Introduction
to
Artificial Intelligence
(AI)

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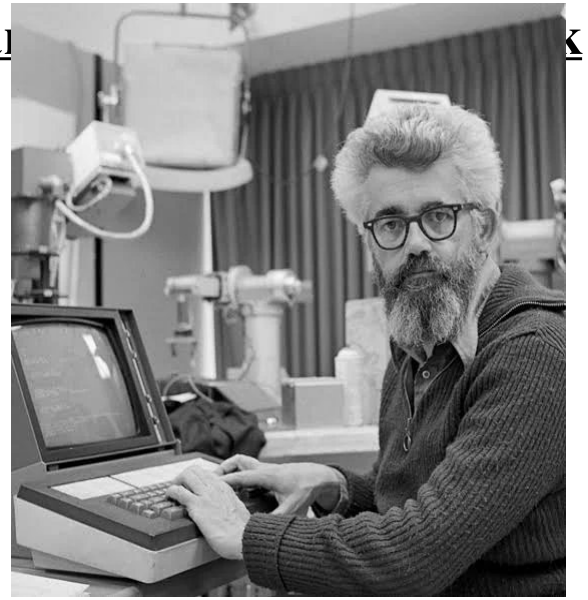
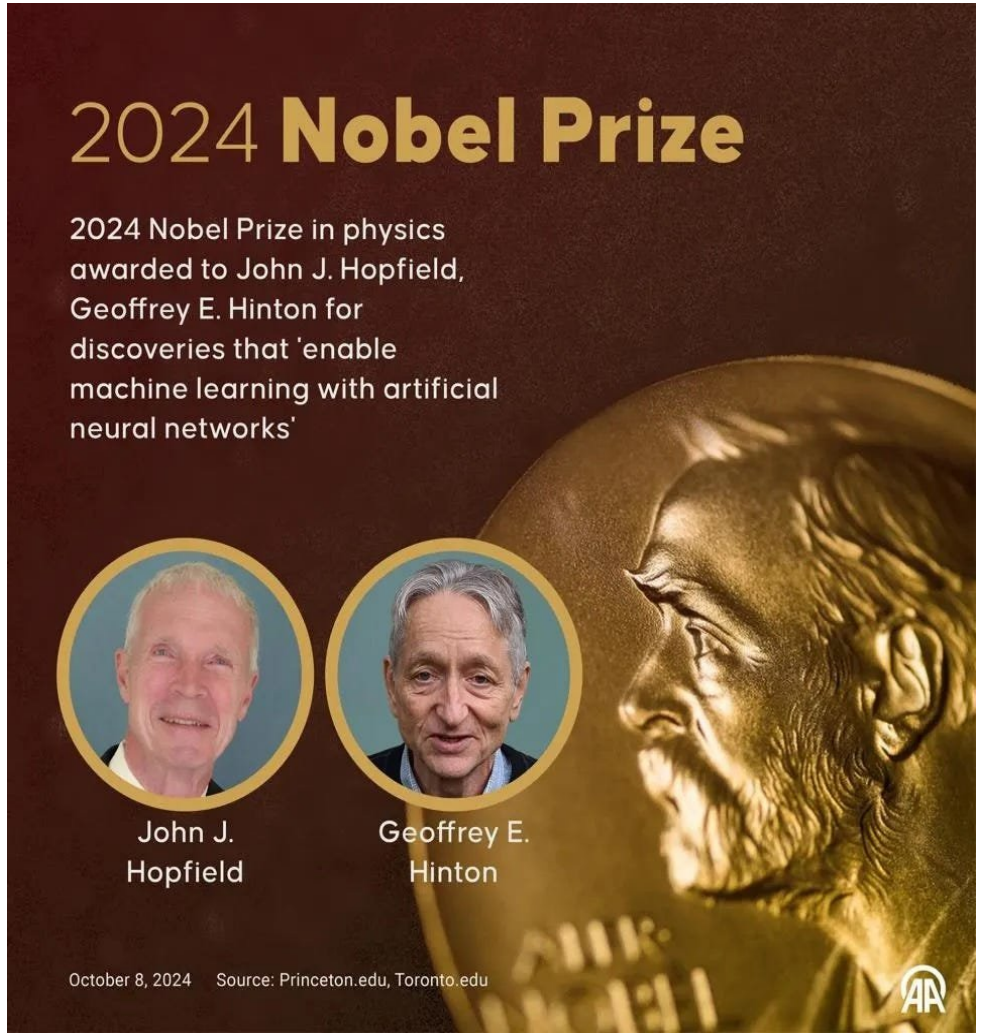
https://www.gcjana.in/courses/shardauniversity/2502/PHD650/

"Father of Artificial Intelligence"

