.

- [Weak decay](#), which shows itself in the decay of a [neutron](#) into an [electron](#), a [proton](#), and an anti-[neutrino](#). Developed in collaboration with [Murray Gell-Mann](#), the theory was of massive importance, and resulted in the discovery of a new force of nature (the [weak interaction](#)).

He also developed [Feynman diagrams](#), a *bookkeeping device* which helps in conceptualising and calculating interactions between [particles](#) in [spacetime](#). This device allowed him, and now others, to work with concepts which would have been less approachable without it, such as time reversibility and other fundamental processes. These diagrams are now fundamental for [string theory](#) and [M-theory](#), and have even been extended topologically. Feynman's mental picture for these diagrams started with the *hard sphere* approximation, and the interactions could be thought of as *collisions* at first. It was not until decades later that physicists thought of analyzing the nodes of the Feynman diagrams more closely. The *world-lines* of the diagrams have become *tubes* to better model the more complicated objects such as *strings* and *M-branes*.

From his diagrams of a small number of particles interacting in [spacetime](#), Feynman could then [model](#) *all of physics* in terms of those particle's [spins](#) and the range of coupling of the fundamental forces. But the [quark](#) model was a rival to Feynman's parton formulation. Feynman did not dispute the quark model; for example, when the 5th quark was discovered, Feynman immediately pointed out to his students that the discovery implied the existence of a 6th quark, which was duly discovered in the decade after his death.

After the success of quantum electrodynamics, Feynman turned to quantum gravity. By analogy with the photon, which has spin 1, he investigated the consequences of a free massless spin 2 field, and was able to derive the [Einstein field equation](#) of general relativity, but little more. Unfortunately, at this time he became exhausted by working on multiple major projects at the same time, including his *Lectures in Physics*.

While at Caltech Feynman was asked to "spruce up" the teaching of undergraduates. After three years devoted to the task, a series of lectures was produced, eventually becoming the famous *Feynman Lectures on Physics*, which are a major reason that Feynman is still regarded by most physicists as one of the greatest *teachers* of physics ever. Feynman later won the Oersted Medal for teaching, of which he seemed especially proud. His students competed keenly for his attention; once he was awakened when a student solved the problem and dropped it in his mailbox at home; glimpsing the student sneaking across his lawn, he could not go back to sleep, and he read the student's solution. That morning, at breakfast, he was again interrupted by a triumphant student, but he informed him that he was too late.

Feynman was a keen and influential popularizer of physics in both his books and lectures, notably a talk on [nanotechnology](#) called [Plenty of Room at the Bottom](#). Feynman offered \$1000 prizes for two of his challenges in nanotechnology. He was also one of the first scientists to realise the possibility of [quantum computers](#). Though he never actually wrote any books, many of his lectures and other miscellaneous talks were turned into books such as *The Character of Physical Law* and *QED: The Strange Theory of Light and Matter*. He would give lectures which his students would annotate into books, such as *Statistical Mechanics* and *Lectures on Gravity*. The

*Lectures on Physics* took a physicist, Robert B. Leighton, as full-time editor a number of years.

Feynman's first wife died while he was working on the Manhattan project. He married a second time, to Mary Louise Bell of Neodesha, Kansas in June, 1952; this marriage was brief and unsuccessful. Feynman did not work only on physics, and had a large circle of friends from all walks of life, including the arts. He later married the British Gweneth Howarth, who shared his enthusiasm for life. Besides their home in [Altadena, California](#), they had a beach house in [Baja California](#). They remained married for life, and had a child of their own, [Carl](#), and adopted a daughter, Michelle. Feynman had a great deal of success teaching Carl using discussions about *ants* and *Martians* as a device for gaining perspective on problems and issues; he was surprised to learn that the same teaching devices did not apply for Michelle. Mathematics was a common interest for father and son; they both entered the [computer](#) field as consultants. The [Jet Propulsion Laboratory](#) would retain Feynman as a computational consultant during critical missions. One familiar coworker characterized Feynman as akin to *Don Quixote* at his desk, rather than at a computer workstation, ready to do battle with the windmills.

Feynman travelled a lot, notably to [Brazil](#), and near the end of his life schemed to visit the obscure [Russian](#) land of [Tuva](#), a dream that, due to [Cold War](#) bureaucratic problems, never succeeded. During this period he discovered that he had a form of [cancer](#), but, thanks to surgery, he managed to hold it off.

Feynman had very liberal views on [sexuality](#) and was not ashamed of admitting it. In *Surely You're Joking, Mr. Feynman!*, he explains that he enjoyed hostess bars and topless dancing, and drew a decoration for a massage parlor. He also explains how he learned to play [drums](#) in acceptable [samba](#) style in Brazil (by persistence and practice). Such actions got him a reputation of [eccentricity](#). In addition, he admitted to being a [cannabis](#) user as well as having experimented with [LSD](#).

Feynman was requested to serve on the presidential Rogers Commission which investigated the [Challenger](#) disaster of [1986](#). Tactfully fed clues from a source with inside information, Feynman famously showed on television the crucial role in the disaster played by the [booster's](#) O-ring flexible gas seals with a simple demonstration using a glass of ice water and a sample of o-ring material. His opinion of the cause of the accident differed from the official findings, and were considerably more critical of the role of management in sidelining the concerns of engineers. After much petitioning, Feynman's minority report was included as an appendix to the official document. The book *What Do You Care What Other People Think?* includes stories from Feynman's work on the commission. His engineering skill is reflected in his estimate of the reliability of the Space Shuttle (98%), which is unhappily reflected in the 2 failures over the 100-odd flights of the Space Shuttle as of [2003](#). However good he was at engineering, Feynman always drew a careful



Feynman served on the commission investigating the [1986 Challenger disaster](#).  
*"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."*

distinction between [science](#) and [technology](#).

The cancer returned in [1987](#), with Feynman entering hospital a year later. Complications with surgery worsened his condition, whereupon Feynman decided to die with dignity and not accept any more treatment. He died on [February 15, 1988](#).