

The background is a dark blue field filled with various white and red line-art illustrations of scientific and engineering concepts. These include a DNA double helix, a test tube, a microscope, a globe, a compass, a pencil, a lightbulb, a gear, a magnifying glass, a rocket, a plus sign, a minus sign, a flask with bubbles, and a book. The author's name is written in red at the top.

John Bailey

Inventive Geniuses Who Changed the World

Fifty-Three Great British
Scientists and Engineers and
Five Centuries of Innovation



Springer

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Engineers and Five Centuries of
Innovation

John Bailey
Evenley, UK

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Timeline for the key achievements of outstanding British scientists and engineers

Seventeenth century	1628	Circulation of blood identified (William Harvey)
	Corpuscular theory of matter (Robert Boyle)	1661
	1665	Micrographia/study of the miniature world and cells (Robert Hooke)
	Universal gravitation theory (Isaac Newton)	1667
	1668	Scientific explanation of colour (Isaac Newton)
	First-generation steam engine (Thomas Savery)	1698
Eighteenth century	1701	Seed drill (Jethro Tull)
	Second-generation steam engine (Thomas Newcomen)	1712
	1733	Flying shuttle loom for weaving wider fabrics (John Kay)
	Latent heat required to induce a change in state (Joseph Black)	1762
	1765	Spinning “jenny” raised productivity of cotton manufacture (James Hargreaves)
	Man-made canal (James Brindley and Duke of Bridgewater)	1765
	1769	Third-generation steam engine, reducing coal need by 60% (James Watt)
	Flush toilet with S-bend	1775
	1780	“Mouth broom”/toothbrush (William Addis)
	Air is not a unitary element (Henry Cavendish)	1780s
	1786	Corn threshing machine (Andrew Meikle)
	Different kinds of air (Joseph Priestley)	1786
	1798	Smallpox vaccination (Edward Jenner)

N.B. Not all discoveries/inventions/theories can be accurately attributed to any particular person, nation or date
(continued)

Timeline (continued)

Nineteenth century	Fourth generation of steam engine that was mobile (Richard Trevithick)	1802
	1808	Atoms exist. First table of atomic weights (John Dalton)
	Use of electrolysis to isolate new metals (Humphrey Davy)	1808
	1812	Parts of an ichthyosaur skeleton found (Mary Anning)
	Miners' safety lamp (Humphrey Davy)	1815
	1810–1820	Macadamised turnpike roads (John McAdam)
	Principle of electric motor (Michael Faraday)	1821
	1823	Liquefaction of gases/principle of refrigeration (Michael Faraday)
	Portland cement (Joseph Aspdin)	1824
	1829	Rocket steam locomotive (Robert Stephenson)
	First public intercity railway line (George Stephenson)	1830
	1831	Principles of AC generator/transformer (Michael Faraday)
	5-year expedition on HMS Beagle begins (Charles Darwin)	1831
	1834	Concept of a general-purpose, programmable computer (Charles Babbage)
	Faraday protective cage (Michael Faraday)	1836
	1837	Telegraphic signalling (William Cooke and Charles Wheatstone)
	Makings of a computer programmer (Ada Lovelace)	1843
	1843	Iron hull, steam propulsion and screw propeller (Isambard Brunel)

(continued)

Timeline (continued)

UK patent for vulcanisation of rubber (Thomas Hancock)	1843
1845	Pneumatic tyre for horse-drawn carriages (Robert Thomson)
First observational epidemiological study showed cholera is a water-borne disease (John Snow)	1849–1854
One-piece water closet (Joseph Jennings)	1852
1855	The Lady with the Lamp (Florence Nightingale)
The making of steel without fuel (Henry Bessemer)	1856
1858	Evolution and natural selection (Charles Darwin and Alfred Wallace)
Applying probability to gas behaviour (James Clerk Maxwell)	1860
1860s	Cistern with floating ballcock (Thomas Crapper)
Trans-Atlantic electric telegraph cable (William Thomson)	1866
1867	Antiseptic surgical procedures (Joseph Lister)
Unifying theory of electricity, magnetism and light (James Clerk Maxwell)	1873
1875	London's integrated sewage system (Joseph Bazalgette)
Telephone for transmitting vocal sounds (Alexander Bell)	1876
1880	Greenwich Mean Time for train time tabling
Dunlop's tyre patent rescinded	1888
1894	First public demonstration of a radio (Oliver Lodge)
Properties of cathode rays/electrons (Joseph Thomson)	1897

