HANS LITTEN AND CIVIL LIBERTY IN GERMANY

DOROTHY HAMILTON STEPLER

HISTORY is going to have a great many perplexing questions to ask of our world, and not the least of them will be this: how could we, confronted as we were by evils which had not been practised for centuries, by the torture and exile of the intellectual leaders of Europe, by the persecution of Jews and Catholics, by the concrete evidence of the concentration camp and the pogrom, warned of danger as few people ever have been warned, how could we watch this danger and destruction without protest at a time when it was early enough for resistance to have prevented catastrophe?

Dorothy Thompson has recently exhorted the Congress of the United States and the British Parliament, with theirc hurches, schools and colleges, to make a formal protest against the outrage of the Nazi shooting of hostages—not that this would have any effect, but merely for the sake of our place in the history of civilization. But why express surprise and horror now about gangsterism which is the logical outcome of the Nazi system and the complete break-down of German law? Ten years ago there was still time to have kept the German state legal and constitutional. Ten years ago German law, though becoming weaker and weaker, was still an objective guardian of the citizens' rights. And ten years ago a young German lawyer was defending with the fervour of a fanatic the justice which he saw the totalitarian state rapidly crushing.

Before the Nazis forced him to commit suicide, he had spent five years in various concentration camps where he was tortured until one eye and leg had been permanently injured, his jawbone fractured and his teeth knocked out. But his spirit was never broken. And when his mother saw his dead body in Dachau, swathed to the chin lest she see his injuries, she resolved never to rest until she had vengeance on his murderers.

Hans Litten was born in 1903 in Königsberg. As his father was a brilliant professor in the university in that town, he had all the advantages that wealth and education could give him. Furthermore, he was not a Jew. But for the world in which he was to live as an adult, he possessed some insurmountable handicaps: a belief in humanitarianism and liberalism, and a devotion to legal and social justice. As he started to practise law in 1929, just at the time the Storm Troopers began their street fighting, his fate was sealed. Realizing where Hitler's idea of law would lead the nation, he inevitably ran headlong into the Nazi gangsters who were building power by breaking it. In nearly all the important political trials before 1933, Litten acted as counsel on behalf of anti-Nazis. In 1931 (and this should give the utmost satisfaction to the frustrated world) he even brought Hitler himself into the witness-box, and gruelled him there for two hours in an attempt to make him confess that Nazism was based on nothing but violence and terrorism. Once, at least, a German had the courage to give Hitler a little of what he deserves!

Naturally, Hitler never forgot or forgave that ordeal, and it is easy to see why Litten was one of the first sent to Spandau prison without trial, charge or sentence on the night of the Reichstag fire. Although his mother knew all the important people in Germany, although she never ceased, for the five years that he was interned, to interview, write letters, pull strings, exhort, badger and bully officials of the Gestapo, as well as Hindenburg, Himmler and Goering, all she succeeded in accomplishing was the occasional improvement of his condition. Once she even offered to have herself interned in her son's place, because she considered she was responsible for his actions since she had brought him up to be a decent human being. But Hans was much more than that. By the poor in North Berlin, whom he defended in court so often without pay, by his fellow prisoners to whom he gave nearly all the delicacies his mother sent him, by innumerable second-hand booksellers, fruiterers and salespeople to whom he was a total stranger, he was considered a saint. On one occasion when he needed a copy of a poem which was very difficult to obtain, a specialist in old High German removed it from a very valuable book, saying: "For Hans Litten I would have a piece of flesh cut out of my body, if I could help him by so doing."

But such veneration only made Litten more disliked by the Nazis. It was said that whenever his name was mentioned, Hitler went purple in the face, and that he once told the Crown Prince: "Anyone that intervenes on Litten's behalf goes straight into camp, even if it is yourself." When finally nothing more could be done in Germany, an attempt was made to arouse public opinion throughout the world. In 1934 a number of well-known English lawyers, headed by Lord Allen of Hurtwood, sent an appeal to Hitler for Litten's release, which received only a curt refusal. Later, as Litten's treatment became worse and worse, his English friends decided to publish the facts of his life, hoping that exposure would save him, but just before the account reached *The Times* (Feb. 5, 1938) he was reported hanged.

What strikes one most forcibly in reading this tragic story as told by his mother* is the complete failure of so many sensible, educated doctors and lawyers to realize in time the kind of state they were living in. They continued to think of it as legal and constitutional in spite of the barbarities which were committed daily—unless of course they themselves were directly affected. When Litten and so many other important people were arrested, it was termed "protective custody," a decent act on the part of the Government to save them from their adversaries. Everyone assumed they would be released in a few weeks, and the rumours of their hideous maltreatment were not believed. To the end, Mrs. Litten, while under no illusions as to the butchers with whom she was dealing, insisted on never having anything to do with illegal methods, which no doubt accounts both for her failure to obtain her son's release, and also for the fact that she accomplished as much as she did in a country where the Gestapo was above the law.

