

Perceptron

What is a Perceptron?

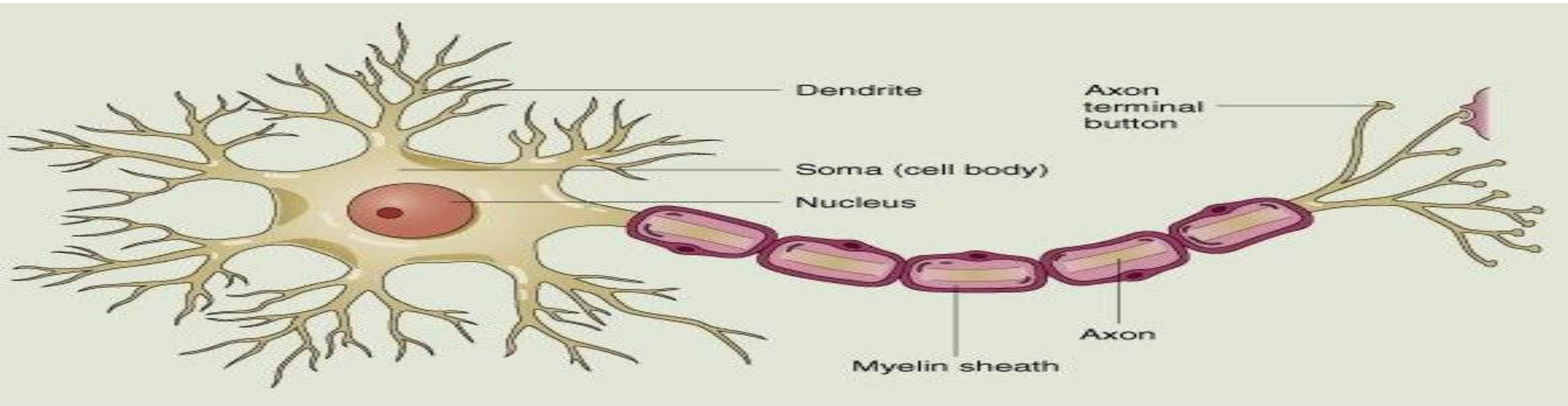
- The perceptron is a simple type of artificial neuron used for **binary classification**.
- It is the foundation of modern neural networks and machine learning models.
- The perceptron takes multiple inputs, applies weights, sums them, and uses an activation function to produce an output of **0 or 1**.