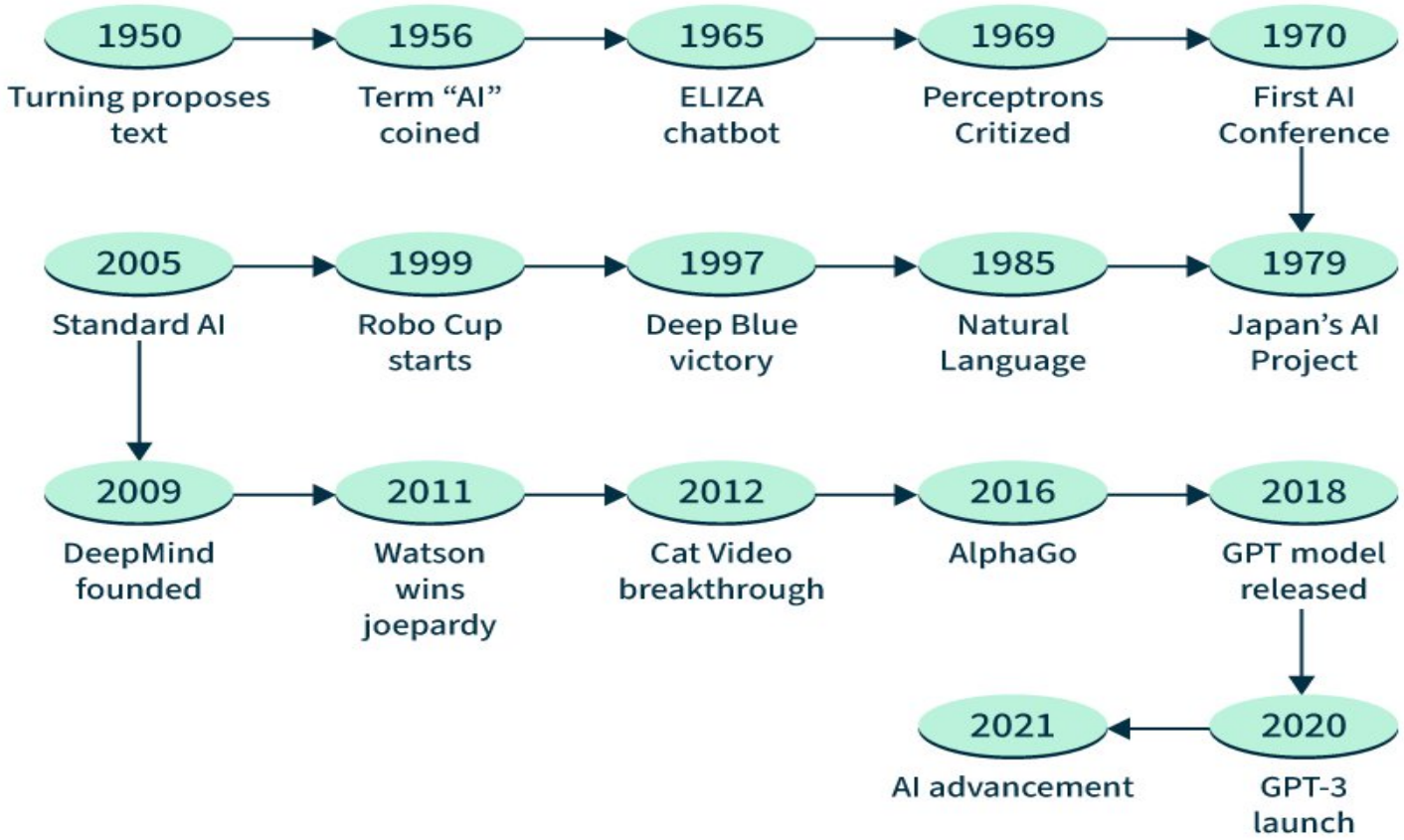
"**Father of Artificial Intelligence**" is most commonly given to **John McCarthy**, an American computer scientist who coined the term "AI" in **1955** and organized the seminal 1956 Dartmouth Workshop, establishing AI as a field.

However, **Geoffrey Hinton**, often called the **"Godfather of AI,"** is crucial for his **deep lea k breakthroughs.** while **Alan Turing** laid the **early theoretical** groundwork, and **Allen Newell & Herbert Simon** created **the first AI program.**

