Advanced Artificial Intelligence Technologies and Applications

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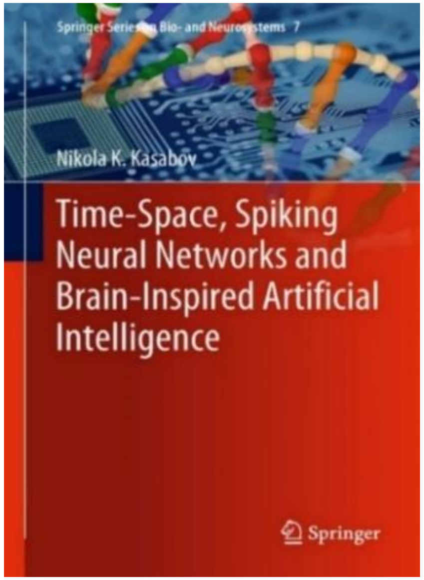
Full course DLU, 2023, Lecture Content

Advanced Artificial Intelligence Technologies and Applications

1. AI and the evolution of its principles. Evolving processes in Time and Space (Ch1, 3-19)
2. From Data and Information to Knowledge. Fuzzy logic. (Ch1,19-33 + extra reading)
3. Artificial neural networks - fundamentals. (Ch2, 39-48).
4. Deep neural networks (Ch.2, 48-50 + extra reading)
5. Evolving connectionist systems (ECOS) (Ch2, 50-78). NeuCom software (IA)
6. Deep learning and deep knowledge representation in the human brain (Ch3)
7. Spiking neural networks (Ch4). Evolving spiking neural networks (Ch5)
8. Brain-inspired SNN. NeuCube. (Ch.6). NeuCube software (IA)
9. Evolutionary and quantum inspired computation (Ch.7)
10. AI applications in health (Ch.8-11)
11. AI applications for computer vision (Ch.12,13)
12. AI for brain-computer interfaces (BCI) (Ch.14)
13. AI for language modelling. ChatBots (extra reading)
14. AI in bioinformatics and neuroinformatics (Ch15,16, 17,18)
15. AI applications for multisensory environmental data (Ch.19)
16. AI in finance and economics (Ch19)
17. Neuromorphic hardware and neurocomputers (Ch20).



Course book: N.Kasabov, Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence Springer, 2019, https://www.springer.com/gp/book/9783662577134

Additional materials: https://www.knowledgeengineering.ai/china

ZOOM link for all lectures: https://us05web.zoom.us/j/4658730662?pwd=eFN0eHRCN3o4K0FaZ0lqQmN1UUgydz09

Lecture 1.

AI and the evolution of its principles. Evolving processes in Time and Space

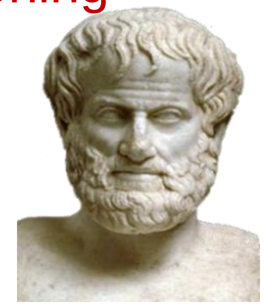
(Ch1, 3-19)

AI: Part of the interdisciplinary information sciences area that develops and implements methods and systems that manifest cognitive behaviour.

AI are also called information systems that have some of following features: learning, adaptation, generalisation, inductive and deductive reasoning, human-like communication, natural language processing,

Some more features are currently being developed: consciousness, self-assembly, self-reproduction, AI social networks,....

Symbolic AI, Rule-based Systems, Deductive Reasoning



- Types of knowledge representation and reasoning systems:
  - Relations and implications, e.g.:
    - A-> (implies) B,
  - Propositional (true/false) logic, e.g.: (*Aristotle, 4 BC*)
    - IF (A and B) or C THEN D
  - Boolean logic (George Boole)
  - Ada Lovelace (1815-1852)
  - Predicate logic: PROLOG
  - Probabilistic logic:
    - e.g. Bayes formula: p(A ! C)) = p (C ! A) . p(A) / p(C)
  - Rule based systems
  - Expert systems, e.g. MYCIN

Logic systems and rules are too rigid to represent the uncertainty in the natural phenomena; they are difficult to articulate, and not adaptive to change. Mainly used in the past.

