# Artificial Intelligence

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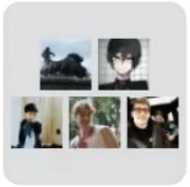

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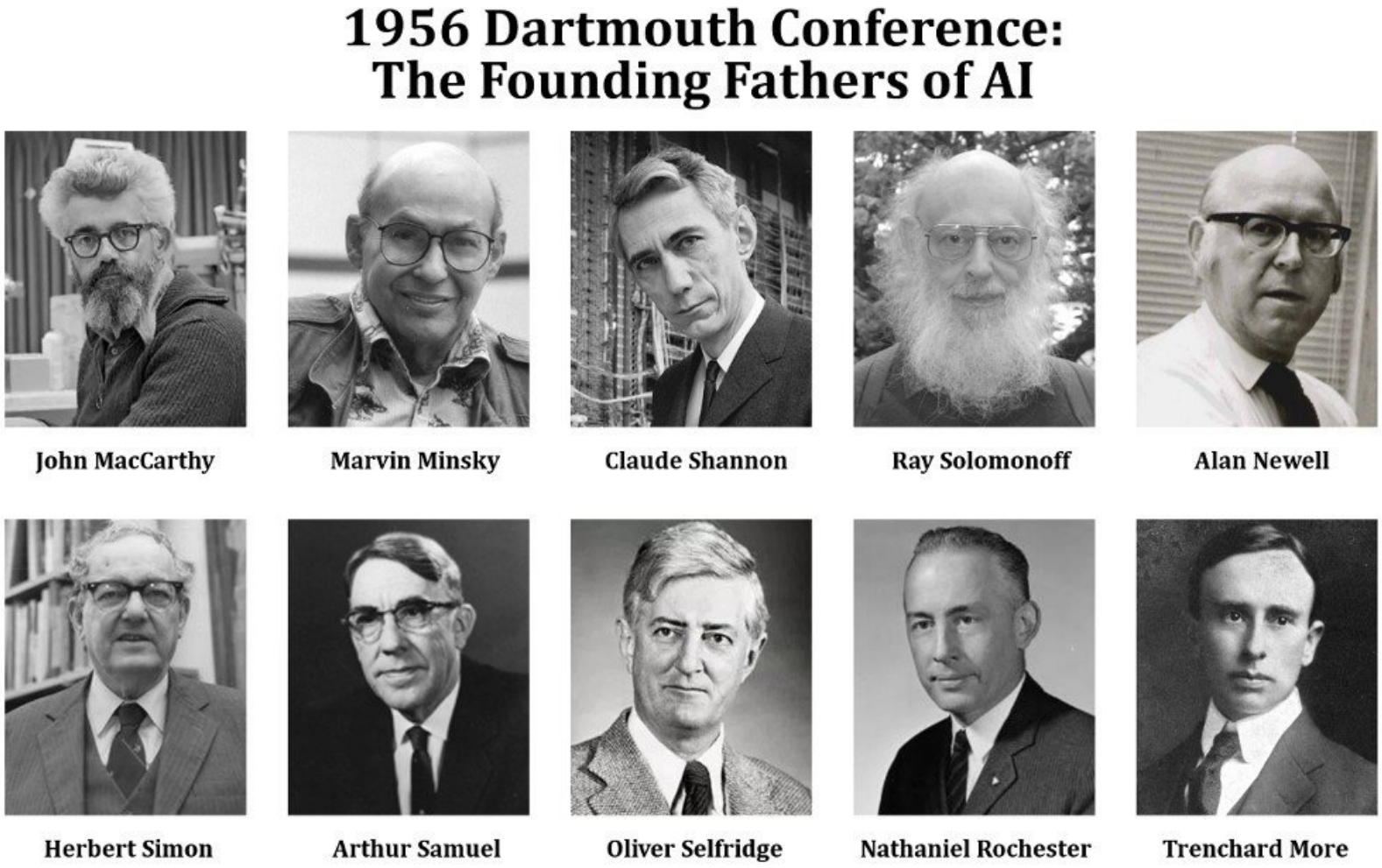
# Books

- George F. Luger. **Artificial intelligence: structures and strategies for complex problem solving (5th edition)**, *Addison Wesley*, 2004.
- **Pattern Recognition and Machine Learning**. Christopher M. Bishop. *Springer*.
- Trevor Hastie, Robert Tibshirani, and Jerome Friedman. **The Elements of Statistical Learning (2nd edition)**, *Springer*.
- Joseph C. Giarratano, Gray D. Riley. **Expert Systems Principles and Programming (3rd Edition)**, *China Machine Press*, 2002.
- George F. Russell, Peter Norvig. **Artificial Intelligence: A Modern Approach (3rd Edition)**. *Prentice Hall*, 2009.

# Dartmouth Workshop

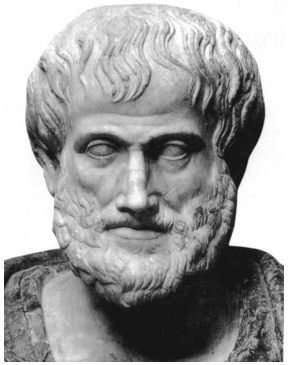


# Greek mythology

**Prometheus** speaks of the fruits of his transgression against the gods of Olympus:

*his purpose was not merely to steal fire for the human race but also to enlighten humanity through the gift of* ***intelligence***.

