Introduction to Artificial Intelligence (AI)

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AI in the News

- **Two 2024 Nobel Prizes for AI**
  - **Physics:** Artificial neural networks
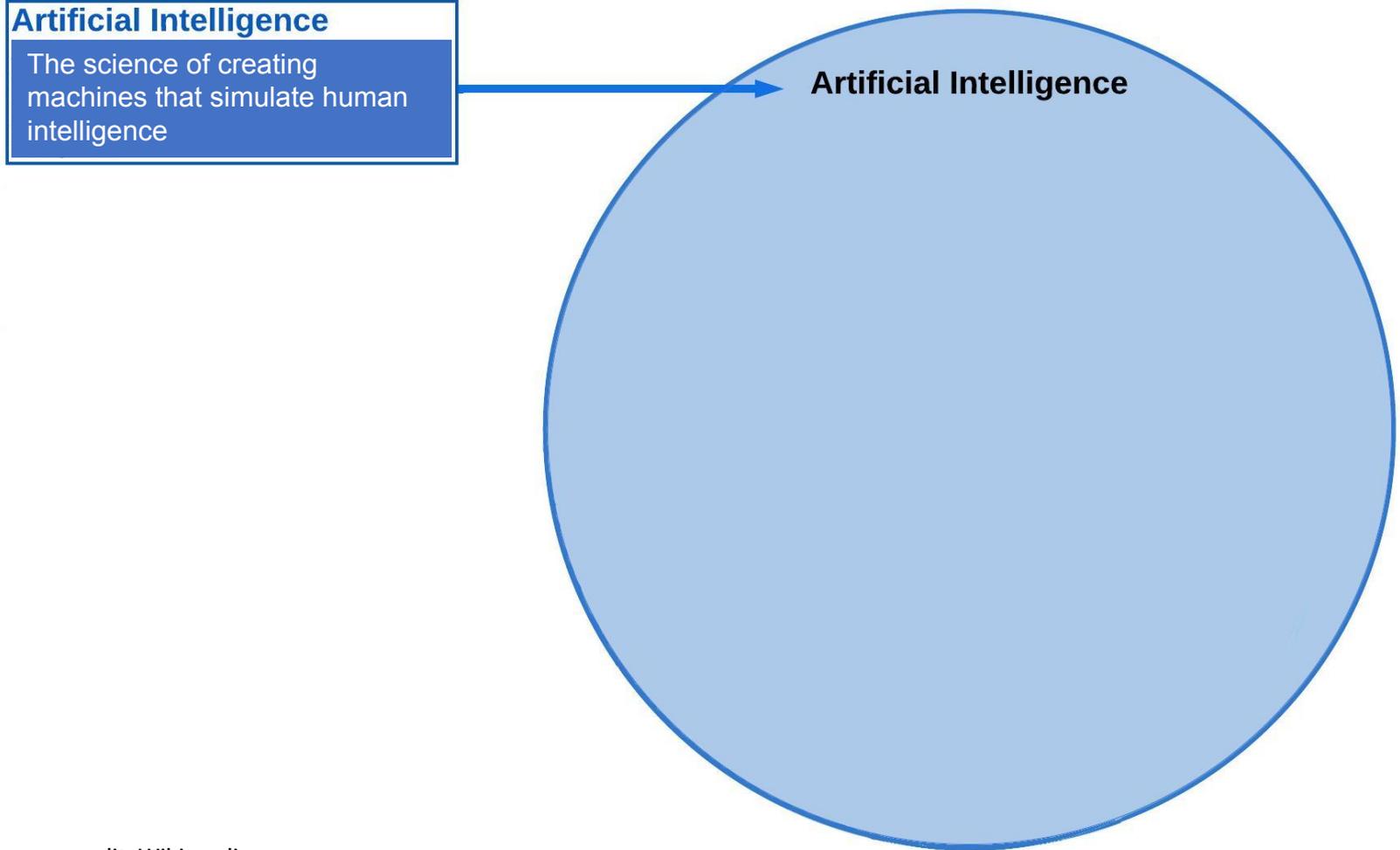 - **Chemistry:** AI solved protein folding

Outline

Artificial Intelligence

Machine Learning

Deep Learning

Generative AI

Image credit: Google
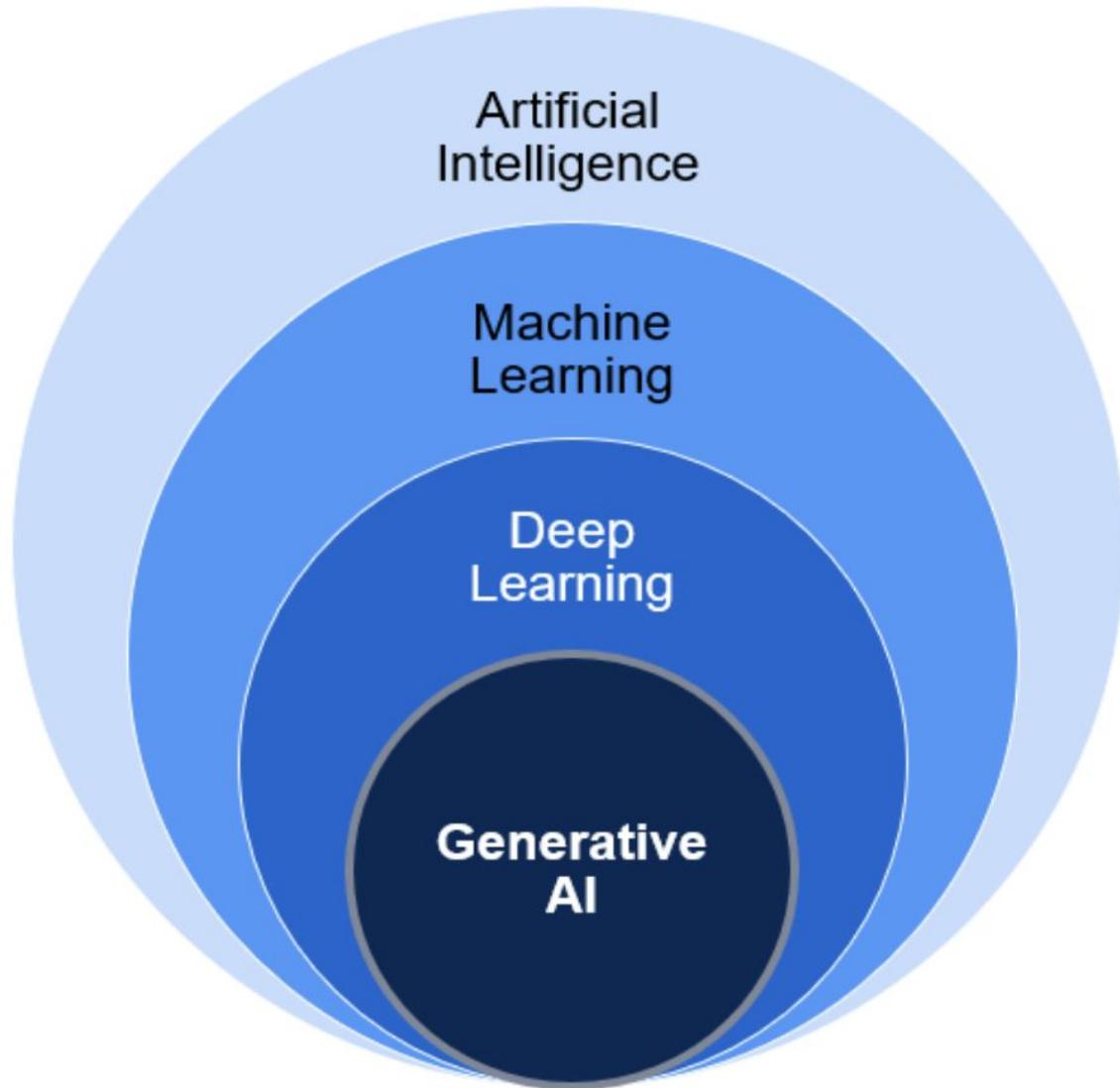
Artificial Intelligence (AI)