Hans Litten personified the final struggle and defeat of democracy in Germany, and the principle of law which he died upholding is of fundamental importance to both Germans and Englishmen. As an eminent English jurist recently told the Canadian Bar Association, it would be just as terrible a thing to contemplate in Canada as anywhere that ordinary citizens of a state can be taken secretly into concentration camps upon the bare word of some secret agent, and left without trial or charge or investigation, in many cases to linger and to die. Eleanor Roosevelt has said that because such people as Hans Litten and his mother have lived in the world and kept faith to the end, one cannot help but be proud for the whole human race. That the particular branch of that race to which such outstanding human beings belonged also produced the outlaws responsible for the unspeakable evil they suffered, is one of the dreadful mysteries of our time.

**Beyond Tears*, by Irmgarde Litten.

ISAAC NEWTON: A TERCENTENARY OBSERVANCE

S. BASTERFIELD

IT is only fifteen years since the scientific world was commemorating the bicentenary of Newton's death. At that time distinguished scholars in various fields delivered addresses and wrote essays reviewing his contributions to science and philosophy, and estimating his place and influence in the history of human thought. Scarcely were these pronouncements published and placed on the library shelves when two new biographical studies of Newton appeared, one by Professor L. T. More[1] in 1934, and another by the late J. W. N. Sullivan[2] in 1938. Professor More's study was evidently prompted by the fact, stated in his preface, that two hundred years after Newton's death there was still no critical biography of the great scientist in existence. His exhaustive study has undoubtedly gone a long way towards remedying the deficiency. Mr. Sullivan's briefer study is a further development of his conception of Newton's character as presented in an article published at the time of the bicentenary celebration.

Now that the tercentenary of his birth calls for notice, it seems appropriate to look again at the character and work of a scientist and philosopher who has influenced human thought so profoundly, and at the same time presented many interesting problems of behaviour both to his contemporaries and to succeeding generations of his followers and admirers.

The standard biography on which most of our judgment of him has been based is, of course, Sir David Brewster's *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton,* published in 1855. This work was adversely criticized by Augustus De Morgan[3] as being too much colored by hero worship, and devoted to the cult of Newton as the complete man whose greatness of intellect was paralleled by his perfection of character. De Morgan undertook the thankless task of correcting the picture drawn by Brewster and giving a more realistic study. In the more recent studies by Professor More and Mr. Sullivan we have renewed efforts to interpret the character of Newton, and to

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1. *Isaac Newton*, by L. T. More, (Scribners, 1934)
2. *Isaac Newton* by J. W. N. Sullivan (Macmillan, 1938)
3. *Essays on the Life and Work of Newton*, by Augustus De Morgan

see him in his personal relations to his contemporaries against the background of life in the seventeenth and eighteenth centuries.

While this essay is not intended as a review of the two books mentioned, it owes a good deal to both. Its purpose is to give a sketch of Newton's life and character, to survey briefly his work in science and philosophy, and to indicate the developments that have superseded his generalizations and his particular philosophy of science.

I

Isaac Newton was born at Woolsthorpe, Lincolnshire, on Christmas Day, 1642 (O.S.). His parents were both of yeoman stock, and he inherited the small manor of Woolsthorpe, where he was born. There is no record of distinguished ability in either of his ancestral lines, and he himself showed no unusual powers as a boy except in the making of mechanical devices and models. His eruption in solitary genius resembles that of another great English scientist, Michael Faraday, who was likewise born of an undistinguished family. It is noteworthy also that neither of these gifted men left descendants.

Newton's father had died a few months prior to his birth, but his mother was able to send the boy to school at Grantham, and later to Trinity College, Cambridge, where he was entered as a sizar in 1661, at the age of nineteen. He had shown no inclination to take up farming and live the life of a small country gentleman, so he was sent, on the advice of his uncle, to the University, possibly with the idea of his taking orders and becoming a country parson. He knew very little mathematics when he entered Trinity, but under the guidance of Dr. Isaac Barrow, the Lucasian Professor, he developed quickly, and in the space of four years had revealed the power of unsuspected genius. In his first two years he studied arithmetic, Euclid, and trigonometry, and attended lectures in astronomy. From Barrow he received instruction in natural philosophy including optics, a subject in which he was destined to make some of his most striking discoveries. It was in optics that he found an outlet for his exceptional experimental skill. From arithmetic and the geometry of Euclid he passed to Descartes's Analytical Geometry, and Wallis's Algebra, and his remarkable powers woke to life. In the years 1664-1666 he made his most important discoveries and laid the foundation of subsequent researches.