Inspiration for the Perceptron

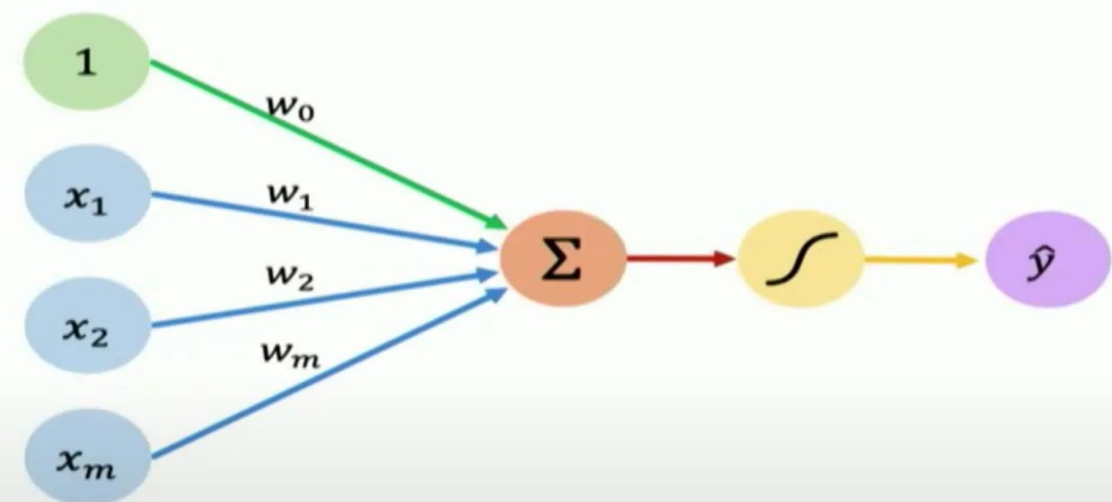
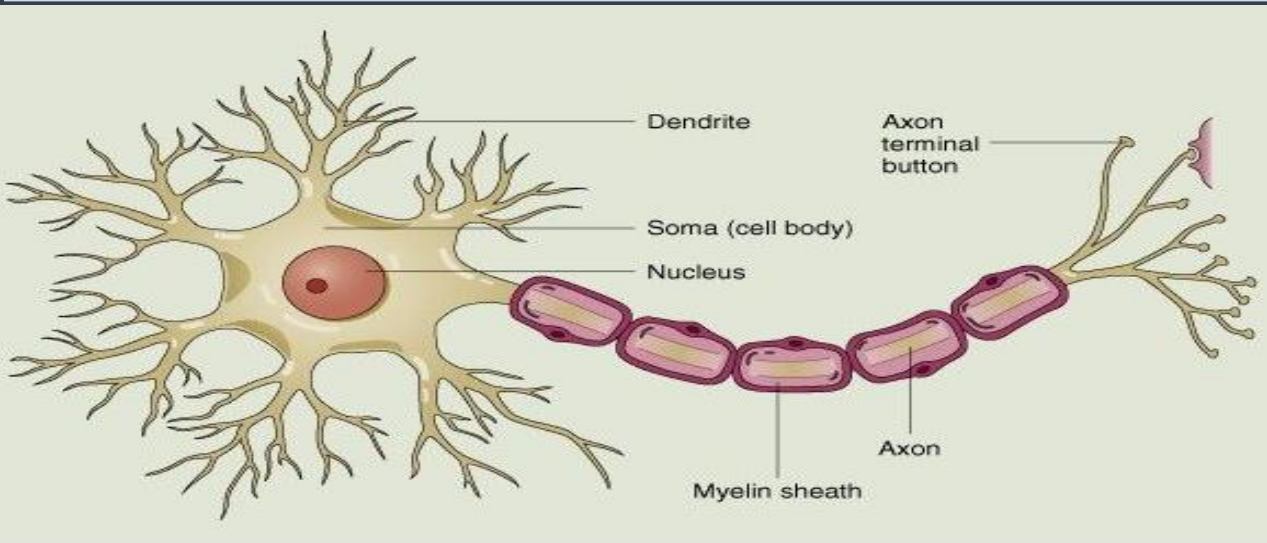
- Inspired by how biological neurons work in the brain.
- First introduced by **Frank Rosenblatt in 1958** as a mathematical model of learning.
- Initially used for simple classification tasks but later expanded into modern neural networks.

What is a Biological Neuron?

- The human brain consists of billions of **neurons**, each receiving and processing signals.
- A biological neuron has:
 - **Dendrites**: Receive input signals.
 - **Cell body (Soma)**: Processes inputs and decides if a signal should be sent.
 - **Axon**: Sends the signal to other neurons.



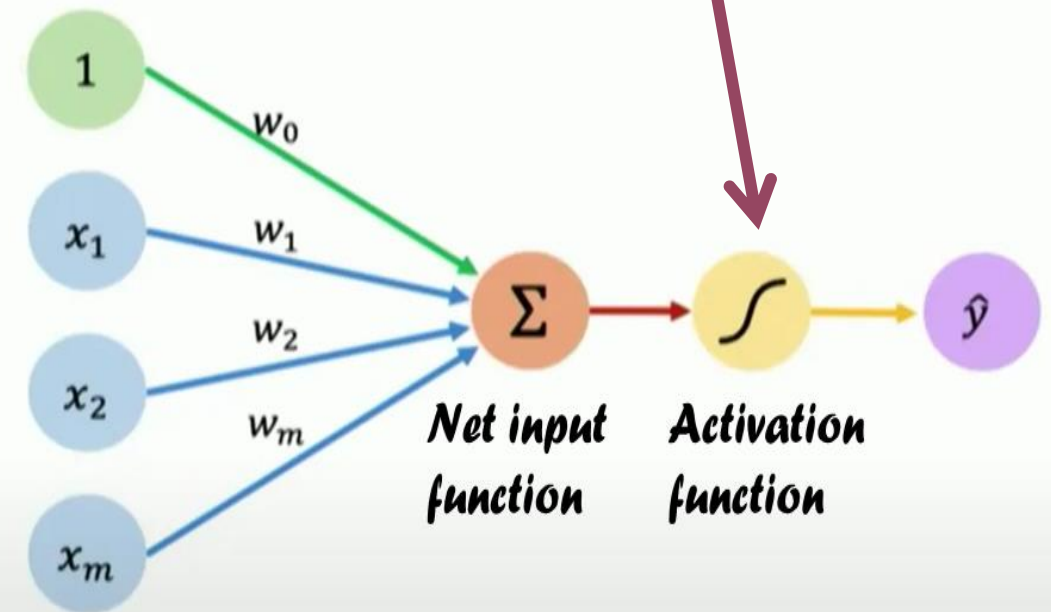
Human Neuron	Perceptron
Dendrites	Inputs (features)
Soma	Weighted Sum Calculation
Axon	Output Decision
Synapses	Weights (adjustable values that influence output)
Action Potential	Activation Function



What is an Activation Function?

