Learning Math through the People Who Lived It

Royal Fireworks Press

About your presenter… Robert Black

VANDERBILT
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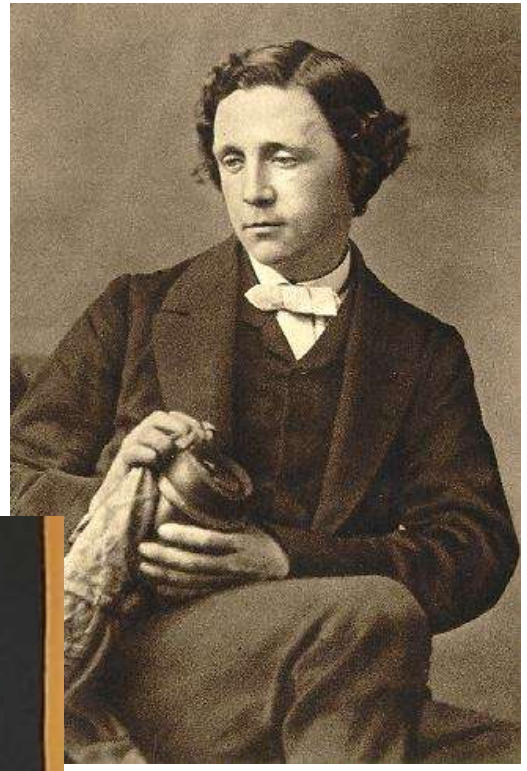
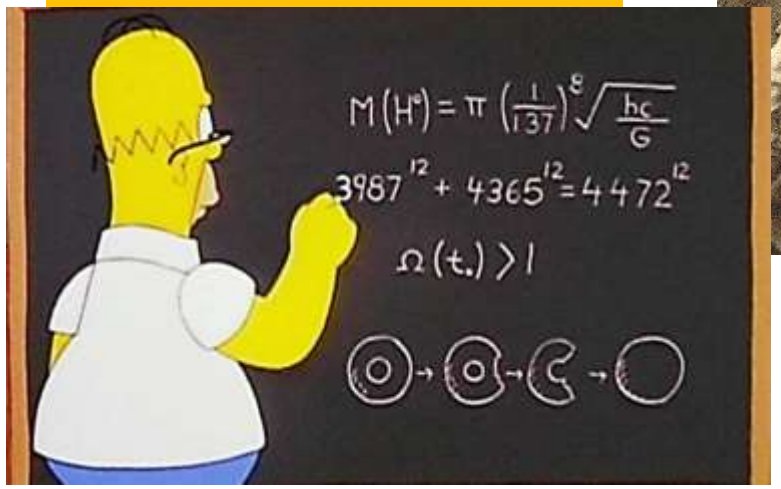
The beginnings of Mathematical Storytelling





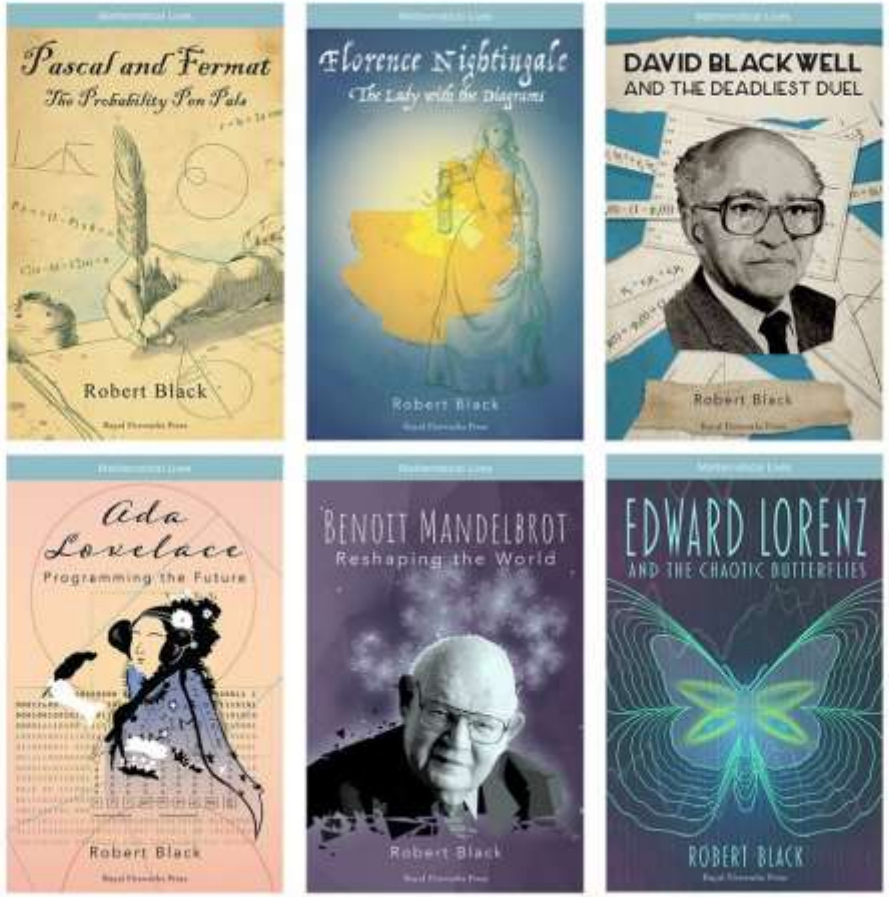
Spooky Math Books

The *Mathematical Lives* Series

- Objective: To tell the stories of famous mathematicians and the problems they worked on.
- The Challenges:
  - How to choose a set of mathematicians?
  - How to choose mathematical subjects that middle school students will understand?
- Every book explores the actual problems the subject solved.
- Every book includes a “Doing the Math” section at the end, where the readers can try problems themselves.