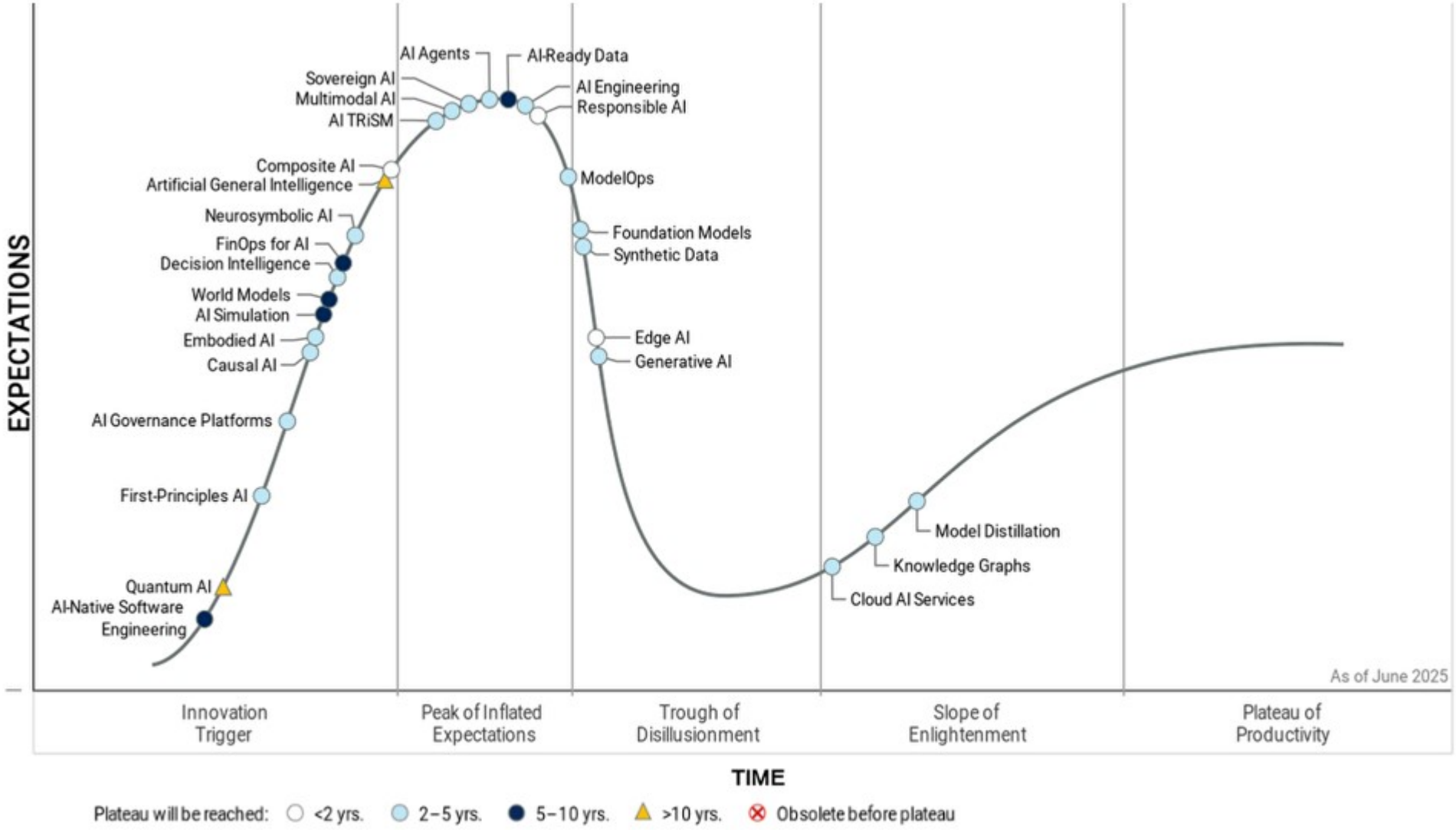




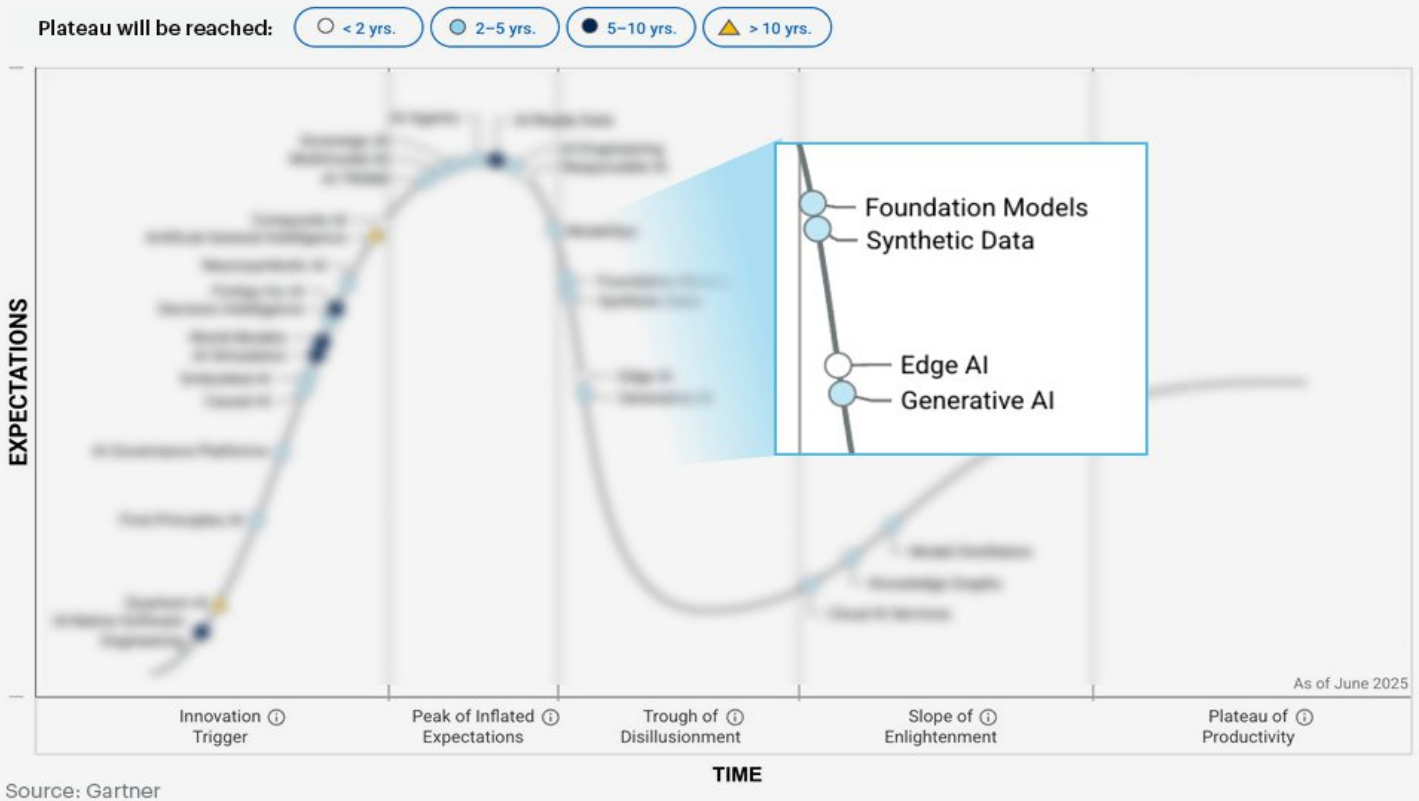
Evolution of AI



Hype Cycle for Artificial Intelligence 2025



The 2025 Hype Cycle for Artificial Intelligence Goes Beyond GenAI



Source: Gartner

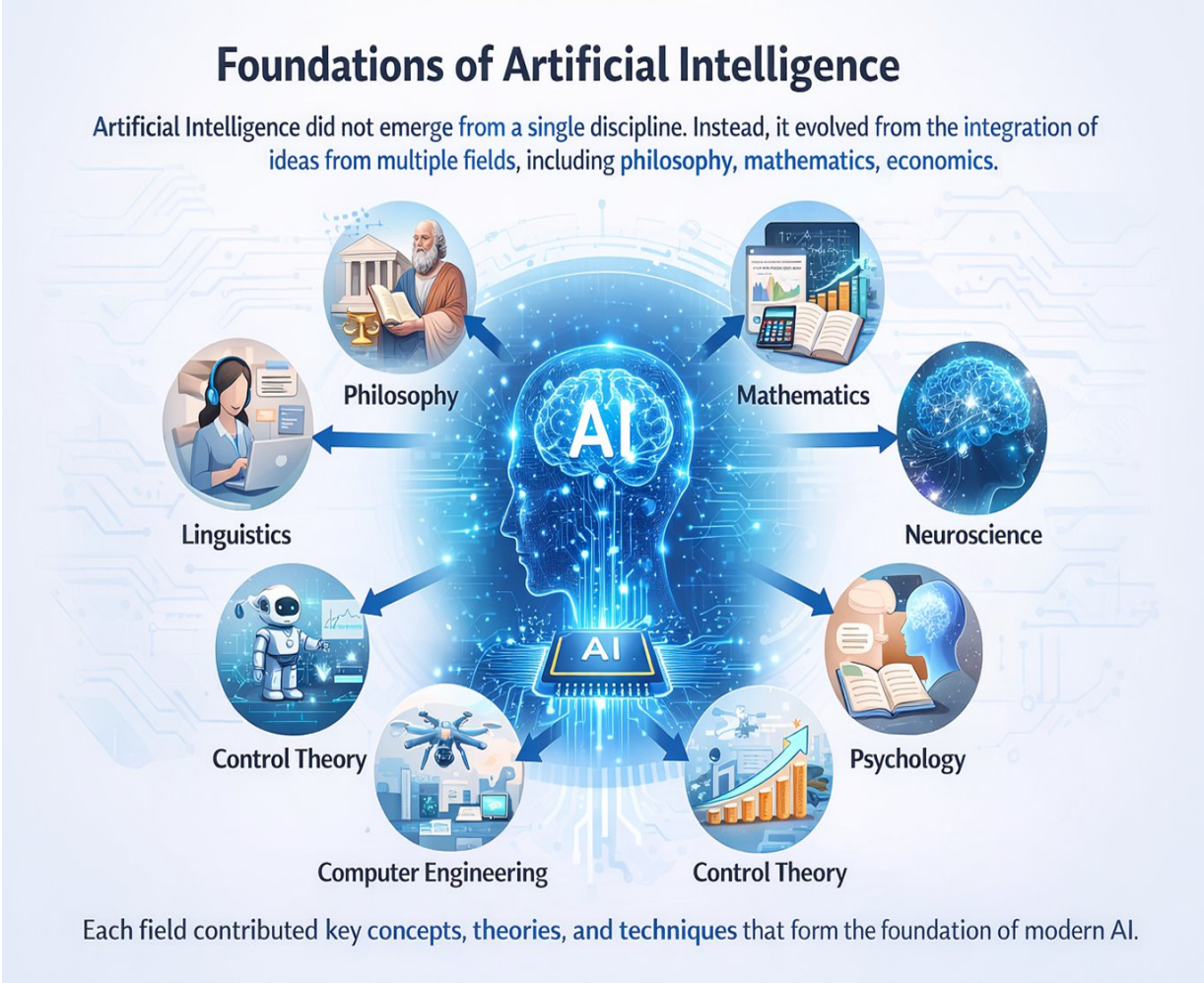
Gartner

A human-centered approach must be in part an empirical science.

Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

The Foundations of Artificial Intelligence

Artificial Intelligence did not emerge from a single discipline. Instead, it evolved from the integration of **ideas from multiple fields, including philosophy, mathematics, economics, neuroscience, psychology, computer engineering, control theory, and linguistics.**



The Foundations of Artificial Intelligence - Philosophy

Key Questions

- Can **formal rules** be used to draw valid conclusions?
- How does the **mind arise from the brain**?
- Where does **knowledge** come from?
- How does knowledge lead to **action**?

Decision Making in Philosophy

Utility Theory - Daniel Bernoulli introduced the concept of utility (subjective value of outcomes).

Utilitarianism - Ethical decisions maximize overall happiness or utility by Jeremy Bentham & John Stuart Mill.

