Isaac Newton: life, labours and legacy
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28 September 2020

Introduction

Welcome to the life, labours and legacy of England's greatest scientist and mathematician, Sir Isaac Newton. He lived from 1642 to 1727, a long life of 84 years. Our book-launch today is based on this illustrated booklet.

Contents

Here are some of the topics we'll be covering. I'll begin with Newton's early years and the London scientific scene. Raymond will then tell you about his work in such areas as gravitation, optics, mathematics, alchemy and divinity, and I'll conclude with his later years in London – but first, let me set the scene . . .

Turbulent times (1640-1649)

Isaac Newton was born at a time of great turmoil. From 1640, relations between King Charles I (on the left) and his parliament deteriorated, leading to the outbreak of the English Civil War in 1642, the year of Newton's birth. Many battles were fought between the King's Royalist forces (the 'Cavaliers') and the Parliamentarian armies (the 'Roundheads'), with the latter prevailing at the Battle of Naseby in 1645.

The king was later arrested and convicted of high treason. Among those signing his death warrant was the military leader Oliver Cromwell (on the right), and in 1649 the king was executed in London, as we see below.

Turbulent times (1650-1660)

Following the collapse of the monarchy, England became a republic, known as the 'Commonwealth', with Cromwell as its Lord Protector. The Civil War had concluded with his victory over the Royalists, and Charles I's son, the future King Charles II, fled to the Continent. Cromwell died in 1658, and anarchy threatened – but eventually, Parliament was recalled, and the monarchy was restored in 1660 with the triumphal return of the new King.

Woolsthorpe Manor

Isaac Newton was born here on Christmas Day 1642, in the tiny hamlet of Woolsthorpe in Lincolnshire. His father was an illiterate but prosperous farmer who lived with his wife Hannah, and on their 100-acre farm they raised sheep and cattle, and grew hay, oats and corn. Here's an early drawing, and a view of it as it is today.

At his birth, Isaac was very premature, and not expected to survive: he later claimed to have been ‘so little they could put him into a quart pot’. Indeed, two women who were sent to collect supplies didn’t hurry back, as they doubted that he’d be alive on their return.

Isaac’s father had died before his son was born, and, when Isaac was just 3 years old, Hannah remarried and moved to a nearby village to live with her new husband, an elderly clergyman. Young Isaac was left at Woolsthorpe with his maternal grandmother, a period of his life which he resented for ever after, and which may have caused the neurotic personality that he eventually became.

It was an eventful time to grow up. The Civil War was raging, and the King’s execution occurred when Isaac was just 6 years old. But such incidents barely affected him as he attended local schools to learn to read and write and to carry out arithmetical calculations. With her new husband, Hannah produced three children.

But in 1653, when Isaac was 10 years old, his stepfather died, and Hannah returned to Woolsthorpe with her new family.

Grantham

Two years later, when Isaac was 12, Hannah decided to send him to school in Grantham, seven miles to the north. At that time his school (now The King’s School) consisted of this single room, which still exists. Here the pupils learned to read, write and speak Latin, together with arithmetic, Bible studies and Greek.

During his time in Grantham, Isaac lodged in the High-Street home of the local apothecary. Here he learned about the composition of medicines and how to mix chemicals, an interest that never left him, as you’ll see.

Isaac was fascinated with making things. According to his later friend and biographer William Stukeley,

> he *‘busyed himself at home, in making knickknacks of diverse sorts and models of wood – furnishing himself with saws, hatchets, hammers, and a whole shop of tools, which he’d use with great dexterity, as if he’d been brought up to the trade’.*

He filled the house of the long-suffering apothecary with sundials and constructed a 4-foot high water clock.

He also made kites and paper lanterns lit by candles, and even a working model of a windmill, powered by a live mouse which set it in motion by continually reaching out for corn that had been placed strategically. Isaac studied hard, eventually becoming head boy of the school.

Back to Woolsthorpe Manor

But when he reached the age of 17, his mother called him back to Woolsthorpe to manage the estate. But Isaac wasn’t cut out for farming. To Hannah’s continued frustration he built dams in streams while his sheep strayed into neighbours’ fields, and on Grantham’s market days he’d let his servant sell the farm’s produce while he read books and constructed wooden models.

Eventually, seeing that Isaac was wasting his time in farming, his headmaster and his uncle (a Cambridge graduate) persuaded Hannah that Isaac should return to school and prepare for University.

