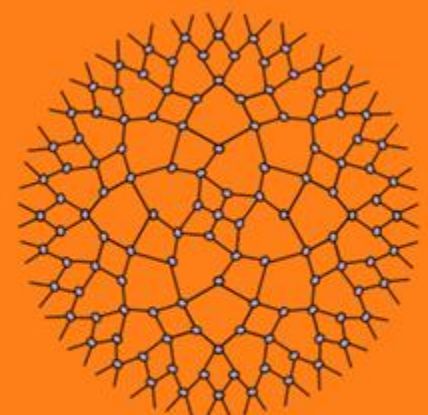
ML Algorithms

NEURAL NETWORKS



Class

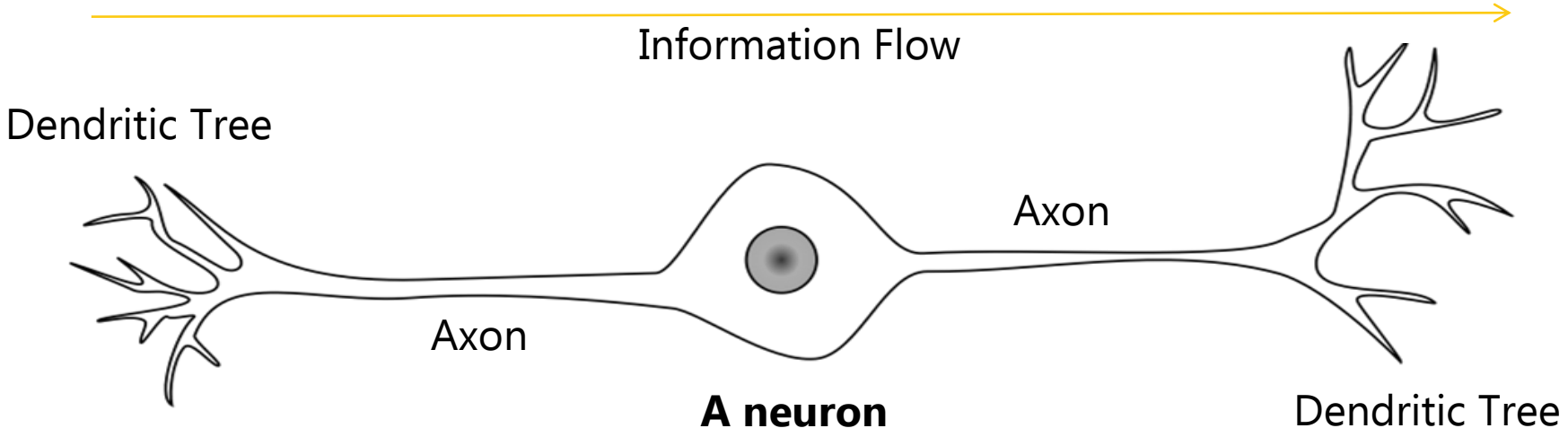
A Detailed Look At Neural Networks

Topic

A Single Neuron

