החשבון האינפיניטסימלי—הדיפרנציאלי והאינטגרלי

Isaac Newton—1642-1727

Gottfried Wilhelm Leibniz----1646-1716

NEWTON מניח היסוד **לדטרמיניזם** במדע

ספרו המונומנטלי ("Principia")

Philosophiae naturalis principia mathematica *(1687)*

קבע את היסוד ה"דטרמיניסטי" של המדע המודרני:

חוקים בסיסיים מהם נגזרים תהליכי הטבע על ידי שימוש בכלים מתימטיים.

נשים לב: הקודמים לו ראו במתימטיקה את המסגרת הנכונה לתיאור התופעות (בייחוד באסטרונומיה), אבל לא את הסברתן כתופעות הנובעות כמסקנות מתימטיות מחוקי יסוד, שאף הם ניתנים בצורה מתימטית (למשל, חוק הגראוויטאציה).

LEIBNIZ מניח היסוד **לפורמליזם** המתימטי המודרני

השפה של הלוגיקה הסימבולית:

$$\forall x, y, z \in R \quad : \{x < y\} \wedge \{y < z\} \Rightarrow x < z$$

במאמרו

Nova Methodus pro Maximis et Minimis, itemque Tangentibus... (*Acta Eruditorum*, 1684)

הציג את כל הנוסחאות הבסיסיות של החשבון הדיפרנציאלי, בסימון המקובל עד היום (ספרו של ניוטון פורסם רק ב-1687 , תחילתה של יריבות מרה).

הכניס את <u>השיטה הבינארית</u> (ייצוג מספרים בבסיס 2):

Essay d'une nouvelle science des nombres (1701)

ומושג הפונקציה:

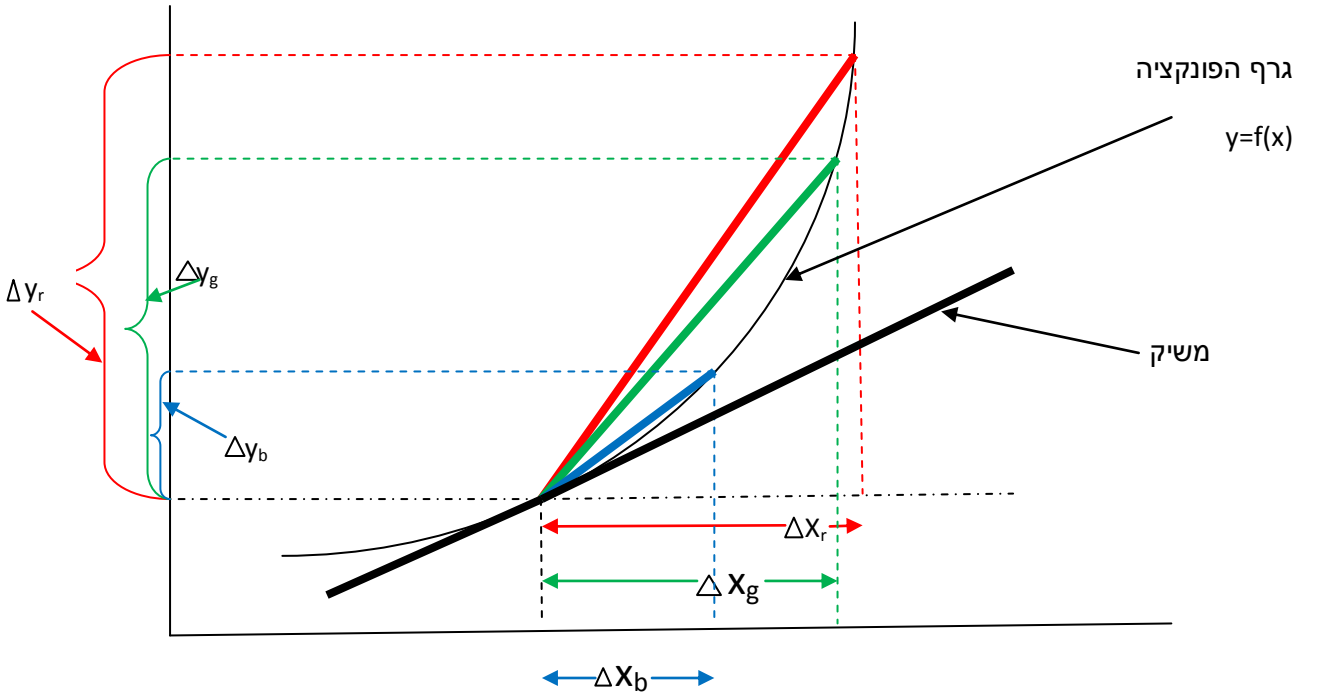
I am pleased that you use the term function in my sense

(מכתב למתימטיקאי Bernoulli)

גם המושג של קואורדינטה הוכנס על ידי לייבניץ.