# Historical foundations



**Aristotle**

- The master of those who know (Dante).
- The Study of thought itself is at the basis of all knowledge

*All men are mortal*
*Socrates is man*

---

*Socrates is mortal*

***Syllogism*** *or* ***modus ponens***

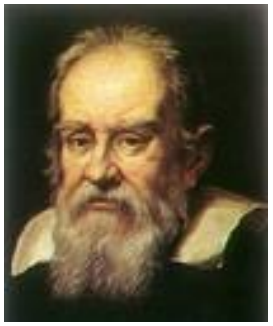
***Two thousand years later***

*Gottlob Frege, Bertrand Russell, Kurt Gödel, Alan Turing, Alfred Tarski, ...*

# Historical foundations

## Copernicus

- Copernican revolution
- Our ideas about the world were seen as fundamentally distinct from its appearance.



## Galileo

- Scientific observations
- Development of mathematics as a tool for describing the world.

## Descartes

- Meditations: attempt to find a basis for reality purely through cognitive introspection.
- Cogito ergo sum (I think, therefore I am).

# Discussion

- The ***structure of ideas*** about the world was not necessarily the same as the ***structure of their subject matter***.
- It is necessary to find a way to ***reconnect*** the mind and the body, because ***interaction*** between the mental and the physical is essential for human existence.
- Mental processes are indeed achieved by ***physical systems*** such as brains. Mental processes, like physical processes, can ultimately be characterized through ***formal mathematics***.

***Reasoning is but reckoning***.

*by 17th century philosopher Hobbes*

# The development of logic

## Leibnitz

- Calculus Philosophy
- Introduce the first system of formal logic and construct a machine for automating its calculation.

## Boole

- Boolean algebra
- Mathematical formalization of the laws of logic that forms very heart of modern computer science.

## Frege

- Foundations of arithmetic
- mathematical specification language for describing the basis of arithmetic in a clear and precise fashion.

# String manipulation

person has fever $\wedge$ fever is less than 39 $\longrightarrow$ take aspirin

person has fever
fever is greater than 39
**AND** $\}$ $\Longrightarrow$ take aspirin

---

$\alpha \wedge \beta \longrightarrow \gamma$

$\alpha$ **AND** $\beta \Longrightarrow \gamma$

*Any mathematic or logic system is simply a set of rules specifying how to change one string of symbols into another set of symbols.*

# Syllogism

*All men are mortal*

he is a man $\longrightarrow$ he will die

*Socrates is man*

Socrates is a man

***Will Socrates die?***

**First order predicate calculus**

# Syllogism

*All men are mortal*

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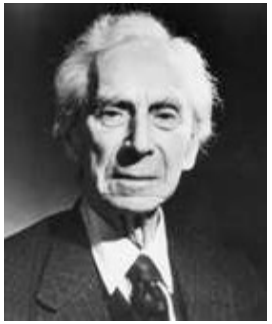
Socrates is a man

***Will Socrates die?***

**First order predicate calculus**

$$\left.\begin{array}{l}\forall x(\text{man}(x) \rightarrow \text{mortal}(x)) \\ \text{man}(\textit{Socrates})\end{array}\right\} \Longrightarrow \text{mortal}(\textit{Socrates})$$

# The development of logic



**Russell**

**Whitehead**

- Foundations of artificial intelligence
- Their goal was to derive the whole of mathematics through formal operations on a collection of axioms.

**Tarski**

- Semantic theory of truth
- Well-formed formulae can be said to refer to the physical world in a precise fashion.

# Tarski's semantic

We know $(A \vee C) \wedge (B \vee \neg C)$ is *true*.

***Question is*:** $(A \vee B)$?

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We know $(A \vee C) \wedge (B \vee \neg C)$ is *true*.

***Question is*: $(A \vee B)$?**

| $A$ | $B$ | $C$ | $(A \vee C)$ | $(B \vee \neg C)$ | *Premise* | *Consequence* |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |

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| 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |