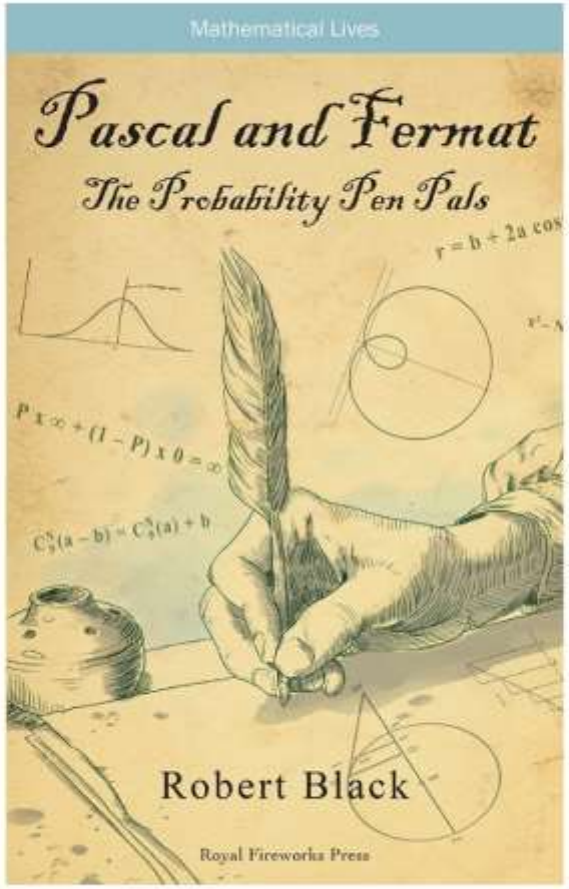
Overall themes

- Math is done by real people, solving real problems.
- Mathematicians build on the math that was done before.
- Mathematicians collaborate individually and in networks.
- One more theme emerged as the books took shape…



Volume 1

Pascal and Fermat: The Probability Pen Pals



A French aristocrat asked Blaise Pascal a gambling question that had defied explanation for more than a century:

Suppose a group of men play a game of chance in which the first to reach a certain number of points wins all the money at stake. If the game is interrupted before anyone has enough points to win, how should the money be divided?

In 1654, Pascal wrote to Pierre de Fermat, and they exchanged a series of letters while working on the problem...

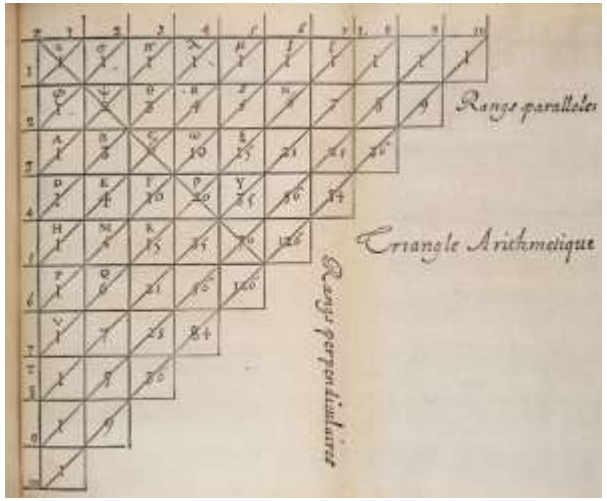
...and modern Probability Theory was born!

Volume 1

Pascal and Fermat: The Probability Pen Pals

Blaise Pascal
(1623-1662)

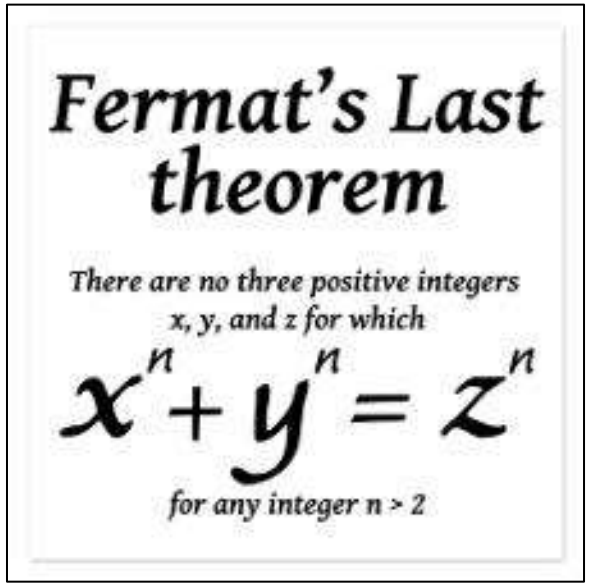
- Blaise Pascal
  - Taught himself geometry after his father forbade it
  - Proved the existence of a vacuum
  - Invented the first mechanical calculating machine
  - Discovered the arithmetical triangle could be used to count combinations



Volume 1

Pascal and Fermat: The Probability Pen Pals

- Pierre de Fermat
  - Considered the greatest "amateur" mathematician of all time.
  - Discovered Analytic Geometry slightly ahead of Descartes, but never published.
  - Favorite subject was Number Theory, well ahead of its time.
  - Known for "Fermat's Last Theorem," not solved until 1994.

