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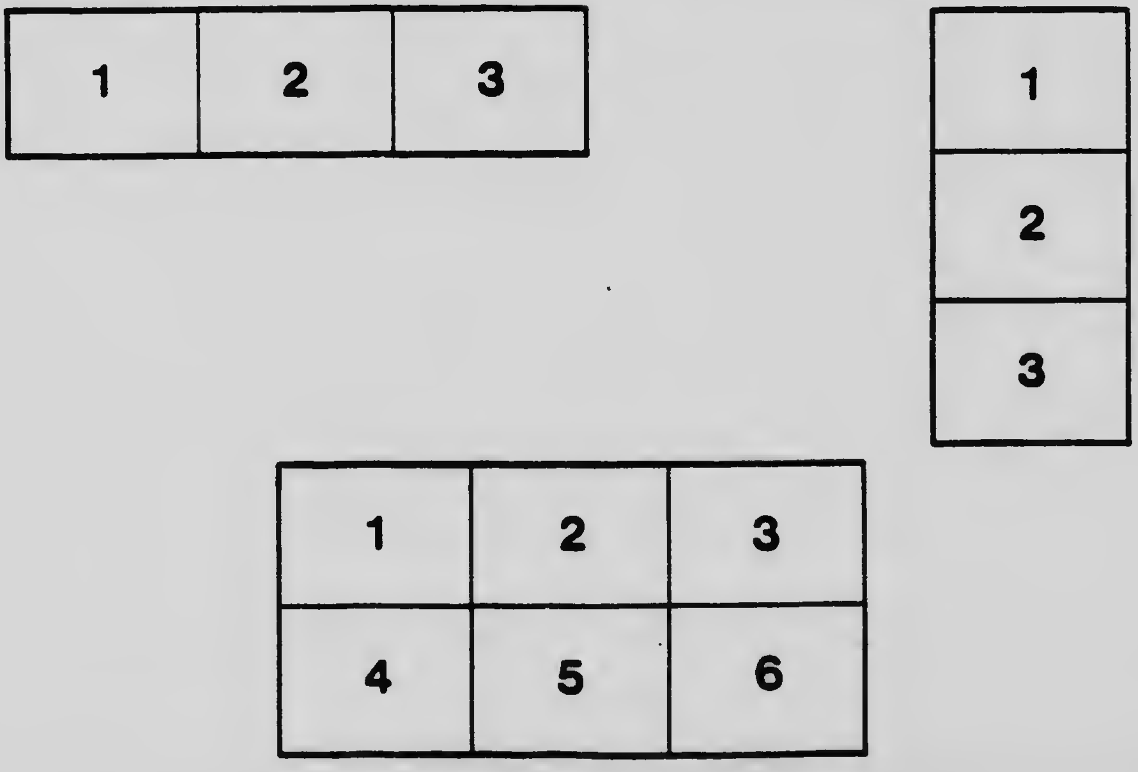
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The Greatest Mathematical Philosopher

By

JOHN A. PATERSON, K.C., M.A.

TORONTO:
1917

PLATE X.

NEWTON

1642-1727

THE GREATEST MATHEMATICAL PHILOSOPHER

By John A. Paterson

Nature and all her laws lay hid in night,
God said "Let Newton be" and all was Light.

THERE is a great attractiveness in opening a parcel; the mystery of its contents, the anticipation of a pleasant discovery, the possibility of disappointment. All these tend to create interest until the string is untied, the paper stripped off, the box opened and then all is revealed. The parcel we open to-night has been opened before by very skilful hands, and all I can venture to do is to untie again the string, strip off the covering, again open the box and place the contents before you with the hope that some part of it may not have been seen before by my patient hearers, and whatever part has been seen before may by a humble hand be lifted from its box and placed upon the table of your attention in a more familiar manner, for you to view it more closely, but not for me to show it more skilfully. A man of large affairs, one of wealth and renown, to whom was given "wisdom and understanding exceeding much and largeness of heart even as the sand which is on the sea shore" — the son of a King, and who ornamented a kingly throne with a royalty of mind far beyond the wisdom of his day wrote —