חשבון דיפרנציאלי: <u>כיצד מגדירים שיפוע של משיק?</u>

לוקחים שיפועים של מיתרים בין נקודות שהולכות ומתקרבות.



$$m_r = \frac{\Delta y_r}{\Delta x_r} \qquad m_g = \frac{\Delta y_g}{\Delta x_g} \qquad m_b = \frac{\Delta y_b}{\Delta x_b}$$

שיפוע המשיק הוא <u>המצב הגבולי</u>

ניוטון קרא לו **FLUXION**. לייבניץ כתב: $\frac{dy}{dx}$

<u>נשים לב</u>: השיפוע הזה משתנה <u>מנקודה לנקודה</u> על גרף הפונקציה, ועל כן הוא עצמו <u>פונקציה (נגזרת)</u> של הנקודה!

דוגמה 1: חישוב הפונקציה הנגזרת של

$$\boxed{f(x)=x^2}$$

כאן,

$$\Delta y = f(x+\Delta x)-f(x)=(x+\Delta x)^2-x^2=2x\cdot\Delta x+\Delta x^2$$

ולכן,

$$\frac{\Delta y}{\Delta x}=2x+\Delta x$$

ובגבול נקבל את שיפוע המשיק

$$\boxed{\frac{dy}{dx}=2x}$$

דוגמה 2: חישוב הפונקציה הנגזרת של

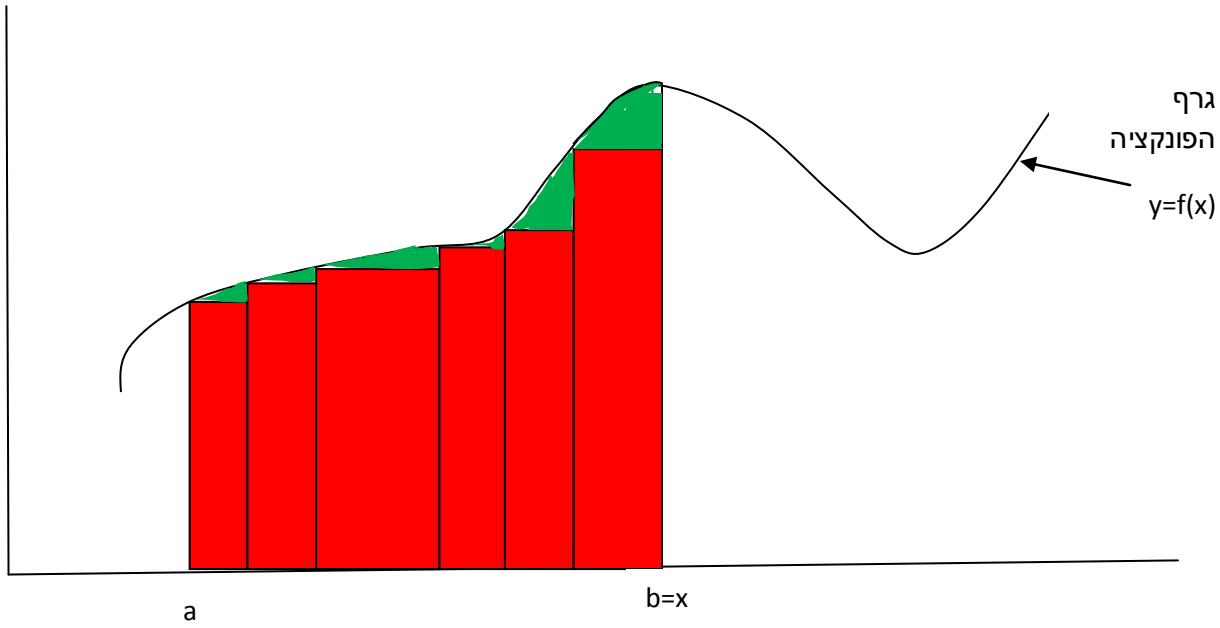
$$\boxed{f(x)=x^3}$$

כאן, כפי שקל לבדוק,

$$(x+\Delta x)^3=x^3+3x^2\cdot\Delta x+3x\cdot\Delta x^2+\Delta x^3$$

כלומר, $\boxed{\frac{\Delta y}{\Delta x}=3x^2+3x\cdot\Delta x+\Delta x^2}$ ובגבול $\boxed{\frac{dy}{dx}=3x^2}$.

חשבון אינטגרלי: <u>כיצד מחשבים שטח מתחת לגרף פונקציה?</u>



נסמן כ-S_a^b **את השטח המבוקש (לייבניץ סימן** $\int_a^b f(x)dx$**)**

השטח האדום של המלבנים הוא <u>קירוב</u> ל--S_a^b .

השטח הירוק הוא ה"שגיאה" בחישוב השטח המדוייק.