The birth and the boom of symbolic AI. Logic, rules and reasoning

Ada Lovelace (1815-1852)

- Machine can deal with symbols (Ada Lovelace)
- Types of knowledge representation and reasoning systems:
  - Relations and implications, e.g.:
    - A-> (implies) B,
  - Propositional (true/false) logic, e.g.:
    - IF (A and B) or C THEN D
  - Boolean logic (George Boole)
  - Predicate logic: PROLOG
  - Probabilistic logic:
    - e.g. Bayes formula: p(A ! C)) = p (C ! A) . p(A) / p(C)
  - Rule based systems; expert systems, e.g. MYCIN.
  - Temporal and spatio-temporal rules.

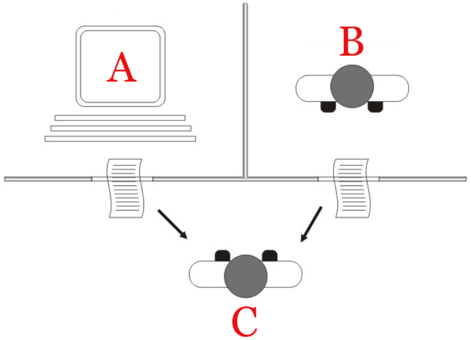
Logic systems and rules are too rigid to represent the uncertainty in the natural phenomena; they are difficult to articulate, and not adaptive to change.

The Turing Test for AI

Can computers have general intelligence to communicate like humans?

Alan Turing (1912-1954) posed a question in 1950: Can machines think?

Then it was formulated as “Can machines play imitation games?”, known now as the **Turing test for AI.** It is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human, evaluated by a human (C on the diagram) .



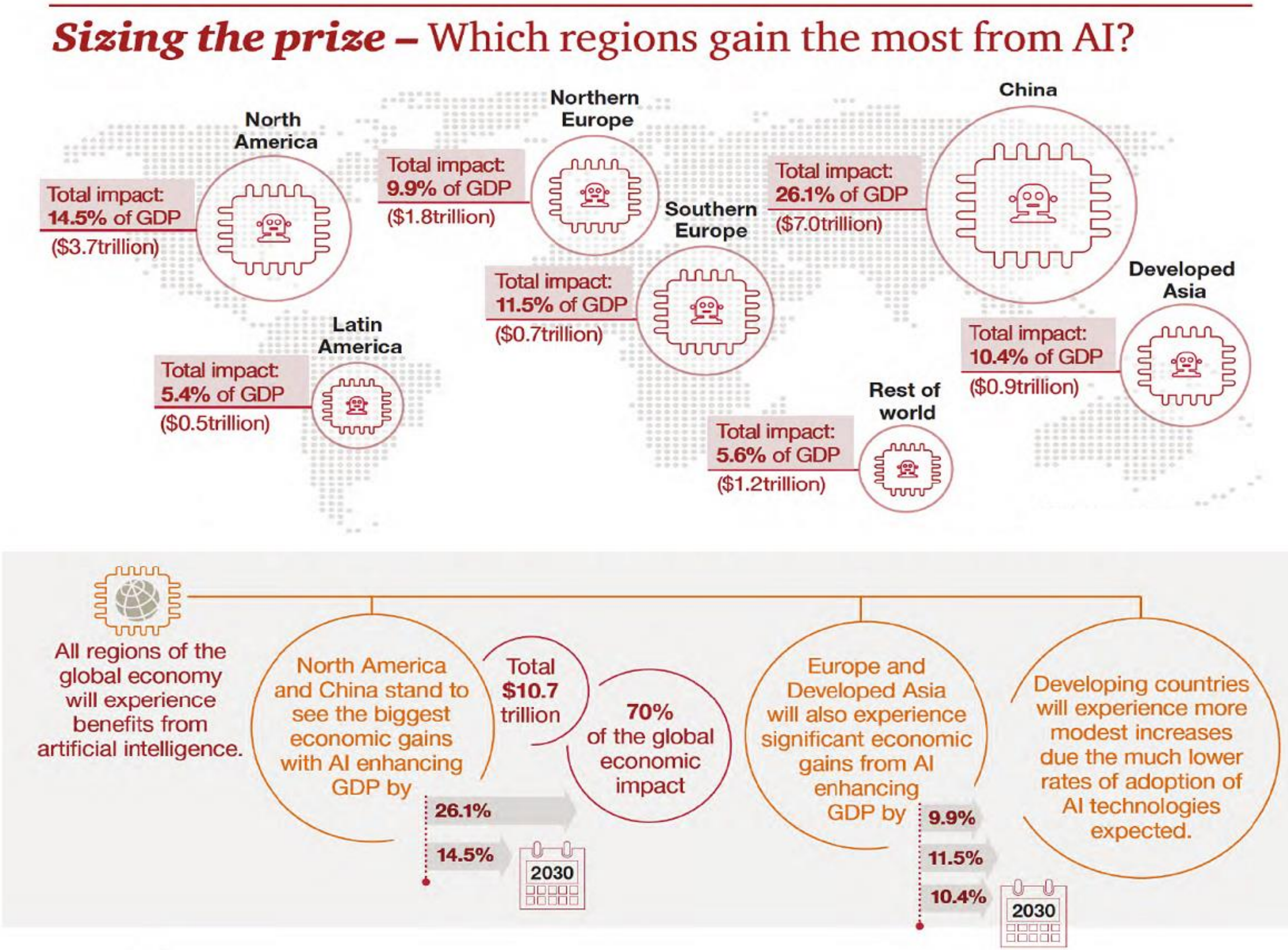
The Turing test has been both highly influential and widely criticised. However, it has become an important concept in the philosophy of artificial intelligence.