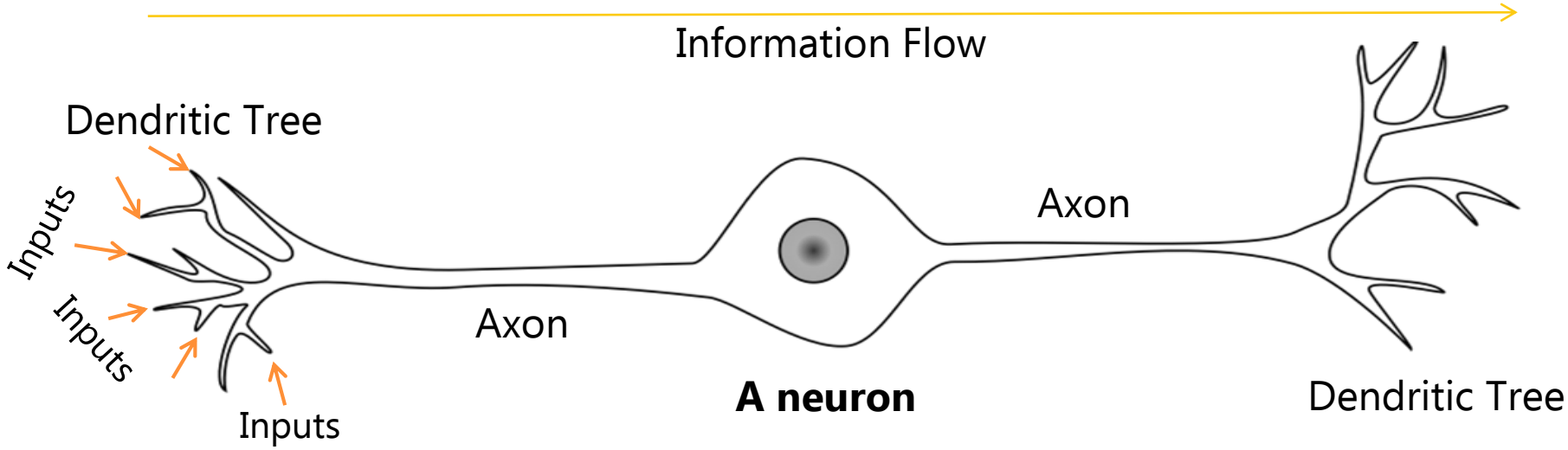
A Single Neuron

Neurons essentially act as transmission lines



A Single Neuron

- Inputs are received through the dendritic tree and computed