<u>ככל שבסיסי המלבנים יהיו צרים יותר-כך יקטן השטח הירוק , כלומר , השגיאה תהיה קטנה יותר!</u>

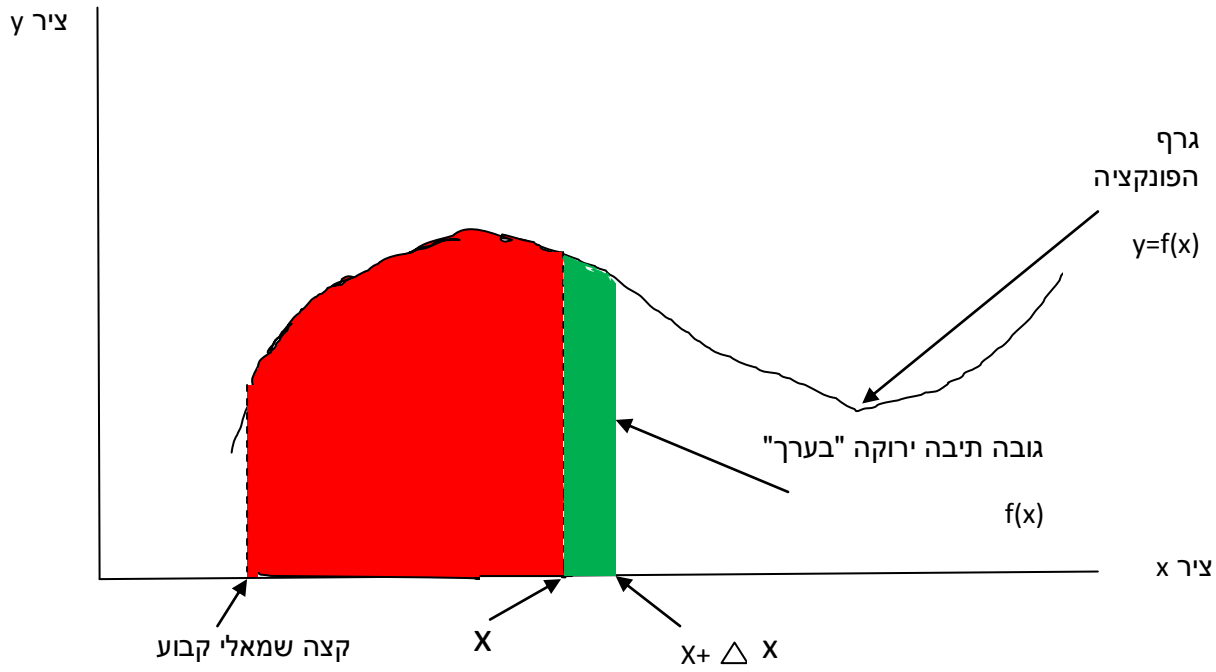
המצב הגבולי, של מספר גדל והולך של מלבנים שבסיסיהם "שואפים לאפס"—ייתן את השטח המבוקש.

<u>רעיון זה היה ידוע כבר לארכימדס (300 לפנה"ס).</u>

המשפט היסודי של החשבון האינפיניטסימלי

הרעיון הבסיסי הוא :

השטח כפונקציה של נקודת הקצה הימנית.

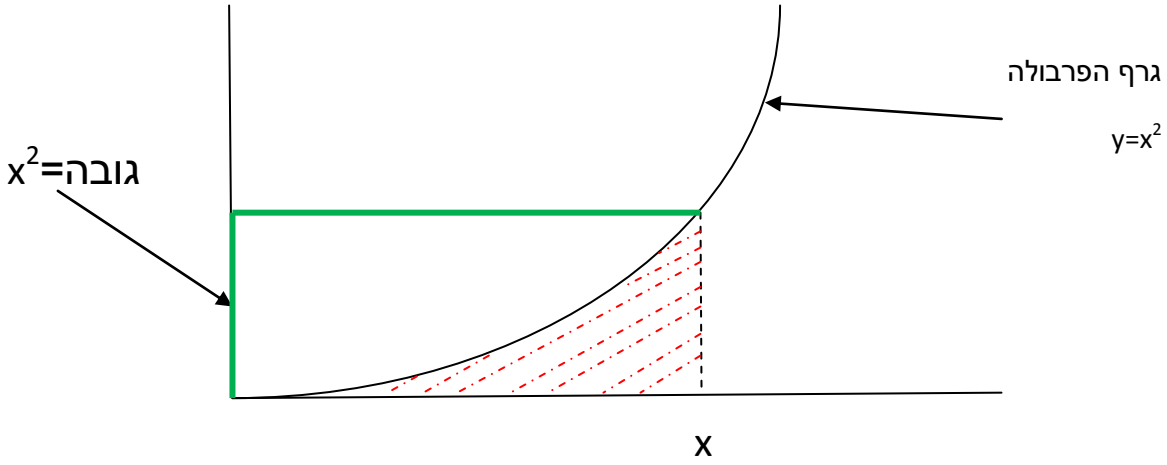


השטח הירוק הוא הפרש השטחים (עם קצה שמאלי קבוע):

$$S(x+\Delta x)-S(x)\approx f(x)\cdot\Delta x$$

$$\frac{S(x+\Delta x)-S(x)}{\Delta x}\approx f(x)\quad\Rightarrow\frac{dS}{dx}=f(x)$$

חישוב השטח מתחת לגרף הפרבולה:



השטח המקווקו הוא **S(x) והוא מקיים את המשוואה:**

$$\frac{dS}{dx} = x^2$$

ולכן:

$$S(x) = \frac{1}{3}x^3$$

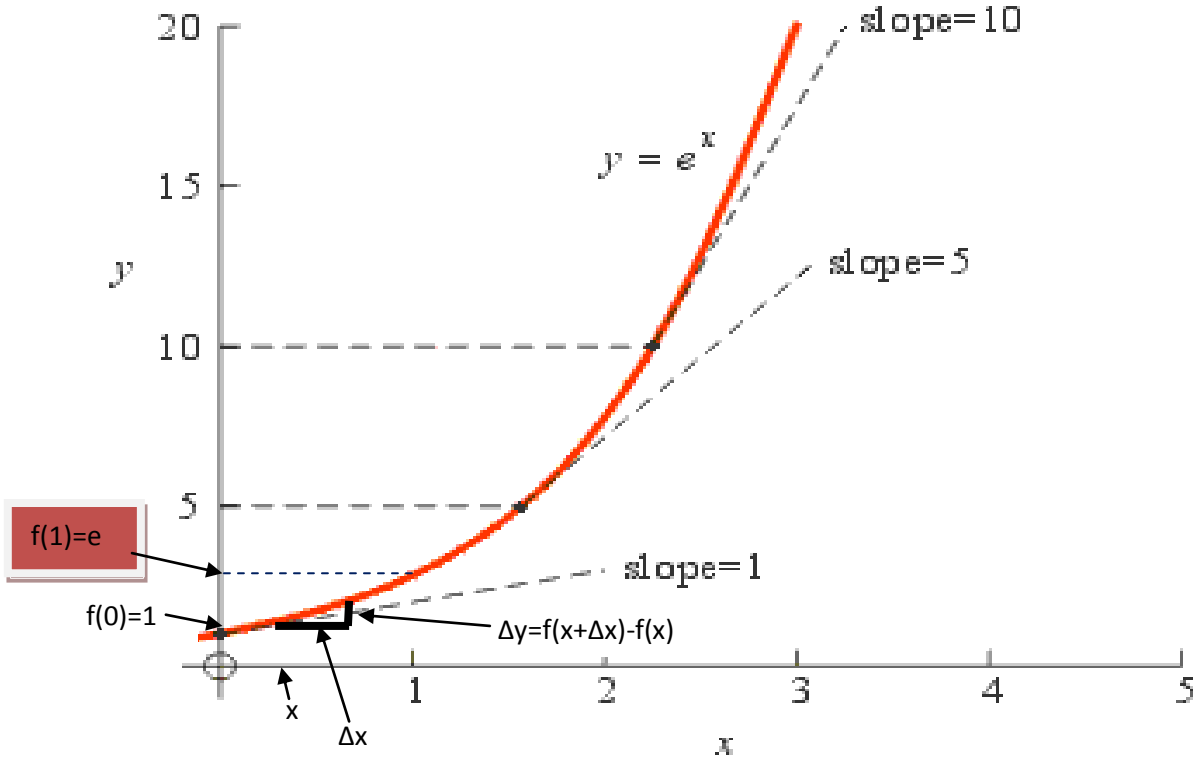
כלומר, שליש שטחו של המלבן במסגרת הירוקה בציור לעיל.

את הנוסחה הזאת ידע ארכימדס בשנת 300 (לפנה"ס!) ראו:

http://en.wikipedia.org/wiki/The_Quadrature_of_the_Parabola

הפונקציה האקספוננציאלית

נחשוב על פונקציה ש"קצב הגידול" שלה שווה לערכה. כלומר, בקירוב (לפי הציור):



למשל $$\frac{f(x+\Delta x)-f(x)}{\Delta x} \approx f(x) \Rightarrow f(x+\Delta x) = f(x)\cdot(1+\Delta x)$$

וכן $$f\left(\frac{1}{3}\right) \approx f(0)\cdot(1+\frac{1}{3}) \Rightarrow f\left(\frac{2}{3}\right) \approx f(0)\cdot\left(1+\frac{1}{3}\right)^2 \Rightarrow f(1) \approx f(0)\cdot\left(1+\frac{1}{3}\right)^3$$

ואם ניקח n טבעי גדל והולך נקבל כי f(1) $$f(1) \approx f(0)\cdot\left(1+\frac{1}{10}\right)^{10}$$

$\left(1+\frac{1}{n}\right)^n$ הוא "גבול" של חזקות מהצורה

את הערך $\boxed{e = \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n}$ ניתן לחשב:

e= 2.71828…

דוגמה (ריבית דריבית):

הסטודנטית קרן היא בעלת חוש עיסקי מעולה

היא מצאה בנק שהיה מוכן לתת לה 100% ריבית על קרן ההשקעות שלה בסך 1 שקל.

היא הגיעה לבנק לאחר שנה וקיבלה 2 שקל...

לאחר מחשבה היא חזרה לבנק ושאלה:

מה הייתי מקבלת אם הייתי מושכת את ההשקעה בתום חצי שנה?

תשובת הבנק: כמובן, 1.5 שקל...

ואז מייד הייתי מפקידה סכום זה וחוזרת בתום חצי שנה?

תשובת הבנק: כמובן, 2.25 שקל...

ואם הייתי מגיעה לבנק כל שלושה חודשים?

תשובת הבנק: בתום שנה היית מקבלת 2.44140625 שקלים.

קרן רואה שהיא מצליחה לשפר את התוצאה וממשיכה לשאול על התשואה אם היתה מגיעה כל חודש, כל שבוע...