***Model***

# Cognitive science

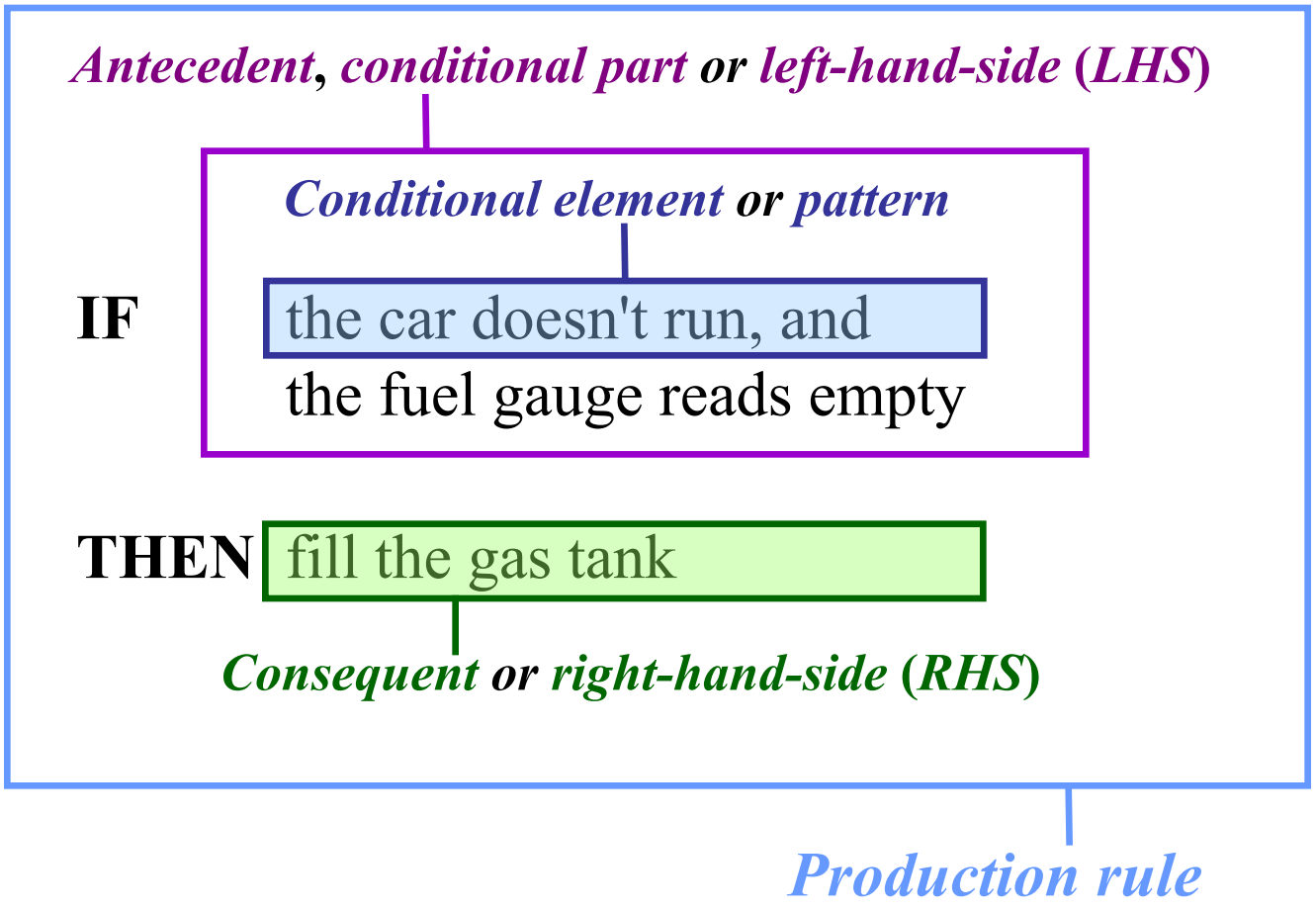
**Newell**

**Simon**

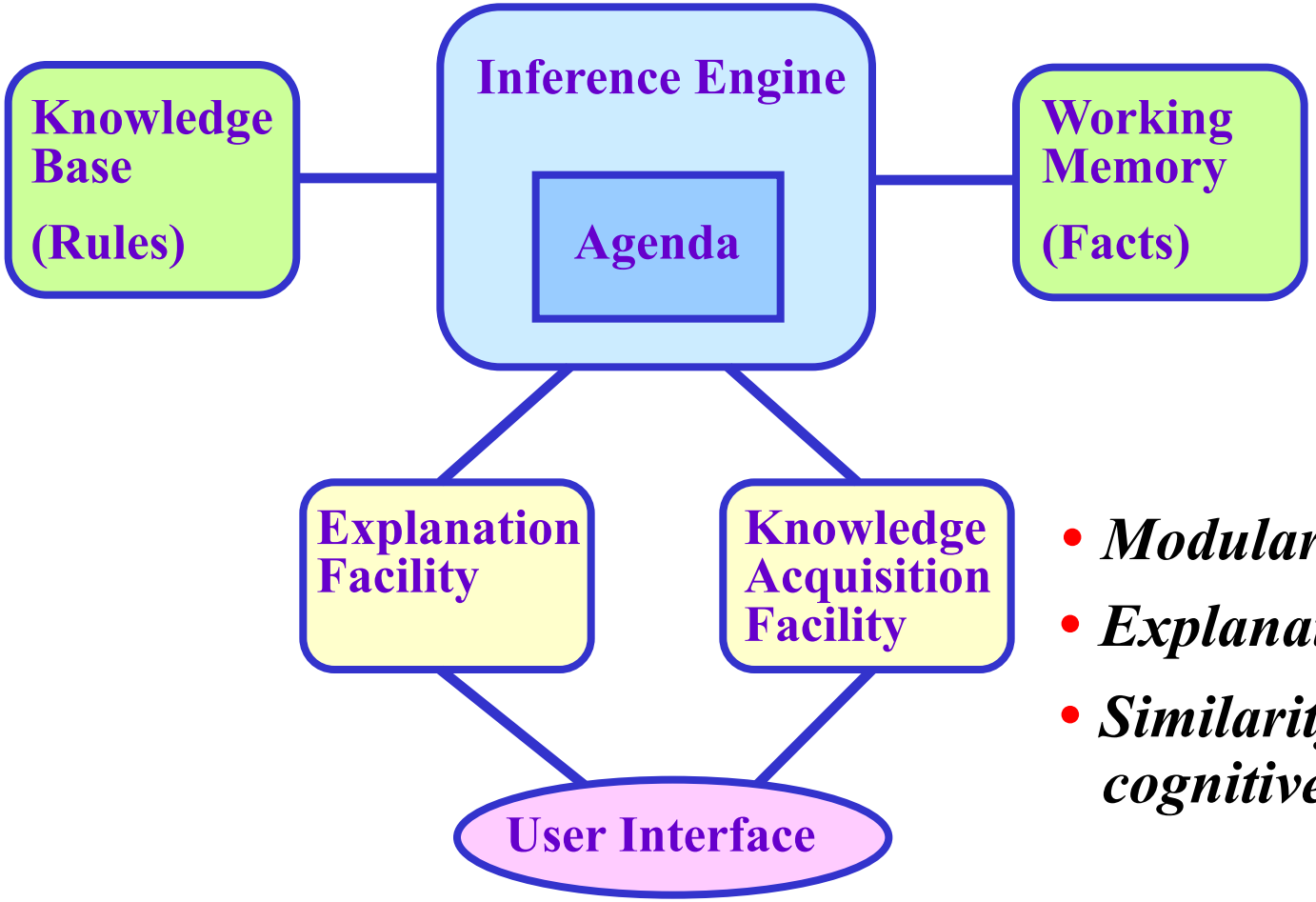
- Much of human problem solving or ***cognition*** can be expressed by IF-THEN type ***production rules***.
- Long-term memory or ***rules***, short-term memory or ***working memory***, and a cognitive processor or ***inference engine***.
- ***General problem solver***

