EDMOND HALLEY 1656 - 1742

EDMOND HALLEY, A FORGOTTEN POLYMATH

by

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The ephemeral nature of fame is one lesson to be drawn from the life of Edmond Halley (1656-1742). In 1986, 2062, 2148, ... his name will be on everyone's lips, his memory attached like another tail to his namesake, and like that tail the memory is without substance.

The popular image of Halley is probably that of a wizened eccentric (aren't all scientists both wizened and eccentric?) peering intensely through a telescope, making random sweeps of the heavens till, in one fortuitous moment he sees something strange .... As always the truth is otherwise. Halley <u>was</u> a man of action and substance, he was a giant who profoundly disturbed his universe. From about the age of 17 till his death at 86 he thought, experimented and wrote on a breathtaking variety of topics.. Let me mimic the Victorian style of biography by simply listing some of Halley's investigations. His first scientific paper (which appeared in <u>The Philosophical Transactions of the Royal Society</u> (1676) whilst he was still an undergraduate at Oxford) concerned the problem of determining the orbit of a planet from three observations. In addition to revealing a knowledge of astronomy this paper also exposed Halley's cleverness with the geometry of conics and spheres. This knowledge was invaluable in his expedition to St. Helena where he was the first to attempt to catalogue the southern stars. By 1682 he was working on one of the most important problems of the time: determining one's position at sea. For the rapidly growing, exploring, mercantile society that was seventeenth century England, the solution of this problem was crucial to its maritime survival. So crucial was it that governments and scientific academics alike offered substantial prizes for its solution. Determining latitude presented no real problem; as long as the sun shone the sextant could be used to find latitude. Longitude was more problematic; for its determination the sailor had to compute the difference between his local time and the time at some fixed standard meridian, say Greenwich. This latter calculation was the cause of maritime angst. Halley's partial solution used the regular motion of the moon as the hand of a clock measuring out standard time.

Halley undertook theoretical and, when the opportunity permitted, experimental investigations into the following problems:

- account for peculiar tidal phenomena;
- discover how gravity varies with height and with latitude;
- improve the range and accuracy of "gunnes";
- determine the earth's isogonics or curves of constant magnetic strength;
- investigate the variation of barometric pressure with height and hence find the height of the earth's atmosphere;
- explain the behaviour of winds;
- determine the age of the earth (by measuring the amount of salt in lakes possessing no outlets);
- discover the distribution of solar heat;
- understand rainbows (ill-understood to this day);
- determine with high precision the average distance to the sun;
- investigate the nature of heat, light and sound;
- improve the design of diving bells;
- determine, via astronomical tables, the place and exact date of Caesar's invasion of Britain;
- find new ways of solving cubic and quartic equations;

The full range of his talents and interests has only recently been unearthed. His Commonplace Book, consisting of thoughts and observations made when he was quite young lay unstudied by scholars until 1985. Its contents reveal how Halley "read and quoted the works of chemists, anatomists, mathematicians, astronomers, astrologers, travellers, church fathers, natural philosophers, Italian novelists, Spanish chroniclers, Portuguese historians, French military tacticians, and Greek and Latin poets". This evident gift for languages extended to teaching himself Arabic for the express purpose of translating a forgotten geometric manuscript of Apollonius of Perga.

In the following excerpt note numbers 45 and 47 for they are problems of ancient lineage that confounded Greek mathematicians, medieval scholastic philosophers and in the case of 45, modern theoretical physicists.

" 43. When an im[m]ediate Effect proceedes from an Im[m]ediate Cause wee ought not to search further why such a Cause should produce such an Effect. Every man being demanded why the fire is hott, is ready to fly to the forme of fire, and alleadge this as the Cause: But should hee inquire farther, why the forme of fire should bee the Cause of heat, hee might perhaps puzell a whole Reading of Philosophers, and Never prove himselfe the wiser.

