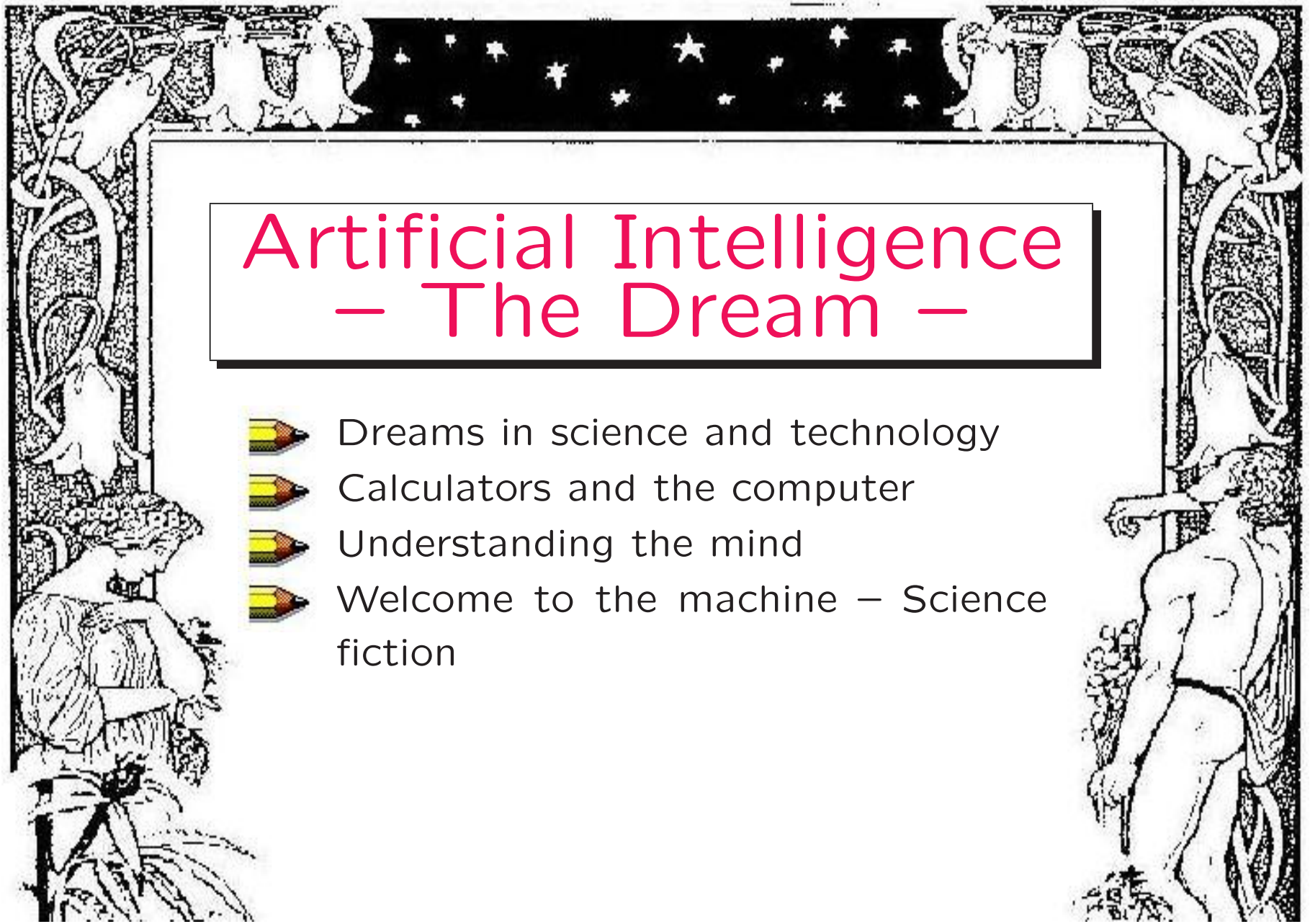
Introduction to Artificial Intelligence

06-08775

Manfred Kerber

School of Computer Science
The University of Birmingham
Birmingham, B15 2TT, England
e-mail: M.Kerber@cs.bham.ac.uk, Office: 137

http://www.cs.bham.ac.uk/~mmk/Teaching/AI



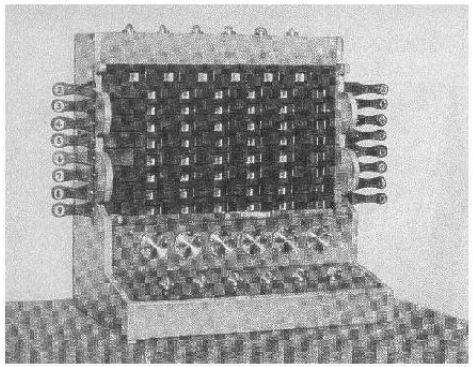
Artificial Intelligence – The Dream –

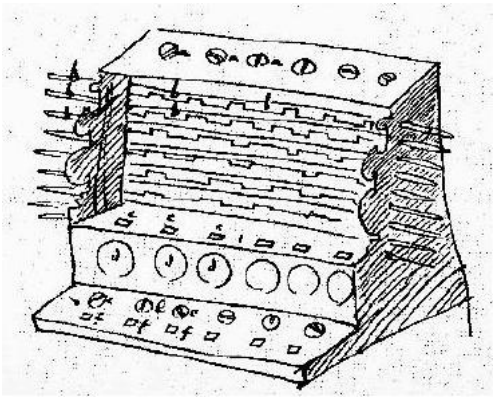
- Dreams in science and technology
- Calculators and the computer
- Understanding the mind
- Welcome to the machine – Science fiction

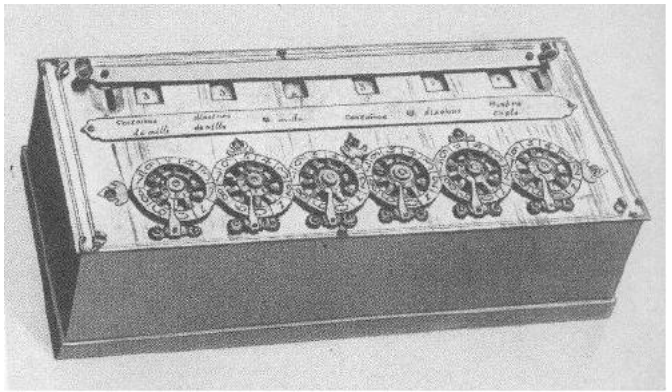
Dreams in Science and Technology

- Flying, Travel to other planets/solar systems,
- Immortality, health, superhuman power,
- Understanding the physical structure of the universe,
- Utopia, a just, peaceful, wealthy society
- Build machines that do the work for us
- Understanding ourselves, our origins, our thinking, our wishes