"Seest thou a man diligent in business? He shall stand before kings; he shall not stand before common men." The man we speak of to night was truly a man diligent in business, in the domain of mathematics; he labored assiduously; he struggled nobly and attained a preeminence that placed him among the most gifted men of this earth. He, indeed, literally stood not only before kings but also queens, and that was more than the wise man thought of, for he was knighted by his sovereign Queen Anne. But his real patent of nobility came from no earthly hand; it came from a higher source, which said—"Behold I have sent thee forth mortal man to teach the world the secrets of my physical control of the universe; to investigate the laws by which the government of all these orbs is on my shoulders; to proclaim these universal laws of matter that govern a myriad blazing thrones, compelling them to reverence the principles of gravitation and mechanics, and to keep as rigidly their behests throughout all the ages from long before that time when the earliest astronomer gazed at them from the rude observatory of a hilltop. I endow thee with the perception first to see the truth, and then to prove the truth, and last of all to proclaim the truth that all these battalions of remote and shining hosts are bound by the chains of the same adamantine regularity that rules our globe." Yes, Isaac Newton not only stood before those who were kings of this earth in the common sense, but he stood among the kings of intellect, who had been touched by the divine afflatus of scientific discovery, and who loyally acknowledged his supremacy. And in speaking of Newton's preeminence I cannot forebear placing before you Dryden's epigram on Milton.

> "Three poets, in three distant ages born,
> Greece, Italy and England did adorn.
> The first in loftiness of thought surpassed;
> The next in majesty, in both the last.
> The force of nature could no further go
> To make the third, she joined the other two."

But why should Dryden in exalting Milton disparage Homer and Virgil? Why cannot the force of nature go further? There can be no flower without the blossom. We cannot vilify nature, or spurn Kepler and Galileo for the sake of glorifying Newton. That is my quarrel with Pope's celebrated epitaph on Newton, which I have quoted at the head of this paper. The knowledge of former ages must not be blotted out to give him a dark ground to stand out on as a brilliant idol. Nature does not move by leaps, but "first the bud, then the ear and then the full corn in the ear." No sun ever rises without the prelude of a twilight. Newton was no Minerva to leap fully armed out of the brain of Jupiter, for we shall see what he owed to the long line of predecessors who labored at the foot hills, and to the long drawn labors of his distinguished contemporaries. For science "widens with the process of the suns."

Isaac Newton was born near the village of Colsterworth, in England, on Christmas Day, 1642, in the same year in which Galileo died. He was so feeble in the early days after his birth, and was of such a diminutive size that his life was despaired of, but the frail casket which held the immortal mind afterwards reached so vigorous a maturity that he attained the age of 85. And as for his intellect, it shattered the locks which barred the secrets of the universe. He was the posthumous son of a farmer in a small way. At school he was far from industrious, according to his own confession, and lacked ambition and initiative, but one day he triumphantly resisted an unprovoked assault from a bigger boy. It is said he so thoroughly thrashed his opponent that he dragged him by the ears and rubbed his nose against the church wall. Thus did the renowned author of the *Principia* in early years illustrate the thoroughness of his work. His opponent in this physical struggle was, however, higher in his classes than young Isaac, which fact stimulated the hero of the church nose-rubbing episode to work so hard that he acquired an intellectual superiority and became head boy of the school. His mother had determined that he had better follow his father's occupation and become a farmer. But it seemed otherwise to the gods, for while young Newton read books under a wide spreading beech tree or was engaged in cutting models of water-wheels with his jack knife, the cattle were treading out the corn for their own use, and the sheep were everywhere where they should not have been. His friends decided that he was not fitted for agrarian pursuits, and sent him to college, being likely the only fit place for a boy who obstinately declined to perpetuate the family traditions as an honest cultivator of the soil. He was destined for higher and more celestial pursuits; the perplexing problems of the rotation of the crops were not his to solve, but rather the rotation of the planets: not the care of the bulls and the rams and the dogs of the farm, but the study of Taurus and Aries and Canis Major and Minor. His philosophic mind early showed its peculiar characteristics. When he was 16 years old, and on the day of the great storm when Cromwell died, he sought to determine the force of the gale, and so he jumped first with the wind and then against the wind, and then compared the results with his jump on a calm day, and so computed the force of the storm. Unconsciously he thus became a disciple of Francis Bacon, the great expounder of experimental philosophy.