Artificial Intelligence

The science of creating machines that simulate human intelligence

Artificial Intelligence

AI Types

Narrow AI
Now

Image credit: Google

AI Techniques

Top 4 Techniques of Artificial Intelligence

Machine Learning

Machine Learning (ML)

Artificial Intelligence

Machine Learning

The science of enabling machines to learn from data

Artificial Intelligence

Machine Learning

Image credit: Wikimedia

DATA (INPUT) 3, 4

f

Machine Learning

f(3, 4) = 7

Output

Program

Image credit: Google

Machine Learning (ML)

Get Data

1

Image credit: Google
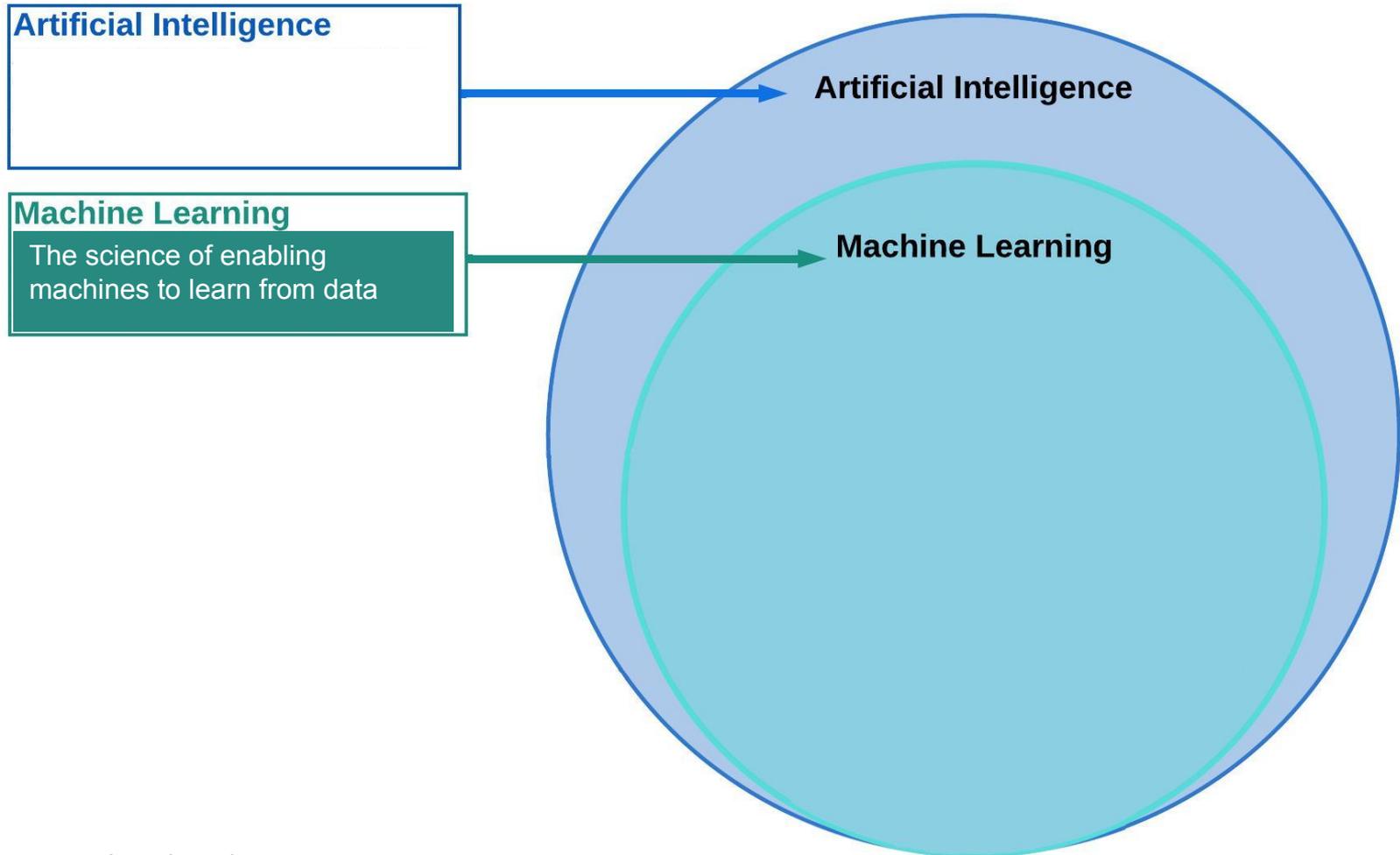
Machine Learning (ML)

Underfit
(high bias)
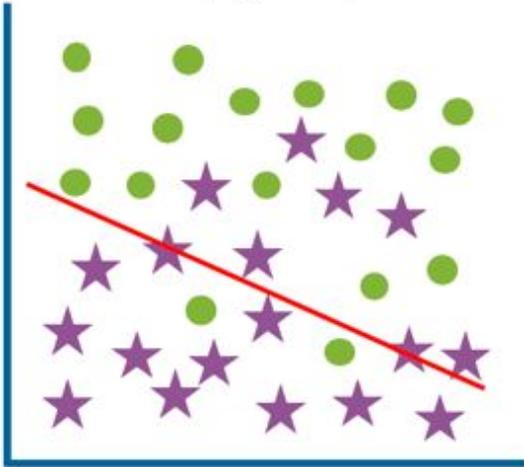
High training error
High test error

Image credit: Google

Machine Learning (ML) Types

Machine Learning

Supervised machine learning

$[x_1, x_2, x_3], y$

Image credit: Microsoft

Deep Learning (DL)

