

Francis Harry Compton Crick (1916-2004)

Francis Harry Compton Crick, who co-discovered the structure of deoxyribonucleic acid (DNA) in 1953 in Cambridge, England, also developed The Central Dogma of Molecular Biology, and further clarified the relationship between nucleotides and protein synthesis. Crick received the Nobel Prize in Physiology or Medicine that he shared with James Watson and Maurice Wilkins in 1962 for their discovery of the molecular structure of DNA. Crick's results on the genetic material found in all living organisms advanced theories of inheritance and spurred further studies into the field of genetics and embryology.

Crick was born on 8 June 1916, the elder of two sons, to Anne Elizabeth Wilkins and Harry Crick in Northampton, England. Crick won a scholarship to attend a preparatory high school in North London, England at Mill Hill School. After four years, he attended University College in London, England where he pursued dual degrees in physics and mathematics.

Crick graduated from University College in 1937 with a second-class honors degree in physics, and he remained at University College to further pursue a PhD in the same field. He worked with Edward Neville da Costa Andrade on a project that examined the viscosity of water at high temperatures and various pressures. The onset of World War II halted the project. In 1940, Crick served on the scientific staff of the British Admiralty designing magnetic and acoustic mines used in naval warfare. By the end of the war, Crick was part of the scientific intelligence department of the British Admiralty Headquarters in Whitehall, England, where he helped design more weapons. Crick married Ruth Doreen Dodd in 1940 and they had one son, Michael F. C. Crick before they divorced in 1947.

Crick resumed his formal education in 1947 at the end of the war. Crick began studies in biology, neurology and consciousness, influenced by physicist Erwin Schrödinger's 1944 book *What Is Life?* Crick focused on an theory presented by Schrödinger, that an understanding of a gene would reveal many of life's mysteries, specifically about consciousness.

Crick began his biological studies at Strangeways Laboratory, in Cambridge, England. Under the direction of Arthur Hughes, Crick studied the physical properties of cytoplasm, or the material surrounding the nucleus, of a chick's cell. Two years later, in 1949, Crick transferred to the Medical Research Council Unit at the Cavendish physics laboratory in Cambridge to work with John Kendrew and Max Perutz, the laboratory director. Crick studied the structure of proteins using x-ray crystallography, a method of capturing a diffraction pattern on photographic film after molecules are exposed to x-rays. Also in 1949 Crick married Odile Speed, with whom he later had two daughters, Gabrielle A. Crick and Jacqueline M.T. Crick. In 1951, James Watson, a US postdoctoral fellow, joined the Cavendish Laboratory. Though never assigned to work together, Crick and Watson both studied the structures and functions of genes and DNA.

In nearby King's College, London, Maurice Wilkins and Rosalind Franklin were working on a similar project, using x-ray crystallography to determine the three-dimensional structure of DNA. By shining x-rays at a DNA crystal and measuring the angles at which the x-rays diffracted, researchers could roughly estimate the shape of DNA. Both Crick and Watson knew of Franklin and Wilkins's work and Crick urged Wilkins and Franklin's group to build experimental models of the DNA. Wilkins and Franklin favored experimental approaches with crystallography that revealed structure in photographs over model building. Franklin and Wilkins continued with their experiments, independent of Crick and Watson.

After two years of urging the King's College group to build models from their own data, Crick and Watson began building models of DNA in 1953 using the King's College group's crystallography

results. By examining the data collected by Franklin, Wilkins, and the King's College group, Crick and Watson interpreted the information and proposed structures of DNA. Crick and Watson built a model of DNA with a twisting ladder form, called a double helix. Throughout the spring and summer of 1953, Crick and Watson wrote four papers summarizing their discovery of the double helical, three-dimensional structure of DNA and its replication, and they described base pairing in DNA. On 25 April 1953, their first article appeared in the journal *Nature* alongside the experimental results from Wilkins, Franklin, and their colleagues, results that supported Crick and Watson's proposed model. When deciding how best to credit their discovery, Watson won a coin toss giving him priority naming in the authorship, thus immortalizing the Watson-Crick model of DNA.

After Watson and Crick's depiction of the structure of DNA, molecular biologist Sydney Brenner joined Crick at the Cavendish laboratory and together they focused on DNA and genetic coding in bacterial viruses to ascertain the specifics of how nucleotides code for specific amino acids during protein synthesis. In 1957 Crick presented a paper to the Symposium of the Society for Experimental Biology, "On Protein Synthesis," in which he outlines the base structure of The Central Dogma. Crick argued that DNA is the material responsible for heredity and as such, must code for all the molecules needed for life. However, Crick questioned how DNA, which is located inside of the nucleus, could cause protein synthesis, which happens outside of the nucleus in the cytoplasm. Crick postulated that there must be some intermediate molecule that delivers the information from the DNA to the cytoplasm, specifically, RNA. Crick elaborated what he called linearity in the Central Dogma, which states that DNA information is transferred to RNA, which is translated into action in protein synthesis, explaining that once the genetic information reaches the protein form, it can never be reverted back to RNA or DNA.

The Central Dogma did not address how the nucleotides in RNA translate to amino acids in proteins. Continuing his research with Brenner in the Cavendish Laboratory, in 1961 Crick and his research team published a code between amino acids and units of three nucleotides. They published their results concurrently with similar results from the geneticist Marshall Warren Nirenberg at the US National Institutes of Health in Bethesda, Maryland. Crick coined the term codon to describe the three bases in a specific sequence code for an amino acid.