Deontological Ethics - Actions are judged by rules, not outcomes (Immanuel Kant).

Major Contributions:

Logic and Reasoning -Aristotle (384–322 BCE) developed syllogistic logic, enabling structured reasoning from premises to conclusions.

Thinking Machines Concept - Thomas Hobbes (1588–1679) proposed that reasoning is similar to computation (adding and subtracting).

Source of Knowledge - Empiricism (Francis Bacon, John Locke) Knowledge comes from sensory experience.

The Foundations of Artificial Intelligence - Mathematics

Key Questions

- What are the **formal rules of reasoning**?
- What problems are **computable**?
- How can we reason with **uncertainty**?

Major Contributions in Formal Logic:

- **George Boole (1847) -** Developed **Boolean logic**.
- **Gottlob Frege (1879)** - Introduced **First-Order Logic**, enabling reasoning about objects and relations.

- These logical systems became the **foundation of knowledge representation in AI**.

The Foundations of Artificial Intelligence - Probability Theory (Part of Mathematics)

❑ Probability handles **uncertainty in reasoning**.

Probability Theory

- **Gerolamo Cardano** – early probability concepts
- **Blaise Pascal & Pierre Fermat** – probability calculations
- **Thomas Bayes** – **Bayes' theorem** for updating beliefs
- **Pierre Laplace** – statistical reasoning

This led to **modern statistics and machine learning**.

Algorithms

• **Euclid's Algorithm** (for GCD) is one of the earliest algorithms.

• The word **algorithm** comes from **Al-Khwarizmi**, a Persian mathematician.

Algorithms are fundamental to **problem-solving in AI**.

The Foundations of Artificial Intelligence - Mathematics

Computability Theory

- **Kurt Gödel (1931)** - Introduced the **Incompleteness Theorem,** Some truths cannot be proven within a formal system.
- **Alan Turing (1936)** - Proposed the **Turing Machine,** Defined what it means for a function to be **computable**.
- **Church–Turing Thesis** - Any computable function can be computed by a **Turing Machine**.

Complexity Theory

Focuses on **tractability of problems**.

- **Polynomial time** → efficiently solvable
- **Exponential time** → computationally infeasible

NP-Completeness

- Developed by **Cook and Karp**
- Helps classify **hard computational problems**.

The Foundations of Artificial Intelligence - Economics

Economics

- How should we make decisions so as to maximize payoff ?
- How should we do this when others may not go along ?
- How should we do this when the payoff may be far in the future ?