Artificial Intelligence

Machine Learning

Deep Learning
The science of using neural networks to learn patterns

Artificial Intelligence

Machine Learning

Deep Learning

Image credit: Wikimedia
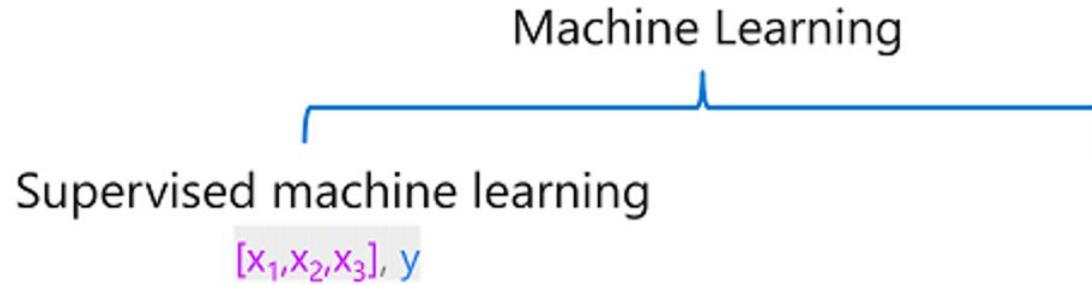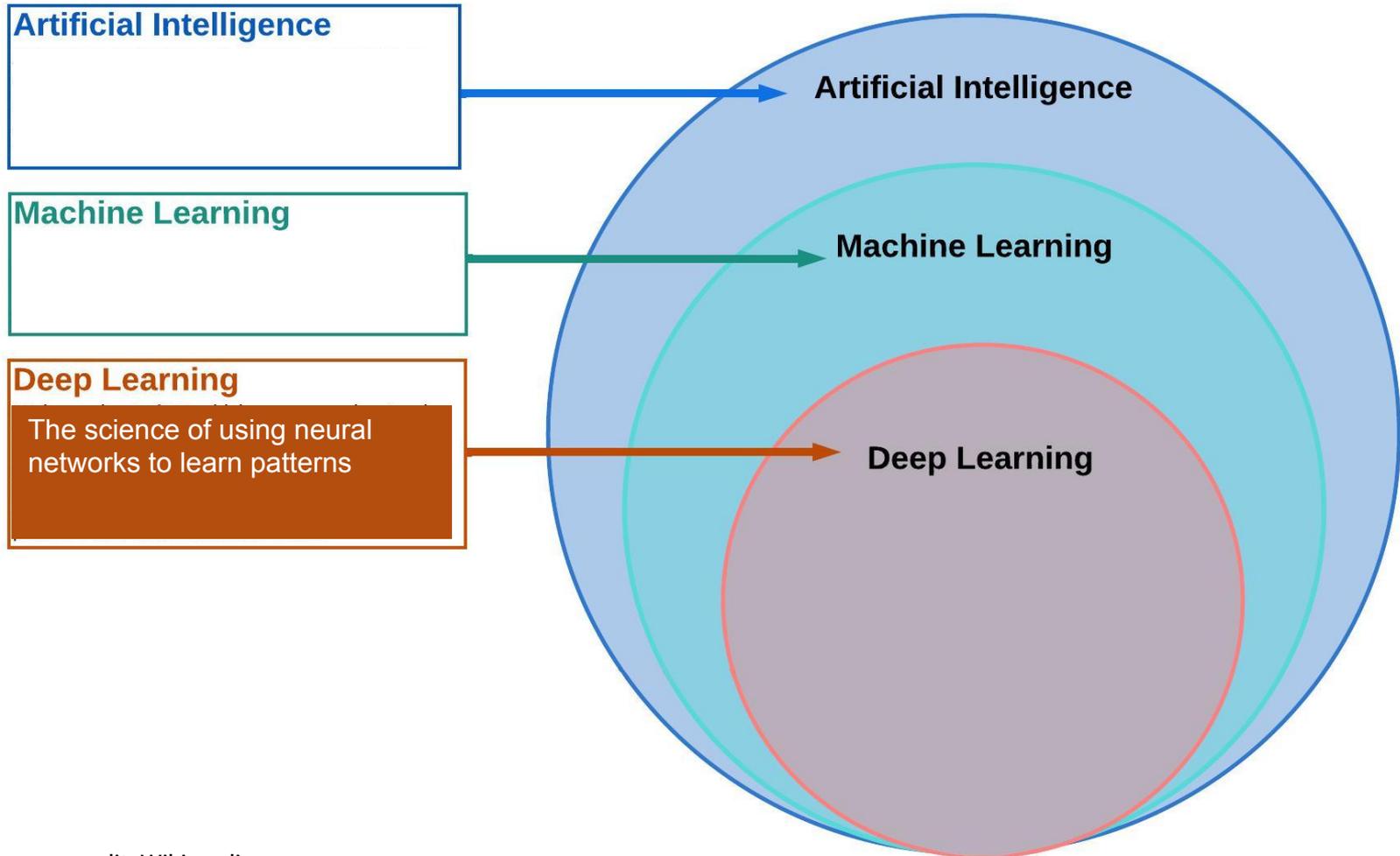
Biological vs Artificial Neuron

Biological neuron

Image credit: Google
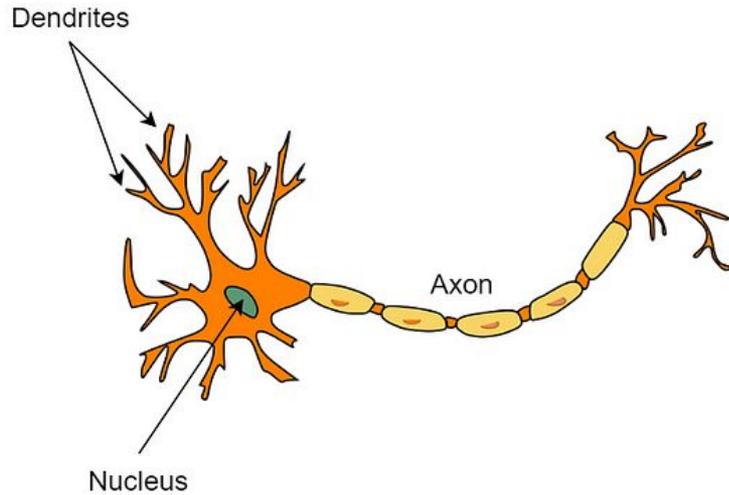
Learning: Biological vs Artificial Neural Network
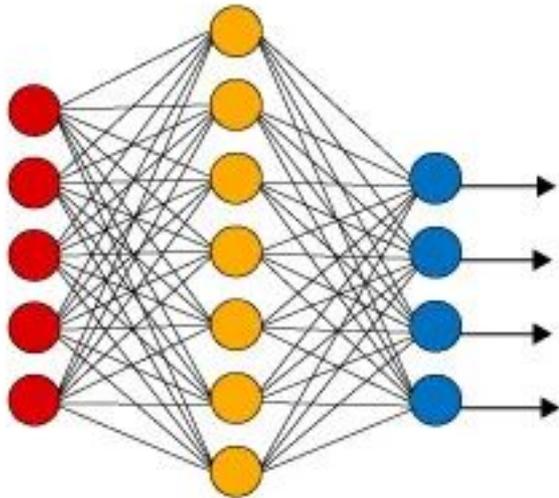

