VIEWPOINTS

Mathematics of the Past

by
Garry Kasparov

Since my early childhood, I have been inspired and excited by ancient and medieval history. I also have a good memory, which allows me to remember historical events, dates, names, and related details. So, after reading many history books, I analysed and compared the information and, little by little, I began to feel that there was something wrong with the dates of antiquity. There were too many discrepancies and contradictions that could not be explained within the framework of traditional chronology. For example, let's examine what we know of ancient Rome.

Edward Gibbon
(1737-1794)

The monumental work *The Decline and Fall of the Roman Empire*, written by English historian and scholar Edward Gibbon (1737-1794), is a great source of detailed information on the history of the Roman Empire. Before commenting on this book, let me remark that I cannot imagine how—with their vast territories—the Romans did not use geographical maps, how they conducted trade without a banking system, and how the Roman army, on which the Empire rested, was unable to improve its weapons and military tactics during nine centuries of wars.

With the use of simple mathematics, it is possible to discover in ancient history several such dramatic contradictions, which historians don't seem to consider. Let us analyze some numbers. E. Gibbon gives a very precise description of a Roman legion, which *"...was divided into 10 cohorts... The first cohort,... was formed of 1 105 soldiers... The remaining 9 cohorts consisted each of 555 soldiers,... The whole body of legionary infantry amounted to 6 100 men."*[1] He also writes, *"The cavalry, without which the force of the legion would have remained imperfect, was divided into 10 troops or squadrons; the first, as the companion of the first cohort, consisted of a 132 men; while each of the other 9 amounted only to 66. The entire establishment formed a regiment... of 726 horses, naturally connected with its respected legion..."*[2] Finally, he gives an exact estimate of a Roman legion: *"We may compute, however, that the legion, which was itself a body of 6 831 Romans, might, with its attendant auxiliaries, amount to about 12 500 men. The peace establishment of Hadrian and his successors was composed of no less than 30 of these formidable brigades; and most probably formed a standing force of 375 000."*[3] This enormous military force of 375 000 men, maintained during a time of peace, was larger than the Napoleonic army in the 1800s.[4] Let me point out that according to the Encyclopædia Britannica,[5] *"Battles on the Continent in the mid-18th century typically involved armies of about 60 000 to 70 000 troops."* Of course, an army needed weapons, equipment, supplies, etc. Again, E. Gibbon gives us a lot of details:[6] *"Besides their arms, which the legionaries scarcely considered as an encumbrance, they were laden with their kitchen furniture, the instruments of fortifications, and the provisions of many days. Under this weight, which would oppress the delicacy of a modern soldier,*[7] *they were trained by a regular step to advance, in about six hours, nearly twenty miles. On the appearance of an enemy, they threw aside their baggage, and by easy and rapid evolutions converted the column of march into an order of battle."* This description of the physical fitness of an average Roman soldier is extraordinary. It brings us to the very strange conclusion that, at some point, the human race retrogressed in its ability to cope with physical problems. Is it possible that there was a gradual decline of the human race, with hundreds of thousands of Schwarzenegger-like athletes of Roman times evolving into medieval knights with relatively weak bodies (like today's teenage boys), whose little suits of armor are today proudly displayed in museums? Is there a reasonable biological or genetic explanation to this dramatic change affecting the human race over such a short period of time?

In order to supply such an army with weapons, a whole industry would have been needed. In his work, E. Gibbon explicitly mentions iron (or even steel) weapons: "*Besides a lighter spear, the legionary soldier grasped in his right hand the formidable pilum..., whose utmost length was about six feet, and which was terminated by a massy triangular point of steel of eighteen inches."*[8] In another place, he indicates *"The use of lances and of iron maces..."*[9] It is believed that the extraction of iron from ores was very common in the Roman Empire.[10] However, to smelt pure iron, a temperature of 1 539°C is required, which couldn't be achieved by burning wood or coal without the blowing or the blast furnaces invented more than a 1000 years later.[11] Even in the 15th century, the iron produced was of quite poor quality because large amounts of carbon had to be absorbed to lower the melting temperature to 1 150°C. There is also the question of sufficient resources—the blast furnaces used in the mid-16th century required large amounts of wood to produce charcoal, an expensive and unclean process that led to the eventual deforestation of Europe. How could ancient Rome have sustained a production of quality iron on the scale necessary to supply thousands of tonnes of arms and equipment to its vast army?