Payoff can be:

- Profit (money)
- Reward (in AI systems)
- Satisfaction (utility)

Concept:

- If outcomes are certain → choose the best option directly
- If uncertain → use **expected value**

Example:

- Option A: ₹100 guaranteed
- Option B: 50% chance of ₹250

Expected value of B = 0.5 × 250 = ₹125 → Better than A

- So, a rational agent selects **Option B**

The Foundations of Artificial Intelligence - Economics

Economics

- How should we make decisions so as to maximize payoff ?
- **How should we do this when others may not go along ?**
- should we do this when the payoff may be far in the future ?

This introduces **strategic decision-making** → studied in **Game Theory**

- Your decision depends on **others' actions**
- Common in:
  - Auctions
  - Negotiation
  - Multi-agent AI systems

Key Idea:

- You must consider:
  - ✓ What others might do
  - ✓ Their incentives

Example: Prisoner's Dilemma

- Two criminals decide whether to confess
- Best joint outcome ≠ best individual decision
- Leads to concept of:
- **Nash Equilibrium**: No player benefits by changing strategy alone

The Foundations of Artificial Intelligence - Economics

Economics

- How should we make decisions so as to maximize payoff ?
- How should we do this when others may not go along ?
- **Should we do this when the payoff may be far in the future ?**

This introduces **time and uncertainty**

- Future rewards are usually **discounted**
- Humans and AI both prefer **immediate rewards**

Example:

- ₹100 today vs ₹100 after 1 year
- Present value of future money is less

Concept: Discounting

Future value is reduced using a **discount factor (γ)**

- If γ is close to 1 → future matters a lot
- If γ is small → focus on immediate rewards

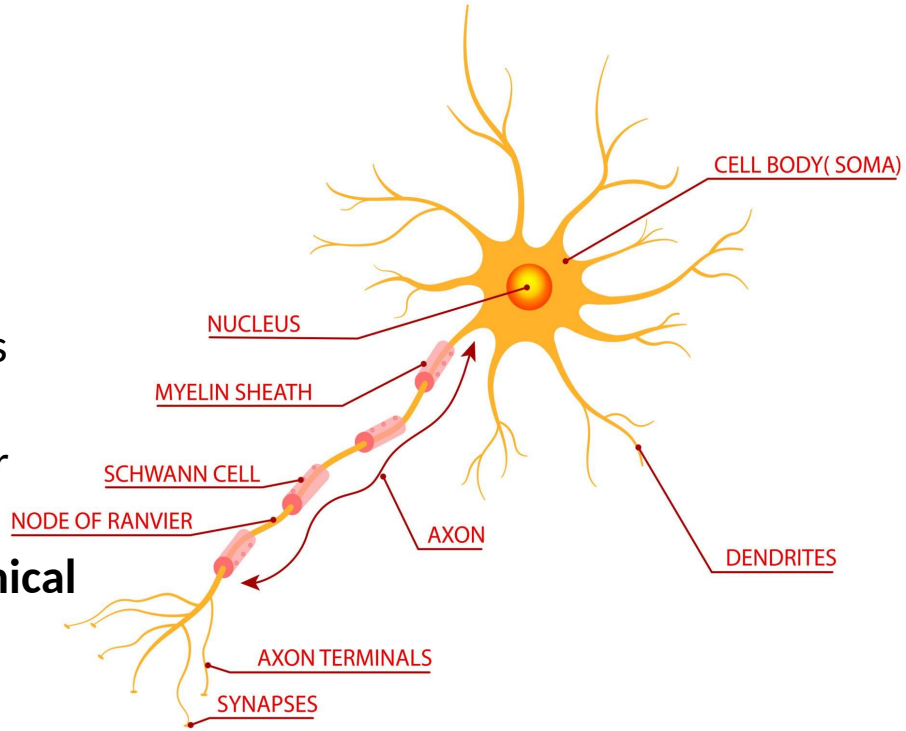
The Foundations of Artificial Intelligence - Neuroscience

❖ How do brains process information?

1. Basic Unit: The **Neuron**
2. Signal Transmission (**Synapse**)
3. Learning in the Brain (Hebbian Learning)
4. Parallel Processing
5. From Brain Network to Neural Network

- ❖ The brain is made up of **billions of neurons**
- ❖ Each neuron has:
  - **Dendrites** → receive signals
  - **Cell body (soma)** → processes signals
  - **Axon** → sends signals to other neurons

Information flows as **electrical + chemical signals**



The Foundations of Artificial Intelligence - Psychology

❖ How do humans and animals think and act?