*Newell Simon Hall*
*Carnegie Mellon University*

# Production rule



# Rule-based expert system structure

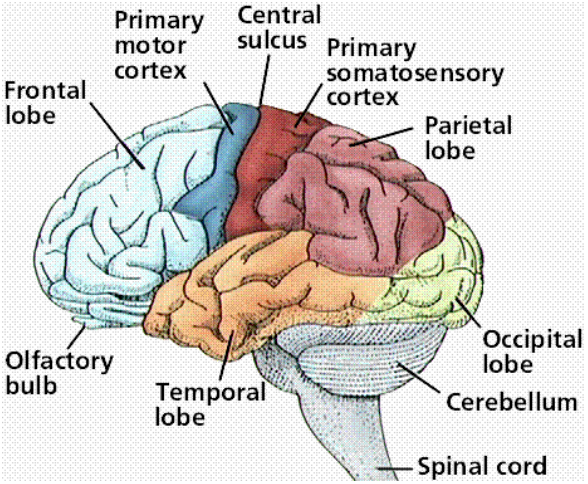


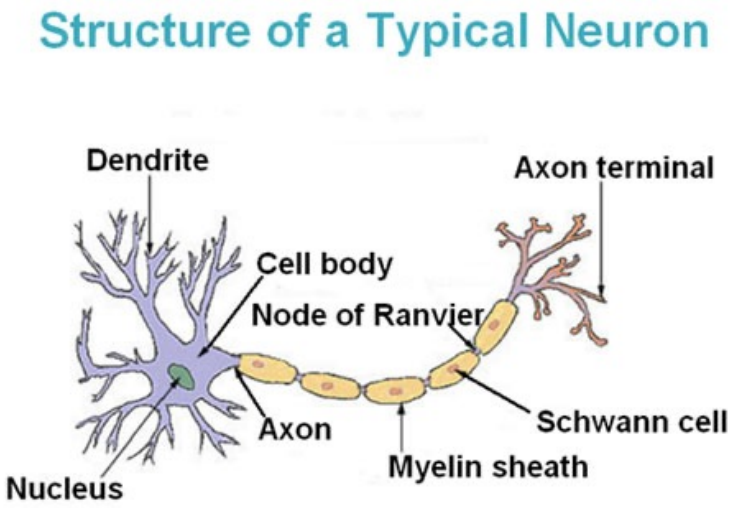

- ***Modular nature.***
- ***Explanation facilities.***
- ***Similarity to human cognitive process.***

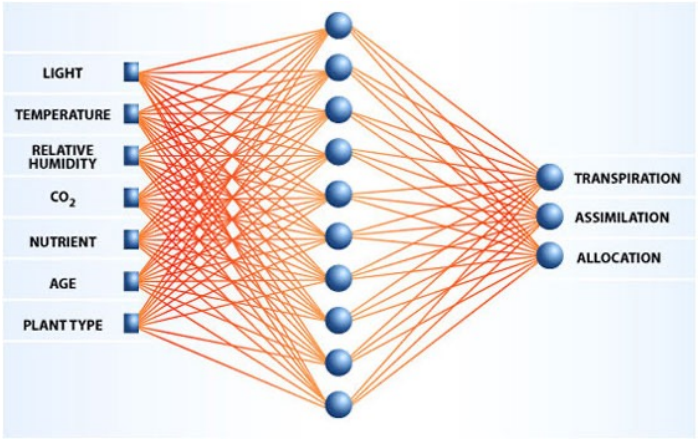
# Expert systems applications

- **MYCIN** uses ***expert medical knowledge*** to diagnose and prescribe treatment for spinal meningitis and bacterial infections of the blood (mid-1970s, Stanford).
- **PROSPECTOR** analyze geologic data for minerals and had discovered a mineral deposit ***worth $100m*** (1979, Duda).
- **XCON** can configure a computer system and saves DEC ***millions of dollars*** a year (1981, Carnegie-Mellon University and Digital equipment Corp).