He entered Trinity College, Cambridge, in 1661, and graduated four years afterwards. His first effort in the line of mathematics was to buy an English edition of Euclid, which he tossed aside "as a trifling book," and applied himself to the study of Descartes' *Geometry*. I venture to offer you a sidelight on the humanity of our hero. Students do not as a rule keep expense accounts. The expense account kept by young Isaac in 1665 is a revelation — in this there was neither philosophical nor mathematical posing; it was only plain every-day nature. Among many items we find the following:

	£	s	d
Drills, hammer, etc. - -		5	
A magnet - - -		16	
Glass bubbles - -		4	
Lost by cards twice - -		15	
At the tavern twice - -		3	6
Three prisms - - -	3	0	0
To the proctor - -	2	0	0
4 oz. of putty - -		1	4
Binding my Bible - -		3	
Oranges for my sister -		4	2
Lent Dr. Wickens - -		11	

Thus loans to friends, oranges for his sister, fines to the proctor, buying apparatus for experiments, losses at cards, social drinks and keeping his Bible in good order are here unconsciously revealed to this generation after a lapse of more than 250 years. Before he graduated, the method of Fluxions, otherwise the Differential Calculus, occurred to Newton's mind, which when developed became the master key in unlocking the problems of mathematics and astronomy. In 1666, on account of the plague, Trinity College was dismissed, and Newton found refuge in the country. It was then that the incident of the apple falling from a tree in the garden first awakened in his mind the theory of gravitation. Voltaire is, I understand, responsible for the story. The question was,—"What caused the apple to fall?" The incident I fear is legendary, although it may be remarked in passing that if on that occasion the apple hit the young philosopher on the head, it would naturally arouse a train of thought, and it might even evoke some power of rapid and energetic expression. However that may be there was a certain apple tree associated with this story, which grew decrepit with age, and was consequently cut down in the year 1820. It is a cruel thing to disturb the veracity of certain stories round which cluster so many beautiful and youthful memories. There is another story about the accidental destruction of valuable papers by his dog "Diamond" upsetting a candle, and so setting them on fire, whereupon Sir Isaac, seeing the dreadful wreck, rebuked the author with an exclamation—"O Diamond, Diamond, thou little knowest the mischief thou hast done!" And yet on another occasion we have been gravely told that Sir Isaac had a cat and a kitten, and he desired them to have free access to his library, and so ordered a carpenter to cut two holes in the door, a large one for the cat and a smaller one for the kitten. This is intended to illustrate the philosophical habit of mental abstraction possessed by the mere theorist, who had no practical ideas of space, or that the greater would include the less. But Clio, the muse of history, sternly forbids any trifling, for *magna est veritas*, and I am compelled by an inborn and highly trained sense of truth to report a remark made by Dr. Humphrey Newton, his Secretary, that Sir Isaac "never had any communion with dogs or cats."

Let us, however, turn back to the broad highway of more profitable investigation. Newton's earlier studies were turned to optics, and with prisms he made many experiments. He discovered the composition of white light, and the different refrangibility of the rays that compose it, as shown in the spectrum. The success which attended his researches in optics was very great, although they were preserved only in oral lectures until in 1672 he presented an account of them to the Royal Society. Thus a new volume was opened in optical science by experiments in a dark room, a hole cut in the shutter, a prism and a screen presided over by this young high priest of science. But it ever is that the hour of the birth of a new discovery is the hour of the birth of battle, and his theories were strongly opposed by the eminent English natural philosopher, Robert Hooke ; by Lucas, Mathematical Professor at Liege ; and by many others. In fact, many refused to believe in the very existence of such a thing as a spectrum. He carried on the discussion with great courtesy and patience, but to his sensitive mind they gave him such pain that he wrote to a friend,—"I see I have made myself a slave to philosophy, but if I get free of Mr. Lucas' business I will resolutely bid adieu to it eternally, excepting what I do for my private satisfaction, or leave to come out after me ; for I see a man must either resolve to put out nothing new, or to become a slave to defend it." It was in these days that his neighbors used to see young Newton blowing soap bubbles in his garden and pursuing them with all the eagerness of a child at play, and they were in doubt as to the perfect mental equilibrium of this strange young gentleman. But he was worshipping at the altar of science, and laying the foundation of truths upon which later generations of equally earnest seekers builded.

It is impossible within the compass of this paper to dwell at length on Newton's contributions to optical science. He was in a certain degree the pioneer and helped to release the thoughts and discoveries of many others in his own and later ages. His corpuscular theory suffered serious attacks, and broke down by the weight of experimental evidence in the early years of the last century, when it was displaced by the wave theory, which states, that light is propagated by undulations set in operation by a luminous body in the ether. The corpuscular theory, which teaches that luminous bodies emit extremely small corpuscles, which can freely pass through transparent substances, and produce the sensation of light by their impact upon the retina of the eye, received its final blow when J. B. L. Foucault proved by direct experiment that the velocity of light in water is not greater than in air as it should be according to the corpuscular theory, but less, as is required by the wave theory.