1. **Perception** (Understanding the Environment) – For human: Vision, Hearing , Touch and AI Agent/System: Cameras, sensors = **input devices**
2. **Learning** (Experience-Based Adaptation) - Behavior improves through experience: **Classical Conditioning** (learning by association) and **Operant Conditioning** (learning by reward/punishment), This inspires **Machine Learning** and **Reinforcement Learning**
3. **Memory** (Storage and Recall) - Information is stored in Short-term memory and Long-term memory, Data storage, trained models = **memory representation**
4. **Decision Making** - Humans choose actions based on: Experience, Emotions, and Goals. AI Agent/system: Decision-making models, search algorithms, and planning.
5. **Behavior (Action)** - Final outcome of thinking = **action,** Behavior depends on: Internal state (hunger, fear), External environment.
6. **Cognitive Architecture (Thinking Process)** - Psychology studies: Reasoning, Problem-solving, Attention

The Foundations of Artificial Intelligence - Computer Engineering

❖ How can we build an efficient computer?

1. **Efficient Hardware Design** - Faster hardware = faster AI computation.
2. **Algorithms and Data Structures** - Choosing better algorithms drastically improves performance.
3. **Parallel and Distributed Computing** - Training deep learning models on clusters.
4. **Memory and Storage Optimization** - Reduce memory access time, Use caching effectively.
5. **Energy and Cost Efficiency** - Efficient computers should: Use less power, Reduce cost.
6. **Reliability and Scalability** - Systems should: Handle failures, Scale with increasing data, use of Cloud computing platforms.

The Foundations of Artificial Intelligence - Control theory and cybernetics

❖How do systems regulate themselves and behave intelligently ?

1. **Control Theory** - Maintaining room temperature using an AC automation.

2. **Feedback Mechanism** (Core Idea) – Thermostat: Desired temp = 24°C, If room < 24 → heater ON, If room > 24 → heater OFF.

3. **Cybernetics** - Both humans and machines use feedback to adapt

4. **Components of a Control System** - Sensor → measures environment, Controller → decides action, Actuator → performs action.

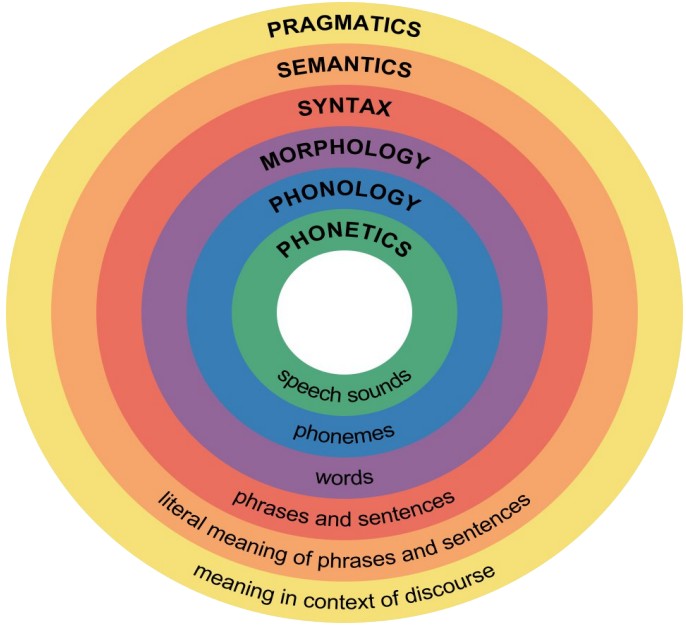
5. **Open Loop vs Closed Loop**

Type	Description	Example
Open Loop	No feedback	Washing machine timer
Closed Loop	Uses feedback	Thermostat