פקיד הבנק (אגב, *<u>בוגר קורס אבני פינה</u>*) מאבד קצת את הסבלנות ואומר לה:

<u>קרן, אם היית מגיעה הנה כל שנייה, במשך שנה שלמה, היית מקבלת מאיתנו e שקל!</u>

<u>קרן מתלהבת ולא נרתעת:</u>

מצויין, ואם הייתי מגיעה כל שנייה במשך שלוש שנים, כמה הייתי צוברת ?

פקיד הבנק: כמובן, e^3 שקלים...

Thomas Robert Malthus (1766-1834)

כלכלן אנגלי שכתב את המאמר הראשון העוסק בבעיית "ההתפוצצות הדמוגרפית": (ראו

(http://en.wikipedia.org/wiki/Malthusian_catastrophe

An Essay on the Principle of Population

וכך כתב:

I.I.13

> According to a table of Euler, calculated on a mortality of 1 in 36, if the births be to the deaths in the proportion of 3 to 1, the period of doubling will be only 12 years and 4-5ths. And this proportion is not only a possible supposition, but has actually occurred for short periods in more countries than one.

I.I.14

I.I.16

> It may safely be pronounced, therefore, that population, when unchecked, goes on doubling itself every twenty-five years, or increases in a geometrical ratio.

I.I.17

> The rate according to which the productions of the earth may be supposed to increase, it will not be so easy to determine. Of this, however, we may be perfectly certain, that the ratio of their increase in a limited territory must be of a totally different nature from the ratio of the increase of population. **A thousand millions are just as easily doubled every twenty-five years by the power of population as a thousand**. But the food to support the increase from the greater number will by no means be obtained with the same facility. ……

John Maynard Keynes: *Newton, the Man*

The Royal Society of London planned an event to celebrate the tercentenary of **Isaac Newton**'s birth in 1942. However World War II made it essentially impossible and the celebrations did not take place until July 1946. Lectures were given by E N da Costa Andrade, H W Turnbull, Niels Bohr and Jacques Hadamard. **John Maynard Keynes** had also been invited to lecture but unfortunately he died in April 1946, three months before the celebrations took place. Keynes was fascinated by Newton's manuscripts and had been the first person to see some of the manuscript material by Newton which had been kept secret until his papers were sold in 1936. Keynes' lecture, Newton, the man was delivered at the celebrations by his brother Geoffrey Keynes. Here is the text of the lecture:-

Newton, the Man

John Maynard Keynes

It is with some diffidence that I try to speak to you in his own home of Newton as he was himself. I have long been a student of the records and had the intention to put my impressions into writing to be ready for Christmas Day 1942, the tercentenary of his birth. The war has deprived me both of leisure to treat adequately so great a theme and of opportunity to consult my library and my papers and to verify my impressions. So if the brief study which I shall lay before you today is more perfunctory than it should be, I hope you will excuse me.

One other preliminary matter. I believe that Newton was different from the conventional picture of him. But I do not believe he was less great. He was less ordinary, more extraordinary, than the nineteenth century cared to make him out. Geniuses are very peculiar. Let no one here suppose that my object today is to lessen, by describing, Cambridge's greatest son. I am trying rather to see him as his own friends and contemporaries saw him. And they without exception regarded him as one of the greatest of men.

In the eighteenth century and since, Newton came to be thought of as the first and greatest of the modern age of scientists, a rationalist, one who taught us to think on the lines of cold and untinctured reason.

I do not see him in this light. I do not think that any one who has pored over the contents of that box which he packed up when he finally left Cambridge in 1696 and which, though partly dispersed, have come down to us, can see him like that. Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind which looked out on the visible and intellectual world with the same eyes as those who began to build our intellectual inheritance rather less than 10,000 years ago. Isaac Newton, a posthumous child bom with no father on Christmas Day, 1642, was the last wonderchild to whom the Magi could do sincere and appropriate homage.

Had there been time, I should have liked to read to you the contemporary record of the child Newton. For, though it is well known to his biographers, it has never been published in extenso, without comment, just as it stands. Here, indeed, is the makings of a legend of the young magician, a most joyous picture of the opening mind of genius free from the uneasiness, the melancholy and nervous agitation of the young man and student.

For in vulgar modern terms Newton was profoundly neurotic of a not unfamiliar type, but - I should say from the records - a most extreme example. His deepest instincts were occult, esoteric, semantic-with profound shrinking from the world, a paralyzing fear of exposing his thoughts, his beliefs, his discoveries in all nakedness to the inspection and criticism of the world. 'Of the most fearful, cautious and suspicious temper that I ever knew', said Whiston, his successor in the Lucasian Chair. The too well-known conflicts and ignoble quarrels with Hooke, Flamsteed, Leibniz are only too clear an evidence of this. Like all his type he was wholly aloof from women. He parted with and published nothing except under the extreme pressure of friends. Until the second phase of his life, he was a wrapt, consecrated solitary, pursuing his studies by intense introspection with a mental endurance perhaps never equalled.