Newton was elected a scholar of Trinity in 1664 and graduated in January, 1665, three and a half years after entering the University. There is no record of his standing at graduation. In the fall of this year, Cambridge was closed on account of the plague, and Newton was forced to return to Woolsthorpe where he spent a good part of the next two years. It was during this period of isolation that, undisturbed by academic duties, and free to follow his inclinations, he became absorbed in enquiries that yielded three outstanding discoveries. These were the mathematical method of fluxions (the foundation of the calculus), the composition of light, and the quantitative law of gravitational attraction. Concerning the last, Newton's own memorandum of 1714, preserved in the Portsmouth Collection of his papers, says:

> In the year (1666) I began to think of gravity extending to the orb of the moon, and having found out how to estimate the force with which a globe revolving within a sphere presses the surface of the sphere, from Kepler's rule of the periodical times of the planets being in a sesquialterate proportion of their distance from the centres of their orbs, I deduced that the forces which keep the planets in their orbs must be reciprocally as the squares of their distances from the centres about which they revolve; and thereby compared the force requisite to keep the moon in her orb with the force of gravity at the surface of the earth, and found them answer pretty nearly.

And then, as if apologizing for this intellectual "scoop", he adds quaintly:

> All this was in the two plague years of 1665 and 1666, for in those days I was in the prime of my age for invention and minded mathematics and philosophy more than at any time since.

The amazing feature of this situation is that at least two of the most significant discoveries in the history of science were worked out casually by an unknown youth sent home from college because of an epidemic, and quietly kept to himself. He made no effort to publish his results. His calculation of centrifugal force referred to in the above quotation was made quite independently of Huygens who published his work on rotational dynamics in 1673, and who is generally credited with the discovery of the principle. The aloofness of spirit, the indifference to public recognition, the impulse to seek laws of Nature and formulate mathematical generalizations for the satisfaction of personal curiosity, were all characteristic of Newton, at least during his most creative years. We may find a parallel to this attitude in another great English scientist, Henry Cavendish, a wealthy bachelor recluse, many of whose brilliant investigations lay unpublished for long years after his death.

For thirteen years Newton neglected to follow up the consequences of his discovery of the quantitative law of gravitation, and it was twenty years before he embodied his massive studies in dynamics in his great work, the *Principia*. Various explanations have been offered by scientists for his delay in giving his results to the world, but none of them have taken much account of Newton's own personality as a possibly important factor in the delay. He had many interests besides mathematics. He must have been fully aware of the importance of his findings, but apparently attached more value to other studies that absorbed his attention, notably the experimental problems of optics.

Newton returned to Cambridge when the plague had subsided somewhat, was elected in 1668 to a Major Fellowship at Trinity, and received his Master of Arts degree in July of the same year. His preliminary studies on the fluxional calculus were expanded into a paper, "On Analysis by Equations with an Infinite Number of Terms", and this with Barrow's endorsement was sent anonymously to John Collins, a scientific friend, who expressed keen interest in the essay. Barrow then revealed the name of the author, and spoke of him as "a young man who is only in his second year since he took the degree of Master of Arts, and who with an unparalleled genius has made very great progress in this branch of mathematics." At this time Barrow was so much impressed by Newton's capacity that he resigned the Lucasian chair in 1669, and Newton, now twenty-seven years old, was appointed to succeed him.

The duties of the professorship were light. Given a wide choice of topics for his lectures, Newton undertook to offer a course in optics, a subject in which he was intensely interested and in which he had made his well-known discovery of the composition of white light. He had early studied the optical writings of Kepler and Descartes, and had acquired skill in the grinding and polishing of lenses. It was while engaged in these operations that he made the discovery of chromatic aberration, the existence of a colored ring blurring the edges of an image produced by a convex lens system and making accurate focussing difficult. It seems probable that this observation led him to his study of the refraction of light by a prism and the separation of white light into components of different colors. He concluded that, because of the unequal refrangibility of the constituents of white light, it was not possible to get rid of the defect in refracting telescopes, and he turned his attention to the construction of a reflecting telescope in which a concave metallic mirror took the place of the object glass of the refractor. This invention was a great success, and the second instrument he made was sent to the Royal Society. It was accepted with enthusiasm, and won for Newton election to Fellowship of the Society in January, 1672. He was greatly encouraged by the reception of his reflecting telescope, and decided to present his discovery of the composition of light in a paper to the Royal Society. The discovery had been made five years before, and had been dealt with by Newton in his lectures at Cambridge, but had not been brought to the notice of the leading learned society in the country. He himself was very elated by the discovery and, in a letter to Oldenburg, the secretary of the Society, described it as "the oddest, if not the most considerable, detection which hath hitherto been made in the operations of Nature."

