Innovation

a Historical Perspective

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Cycles of Capitalism

The steam engine provides power for factories and fuelled unprecedented economic growth

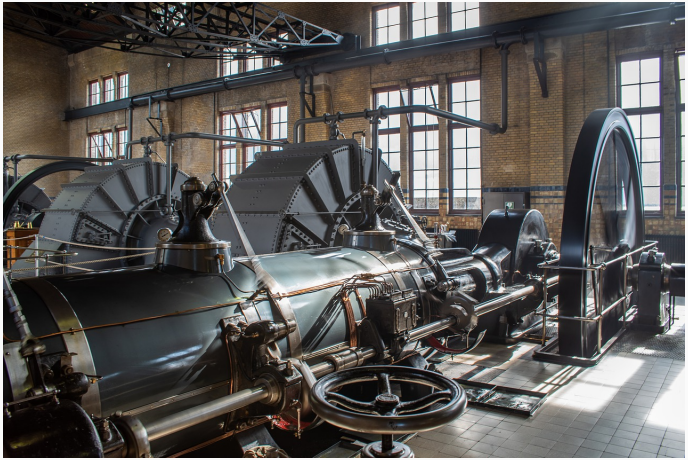


Figure 1: Steam Engine in factgory — image by Kobus van Leer from `pixabay.com`

The Steam Engine

- Taqi al-Din in 1551 and Giovanni Branca in 1629 describe a steam engine
- Thomas Savery (1698) invents steam pump and in 1712 Thomas Newcomen invents the first practical steam engine
- invention of the steam engine with separate condenser by James Watt in 1765
- Ivan Polzunov (1766) builds the first two-cylinder steam engine
- explosive economic growth since the early 1800s
- The "Panic of 1857", 1866, and "The Panic of 1873", that initiated the "Long Depression"
- Karl Marx writes "Das Kapital" in 1867

The Train

Figure 2: The Train provided reliable mass transport — image Image by Erich Westendarp from pixabay.com

The Train

- 1804: first train (it pulled 25 tonnes of iron material and 70 people over the distance of 10 miles)
- First commercial steam train (Stephenson's "The Rocket") managed to reach speed of 96 km/h.
- about 40% of the world's cargo go still by train (ecological and efficient)
- end: "The Panic of 1901" and ultimately WWI

The Internal Combustion Engine

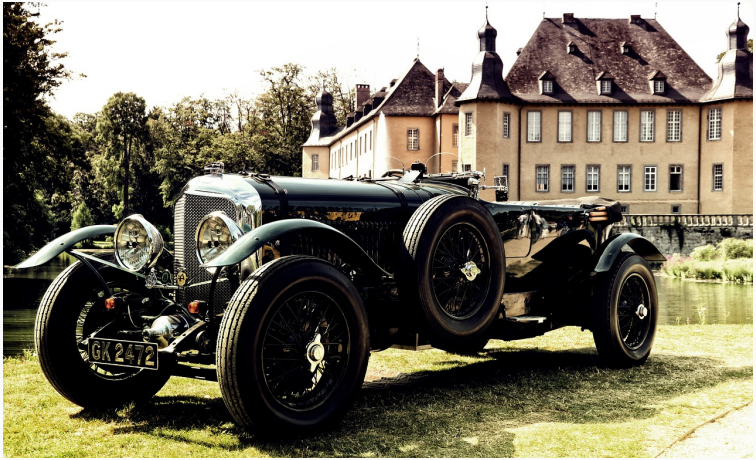


Figure 3: The internal combustion engine gave rise to reliable individual transport — image by S. Hermann & F. Richter from `pixabay.com`

Electricity and Magnetism

Figure 4: Electricity and Magnetism provided lightbulbs, radio, and all kinds of powered appliances — image by PublicDomainPictures from `pixabay.com`

The Internal Combustion Engine, Electricity and Magnetism

- 1805 Humphry Davy invets the “carbon ark” (electric light)
- 1832: first DC electro-motor (William Sturgeon); 1837
- 1885: first practical gasoline automobile by Karl Benz
- Ford T (since 1908)
- Automation both at home and in the factory due to electricity and magnetism
- end: “Wall Street Crash of 1929”, that initiated the “Great Depression” and ultimately WWII.

