Edmond Halley

English astronomer and mathematician **Edmond Halley** (November 8, 1656 – January 14, 1742) was a key figure in the English scientific community at the height of its creativity. He pioneered understanding of trade winds, tides, cartography, naval navigation, mortality tables, and stellar proper motions. In his most important scientific work, *A Synopsis of the Astronomy of Comets,* begun in 1682 and finished in 1705, Halley applied Newton's Laws of Motion to all available data on comets. His calculations led him to deduce that the comet he observed in 1682 was periodic and was the same comet that had appeared in 1607, 1531, 1456, 1380, and 1305. He published his prediction that it would reappear in 76 years. Halley achieved lasting fame, even though he had been dead for fifteen years, when the comet was observed on December 25, 1758. This was only a few days later than when Halley expected it. This demonstrated conclusively that comets were celestial bodies and not meteorological phenomena, as previously had been believed. The word "meteorology" comes from this mistaken idea of Aristotle. Figure 11.7 is a depiction of the orbit of Halley's' comet.

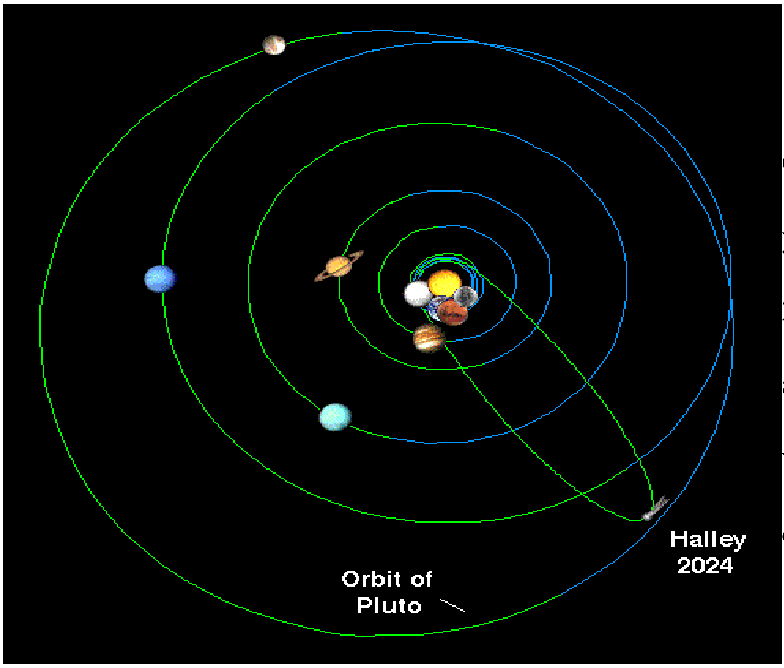

Figure 11.7

Comets have been known for thousands of years. Chinese records, dating from before 240 BCE, speak of "broom stars," which appeared in the sky for days and even weeks before disappearing. The name *comet* is derived from the Greek word *kometes*, which means “head of hair.” Comets are small objects of the solar system, usually a few miles in diameter, and have been described as “dirty snowballs.” They are composed of a solid nucleus of frozen ice, dust, a gaseous coma of water vapor, carbon dioxide, and other gases, and a long tail made of dust and ionized gases. They are believed to have been formed from the earliest materials of the solar system.   Aristotle believed that comets existed in the Earth’s atmosphere, but in 1577 Tycho Brahe proved that they were much more distant than that, belonging to space not Earth.

Halley was born at Haggerston in Shoreditch, near London, the eldest of three children. His birthday was October 26 by the Julian calendar, but November 8 according to the Gregorian calendar. His father was a prosperous merchant who owned a salting and soap-making business in London at a time the use of soap was becoming all the fashion throughout Europe. Even though Halley’s father suffered considerable losses during the Great Fire in 1666, he was wealthy enough to support his son’s scientific interests for the rest of his life. Halley’s mother died in 1672 and his father died in 1684, a victim of murder, although no one was ever charged with the crime. Halley was tutored at home before attending St. Paul’s School, where he distinguished himself in both mathematics and the classics. He entered Queen’s College, Oxford in 1673, and before the age of twenty communicated a paper on theoretical astronomy to the Royal Society. Even before arriving at Oxford, Halley was an expert astronomer. His father had encouraged his early interest in the subject by buying him the best scientific instruments.