Newton also invented a reflecting telescope, which differs from the Gregorian, the Cassegrain and the Herschellian, and is the form most frequently used in ordinary present day reflectors, although the Cassegrain plan is used for the great Melbourne telescope, and for the 60-inch reflector of the Mount Wilson Solar Observatory. The Newton reflector consists of a large concave mirror, which reflects the image on a small plane mirror placed at an angle of 45° and thence to the eye piece, which is placed at the side of the instrument.

My principal object in this paper is to give an account of Newton's investigations and discoveries as to the theory of gravitation, which has made his name most celebrated.

When he turned his mind to this great subject he found that his way had, to a great extent, been prepared by the labors of other astronomers. A great alliance of distinguished men from the days when the worshipping astronomer Job was perplexed with questions,—"Whereupon are the foundations of the earth fastened? Who laid the corner stone thereof? When did the morning stars sing together and all the sons of God shout for joy?"—had long struggled to lighten up the labyrinths, and many a strong hand had grasped the barriers that held the secrets of nature, and had shaken but not opened them. Newton was the great leader of that phalanx, and it was reserved for him to wrench these barriers from their fastenings and cast them down. John Kepler had, by an elaborate system of measurements, proved three cardinal laws that governed the solar system.

(1) That each planet revolves in an ellipse round the sun whose centre is in a focus of the orbit.

(2) That the radius vector of each planet, or the line drawn from each planet to the sun, describes equal areas in equal times.

(3) That the squares of the years of the planets are proportional to the cubes of their mean distances from the sun.

Kepler deduced these laws by long and laborious observation. He laid them down as facts, but could not, or at least did not, ascertain the reason of them or any relation between them. Newton commenced at the other end and proved: —

(1) If a body move in any orbit about a fixed centre of force, the areas described by lines drawn from the centre to the body lie in one plane, and are proportional to the times of describing them (*Principia*, Sec. II., Prop. 1).

This is a generalization of Kepler's Second Law.

(2) That if a body revolves in an ellipse, the law of force tending to the focus varies inversely as the square of the distance. (*Principia*, Sec. III., Prop. 11).

(3) Conversely if a body be projected at a given distance from a centre of force, which varies as the inverse square of the distance, and in a direction making a finite angle with the distance, it will describe an ellipse, a hyperbola or a parabola. (*Principia*, Sec. III., Prop. 13, Cor.).

(4) That if a body revolves in an ellipse round a centre of force in the focus, the squares of the periodic times in all ellipses described round the same centre of force in the focus are as the cubes of the major axes. (*Principia*, Sec. III., Prop. 15).

This is a generalization of Kepler's Third Law.

Let us understand clearly in this regard what Newton accomplished. Kepler discovered the truth of his theorems by laborious and multitudinous calculations from previous observations. There is no record of any astronomical observation that Newton er n de. Kepler built up his propositions by a process of induction. Newton reached his conclusions by deduction. Kepler labored at his work with unparalleled industry for years. Newton reached his results rapidly, basing them on the principles of his wonderful calculus. The four theorems I have quoted above occupy less than four printed pages in his *Principia*. Kepler's workshop was in the sky, and his tools quadrants and sextants. Newton's was in his study, and his tools a pencil and paper. Kepler needed his eyes. Newton could have reached his results if he had been as blind as Milton—an equally great genius in another kind of *magnum opus*. Kepler proved that things were. Newton proved that these results had to be, and if they were not, then mathematics was an aggregation of monstrous absurdities. But more than that, Kepler with all his industry and all his sagacity failed to discover the law that governed the universe, or in other words the law of gravitation, that the force governing the planetary and astral systems was one varying directly as the mass and inversely as the square of the distance. But Newton discovered it. (See *Princip* Sec. III., Prop. 11).