The communication to the Royal Society described in detail Newton's careful and ingenious analysis of white light with the prism, and his proof that white light was made up of colored rays of different refrangibilities; "that colors are not qualifications of light derived from refractions or reflections of natural bodies (as is generally believed), but original and connate properties, which in divers rays are diverse; that to the same degree of refrangibility ever belongs the same color, and to the same color ever belongs the same degree of refrangibility." And he goes on to explain his attempts to change the color of rays by many devices but without success.

The paper is a model of clear, concise, and logical exposition, the work of a mature scientific mind, and it set the standard for all his subsequent publications. It was so unusual that a committee of the Royal Society was appointed to examine it and report on it. It involved no speculative hypotheses as to the nature of light, but the conclusions were drawn entirely from a set of experimental observations. Here was a new departure in scientific reporting; it marked the inception of a method and a philosophy that have strongly influenced scientific investigation down to the present time. Not that experimental procedure and observation were new! Others had been exponents of the experimental philosophy before Newton, but none other had realized the full implications of this philosophy. He limited his conclusions to generalizations or laws which could be drawn from the observed phenomena, and refused to go beyond phenomena into hypotheses as to the nature of things. He was not averse to speculative or metaphysical ideas in their place, but he aspired to keep his science and his metaphysics apart. We shall return to this point in estimating the influence of Newton's thought, but it may be noted here that the controversy aroused by his first published research hinged on this difference between his view of scientific method and that of most of his contemporaries who were still largely under the sway of Descartes.

The criticism directed at Newton's conclusions was based not on other experimental evidence that disagreed with his, but essentially on preconceptions about the nature of light and color. He at first accepted with patience the comments of Hooke and Huygens, as well as of certain other critics, but as the controversy continued, bitterness developed on both sides. Newton pointed out that his conclusions on color were not dependent on any conception of the ultimate nature of light or the hidden mechanisms of the observed phenomena. He was willing to concede the possibility that corpuscles or ether vibrations might be associated with the phenomena, but these were matters of pure hypothesis, and could not alter the facts he had discovered. As showing the unsatisfactory nature of hypotheses, he made a very acute criticism of Hooke's hypothesis of ethereal vibrations, a criticism which so angered Hooke that he insinuated Newton had stolen ideas from his own "Micrographia".

Newton's stand was quite clear. It amounted to a demand that his critics should produce experimental evidence in refutation of his, and cease to bother him with hypotheses, and opinions, and *a priori* arguments. They in turn were affronted by his refusal to give serious consideration to hypotheses and *a priori* principles in the study of Nature. To Newton's mind they were flying in the face of facts, and deluding themselves with an appearance of knowledge.

The effect of the controversy on Newton was unfortunate. Like the young anatomist Vesalius, under similar circumstances, he resented the hostility and prejudice displayed by his opponents, and withdrew into himself. Naturally a sensitive and secretive man, his enthusiasm for research received a rude jolt: he seems to have resolved to go his own way, and while following his normal inclination to experiment and meditate, to keep his observations and ideas to himself. In particular he developed an animosity towards Robert Hooke, a man of brilliant mind and an ingenious experimenter, active in many fields, but just falling short of the level of genius in anything. Hooke saw a potential rival for leadership and recognition, and clutched jealously at any chance to assert priority of discovery or discredit his own ability. It was chiefly due to Hooke's antagonism that Newton's optical researches were withheld from publication until 1704, a year after Hooke's death.

Although Newton withdrew from the scientific world for the time and sent no more communications to the Royal Society on his optical researches, he was actually induced to reconsider his resolve by letters from Hooke himself. The first of these, written in 1676, was an attempt to placate Newton by expressing admiration for his qualities and suggesting correspondence between them on subjects of mutual interest. Newton replied in similar vein, but nothing came out of the rapprochement. In 1678 Oldenburg, the secretary of the Royal Society, died, and Hooke was elected joint secretary with Nehemiah Grew the botanist. On instructions from the Society, Hooke, in 1679, wrote again to Newton requesting him to favor the Society with further communications on his philosophical work. The new secretary again urged Newton to correspond with him on scientific matters, especially on the problem of the motion of planets as compounded of a tangential motion and an attractive motion towards the central body. Newton's reply to this indicates that he had made good his resolve to leave science alone. He admits that he is tempted to accept Hooke's proposal to enter into a philosophical correspondence, but says he has nothing to offer. He has been cumbered with family affairs for six months, and before that, he goes on, "I had for some years past been endeavouring to bend myself from philosophy to other studies, in so much that I have long grudged the time spent in that study unless it be perhaps at idle hours sometimes for a diversion; which makes me almost wholly unacquainted with what philosophers at London or abroad have of late been employed about."