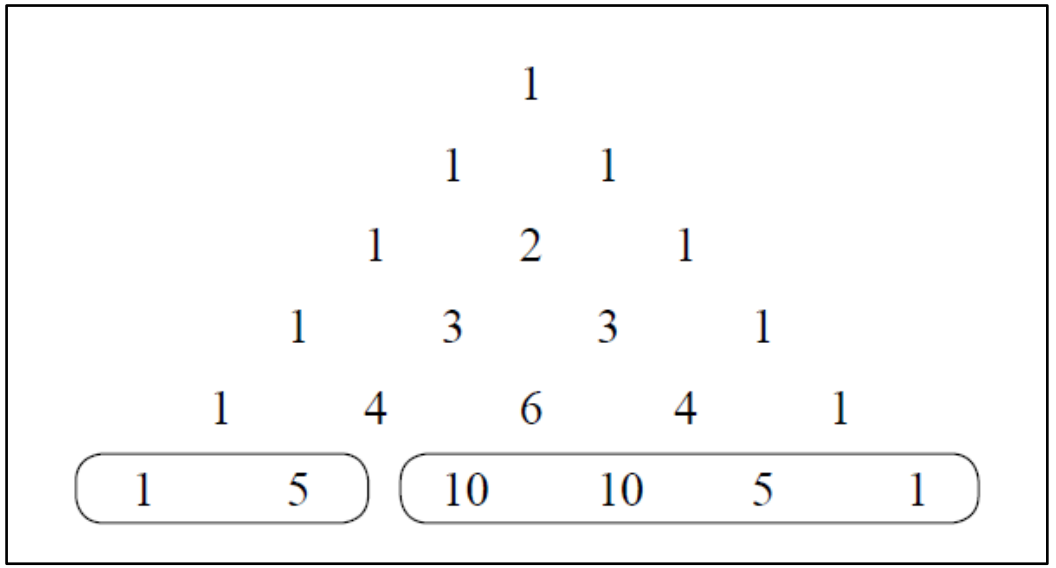


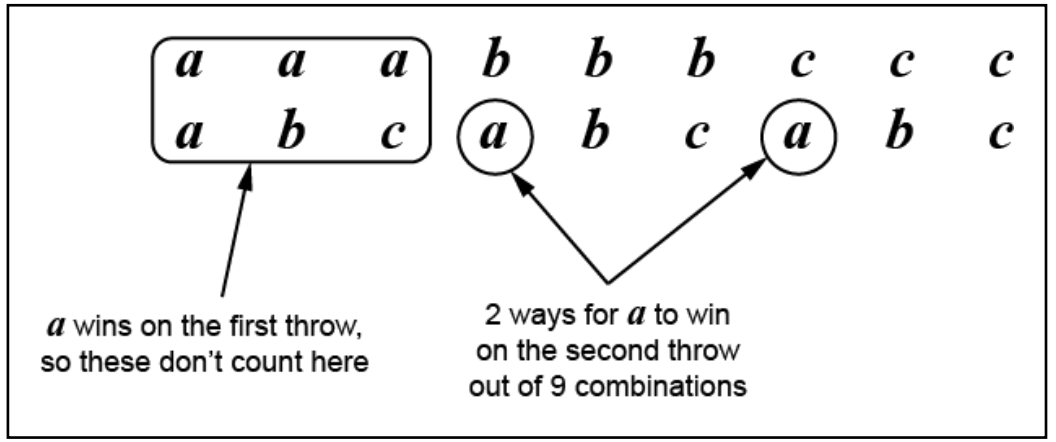
Pierre de Fermat
(1607-1665)

Volume 1

Pascal and Fermat: The Probability Pen Pals

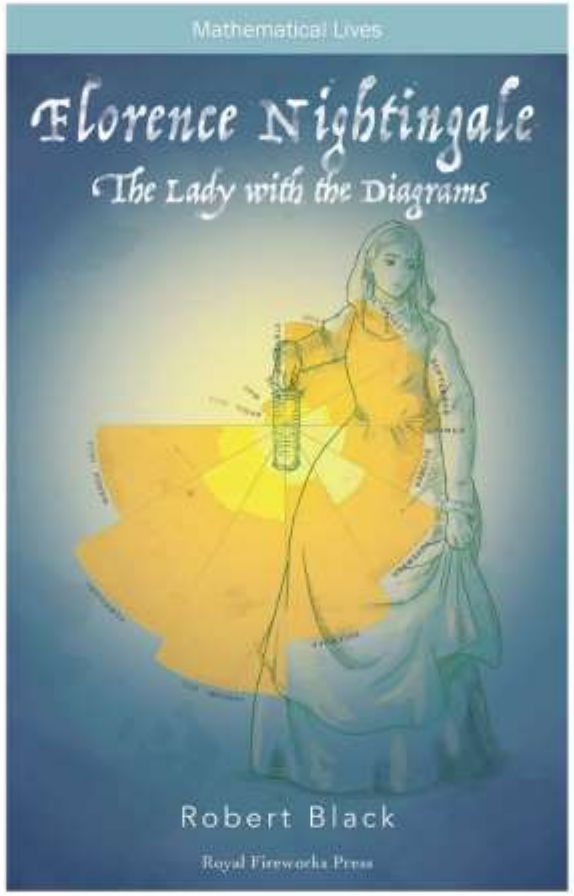
- Pascal and Fermat used different methods to solve the “Problem of the Points,” but they arrived at the same conclusion.
- *The Probability Pen Pals* takes the reader through both solutions.





Volume 2

Florence Nightingale: The Lady with the Diagrams



When Florence Nightingale returned from the Crimean War, she persuaded Queen Victoria to form a Royal Commission for studying the improvement of sanitary conditions in the Army.

What was the best way to communicate its statistical findings to the general public?

Volume 2

Florence Nightingale: The Lady with the Diagrams

- Florence Nightingale (1820-1910)
  - Largest UK hero of the Crimean War
  - Inventor of the modern nursing profession
  - Skilled statistician, mentored by Adolphe Quetelet (1796-1874) and William Farr (1807-1883)
  - Spent her post-war career campaigning for sanitary and social reform in both Britain and the empire

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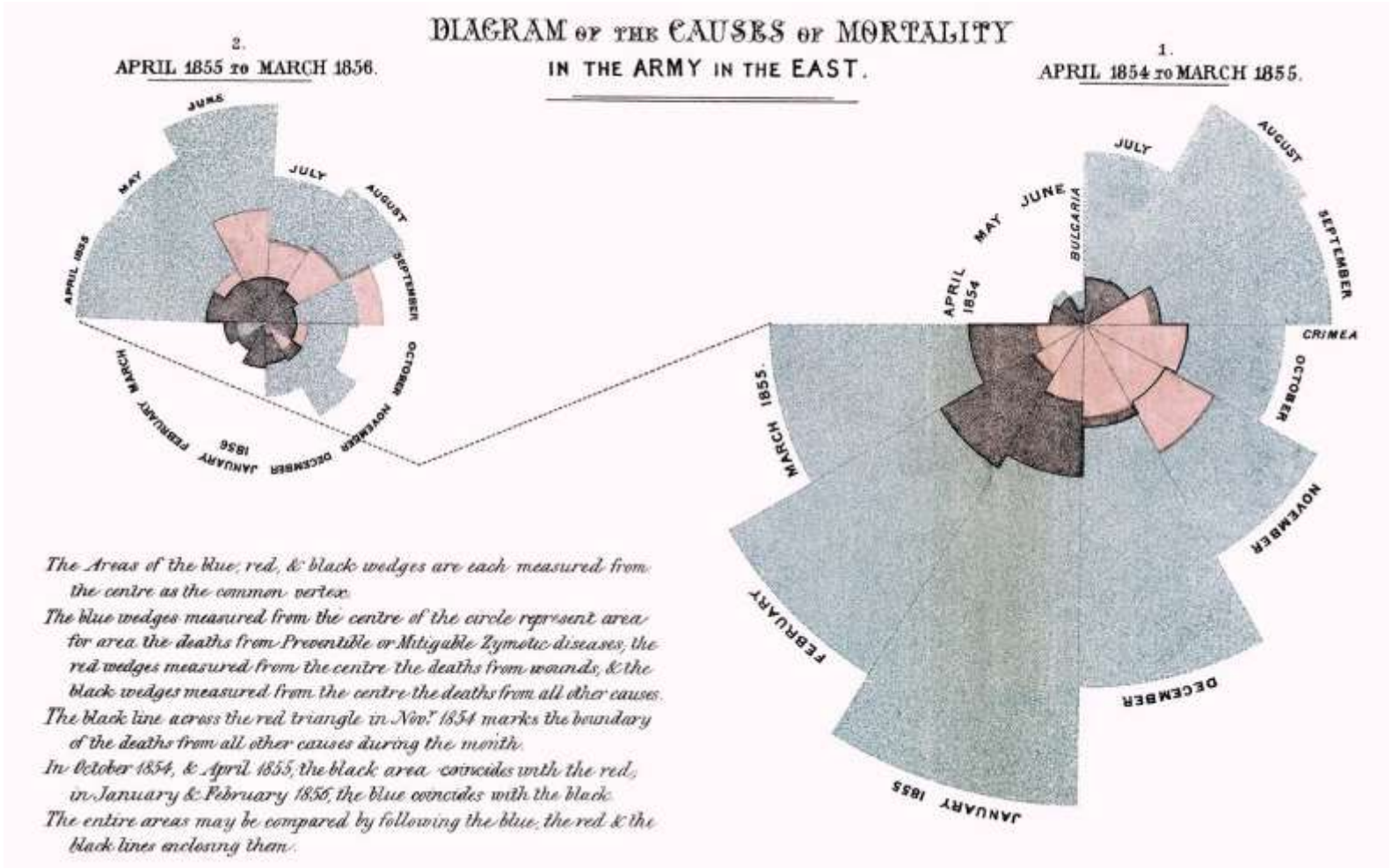
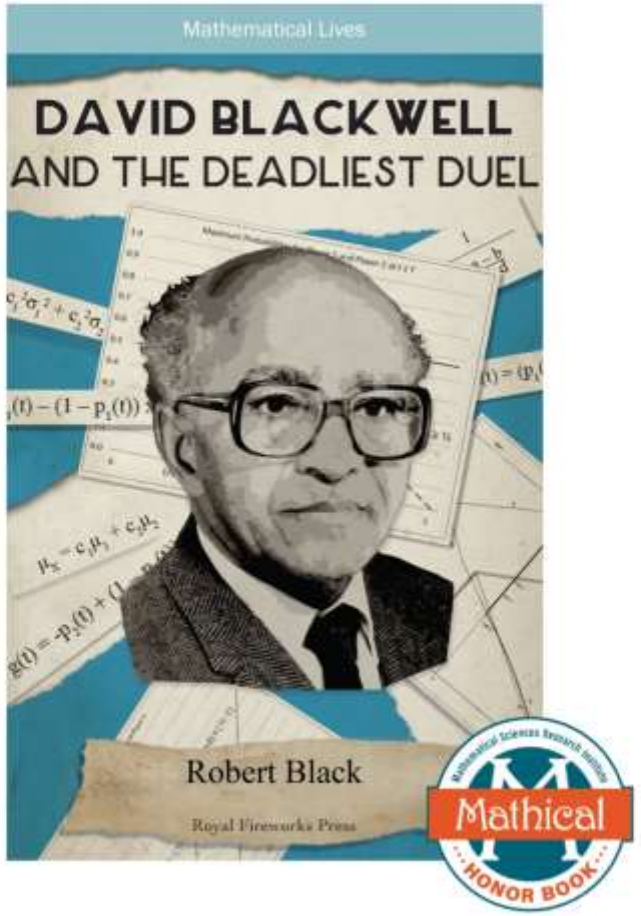