Before Newton other scien had suggested or suspected the existence of this law of gra ity. In January, 1684, Sir Christopher Wren, Halley and Hooke discussed the law of gravity, and although probably they all agreed to the truth of the law of the inverse square, yet it was not established. Hooke professed to have a solution of the problem of the path of a body moving round a centre of force attracting as the inverse square of the distance; but although Hooke promised to show his solution to Wren, he failed to do it, and Halley started off in August, 1684, to consult Newton on the subject. He did not mention the speculations which had been made, but he asked Newton what would be the orbit described by a planet round the sun, assuming that the sun's force diminished as the square of the distance. Newton replied promptly "an ellipse." Halley asked him the reason, and he replied,—"I have calculated it." He could not, however, find his calculation, but promised to reproduce it and send it to Halley, which he afterwards did, and thus at last the secret of the physical government of the universe was out. In February, 1685, he sent to the Royal Society a treatise consisting of 24 octavo pages entitled *De Motu*, which was the germ of *Philosophiæ Naturalis Principia Mathematica*, commonly known as the *Principia*. In due time the whole manuscript appeared, and on the 2nd of June, 1686, the Royal Society ordered "that Mr. Newton's book be printed." But here arose a difficulty, for it appeared that the Royal Society had not sufficient money to pay the printer, or was unwilling to risk the venture. Whereupon his friend Halley, although poor in pocket, but rich in intellect as most scientists are, provided the money, and the greatest Treatise on Natural Philosophy was given to the world. The nobility and gentry who then composed the Royal Society declined to take any chances, fearing that this manuscript of Mr. Newton's might land them into a serious debt. For this generous act the world of intellect owes Halley a great debt of gratitude, far more, indeed, than the discovery and calculations regarding the famous comet.

The original manuscript of the *Principia* is now in the possession of the Royal Society, and dropping the veil over its former financial scepticism, it regards this as the most precious of its archives. The publication of the *Principia* caused a great excitement in Europe. Many of the most skilful mathematicians, who studied it, could not at once fathom its depths or follow its intricacies. The whole edition was very soon sold. In all great discoveries there is often a little bitter-sweet, and this was exemplified more than once in Newton's life. The originality of his invention of Fluxions was challenged by Leibnitz, and thence arose a fierce controversy. We are too apt to regard great men of the order of Newton and Leibnitz and Hooke as exempt from the common infirmities of human nature, and to bow down to them as demigods, rather than admire them as sages. But it is not so, and we feel disappointed at the discovery that after all they are men of like passions as we ourselves are. Newton was, however, generous, and in order to soothe asperities, which arose from claims made by Hooke that he had anticipated Newton's discovery of the law of the inverse square of the distance he wrote to Halley,—"And now having sincerely told you the case between Mr. Hooke and me, I hope I shall be free for the future from the prejudice of his letters. I have considered how best to compose the present dispute, and I think it may be done by the enclosed scholium to the Fourth Proposition." This scholium was—"The inverse law of gravity holds in all the celestial motions, as was discovered also independently by my countrymen Wren, Hooke and Halley." That may have been true in a certain sense, but it must be remembered that these "my countrymen" had only barely suggested the law but had given no reason or proof of it.

I cannot forebear at this point quoting some eloquent passages from that classic Sir David Brewster's *Life of Newton*.

"The *Principia* will be memorable not only in the annals of one science or of one country, but it will form an epoch in the history of the world, and will ever be regarded as the brightest page in the records of human reason,—a work, may we not add which would be read with delight in every planet of our system—in every system of the universe. What a glorious privilege was it to have been the author of the *Principia!* There was but one earth upon whose form and tides and movements the philosopher could exercise his genius,—one moon, whose perturbations and inequalities and actions he could study,—one sun, whose controlling force and apparent motions he could calculate and determine,—one system of planets, whose mutual disturbances could tax his highest reason,—one system of comets, whose eccentric paths he could explore and rectify,—and one universe of stars, to whose binary and multiple combinations he could extend the law of terrestial gravity. To have been the chosen sage summoned to the study of that earth, these systems, and that universe; the favored lawgiver to worlds unnumbered, the high-priest in the temple of boundless space, was a privilege that could be granted but to one member of the human family, and to have executed the task was an achievement which in its magnitude can be measured only by the infinite in space, and in the duration of the triumph by the infinite in time. That Sage, that Lawgiver, that High-Priest was Newton."

Newton sought to extend to the universe the law of gravitation by considering the orbit of the moon, and so test the universality of his discovery. He observed the distance through which a body would fall in one second of time on the earth's surface to be 16·1 feet, and as the moon was 60 times as far from the earth as the radius of the earth, it must follow that the distance of the moon a free body would fall towards the earth a distance of $16{\cdot}1/60^2$ in one second of time, which is ·00447 feet. If the moon had not a certain motion of its own in the direction of the tangent to its orbit, the moon would travel straight to the earth travelling a distance of ·00447 feet in the first second. But the moon has a tangential motion of its own given to it in some remote age and by some power, which we need not now attempt to consider.

The attraction of the earth, however, operates on the moon, and draws it every second of time into a curve concave to the earth, and the question to be considered is, What is the distance of that earth-pull in one second of time?