An undergraduate at Cambridge

In 1661 Newton entered Trinity College as an undergraduate. Here's the Great Court with the College Chapel, and the Great Gate on the far right – Newton's room was to the left of the Great Gate on the first floor. The Chapel now contains this famous statue of Newton by Roubiliac.

Although Isaac's mother was now wealthy, she gave limited financial support, and he initially had to work his passage by carrying out menial tasks, such as cleaning the Fellows' shoes and waiting on table at meal-times. These duties ended in 1664 when he was elected a Scholar of the College.

Newton was out of sympathy with Cambridge's traditional curriculum of Aristotelian science and philosophy. Instead, he read books that interested him: geometry from Euclid and Descartes, astronomy from Kepler and Galileo, philosophy from Thomas Hobbes, and contemporary mathematics from John Wallis of Oxford. He probably received instruction, too, from Isaac Barrow, the first holder of Cambridge's newly created Lucasian Chair of Mathematics, and he graduated with a Bachelor's degree early in 1665.

Cambridge

Here's Newton's notebook of his expenses during an early visit to Cambridge. Included are a Stilton cheese for 2s., a chamber pot for 2s.2d., and 'a table to jot down the number of my cloathes in the wash' for 1s.

Below is Cambridge's famous 'Mathematical bridge'. Often claimed to have been designed by Newton to require no supporting bolts, it was actually built in 1749, more than 20 years after his death.

The Royal Society

Meanwhile, in 1660, the monarchy had been restored with the return of Charles II from the Continent. In the words of the diarist John Evelyn, the new king was

> *'a prince of many virtues and many great imperfections, debonair, easy of access, not bloody or cruel. He also had a laboratory, and knew of many empirical medicines, and the easier mechanical mathematics.'*

So, the king was interested in science, and with his encouragement, 'The Royal Society of London for Improving Natural Knowledge' was established. Founded to promote experimental science, it received its Royal Charter in 1662.

The engraving on the left, from an early history of the Society, captures the spirit of Restoration science. It shows the crowning of the king with a laurel wreath, while the surrounding books and scientific instruments indicate the practical and experimental interests of the members.

The Royal Observatory

Also, with Charles's patronage, the Royal Observatory at Greenwich was founded in 1675. Designed by Christopher Wren, its purpose was to improve the accuracy of tables of the moon's motion, in order to help mariners find their longitude at sea.

Boyle & Hooke

And while we're on the subject of science, here are two notables who contributed to the Royal Society's early years – Robert Boyle and Robert Hooke. In the 1650s they'd designed this air pump (bottom left) to show how a vacuum can exist in nature. Boyle also found the rule '*PV* = constant', now known as 'Boyle's law', which connects the pressure and volume of a gas at constant temperature.

Meanwhile, Hooke had invented the microscope (in the middle), and his *Micrographia* of 1665 was the first work to present such dramatic images as this drawing of a flea. He's also remembered for 'Hooke's law' on the extension of springs, shown here in his diary, and for designing the universal joint below. For over 35 years he was Professor of Geometry at London's Gresham College, where the Royal Society held its meetings. As the Society's 'Curator of Experiments' he was frequently required to design and present experiments to its members.

The Great Plague

Newton's Cambridge career was to be interrupted by the devastations of the Great Plague. These London scenes show people fleeing from St Paul's Cathedral and burying their dead in Covent Garden. The dramatic caption reads:

> *'Surely the loud groans of raving sick men, the struggling pangs of souls departing – servants crying out for masters, wives for husbands, parents for children, and children for their mothers. Here he should have met same, frantically running to knock up sextons: there, others fearfully sweating with coffins to steal dead bodies.'*

Back in Lincolnshire

By the summer of 1665 the plague had reached Cambridge, and the University closed its doors and sent everyone away. Newton returned to Lincolnshire and continued his investigations into mathematics, optics and gravity (as depicted here). Here he laid the foundations for his ground-breaking work in these subjects, as you'll see, and many years later he recalled these productive years in the rural calm of Lincolnshire, writing:

> *'In those days I was in the prime of my age for invention, and minded Mathematics and Philosophy more than at any time since'.*

His discoveries, while still in his early 20s, made him one of the world's leading mathematicians and scientists. The clue to his mind may be found in his unusual powers of concentration: he could hold a problem in his mind for days and weeks until it surrendered to him its secrets.