Calculators – Schickard, Pascal, Leibniz





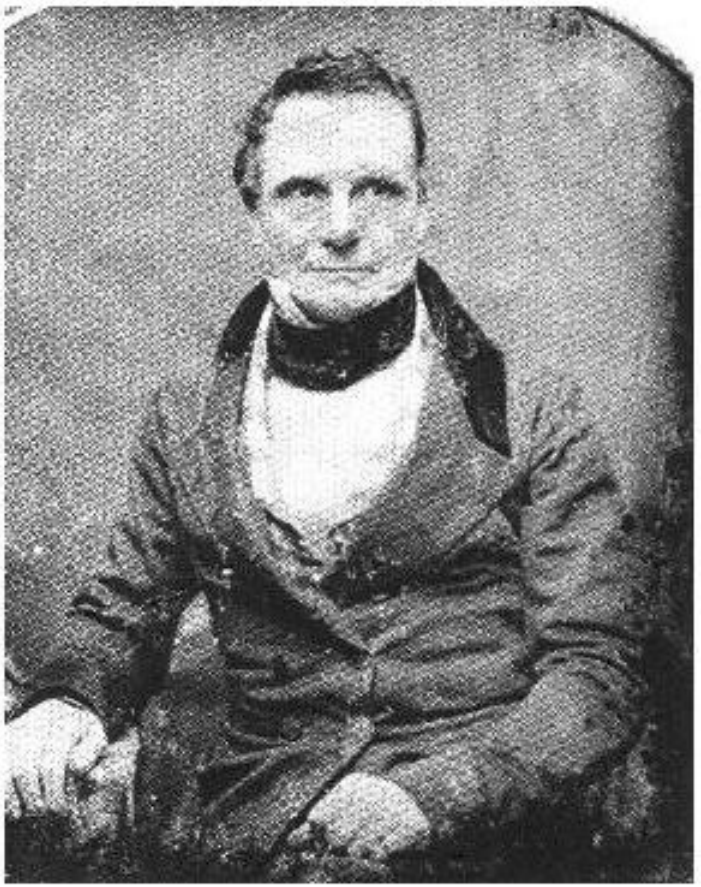


Wilhelm Schickard (1592–1635)

Blaise Pascal (1623–1662)

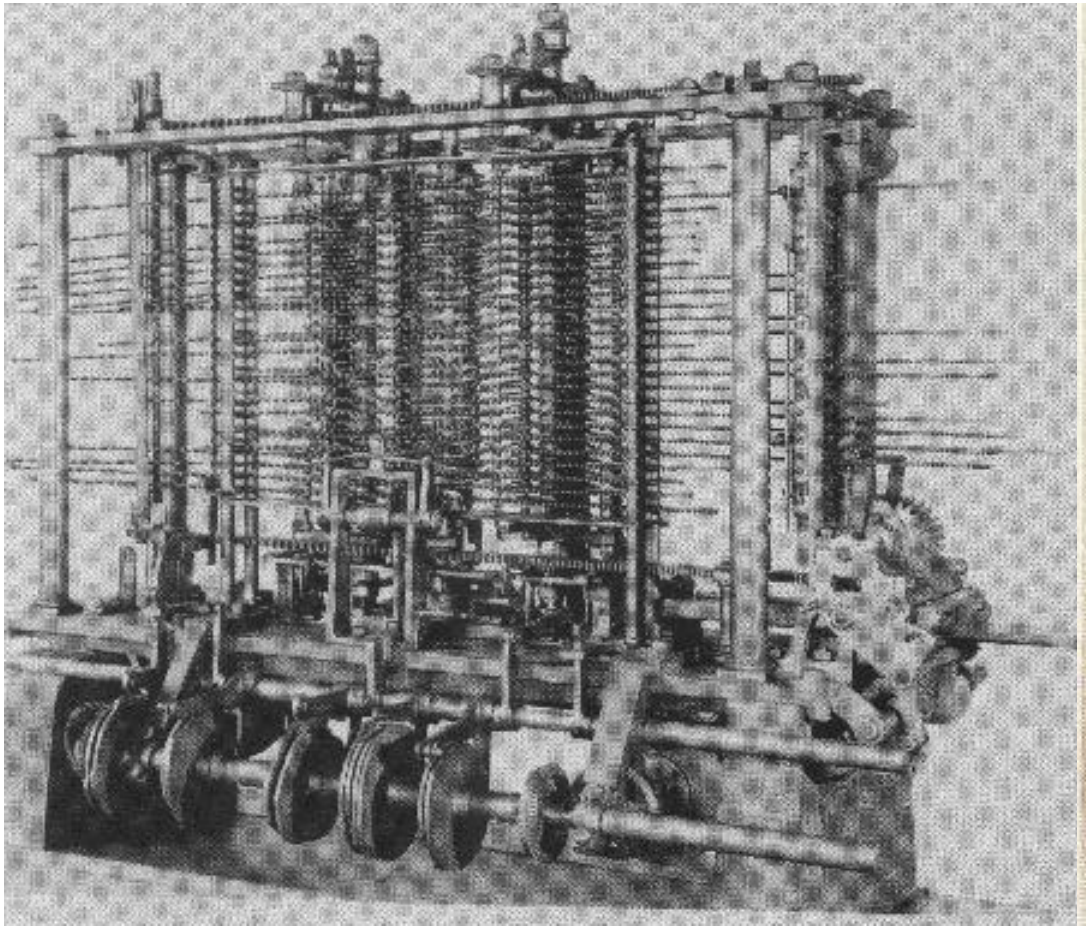
The dream of the automation of computation – partly realised