BIOLOGICAL NEURON

SYNAPSE

STRONGER

WEAKER
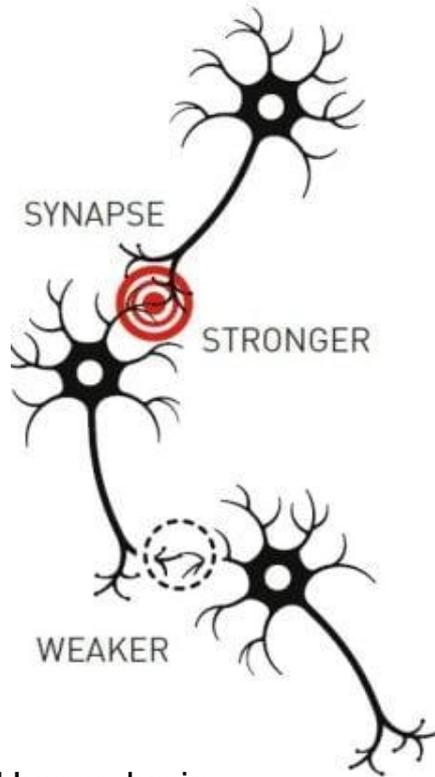
Human brain
100B (1B=1K M) Neurons
100T (1T=1M M) Synapses

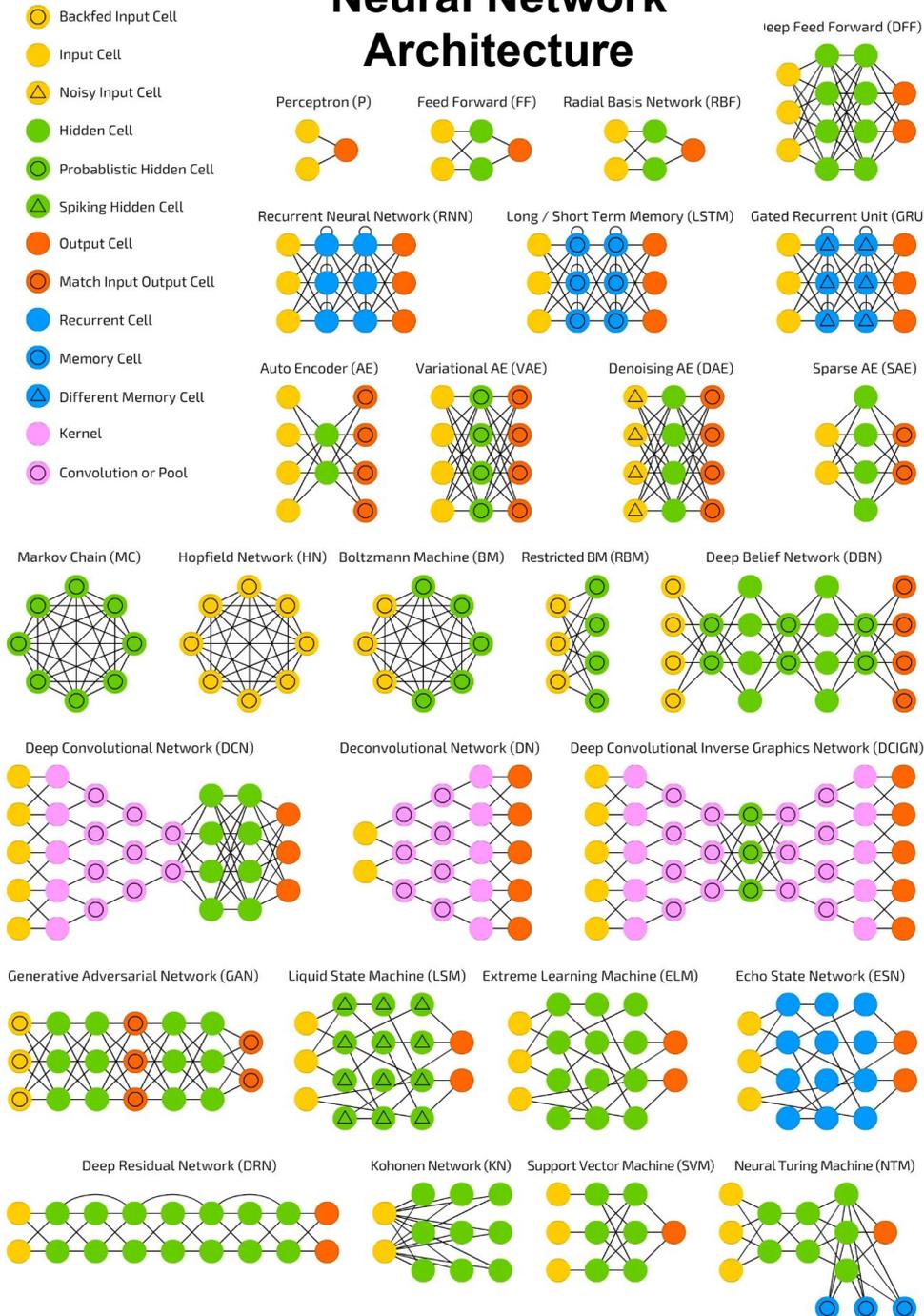# Artificial Neural Network (ANN)

Simple Neural Network

● Input Layer   ● Hidden Layer   ● Output Layer

Image credit: Google

Neural Network Architecture

Transformer Architecture
Generated Pre-Trained Transformer (GPT)

Legend:
- Backfed Input Cell
- Input Cell
- Noisy Input Cell
- Hidden Cell
- Probablistic Hidden Cell
- Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Different Memory Cell
- Kernel
- Convolution or Pool

Perceptron (P)

Feed Forward (FF)

Radial Basis Network (RBF)

Deep Feed Forward (DFF)

Recurrent Neural Network (RNN)

Long / Short Term Memory (LSTM)

Gated Recurrent Unit (GRU)

Auto Encoder (AE)

Variational AE (VAE)

Denoising AE (DAE)

Sparse AE (SAE)

Markov Chain (MC)

Hopfield Network (HN)

Boltzmann Machine (BM)

Restricted BM (RBM)

Deep Belief Network (DBN)

Deep Convolutional Network (DCN)

Deconvolutional Network (DN)

Deep Convolutional Inverse Graphics Network (DCIGN)

Generative Adversarial Network (GAN)

Liquid State Machine (LSM)

Extreme Learning Machine (ELM)

Echo State Network (ESN)

Deep Residual Network (DRN)

Kohonen Network (KN)

Support Vector Machine (SVM)

Neural Turing Machine (NTM)