However, as he afterwards put it, "to sweeten the answer," he offered a suggestion about proving the earth's diurnal motion. He made the statement that a stone dropped from a height would fall to the east of the spot vertically below it, and that if the stone could pursue its course to the centre of the earth, it would describe a spiral path. Newton was wrong on this point; Hooke quickly saw a chance to put him right, and possibly to enhance his own reputation with the Royal Society. He introduced the letter at a meeting of the Society, and read his proposed reply to Newton. The latter was greatly annoyed at Hooke's behaviour, but, in a letter, admitted his error, though he did not agree with Hooke's version of the path of the falling body. It seems likely that he was as much annoyed with himself for a mistake he would not have made, had he continued his studies in gravitational dynamics. It was the stimulus required to send him back to consider the consequences of the inverse square law. He apparently proved, at this time, that the path of a planet under this law of force is an ellipse. Having satisfied himself, however, he did not communicate the result either to Hooke or to the Royal Society, and for five years he turned his mind to other matters. He actually lost the notes containing the demonstration.

But many of Newton's contemporaries besides Hooke were interested in gravitational force and planetary orbits. The inverse square law had been derived by others, but no one had been able to demonstrate that the observed elliptic orbits were related to the law of force. In January, 1684, Hooke discussed the problem with Edmund Halley the astronomer and Sir Christopher Wren the architect, at a private meeting. Hooke boasted that he had proved the motions of the planets to follow from the law. Halley admitted his failure to do so, and Wren offered a present of a book worth forty shillings to whichever of his two friends would bring him the demonstration in two months' time.

Hooke, as Wren doubtless expected, failed to make good his boast, and in the late summer Halley went to Cambridge to seek the help of Newton. When he asked directly what would be the shape of the orbit of a planet under gravity if the inverse square law of force prevailed, Newton promptly replied "An ellipse". Pressed further as to how he knew this, he said that he had calculated it. He could not find the calculation, but promised to send it, which he did, solving the problem by two different methods.

Once started, Newton threw himself wholly into the problems of dynamics and prepared lectures on the subject which he delivered at Cambridge. Halley, having paid another visit to Newton to induce him to publish his proof of the planetary orbits, saw the manuscript, *De Motu Corporum*, and was greatly impressed by it. He urged that it be sent to the Royal Society, and received a promise that it would be. Back in London, Halley reported his find to the Society, and he and Paget, Mathematical Master of Christ's Hospital, were appointed to remind Newton of his promise.

Thus was begun the great work which appeared two years later under the title *Philosophia Naturalis Principia Mathematica*, usually called the *Principia*, held by some to be the greatest single work in the history of science, and one of the greatest intellectual feats in human history. Newton, having been lured into the old problem by Hooke's pretensions and Halley's generous enthusiasm, became completely absorbed, and in a period of intense concentration finished his masterpiece in about a year and a half. No one but a mathematical genius of the first rank could have produced such a work. Beginning in classic geometric style with definitions and postulates, it lays down the basis of the fluxional calculus, states the laws of motion, develops the principle of gravitational force and solves the problems of orbits. In the second book the motion of bodies through fluids is examined, while the third book applies gravitational theory to explain the tides, the precession of the earth's axis, and other phenomena. There are one hundred and ninety-two propositions in all, a few of which Newton had developed as early as 1679, but the great bulk of them were enunciated and proved, *de novo*, in seventeen months of continuous work from December, 1684 to May, 1686. This single achievement places Newton in the circle of the immortals. Even if his optical researches were set aside and his claim to independent invention of the calculus rejected, his glory would remain undimmed.