Just by estimating the size of the army, we can conclude that the population of the Eastern and Western Roman Empire in the second century AD was at least 20 million people, but it could have been as high as 40 or even 50 million. According to E. Gibbon, *"Ancient Italy... contained eleven hundred and ninety seven cities."*[12] The city of Rome had more

[1] See [1], page 30.
[2] See [1], p. 32.
[3] See [1], p. 35.
[4] After 1800, Napoleon routinely maneuvered armies of 250 000. See the Encyclopædia Britannica.
[5] Encyclopædia Britannica online at `http://www.britannica.com/`
[6] See [1], p. 35.
[7] E. Gibbon wrote these words in the years 1776–88, before the French Revolution and the Napoleonic wars.
[8] See [1], p. 31.
[9] See [1], p. 33.
[10] See Encyclopædia Britannica.
[11] See [7], where the presented facts prove that real metallurgy started in the 16th century. Coal was discovered in England only in the 11th century.
[12] See [1], page 71.

than a half-million inhabitants, and there were other great cities in the Empire. All of these cities were connected by a network of paved public highways, their combined lengths totalling more than 4000 miles![13] This could only be possible in a technologically advanced society. According to J.C. Russell,[14] in the 4th century, the population of the Western Roman Empire was 22 million (including 750 000 people in England and five million in France), while the population of the Eastern Roman Empire was 34 million.

It is not hard to determine that there is a serious problem with these numbers. In England, a population of four million in the 15th century grew to 62 million in the 20th century. Similarly, in France, a population of about 20 million in the 17th century (during the reign of Louis XIV), grew to 60 million in the 20th century—and this growth occurred despite losses due to several atrocious wars. We know from historical records that during the Napoleonic wars alone, about three million people perished, most of them young men. But there was also the French Revolution, the wars of the 18th century in which France suffered heavy losses, and the slaughter of World War I. By assuming a constant population growth rate, it is easy to estimate that the population of England doubled every 120 years, while the population of France doubled every 190 years.

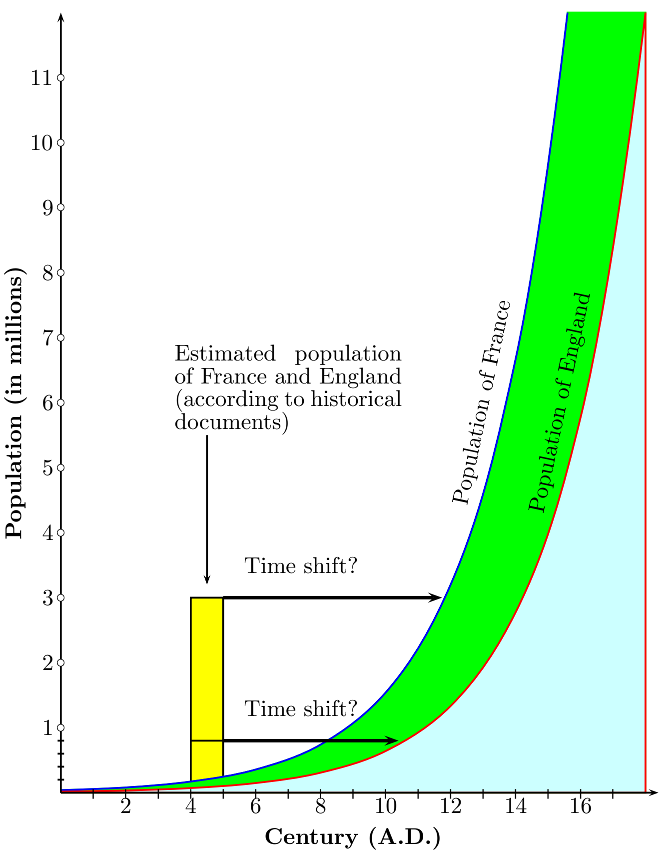


Figure 1

Graphs showing the hypothetical growth of these two functions are provided in Figure 1. According to this model, in the 4th and 5th centuries, at the breakdown of the Roman Empire, the (hypothetical) population of England would have been 10 000 to 15 000, while the population of France would have been 170 000 to 250 000. However, according to estimates based on historical documents, these numbers should be in the millions.