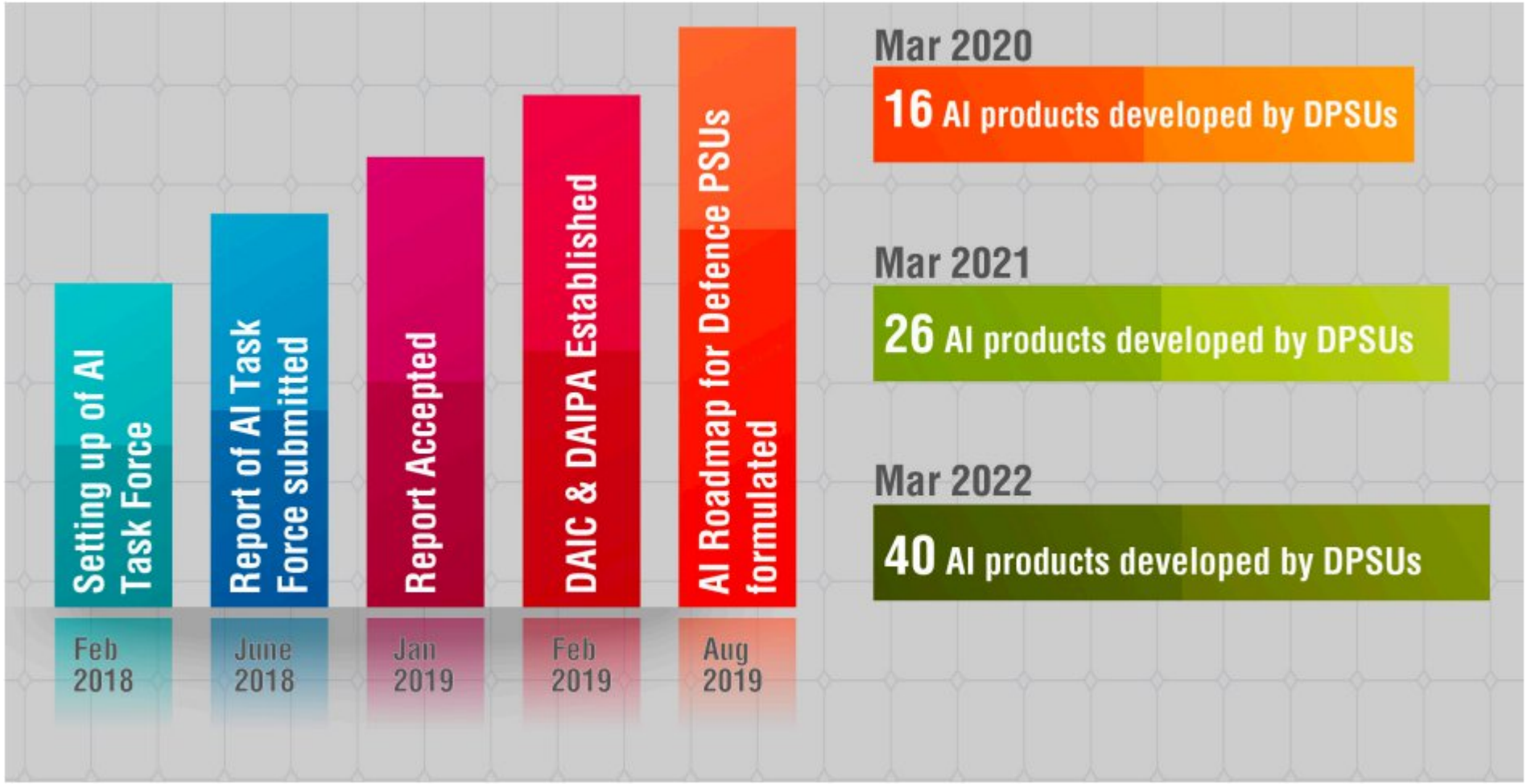
The Foundations of Artificial Intelligence - Linguistics

❖ How does language relate to thought?

1. **Language as a Medium of Thought** - Language is not just communication — it helps us **think and organize ideas using** Words, Sentences, and Symbols. In AI, Language becomes a way to **represent knowledge.**
2. **Structure of Language** (Levels of Linguistics)
3. **Language and Meaning** (Semantics)
4. **Language and Reasoning**
5. **Natural Language Processing** (NLP)



Applications:- Indian Defence Sector Initiatives



Source: https://www.ddpmod.gov.in/sites/default/files/2023-11/ai.pdf

Summary: AI Perspectives and Development

Artificial Intelligence (AI) can be approached from different perspectives based on two key questions:

- Should AI focus on **thinking vs. behavior**?
- Should it **model human intelligence or aim for optimal (rational) performance**?

The **standard view of AI** emphasizes **rational action**, where an intelligent agent selects the best possible action in a given situation. However, this idea is refined by recognizing that:

- Perfect rationality is limited by **computational constraints**.
- AI systems should **serve human interests**, even when their exact objectives are uncertain.

Summary: Interdisciplinary Foundations of AI

AI has evolved through contributions from multiple fields:

- **Philosophy**: Viewed the mind as a machine using internal representations.
- **Mathematics**: Enabled logical reasoning, probability, and algorithm design.
- **Economics**: Introduced decision-making based on **expected utility**.
- **Neuroscience**: Provided insights into brain functioning.
- **Psychology & Linguistics**: Modeled humans as information-processing systems.
- **Computer Engineering & Software**: Built powerful and usable AI systems.
- **Control Theory**: Focused on optimal decision-making using feedback.

Summary: Evolution and Progress of AI

- AI development has experienced cycles of **optimism, setbacks, and innovation**.
- The field has progressed from:
  - **Boolean logic → Probabilistic reasoning**
  - **Handcrafted knowledge → Machine learning from data**
- These advances have improved real-world applications and interdisciplinary integration.

Summary: Current Challenges and Future Concerns

- Growing deployment of AI raises **ethical, safety, and societal risks**.
- A major long-term challenge is **controlling superintelligent AI systems**, which may behave unpredictably.
- Addressing this requires **rethinking traditional AI concepts and goals**.

Thank You!

Post your doubts: https://www.gcjana.in/courses/shardauniversity/2502/PHD650/#Post-doubts