Transformer Architecture diagram

Output Probabilities

Softmax

Linear

Add & Norm

Feed Forward

Add & Norm

Multi-Head Attention

Add & Norm

Feed Forward

Add & Norm

Multi-Head Attention

Add & Norm

Masked Multi-Head Attention

Nx

Nx

Positional Encoding

Positional Encoding

Input Embedding
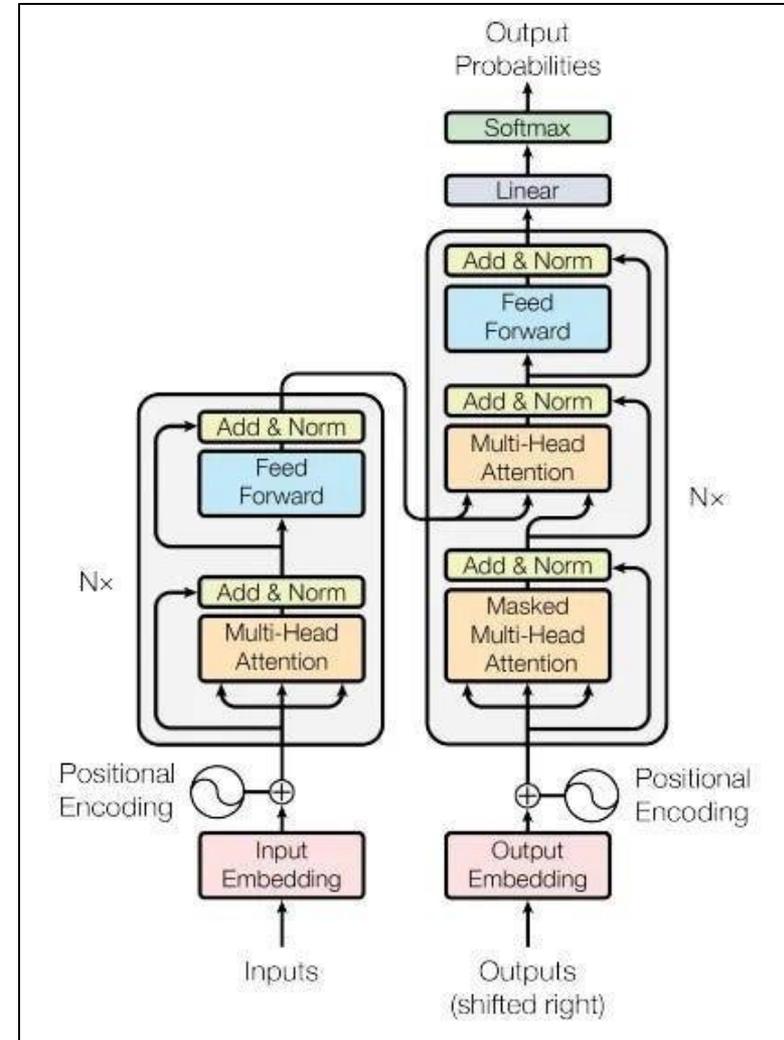
Output Embedding

Inputs

Outputs (shifted right)

Image credit: Google

Generative AI (genAI or gAI)

Artificial Intelligence

Machine Learning

Deep Learning

Generative AI

The science of enabling machines to create new content (text, images, audio, video, etc.) from learned patterns

Artificial Intelligence

Machine Learning

Deep Learning

Generative AI

Image credit: Wikimedia
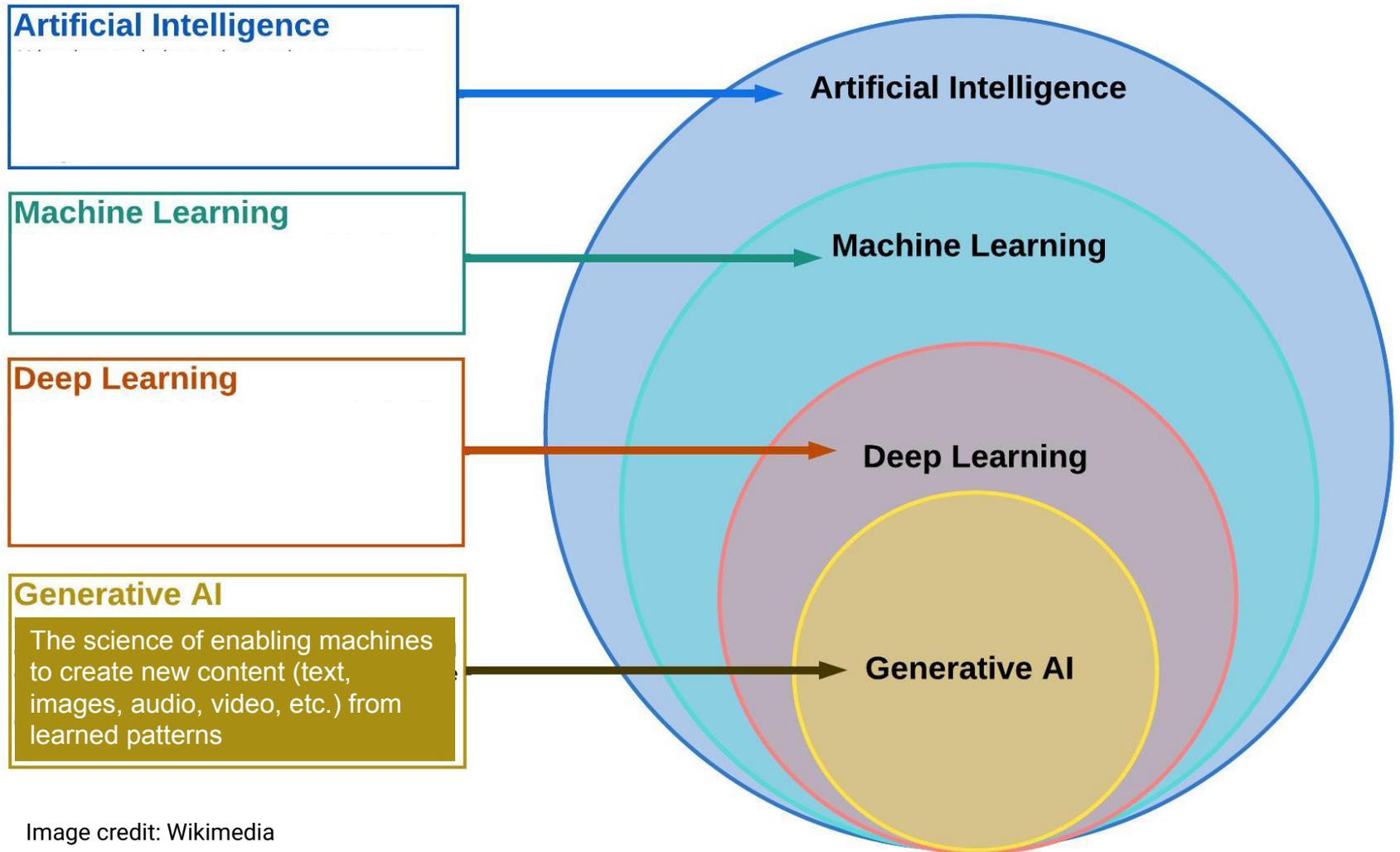
Large Language Models (LLMs)
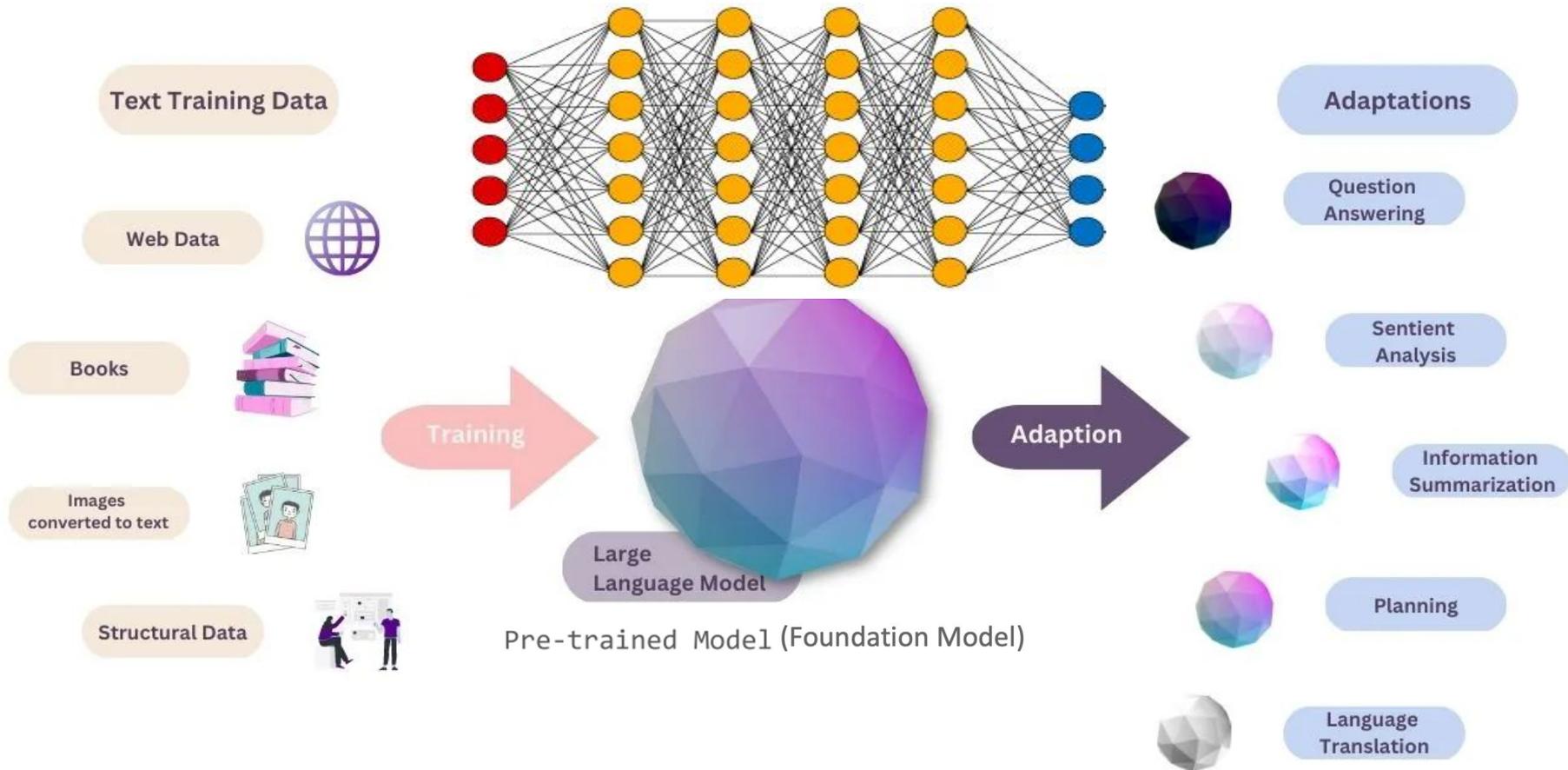
LLM Size