The Great Fire of London
In September 1666, while Newton was making these momentous discoveries, the Great Fire of London destroyed much of the capital city, as depicted here. Below is a fire engine of the time, which was clearly inadequate for dealing with fires of such ferocity.

In 1667 Cambridge University reopened, and Newton returned to Trinity where he was elected a Fellow of the College and began to climb the academic ladder. Within two years, when only 26, he succeeded Isaac Barrow as the Lucasian Professor of Mathematics. Over the centuries this position has been held by many distinguished figures, such as Stephen Hawking. Newton occupied the Chair for 32 years, before moving to London, as you'll see.

Let me now hand over to Raymond who'll tell you about Newton's wide-ranging achievements.

The new astronomy
We'll begin with astronomy.

In 1543 Nicolaus Copernicus had transformed the subject by replacing the ancient Greek Earth-centred system of planetary motion by this Sun-centred one, with the Earth as just one of several planets moving in circular orbits around it.

Some 90 years later, Galileo (below left) compared the two planetary systems, coming out strongly in favour of Copernicus: this led to his trial and house arrest by the Inquisition which forced him to recant his views.

Galileo determined how the position, velocity and acceleration of a moving body all vary with time, thereby laying the mathematical foundations that underpinned his belief that the Earth really moves. His work led to further advances by others, and particularly by Isaac Newton who was born in the year that Galileo died.

Meanwhile, the German mathematician and astronomer Johannes Kepler had proposed that planets travel around the Sun in *elliptical* orbits, rather than circular ones. He also proposed that the line from the Sun to each planet sweeps out equal areas in equal periods of time (as shown here), so that the planet moves most quickly when it's nearest to the Sun. Kepler derived these laws from observed results, and years later Newton explained why they're true, based on his laws of motion and on his *Universal law of gravitation*, the 'inverse-square law', to which we now turn.

Newton and the apple
One of the most celebrated stories in scientific folklore is a tale that Newton recalled in old age. Seeing an apple fall – yes, research shows that the original apple was green! – he realised that the gravitational force pulling the apple to Earth is the same as the force that keeps the Moon orbiting the Earth, and the Earth orbiting the Sun. As Newton's biographer, William Stukeley, recalled years later:

> *'After dinner, the weather being warm, we went into the garden, and drank tea under the shade of some apple trees; only he and myself. Amidst other discourse, he told me he was just in the same situation as, when formerly, the notion of gravitation came into his*

mind. Why should that apple always descend perpendicularly to the ground?, thought he to himself, occasioned by the fall of an apple, as he sat in a contemplative mood.'

Newton proposed that the motion of the Moon and planets is governed by a single Universal law of gravitation – *the inverse-square law*:

'The force of attraction between two objects varies as the product of their masses, and inversely as the square of the distance between them.'

So, for example, doubling both masses increases the force between them by a factor of 4, and increasing the distance between them 10-fold decreases the force by a factor of 100.

<u>Newton's apple in popular culture</u>

The story of the falling apple is now so deeply embedded in popular culture that it's sometimes used without explanation for comic effect, as in the cartoon on the left, from *Punch* magazine. And on the cereal packet in the centre, Newton is so enjoying his *Crunchy-nut Corn-flakes* that he fails to notice loads of apples – and even a piano, for some reason – that descend on his head. As the caption at the top says, 'The gravity of the situation escapes Isaac Newton'.

And in the 1957 film *The Story of Mankind*, in casting that was imaginative even by Hollywood's standards, Newton was portrayed by Harpo Marx, of the Marx brothers: in the film a whole bushel of apples was seen to land on his head as he played his harp.

<u>Newton's Principia Mathematica</u>

1687 saw the publication of Newton's *Mathematical Principles of Natural Philosophy*, known as the *Principia*. In this book, arguably the greatest scientific book of all time, Newton unified terrestrial and celestial mechanics for the first time – investigating the motion of bodies, both on Earth and in the heavens. He also accounted for the orbits of comets, the variation of our tides, and the flattening of the Earth at its poles due to rotation. His approach used ideas from geometry, with forces, velocities, accelerations, distances and times all represented by lines and areas.

<u>Newton's Principia</u>

On the left is Newton's geometrical proof that the orbit of a planet moving under an inverse-square law is an ellipse.

In the middle is his demonstration of Kepler's second law, that planets trace out equal areas in equal periods of time.