(continued)

Timeline (continued)

Twentieth century	1900	Transmutation of atoms (Ernest Rutherford)
	Nuclear model of the atom (Ernest Rutherford)	1909
	1912	Prototype of modern X-ray diffractometers (William Henry Bragg)
	Structural analysis of crystals (William Lawrence Bragg)	1913
	1914	Atomic number/periodic law (Henry Moseley)
	Identified 212 of 254 naturally occurring, stable isotopes (Francis Aston)	1919
	1919	Artificial nuclear transformation (Ernest Rutherford)
	Proton as a nuclear particle (Ernest Rutherford)	1920
	1928	Anti-microbial penicillin (Alexander Fleming)
	Proof of the existence of neutrons (James Chadwick)	1932
	1932	First particle accelerator to split the atom (John Cockcroft and Ernest Walton)
	Molecular structure of nucleosides and nucleotides via chemical synthesis and degradation (Alexander Todd)	1930s and 1940s
	1937	J. J. Thomson's son jointly awarded Nobel Prize for diffraction of electrons by crystals (George Thomson)
	Partition chromatography (Archer Martin and Richard Synge)	1941
	1941	Maiden flight of propeller-less plane with jet engine (Frank Whittle)

(continued)

Timeline (continued)

	Breaking the Enigma code (Alan Turing)	1941
	1942	Decryption of Lorenz ciphers (William Tutte)
	World's second electronic and digital computer with programmability—Colossus (Tommy Flowers)	1944
	1950s	Structure of the globular protein, myoglobin (John Kendrew)
	DNA's complex double-helical structure (Francis Crick and James Watson)	1953
	1955	Reagent to facilitate amino acid sequencing of complex proteins (Frederick Sanger)
	First nuclear reactor for domestic use (Calder Hall 1)	1956
	1977	Sequencing technique for nucleotides of DNA (Frederick Sanger)
	In vitro fertilisation (Patrick Stephoe and Robert Edwards)	1977
	1984	DNA genetic fingerprinting (Alec Jeffreys)
	DNA profiling (Alec Jeffreys)	1985
	1990	Enablers for the World Wide Web (Timothy Berners-Lee)
Twenty-first century	Methodologies for forensic investigations, including soil science (Lorna Dawson)	2011

Talent hits a target no one else can hit; Genius hits a target no one else can see.

Arthur Schopenhauer, 1818

Preface

Scope

From the cradles of civilisation to the twenty-first century, great scientific and engineering minds have changed the way we understand ourselves and the universe we inhabit. Certain, elite individuals have made monumental contributions to specific scientific and engineering fields, changing our world forever and propelling humanity forward.

This publication explores the scientific and inventive endeavours of some of our most noteworthy British scientists and engineers. Fifty of them are deceased; three are still alive and continue to make weighty contributions to the scientific world.

They all have one thing in common, namely commanding abilities which they applied to make a profound influence on mankind, thereby attaining a foremost place in the history of science and its practical application.

The manuscript looks at their childhood, education, notable achievements and decorations. It endeavours to make some of their complex theories more comprehensible and accessible. It aspires to set these things in the sociopolitical context of their place in history, sometimes wandering from their own activities to those of others, to round off their story.

In the introductory chapter, a sociopolitical context is set and the national and personal attributes of, and characteristics for, scientific and engineering greatness are defined. The second chapter explores scientific, agricultural and industrial “revolutions”, trying to pinpoint the reasons why Great Britain was

such fertile ground for the world's First Industrial Revolution. It asks why did it occur; why did it occur when it did; and why did it occur in Great Britain before other nations?