# Artificial neural systems



# Evolution

*"... no limit to this power of slowly and beautifully adapting each form to the most complex relations of life ..."*

——— ***Charles Darwin***

# Example

**Maximum** $f(x) = x^2$, $x \in [1, 31]$

- **Representation**

  $x \in \{0,1\}^5$

- **Initialization**

| | | | | |
|---|---|---|---|---|
| 1st generation | 01101, | 11000, | 01000, | 10011 |
| Interpretation | 13, | 24, | 8, | 19 |
| Fitness | 169, | 576, | 64, | 361 |

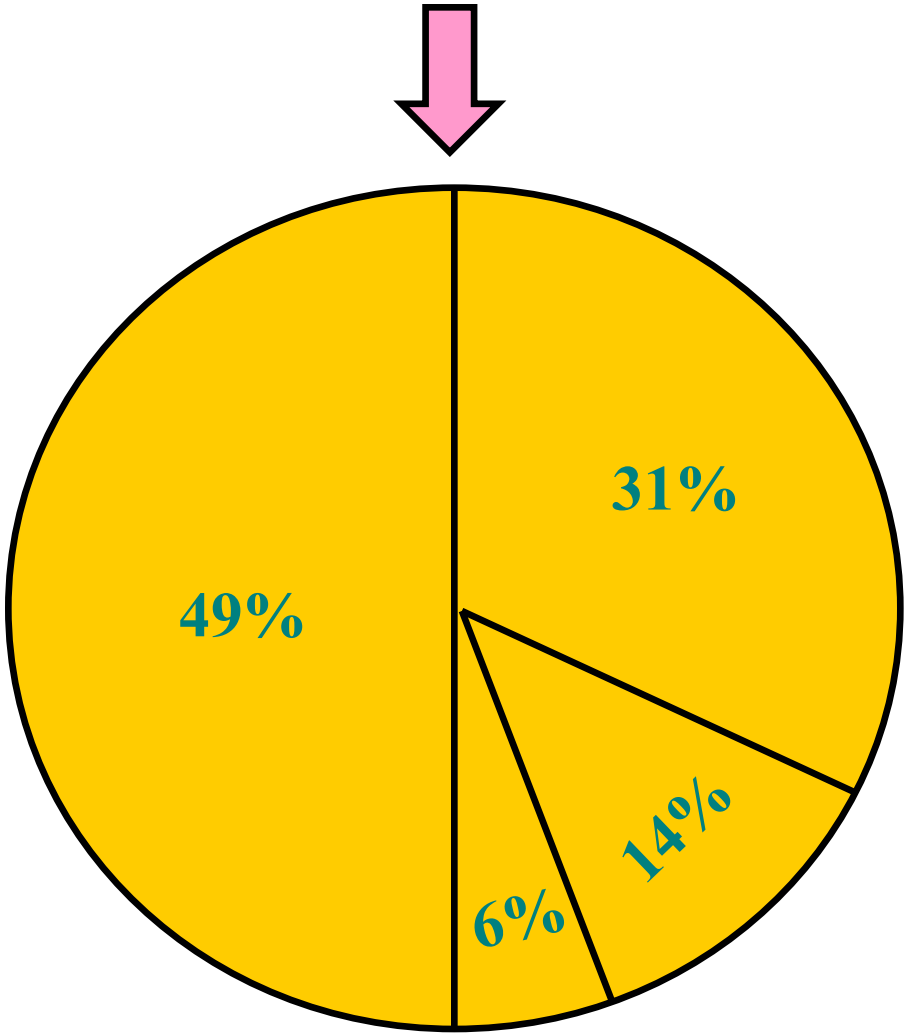
# Example

**Maximum** $f(x) = x^2$, $x \in [1, 31]$

- **Selection**

| | |
|---|---|
| Individual | 01101, 11000, 01000, 10011 |
| Fitness | 169, 576, 64, 361 = 1170 |
| Probability | 0.14, 0.49, 0.06, 0.31 = 1.0 |
| Result | 01101, 11000, 11000, 10011 |

# Russian roulette

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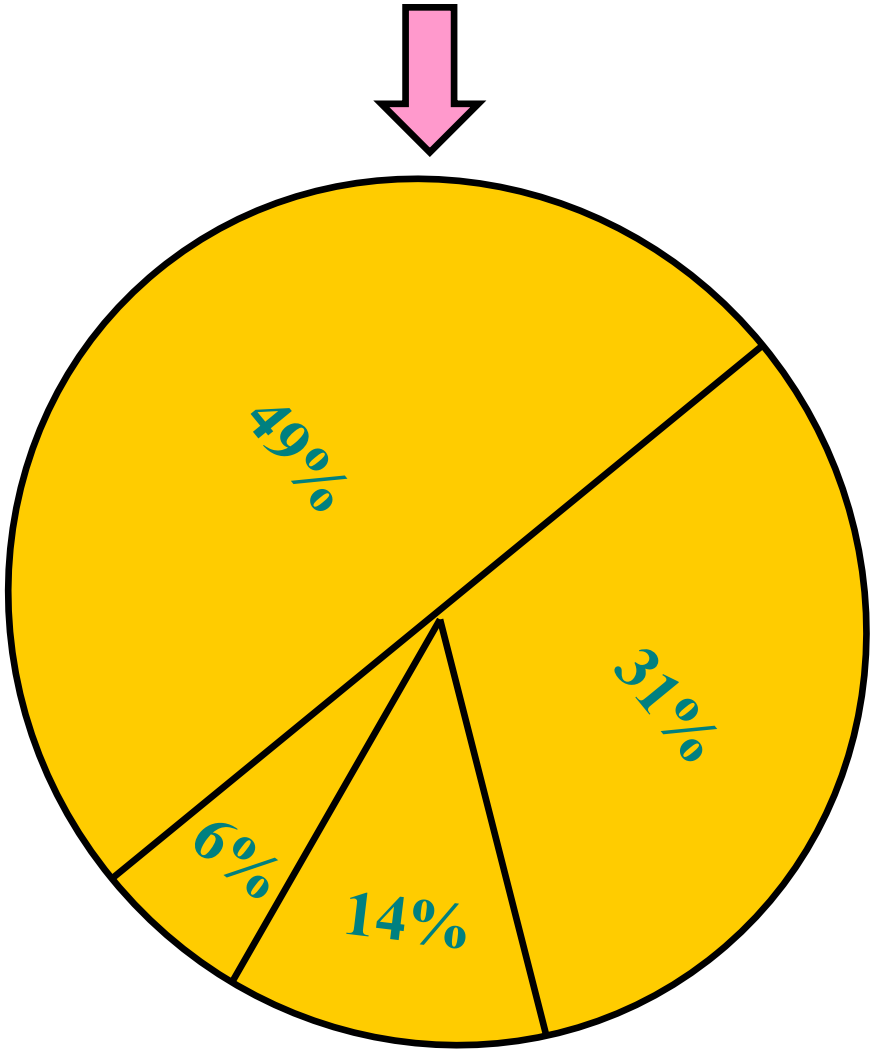