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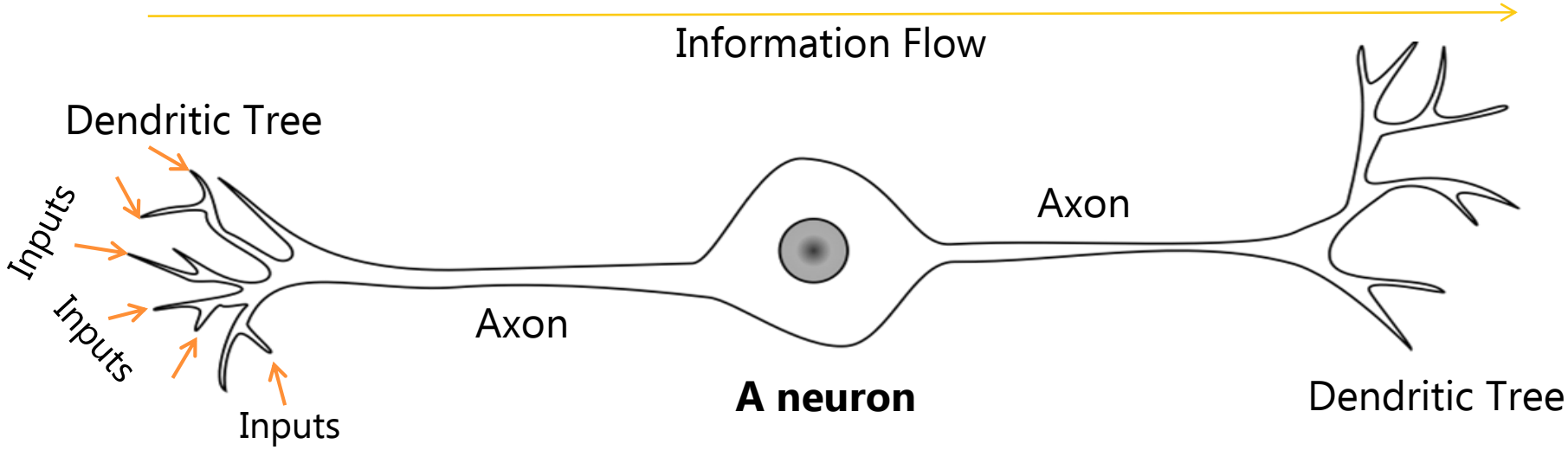
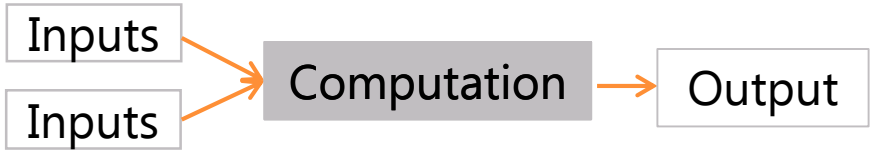
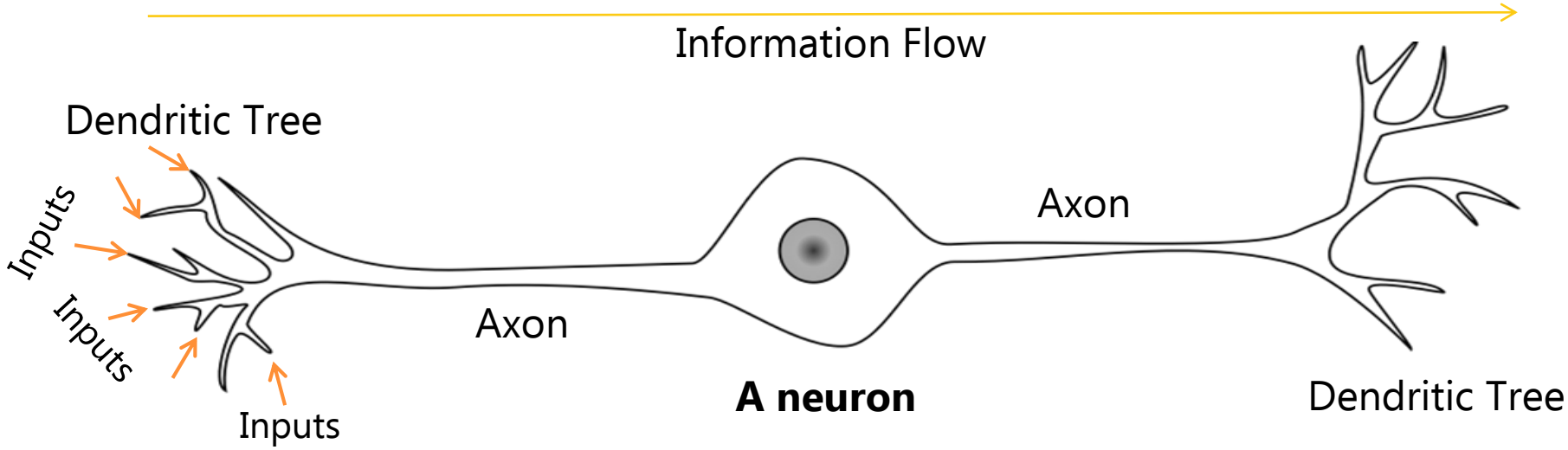