Small models (<= 100b parameters)
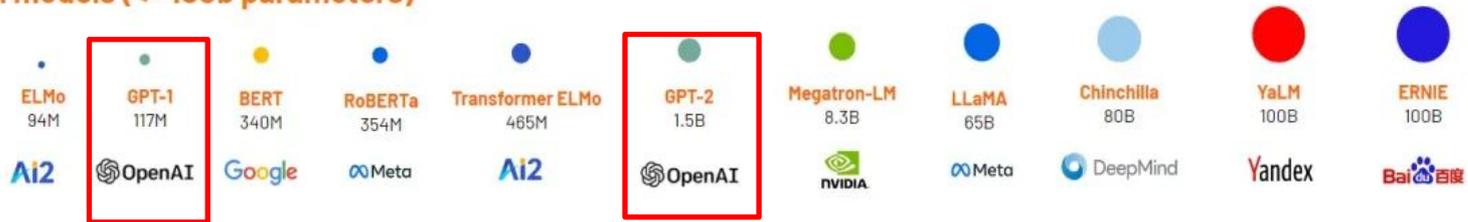
LLM Cost (Training)

Image credit: Google

1B = 1K M
1T = 1M M
1P = 1K T

100B petaFLOP/month = 25K homes electricity/year
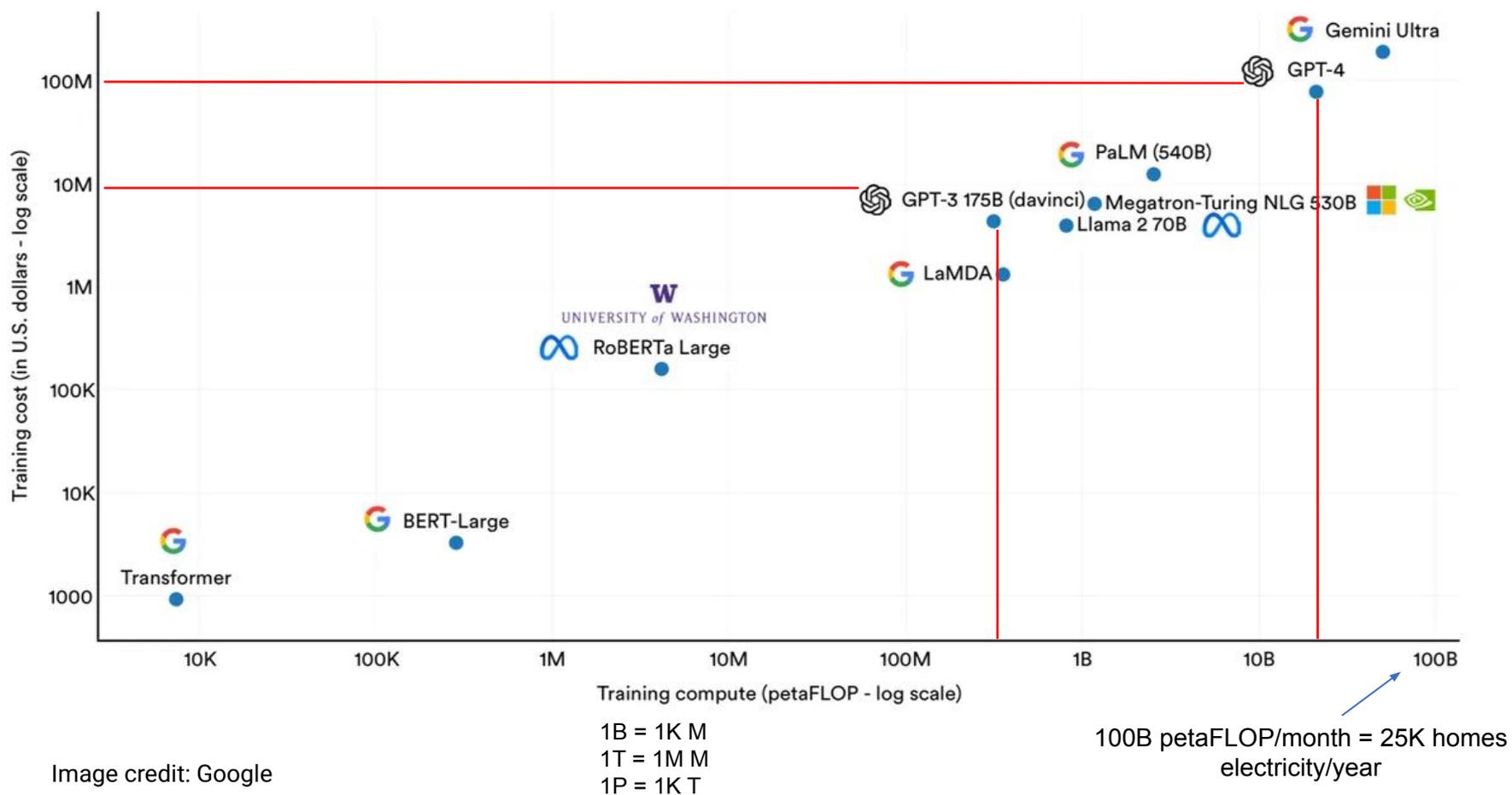
Enhancing LLMs