The test though was too difficult to achieve without *machine learning* in an adaptive, incremental way.

NOW

"*. . .AI could contribute up to $15.7 trillion to the global economy in 2030, more than the current output of China and India combined. Of this, $6.6 trillion is likely to come from increased productivity and $9.1 trillion is likely to come from consumption... " PwC Report 'Sizing the price', July 2017*

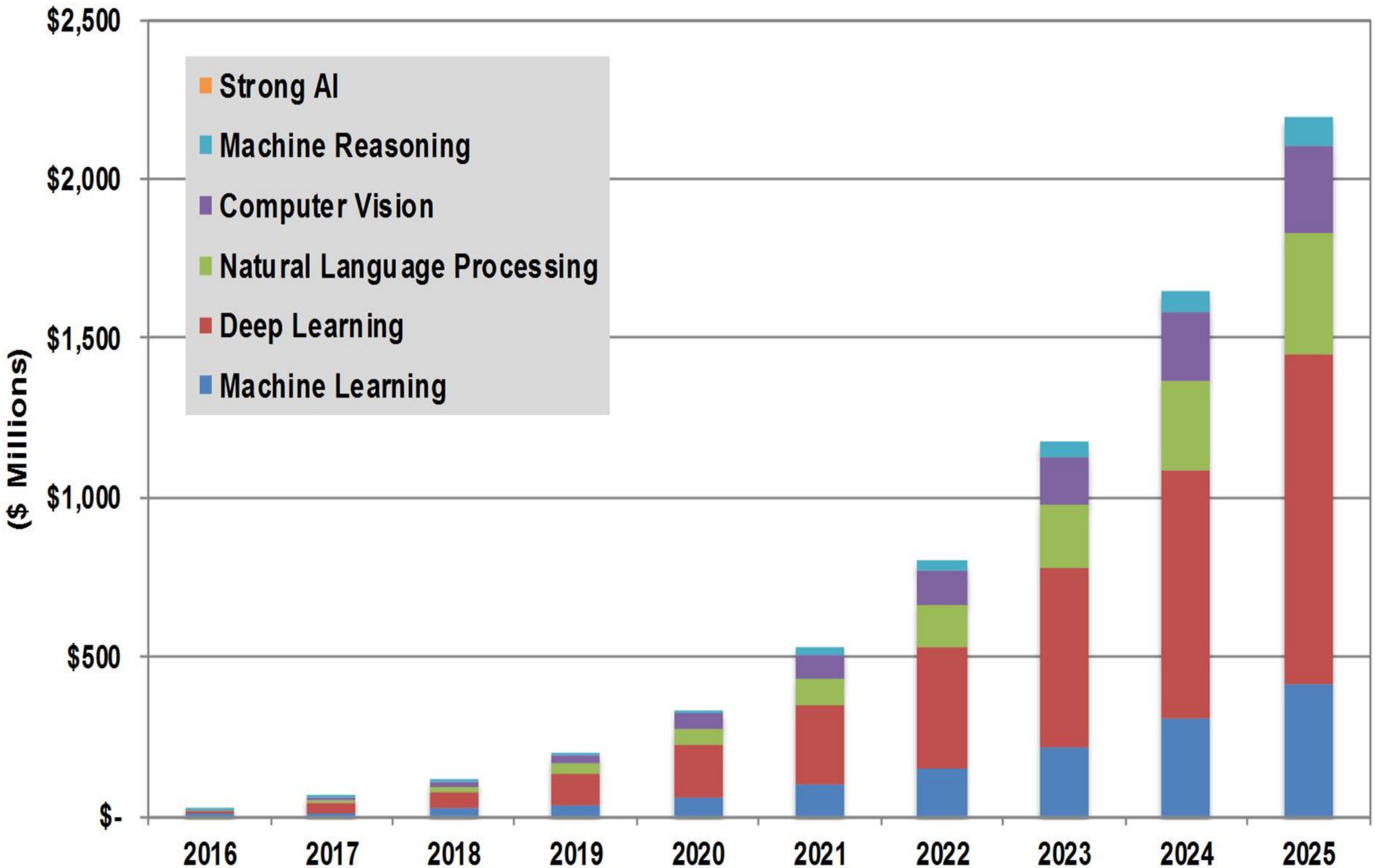
"*The rapid emergence and adoption of artificial intelligence (AI) techniques like machine learning and deep learning are a wakeup call: AI will transform the technology landscape and touch almost every industry over the next 10 years…"*
Tractica - *a market intelligence firm that focuses on human interaction with technology.*