The accompanying figure represents the orbit of the moon, *M*, round the earth, *E*. *M D* is the tangent along which the moon would move if the earth did not attract it. The angle

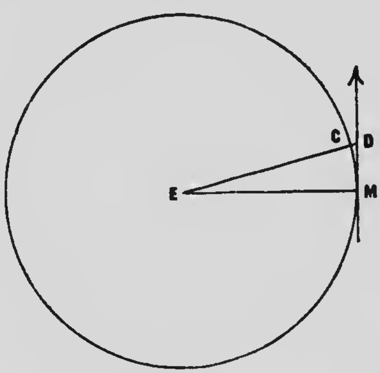

DIAGRAM TO ILLUSTRATE THE MOTION OF THE MOON

MED is necessarily exaggerated. But on account of the earth's attraction the moon describes the curve MC, and therefore in one second the moon is at C and not at D. The problem is to measure the distance CD, which represents the pull of the earth on the moon in one second of time, or in other words the distance that the moon falls to the earth in one second of time.

The moon in one second describes an angle

$$\frac{360^\circ}{27\tfrac{1}{3} \times 24 \times 60 \times 60} = \omega = \text{about } 0''{\cdot}5.$$

The angle MED is ω. During this time the approach to the earth $= 60 \times 4000 \times 5280 \times \text{vers. } \omega$ foot,

$$= \frac{60 \times 4000 \times 5280 \times 2\pi^2}{(27\tfrac{1}{3} \times 24 \times 60 \times 60)^2},$$

$$= \frac{3 \times 3 \times 60 \times 4000 \times 5280 \times 2 \times 22 \times 22}{82 \times 82 \times 24 \times 24 \times 60 \times 60 \times 60 \times 60 \times 7 \times 7},$$

which, on cancelling out common factors,

$$= \frac{55 \times 11 \times 11}{7 \times 7 \times 41 \times 41 \times 18} = \frac{6655}{1482642} = {\cdot}00447 \text{ ft.}$$

which is the same result obtained before.

It is to be noted that Newton in 1665 attempted this calculation but the result did not agree with the observed force of gravity on the earth, and so he gave the problem up, and doubted the universal applicability of the law of the inverse square of the distance, and so continued his brooding. He had been, however, proceeding upon erroneous data of the earth's diameter, and nineteen years thereafter, being 1684, having been supplied with a more accurate measurement of the earth's diameter by Picard, he looked up his old papers and made fresh calculations. As they drew to a close he observed that the figures were shaping themselves to prove the truth of his theory, and it is recorded that he became so agitated that he asked a friend to finish the calculation.

His great work consists of three books. The first and second, which occupy three quarters of the work, are entitled

"On the Motion of Bodies." The first treating of their motions in free space, and the second of their motions in a resisting medium. The third bears the title "On the System of the World," and consists of five sections:—

(1) On the Causes of the System of the World.

(2) On the Quantity of Lunar Errors.

(3) On the Quantity of the Tides.

(4) On the Precession of the Equinoxes.

(5) On Comets.

It concludes with a general scholium containing reflections on the constitution of the universe, and on the "Eternal Infinite and Perfect Being" by whom it is governed. Its argument was by no means readily understood by the great scientists of his day, and I well know with what difficulty university medallists touched even the fringe of its garments.

There is extant a curious letter written by Newton to the great scholar and critic, Dr. Richard Bentley, Master of Trinity College. It is dated in July, 1691, and consisted of directions to Bentley respecting the books necessary to be read before studying the *Principia*. Some of the passages are as follows: "Next after reading Euclid's *Elements*, the Elements of ye Conic sections are to be understood. And for this end you may read the first part of ye *Elementa Curvarum*, of John De Witt. For Algebra read first Bartholius' *Introduction*, and then peruse such problems as you will find scattered up and down in ye *Commentaries on Cartes' Geometry* and other algebraical writings of Francis Schooten. For Astronomy read first ye short account of ye Coppernican System in the end of Gassendus' *Astronomy*. These are sufficient for understanding my work, but if you can procure Hugenius' *Horologium Oscillatorium* the perusal of that will make you much more ready. At ye first perusal of my book it's enough if you understand ye Propositions with some of ye demonstrations that are easier than the rest. For when ye understand ye easier, they will afterwards give you light into ye harder. When you have read ye first 60 pages pass to ye Third Book, and when you see the design of that you may turn back to such propositions as you shall have a desire to know, or peruse the whole in order if you think fit"