And on the right, in his *Treatise of the System of the World*, Newton imagined projecting an object horizontally from a mountain. As the speed of projection increases, the object lands further and further away, until eventually, when the speed is great enough, it circles the Earth for ever, much as the Moon remains in orbit.

<u>Newton's laws of motion</u>

Newton began the *Principia* with his three 'laws of motion'.

The first, already known to Galileo, states that:

> *'Every body continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed on it.'*

His other two laws state that:

> *'Any change of motion is proportional to the force, and is made in the direction of the line in which the force is applied',*

and that:

> *'To any action there's an equal and opposite reaction.'*

'Newton's cradle', shown on the right, is based on these laws. When an end-ball is raised and then released, it strikes the next one – but instead of *all* the remaining balls moving, only the one at the far end does, because the force of collision is transmitted through the intervening balls. The cartoon below tells us why science teachers should never be given playground duty.

<u>Edmond Halley</u>

At this point, another of Newton's contemporaries enters our story. In 1684, following disputes within the Royal Society, Edmond Halley visited Newton in Cambridge and asked him for the path of a planet moving under the influence of an inverse-square law:

> *'Sir Isaac replied immediately that it would be an Ellipse.'*

Dr Halley, struck with joy and amazement, asked him how he knew it. Why, said he, 'I have calculated it', whereupon Halley asked him for his calculation without any further delay. Sir Isaac looked among his papers but could not find it, but he promised to rework it and then send it to Halley.

It was indeed Halley who coaxed and cajoled Newton into writing the *Principia*. He even paid for its publication, because the Royal Society had just produced this expensive *History of Fishes* and had run out of money. Halley's reward from the Society was 50 copies of the *History of Fishes*.

<u>Halley's comet</u>

Using Newton's laws, Halley attempted to fit observations of recent comets to elliptical orbits, suggesting that the comet of 1682, shown here, might be the same as those observed on previous occasions, such as at the Battle of Hastings in 1066, as shown here in the Bayeux tapestry. 'Halley's comet' became his memorial when it made its predicted return in 1758–59. It last visited us in 1986, and returns again in 2061.

Halley's prediction of the comet's return was a most successful vindication of Newtonian theory, demonstrating its power to account for, and to predict, previously unexplained phenomena.

Optics

We don’t know how Newton’s interest in optics began. We know that, while an undergraduate, he bought a prism at a fair – or maybe the stimulus of Hooke’s *Micrographia* started him thinking about colours and their relation to white light.

Newton’s investigations led him to conclude that white light is composed of different immutable colours, as shown above: this formed the basis of his new theory of light and colour. Below is Newton’s own drawing of his so-called ‘crucial experiment’ from the plague years, showing that when sunlight is refracted through a prism, and one colour is then refracted through a second prism, it undergoes no further change.

But Newton’s first optical contribution to be publicly recognised was his *reflecting telescope* on the right. Only six inches long, it used mirrors instead of lenses to reflect the incoming light. This avoided the colouring round the edges caused by lenses in a refracting telescope.

Newton’s telescope caused a sensation and ensured his election to the Royal Society. With his great manual skills, he had designed and built it himself, also making the tools that he needed for its construction.

As part of his early investigations, Newton wished to discover the effect of altering the curvature of his own eyeball. He found that coloured circles could be produced by applying pressure from a blunt needle placed behind his eye, but for several days afterwards he suffered the effects of this dangerous activity. On the left is his description of this experiment.

Another important phenomenon that Newton investigated was the appearance of coloured concentric rings when two pieces of glass are in contact. This pattern is now known as ‘Newton’s rings’.

As we’ll see later, Newton eventually published these researches in his 1704 book *Opticks*, viewed by many as a model of how to do experimental science.

Newton and music

It’s not widely known that Newton was interested in music – though not in practical music-making, for it’s recorded that he once saw the composer Handel play on a harpsichord, and the only thing he commented on was the elasticity of Handel’s fingers.

But Newton was interested in the arithmetic of musical intervals – where the frequencies of the notes an octave apart are in the ratio 2 : 1 [# # #], in a perfect fifth are 3 : 2 [# # #], in a perfect fourth are 4 : 3 [# # #], and so on. Inconsistencies in the scales then in use led him to investigate such ratios. On the left is a page he wrote on these, with his proposed ratios under the keyboard below.