It seems that starting with the 5th century, there were periods during which the population of Europe stagnated or decreased. Attempts at logical explanations, such as poor hygiene, epidemics, and short lifespan, can hardly withstand criticism. In fact, from the 5th century until the 18th century, there was no significant improvement in sanitary conditions in Western Europe, there were many epidemics, and hygiene was poor. Also, the introduction of firearms in the 15th century resulted in more war casualties. According to UNESCO demographic resources, an increase of 0.2 per cent per annum is required to assure the sustainable growth of a human population, while an increase of 0.02 per cent per annum is described as a demographical disaster. There is no evidence that such a disaster has ever happened to the human race. Therefore, there is no reason to assume that the growth rate in ancient times differed significantly from the growth rate in later epochs.

These discrepancies lead me to suspect that there is a gap between the historical dates attributed to the Roman Empire and those suggested by the above computations. But there are more inconsistencies in the historical record of humankind. As I have already noted, there are similar gaps of several centuries in technological and scientific development. Notice that knowledge and technology traditionally associated with the ancient world presumably disappears during the Dark Ages, only to resurface in the 15th century during the early Renaissance. The history of mathematics provides one such example. By chronologically and logically ordering major mathematical achievements, beginning with arithmetic and Greek geometry and finishing with the invention of calculus by I. Newton (1643–1727) and G.W. Leibnitz (1646–1716), we see a thousand-year gap separating antiquity from the new era. Is this only a coincidence? But what about astronomy, chemistry (alchemy), medicine, biology, and physics? There are too many inconsistencies and unexplained riddles in ancient history. Today, we are unable to build simple objects made in ancient times in the way they were originally created[15]—this in a time when technology has produced the space shuttle and science is on the brink of cloning the human body! It is preposterous to blame all of the lost secrets of the past on the fire that destroyed the Library of Alexandria, as some have suggested.

It is unfortunate that each time a paradox of history unfolds, we are left without satisfactory answers and are persuaded to believe that we have lost the ancient knowledge. Instead of disregarding the facts that disagree with the traditional interpretation, we should accept them and put the theory under rigorous scientific scrutiny. Explanations of these paradoxes and contradictions should not be left only to historians. These are scientific and multidisciplinary problems and, in my opinion, history—as a single natural science—is unable on its own to solve them.

I think that the chronology of technological and scientific development should be carefully investigated. The too-numerous claims of technological wonders in antiquity turn history into science fiction (e.g., the production of monolithic stone blocks in Egypt, the precise astronomical calculations obtained without mechanical clocks, the glass objects and mirrors made 5000 years ago,[16] and so on). It is un-

[13] See [1], page 74.

[14] See [6].

[15] For example, try to build a working wheel according to ancient diagrams, but do it without using iron or iron tools.

[16] Making glass, in technical terms, is a secondary product of black metallurgy requiring a temperature of 1 280°C.

fortunate that historians reject scientific incursion into their domain. For instance, the most reasonable explanation of Egyptian pyramid-building technology, presented by French chemist Joseph Davidovits[17] (the creator of the geopolymer technology), was rejected by Egyptologists, who refused to provide him with samples of pyramid material.

About five years ago, I came across several books written by two mathematicians from Moscow State University: academician A.T. Fomenko and G.V. Nosovskij. The books described the work of a group of professional mathematicians, led by Fomenko, who had considered the issues of ancient and medieval chronology for more than 20 years, with fascinating results. Using modern mathematical and statistical methods,[18] as well as precise astronomical computations,[19] they arrived at the conclusion that ancient history was artificially extended by more than 1000 years. For reasons beyond my understanding, historians are still ignoring their work.