Automobiles and the Petro-Chemical Industry

Figure 5: The petro-chemical industry — image by Frauke Feind from `pixabay.com`

Automobiles and the Petro-Chemical Industry

- Technological improvements on cars and their production
- First oil wells in USA (1846), Poland (1853), Romania (1857)
- First modern oil well (1854) and first oil refinery (1856) by Ignacy Łukasiewicz
- 1600 BCE: Mesoamericans used natural rubber for balls, bands, and figurines
- 1856: first man-made plastic by Alexander Parkes
- 1872: invention of polyvinyl chloride (PVC)
- 1923: Durite Plastics Inc. produced phenol-furfural resins
- 1930s: production of polystyrene (PS) and PVC by BASF
- 1933: polyethylene discovered by Imperial Chemical Industries (ICI) – Reginald Gibson and Eric Fawcett.
- 1941: polyethylene terephthalate (PET) discovered by Calico Printers' Association (a replacement for glass in many applications)
- 1954: polypropylene by Giulio Natta
- 1957: production of polypropylene
- 1954: expanded polystyrene (building insulation, packaging, and cups) invented by Dow Chemical.
- end: 1973–74 stock market crashes

The Electronic Computer

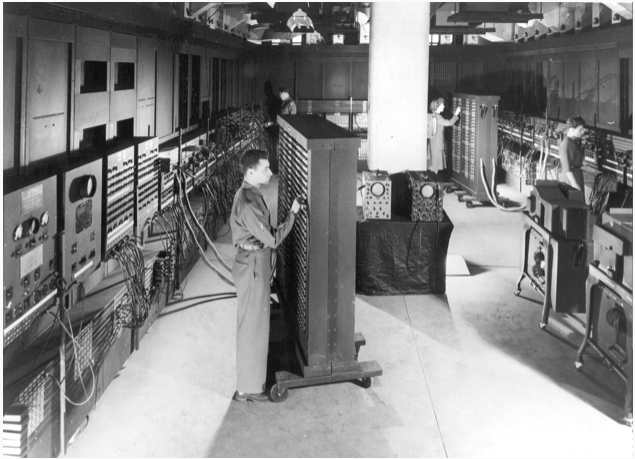


Figure 6: The ENIAC (Electronic Numerical Integrator and Computer) — image by Unidentified U.S. Army photographer - Public Domain

Moore's Law

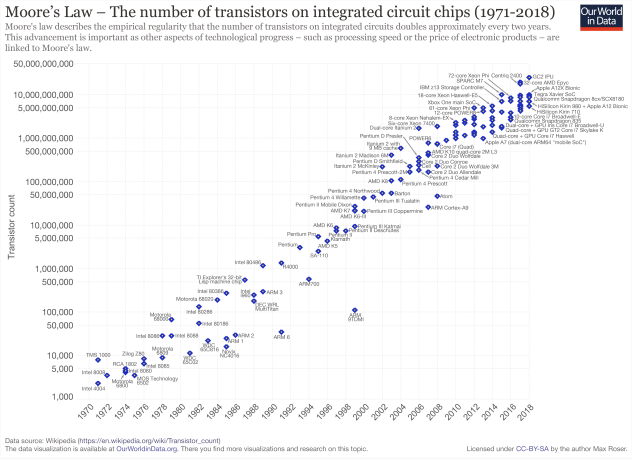


Figure 7: Moore's Law — image Wikimedia Commons `wikipedia.org`

The Computer: Key Dates

- Charles Babbage's Analytical Engine (1930s) and Ada Lovelace's code for it in 1843
- first computers: ABC in 1942, Collossus 1943
- 1946: ENIAC, first programmable general purpose computer
- 1952: IBM sells first mainframe
- 1953: Hard-disk
- 1959: metal–oxide–semiconductor field-effect transistor (MOSFET), invented by Mohamed Atalla and Dawon Kahng
- 1968: Network of Networks (UCLA) with Telnet, FTP, messaging and email — The ARPA-net in 1977 (now "the Internet")
- 1973: C (by Dennis Ritchie in the Bell Labs)
- 1980: DOS
- 1989: WWW is developed and used in CERN
- 1993: IBM Simon (first smart-phone)
- 2000: Nokia 3310
- end: Dot-Com Bubble of 2000 and the 2008 Global Meltdown

