

died on 12 August 2004 in Kingston upon Thames, England.

A quiet, unassuming person, Godfrey was born on 28 August 1919 in Newark, England, and grew up nearby on a farm in Sutton on Trent. Although he did not excel at school, he was known for experimenting with electronics and the farm's mechanical and electrical machinery, and for building a homemade hang glider to test the principles of flight from haystacks. When World War II broke out in 1939, he joined the Royal Air Force (RAF) and found himself building an oscilloscope and carrying out radar R&D.

Although Godfrey never received a PhD, he had enrolled in a college course just before the start of the war. Following his discharge from the RAF, he won a government grant to the Faraday House Electrical Engineering College in London, from which he graduated in 1951. That same year, he joined the research staff of Electric and Musical Industries (later known as EMI).

Godfrey could well have been remembered for his significant contribution to the computer field, because in 1958 he was responsible for the development of the first solid-state computer in the UK, the EMIDEC 1100. After that effort, he was asked to add his intellect to the area of pattern recognition, in which EMI had a project team.

One day around 1967, as he walked the countryside—an activity he was keen on doing—his work in the area of pattern recognition combined with his work in computers to spark the realization that if sufficient measurements were taken of an energy beam around an object, it should be possible to calculate the structure within the object.

Following the initial theoretical calculations, Godfrey constructed a laboratory model using a lathe bed. His early model used a gamma source placed on one side of the specimen object and a detector on the other. The specimen object was rotated 1 inch at the end of each sweep. Each scan generated 28 000 measurements, which were digitized and recorded onto paper tape that was then fed into a computer system for processing.

The early pictures were encouraging, but it took nine days to scan an object and 2-½ hours to process each scan on a computer. The result of the processing was paper-tape output that was used to modulate a spot of light on a cathode-ray tube in front of a camera to produce a photograph, a process that took an additional 2 hours.



Godfrey Newbold Hounsfield

One of the first pictures using Godfrey's model, an image of a human brain, was of a museum specimen and showed good gray-white matter differentiation. Unfortunately, further study showed that the formalin used to preserve the brain had caused the readings to be enhanced. Godfrey then took pictures of animal specimens and proved that differences within the brain could be clearly seen. He often recalled stories of traveling across London on the subway with bullocks' brains and parts of pig bodies in a carrier bag.

It was obvious that a long scan time would not be feasible for a clinical system. After some experimentation, Godfrey chose x rays as the energy source. He approached the Department of Health and Social Security in London for support in building the clinical prototype; Godfrey and his funding agency agreed on a scan time of 4 minutes and an accuracy of 0.5% in pixel density.

In 1971 at the Atkinson Morley Hospital in South London, a woman with a suspected brain tumor was the first human patient to undergo a scan. The resulting picture clearly showed a dark lesion. Godfrey was still reserved; he feared that would just be the luck of the first clinical experiment. Not until he had scanned several patients and processed the pictures did he become convinced that the system was going to be sensitive enough to distinguish between normal and abnormal brain tissue. Godfrey's model then evolved from being simply a brain scanner to the whole-body scanners with which we are familiar today. His R&D interests moved beyond computerized tomography to provide a significant contribu-

tion to the field of magnetic resonance imaging development.

The invention of the CT scanner revolutionized x-ray investigation, which had remained virtually static since the turn of the 20th century, following Wilhelm Konrad Roentgen's discovery of x rays. Certainly it was the most significant development in the field of neurological diagnosis since Walter Dandy's air encephalography in 1918. In recognition of his contribution to CT scanning technology, Godfrey's name was given to the absorption scale (Hounsfield units) that identifies the x-ray attenuation in CT images.

Godfrey headed EMI's medical systems section from 1972 to 1976, became a senior staff scientist in 1977, and retired from EMI in 1986. He received numerous awards, including a knighthood from Queen Elizabeth II in 1981.

Godfrey was a keen lover of jazz and played it on the piano. He was also an eccentric; one particular example of his eccentricity was his insistence on remaining on UK time wherever he was in the world. He was even known to insist on presenting a lecture at 10am Greenwich Mean Time, even if it meant the audience attended at what was the middle of the night locally.