I believe that the clue to his mind is to be found in his unusual powers of continuous concentrated introspection. A case can be made out, as it also can with Descartes, for regarding him as an accomplished experimentalist. Nothing can be more charming than the tales of his mechanical contrivances when he was a boy. There are his telescopes and his optical experiments, These were essential accomplishments, part of his unequalled all-round technique, but not, I am sure, his peculiar gift, especially amongst his contemporaries. His peculiar gift was the power of holding continuously in his mind a purely mental problem until he had seen straight through it. I fancy his pre-eminence is due to his muscles of intuition being the strongest and most enduring with which a man has ever been gifted. Anyone who has ever attempted pure scientific or philosophical thought knows how one can hold a problem momentarily in one's mind and apply all one's powers of concentration to piercing through it, and how it will dissolve and escape and you find that what you are surveying is a blank. I believe that Newton could hold a problem in his mind for hours and days and weeks until it surrendered to him its secret. Then being a supreme mathematical technician he could dress it up, how you will, for purposes of exposition, but it was his intuition which was pre-eminently extraordinary - 'so happy in his conjectures', said De Morgan, 'as to seem to know more than he could possibly have any means of proving'. The proofs, for what they are worth, were, as I have said, dressed up afterwards - they were not the instrument of discovery.

There is the story of how he informed Halley of one of his most fundamental discoveries of planetary motion. 'Yes,' replied Halley, 'but how do you know that? Have you proved it?' Newton was taken aback - 'Why, I've known it for years', he replied. 'If you'll give me a few days, I'll certainly find you a proof of it' - as in due course he did.

Again, there is some evidence that Newton in preparing the *Principia* was held up almost to the last moment by lack of proof that you could treat a solid sphere as though all its mass was concentrated at the centre, and only hit on the proof a year before publication. But this was a truth which he had known for certain and had always assumed for many years.

Certainly there can be no doubt that the peculiar geometrical form in which the exposition of the *Principia* is dressed up bears no resemblance at all to the mental processes by which Newton actually arrived at his conclusions.

His experiments were always, I suspect, a means, not of discovery, but always of verifying what he knew already.

Why do I call him a magician? Because he looked on the whole universe and all that is in it as a riddle, as a secret which could be read by applying pure thought to certain evidence, certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood. He believed that these clues were to be found partly in the evidence of the heavens and in the constitution of elements (and that is what gives the false suggestion of his being an experimental natural philosopher), but also partly in certain papers and traditions handed down by the brethren in an unbroken chain back to the original cryptic revelation in Babylonia. He regarded the universe as a cryptogram set by the Almighty - just as he himself wrapt the discovery of the calculus in a cryptogram when he communicated with Leibniz. By pure thought, by concentration of mind, the riddle, he believed, would be revealed to the initiate.

He did read the riddle of the heavens. And he believed that by the same powers of his introspective imagination he would read the riddle of the Godhead, the riddle of past and future events divinely fore-ordained, the riddle of the elements and their constitution from an original undifferentiated first matter, the riddle of health and of immortality. All would be revealed to him if only he could persevere to the end, uninterrupted, by himself, no one coming into the room, reading, copying, testing-all by himself, no interruption for God's sake, no disclosure, no discordant breakings in or criticism, with fear and shrinking as he assailed these half-ordained, half-forbidden things, creeping back into the bosom of the Godhead as into his mother's womb. 'Voyaging through strange seas of thought alone', not as Charles Lamb 'a fellow who believed nothing unless it was as clear as the three sides of a triangle'.

And so he continued for some twenty-five years. In 1687, when he was forty-five years old, the *Principia* was published.

Here in Trinity it is right that I should give you an account of how he lived amongst you during these years of his greatest achievement. The east end of the Chapel projects farther eastwards than the Great Gate. In the second half of the seventeenth century there was a walled garden in the free space between Trinity Street and the building which joins the Great Gate to the Chapel. The south wall ran out from the turret of the Gate to a distance overlapping the Chapel by at least the width of the present pavement. Thus the garden was of modest but reasonable size. This was Newton's garden. He had the Fellow's set of rooms between the Porter's Lodge and the Chapel - that, I suppose, now occupied by Professor Broad. The garden was reached by a stairway which was attached to a veranda raised on wooden pillars projecting into the garden from the range of buildings. At the top of this stairway stood his telescope - not to be confused with the observatory erected on the top of the Great Gate during Newton's lifetime (but after he had left Cambridge) for the use of Roger Cotes and Newton's successor, Whiston. This wooden erection was, I think, demolished by Whewell in 1856 and replaced by the stone bay of Professor Broad's bedroom. At the Chapel end of the garden was a small two-storied building, also of wood, which was his elaboratory. When he decided to prepare the *Principia* for publication he engaged a young kinsman, Humphrey Newton, to act as his amanuensis (the MS. of the *Principia,* as it went to the press, is clearly in the hand of Humphrey). Humphrey remained with him for five years - from 1684 to 1689. When Newton died Humphrey's son-in-law Conduitt wrote to him for his reminiscences, and among the papers I have is Humphrey's reply.

During these twenty-five years of intense study mathematics and astronomy were only a part, and perhaps not the most absorbing, of his occupations. Our record of these is almost wholly confined to the papers which he kept and put in his box when he left Trinity for London.

Let me give some brief indications of their subject. They are enormously voluminous - I should say that upwards of 1,000,000 words in his handwriting still survive. They have, beyond doubt, no substantial value whatever except as a fascinating sidelight on the mind of our greatest genius.