- The activation function determines whether the perceptron **fires (outputs 1) or stays inactive (outputs 0)**.
- The most basic activation function for a perceptron is the **Step Function**:
- More complex neural networks use functions like **Sigmoid, ReLU, or Tanh** for more flexibility.

```
def activation_function(x):  
    if x >= 0:  
        return 1  
    else:  
        return 0
```



The Perceptron Algorithm (Learning Rule)

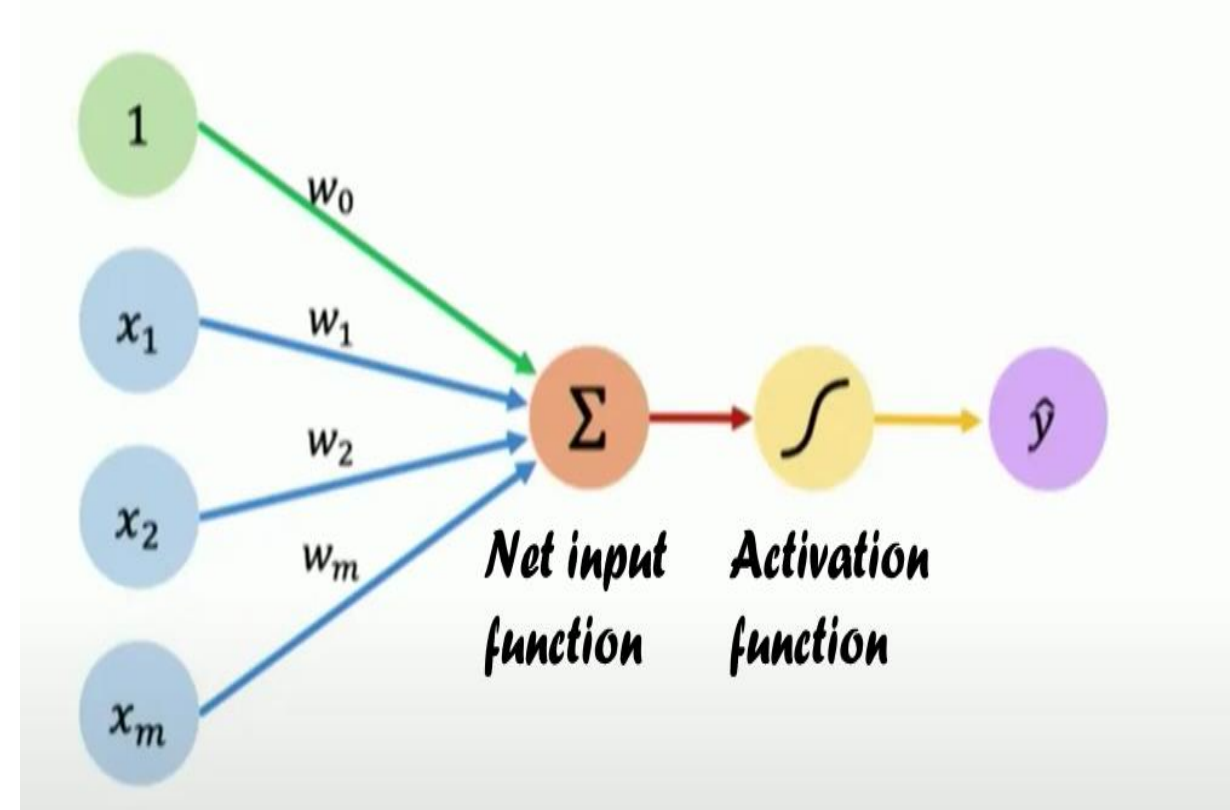
Initialize weights to zero or small random values.