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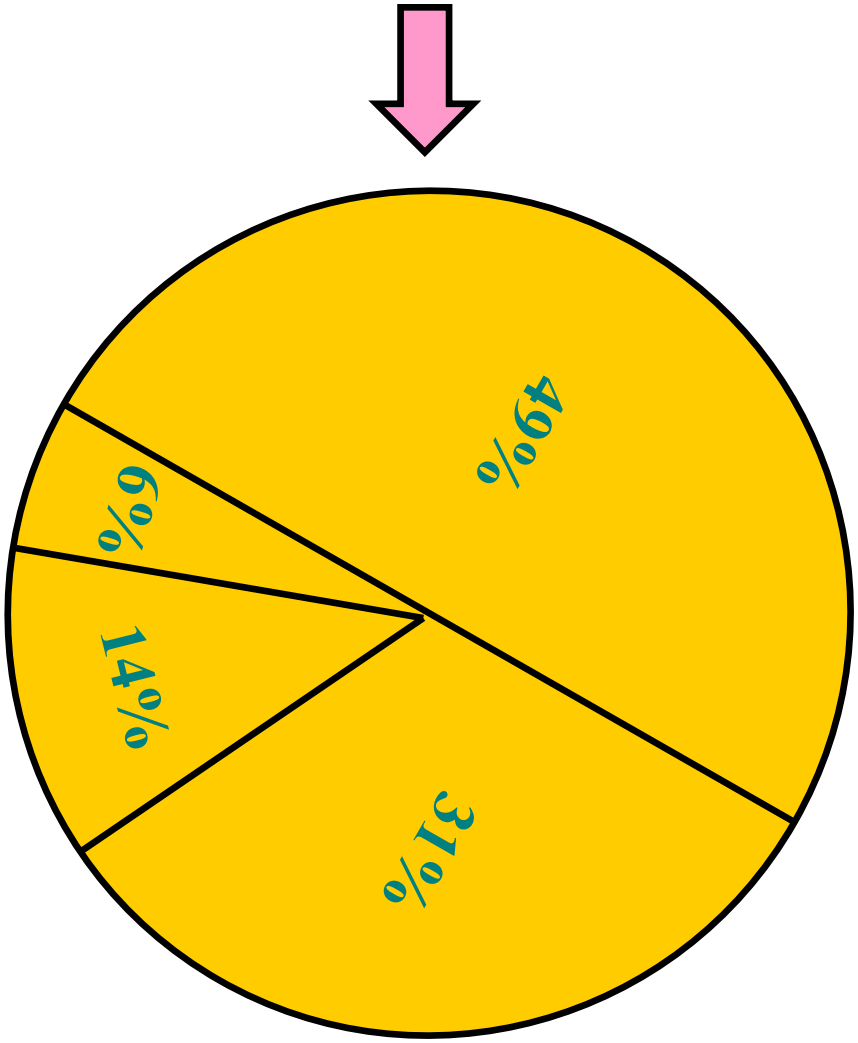