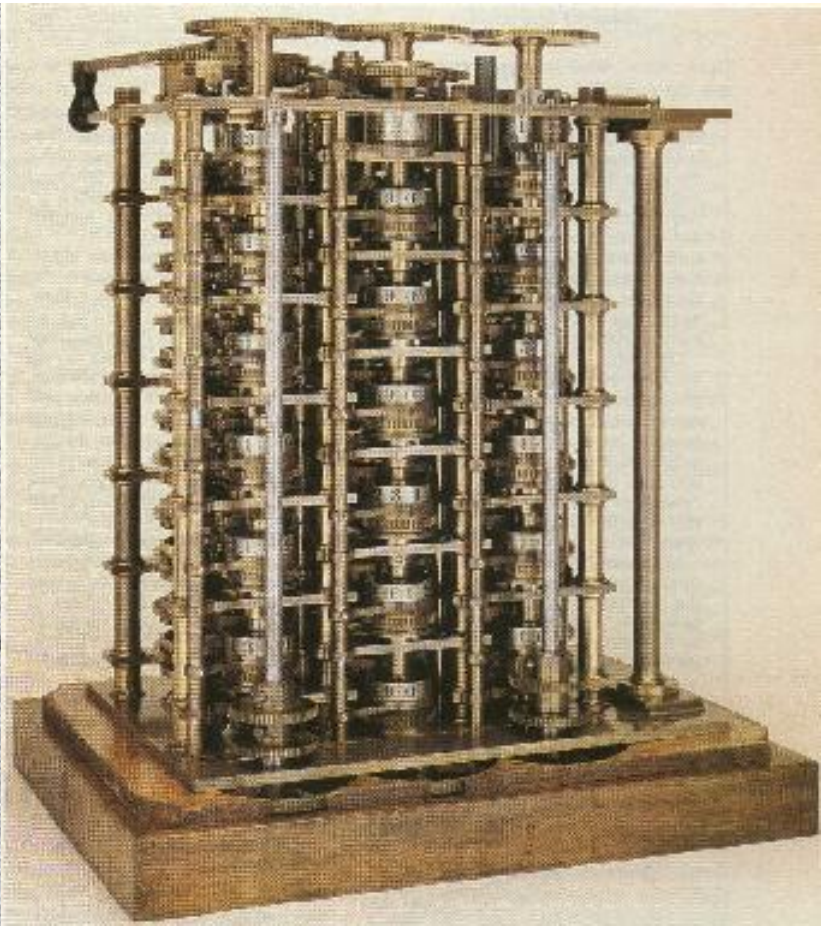
The Dream of a Universal Computer
Charles Babbage and Ada Lovelace



Charles Babbage (1792-1871) **Ada Lovelace** (1815–1852)

Difference Engine/Analytical Engine



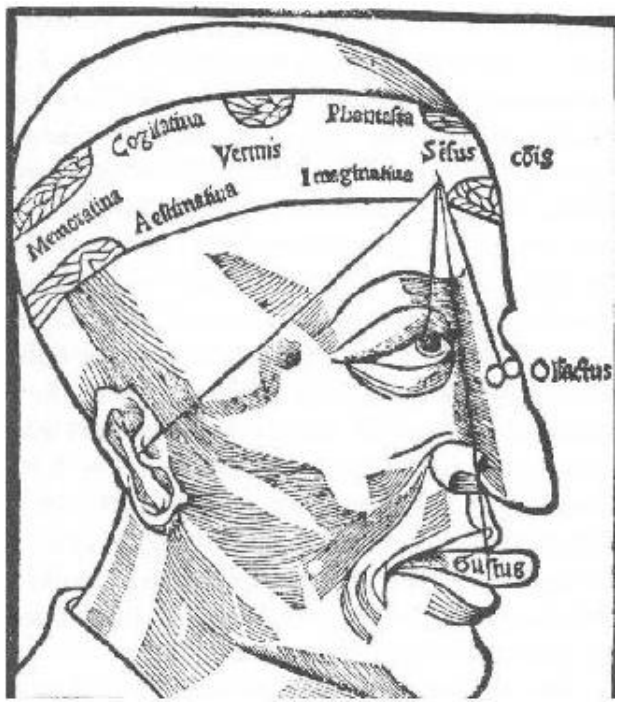


The dream of a universal computing machine, almost realised

Science or Mystery?

Robert Fludd (1574–1637): Universe as a mixture of opposite principals (like light and darkness, sympathy and antipathy)