He disliked lecturing, the publicity, and the public activities that the invention of CT gave him, and preferred instead to dedicate his time to his R&D projects. Whenever possible, he would decline requests for lecturing or find a colleague to fill in for him. He was passionate about his research and dedicated to increasing his knowledge and to looking for other areas in which technology could improve medicine.

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Fred Lawrence Whipple

At the first press conference after the *Stardust* spacecraft flew past comet Wild 2 in January 2004, a reporter asked, "What is a whipple?" Like Edwin Hubble, another great astronomer had become synonymous with a piece of space hardware. The first part of the answer was that a whipple is a Whipple bumper, a clever, lightweight structure invented by Fred Lawrence Whipple and designed

to protect the spacecraft from the 6-kilometer-per-second impact of comet rocks as large as a centimeter across. The second part was that Fred Whipple was the originator of our modern understanding of comets and a key reason why there was a mission to a comet. Whipple's icy-conglomerate model outlined why comets were made of ice and dust and not the tenuous particle swarms called flying sandbanks that they were previously imagined to be. Fred was a remarkable person whose long career spanned three-quarters of a century. He died in Cambridge, Massachusetts, on 30 August 2004 following a prolonged illness.

Fred was born on 5 November 1906 in Red Oak, Iowa. He studied at Occidental College in Los Angeles and received his AB in mathematics at UCLA in 1927 and completed his PhD in astronomy at the University of California, Berkeley, in 1931. He was an instructor at Stanford University in 1929, and, in 1931, became a staff member of the Harvard College Observatory in Cambridge, where he worked for more than 70 years.

From the beginning of his career, Fred had developed a strong and long-lasting interest in meteors. In the 1930s, he started the Harvard Meteor



Fred Lawrence Whipple

Project, which ultimately included measurements with both optical and radio methods. He was motivated early on by his belief that some meteors had hyperbolic orbits and came from other planetary systems. Fred calculated the radiant, an apparent source direction, of meteors coming from the star Sirius, but measurements of thousands of meteors did not yield unambiguous detection of extra-

solar meteors. (More recent work using spacecraft- and ground-based radar on smaller particles finally found the elusive extrasolar component that intrigued Whipple back in the 1930s.) In 1936, he made the first measurements of the atmospheric density at 60 km by determining the drag-induced deceleration of meteors.

Eleven years later—a decade before the first satellite launch—Fred first described his Whipple bumper in a paper published in the *Astronomical Journal*. In that short article, he calculated the meteoroid impact risk that future spacecraft would face. In two classic papers published in the *Astrophysical Journal* in 1950 and 1951, he described what comets are, how they evolve, and how they relate to meteor streams. His vision of comets as conglomerates made of dust and volatile ices, often called dirty snowballs, quantitatively explained the more than 1000-year lifetimes of periodic comets. The model also explained the odd behavior of comets that deviate slightly from purely gravitational orbits as being the result of the rocket effect of anisotropic sublimation and jetting of volatiles into space. Previous suggestions for the devious motions of comets had included the presence of an unknown

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resistive medium. Fred's two papers have been the most-cited works in the *Astrophysical Journal* during the past half century.

Fred became the director of the Smithsonian Astrophysical Observatory when it moved in 1955 to begin an association with the Harvard College Observatory. As director for the next 18 years, he helped to form the Harvard-Smithsonian Center for Astrophysics (CfA). He was a superbly innovative and imaginative scientist, an instigator, and a skilled administrator who also was involved with remarkable engineering feats. In addition to the invention of the meteor bumper, he is internationally famous for his work in World War II on aluminum foil chaff (code-named "window" by the British), shreds of aluminum foil that were dropped from aircraft as a countermeasure to Germany's radar. That work earned him the nickname "Chief of Chaff." Early in the war, he co-invented a cutter that would turn 3 ounces of aluminum foil into 3000 half-wave dipoles, and he also found optimum aspect ratios for the foil strips that would work over a range of radar frequencies. President Harry S Truman awarded Fred a Certificate of Merit in 1948 for that work.