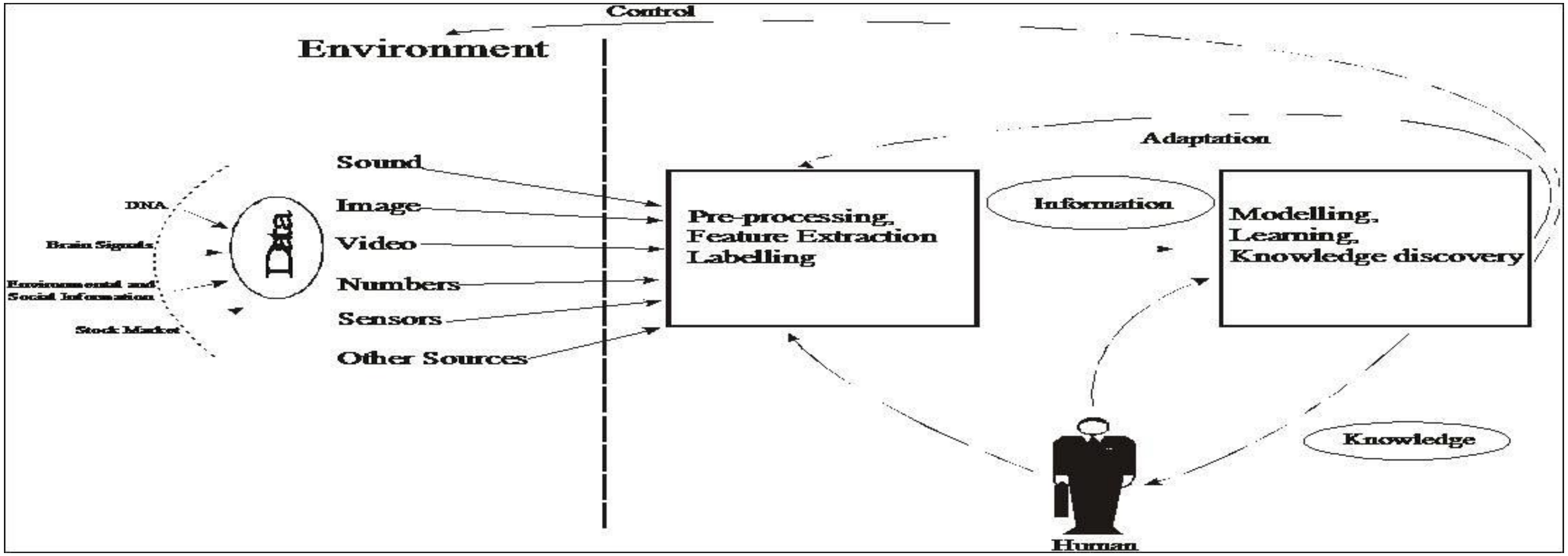
Sizing the prize – Which regions gain the most from AI?
North America
Total impact: 14.5% of GDP ($3.7trillion)
Northern Europe
Total impact: 9.9% of GDP ($1.8trillion)
Southern Europe
Total impact: 11.5% of GDP ($0.7trillion)
China
Total impact: 26.1% of GDP ($7.0trillion)
Developed Asia
Total impact: 10.4% of GDP ($0.9trillion)
Latin America
Total impact: 5.4% of GDP ($0.5trillion)
Rest of world
Total impact: 5.6% of GDP ($1.2trillion)
All regions of the global economy will experience benefits from artificial intelligence.
North America and China stand to see the biggest economic gains with AI enhancing GDP by
26.1%
14.5%
2030
Total $10.7 trillion
70% of the global economic impact
Europe and Developed Asia will also experience significant economic gains from AI enhancing GDP by
9.9%
11.5%
10.4%
2030
Developing countries will experience more modest increases due the much lower rates of adoption of AI technologies expected.