Newton also tried to link his ideas on light and sound, by linking the colours in the spectrum to the 7 notes of the musical scale, as shown on the right. That’s why we now say that there are 7 colours in the rainbow – it’s because of Newton.

Mathematics: Calculus

The 17th century witnessed the beginnings of modern mathematics. Fundamental problems were investigated, while new areas developed, such as *coordinate geometry* and the *calculus*.

Calculus is made up from two seemingly unrelated strands, now called *differentiation* and *integration*. Differentiation is concerned with how fast things move or change and is used to find tangents to curves. Integration is used to find the areas of shapes.

As the 17th century progressed, it was gradually realised that these two strands are intimately connected. Indeed, they're 'inverse processes' – if we follow either by the other, we return to our starting point, as shown below: differentiating and then integrating – or integrating and then differentiating – leaves things as they are.

This connection was explained by both Newton in England and Leibniz in Germany, but with different motivations. Leibniz was concerned with curves and tangents, while Newton focused on motion – how things change with time, or 'flow'.

Newton's tangent problems involved velocities, and in his treatise on 'fluxions' (flowing quantities), he presented rules for calculating them. On the right is its title page, linking ancient Greek mathematicians (at the bottom left) with those in the middle enjoying traditional 17th-century country pursuits.

<u>Mathematics: Curves</u>

Newton was also interested in curves. The Greeks had studied those obtained by slicing a cone in different ways. There are three basic types: the ellipse, parabola and hyperbola, and their equations involve quadratic terms such as x^2, y^2 and xy.

Newton looked at the corresponding problem of classifying the so-called 'cubic curves', and found that there are no fewer than 78 different types – below are two of them. This achievement was way ahead of its time.

Newton never shied away from extensive calculation. The manuscript page on the right shows his calculation of the area under a hyperbola to 55 decimal places, found by adding terms of an 'infinite series'. Newton's realisation of the importance of infinite series was a major contribution to mathematics.

<u>Alchemy</u>

Although he's remembered mainly for his work in mathematics and physics, Newton spent thousands of hours over several decades on alchemy and divinity, subjects that he knew better than almost anyone else. Because his views were unconventional, he kept secret his extensive writings on these subjects, amounting to over a million words. For many years afterwards these were dismissed as of little value, but recent scholars have preferred to view them more as connecting with other aspects of his work.

Here's Newton's alchemical laboratory at Trinity College, on the right beyond the trees and next to the chapel. For his extensive alchemical experiments Newton designed and built furnaces and other equipment, and twice a year he hid himself away in his laboratory for up to 6 weeks of frenzied activity, often forgetting to eat or sleep.

Newton’s interest in alchemy can be traced back to his schooldays in Grantham when he learned about the mixing of chemicals. In the 17th century alchemy was the part of chemistry that attempted to imitate transmutations in nature (such as the change from a tadpole to a frog), in order to convert one substance to another – and in particular, to change from ordinary metals (such as lead) to silver and gold.

The subject involved experiments with substances (such as mercury) that combine well with other metals, and became intimately tied up with studies of the occult.

On the right is part of a list, drawn up by Newton, of metals and their alchemical symbols, while on the left is his drawing of the philosopher’s stone, which was supposedly involved in the process of turning base metals into gold.

<u>Divinity</u>

Newton’s views on religion were equally controversial. Although believing in a Supreme God, which he described as ‘eternal, infinite, and absolutely perfect’, he refused to countenance the Christian doctrine of the ‘Trinity’, where the Father, Son and Holy Spirit are considered as one and the same.

Newton knew the ancient texts as well as any theologian, having compared them assiduously in their original languages of Latin, Greek and Hebrew. Starting from these writings, he spent much time in trying to date the Creation and, using verses from the book of Ezekiel, he reconstructed the layout of Solomon’s temple in Jerusalem, as shown here. Here, too, is Newton’s study of Biblical prophecy, as presented in the Book of Daniel and the Revelation of St John.

Newton kept his anti-Trinitarian views to himself, as they’d have been considered heretical by both the Church of England and the University of Cambridge. However, the statutes of his Lucasian Chair required him to take holy orders after 7 years, and Newton, unwilling to do so, was expecting to have to resign – but at the last moment Isaac Barrow, his Lucasian predecessor, managed to obtain a special dispensation from the King releasing Newton from this obligation.