[44.] Men &c drowned first sinks to the bottom And after a Certain times doe slowly buoy themselves upon again to the top of the Water, Not for that the breaking of the Gall becomes the Cause of their Ascending (as some would perscuade us) but because such bodyes formerly heavier then water, Quantity for Quantity, And consequently apt to sink have now acquired a larger dimention, while they how ever increase not their weight but becoming lighter are prot[r]uded by it to ye top where by degrees swell yet bigger. A dogg will lye with more than one half above the Surface of the water

[45.] The Motions of all Animals seemes to be performed by Snatches and Jerks; And it is indeed a great Question among school-Philosophers whither any locall Motion be (speaking strictly) continuall And not rather consisting of short Motions & frequent rests As it were compounded together

[46.] Birds seem to grind their meat in their Gizards, after it is first well soaked in their Craps, for which purpose they pick up small stones And their Stomachs are made of two larg Muscles; One on either side. the cheif instruments in this work of Moliture or grinding. The locusta or lobster has his teeth placed in his Stomach, And so have the rest of that kind which they imploy for the same purpose. And as ~~this~~ grinding or jawing meate helps to concotion So the Inward Membranes or Skinns of the Gizards of most birds (especially such as feed on corne) prepared by drying & powdring them, are held a great help to Concoction. Now the Acidity of them is very manifest, And no doubt they doe not otherwise comfort our Stomachs, then by increasing & corroborating that fermént so often mentioned

[47.] When a Geometrician defines to me an Hyperbole, I quickly gain a ~~distinct~~ clear and distinct Idea of it, But when he proves to me that this Hyperbole may have such a Relation to a strait Line which he calls assymptote, that this line being continued still comes neerer and neerer to the Prolonged side of the hyperbole, and yet how far soever both be drawn, twill never come to touch it, his subtile demonstrations present me with an inferr'd or illative truth, at which we arrived not but by the help of a traine of Ratiocinations, and on which if we exercise our imagination, we that find this factitious truth, if we may so call it, accompanied but with a very dim and confused Idea. "

Two more of Halley's accomplishments deserve mention. He was the first to collect and analyze mortality rates (in the city of Breslau), thus laying the foundations for actuarial science. Doubtless his most memorable contribution to science was his calculation of cometary orbits. Based on that calculation he predicted the return of his comet in 1759. As a contemporary astronomer wrote, this "afforded a more striking demonstration of the great principle of attractions than we could have dared to hope for".

Many of Halley's contemporaries placed him on a par with Newton, in retrospect an unduly flattering comparison. Few thinkers before or since Newton have had his depth of physical insight or fecundity of mathematical creativity. And in Newton these talents were fused into an awesome intellectual force. Perhaps only Archimedes and Einstein merit comparison with him. But history should not even try to compare the relative worth of two people, rather it should try to assess and understand the mutual impact between an individual and his times.

Scientifically the seventeenth century was a time of radical change in outlook. Before the late Renaissance the church held powerful sway over man's thoughts. For doctrinaire reasons the world was agreed to be comprehensible to God alone. Now, with the advent of the scientific revolution under the leadership of Descartes and Galileo, man realized that he too could comprehend, that via a marvellous tool called mathematics he could understand, predict and control his universe.

In terms of the sociology of science Halley's era was one of transition between the largely self-taught amateur scholar of the late Renaissance who saw no demarcations between regions of knowledge, to the eighteenth century's almost professional scientists, formally schooled and increasingly specialized.

One suspects that temperamentally Halley was a Renaissance man with an unbridled curiosity about all natural phenomena. At the same time he played a significant part in the institutionalization and professionalization of science. As secretary to the fledgling Royal Society and as advisor and confidant to Newton his import was seminal. Modern science, "big" science, owes much to Edmond Halley's energy.