For about ten years from the mid-1960s while still at the Cavendish Laboratory, Crick researched in the fields of developmental biology and embryology. He studied how genes affected cellular growth, and thus, tissue, organ and organismal development. During this time he published "Diffusion of Embryogenesis" in 1970. Crick proposed that concentration gradients underlie many processes of embryological development. Crick's theories influenced developmental biologist Lewis Wolpert in London, England, who elaborated on Crick's works to establish new concepts such as the positional-value concept in the biological development of embryos.

In 1976, Crick began a sabbatical year at the Salk Institute for Biological Studies in La Jolla, California and in 1977 accepted a position as research professor there. He remained at the Salk Institute until his death conducting research in the field of neurobiology with the intent to elucidate human consciousness. His research produced *The Astonishing Hypothesis* in 1994, a book in which Crick explores the scientific study of consciousness and investigates concepts like free will and the human soul.

Crick received recognition through a number of awards in his lifetime for his contributions to molecular biology, including the Lasker Award in 1960, the Nobel Prize in Physiology or Medicine that he shared with James Watson and Maurice Wilkins in 1962 for their discovery of the molecular structure of DNA and its importance in transferring information in living organisms, and in 1975 the Copley medal from The Royal Society in the UK. He died of colon cancer on 28 July 2004 at the age of 88.

Sources

1. Brenner, Sydney, Leslie Barnett, Francis Crick, and Alice Orgel. "The theory of mutagenesis." *Journal of Molecular Biology* 3 (1961): 121-124. <http://profiles.nlm.nih.gov/ps/access/SCBCBH.pdf> (Accessed October 30, 2013).

2. Crick, Francis H.C. "On Protein Synthesis." *Symposia of the Society for Experimental Biology* 12 (1958): 138-63. <http://profiles.nlm.nih.gov/ps/access/SCBBZY.pdf> (Accessed October 30, 2013).
3. Crick, Francis H.C. "Diffusion in Embryogenesis." *Nature* 225 (1970): 420-2. <http://profiles.nlm.nih.gov/ps/access/SCBCCF.pdf> (Accessed October 30, 2013).
4. Crick, Francis H.C. *The Astonishing Hypothesis*. New York, NY: Touchstone, 1994.
5. Crick, Francis H.C., Leslie Barnett, Sydney Brenner, and R.J. Watts-Tobin. "General Nature of the Genetic Code for Proteins." *Nature* 192 (1961): 1227-32. <http://profiles.nlm.nih.gov/ps/access/SCBCBJ.pdf> (Accessed October 30, 2013).
6. "Crick, Francis (1916-)." *World of Microbiology and Immunology*. Ed. Brenda Wilmoth Lerner and K. Lee Lerner. Vol. 1. Detroit: Gale, 2003. 138-141. Gale Virtual Reference Library.
7. "Francis Crick - Biography". From *Nobel Lectures, Physiology or Medicine 1942-1962*, Amsterdam, Holland: Elsevier Publishing Company, 1964. http://www.nobelprize.org/nobel_prizes/medicine/laureates/crick.html (Accessed May 12, 2012)
8. "Francis Harry Crompton Crick." *Encyclopedia of World Biography*. 2nd ed. Vol. 4. Detroit: Gale, 2004. 310. Gale Virtual Reference Library.
9. Franklin, Rosalind. and Raymond G. Gosling. "Molecular Configuration in Sodium Thymonucleate." *Nature* 171 (1953): 740-741.
10. Magner, Lois N. "Francis Harry Compton Crick." *Science and Its Times*. Ed. Neil Schlager and Josh Lauer. Vol. 7: 1950 to Present. Detroit: Gale, 2001. 149-150. Gale Virtual Reference Library.
11. Martin, Robert G., J. Heinrich Matthaei, Oliver W. Jones, and Marshall W. Nirenberg. "Ribonucleotide composition of the genetic code." *Biochemical and Biophysical Research Communications* 6 (1961-2): 410-414
12. Robinson, Richard. "Crick, Francis." *Genetics*. Ed. Richard Robinson. Vol. 1. New York: Macmillan Reference USA, 2003. 192-4. Gale Virtual Reference Library.
13. Schrödinger, Erwin. *What Is Life?*. Cambridge: University of Cambridge Press, 1944.
14. "The Francis Crick Papers." *Profiles in Science*, National Library of Medicine. <http://profiles.nlm.nih.gov/ps/retrieve/Narrative/SC/p-nid/145/p-docs>true> (Accessed October 30, 2013).
15. Watson, James D., and Francis H. C. Crick. "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid." *Nature* 171 (1953): 737-8. <http://profiles.nlm.nih.gov/ps/access/SCBBYW.pdf> (Accessed October 30, 2013).
16. Watson, James D., and Francis H. C. Crick. "Genetical Implications of the structure of Deoxyribonucleic Acid." *Nature* 171 (1953): 964-7. <http://profiles.nlm.nih.gov/ps/access/SCBBYX.pdf> (Accessed October 30, 2013).
17. Wilkins, Maurice Hugh Frederick, Alex R. Stokes, and Herbert R. Wilson. "Molecular Structure of Deoxypentose Nucleic Acids." *Nature* 171 (1953) 738-740.
18. Wolpert, Lewis. "Positional Information and the Spatial Pattern of Cellular Differentiation." *Journal of Theoretical Biology* 25 (1969): 1-47.