The Future

Kondratiev (1935)

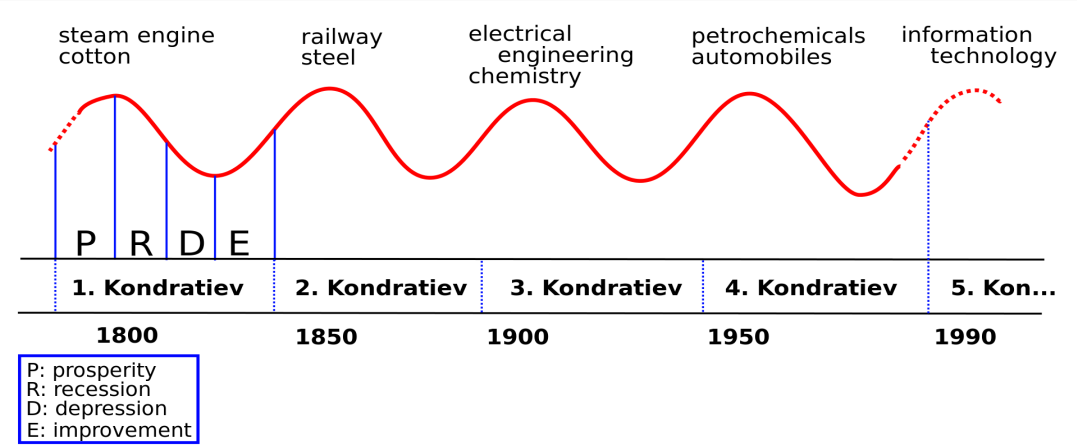


Figure 8: Kondratiev waves — image By Rursus - Own work, CC BY-SA 3.0, `https://commons.wikimedia.org/w/index.php?curid=7833300`.

The Scientific Method

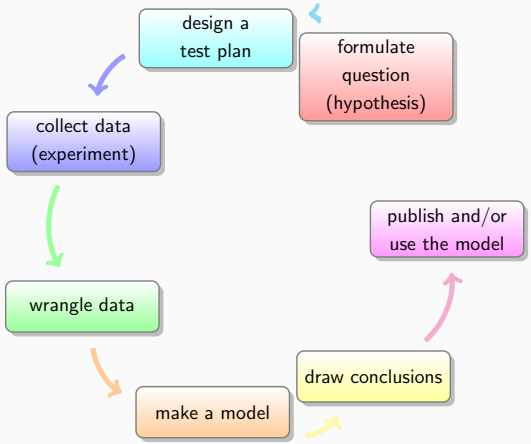


Figure 9: The steps in the scientific method for the data scientist.

The Next Large Trend Candidates

1. artificial intelligence, machine learning, big data, and robotic process automation;
2. nano technology
3. biotechnology, and
4. quantum computing;

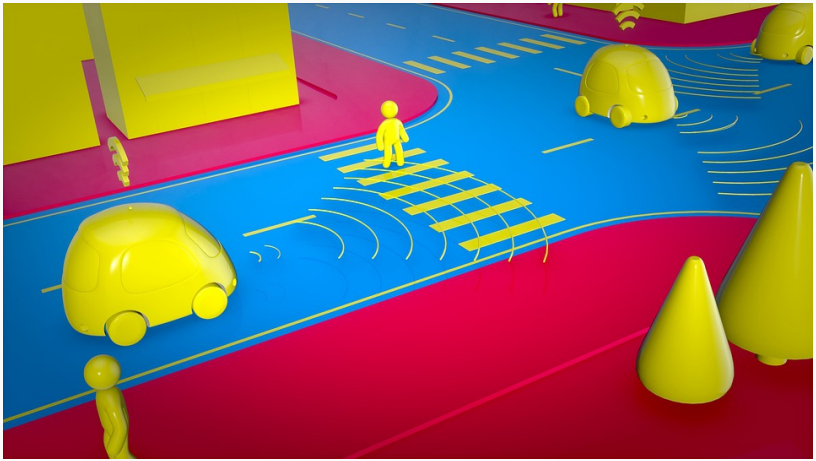


Figure 10: Self driving cars will become commonplace — image by Julien Tromeur from `pixabay.com`.

