

# Biological Neurons vs. Artificial Neural Networks

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*Abstract - Biological neurons are the building blocks of the human brain, responsible for processing and transmitting information through electrical and chemical signals. Inspired by this, researchers developed artificial neural networks (ANNs), which are computer models designed to perform problem-solving and pattern recognition. While ANNs are based on the structure of biological neurons, they function in very different ways. This paper explores the similarities and differences between biological neurons and artificial neural networks, showing how nature inspired technology, and how the two systems compare in structure, processing, and efficiency.*

## I. INTRODUCTION

The human brain is often regarded as the most powerful and efficient information-processing system known. Containing nearly 86 billion neurons, it performs countless operations every second, enabling us to sense the world, process information, learn, remember, and respond. These neurons are not isolated units — each one communicates with thousands of others, forming an immense and intricate network of connections. This interconnectedness allows the brain to adapt, learn from experiences, and perform tasks ranging from basic reflexes to higher-order thinking, creativity, and problem-solving. Unlike machines, the human brain is capable of generalization, intuition, and learning from very limited examples, making it an unmatched biological marvel.

Inspired by this natural design, scientists and engineers created Artificial Neural Networks (ANNs). ANNs are mathematical and computational models that aim to capture some aspects of how neurons work, but in a simplified form. While they do not replicate the full complexity of the human brain, they take inspiration from its fundamental principles: interconnected units (nodes), weighted connections, and learning through adjustment.

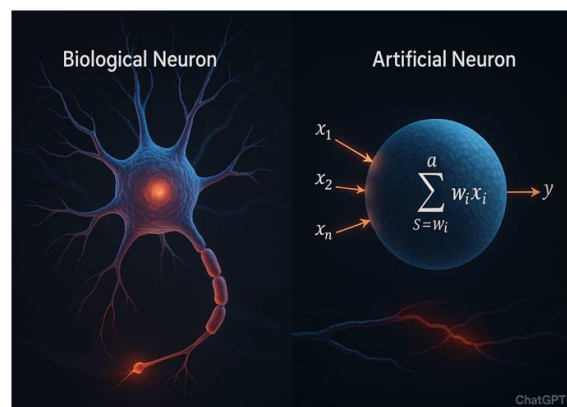
These artificial models have become the backbone of modern artificial intelligence (AI), enabling

machines to recognize images, understand speech, translate languages, detect diseases, and even drive autonomous vehicles.

The comparison between biological neurons and artificial neural networks is essential because it shows both the inspiration behind AI and the limitations of current technology. While biological neurons function through electrical and chemical signals in a highly energy-efficient manner, artificial neurons operate with mathematical functions and require large datasets and high computational power.

Understanding these similarities and differences not only deepens our knowledge of the brain but also guides future research in building more advanced and brain-like AI systems.

This paper focuses on comparing the structure, function, and learning processes of biological neurons and artificial neural networks. It highlights how closely technology has been modeled after biology, while also recognizing the clear gaps that remain between natural intelligence and artificial intelligence.



## II. BIOLOGICAL NEURONS

A biological neuron is a specialized cell in the nervous system. Its main parts include:

- Dendrites: Receive signals from other neurons.

- Cell Body (Soma): Processes the signals and decides if they are strong enough to pass forward.
- Axon: Transmits the signal away from the cell body.
- Synapse: Connects one neuron to another, where signals are transferred using neurotransmitters.

Neurons communicate using electrical impulses (action potentials) and chemical signals. Learning in the brain occurs through changes in synaptic strength, a process known as neuroplasticity.

### III. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks are simplified models inspired by biological neurons. Instead of cells, they use mathematical nodes.

- Input layer: Receives the data.
- Weights: Each input has a weight that determines its importance.
- Summation & Activation: Inputs are combined and passed through an activation function to decide whether the signal continues.
- Output layer: Produces the result.

Learning in ANNs happens through backpropagation, where the system adjusts weights based on errors in prediction.

### III. HOW NEURONS WORK

The working of a neuron involves both electrical and chemical processes that allow information to flow through the nervous system efficiently.

When a neuron receives signals through its dendrites, these inputs cause small changes in the electrical potential of the cell membrane. If the combined input signals reach a certain threshold, the neuron generates an action potential — a rapid electrical impulse that travels along the axon.

This is often described as an “all-or-none” response, meaning that once the threshold is crossed, the neuron fires completely.

As the action potential reaches the end of the axon (the axon terminals), it triggers the release of neurotransmitters — chemical substances that cross the synaptic gap and bind to receptors on the

dendrites of the next neuron. This chemical binding either excites or inhibits the receiving neuron, influencing whether it will generate its own action potential.

This continuous process of electrical transmission within neurons and chemical transmission between them forms the basis of all brain activity — from reflex actions to complex thoughts. The efficiency, adaptability, and self-regulating nature of this process make biological neurons highly effective for learning and problem-solving. Moreover, the brain’s plasticity enables it to reorganize itself after injury or experience, a feature that artificial systems are only beginning to emulate.

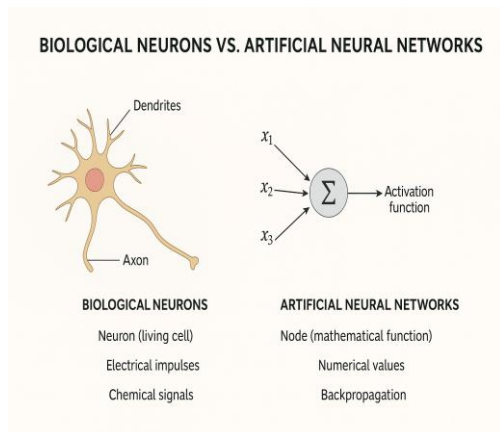
### IV. COMPARISON BETWEEN BIOLOGICAL AND ARTIFICIAL NEURONS

Aspect	Biological Neurons	Artificial Neural Networks
Basic Unit	Neuron (living cell)	Node (mathematical function)
Signal Type	Electrical impulses + chemical signals	Numerical values
Connections	Synapses	Weighted links
Learning	Neuroplasticity	Backpropagation
Speed	Milliseconds per signal	Nanoseconds per calculation
Energy	Highly efficient (~20W for whole brain)	High energy usage (GPUs/TPUs)
Scale	~86 billion neurons	Millions of nodes in advanced ANNs

### V. LIMITATIONS AND FUTURE DIRECTIONS

- Biological neurons are adaptive and flexible, capable of learning from very few examples.
- Artificial networks need large datasets and heavy computation to learn.
- Current ANNs are powerful but still lack the creativity, adaptability, and efficiency of the human brain.

- Future research, such as neuromorphic computing, aims to create AI systems that function more like real neurons.



Comparison between Biological Neurons and Artificial Neural Networks.

## VI. CONCLUSION

Both biological neurons and artificial neural networks are designed to process information, but in different ways. Biological neurons are complex, energy-efficient, and capable of flexible learning. Artificial neural networks, though inspired by biology, use mathematical operations to achieve tasks like image recognition and decision-making. While ANNs have revolutionized technology, they are still far from matching the power of the human brain.

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