Dawn of Science

21. All Was Light – 1

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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.

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Newton and his years of discovery.

In the history of physics, there have been four men who belonged to a class of their own, far above the rest. They were Archimedes, Galileo, Newton and Einstein. Of the four, Isaac Newton (1642–1721) belonged to a period neither too far in the past nor too close to the present; this left a trail of fables and (exaggerated) anecdotes about him. In this and the next instalment, we shall examine the life and work of Newton.

Newton was born on 4 January 1643, and was not really a Christmas baby as is popularly made out. This date is based on the modern Gregorian calendar which is in conformity with Nature. This calendar was being followed all over Europe at the time of Newton's birth. England, however, was following the Julian calendar, according to which Newton was born on 25 December, 1642, thereby giving him the glamour of being a Christmas baby. His father was illiterate (though prosperous) and had died three months before Newton was born. His mother married again when he was three and left Newton with his grandmother for about nine years. (Much later, in 1662, Newton recorded that he had threatened his mother and stepfather "to burne them and the house over them". This statement has provided much fodder for psychoanalysists to attrribute every trait of Newton to lack of motherly love in his childhood!). His mother returned to him after nine years when her second husband died, bringing with her the three children from the second marriage. Some attempt was then made to make Newton manage the family estate which would have been disastrous – both for the estate as well as Newton. Fortunately, Newton's weakness was detected quite early and he was sent to the Free Grammar School of Grantham to prepare for entering the University of Cambridge.

In June 1661, Newton joined the Trinity College, Cambridge, which was to be his home for most of the next 35 years. The official curriculum in Cambridge was distinctly Aristotelian, resting on the geocentric view of the universe and dealing with Nature in very qualitative terms. However, the scientific revolution was well advanced in Europe and the writings of Copernicus, Kepler, Galileo and Descartes were available to those who were interested. By around 1664, Newton had read and thought over many of these works. In particular, he was strongly influenced by the mechanistic philosophy advocated by Descartes in his works. In one of his notebooks, he had entered the slogan *Amicus Plato, amicus Aristotle, magis amica veritas* (Plato is my friend, Aristotle is my friend, but my best friend is truth). A scientist was thus born, in spite of the best efforts of a university.

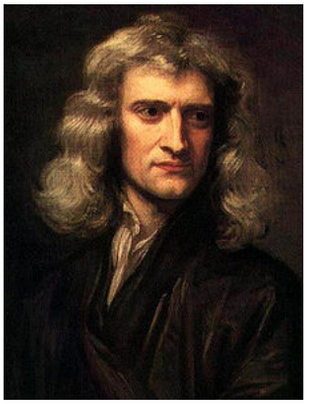

Figure 1. Isaac Newton. Courtesy: http://en.wikipedia.org/wiki/Isaac_Newton)

Around this time, Newton had mastered most of classical mathematics and was fast moving into new territory. The basic ideas of the binomial theorem and calculus were probably already in place though the world came to know of this much later. He received his bachelor's degree (which was a formality, merely recording his completion of four years at Trinity) in 1665, one

Figure 2.