In 1675 Halley became an assistant to John Flamsteed, the Astronomer Royal at the Greenwich Observatory. Halley traveled to the island of St. Helena, where he stayed two years, cataloguing the stars of the Southern hemisphere. His results were published as the *Catalogus Stellarum Australium* (1678). It was the first accurate catalogue of stars in the southern sky and also the first star survey determined with the use of a telescope. Flamsteed described Halley as the “southern Tycho.” Their initial amicable relationship later deteriorated due to a power struggle with Flamsteed on one side and

Newton and Halley on the other. The disagreement exploded when Halley edited Flamsteed's *Historia Coelestis Britannica* against the Astronomer Royal's wishes. The latter accused Halley of plagiarizing other astronomers and spent the rest of his life attempting to ruin Halley's reputation. In 1704 Halley succeeded John Wallis as Savilian Professor of Geometry at Oxford, a post he held until his death.

Halley's long and fruitful friendship with Newton began in 1684, when the astronomer paid him a visit at Cambridge to discuss Newton's views on planetary motion. What may have been Halley's most important scientific contribution was raising the relatively narrow question with Newton, as to what would be the shape of the orbit of a comet if the force of gravitation pulling on the comet were inversely proportional to the distance from the comet to the Sun? Without hesitation, Newton replied, "an ellipse." He told Halley that he had worked this out some 20 years earlier, but had never published it. His reluctance to do so was at least in part that he was still smarting from Robert Hooke's earlier criticism of Newton's theory of light. Halley had to sooth Newton's feelings to induce him to write his greatest work, the *Principia*. Halley persuaded Newton to publish it through the Royal Society of which Halley was clerk and editor. When the Royal Society could not afford to do so, Halley even arranged to pay for the printing of the book from his own funds.

Halley was a major astronomical figure of his time. He succeeded Flamsteed as Astronomer Royal in 1720 when he was 63 and commenced and completed an observation of the 19-year lunar cycle, which confirmed the secular acceleration of the Moon. Among his many other scientific accomplishments, Halley published the first meteorological chart of the winds on the Earth's surface in 1686, thus founding the field of scientific geophysics. He depicted the winds by short broken lines, each dash having a thick front and a pointed tail to indicate direction and formulated a relationship between height and air pressure. Between 1687 and 1720 Halley published seven papers on pure mathematics, ranging from higher geometry and construction and determination of the roots of equations to the computation of logarithms and trigonometric functions. When life insurance was in its infancy, there were several attempts to make a set of mortality tables. Halley was the author of one of the earliest, basing his on statistics of the city of Breslau, published by the Royal Society in 1693. Halley died at Greenwich of a circulatory disorder at age 86.

In 1757, French mathematician Alexis Clairaut and French astronomer Joseph Lalande, director of the Paris Observatory, set out to improve Halley's tables for his comet. They chose French astronomer Nicole-Reine Hortense Lepaute, a first-class mathematician, to determine the extent of the gravitational attraction of Jupiter and Saturn on the comet and the exact time of its return. If Halley was correct about the comet's return, there was little time for Lepaute to perform the enormous, meticulous calculations. She worked day and night for six months and determined that Saturn's' gravity would detain the comet by 100 days and Jupiter's gravity meant a delay of at least 518 days. The scientific trio found that Halley had made calculation errors that canceled each other out, making his prediction of the return of the comet essentially correct. They predicted that the comet would achieve perihelion (the point of its orbit nearest to the Sun) on April 13, 1759. They were off by only one month when the comet achieved perihelion on March 13, 1759. Thus Halley and the French scientists established that Newton's gravitational physics could foretell the future. Clairaut never publicly acknowledged the importance of Lepaute's contribution, while Lalande gave her full credit, and praised her not allowing being a good scientist to interfere with her being a good housewife.

On March 14, 1986, the space probe *Giotto* (named for Giotto Ambrogio di Bondone, whose famous 1304-nativity painting "Adoration of the Magi" depicted a comet believed to be Halley's), launched by the European Space Agency, and flew directly into the nucleus of Halley's Comet as the comet reached its perihelion. The probe relayed television footage as well as scientific readings to earth. Before its instruments were rendered unusable, Giotto's more than 2000 pictures showed the comet's nucleus to be 9.3 miles long, 6 miles wide, a coal-black, potato-shaped object marked by hills and valleys. Two bright jets of gas and dust, each 9 miles long, shoot out of the nucleus. Giotto's instruments found that the comet loses about thirty tons of water and five tons of dust every hour so it will eventually disintegrate.

Quotation of the Day: "Now we know

The sharply veering ways of comets, once

A source of dread, no longer do we quail

Beneath appearances of bearded stars."

- Edmond Halley