<u>London – The Royal Mint</u>

In 1696 Isaac Newton, then in his early 50s, left Cambridge to become Warden of the Royal Mint in London, living in the Tower of London where the Mint was based. For the last 30 years of his life, our secretive retiring scholar became an influential public figure, gaining position and power which he then ruthlessly exploited to achieve his aims.

On the right is a coining screw press in operation. The person in the middle inserted the blanks and removed them after they were struck by the press: this happened 20–30 times per minute as the balance arm was swung back and forth.

Newton was an extremely efficient administrator and political operator, who immediately set to sorting out the problems at the Mint. Because he did nothing in a half-hearted way, he managed to effect the re-coinage necessary to resolve monetary crises in the economy.

But his duties went beyond administration. Being responsible for prosecuting counterfeiters, he recommended their execution when he thought this appropriate, a task that he undertook with the same commitment that he used for his academic researches. So successful was he in reducing forgery that in 1699 he was promoted to Master of the Mint.

Among Newton's other activities at the Royal Mint was the design of medals. One of these celebrated the Coronation of Queen Anne in 1702, and depicts her as the goddess Athena, striking down a two-headed monster that represented the threat of Catholic rivals to her throne.

London: The Royal Society

During his early years in London, Newton paid little attention to the Royal Society, which was in a bad state financially and in which its Fellows barely contributed to its activities. But after the death in 1703 of Robert Hooke, with whom Newton had disagreed on gravity and light, he re-engaged with the Society and was elected its President, a position he held for over 20 years. This portrait of him as President was painted at this time.

As with the Mint, Newton applied his organisational skills to turning the Royal Society around. This Victorian drawing of a meeting of the Society shows him seated in the centre behind a table on which is laid the Society's mace – and below his signature appears on an election notice of 1712.

Achievements

Newton's appointment as the Royal Society's President seems to have rekindled his interest in science, and in the following year, 1704, he brought out *Opticks*, his treatise on light. Written in English, rather than Latin, it was easier to understand than the *Principia*, and became a popular book that was accessible to a much wider audience.

Newton's success and public recognition were growing rapidly, and in 1705 he was knighted by Queen Anne for services to the State. He was the first British scientist to receive such a recognition.

Disputes and disagreements

Although his health was failing, Newton continued working, in order to ensure that Newtonian philosophy would spread and become established. He supported and influenced the appointment of his followers to university positions where they could lecture and write books that adopted his approach.

But one thing that continued was his capacity to take offence and to become involved in arguments. One of these was a major disagreement with John Flamsteed, the first Astronomer Royal, over access to Flamsteed's astronomical observations.

But the most notorious dispute was with Leibniz over the invention of the calculus, with Newton's followers accusing Leibniz of plagiarism. With much ill-feeling between Britain and the Continent on this issue, Newton arranged for an 'independent' commission to investigate it. This was not Newton's finest hour – he personally chose the members of the commission, writing much of the evidence for them to consider. Unsurprisingly they ruled in his favour.

Final years

Isaac Newton died aged 84 in March 1727, and his body lay in state in Westminster Abbey for a whole week. At the funeral service his coffin was carried by two dukes, three earls and the Lord Chancellor – and, as the French writer Voltaire observed:

> *‘He was buried like a king who had done well by his subjects’.*

Here’s a death mask of Newton that was used when creating his features on his tomb at Westminster Abbey, erected in 1731, where you’ll find the exhortation:

> *‘Let Mortals rejoice that there has existed such, and so great, an ornament of the human race’.*

This shows the extent of his standing and the view of his achievements among his contemporaries. Since then, his reputation has hardly faded, and he’s still considered by many as having the greatest scientific mind of all time.

<u>Reactions to the *Principia*</u>

What can we say about Newton’s legacy?