Let me not exaggerate through reaction against the other Newton myth which has been so sedulously created for the last two hundred years. There was extreme method in his madness. All his unpublished works on esoteric and theological matters are marked by careful learning, accurate method and extreme sobriety of statement. They are just as sane as the *Principia,* if their whole matter and purpose were not magical. They were nearly all composed during the same twenty-five years of his mathematical studies. They fall into several groups.

Very early in life Newton abandoned orthodox belief in the Trinity. At this time the Socinians were an important Arian sect amongst intellectual circles. It may be that Newton fell under Socinian influences, but I think not. He was rather a Judaic monotheist of the school of Maimonides. He arrived at this conclusion, not on so-to-speak rational or sceptical grounds, but entirely on the interpretation of ancient authority. He was persuaded that the revealed documents give no support to the Trinitarian doctrines which were due to late falsifications. The revealed God was one God.

For some of Newton's arguments, see our article Newton the Arian

But this was a dreadful secret which Newton was at desperate pains to conceal all his life. It was the reason why he refused Holy Orders, and therefore had to obtain a special dispensation to hold his Fellowship and Lucasian Chair and could not be Master of Trinity. Even the Toleration Act of 1689 excepted anti-Trinitarians. Some rumours there were, but not at the dangerous dates when he was a young Fellow of Trinity. In the main the secret died with him. But it was revealed in many writings in his, big box. After his death Bishop Horsley was asked to inspect the box with a view to publication. He saw the contents with horror and slammed the lid. A hundred years later Sir David Brewster looked into the box. He covered up the traces with carefully selected extracts and some straight fibbing. His latest biographer, Mr More, has been more candid. Newton's extensive anti-Trinitarian pamphlets are, in my judgement, the most interesting of his unpublished papers. Apart from his more serious affirmation of belief, I have a completed pamphlet showing up what Newton thought of the extreme dishonesty and falsification of records for which St Athanasius was responsible, in particular for his putting about the false calumny that Arius died in a privy. The victory of the Trinitarians in England in the latter half of the seventeenth century was not only as complete, but also as extraordinary, as St Athanasius's original triumph. There is good reason for thinking that Locke was a Unitarian. I have seen it argued that Milton was. It is a blot on Newton's record that he did not murmur a word when Whiston, his successor in the Lucasian Chair, was thrown out of his professorship and out of the University for publicly avowing opinions which Newton himself had secretly held for upwards of fifty years past.

That he held this heresy was a further aggravation of his silence and secrecy and inwardness of disposition.

Another large section is concerned with all branches of apocalyptic writings from which he sought to deduce the secret truths of the Universe - the measurements of Solomon's Temple, the Book of David, the Book of Revelations, an enormous volume of work of which some part was published in his later days. Along with this are hundreds of pages of Church History and the like, designed to discover the truth of tradition.

A large section, judging by the handwriting amongst the earliest, relates to alchemy - transmutation, the philosopher's stone, the elixir of life. The scope and character of these papers have been hushed up, or at least minimized, by nearly all those who have inspected them. About 1650 there was a considerable group in London, round the publisher Cooper, who during the next twenty years revived interest not only in the English alchemists of the fifteenth century, but also in translations of the medieval and post-medieval alchemists.

There is an unusual number of manuscripts of the early English alchemists in the libraries of Cambridge. It may be that there was some continuous esoteric tradition within the University which sprang into activity again in the twenty years from 1650 to 1670. At any rate, Newton was clearly an unbridled addict. It is this with which he was occupied 'about 6 weeks at spring and 6 at the fall when the fire in the elaboratory scarcely went out' at the very years when he was composing the *Principia* - and about this he told Humphrey Newton not a word. Moreover, he was almost entirely concerned, not in serious experiment, but in trying to read the riddle of tradition, to find meaning in cryptic verses, to imitate the alleged but largely imaginary experiments of the initiates of past centuries. Newton has left behind him a vast mass of records of these studies. I believe that the greater part are translations and copies made by him of existing books and manuscripts. But there are also extensive records of experiments. I have glanced through a great quantity of this at least 100,000 words, I should say. It is utterly impossible to deny that it is wholly magical and wholly devoid of scientific value; and also impossible not to admit that Newton devoted years of work to it. Some time it might be interesting, but not useful, for some student better equipped and more idle than I to work out Newton's exact relationship to the tradition and MSS. of his time.

In these mixed and extraordinary studies, with one foot in the Middle Ages and one foot treading a path for modern science, Newton spent the first phase of his life, the period of life in Trinity when he did all his real work. Now let me pass to the second phase.

After the publication of the *Principia* there is a complete change in his habit and way of life. I believe that his friends, above all Halifax, came to the conclusion that he must be rooted out of the life he was leading at Trinity which must soon lead to decay of mind and health. Broadly speaking, of his own motion or under persuasion, he abandons his studies. He takes up University business, represents the University in Parliament; his friends are busy trying to get a dignified and remunerative job for him - the Provostship of King's, the Mastership of Charterhouse, the Controllership of the Mint.