Newton had no satisfactory theory as to the genesis of the solar system or astral systems. So far as I can understand from his letters to Dr. Bentley, he thought the orbs were completed and propelled by some extraneous force, possibly the Almighty hand, and by the attracting centre were wheeled into ellipses. The later hypotheses such as the Nebular or Planetesimal or Meteoritic or any modification or adaptation of these had not occurred to his wonderful intellect. It was not until 1796, sixty-nine years after Newton's death, that Laplace, who was called the "Newton of France" advanced his celebrated and much debated theory. Sir David Brewster, Newton's distinguished biographer, speaking of these letters, remarks,—"They show that the Nebular Hypothesis, the dull and dangerous heresy of of the age, is incompatible with the established laws of the material universe, and that an omnipotent arm was required to give the planets their positions and motions in space, and a presiding intelligence to assign to them the different functions they had to perform." With profound respect to this justly celebrated biographer I venture a *caveat* on his conclusions. I am not now prepared to spend time on any proof of the Nebular Theory, but I dare affirm that it is not incompatible with divine omnipotence or divine intelligence—nay, rather it illustrates them. If gravitation is a law of the Creator, and that is admitted, the laws of the same Creator may work out the moulding and construction of worlds quite harmoniously with a well ordered and divinely created universe. A wisdom that can construct a huge machine, which, by natural processes, can construct from itself smaller machines with their own revolutions and orbits, is, I venture to think, at least equal to a power that drastically and dramatically hurls great orbs into space ready made to find their own orbits and revolutions. Cohesion and gravitation are not only great natural laws, they are even more truly the strong right hand of God which holds each atom in the universe in its own appointed place and time.

Our philosopher was more than a personified calculus, he held himself in no orbit cabined and cribbed by mathematical formulæ, for he has left on record views which reach far beyond the clouds, on problems which have interested and inspired the intellectual strivings of men far his inferiors. His mathematical gifts were subordinated to religious meditations, which brightened and uplifted them.

For example upon the universal and not fruitless speculation as to the habitability of other worlds he has left this record. "For in God's house (which is the universe) are many mansions, and He governs them by agents which can pass through the heavens from one mansion to another. For if all places to which we have access are filled with living creatures, why should all these immense spaces of the heavens above the clouds be incapable of inhabitants."

Some lines from Tennyson are appropriate in this connection :

> "And this within thy mind rehearse,
> That, in a boundless Universe,
> Is boundless better boundless worse.
> Think'st thou this mould of hopes and fears
> Can find no statelier than his peers
> In yonder hundred millions spheres?"

Newton, as might be expected, was of an intensely religious temperament and conviction, and in a letter to his friend, Dr. Bentley, he says that in writing the Third Book of the *Principia* he had an eye upon such principles as might work with considering men for the belief of a Deity, and he expresses his happiness that it has been found useful for that purpose. "But if I have done," he adds "the public any service this way, it is due to nothing but industry and patient thought." Here spoke out the real greatness of one of the greatest souls in the world, his greatness consisted in his great humility. He bowed his massive intellect to another great philosopher, Him of Bethlehem, who when he was asked,—"Who is the greatest in the kingdom of heaven?" answered by setting a little child "in the midst of them" and said,—"Whosoever, therefore, shall humble himself as this little child, the same is greatest in the kingdom of heaven." This reflection suggests to me a beautiful story of Newton in his old age, which I would fain take as proved without demonstration. I have given up the apple story and the cat-and-dog story, but this one I fondly, if not logically, hold to. When in a company of friends, who surrounded him affectionately and even worshipfully in his declining years, some one ventured to compliment him on his outstanding pre-eminence as a man of science, and spoke of the wonderful discoveries he had made; he gently said, "Nay not so, for indeed I am only as a little child wandering along the seashore, and picking up here and there some pebble or shining shell, while the vast undiscovered but not undiscoverable ocean of Truth lies before me."