But he was somehow unaware of the remarkable quality of his genius, and even seemed to resent or at least to be indifferent to its exercise. It seemed destined to lead him into controversy, which he loathed, and to destroy his quiet, which he valued above all else. When the first book of the *Principia* was completed, it was presented to the Royal Society by a Dr. Vincent, and Hooke immediately declared that Newton had taken the idea of the inverse square law from him and had not acknowledged it. When this was intimated to Newton, his indignation vented itself in a letter to Halley, in which he expressed his opinion of Hooke in no uncertain terms and set out the history of his own work at great length. He was generally indifferent to claims of independent discovery by other men, but he would brook no charge of plagiarism against himself. He was extremely jealous for his own discoveries, great or small, and when once aroused in his own defence pursued his detractors with a cold implacability. His reaction in this instance was not only to denounce Hooke but also to decline to continue work on the third book of his treatise. He had completed the second book, but now he says: "The third I now design to suppress. Philosophy is such an impertinently litigious lady, that a man had as good be engaged in lawsuits as have to do with her. I found it so formerly, and now I am no sooner come near her again, but she gives me warning." He suggests keeping the original title, although the contents of the two books hardly justify it, but for Halley's sake he will retain it to help the sale of the book. Halley, it should be noted, had undertaken to bear the expense of publication when the Royal Society had, for lack of funds, been unable to proceed with it.

It is an extraordinary revelation of Newton's attitude to his own incomparable work that he should have been ready to let a personal grievance prevent the offering of the complete masterpiece to the world, and to think of its curtailment only in terms of Halley's possible financial loss. He was doubtless deeply grateful to Halley for his generosity, and he later referred to the *Principia* as Halley's book, but there is evident from this incident some lack in Newton of a proper sense of values, both intellectual and social. It marred his relationships with many people in the course of his long life.

Halley hastened to reassure Newton that neither he nor the Royal Society accepted Hooke's claims, for Hooke had failed to produce his demonstrations, and he begged Newton not to carry out his threat to withhold the third book. Newton, having got over his first heat and being mollified by the Society's attitude, agreed to go on with the work, and even to add a scholium giving credit for independent discovery of the inverse square law to Hooke, Halley and Wren. He hoped that this would end the dispute.

The completed work was published in the summer of 1687. Though the first edition was quickly sold out, few people understood the argument of the book. Only accomplished mathematicians could read it, but these were the only ones that Newton cared to interest. He gained recognition and fame throughout Europe, but his ideas were only slowly accepted.

As a result of the strain of prolonged concentration and indifference to proper habits of eating and sleeping, his health had become seriously impaired. He became irritable and despondent, and sought earnestly for a means of escape from Cambridge. He was forty-five years old, and although in the prime of life he never again revealed his creative powers on such a scale. He began to solicit help among influential friends in London to secure a lucrative government post. For a time he was perilously close to serious mental breakdown. Meanwhile he continued work in celestial mechanics, and devoted himself to the theory of lunar motion which he declared was the only problem that ever made his head ache.

II

We shall not enter into the story of Newton's relations with the Rev. John Flamsteed, the first Astronomer Royal, from whom he hoped to get the data required for his lunar theory. It need only be said that their temperaments were such that they completely failed to collaborate, and ended by quarrelling bitterly. Newton was undoubtedly patronising and overbearing in his attitude to Flamsteed, while the latter, self-righteous and stiffnecked, lectured Newton about his faults and those of his friends, especially Halley, to whom Newton was greatly attached. Flamsteed carried on his work under extremely adverse conditions, borne down by ill-health and poverty, and Newton seems to have been less than just to him. Flamsteed shrewdly hinted that Newton's weakness of character made him too susceptible to the flattery of his friends, after the success of the *Principia*, and that he thought too highly of himself. He had become too much the high priest of science.

After the publication of the *Principia*, Newton's interest in mathematical physics suffered a marked decline. He blamed Flamsteed's dilatoriness for his loss of interest in the lunar theory, but the real reason lay in himself. He had gone as far as he wished to go, and desired now to be occupied with other matters. He was concerned about his own affairs. He craved for a wider life and a more influential position. He had almost despaired of escaping from what had become the uncongenial atmosphere of Cambridge when he was notified of his appointment to be Warden of the Mint through the good offices of his former Cambridge friend, Charles Montagu, at this time Chancellor of the Exchequer.

Newton was not a stranger to political life. He had taken an active part in 1687 in resisting the attempt of James II to interfere with the rights of the University of Cambridge in the matter of admitting Roman Catholics to degrees, and had also sat in the House of Commons as member for the University. He was a staunch Whig, a member of the Church of England,

and definitely opposed to the influence of the Church of Rome. Aside from his political leanings, and his eminence in physics, he had a life-long interest in chemistry, or more correctly, in alchemy, and had experimented a good deal with metals. This was probably an additional factor in influencing Montagu's choice of him for the post at the Mint. The Chancellor was about to undertake complete recoinage of the currency, and doubtless preferred a man to supervise the work who had merits above those of a merely political nominee. Furthermore, Newton was recognized as a man of high integrity, an especially desirable qualification for a Warden of the Mint at any time, but particularly so during the handling of huge quantities of bullion and currency, and in the face of possible bribery by unscrupulous interests.