Newton could not be Master of Trinity because he was a Unitarian and so not in Holy Orders. He was rejected as Provost of King's for the more prosaic reason that he was not an Etonian. Newton took this rejection very ill and prepared a long legalistic brief, which I possess, giving reasons why it was not unlawful for him to be accepted as Provost. But, as ill-luck had it, Newton's nomination for the Provostship came at the moment when King's had decided to fight against the right of Crown nomination, a struggle in which the College was successful.

Newton was well qualified for any of these offices. It must not be inferred from his introspection, his absent-mindedness, his secrecy and his solitude that he lacked aptitude for affairs when he chose to exercise it. There are many records to prove his very great capacity. Read, for example, his correspondence with Dr Covell, the Vice-Chancellor when, as the University's representative in Parliament, he had to deal with the delicate question of the oaths after the revolution of 1688. With Pepys and Lowndes he became one of the greatest and most efficient of our civil servants. He was a very successful investor of funds, surmounting the crisis of the South Sea Bubble, and died a rich man. He possessed in exceptional degree almost every kind of intellectual aptitude - lawyer, historian, theologian, not less than mathematician, physicist, astronomer.

And when the turn of his life came and he put his books of magic back into the box, it was easy for him to drop the seventeenth century behind him and to evolve into the eighteenth-century figure which is the traditional Newton.

Nevertheless, the move on the part of his friends to change his life came almost too late. In 1689 his mother, to whom he was deeply attached, died. Somewhere about his fiftieth birthday on Christmas Day 1692, he suffered what we should now term a severe nervous breakdown. Melancholia, sleeplessness, fears of persecution - he writes to Pepys and to Locke and no doubt to others letters which lead them to think that his mind is deranged. He lost, in his own words, the 'former consistency of his mind'. He never again concentrated after the old fashion or did any fresh work. The breakdown probably lasted nearly two years, and from it emerged, slightly 'gaga', but still, no doubt, with one of the most powerful minds of England, the Sir Isaac Newton of tradition.

In 1696 his friends were finally successful in digging him out of Cambridge, and for more than another twenty years he reigned in London as the most famous man of his age, of Europe, and - as his powers gradually waned and his affability increased - perhaps of all time, so it seemed to his contemporaries.

He set up house with his niece Catharine Barton, who was beyond reasonable doubt the mistress of his old and loyal friend Charles Montague, Earl of Halifax and Chancellor of the Exchequer, who had been one of Newton's intimate friends when he was an undergraduate at Trinity. Catharine was reputed to be one of the most brilliant and charming women in the London of Congreve, Swift and Pope. She is celebrated, not least for the broadness of her stories, in Swift's *Journal to Stella*. Newton puts on rather too much weight for his moderate height. 'When he rode in his coach one arm would be out of his coach on one side and the other on the other.' His pink face, beneath a mass of snow-white hair, which 'when his peruke was off was a venerable sight', is increasingly both benevolent and majestic. One night in Trinity after Hall he is knighted by Queen Anne. For nearly twenty-four years he reigns as President of the Royal Society. He becomes one of the principal sights of London for all visiting intellectual foreigners, whom he entertains handsomely. He liked to have clever young men about him to edit new editions of the *Principia* - and sometimes merely plausible ones as in the case of Facio de Duillier.

Magic was quite forgotten. He has become the Sage and Monarch of the Age of Reason. The Sir Isaac Newton of orthodox tradition - the eighteenth-century Sir Isaac, so remote from the child magician born in the first half of the seventeenth century - was being built up. Voltaire returning from his trip to London was able to report of Sir Isaac - 'twas his peculiar felicity, not only to be born in a country of liberty, but in an Age when all scholastic impertinences were banished from the World. Reason alone was cultivated and Mankind could only be his Pupil, not his Enemy.' Newton, whose secret heresies and scholastic superstitions it had been the study of a lifetime to conceal!

But he never concentrated, never recovered 'the former consistency of his mind'. 'He spoke very little in company.' 'He had something rather languid in his look and manner.'

And he looked very seldom, I expect, into the chest where, when he left Cambridge, he had packed all the evidences of what had occupied and so absorbed his intense and flaming spirit in his rooms and his garden and his elaboratory between the Great Gate and Chapel.

But he did not destroy them. They remained in the box to shock profoundly any eighteenth- or nineteenth-century prying eyes. They became the possession of Catharine Barton and then of her daughter, the Countess of Portsmouth. So Newton's chest, with many hundreds of thousands of words of his unpublished writings, came to contain the 'Portsmouth Papers'.

In 1888 the mathematical portion was given to the University Library at Cambridge. They have been indexed, but they have never been edited. The rest, a very large collection, were dispersed in the auction room in 1936 by Catharine Barton's descendant, the present Lord Lymington. Disturbed by this impiety, I managed gradually to reassemble about half of them, including nearly the whole of the biographical portion, that is, the 'Conduitt Papers', in order to bring them to Cambridge which I hope they will never leave. The greater part of the rest were snatched out of my reach by a syndicate which hoped to sell them at a high price, probably in America, on the occasion of the recent tercentenary.

As one broods over these queer collections, it seems easier to understand - with an understanding which is not, I hope, distorted in the other direction - this strange spirit, who was tempted by the Devil to believe at the time when within these walls he. was solving so much, that he could reach all the secrets of God and Nature by the pure power of mind Copernicus and Faustus in one.

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