Georges-Louis Leclerc de Buffon (September 7, 1707 – April 16, 1788)

by HEINZ KLAUS STRICK, Germany

GEORGES-LOUIS LECLERC, COMTE DE BUFFON, was born on September 7, 1707, in Montbard (Burgundy) as GEORGES-LOUIS LECLERC. When he was ten years old, his mother inherited a large fortune, which included estates in Buffon and Montbard. The family name was then augmented to include the title "DE BUFFON". Following his attendance at a Jesuit school in Dijon, he studied – at his father's wish and without much interest – jurisprudence, although he would rather have studied mathematics, medicine, and biology. Over the course of his studies, he gradually shifted his focus to the subjects that were of greater interest to him.

At the age of 20, he discovered (independently of NEWTON) the binomial theorem

$$(a+b)^n = \binom{n}{0} \cdot a^n b^0 + \binom{n}{1} \cdot a^{n-1} b^1 + \ldots + \binom{n}{n} \cdot a^0 b^n .$$

He corresponded with the Swiss mathematician and physicist GABRIEL CRAMER (1704–1752) on problems in mechanics, geometry, number theory, differential and integral calculus, as well as the St. Petersburg paradox in the theory of probability:

- *Can one be certain of a net win in roulette if one continually doubles one's wager until one has a net profit?*

At the age of 25, BUFFON inherited his mother's fortune, and was obligated to assume responsibilities for the family's estates in Montbard. But aside from that, his wealth allowed him to move socially in the highest political circles of Paris. And he impressed the scientific community with his professional expertise: as an expert in botany, he advised the lord of the admiralty on suitable species of wood for the construction of warships.

In 1733, he published a mathematical article called *"Mémoire sur le jeu de franc-carreau,"* which led to his election at the age of 26 to the French Academy of Sciences.

BUFFON translated ISAAC NEWTON's *Method of Fluxions and Infinite Series* into French, and he contributed to the translation an extensive foreword (publication in 1740). In 1739, he was appointed by the French king to the post of head of the Parisian *Jardin du Roi*.

Thereafter, he devoted himself more intensively to questions of natural history; over the years, he enlarged the royal gardens considerably (to be seen today under the name *Jardin de Plantes*), and he assembled a unique collection, the "*Cabinet d'Histoire Naturelle du roi*".

Together with LOUIS JEAN-MARIE DAUBENTON (1716–1800), he published a multivolume *Histoire naturelle, générale et particulière* (A Natural History, in General and in Detail), planned to comprise fifty volumes, dealing with the origin of the Earth, minerals, and the development of organisms, in particular the various species of animals. The first volumes appeared in 1749, and three years later, it appeared in German translation, and it was also translated into many other languages, including English.

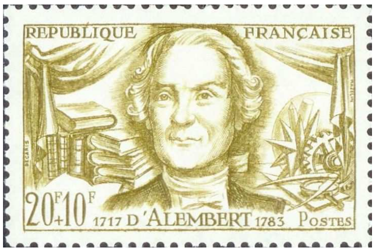
Publication led to conflict with the Church because of the work's advocacy of a theory that the Earth arose through collision of a comet with the Sun and that the motion of the planets is to be explained not by divine intervention but by the laws of mechanics.

BUFFON formulated the hypothesis that all life developed from tiny particles and that further development was influenced by climate change. On the basis of research in comparative anatomy, he conjectured, among other things, that apes and human beings have the same ancestry.

His research led him to estimate the age of the Earth at about 75000 years. Until that time, the Church—based on biblical genealogy—had declared the age of the Earth to be about 6000 years.

During BUFFON's lifetime, 36 volumes of the encyclopaedia were published. They were among the most widely disseminated works of the *Age of Enlightenment*, and they brought BUFFON international renown.

For his services, he was granted by the king in 1773 the title of *Comte*. He was elected to the *Académie française* in 1753 in recognition of his cultivated writing style; indeed, his texts were reprinted in French readers until well into the twentieth century.

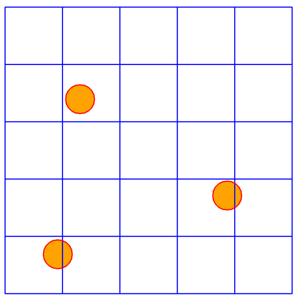


Critics, among whom can be counted the mathematician and physicist JEAN-BAPTIST LE ROND D' ALEMBERT (1717–1783), belittled his style, calling him a "grand phrasemonger." However, throughout his life, he serenely sidestepped criticism, on the principle that criticism would redound unfavourably on the critics.

BUFFON married twice. His only son, on whom he pinned his hopes for a continuation of his work, was a disappointment. His life ended under the guillotine during the turmoil of the French Revolution.