An account of each scientist or engineer is assigned to one of 14 chapters. In numerical order, these chapters deal with: (3) The Steam Age; (4) New Forms of Transport and its Infrastructure; (5) Holistic Approach to Public Health via Sanitation Technology; (6) Polymaths; (7) Natural Science; (8) History of the Atom; (9) Life Sciences; (10) Electricity, Magnetism and Light; (11) Palaeontology and Evolution; (12) X-ray Crystallography and Biomolecules; (13) Nucleosides, Nucleotides and DNA; (14) Science of Key Building Materials; (15) Communication, Telephone, Computers, WWW, the Digital Age; and (16) Solving Crime via Forensic Science. Chapter 17 guides the reader forward to consider current scientific and technological challenges and potential opportunities that lie ahead. How satisfying it would be if some of my readers were to rise to the challenge and become the great scientists or engineers of the future.

Examples of our scientific and engineering prowess are given in the 14 chapters. Each chapter begins with a *précis*. The author hopes that these prefatory tasters will whet the readers' appetite for a more detailed account of the luminaries appearing under the appropriate chapter heading. To dispel the adage that "a little learning is a dangerous thing", the author encourages the reader to devour more.

How Were These Fifty-Three Eminent British Scientists and Engineers Chosen?

Many of us have an unquenchable thirst for knowledge. The UK has been blessed with a growing number of relentlessly curious people having an insatiable desire to better understand the universe in which we live, hoping to uncover nature's secrets and mysteries. In the last 450 years, few other countries can claim such prowess and achievement in science and engineering.

I have singled out 53 exceptional British scientists and engineers whose search for fundamental truths has powered scientific and engineering endeavour. Fifty-three is, indeed, an odd number to choose. The target was fifty, but another three were so exceptional that they could not be omitted. There are many more deserving of inclusion. Some have been mentioned in the text because they laid the theoretical or practical groundwork for those selected.

The choice was based not only on their ingenuity and brilliance in their chosen field, but also on the extent to which their contribution had profound socio-economic consequences, improving the lives of mankind. I have chosen neither pure theorists (e.g. S. W. Hawking) nor solely pragmatists. Instead, I have concentrated on those who, by scientific and/or engineering wizardry, satisfied a fundamental human need, bringing about an extraordinary change to the way ordinary people conduct their lives.

Those chosen had time to explore and develop their exceptional thoughts devoid of a prescribed pathway. In the main, they did not have a route bulldozed by their parents. It is noteworthy that, before they reached adolescence, ten of them either lost one parent or both or they were abandoned by both parents. Only four were from privileged backgrounds, and only three attended famous public schools. Three of them had no formal primary or secondary education. Twenty-five of them were not university graduates.

Living in a pluralist society and stable democracy, they had the freedom to imagine, exchange ideas, experiment, hypothesise, invest and fail, before success brought them to public attention. In previous centuries, it was the private sector, and not the state, that played the major role in key advances such as steam engines, canals, vaccinations, railways, cementitious materials, steel, electrical mechanisation, textiles, the telegraph, telephone and other forms of mass communication. Likewise, in the twentieth century, the computer, antibiotics, IVF and forensic science, all had their roots in academia or the private sector.

Sources of Information

In the main, I have used sources freely available on the Internet, supported by TV and radio documentaries, articles in newspapers and periodicals, together with my own knowledge and reference books.

Chapter lengths vary depending on the availability of biographical information.

In seeking validation of my synopses, I have contacted five of the contemporary scientists and engineers or their offspring, inviting comment on my draft scripts.

Inevitably, however, there will be errors of fact, for which I apologise. Should a second edition be forthcoming, I will endeavour to correct any errors of fact or misinformation about which I am notified.

No book can ever be finished. The moment one turns away from it, one becomes aware of omissions and shortcomings.

Acknowledgements

The project started as a casual outlet for a retiree during the Brexit debate. It became all-consuming during the COVID-19 quarantine period which made it easy for me to lock myself in my office. It did mean that I neglected my wife and family and I thank them for their forbearance.

I am extremely grateful to Prof. Alec Jeffreys and Prof. Lorna Dawson for sighting my draft document on their achievements and making valuable comments on my synopses.

I also appreciate helpful clarifications from Prof. Andrew Steptoe (son of Patrick Steptoe); Jenny Joy and, sister, Caroline Roberts (daughters of Robert Edwards); and Ian Whittle (son of Frank Whittle) on their respective fathers' story.

Every effort has been made by the author to ensure the accuracy of the information contained in this book. The opinions expressed herein are those of the author and not the publishing company.

Evenley, UK
May 2021

John Bailey, BSc PhD (Cantab)

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