Volume 3

David Blackwell and the Deadliest Duel



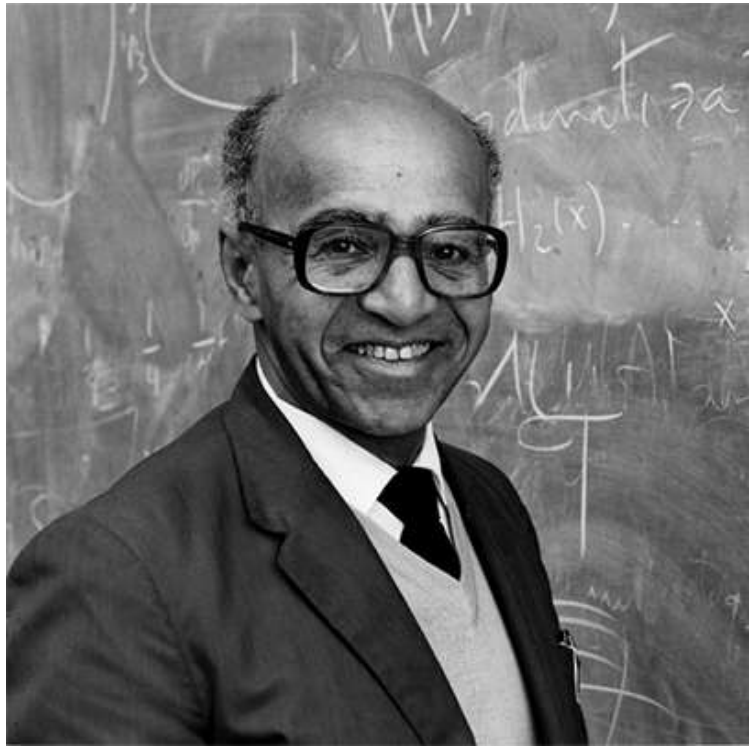
In the early days of the Cold War, the US Government established the RAND Corporation, where scientists and mathematicians could research new weapons and strategies.

One day in the late 1940s, a RAND economist asked visiting mathematician David Blackwell...

What was the probability of another world war in the next five years?

Volume 3

David Blackwell and the Deadliest Duel

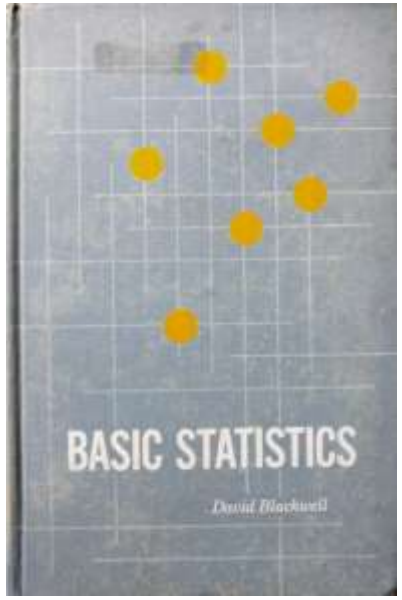


- David Blackwell (1919-2010)
  - Professor and Department Chair at Howard University (1944-54) and at UC Berkeley (1954-89)
  - First African-American elected to the National Academy of Sciences
  - Research in probability, game theory, and information theory
  - Studied the “theory of duels” for RAND Corporation, 1948-50

Volume 3

David Blackwell and the Deadliest Duel

- Bayesian Statistics
  - First developed by Thomas Bayes (1702-1761) as part of a religious debate with David Hume.
  - Controversial because of its reliance on an initial “guess.”
  - David Blackwell was the only professor at UC Berkeley to teach using the Bayesian approach.
  - Blackwell wrote the first elementary Statistics textbook to use the Bayesian approach.