Understanding the Mind

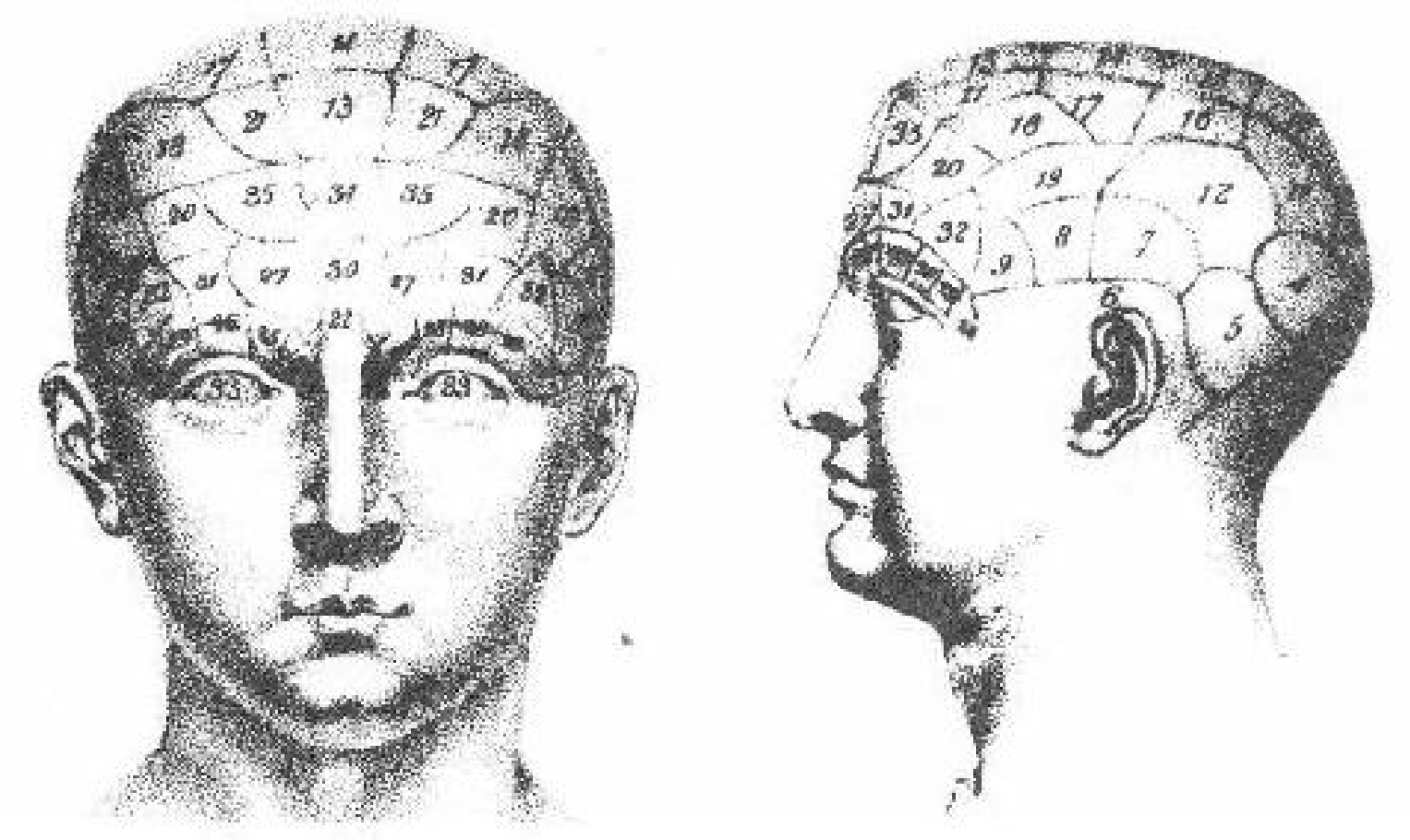


Ventricle theory of 1524, First attempts to locate cognitive abilities in regions of the brain.

Understanding the Mind (Cont'd)

René Descartes' (1596–1650) description in "Traité de l'Homme" to explain reflex actions. The long fiber running from the foot to the cavity in the head is pulled by the heat and releases a fluid that makes the muscles contract.

Understanding the Mind (Cont'd)



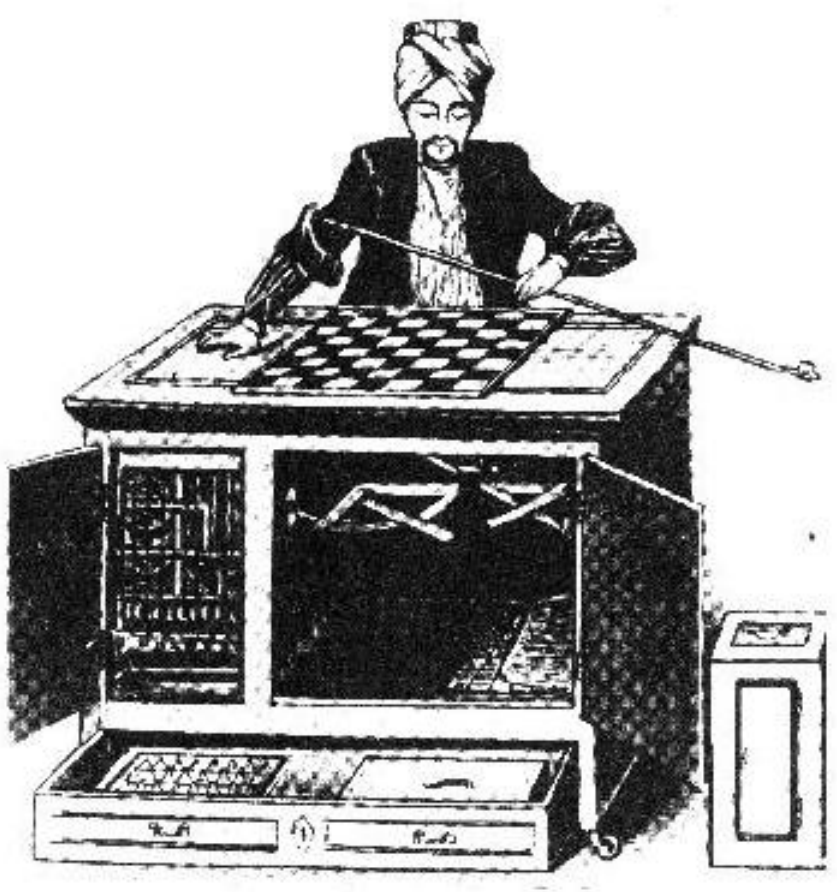
Phrenology, localisation of mental functions in the brain
Introduced by **Franz Joseph Gall** (1758–1828)
picture from his disciple **Johann Kaspar Spurzheim** (1776–1832)

Intelligent Machines – Fakes Speech

Dream: Build intelligent machines that can speak!

(Entertainment)

Intelligent Machines – Fakes Chess



Build intelligent machines that can play chess!

Kempelen's chess playing Turk (1768)