The Singularity

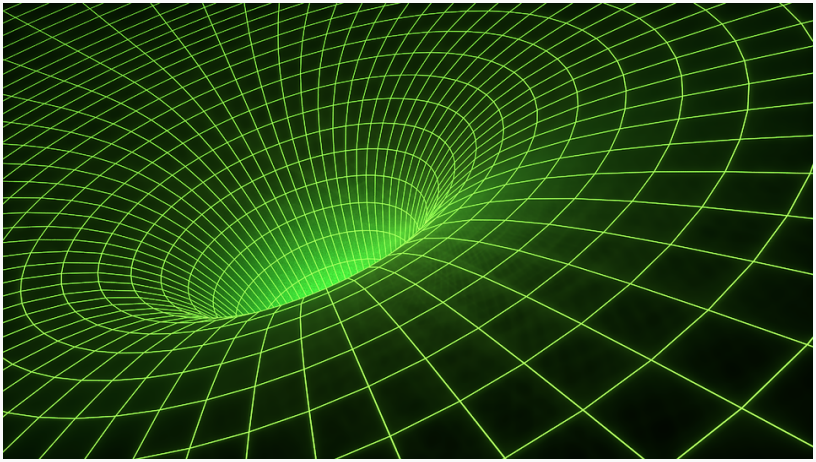


Figure 11: The singularity occurs when a machine will be able to improve on itself faster and faster — image by Johnson Martin from `pixabay.com`.

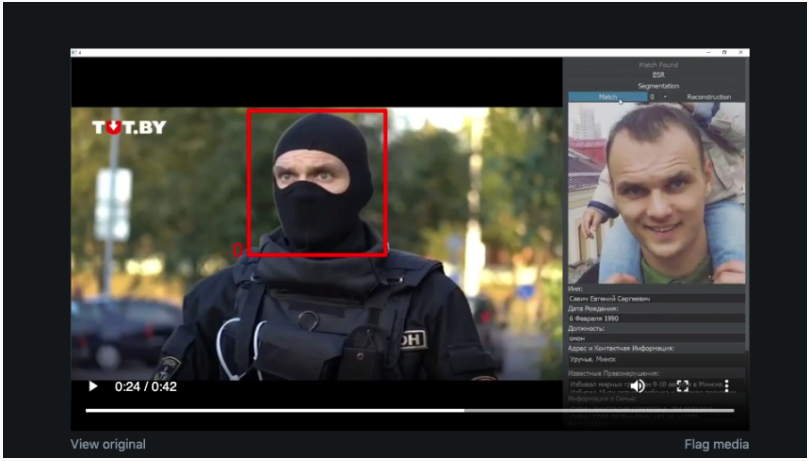


Figure 12: Police brutality under scrutiny: masked OMON police unmasked by AI.

Nano Technology

Figure 13: Vanta Black and similar coatings use nano technology – source: `https://www.coating.co.uk/vantablack-coating`.