In 1777, BUFFON's "*Essai d'Arithmétique Morale*" appeared in a supplementary volume to his *Histoire naturelle*, in which he discussed questions of probability and statistics. Using an extensive collection of data on births, marriages, and deaths in Paris, he developed *mortality tables* that make it possible to estimate the probability that a person aged n would live another x years. It becomes clear that he had difficulty in making precise the notion of the probability of an outcome when we read that he gave 1/10000 as the probability that a 56-year-old individual would die in the course of any one day and then asserted that in his opinion, such a probability could not be distinguished from the probability zero.

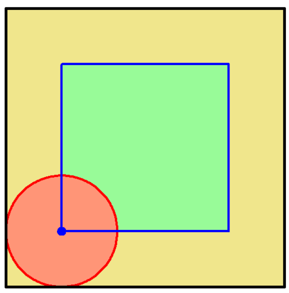
He gave considerable attention to the *St. Petersburg paradox*, holding the problem for unrealistic because it could not be carried out in practice. Moreover, he repudiated games of chance fundamentally, even those with rules that are fair.



With a paper of 1733, BUFFON became the first mathematician to deal with *random trials*, which lead to so-called geometric probabilities. He extended this in his 1777 book:

The game *franc-carreau* involves allowing a coin of radius r to fall at random on a surface with a pattern of squares (c is the side length of a square). The first player bets that the coin will end up lying completely *within* a square, while the second player bets that the coin will lie over at least one line separating the squares. The question of interest is this:

- *What size square will give both players equal odds in this game?*

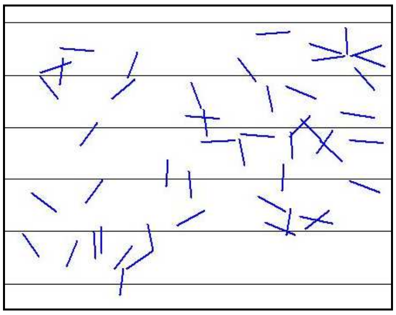


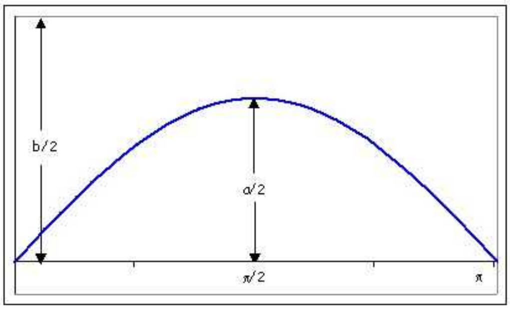
BUFFON demonstrated that the determination of the probability of winning depends on the size of the squares as follows: If the centre of the coin lies within the region of the square shown in green, then the first player wins.

Therefore, if the green region and the remaining yellow region of each square are the same size, that is, $(c-2r)^2 = \frac{1}{2}\cdot c^2$, or equivalently, if one has the ratio $\frac{c}{r} = 4+\sqrt{8} \approx 6{,}8$, then the game is fair.

BUFFON varied the problem description to include patterns consisting of equilateral triangles or hexagons. He also considered how to determine the probabilities if one tossed some object other than a coin, such as a square marker, a rod, or a needle, onto various regular floor patterns – for example:

- *A needle of length a is tossed at random onto a floor of identical parallel boards of width b (a < b). The position of the needle is then determined uniquely by the distance x from the midpoint of the needle to the nearest straight line and the angle α.*





To determine the probability of the event *E* that the needle intersects the line, one must determine the mean value of the vertical (in the sense of the figure) distance $f(\alpha) = \frac{1}{2}\cdot a\cdot \sin(\alpha)$ $f(\alpha)$ from the needle's midpoint to its endpoint within the interval $\alpha \in [0, \pi[$ and compare that with the distance $\frac{1}{2}\cdot b$. The desired probability may then be obtained using the integral calculus; it is $P(E) = \frac{2\cdot a}{b\cdot \pi}$.

What is known as the experiment of BUFFON's needle can be used in principle to determine an approximation to the number π, the ratio of a circle's circumference to its diameter. However, the precision of this experiment is not useful in practice because one would need already a huge number of random trials in order "calculate" the first few digits.

The solution of the BUFFON needle problem – a problem conceived by BUFFON and named for him – provoked considerable discussion in his time among mathematicians, leading eventually to an increased understanding of the notion of probability. PIERRE SIMON LAPLACE integrated BUFFON's methods into his book *Théorie analytique des probabilités* (published 1812).

First published 2007 by Spektrum der Wissenschaft Verlagsgesellschaft Heidelberg

https://www.spektrum.de/wissen/georges-louis-leclerc-buffon-1707-1788/897134

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English version first published by the *European Mathematical Society* 2012