Newton took up residence in London early in 1696. He did not resign his chair till a few years later, but he seems to have had no regrets about his decision to leave Cambridge. He was fifty-three years old, and one would have thought him unsuited to a position so different from an academic post. But he concentrated on his task with his customary diligence, and completed the whole difficult business in three years. He was then made Master of the Mint at a salary of £1200 to £1500 a year, and he held this office for the remainder of his life. It was practically a sinecure, involving attendance at the Mint only one day a week. It gave him the large leisure which might have been expected to yield further fruitful results in physics and mathematics, but apart from controversies and new editions of the *Principia*, the revision of which was undertaken mostly by others, it yielded nothing of importance. Newton was absorbed in sacred chronology and theology, and showed flashes of his old power only when challenged on problems put to him by contemporary mathematicians. It is recorded that two problems published by Leibniz and John Bernoulli, which required for their solution a thorough grasp of the calculus and which it was hoped Newton would be unable to answer, were solved by him in one evening after a hard day's work at the Mint. The solutions were published anonymously in the Philosophical Transactions, but Bernoulli recognized the hand of Newton in the power and originality of the treatment.

Although Newton had taken little interest in the Royal Society while in Cambridge, he attended its meetings faithfully during his residence in London. He was soon elected President, and was re-elected annually till his death. He lived to be eightyfive, and enjoyed fairly good health until the last few years, when he developed a complication of diseases incident to old age. He was knighted by Queen Anne in 1704, and was deferred to as the dictator of science during his long presidency of the Royal Society. When he died in 1727, his body lay in state in Westminster Abbey, and he was borne to the tomb by peers who were Fellows of the Royal Society.

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Newton's abandonment of his scientific career and his resignation of the Lucasian chair for the position of a government official have always excited speculation and more or less unfavorable comment from biographers and critics. Sir David Brewster in his *Memoirs* undertakes to justify the action thus: "At the age of fifty, the high priest of science found himself the inmate of a college, and but for the generous patronage of a friend, he would have died within its walls". De Morgan replies scornfully "And where should a high priest of science have lived and died? At the Mint?—One year of his Cambridge life was worth more to his philosophical reputation and utility than all his long official career.—Newton was removed, the high priest of science was transferred to the temple of Mammon, at the time when the differential calculus was, in the hands of Leibniz and the Bernoullis, beginning to rise into higher stories. Had Newton remained at his post, coining nothing but ideas, mathematical science might have gained a century of advance." One sympathizes with De Morgan's irritation, but it seems fairly certain that had Newton not gone to London, he would still have made no further contributions to science. The fact was that he was not sufficiently interested in science to carry on sustained work in it year after year. It was only when his genius gripped him and carried him forward in spite of himself that he accomplished great things. In spite of his extraordinary achievements, he never regarded mathematics and physical science as of primary importance, and he was, for the most part, actually indifferent to them. Mr. J. W. N. Sullivan sums up his career in the following words:

> We may say that for the first twenty years of his working life his attitude towards science was one of bursts of intense absorption alternating with stretches of indifference. For the last forty years of his life, his bursts of absorption were far less intense and the stretches of indifference much longer. The paradox of Newton's scientific career is due to the fact, probably unique in the history of scientific men, that he was a genius of the first order at something he did not consider to be of the first importance.

III

The *Principia* presents us with a highly mechanistic picture of the physical universe, a system of masses of matter moving in accordance with the laws of motion and gravitation, abstract principles which can be given strict mathematical definition, and which correlate all motions of bodies throughout the universe. Newton advocated rigid adherence to a scientific method in which principles must be derived only from observations of phenomena. He was consistently opposed to hypotheses of a speculative or metaphysical kind, as being outside the scope of science. Even when scientific objects such as atoms were beyond the reach of perception, they were given an existential status by inference and endowed with properties similar to those of sensible objects. And of such principles as mass, gravity, hardness, inertia, etc., which might be regarded as occult properties, he says, "I consider them not as occult qualities but as general laws of nature, their truth appearing to us by phenomena."

Although he tried to be completely empirical, it is evident both in the *Principia* and the *Opticks* that he fails to escape the clutch of metaphysical assumptions. In order to define accelerated motion, he finds it necessary to postulate absolute space and time, and subsequent generations of scientists accepted these concepts uncritically. He speaks of "absolute time, or mathematical time of itself and from its own nature flowing equably without regard to anything external, and by another name being called duration." The phrase "flowing equably" implies a rate of flow which itself must be measured by another time, and so on in endless regression. It is poetic rather than scientific, like Plato's "moving image of eternity." Since the beginning of this century the concepts of absolute space and time have been abandoned by science as untenable. They are not usable ideas to the physicist. Time and space as measured are always relative to a frame of reference. It is only of late that we have learned that measured space and time may be different in different frames of reference, the difference depending on how the frames of reference are moving with respect to each other.