Let us speak of Newton in other connections. While he was engaged in writing the *Principia* a very important event occurred at Cambridge, which hurried the philosopher out of his study and set him before the public eye in a new light. James II., of not very fragrant memory, in his wild effort to establish Roman Catholicism issued a Mandate directing that Father Alban Francis, a Benedictine Monk, should be admitted as a Master of Arts of the University of Cambridge without taking the oaths of allegiance and supremacy. This was fiercely resisted and Newton was appointed by the Senate as one of eight deputies to oppose this act of royal tyranny before a High Commission Court at Westminster. The infamous Judge Jeffreys (he of the Bloody Assize) presided, and he let loose his insolence at the Vice-Chancellor, who ventured to argue the question, and then ordered the rest of them out of Court, and closed a fierce snarling address with the following specimen of oratory,—"Therefore I shall say to you what the Scripture says, and rather because most of you are divines, 'Go your way and sin no more, lest a worse thing come upon you.'" Under his rebuke and in front of such a judge, the most infamous that ever sat on a British Bench, stood the immortal author of the *Principia*, who had risen from investigating the secrets of creation to defend the religion which he professed and the University which he loved and adorned. It was a man of imperishable fame before a creature of imperishable infamy, a faithful fighter before a judicial beast of the jungle. The bloody judge that day won out, and Right was wounded but not killed, for in the end Right prevailed. That day the battle was lost, but not long thereafter the campaign was won. Good is the final goal of ill, and the active part which Newton took in defending the legal privileges of the University against the encroachments of the Crown added to his scientific reputation, procured for him the election to a seat in Parliament as a representative of the University of Cambridge.

In 1714 the question of calculating the longitude of a vessel at sea, as one of the most important questions involving the commercial supremacy at sea, came before Parliament, and Newton gave evidence, criticizing the means then commonly practiced. It was mainly upon his views that an act was passed to settle a reward "upon such person as shall discover a more certain and practicable method of ascertaining longitude than any yet in practice."

In 1669, Newton became Lucasian Professor of Mathematics at Cambridge, and held the position for thirty-two years. In 1699 he was appointed to the influential and lucrative position of Master of the Mint, for which his chemical and mathematical knowledge specially fitted him.

He was a very popular visitor at the Court of George I., and was much honored by the Princess of Wales, afterwards Queen Caroline, wife of George II. In 1705 he was knighted by Queen Anne.

In 1703 he was elected President of the Royal Society, and was annually re-elected during the remaining twenty-five years of his life, having held the office for a longer time than any of his predecessors, and longer too than any of his successors, excepting Sir Joseph Banks.

Honors were showered upon him by European Universities and Academies, who esteemed it an honor to rank him among their Fellows or Graduates.

Newton wrote many theological tracts, and had definitely strong beliefs not only in doctrine, but he was so filled with the spirit of Truth that he was often consulted by his friends about their spiritual state. He cherished the great principles of religious toleration, and preserved a broad understanding on all matters of personal faith. Immorality and impiety were to him abhorrent. When Dr. Halley ventured to say anything disrespectful of religion he invariably cut him short with the remark, —"I have studied these things, you have not."

The mighty spirit of this truly great man passed away in the eighty-fifth year of his life. The measure of his life was full, and his body resigned to heaven its occupant. His remains lay in the Jerusalem Chamber and were buried in Westminster Abbey.

The Lord High Chancellor with earls and dukes followed him to the tomb. The proudest men in England, the learned and lofty were there, and noblemen doffed their coronets before this prince of the intellectuals. A splendid monument marks his resting place. A figure of Astronomy as Queen of the Sciences sits on a Globe weeping with a sceptre in her hand, and a star surmounts the summit of a pyramid. And on the monument is inscribed an epitaph in the Latin language, which rendered into English reads :

Here lies
Sir Isaac Newton, Knight,
Who, by a vigour of mind almost supernatural,
First demonstrated
The Motions and Figures of the Planets,
The Paths of the Comets, and the Tides of the Ocean.
He diligently investigated
The different refrangibilities of the Rays of Light,
And the properties of the Colours to which they give rise.
An Assiduous, Sagacious, and Faithful Interpreter
of Nature, Antiquity and the Holy Scriptures,
He asserted in his Philosophy the Majesty of God,
And exhibited in his Conduct the simplicity of the Gospel.
Let Mortals rejoice
That there has existed such and so great
AN ORNAMENT OF THE HUMAN RACE.
Born 25th December, 1642, Died 20th March, 1727.

The tribute of Pope, the poet, was eloquent; he wished for some memoirs and character of Newton as a private man, "for no doubt his life and manners would make as great a discovery of virtue and goodness and rectitude of heart, as his works have done of penetration, and the utmost stretch of human knowledge."

And so passed Isaac Newton, appointed by God on the 25th day of December, 1642, to solve the problem of the relation between material worlds; and on that 20th day of March, 1727, he solved, as all will solve, the greater problem of the relation between the material and spiritual worlds, which indeed is far beyond all human calculus.