Trains model from scratch

Retrieval Augmented Generation(RAG)

Question → Large Language Model → Response

Image credit: Google

Retrieval Augmented Generation(RAG)

Without RAG: LLM model has to be the only source of knowledge

Without RAG

Ungrounded hallucination

Old information

No idea what that means

Not my data
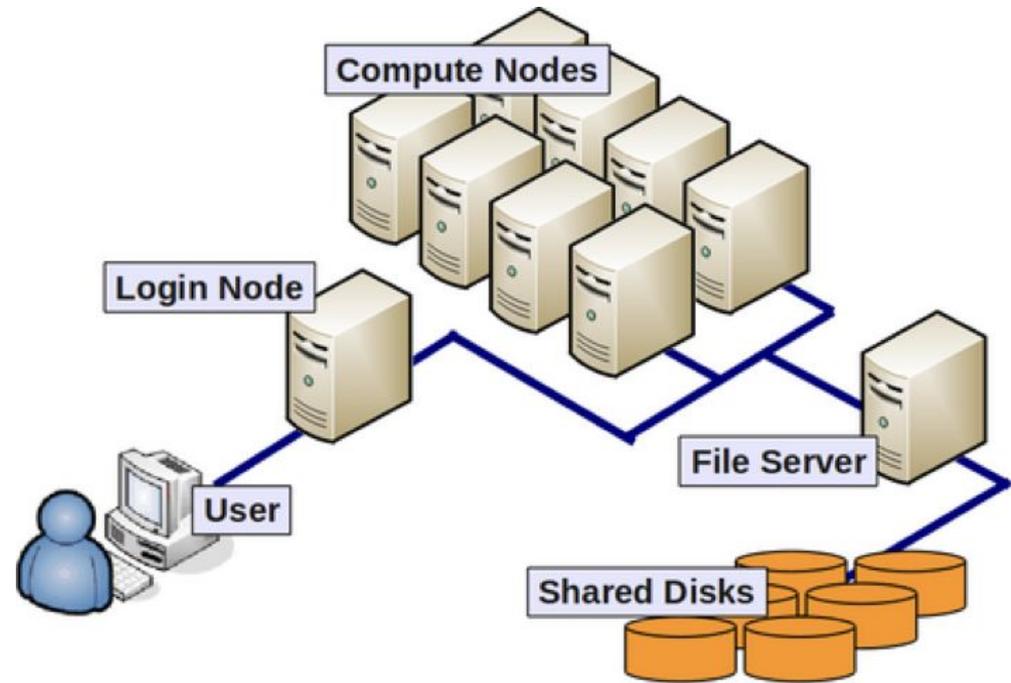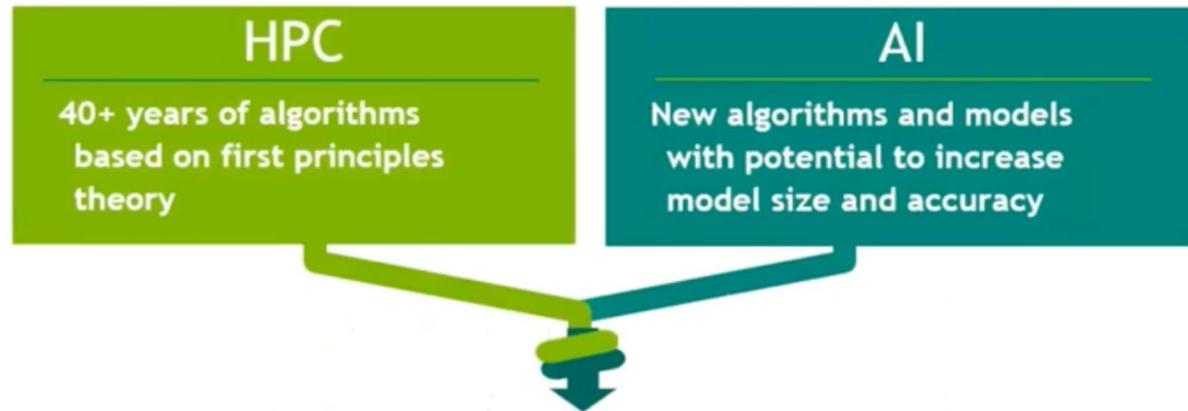
Image credit: Google

High-Performance Computing (HPC)

Compute Nodes

Login Node

User

File Server

Shared Disks

AI and High-Performance Computing (HPC)

