Dawn of Science

22. All Was Light – II

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Previous parts:
Resonance, Vol.15: p.498, p.590, p.684, p.774, p.870, p.1009, p.1062; Vol.16: p.6, p.110, p.274, p.304, p.446, p.582, p.663, p.770, p.854, p.950, p.103; Vol.17: p.6, p.106, p.230.

Principia, calculus and some bitter fights over priorities.

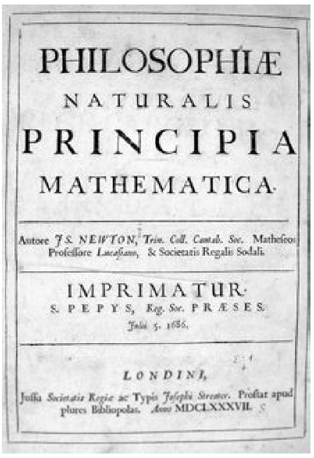
Newton presented his first paper on optics to the Royal Society in 1672 and a second in 1675. Both came under attack from Robert Hooke (1635–1703) who was then one of the leading figures of the Royal Society. Hooke wrote a condescending critique of the first paper and accused Newton of stealing his ideas in the second. Newton, who could never respond to criticism rationally, was deeply disturbed and the two scientists became sworn enemies.

Around the same time, Newton was carrying on correspondence with a group of English Jesuits in Liege who were also raising objections against Newton's theory of light. Their objections were very shallow (and arose from a mistaken notion about Newton's experiments) but again Newton failed to react objectively. As a result, the correspondence dragged on for three years and ended with Newton suffering a severe nervous breakdown in 1678. What is more, these exchanges made Newton withdraw from the mainstream of intellectual life and become a recluse.

During these years, Newton turned to another passion of his – alchemy. He spent a considerable amount of time copying ancient texts by hand and trying to make sense out of the mystical imageries present in them. He failed in providing a scientific basis for chemistry – a task, which was achieved by people of far lesser genius in the next century showing that intellectual ability alone cannot precipitate a major scientific discovery. It is, however, possible that Newton's dabbling with alchemy had another favourable influence: it made him think in terms of 'attraction' and 'repulsion' between particles and the mechanical notion of 'force' exerted by particles on one another.

Keywords
Newton, Hooke, Principia, Halley, Calculus, Leibniz.

Around this time, Hooke tried to restart his correspondence with Newton on the topic of planetary motion, based on the notion that planets are influenced by the force exerted by a central agency. During this correspondence – which was actually quite brief, with Newton terminating it abruptly – they debated the question: what will be the path followed by a particle dropped from a tower to the Earth? Newton drew a figure for this path as a spiral ending at the centre of the Earth. This was wrong and Hooke immediately pointed it out. According to Hooke, the path would have been elliptical and the particle would return to its original position if the Earth was split along the path of the particle. Newton hated being proved wrong (especially by Hooke) but had to admit it this time. He, however, changed the elliptical curve drawn by Hooke by introducing the assumption that the gravitational force exerted by a body is a constant, independent of distance! Hooke immediately responded saying that he assumed the force of gravity decreases as the square of the distance from the body.


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

Figure 1. Title page of *Principia*, first edition (1687). Courtesy: http://en.wikipedia.org/wiki/Philosophiæ_Naturalis_Principia_Mathematica

Thereby hangs a tale of bitter fight over priorities. Hooke felt that he should also get credit as a co-discoverer of the law of gravitation and Newton – quite characteristically – refused to share the prize of recognition. The turn of events which led to this historic controversy are as follows. Sometime in 1684, Edmund Halley (1656–1742), the discoverer of Halley's comet, got interested in the problem of planetary orbits and asked Hooke whether he knew what force could cause the elliptical orbits. Hooke gave the correct answer but could not produce any detailed justification. Later that year, Halley visited Newton in Cambridge and asked him the same question. Newton not only gave the correct answer but also could send Halley a proof of this claim in a short paper called *De motu corporum in gyrum* (On the Motion of Bodies in Orbits). The discussion with Halley convinced Newton of the importance of his work. By 1686, Newton had converted the nine-page *De motu* into the classic work *Principia Mathematica*. He sent this work to the Royal Society for publication. The society's finances were in poor shape at this time (due to the earlier publication of the handsome book *History of Fishes*,

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which sold very poorly!), but Halley decided to publish the book at his own expense. As soon as *Principia* was submitted to the Royal Society, Hooke raised the cry of plagiarism. Newton's response was typical. He went through his manuscript and eliminated almost all the references he had originally made to Robert Hooke. There is no question that *Principia* was a work of an intellectual giant; but in his reaction to Robert Hooke, Newton showed how small a man he was.