Greek and Roman Counting System

Modern	Greek	Roman	Modern	Greek	Roman
1	α	I	25	$\kappa\varepsilon$	XXV
2	β	II	50	ν	L
3	γ	III	70	o	LXX
4	δ	IV	80	π	LXXX
5	ε	V	100	ρ	C
6	ς	VI	200	σ	CC
7	ζ	VII	500	ϕ	D
8	η	VIII	800	ω	DCCC
9	θ	IX	1000	${}^{\iota}\alpha$	M
10	ι	X	10000	M^{α}	$\overline{\mathrm{X}}$
20	κ	XX	20 000	M^{β}	$\overline{\mathrm{XX}}$
24	$\kappa\delta$	XXIV	100 000	M^{ι}	$\overline{\mathrm{C}}$

Table 1

But let us return to mathematics and to ancient Rome. The Roman numeral system discouraged serious calculations. How could the ancient Romans build elaborate structures such as temples, bridges, and aqueducts without precise and elaborate calculations? The most important deficiency of Roman numerals is that they are completely unsuitable even for performing a simple operation like addition, not to mention multiplication, which presents substantial difficulties (see Table 1).[20] In early European universities, algorithms for multiplication and division using Roman numerals were doctoral research topics. It is absolutely impossible to use clumsy Roman numbers in multi-stage calculations. The Roman system had no numeral "zero." Even the simplest decimal operations with numbers cannot be expressed in Roman numerals.

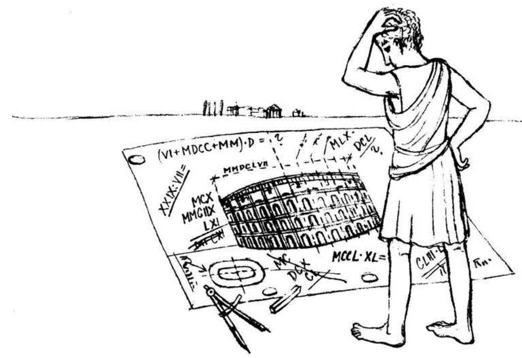
Just try to add Roman numerals:[21]

$$\begin{array}{c}\textbf{MCDXXV}\\ +\\ \textbf{MCMLXV,}\end{array}$$

or multiply:[22]

$$\begin{array}{c}\textbf{DCLIII}\\ \times\\ \textbf{CXCIX.}\end{array}$$

Try to write a multiplication table in Roman numerals. What about fractions and operations with fractions?



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Despite all of these deficiencies, Roman numerals supposedly remained the predominant representation of numbers in European culture until the 14th century. How did the ancient Romans succeed in their calculations, including complicated astronomical computations? It is believed that in the 3rd century, the Greek mathematician Diophantus was able to find positive and rational solutions to the following system of equations, called *Diophantic* today:

$$\begin{aligned} x_1^3 + x_2 &= y^3, \\ x_1 + x_2 &= y. \end{aligned}$$

According to historians, at the time of Diophantus, only one symbol was used for an unknown, a symbol for "plus" did not exist; neither was there a symbol for "zero." How could Diophantic equations be solved using Greek letters or Roman numerals (see Table 1)? Can these solutions be reproduced? Are we dealing here with another secret of ancient history that we are not supposed to question? Let us point out that even Leonardo da Vinci, at the beginning of the 16th century, had troubles with fractional powers.[23] It is also interesting that in all of da Vinci's works, there is no trace of "zero" and that he was using 22/7 as an approximation of π—probably it was the best approximation of π available at that time.[24]

It is also interesting to look at the invention of the logarithm. The logarithm of a number x (to the base 10) expresses simply the number of digits in the decimal representation of x, so it is clearly connected to the idea of the positional numbering system. Obviously, Roman numerals could not have led to the invention of logarithms.

Knowledge of our history timeline is important, and not only for historians. If indeed the dates of antiquity are incorrect, there could be profound implications for our beliefs

[17] See [3].

[18] See [4].

[19] See [5].

[20] Even in 1768, in the first edition of Encyclopædia Britannica, there were some variations in the use of the Roman numerals. For example, the symbol IIII was sometimes used instead of IV for the number four.