$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

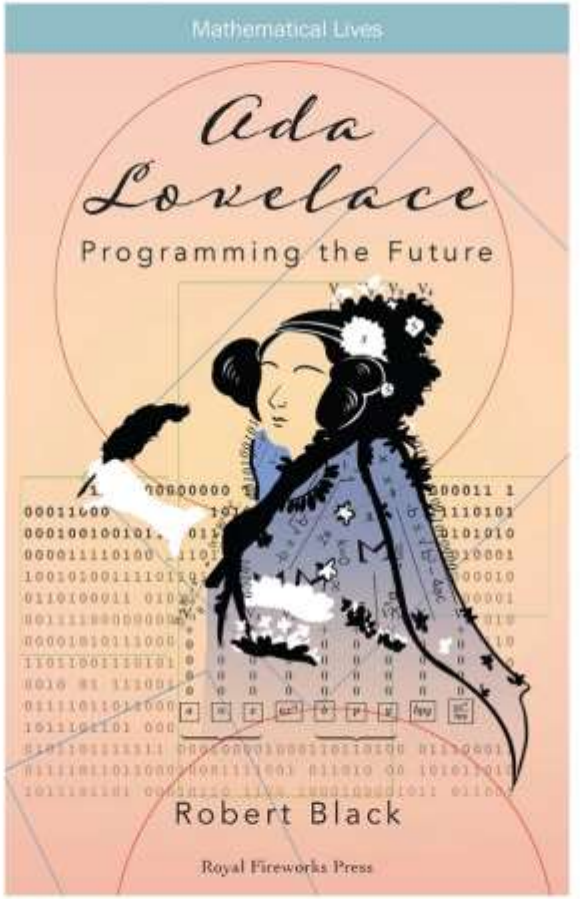
Volume 4

Ada Lovelace: Programming the Future

In 1843, a British scientific journal needed someone to translate a description of the "Analytical Engine," a steam-powered computing machine proposed by inventor Charles Babbage.

He turned to Babbage's friend Ada Lovelace, who not only translated the article, but added a series of explanatory notes. She was the first person to explore the questions...

What can a computer do, and how would it know how to do it?



Volume 4

Ada Lovelace: Programming the Future

- Augusta Ada King, Countess of Lovelace (1815-1852)
  - Only legitimate child of legendary poet Lord Byron
  - Given a rigorous education in math and science to discourage following in her father's footsteps

"I find that nothing but very close and intense application to subjects of a scientific nature now seems at all to keep my imagination from running wild, or to stop up the void which seems to be left in my mind from a want of excitement." (1834)

Volume 4

Ada Lovelace: Programming the Future

Lovelace's Notes include an explanation of what a computer *cannot* do, as well as what it *can* do.

"The Analytical Engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform. It can follow analysis; but it has no power of anticipating any analytical relations or truths."

Alan Turing called this statement...

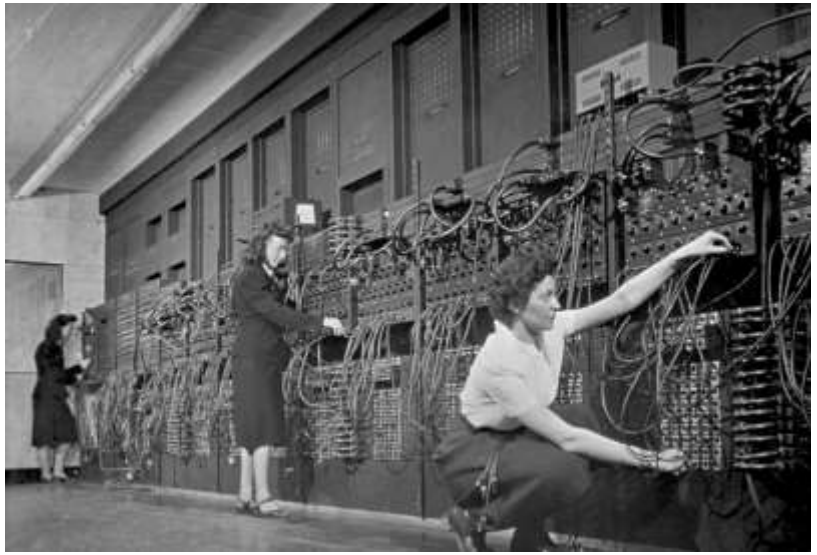
"Lady Lovelace's Objection"

Volume 4

Ada Lovelace: Programming the Future

Readers are also introduced to some of the women who pioneered computer programming in the 20th century, Ada Lovelace's digital legacy:

Grace Hopper
(1906-1992)

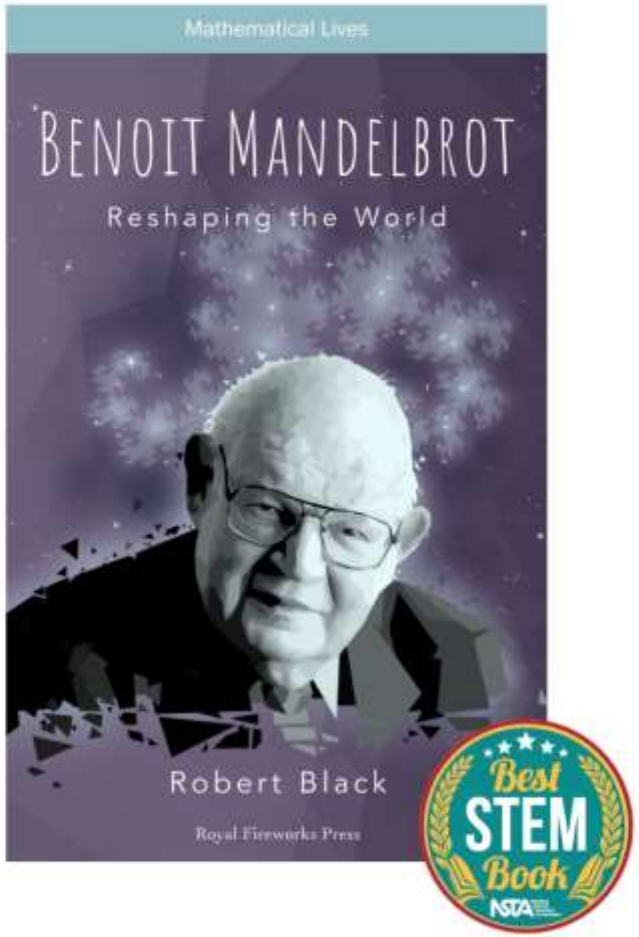


The ENIAC
programmers
(1946)

Margaret Hamilton
(1936-)

Volume 5

Benoit Mandelbrot: Reshaping the World



In the 1960s and 70s, IBM researcher Benoit Mandelbrot studied several different phenomena in several different fields of study, and noticed the same behaviors in all of them.

This discovery caused him to ask...

Is there a form of mathematics that can describe all the irregular patterns and structures of nature?