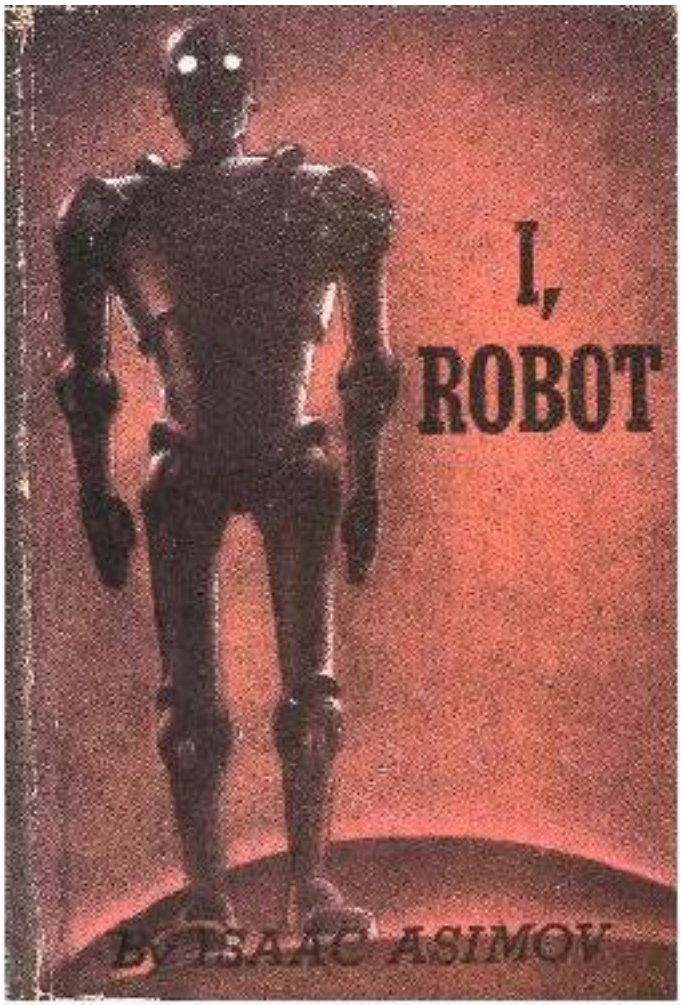
Predicting the Future

Pierre Simon Laplace
(1749–1827)

Laplace's Demon

Build a super-human intelligence which is able to compute all of the world (past, present, and future) if only it knows for a single point in time the positions and speeds of all particles in the universe.

Science Fiction – Building Companions



Karel Čapek (1890–1938), **robota** = forced labour.

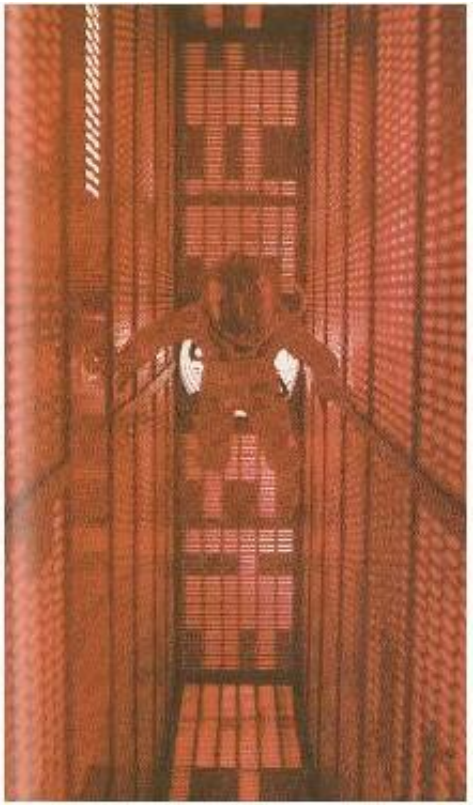
Build intelligent machines that can work for you!

Asimov's Robot Laws:

1. A robot must not harm a human being or allow by inactiveness that a human being is harmed.
2. A robot must obey to orders given by a human being unless the execution of the order is in conflict with law 1.
3. A robot must protect its own existence, unless this is in conflict with laws 1 or 2.

AI = Build Machines that Behave as in the Movies

Metropolis

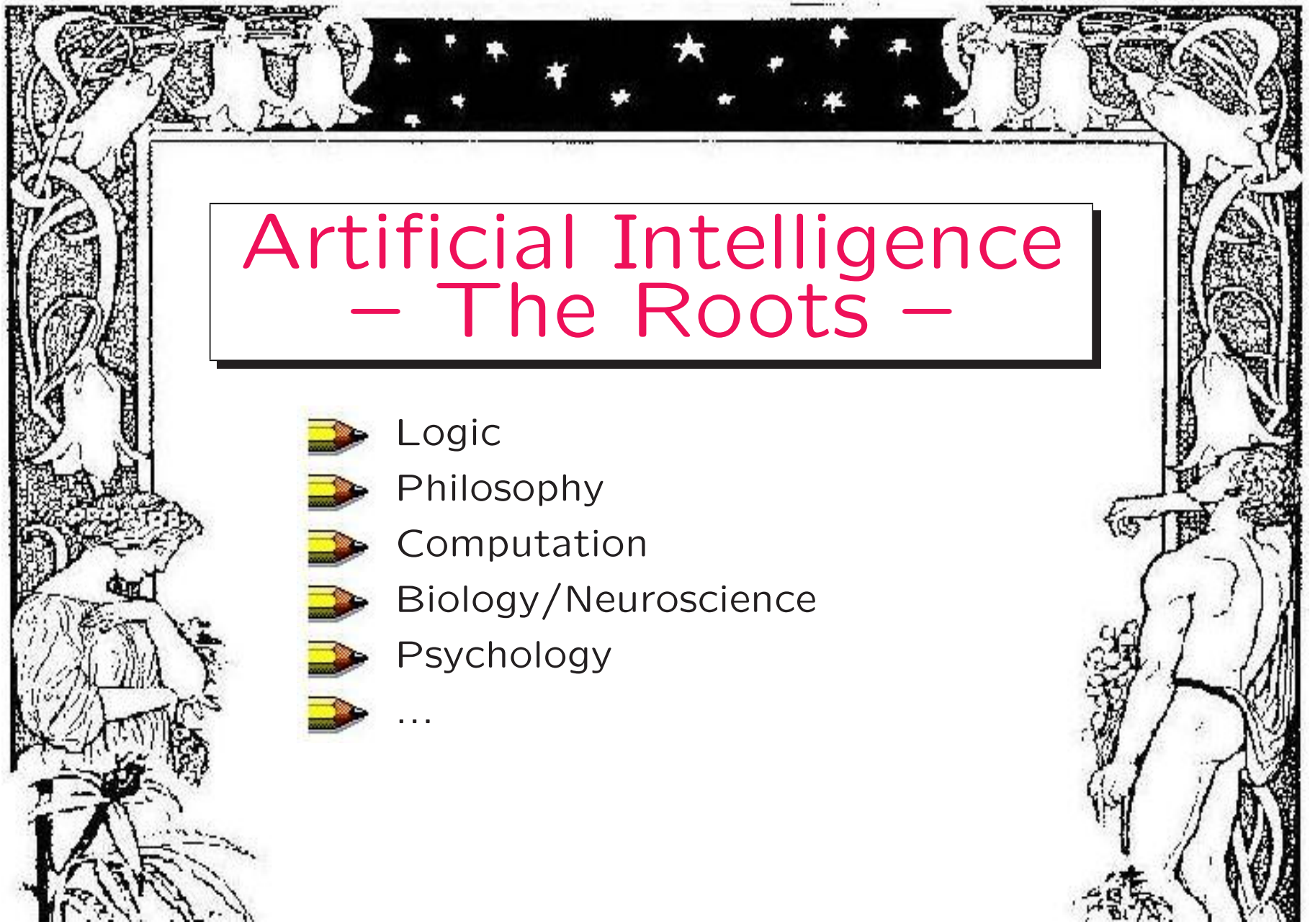


2001 (HAL)