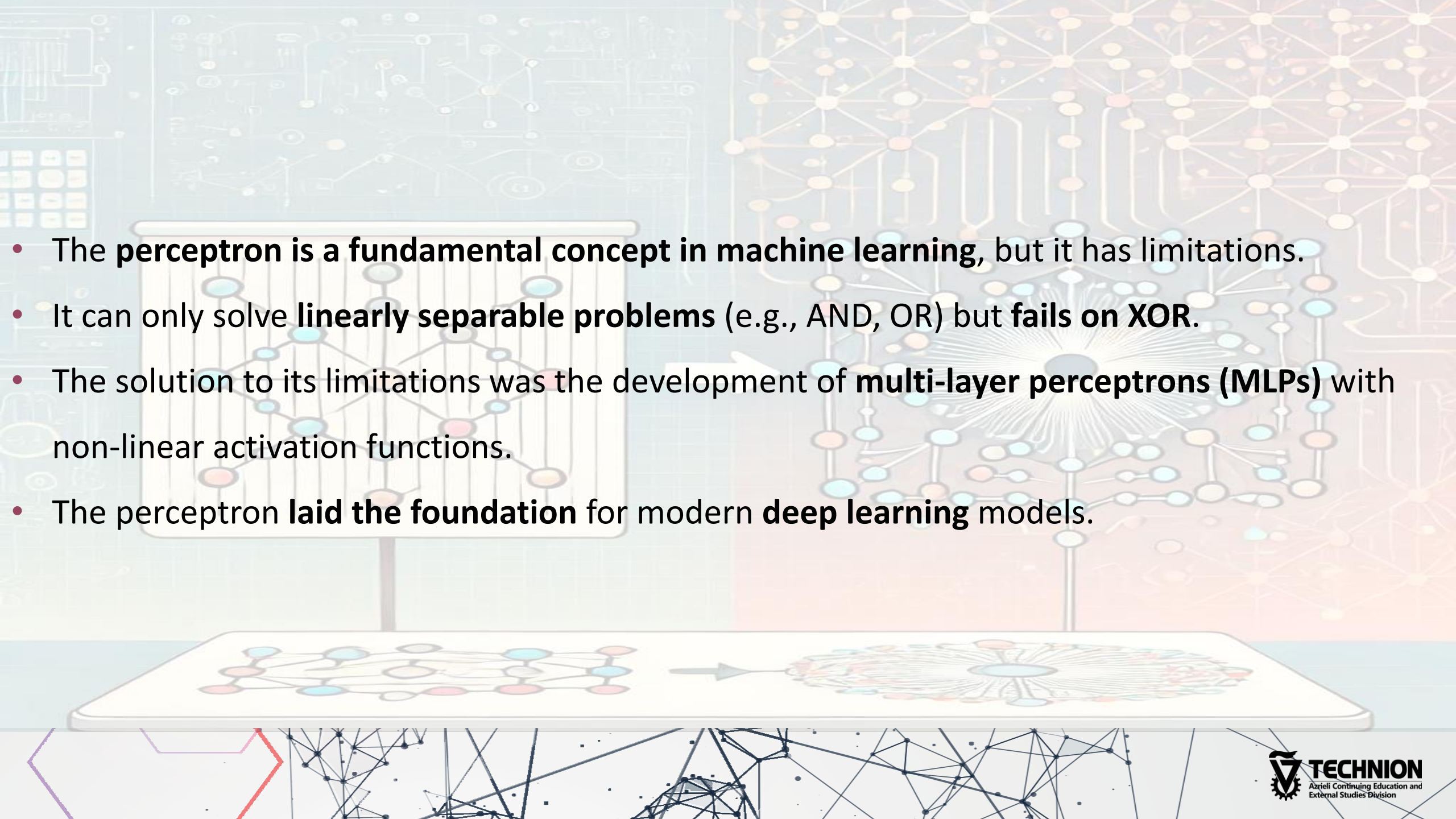
2. For each training example:

- Compute net sum.
- Apply the activation function to get a prediction.
- Compute the error.
- Update the weights based on the error,

Using the learning rate.

3. Repeat until all training examples are classified correctly or a maximum number of iterations is reached.



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- The **perceptron** is a fundamental concept in machine learning, but it has limitations.
 - It can only solve **linearly separable problems** (e.g., AND, OR) but **fails on XOR**.
 - The solution to its limitations was the development of **multi-layer perceptrons (MLPs)** with non-linear activation functions.
 - The perceptron **laid the foundation** for modern **deep learning** models.