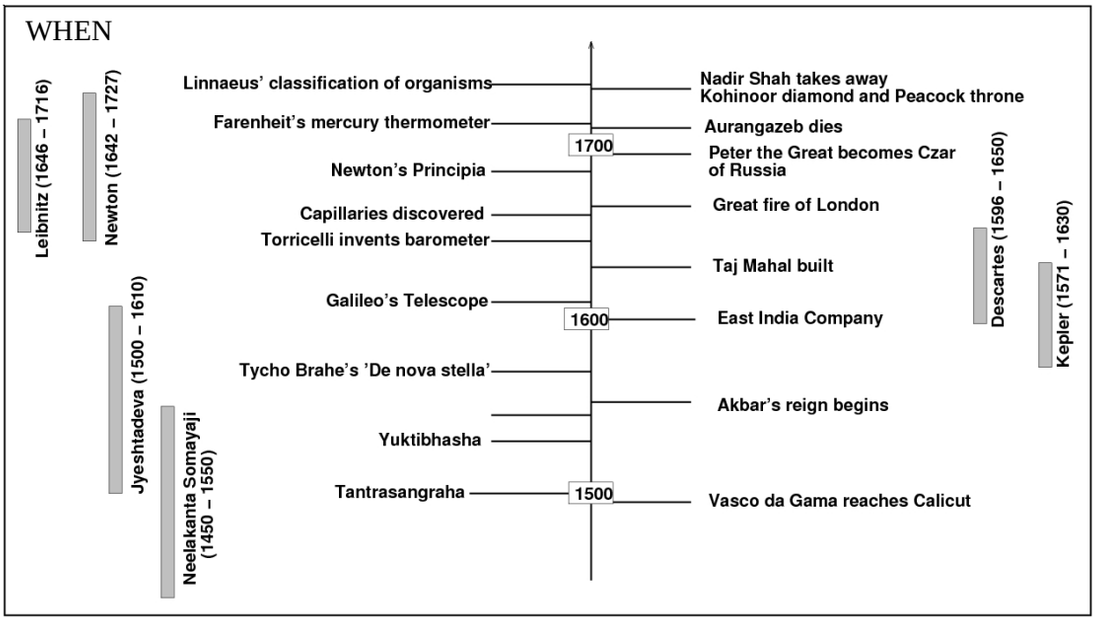

Figure 3.

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year after he was elected a Scholar of Trinity. But his stay in Cambridge came to an abrupt end in 1665 when the university was closed because of the plague. Newton returned home and continued working and thinking for the next few years. If we are to believe Newton's own account of what took place in the next two years (taken from RS Westfall's biography *Never at Rest*, Cambridge Univesity Press, see *Box* 1), then it must be concluded that no person has ever achieved so much in such a short span of time. Though historians have raised doubts about Newton's 'recollection', it is clear that he did lay the foundations for new areas in mathematics, optics and celestial dyamics around this time. During the same period, Newton also developed a keen interest in alchemy, something he pursued vigorously for the rest of his life.

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One trait in Newton's character has puzzled historians. Newton had an abnormal fear of criticism and of even a healthy academic debate of his ideas. Time and again he refused to let the world know of his work lest there should be criticism and controversy. At the same time, he was very possessive of what he had discovered and could never tolerate even sharing the credit for these discoveries with anyone else. Much of Newton's scientific career could have been different had he publised his results or collaborated with other scientists; this would have probably led to far greater scientific achievements for Newton and a more rapid growth of science itself.