Nano Technology

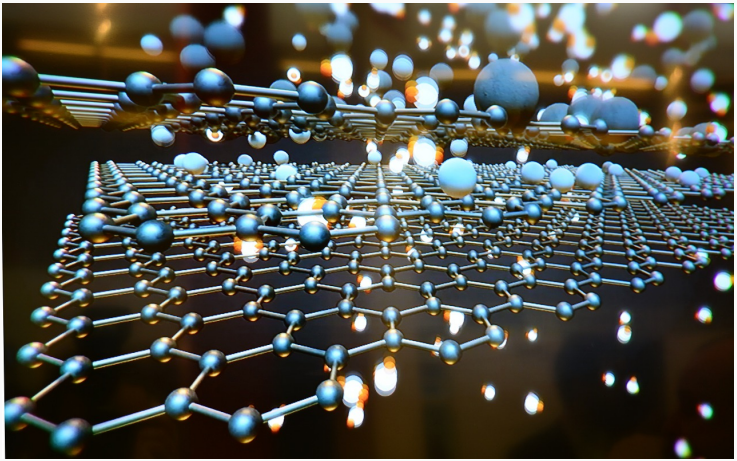


Figure 14: Graphene — image: Image by seagul from pixabay.com.

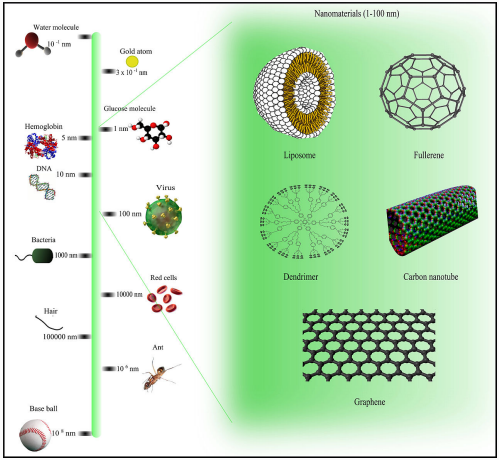


Figure 15: Nano material sizes — source: By Sureshbup - `http://www.mdpi.com/1422-0067/15/5/7158`, CC BY-SA 3.0, `https://commons.wikimedia.org/w/index.php?curid=32395880`

Nano Technology

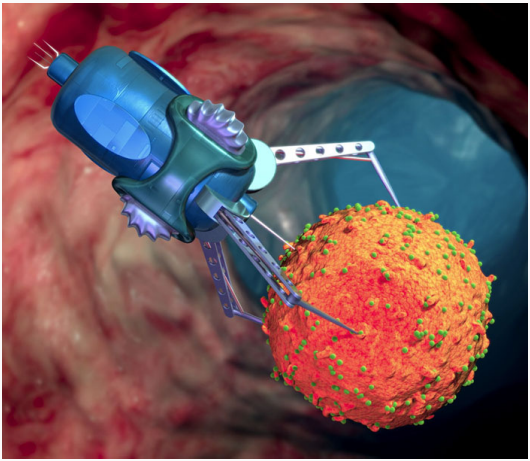


Figure 16: Nano robots — source:
https://www.yaabot.com/23051/nano-robots-medicine-miniscule-wonders/.

Biotechnology and genetic manipulation is as old as farming: more than 10,000 years

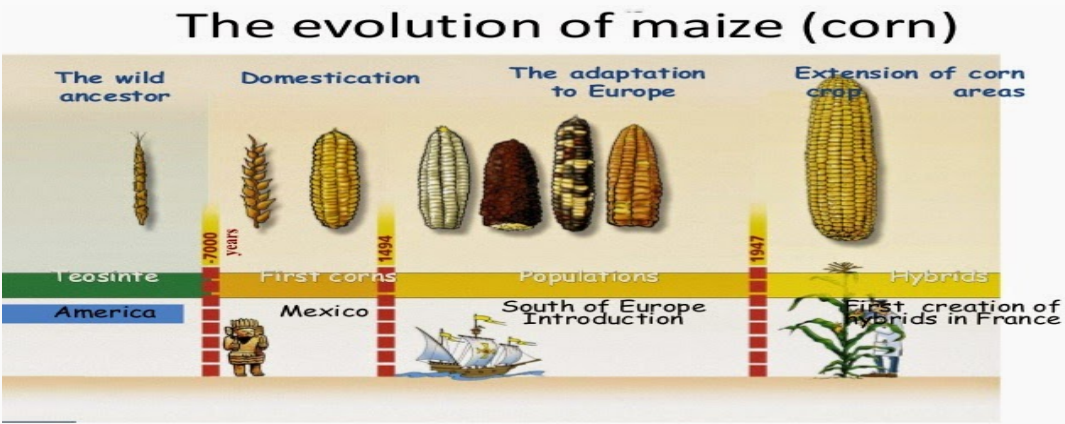


Figure 17: the guided evolution of corn — source: unknown.