Star Wars (R2-D2)

Literature

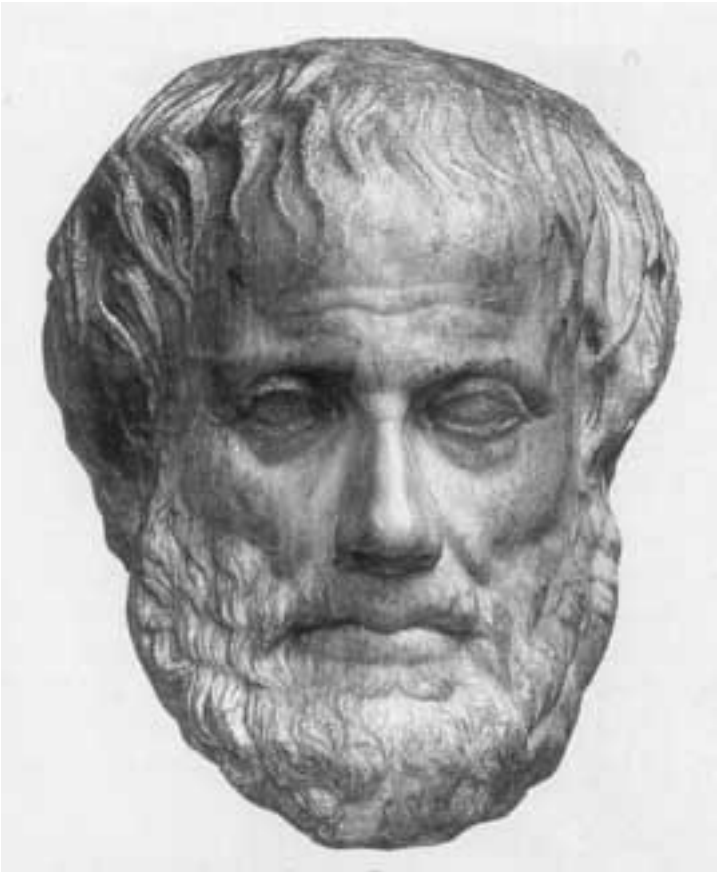
- *Artificial Intelligence: A New Synthesis*, Nils J. Nilsson, Morgan Kaufmann 1998.
- *Artificial Intelligence - A Modern Approach*, Stuart Russell & Peter Norvig, Prentice Hall, 2nd edition.
- *Artificial Intelligence*, 3rd Edition, Patrick Henry Winston, Addison-Wesley, 1992.
- *Artificial Intelligence*, 2nd Edition, Elaine Rich & Kevin Knight, McGraw Hill 1991.



Artificial Intelligence – The Roots –

- Logic
- Philosophy
- Computation
- Biology/Neuroscience
- Psychology
- ...

Logic



Aristotle
(384–322 B.C.)

Codify different styles of **deductive reasoning** by so-called **syllogisms**, e.g. **Modus Ponens**

$$\frac{A \qquad A \rightarrow B}{B}$$

Read: For any statements A and B holds: if A is true and A implies B is true then B is true.

Or more concretely:

$$\frac{\text{It's raining} \qquad \text{If it's raining then the street gets wet}}{\text{The street gets wet}}$$

The Idea of the Mechanisation of Logic

Raimundus Lullus

(1235–1316)

Ars Magna:

Try to build a machine which can answer all questions, in form of wheels like:

Regulae ad directionem ingenii

René Descartes
(1596–1650)

- translate any problem into a mathematical problem
- transform any mathematical problem into a system of equations
- translate any system of equations into one equation
- **solve** this **one equation**

(Carried through for geometry by analytical geometry)

Mind-body separation

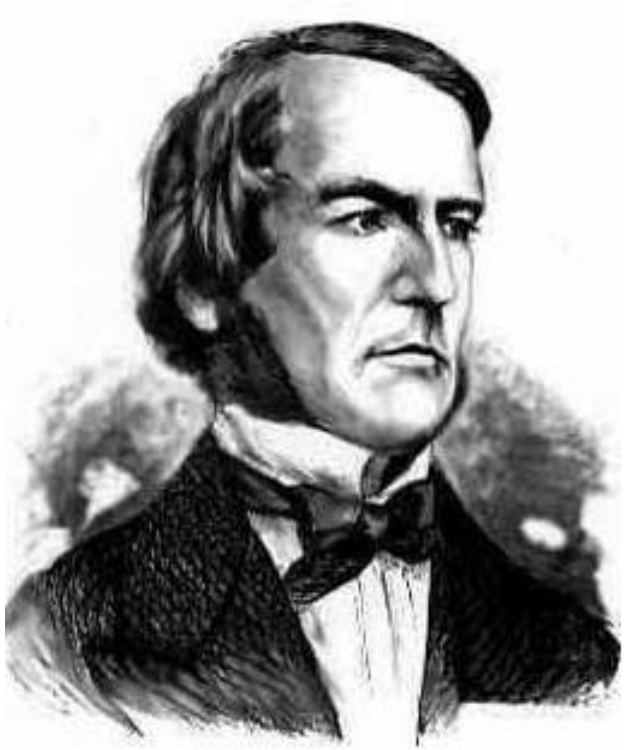
Calculemus = Let's calculate

Gottfried Wilhelm Leibniz
(1646–1716)