AI Impact Index across sectors

Healthcare AI Revenue by Technology, World Markets: 2016-2025



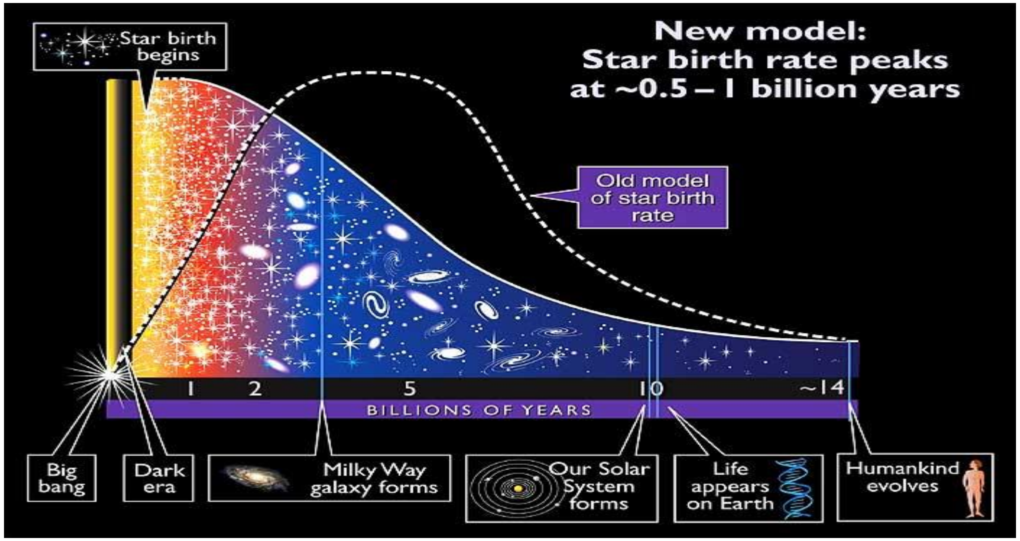
Evolving processes in time and space



- **S**earching: Observe phenomena; Collect data; Store data;
- **A**nalysis (e.g. pre-process data, filter, select features, visualise, label)
- **L**earning (create a model, validation and reasoning)
- **K**nowledge creation (Create/extract rules) and reasoning (deductive, inductive)
- **A**daptation (accommodate new data and knowledge)

Generic AI methods and tools → Specific methods and tools → Application systems

Everything in nature is evolving, changing in Time and Space



Different types of evolving spatio-temporal data:

- Temporal (e.g. climate, financial data, gene expression)
- Spatio-temporal with fixed spatial location, (e.g. brain data; seismic; GPS)
- Spatio-temporal with changing locations of the spatial variables (e.g. moving objects)
- Spectro-temporal data (e.g. radio-astronomy; audio; speech; music)

Different characteristics of STD:

- Sparse features/low frequency (e.g. climate data; ecological data; multisensory data);
- Sparse features/high frequency (e.g. EEG brain signals; seismic data);
- Dense features/low frequency (e.g. fMRI; gene expression data);
- Dense features/high frequency (e.g. radio-astronomy data).

Course References

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Questions, exercises, assignments and project work

1. What is an evolving process?

2. Name one evolving process in nature or in biology and explain it (pages 3-9).

2. Write a mathematical formula to express each of the characteristics of evolving processes following the description on pages 9-15:
(a) frequency;
(b) probability;
(c) entropy;
(d) information.

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