Image credit: Google

AI Summary

Artificial Intelligence
Simulate human intelligence

Machine Learning
Learn patterns from data

Deep Learning
Use neural networks to learn patterns

Generative AI
Create new content from learned patterns

Large Language Model (LLM)
Learn to understand natural language

Artificial Intelligence

Machine Learning

Deep Learning

Generative AI

LLM

Image credit: Wikimedia
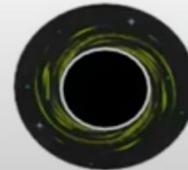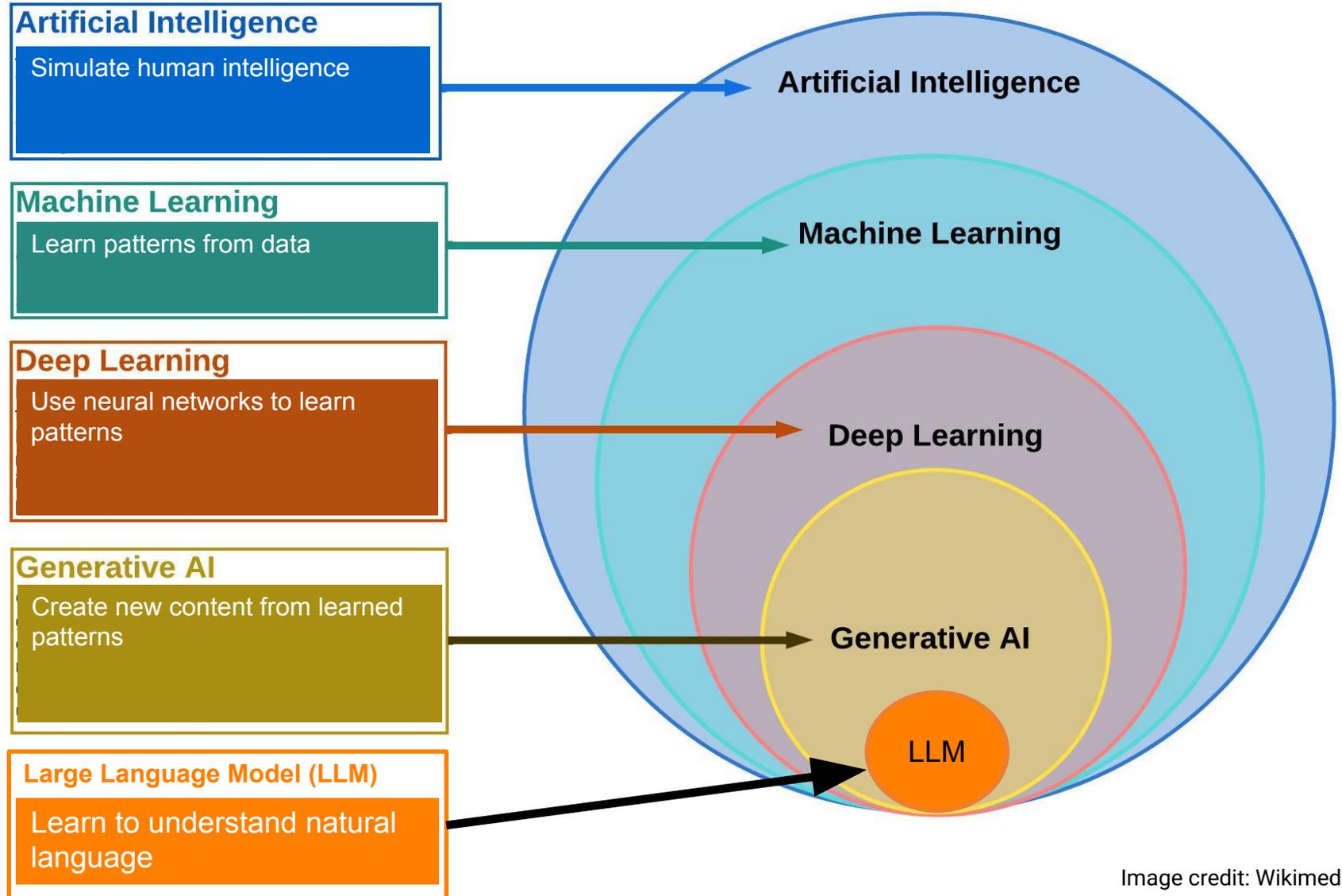
Essential AI Skills to Accelerate Research

AI in Education
The usage of AI tools in teaching and learning

AI Literacy
The foundational understanding of AI, how it works, how to use it, and the risks of usage

AI Education
AI Literacy + the technical skills required to build AI
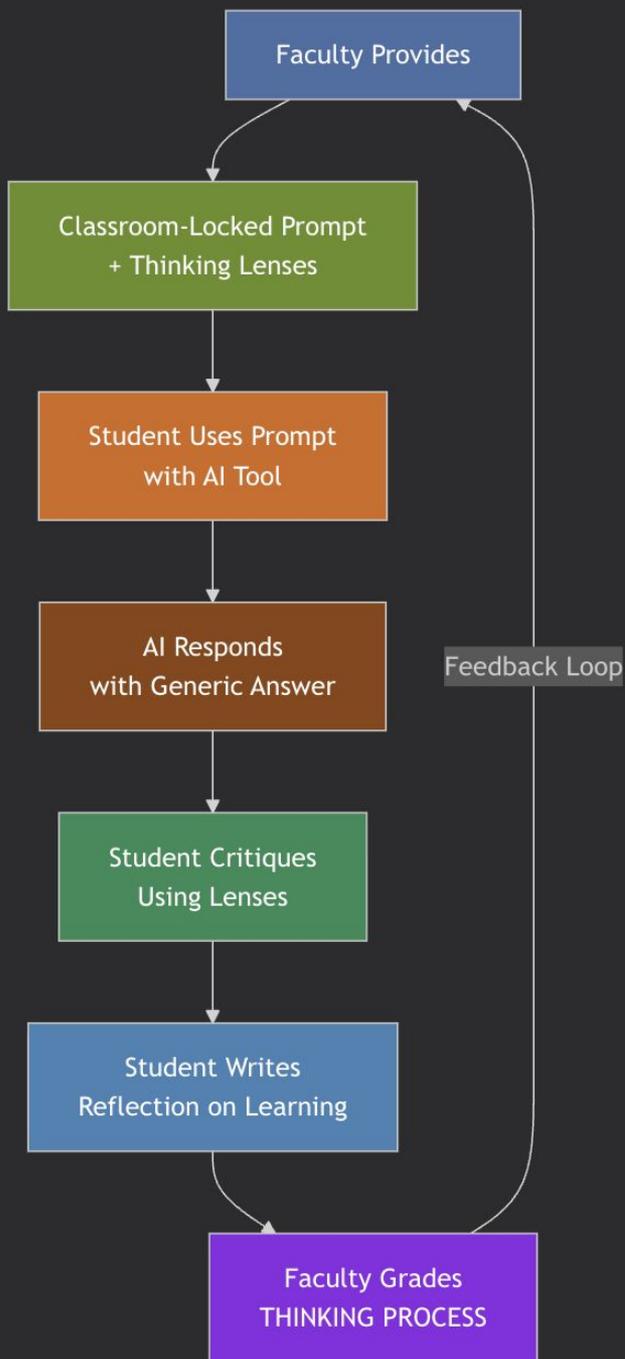
AI-First Critique Learning (AFCL) Framework

- **90+% of students use AI tools for academic work**
- AFCL turns AI from a **threat** into a **teaching tool**

- AFCL Makes Assignments **AI-Ready**

- **AI-Ready Assignment Test:** "Could someone who missed my class complete this using only AI?"
  >> NO = AI-Ready
  >> YES = Redesign Needed

The AFCL Cycle:

1. **You Provide**
   → Classroom-Locked Prompt + Thinking Lenses

2. **Students Engage with AI**
   → Use prompt → Critique using lenses → Reflect

3. **You Grade**
   → Focus on **thinking process**, not final answer

AFCL lets you **see, assess, and grade real student thinking**—even with AI.

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My AI Research

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