- **Lingua characteristica universalis:**
  Find a universal language which can be used to represent any problem
- **Calculus ratiocinator:**
  Can solve any problem automatically (without dispute): **Calculemus**

Interest linked to the development of calculator
Leibniz invented the dual representation of numbers

The Laws of Thought

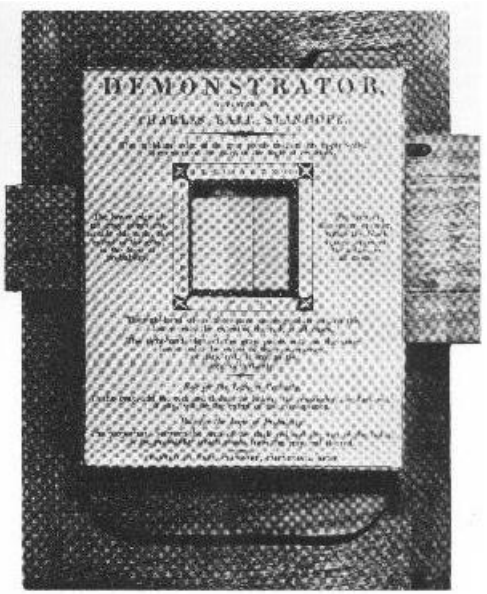


George Boole
(1815-1864)

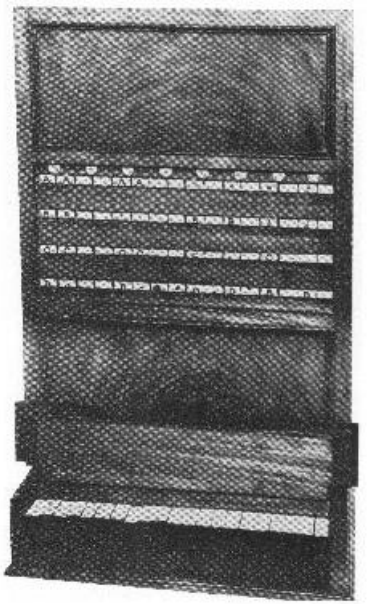
- Foundations of **propositional logic**
- Investigate the algebraic **laws of logic**, e.g.: $A \wedge A \equiv A$ (i.e., A and A is the same as A)
- purpose: "to collect ... some probable intimations concerning the nature and constitution of the human mind."

(Boolean Algebra, Boolean values in computer science)

Special Reasoning Machines



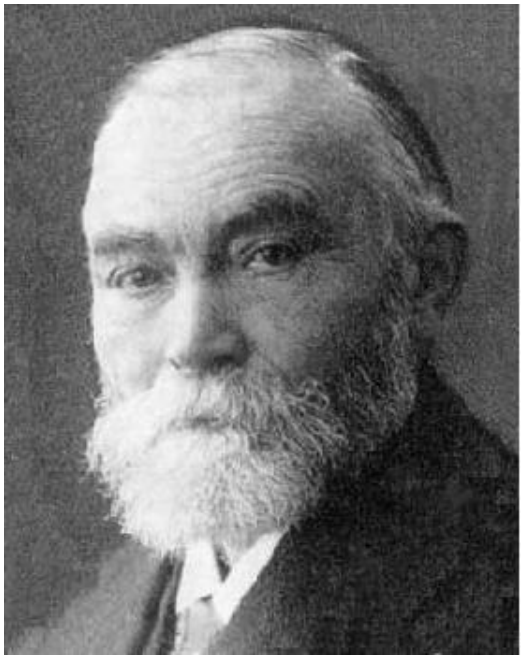
Earl Stanhope's Logic Demonstrator, 1777



William Jevons' Logic Machine, 1869

- machine for solving syllogisms, numerical problems in in logical form, elementary questions of probability.
- Machine for Boolean algebra and Venn diagrams, able to solve logical problems faster than human beings

Classical Logic



Gottlob Frege
(1848-1925)

Begriffsschrift, foundations of classical logic

Bertrand Russell
(1872-1970)

Paradoxes, types, principia mathematica

Strength and Limitations of Classical Logic

Kurt Gödel
(1906-1978)

- **Completeness** of first-order logic, that is, any reasoning whether something is a **logical consequence** of something else can be mechanised in this powerful reasoning system
- **Incompleteness** of sufficiently rich logic, there are truths which do not have a finite proof

Modern Computers

Alan Turing
(1912-1954)

John von Neumann
(1903–1957)

- What can be computed by a computer? – Halting problem
  Turing test for intelligence

- von Neumann architecture: give a description that is independent from the particular realisation of a computer

The Role of Logic

- McCarthy: **The relationship between computation and math. logic will be as fruitful as that between physics and analysis**
- Logic as powerful **knowledge representation formalism**
- Logical **reasoning** as a model for human reasoning
- Mechanisation of reasoning by **logical rules**
- **Extensions** to logic necessary for adequate reasoning:
  - probabilistic reasoning
  - fuzziness
  - non-monotonicity (revision of judgements)
  - non-deductive reasoning (analogy, induction, abduction)