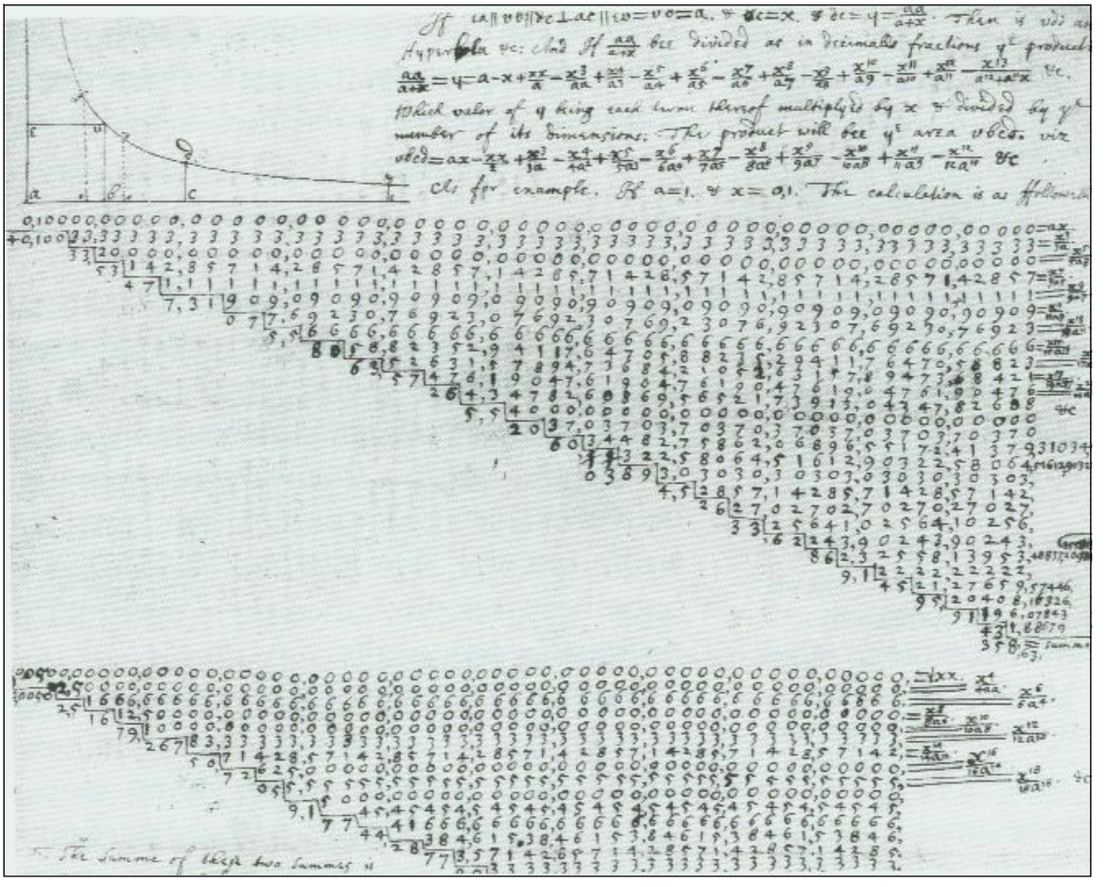


Figure 3. An example of the kind of hard work Newton was capable of. In this page of a manuscript, he has calculated the area under a hyperbola (which is essentially a logarithm) to 55 significant figures by adding the values from each term of an infinite series.
Courtesy:
http://www. departments. bucknell.edu/history/carnegie/newton/logarithm.html

What finally prompted Newton to come out of his shell was the fact that in 1668 there appeared a book *Logarithmotechnia* by Nicholas Mercator in which the author had explained several results regarding the infinite series. Newton had worked out the same results, in much greater generality, a few years earlier and was horrified to see someone else taking the credit. He hastily wrote a treatise called *De Analysi* and asked his friend Isaac Barrow at Cambridge to communicate it to a select band of London mathematicians. Even at this stage, Newton asked Barrow to withhold the name of the author! Only when the treatise met with positive response did Newton reveal himself.

During the next few years, Newton perfected his early work on the branch of mathematics we now call calculus and wrote it up as

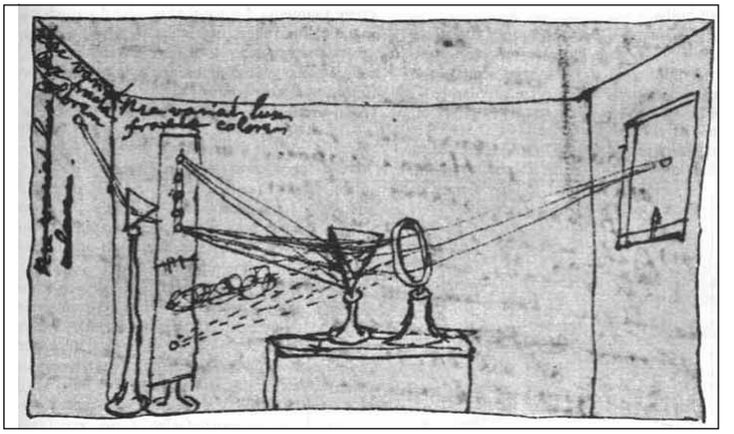
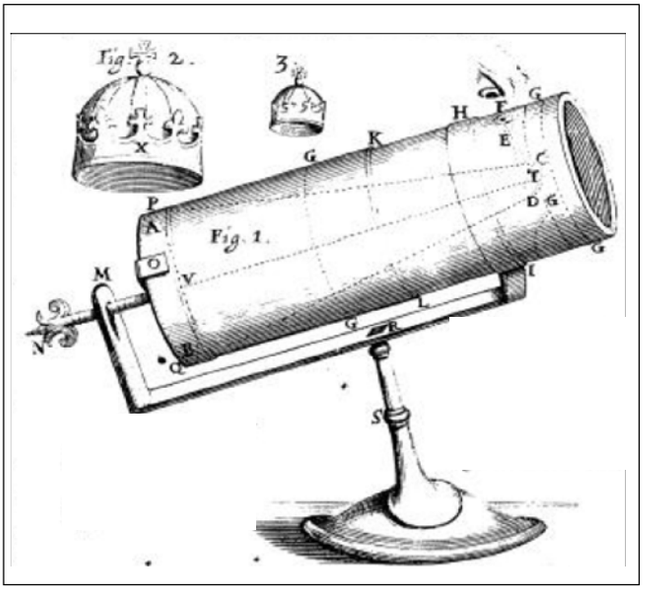