The *Principia* is divided into an introduction and three books. Together, they provide a complete and systematic exposition of mechanics and a description of the system of the world. The introduction contains, among other things, the laws of motion, which allow mechanics to be formulated in a rigorous manner. Books 1 and 2 consider different hypothetical forces and motions under these forces. Finally, Book 3 applies the general theory developed in the previous two books to the study of planetary and terrestrial motions. Most of the proofs use geometrical techniques rather than algebraic or analytic methods, in accordance with the

Box 1.

LIFE OF NEWTON

Birth of Newton	—	1642
Goes to Trinity College, Cambridge	—	1661
Royal Society founded	—	1662
Moves back to Lincolnshire because of plague	—	1665
Returns to Cambridge, elected Fellow of Trinity	—	1667
Elected Lucasian Professor of Mathematics	—	1669
Elected fellow of Royal Society	—	1672
Halley's visit leads to preparation of *Principia* } Leibniz's first paper on calculus	—	1684
Publication of *Principia*	—	1687
Member of Parliament for Cambridge University	—	1689
Master of the Mint	—	1700
Elected President of the Royal Society	—	1703
Knighted by Queen Anne	—	1705
Death of Isaac Newton	—	1727

tradition of those days. The third book also contains the statement of the law of universal gravitation. This was probably the first time in the history of science that a fundamental force had been recognised and described as such.

The *Principia* gave Newton international fame and rightly so. Young British scientists took Newton as a role model and within a generation, most of the salaried chairs in English universities were filled with Newtonians. In 1689, Newton was elected the Member of Parliament for Cambridge University. However, he suffered a nervous breakdown in 1693 and regained stability only after a couple of years. His creative life and scientific contributions slowly came to an end after this. Finally, in 1696, he took up the position of the Warden of the Mint and shifted his residence from Cambridge to London. Honours continued to be heaped on him: in 1703, he was elected president of the Royal Society and in 1705 was knighted.

There is no doubt that Newton thoroughly enjoyed and took tremendous pride in his worldly success (which, of course, he fully deserved). On being knighted, Newton took the trouble to establish his pedigree and applied to the College of Heralds for his coat of arms. Also, based on his often quoted statement, "If I have seen further, it is by standing on ye shoulders of giants." a

Figure 2. These figures, on the windows of a cathedral built in Europe in 1227, relate to the theme "on the shoulders of giants". It shows saints on the shoulders of earlier prophets.
Compiled from figures in: http://www.therosewindow.com/pilot

Box 2. Newton, Leibniz and Calculus

One of the important mathematical contributions made by Newton was in systematising the branch of mathematics we now call calculus, though, as we saw in a previous installment, the basic ideas were developed in Kerala, India much earlier. He put together several ideas known earlier and added some significant innovations of his own, thereby developing both differential and integral calculus. In the simplest terms, these subjects deal with the manipulation of infinitesimally small quantities in a proper way.

Figure 3. Leibniz. Courtesy: http://en.wikipedia.org/wiki/Gottfried_Leibniz

Newton's approach to calculus was that of a mathematical physicist and he thought of calculus as a calculational tool. The rules of calculus were also developed independently in Europe by the German mathematician, G W Leibniz (1646–1716). As usual, Newton was dragged into another bitter fight over priorities – this time with national pride at stake. It has now been established with reasonable certainty that Newton did develop calculus first. However, Leibniz arrived at it independently and published (in 1684) the results before Newton did. Both men stooped very low in their conduct of the controversy and probably Newton's behaviour was the worse. At one stage, as President of the Royal Society, he appointed an 'impartial' committee to investigate this issue, clandestinely wrote the report published by the Society, and reviewed it anonymously.

As a consequence of this dispute, British mathematicians were alienated from their European counterparts throughout the eighteenth century and, in fact, the standard of British mathematics fell behind that of continental Europe after Newton's death.

sense of modesty is usually attributed to Newton. However, this may not be so. In his remarkable book, *On the Shoulders of Giants*, sociologist Robert Merton argues convincingly that this expression had achieved a very conventional meaning by Newton's time. It was what the great and the noble were expected to say on certain occasions (more like 'hello' or 'good morning') without, of course, meaning it in its true sense. So familiar was this usage that themes based on it could be found decorating the windows of some cathedrals. Merton also lists several earlier and later uses of this expression by other famous people. Anyway, an objective historian studying the way Newton dealt with his fellow scientists would find it hard to accuse him of modesty!

Newton died in 1727 in his eighty-fifth year – a death which triggered the display of pomp and pageantry, poems, statues and other commemorations. He was buried in Westminster Abbey like "a king who had done well by his subjects" as Voltaire put it.

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Suggested Reading

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[2] Joy Hakim, *The Story of Science – Newton at the Center*, Smithsonian Books, 2005.

[3] Also see: http://www.newtonproject.sussex.ac.uk/.

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