[21] Answer: MMMCCCXC. You can check your work with this online Roman numeral calculator: http://www.naturalmath.com/tool2.html.

[22] Answer: $\overline{\mathrm{CXX}}\mathrm{M}\overline{\mathrm{X}}\mathrm{CMXLVII}$.

[23] Da Vinci made a mistake in his computations of the area of a cross-section of a cube—he wasn't able to express his result, which contained the fractional power 3/2. See [8], F., p. 59.

[24] See [9], p. 1.

about the past, and also for science. Historical knowledge is important to better understand our present situation and the changes that take place around us. Important issues such as global warming and environmental changes depend on available historical data. Astronomical records could have a completely different meaning if the described events took place at times other than those provided by traditional chronology. I trust that the younger generation will have no fear of "untouchable" historical dogma and will use contemporary knowledge to challenge questionable theories. For sure, it is an exciting opportunity to reverse the subordinate role science plays to history, and to create completely new areas of scientific research.

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[7] J.E. Dayton. Minerals, Metals, Glazing and Man. Harrap, London, 1978. ISBN: 0245528075.

[8] The Notebooks of Leonardo da Vinci, 2nd ed., 2 vol. (1955, reissued 1977); and Jean Paul Richter (compiler and ed.). Original kept at Institut de France, Paris.

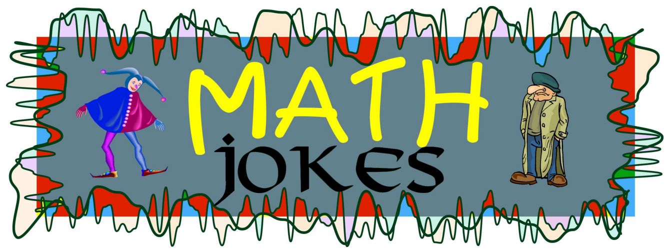
[9] Leonardo da Vinci. Codex Atlanticus. Kept in Biblioteca Ambrosiana in Milan, Italy.

Garry Kasparov has been the chess world champion since 1985, when he won the title at the age of 22. In 1997, during a historical chess challenge that made headlines all over the world, he defeated IBM's Deep Blue supercomputer. There are many web sides devoted to Garry, but we recommend:

http://www.kasparovchess.com/.

A biography can be found at

http://www.chennaiweb.com/sp/chess/bio/garyk/.



The math professor's six-year-old son knocks at the door of his father's study.

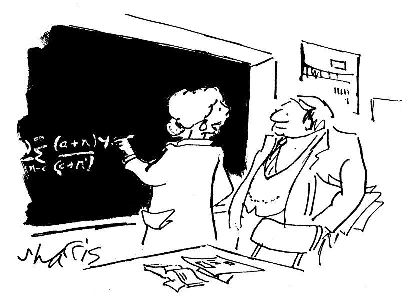
"Daddy," he says. "I need help with a math problem I couldn't do at school."

"Sure," the father says and smiles. "Just tell me what's bothering you."

"Well, it's a really hard problem: *There are four ducks swimming in a pond when two more ducks come and join them. How many ducks are now swimming in the pond?"*

The professor stares at his son in disbelief. "You couldn't do that?! All you need to know is that $4 + 2 = 6$!"

"Do you think, I'm stupid?! Of course I know that $4 + 2 = 6$. But what does this have to do with ducks!?"



"The beauty of math, of course, is that we don't even need an ethicist"

A visitor to the Royal Tyrell museum in Alberta asks a museum employee:

"How old is the skeleton of that T-Rex?"

"Precisely 60 million and three years, two months, and 12 days."

"How can you know that with such precision?"

"That's easy. When I started working here, a sign said that the skeleton was 60 million years old. And that was three years, two months, and 12 days ago…"

"What is π?"

A mathematician: "π is the ratio of the circumference of a circle to its diameter."

A computer programmer: "π is 3.141592653589 in double precision."

A physicist: "π is 3.14159 plus or minus 0.000005."

An engineer: "π is about 22/7."

A nutritionist: "Pie is a healthy and delicious dessert!"

Q: How do you make one burn?

A: Differentiate a log fire!