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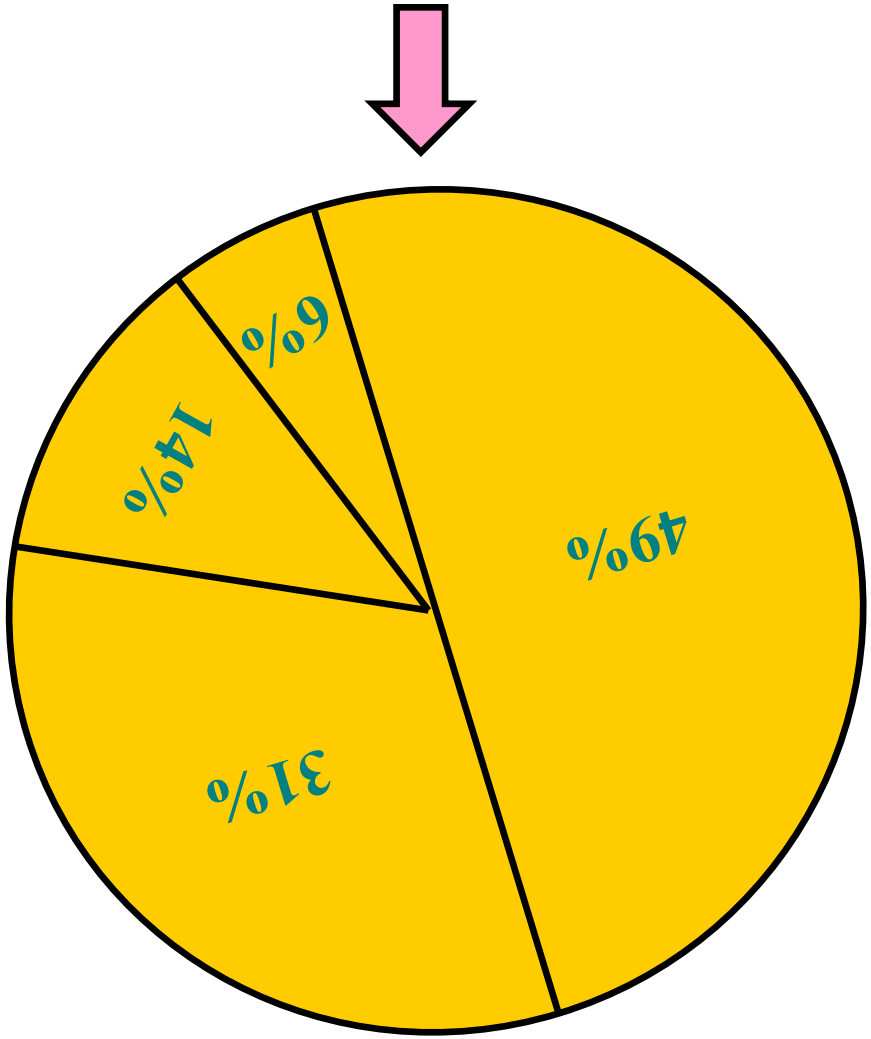


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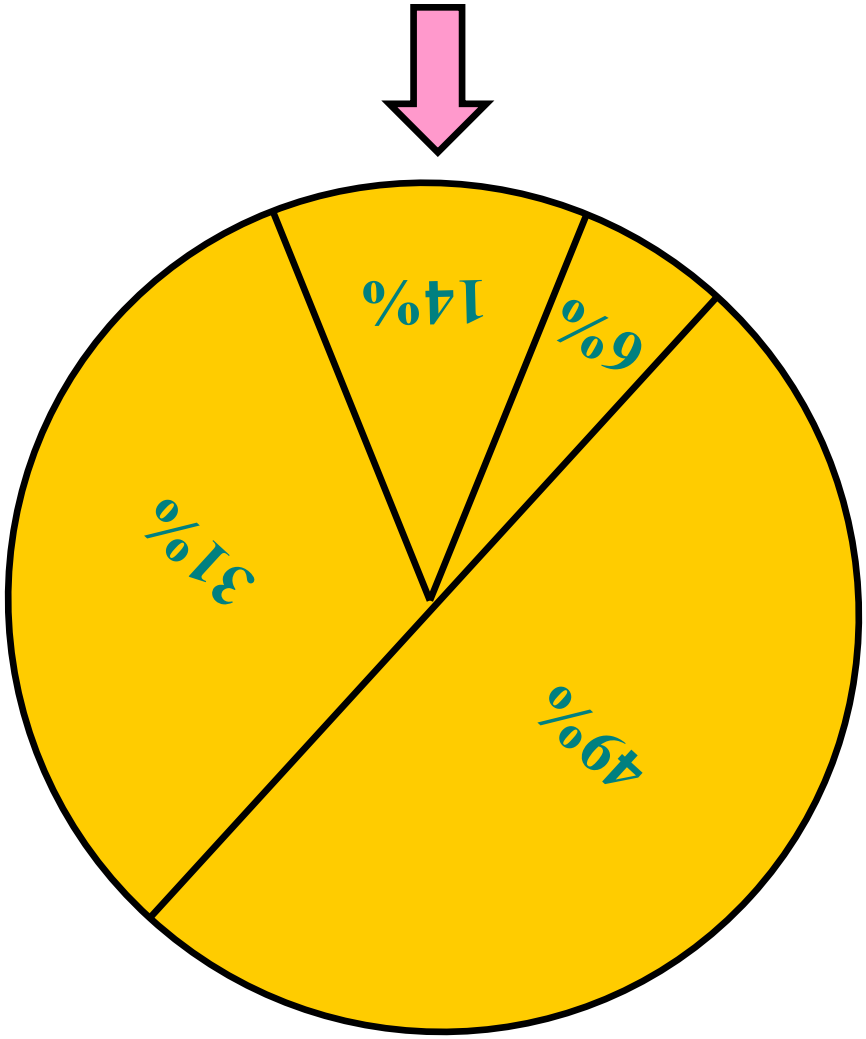


# Example

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- **Selection**

| | |
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| Fitness | 169, 576, 64, 361 = 1170 |
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- **Crossover**