symbolic representation of knowledge

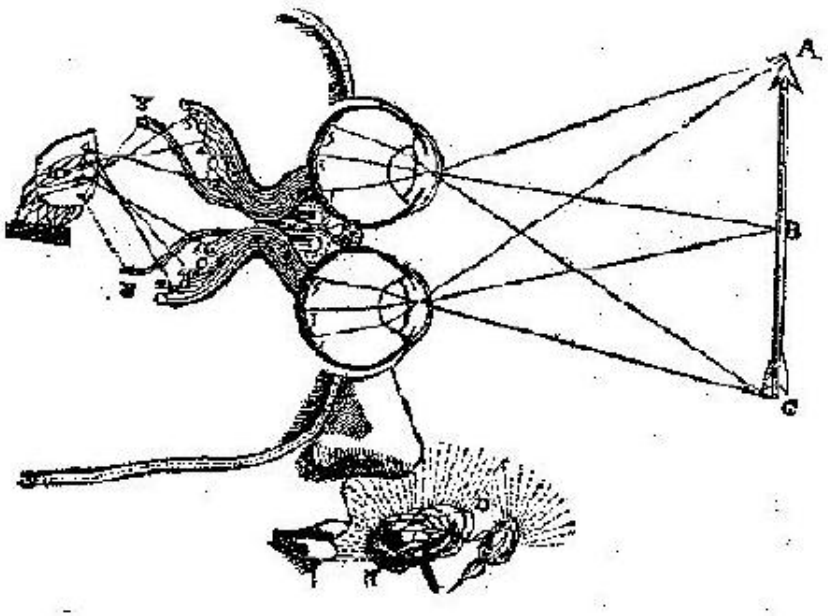
Brain science – Neuroscience

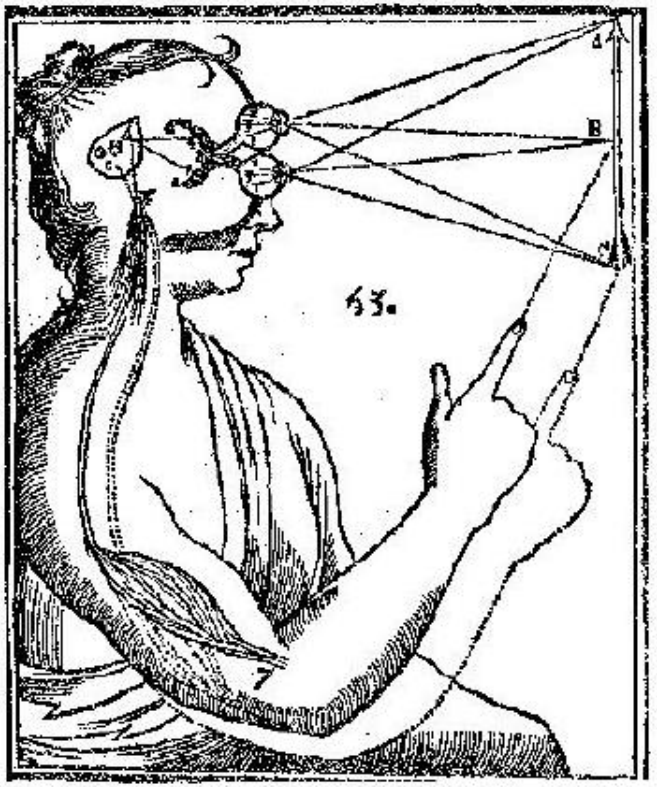
☞ Brain (vs heart) as seat of the soul and the mind

☞ Understand the function of the brain

- ventricle theory (ventricles = empty parts of the brain do the job)
- brain as a big gland
- phrenology (which part does what)
- understand brain as a highly connected set of **neurons**, 10^{10} neurons with each 100 connections on average
- neuron as a digital entity which either does or does not **fire** depending whether an **activation threshold** is exceeded or not

Brain science – Neuroscience (Cont'd)

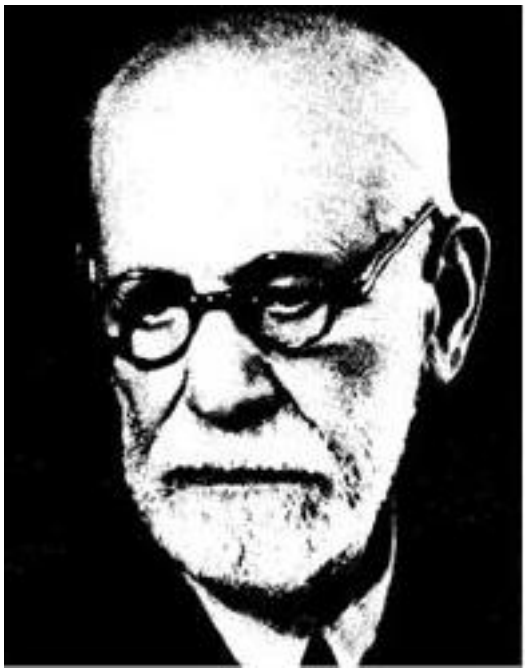




Gives raise to **neural nets**,

subsymbolic representation of knowledge

Psychology



Sigmund Freud

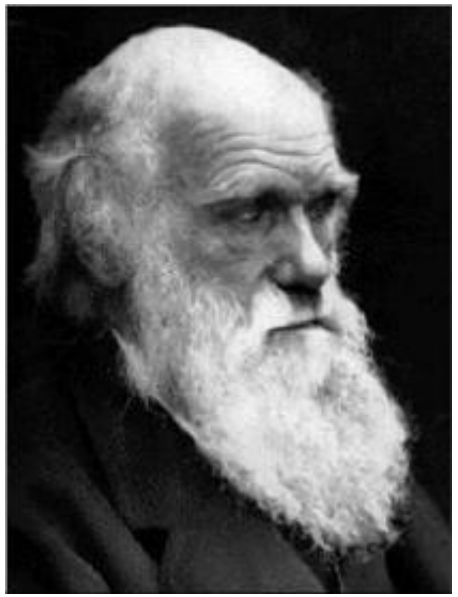
(1856–1939)

Founder of psychoanalysis

- Try to understand the psyche
- Try to understand motivations as well as anomalies of human behaviour/human mind/human **soul** (clues to **mental activity/conflicts**)
- The conscious vs the unconscious
- Psychoanalysis

Relationship between **psychology** – **cognitive science** – **artificial intelligence**

Darwinism



Charles Darwin
(1809–1882)

"On the origin of species by means of **natural selection**"

- different species develop by natural selection
- **cross-over** and random **mutation**
- **survival of the fittest** (only the fit ones mate and reproduce)

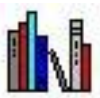
What does it mean to be "fittest"?

Gives raise to **evolutionary computation** (rather than programming, breed programs)

Summary

- **Different origins of AI:** philosophy, logic, computation, psychology, biology
- In this module we follow mainly the logical/computational origins: **symbolic representation of knowledge**

Reading



- Introduction chapters in the AI books
- *The story of Cybernetics*, Maurice Trask, Studio Vista, 1971.
- *Minds, Brains & Computers*, edited by R. Morelli et al., Ablex Publ., 1992.
- *Gehirn, Bewusstsein und Erkenntnis*, E. Oeser, Franz Seitelberger, Wissenschaftliche Buchgesellschaft, 1988.