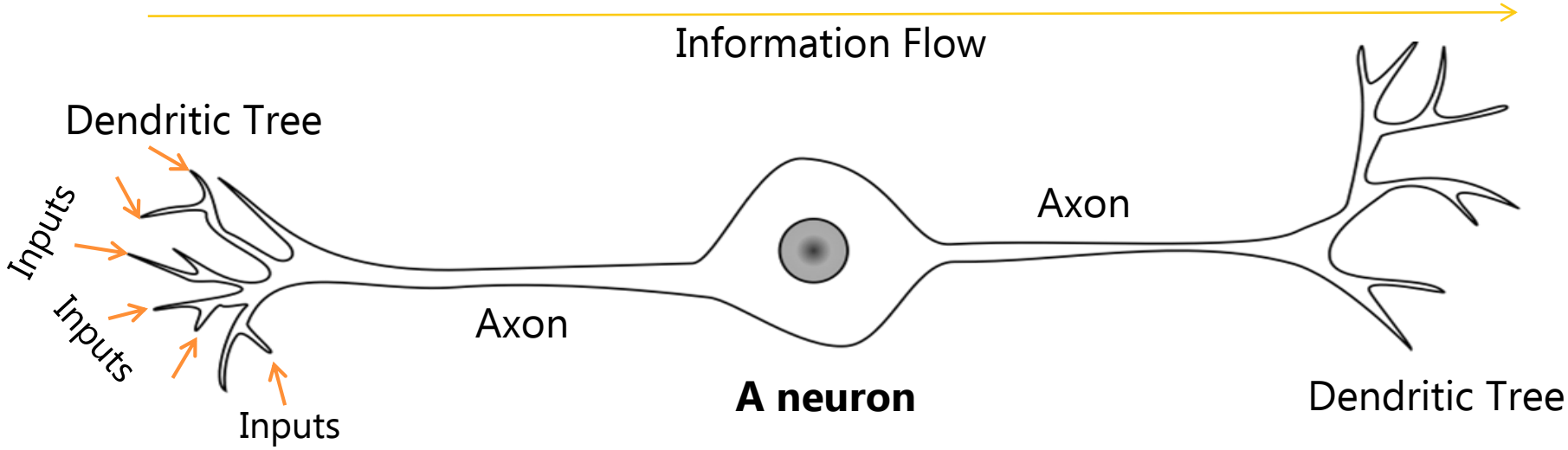
A Single Neuron

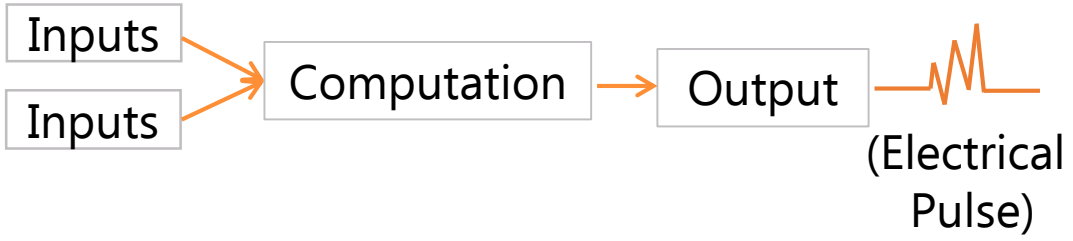
- Inputs are received through the dendritic tree and computed
- An output is sent along the axon



A Single Neuron

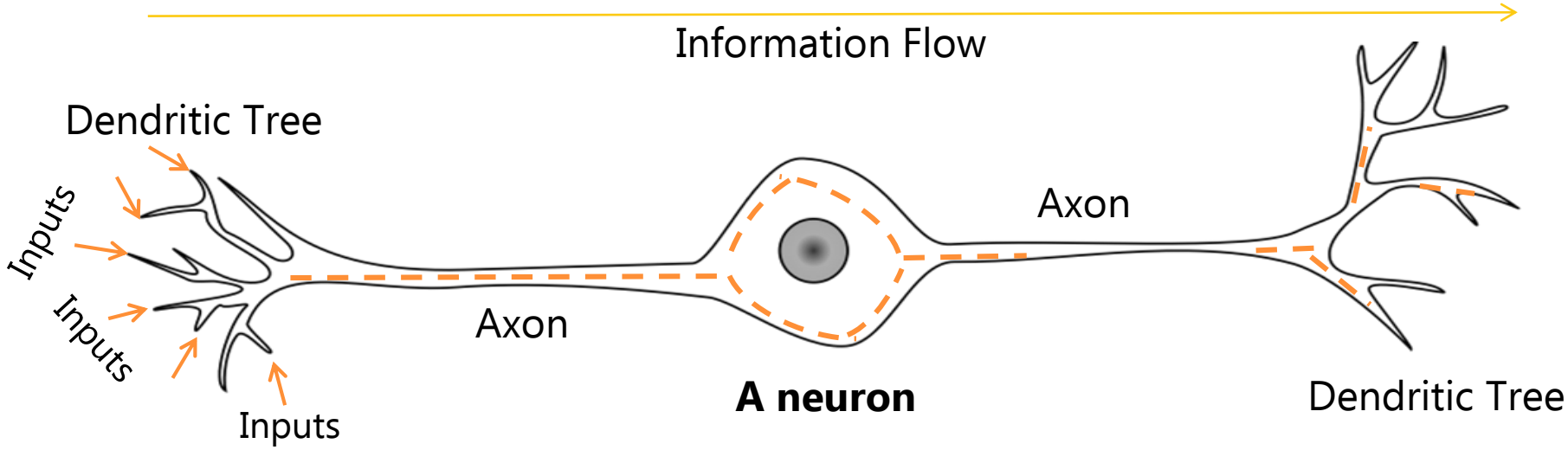
For neurons, the output is an electrical pulse