Volume 5

Benoit Mandelbrot: Reshaping the World

- Benoit Mandelbrot (1924-2010)
  - Born in Warsaw, Poland
  - Spent World War II as a Jewish youth in Vichy France
  - Developed **Fractal Geometry** after researching economic trends, telephone signals and coastlines

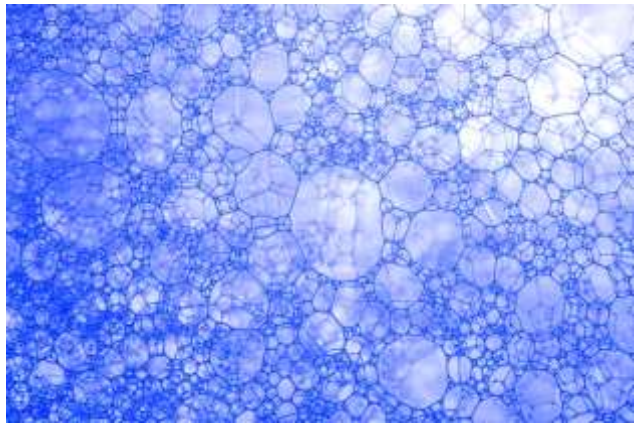
From *The Fractal Geometry of Nature*, 1980:

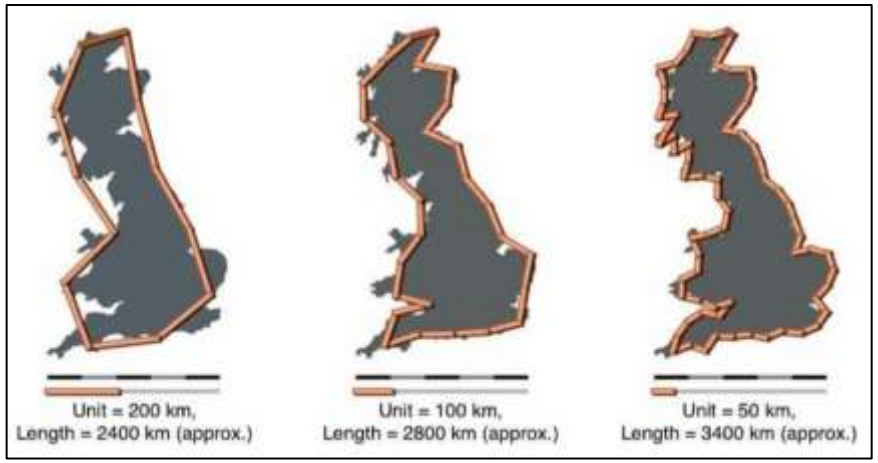
"Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line."

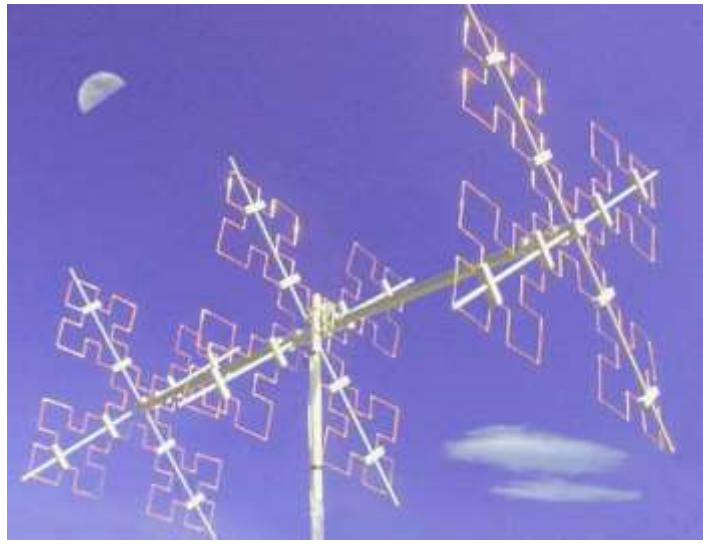
Volume 5

Benoit Mandelbrot: Reshaping the World

Fractals in our world…







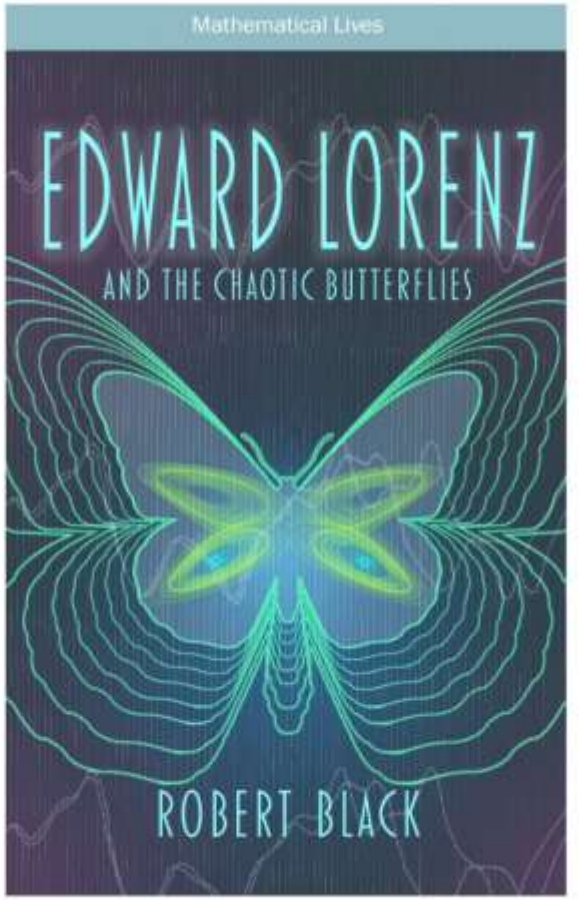
Volume 6

Edward Lorenz and the Chaotic Butterflies

In the 1950s, meteorologists hoped that electronic computers would enable them to forecast the weather many weeks or even months in advance.

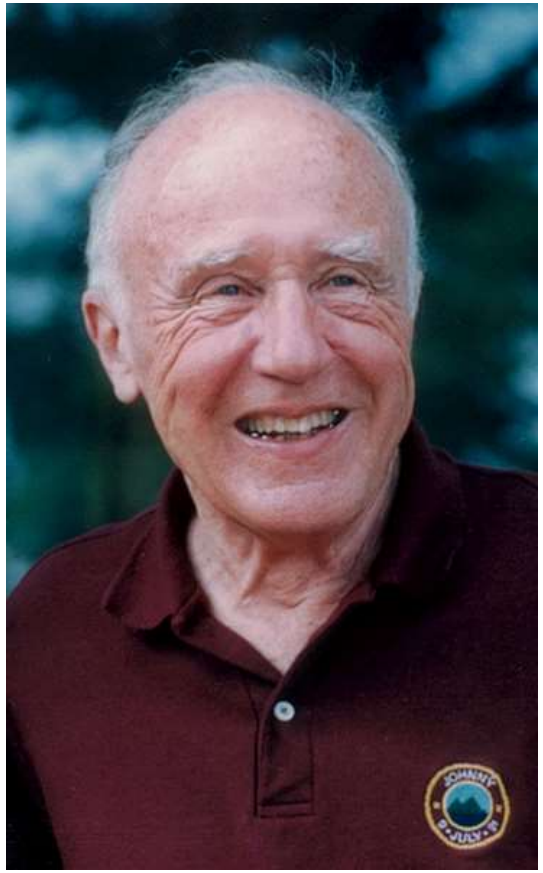
In 1960, MIT professor Edward Lorenz made a tiny data entry error while rerunning a weather simulation program, and it produced a completely different set of results from the one he had seen before.