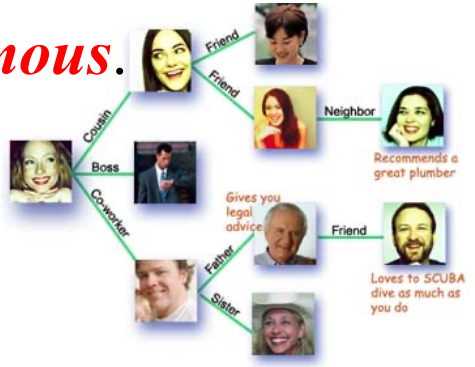

- **Mutation**

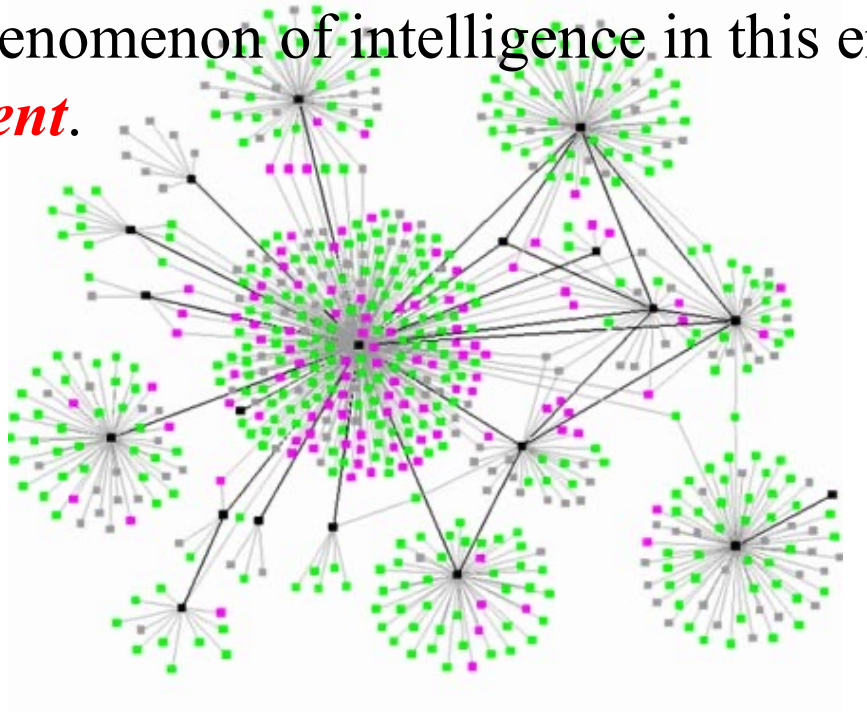
# Genetic algorithm

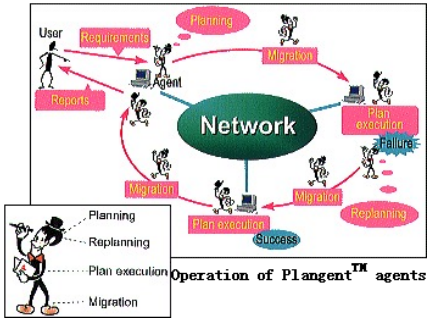
**begin**
  **set** time $t = 0$
  initialize the ***population*** $P(t)$
  **while** the termination condition is not met **do**
    **begin**
      evaluate fitness of each member of the population $P(t)$;
      select members from population $P(t)$ based on ***fitness***;
      produce the ***offspring*** of these pairs using ***genetic operators***;
      replace  candidates of $P(t)$, with these offspring;
      **set** time $t = t + 1$
    **end**
**end**

# Multi-agent systems

- Agents are ***autonomous*** or ***semi-autonomous***.
- Agents are ***situated***.
- Agents are ***interactional***.
- The society of agents is ***structured***.
- The phenomenon of intelligence in this environment is ***emergent***.



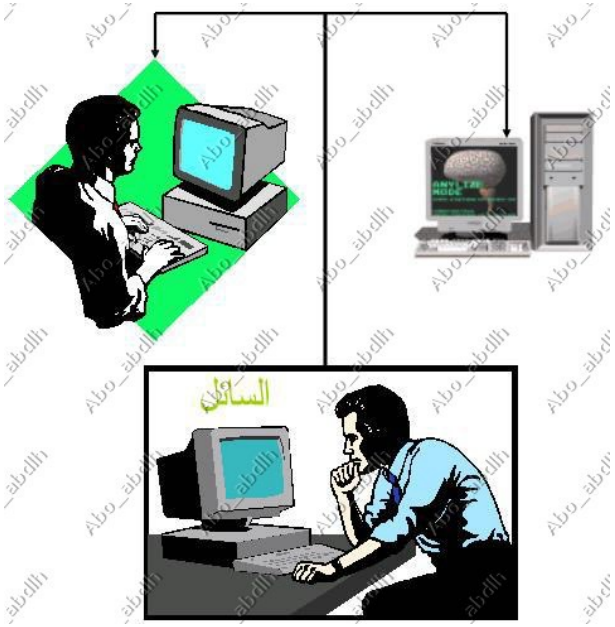





# The development of logic

**Turing**

- Computing machinery and intelligence
- The theory of computability: the question of whether or not a machine could actually be made to think.




*What is **thinking**?*

*What is **machine**?*

*What is **intelligence**?*

# Post-modern thought

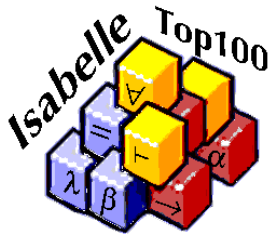
*What is **chair**?*

*by philosopher Wittgenstein 1953*

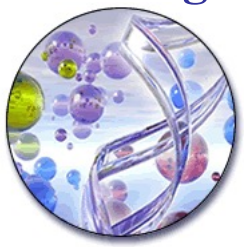
# Overview of AI application areas

- Game playing

- Automated reasoning




- Machine learning



AI

- Natural language understanding


- Expert systems

- Planning and robotics

# Any questions?

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