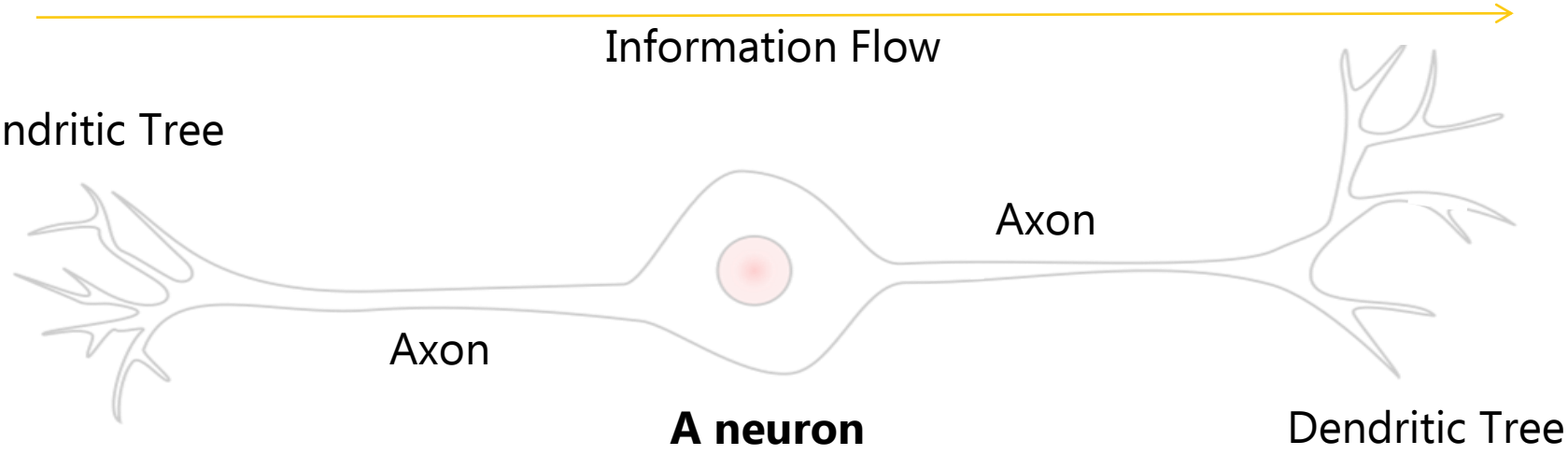
A Single Neuron

- A neuron is activated based on inputs



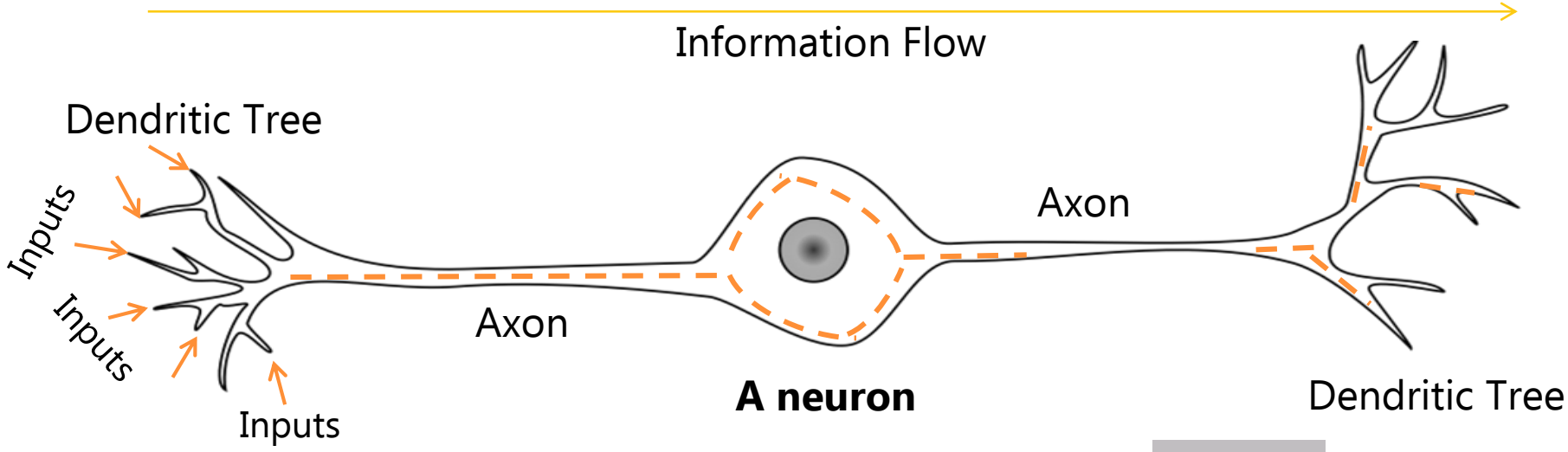
A Single Neuron

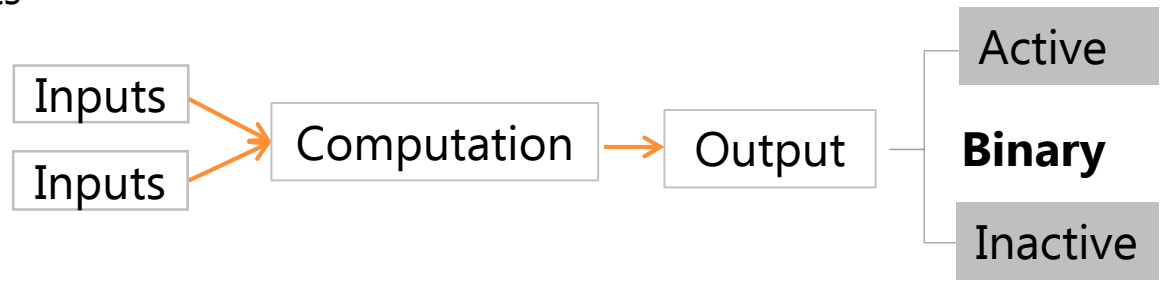