Why had such a small change made such a big difference?



Volume 6

Edward Lorenz and the Chaotic Butterflies



- Edward Lorenz (1917-2008)
  - Born in West Hartford, CT
  - Meteorologist for the US Army Air Corps during World War II
  - Landmark work: “Deterministic Nonperiodic Flow,” 1963. It went largely unnoticed for 10 years.
  - “Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?” Presented in 1972.

Volume 6

Edward Lorenz and the Chaotic Butterflies

1963: The "strange attractor"

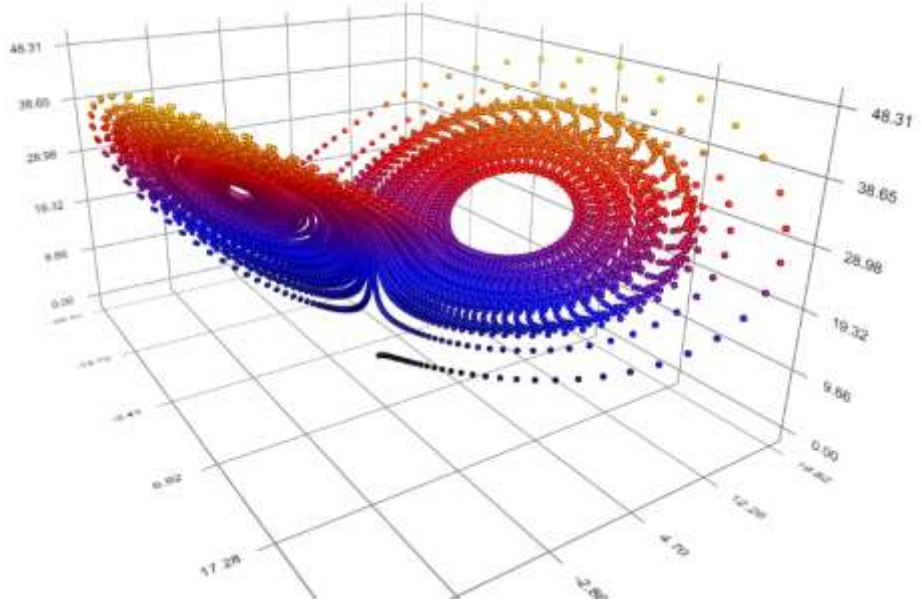
$dx/dt = \sigma(y - x)$

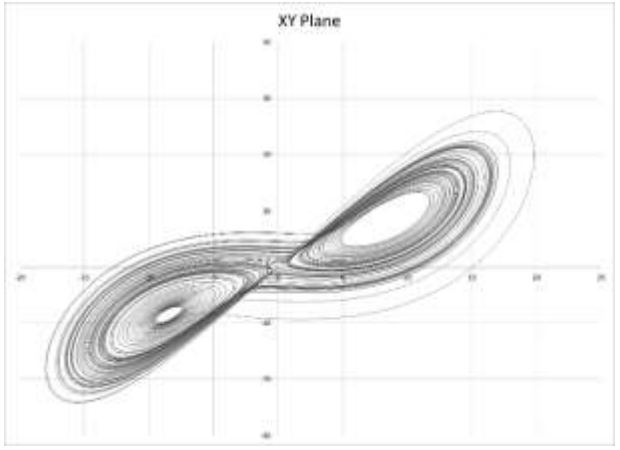
$dy/dt = x(\rho - z) - y$

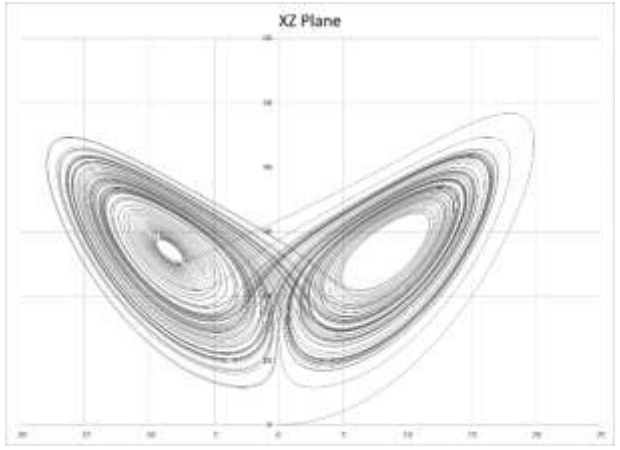
$dz/dt = xy - \beta z$

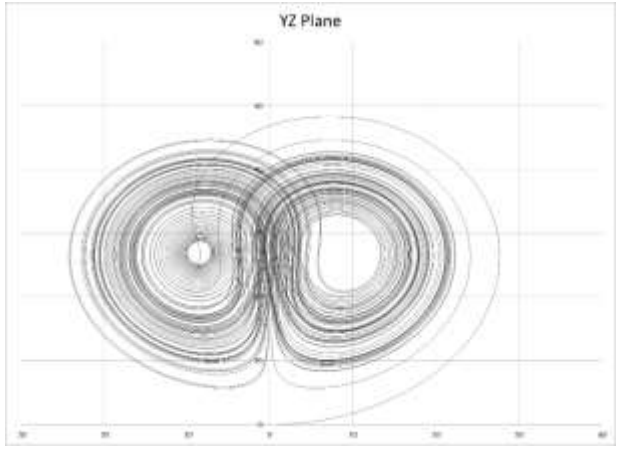
Where $\sigma = 10$, $\rho = 28$, and $\beta = 8/3$