Fred's earlier work on meteors and other natural space objects led him to artificial satellites and the birth of the US space program. That program officially began in 1954 when the Office of Naval Research asked Fred, Fred Singer, and Wernher von Braun to make specific proposals for the American satellite program, an effort that was part of the International Geophysical Year (1957-58).

Fred built a worldwide network of cameras to precisely track satellites with the intention of improving the global geodetic uncertainty from hundreds of meters to 10 meters. When the Soviet Union launched *Sputnik* in October 1957, one of the cameras was already set up and took precise data. Fred also set up Moonwatch, a global network of amateur astronomers using special Moonwatch telescopes, small refractors that looked downward at the image of the sky that was bounced off an upward-facing flat mirror. The Moonwatch program provided the first publicly available US information on Earth's first artificial satellite. The satellite effort evolved into a tracking network of elegant Baker-Nunn cameras that were optical marvels of the space age. In 1963, President John F. Kennedy gave Fred the Distinguished Federal Civilian Service award for his work contributing to the birth of the space age.

Fred remained quite active and influential until his death at age 97. He lectured to teachers and other attendees at the 1999 launch of the Stardust comet mission, and he was an official co-investigator of the Contour comet mission launched in 2002. He participated in the development of large multimirror telescopes; the Fred Lawrence Whipple Observatory on the summit of Arizona's Mt. Hopkins includes the 6.5-m Multiple Mirror Telescope, the Whipple 10-m Gamma Ray Telescope, and others.

In addition to his remarkable scientific, technical, and organizational contributions, Fred was also revered by colleagues for his ever-handy telescoping pointer, his car's "COMETS" license plate, and his outstanding collection of astronomical neckties. A small but spectacular collection of those ties is on permanent display at the visitor center at the base of the impressively winding road that leads to Whipple Observatory. For those who love comets, meteors, or any of the other many things on which Fred Whipple worked his magic, a pilgrimage to see his ties is highly recommended.

**Don Brownlee
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David Mervyn Blow

Biophysicist David Mervyn Blow played a pivotal role in the development of x-ray macromolecule crystallography. This discipline provides critical structural information for understanding the function of biological molecules and is particularly applicable in the field of drug design. David's contributions to this outstandingly successful field have led to the detailed structure determinations of thousands of proteins. He died of lung cancer on 8 June 2004 in Devon, England.

David was born in Birmingham, England, on 7 June 1931. After completing his education at Kingswood School in Bath, he interrupted his studies to serve in the Royal Air Force as a glider pilot. He then pursued an undergraduate physics degree at Corpus Christi College of Cambridge University.

From there he continued research in 1954 under the direction of Max Perutz at the renowned Cavendish Laboratory, where he worked on the structural elucidation of the protein hemoglobin. Having a strong mathematical background, David was able to develop methods for analyzing the diffraction data collected from horse hemoglobin.



NICK JACKSON

David Mervyn Blow

That effort led to the successful elucidation of one of the first protein structures. (The structure of myoglobin was determined by John Kendrew at approximately the same time.)

David was fortunate to be part of the Perutz laboratory during a dynamic and exciting period in the field of structural and molecular biology. Also present in the lab at the time were James Watson and Francis Crick, who shared the Nobel Prize in Physiology or Medicine in 1962 with Maurice Wilkins. Another lab member was Kendrew; he and Perutz won the 1962 Nobel Prize for Chemistry. Being in the company of such great minds influenced David considerably; he pursued further exciting work toward protein structure determination. One of his most important contributions, and indeed a seminal paper in the field, was a joint work with Crick on the development of methods for minimizing errors that arise in the so-called isomorphous replacement technique.

David next came to the US, where he spent two years as a Fulbright scholar at the National Institutes of Health and MIT. During that period, he and Michael Rossmann worked closely to develop a method of molecular replacement, a technique for determining the three-dimensional structures of proteins based on expected structural similarities to other proteins for which structures are already known. They published a series of classic papers describing the theory and mathematics of the technique, which remains one of the most powerful methods for structure determination today. David returned to the Cavendish Laboratory in 1959. In 1962, the Cavendish Medical Re-