Figure 5. A drawing by Newton, describing his crucial experiment involving the prism. The first prism separates white light into different colours and one of the colours is further refracted by a second prism without any change.
Courtesy: http://www.astro.umontreal.ca/~paulchar/grps/histoire/newsite/sp/great_moments_e.html.

Figure 6. The March 1672 issue of *Philosophical Transactions of the Royal Society* had an account of Newton's telescope (marked Fig.1 in the picture). The two crowns show how an object 300 feet away will look through the telescope made by Newton (marked Fig.2) and through a more conventional 25-inch telescope (Fig.3).
Courtesy: http://rstl.royalsocietypublishing.org/content/7/81-91.toc

a short treatise. Though only a few knew it at that time, Newton had already become the foremost mathematician of his time. Shortly afterwards, Isaac Barrow resigned from the Lucasian Chair at Cambridge and recommended Newton for the job. Newton was appointed the Lucasian professor of mathematics at the young age of 26 and held this position for the next 32 years.

In the first few years as the Lucasian professor, Newton lectured on some of his works in optics. At that time, there existed two conflicting viewpoints on light. The original idea of Aristotle treated light very qualitatively and considered phenomena like colours as arising out of the *modification* of light by materials. According to Aristotle, 'pure' light was colourless and homogeneous. An alternative point of view was advocated by Descartes who considered optical phenomena as inherently mechanical. Descates had made optics a quantitative science by stating clearly the laws governing reflection, refraction, etc. Newton accepted the mechanical view of light and, as usual, pushed it to its logical extreme. By sending a



Box 1. Years of Discovery

Here is Newton's own account of his ideas and work during the two years, 1665–66 (From *Never at Rest*, by R S Westfall, [1]).

"In the beginning of the year 1665 I found the Method of approximating series & the Rule for reducing any dignity of any Bionomial into such a series. The same year in May I found the method of Tangents of Gregory & Slusius, & in November had the direct method of fluxions & the next year in January had the Theory of Colours & in May following I had entrance into ye inverse method of fluxions. And the same year I began to think of gravity extending to ye orb of the Moon & (having found out how to estimate the force with wch [a] globe revolving within a sphere presses the surface of the sphere) from Keplers rule of the periodic times of the Planets being in sesquialterate proportion of their distances from the center of their Orbs, I deduced that the forces wch keep the Planets in their Orbs must [be] reciprocally as the squares of their distances from the centers about wch they revolve: & thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the earth, & found them answer pretty nearly. All this was in the two plague years of 1665–1666. For in those days I was in the prime of my age for invention & minded Mathematicks & Philosophy more then than at any time since."

beam of white light through a prism and splitting it into varied colours, Newton demonstrated his point of view that white light could be thought of as a heterogeneous mixture of different colours. He also showed that these colours could be mixed together to produce white light again. In his view, material bodies only separated out the components in light rather than modified it. Using this idea, Newton could provide quantitative explanations for several optical phenomena including the rainbow.

Since lenses and prisms split white light into coloured bands, telescopes which use lenses suffer from a defect known as 'chromatic aberration'. This aberration causes coloured fringes to appear around images viewed through a telescope. Newton believed (though wrongly) that this defect could never be eliminated in telescopes using lenses. To tackle this problem, he developed the first reflecting telescope using concave mirrors. This telescope caused a sensation when it reached London in late 1671 and ensured Newton's election to the Royal Society.

Suggested Reading

[1] Richard S Westfall, ***Never At Rest: A Biography of Isaac Newton,*** **Cambridge University Press, New York, 1980.**

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

[3] Also see: http://www. newton-project. sussex.ac.uk/.

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