Certainly, his *Principia* had been an instant success in Britain. Halley praised it enthusiastically, as we’ll see, while the antiquary and biographer John Aubrey talked of

> *‘the greatest Discovery in Nature that ever was since the World’s Creation. It never was so much as hinted by any man before’.*

There was also enthusiasm for the *Principia* in Italy and the Netherlands, but less so in France where Newton’s ideas on gravitation contradicted those of the great philosopher Descartes. However, the Marquis de l’Hôpital, writer of the first textbook on the calculus, could hardly restrain his excitement when he was shown a copy of it, crying out with admiration:

> *‘Good God, what a fund of knowledge there is in that book’ – and asking all sorts of questions about Sir Isaac, such as the colour of his hair, and ‘does he eat & drink & sleep?’ and ‘Is he like other men?’.*

<u>Translations and commentaries</u>

The first French translation of Newton’s *Principia* was by Emilie du Châtelet, mathematician and physicist, who added a perceptive commentary on his writings. Three centuries later it’s still the best-known French translation. She and her lover, Voltaire, did much to spread Newton’s ideas in France. On the right is the frontispiece from Voltaire’s *Elements of Newton’s Philosophy*, where Voltaire is seen writing, illuminated by Divine light that comes from behind Newton via a mirror held by Emilie du Châtelet.

<u>Newtonianism for the Ladies</u>

Meanwhile, several books appeared that tried to explain Newton’s *Principia* to a range of potential readers. In 1737 Francesco Algarotti produced his *Newtonianism for the Ladies*, explaining Newton’s ideas on light and colour, and showing Algarotti with Emilie du Châtelet...

Newton for the Young

. . . and later, in 1761, six lectures on Newton's ideas, 'adapted to the Capacities of young Gentlemen and Ladies', were given by a certain 'Tom Telescope', depicted here.

Blake and Paolozzi

Newton has also been represented in engravings, paintings and sculptures. One of the most intriguing was by the radical poet and artist William Blake, and shows Newton sitting on a rock under the sea, engrossed in a geometrical diagram that he's drawing with a pair of compasses.

Blake was opposed to many of Newton's views, but years later his picture provided the inspiration for a large bronze statue, Paolozzi's '*Newton, after William Blake'*, which can be seen in the piazza of the British Library in London.

Salvador Dali's Homage to Newton

Another artist who was fascinated by Newton was the surrealist Salvador Dali, whose bronze statues called *Homage to Newton* show an open torso of Newton holding a suspended ball or apple. These exist in various forms and sizes, ranging from miniature versions suitable for the home, to large public sculptures in Singapore and Madrid.

Money and medals

Newton has also been celebrated on banknotes, coins, and medals. Here's a selection.

For 10 years, British pound notes showed Newton's planetary system, telescope, prism and the *Principia*, although the note's designer chose to 'improve' our entire planetary system by placing the Sun at the centre of the ellipse. More recently, this British 50 pence coin depicts Newton's planetary system.

Newton once claimed that:

> *'If I have seen further, it is by standing on the shoulders of giants',* and these words appear around the edges of many of our £2 coins.

Commemorative medals have also been cast, such as this 18th-century one from Switzerland.

British postage stamps

Many countries have also issued postage stamps that feature him. In 1987 these four British stamps commemorated the 300th anniversary of the *Principia* and his work on optics . . .

Some world-wide postage stamps

. . . while below are some other Newton stamps from around the world – from the Ascension Islands, Monaco, Dubai, Hungary and Nicaragua.

Two quotations

We end with some well-known quotations. The first is said to be by Newton himself:

> *'I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all discovered before me.'*

The second encapsulates the reverence with which Newton was held during (and immediately following) his lifetime, when the poet Alexander Pope produced the following memorable epitaph of his achievements:

> *'Nature and Nature's Laws lay hid in Night.*
> *God said, Let Newton be! and All was Light.'*

Halley's Ode to Isaac Newton

But we leave the final words to Edmond Halley, whose 'Ode to Isaac Newton' introduces the *Principia* and concludes with the words:

> *'Then ye who now upon heavenly nectar fare,*
> *Come celebrate with me in song the name*
> *Of Newton, to the Muses dear; for he*
> *Unlocked the hidden treasuries of Truth:*
> *So richly through his mind had Phoebus cast*
> *The radiance of his own divinity.*
> *Nearer the gods no mortal may approach.'*

Finally, here are some suggestions for Further reading.
Thank you very much for listening.

Further Reading

'Let Newton Be? A New Perspective on his Life and Works' by John Fauvel; Raymond Flood; Michael Shorthand; and Robin Wilson, Editors.1988

'Newton: A Very Short Introduction' by Rob Lliffe. 2007

'Remarkable Lives: Newton' by Raymond Floor and Robin Wilson. 2020

'The Mathematical Papers of Isaac Newton. Volume 3:1670-1673' D.T Whiteside, Editor.

'Never a Rest: A Biography of Isaac Newton' by Richard S. Westfall. 1983