Biotech

What

- Recombinant DNA
- Cloning
- Stem Cell Therapy
- Designer Drugs
- Genomics & genetic engineering

Why

- less pesticides, $C0_2$, etc.
- better and more crops
- better plant and animal health
- better human health

The Holy Grail

Figure 18: The holy grail of Biotechnology — source: unknown.

Quantum Computing

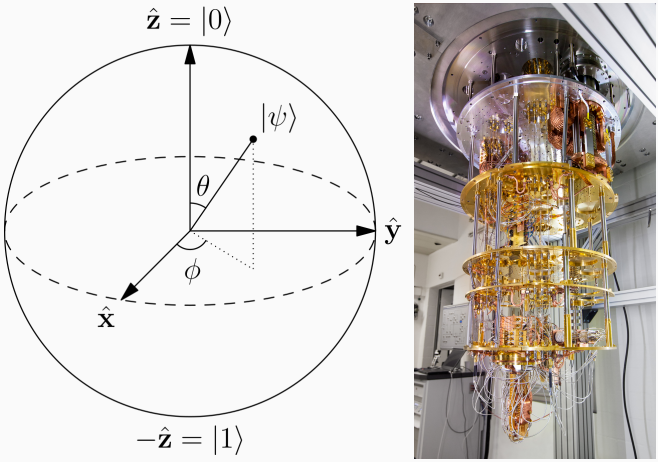


Figure 19: Quantum Computers. – Source: Wikimedia

Potential of Quantum Computers

- Adiabatic Optimization (D-Wave)
  - optimizations
  - ... but there is also the Quantum Monte-Carlo (QMC) technique for classical computers
- Shor's Alogorithm (1994): factor numbers
  - break most of today's encryption
  - ... including today's blockchain technology
- Lov Grover's (1996): invert functions without prior knowledge of the function
  - searching in unstructured data
- Solve large linear systems
  - solve ODE and PDE systems
  - regressions
  - machine learning

Conclusions

Life Expectancy over Time

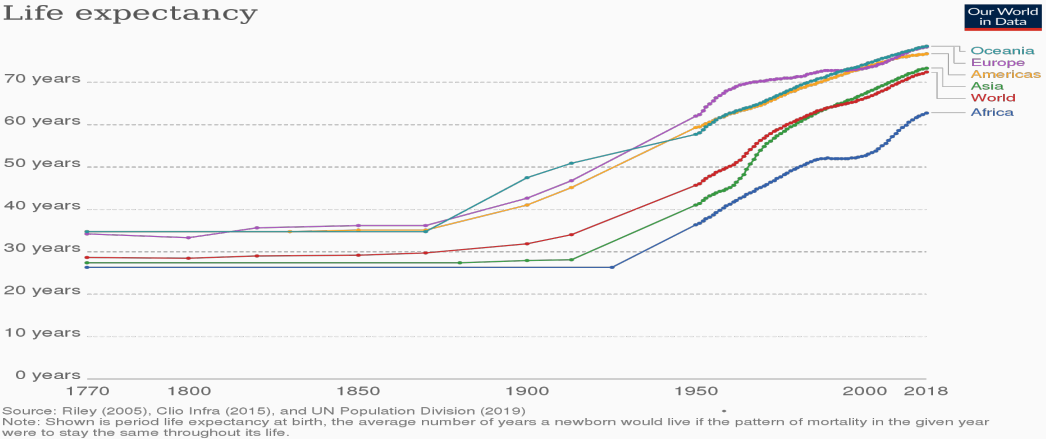


Figure 20: The evolution of life expectancy over time — image by Max Roser - `https://ourworldindata.org/life-expectancy`, CC BY 4.0, `https://commons.wikimedia.org/w/index.php?curid=83546093`