Integrate using the fourth-order Runge-Kutta scheme





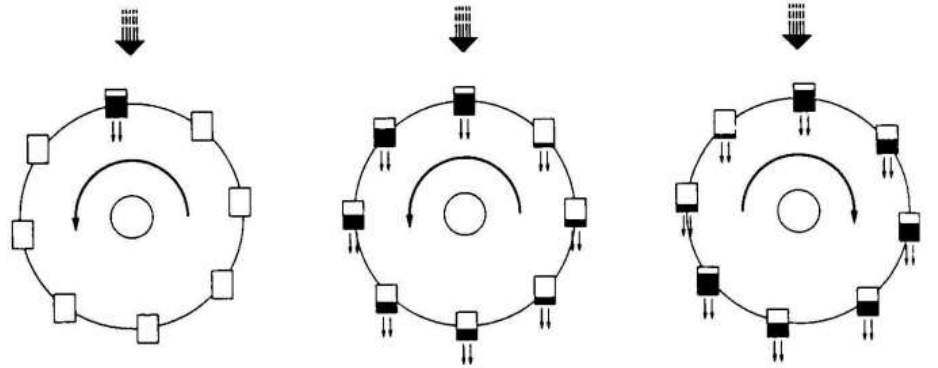


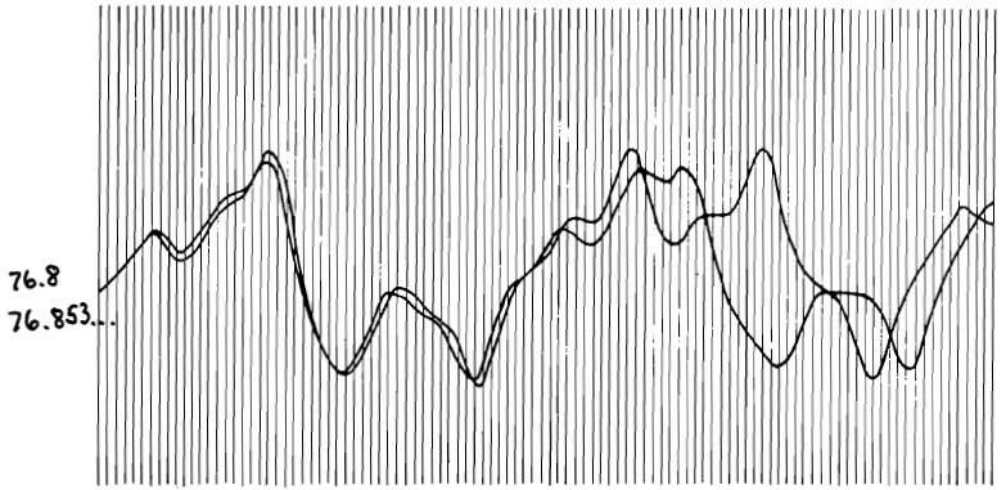


Volume 6

Edward Lorenz and the Chaotic Butterflies

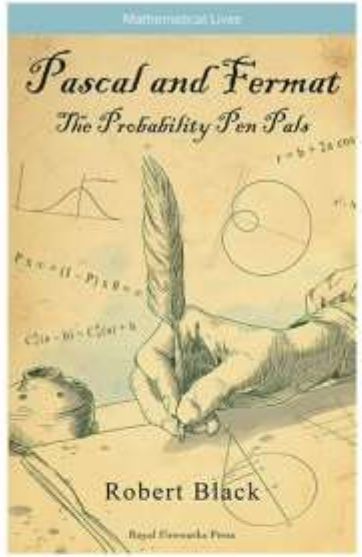
Chaos Theory: Small changes in the initial conditions of a dynamic system can produce very different results.

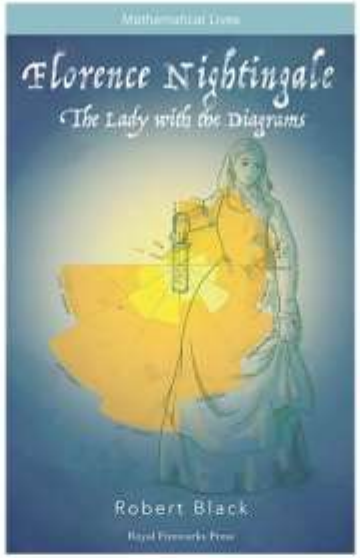


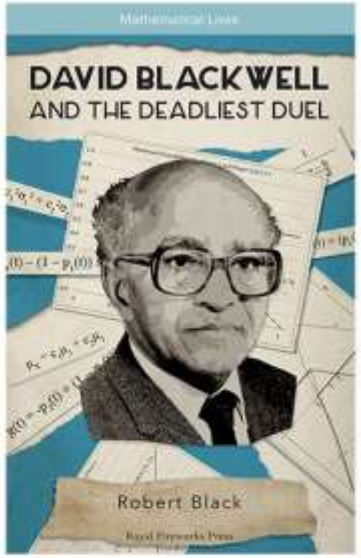


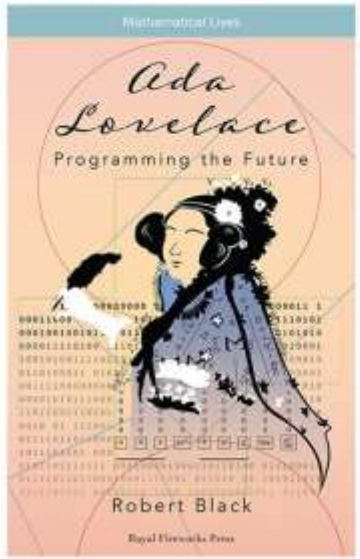
The Lorenz Waterwheel –
A demonstration of the strange attractor

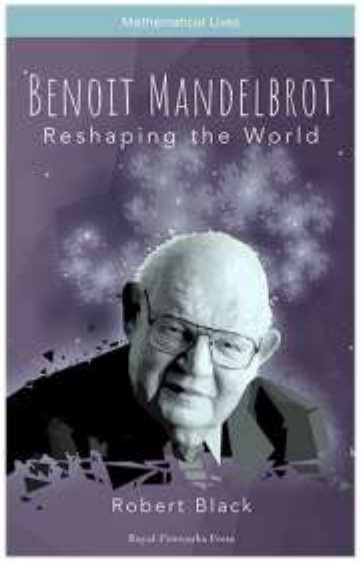
The unexpected story of the *Mathematical Lives*…

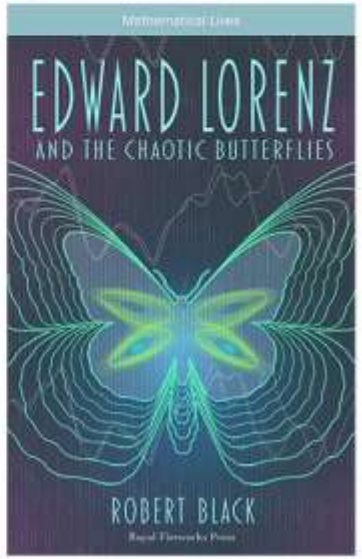












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