Again in the *Opticks*, in dealing with the corpuscular structure of matter, Newton argues that the ultimate particles must be hard and unbreakable; otherwise the nature of things would be changed. Water and earth composed of old worn particles would be different in nature and texture from water and earth composed of entire and unworn particles. "*And therefore that Nature may be lasting*, the changes of corporeal things are to be placed only in the various separations, and new associations and motions of these permanent particles." It is evident, as Dewey has pointed out, that a metaphysical principle is invoked to justify the atomic hypothesis, although the atoms are endowed with only sensible qualities. Newton is committed to a metaphysical belief in permanent and unchanging substance to give reality and stability to phenomena and scientific knowledge, although such substance is beyond the reach of sensory perception. For mathematical physics the belief makes no difference, since the "essential properties" enter the treatment only as terms symbolising quantities.

Recent trends in scientific philosophy have led away from the Newtonian point of view. The concepts of science are not regarded as mere abstractions from sense experience, but are viewed as largely operational. The sense qualities themselves are problems to be investigated, and their meaning is found in operations developed by a thinking mind in relation to them. Concepts of science then signify relationships rather than essential qualities belonging to things or inherent in them. In common sense thinking we still cling to the old permanent substance—fixed quality view of the world, but physics has become far too sophisticated to retain such a simple philosophy. Absolute space and time, solid matter and fixed properties, have all departed together. The Newtonian generalization of universal gravitation as a basis for interpreting the world of matter and motion has given place to the wider generalization of Relativity in which Newton's law appears as a special case depending on the frame of reference selected to describe the phenomena. Space and time are unified in a four-dimensional continuum where Newtonian "force" is no longer necessary, accelerated motion in a gravitational field being simply a function of the metrical properties of the continuum in the neighborhood of matter. Relativity represents a degree of abstraction and generalization far beyond the mathematical dreams of Newton and his contemporaries.

In the matter of hypothesis and the nature of scientific concepts, modern physics has departed considerably from the Newtonian position. Quite apart from the recognition that all scientific knowledge presupposes metaphysical assumptions, and that scientific concepts are on the whole operational or relational rather than abstractions from sense qualities, it has been found necessary in subatomic physics to use concepts that have no counterpart in the world of sense, nor, except through mathematics, any discernible connection with actual experience. In Quantum and Wave Mechanics the mathematical physicist often appears to be doing things as senseless as "dividing nothing by two", and yet the results of his evolutions make sense in the world of sense. These intellectual devices, pure inventions of the mind, so utterly remote from the models and mechanisms of classical physics, successfully correlate observations and give meaning to a complex of data. There is a challenging mystery here, a mystery that will perhaps be partially resolved in a new understanding of the relation of thought to Nature. As the late Sir William Bragg expressed it in his delightful book *The Universe of Light*, "We conclude that what at one time may be beyond our understanding may later become clear not only through the acquisition of fresh knowledge but also by training our minds to new ways of thought."

Newton, like other philosophers of his day, was a deeply religious man. He saw in the far-flung universe the evidence of the wisdom and majesty of God, and the laws of motion and gravitation were to him expressions of the divine thought and will in organizing the universe out of chaos. He held that the great machine was not self-sustaining, since motion was continually lost and had to be made good by the direct operation of the will of God throughout all space. He at no time regarded his mechanistic science as an adequate account of the physical universe in all its aspects. It was an abstraction, a chart, a limited view describing and correlating certain features of the universe that could be treated mathematically.

With the further development of the Newtonian scheme in the hands of later mathematicians, notably Laplace, the mechanistic scheme took on the virtues of a self-sustaining machine in which Deity was not required to act. Whatever may have been the origin of things, when once the mechanism had been set going it needed no further interference; it ran on inexorably in accordance with the eternal laws of matter and motion. And so it came about that out of a scientific mechanical theory there arose a mechanistic philosophy which presumed to cover the universe of nature and man, and proclaim an iron determinism for living and non-living alike. It is one of the ironies of the recent history of thought that the devout Newton, who saw in the mechanical universe a witness to the power and glory of an all-wise Creator, should have started a train of thought which later led to the expulsion of God from his universe, and the reduction of his creature man to the status of "a fortuitous concourse of atoms". But the tide of thought has flowed into a new channel, and the materialist-mechanist philosophy of "dead" matter and force has been left stranded, as new and stauncher boats are launched on the endless voyage in quest of truth.