Life Expectancy vs GDP per capita

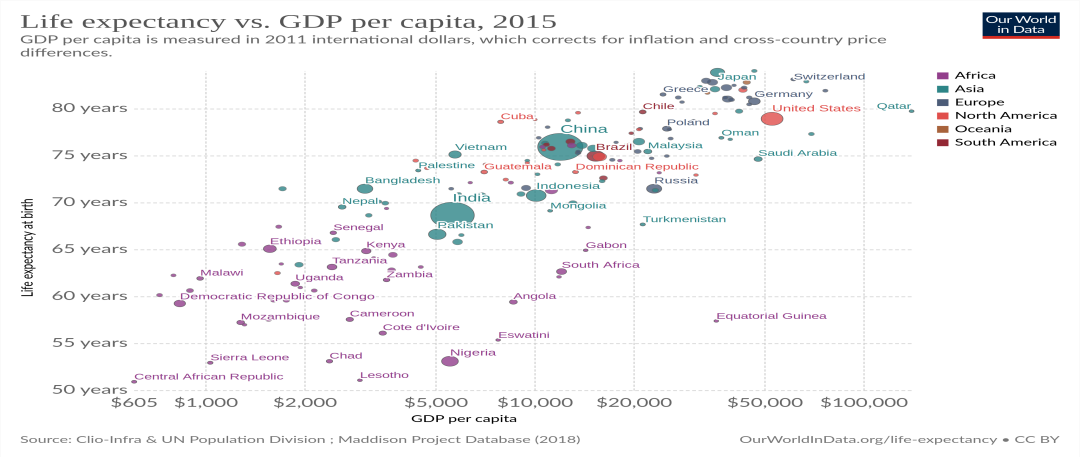
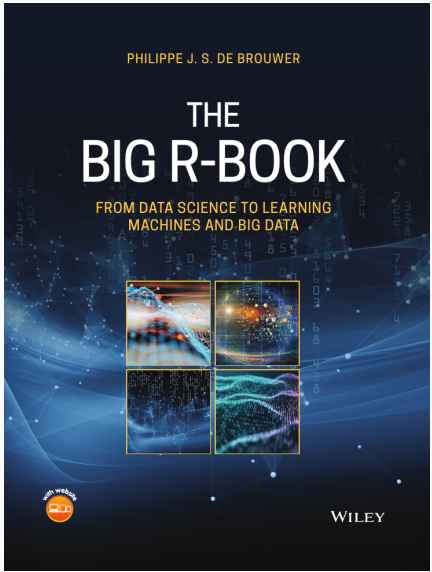


Figure 21: Life expectancy vs GDP per capita. – Source: `https://ourworldindata.org`

1. The scientific method works, and is able to make this world a better place
2. Data Science and related subjects such as Big Data, Machine Learning (and Artificial Intelligence) are our best bet towards a new wave of development, exponential growth and wealth creation
3. . . . and "The Big R-Book" will help you to master the subject.

The Big R-Book: from Data Science to Learning Machines and Big Data

1. Introduction
2. Starting with R and Elements of Statistics
3. Data Import
4. Data Wrangling
5. Modelling
6. Introduction to Companies
7. Report
8. Bigger and Faster R
9. Appendices



Nomenclature i

AI	artificial intelligence, page 19
AIML	artificial intelligence and machine learning, page 19
BASF	Badische Anilin- und SodaFabrik, page 11
BCE	before common era, page 11
$C0_2$	carbon dioxide, page 27
DOS	disc operating system, page 14
ENIAC	Electronic Numerical Integrator and Computer, page 12
FTP	file transfer protocol, page 14
IBM	International Business Machines Corporation, page 14
ML	machine learning, page 19
MOSFET	metal–oxide–semiconductor field-effect transistor, page 14
OMON	Special Purpose Mobile Unit – Russian and Belarusian police force, page 21

Nomenclature ii

PS	polystyrene, page 11
PVC	polyvinyl chloride, page 11
UCLA	The University of California, Los Angeles, page 14
WWI	World War I, page 6
WWW	world wide web, page 14