Halley should be remembered as more than a first rate scientist/ mathematician and more than an efficient organizer and administrator, for like many 'seekers of truth' he showed great personal courage too. Before the Restoration Halley supported and espoused royalist courses when loss of head was a conceivable penalty. At a time of great personal financial hardship he paid for the publishing of Newton's opus Principia Mathematica. Being generous of spirit he readily proclaimed the genius of Newton and constantly encouraged his efforts. Not all were so magnanimous. Robert Hooke (of Hooke's law), claimed priority over Newton for the discovery that Kepler's laws of celestial motion could be derived from the inverse square law. When challenged by Christopher Wren (a mathematician in architectural clothing) as to why he had not published his work his reply was revealing. He wished, he said, to "conceale it for some time, that others triing and failing, might know how to value it when I should make it publick ...".

In 1691 Halley's sceptial and unorthodox religious beliefs cost him the Savilian Chair of Astronomy at Oxford. As an observer later recalled "Mr. Halley was then thought of for Successor, to be in a Mathematick Professorship at Oxford; and Bishop Stillingfleet was desired to recommend him at Court; but hearing that he was a Sceptick and a Banterer of Religion, he scrupled to be concerned; ... . But Mr. Halley was so sincere in his Infidelity, that he would not so much as pretend to believe the Christian Religion, tho' he thereby was likely to lose a Professorship; which he did accordingly; and it was then given to Dr. Gregory ...". Thirteen years later, without recanting and in spite of having a reputation as one who "talks, swears, and drinks brandy like a sea-captain" Halley was appointed to the Savilian Chair of Mathematics at Oxford.

Halley's religious views were the stimulus for a quite famous episode in the history of mathematics. Religious leaders of the early eighteenth century were disturbed by the ever more mechanistic development of scientific thought. Through the clarity, power and certainty of mathematical models astronomers particularly appeared to be challenging god's domain. With the causality guaranteed by their mathematics the need for god seemed to be shrinking. Where was there need for the spirit in a world that worked in a precise and predictable manner? The certainty that man seeks and that he previously found in faith he now found in mathematics. The mathematical tool that enabled one to predict, with clock-like certainty, the behaviour of the cosmos was the calculus, invented simultaneously by Newton and Leibnitz. Yet, in spite of the certainty of its predictions the very foundations of the calculus were unsure and scantily attended. What is $\frac{dy}{dx}$, the sceptics asked? Before the limit it is $\frac{\Delta y}{\Delta x}$, a ratio of two quantities each tending to 0. At the limit it is no longer a ratio! (If it was a ratio it would necessarily be $\frac{0}{0}$.) Even more bizarre was the thought of dx standing alone. Is it zero or is it non-zero or is it both zero and non-zero or is it, horror of horrors, something in between - an "infinitesimally" small quantity? Most mathematicians were too busy using the calculus to worry seriously about these issues. Not so the protectors of religion. Johnathan Swift, a dean in the Church of England, lampooned the foundational insecurity in mathematics in Gulliver's travels. More seriously, George Berkeley, Bishop of Cloyne in Ireland, a philosopher of considerable insight, wrote a devastating attack on these weaknesses. Calling infinitesimals "ghosts of departed quantities" he published his diatribe in 1743 under the title The analyst, or a discourse addressed to an infidel mathematician. The infidel in question was Edmond Halley.

It is hard not to feel a little sorry for Halley. Like the brilliant student in a class with an even more brilliant student, Halley was overshadowed by Isaac Newton, so much so that his first serious biographer didn't put pen to paper till 1966. Although scientists are seekers of truth they remain human seekers of truth. They too have egos, they too seek the acclaim of their peers and they too hope for some small degree of immortality through their work. Halley's immortality should rest on more than the sporadic return of a minor comet. He deserves better.

Further Reading.

The first biography of Halley is Edmond Halley by A. Armitage; Nelson, 1966. Unfortunately its uninspiring style is exacerbated by inadequate explanations of Halley's scientific work. For a more recent biography see - Halley and his comet by P. Lancaster-Brown; Poole, Blanford Press, 1985. For an accessible article on the comet see - Halley's Comet by Alistar Carr in Teach. Maths & its Appl., 4 (3) 1985, 102-111, or write for a reprint to Dr. Carr at the School of Applied Science, Gippsland IAE, Switchback Rd., Churchill, Vic. 3842.

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