- A neuron is activated based on inputs
- If not, it remains in an idle state



A Single Neuron

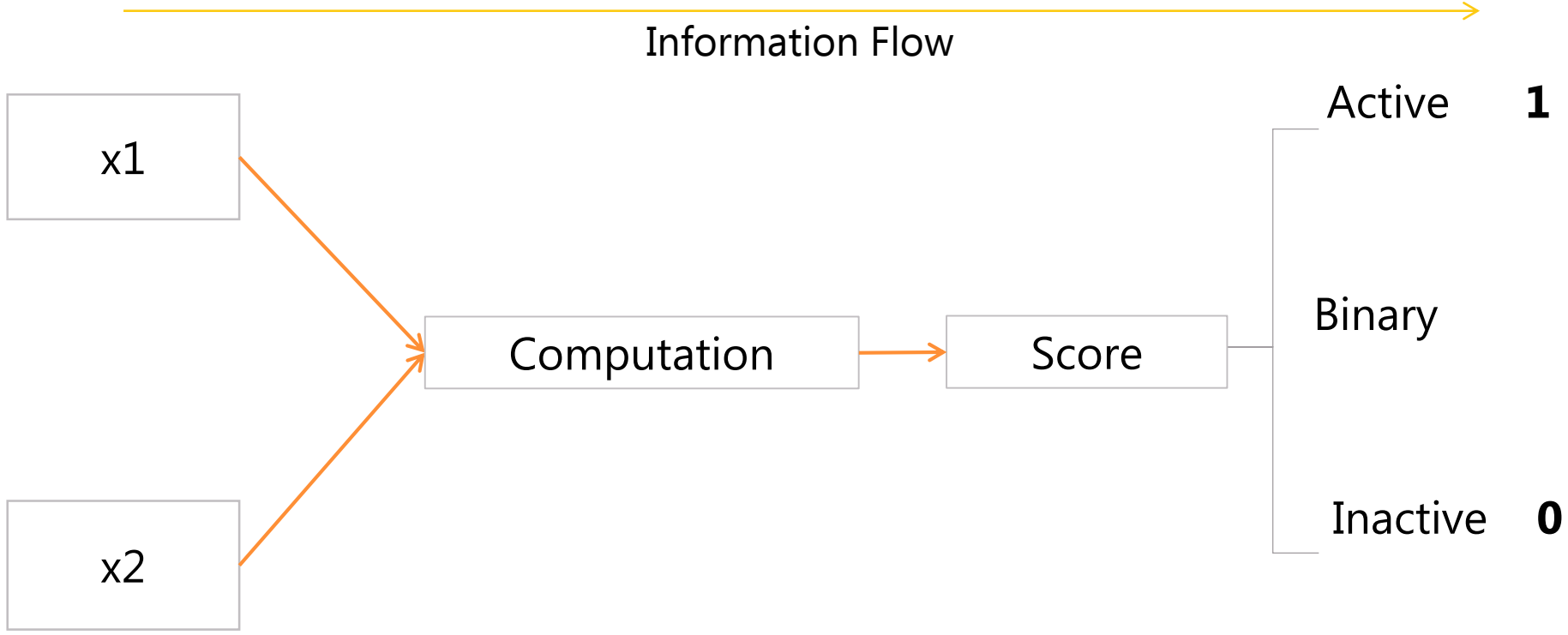
Neuronal output is binary: **active** and **inactive**





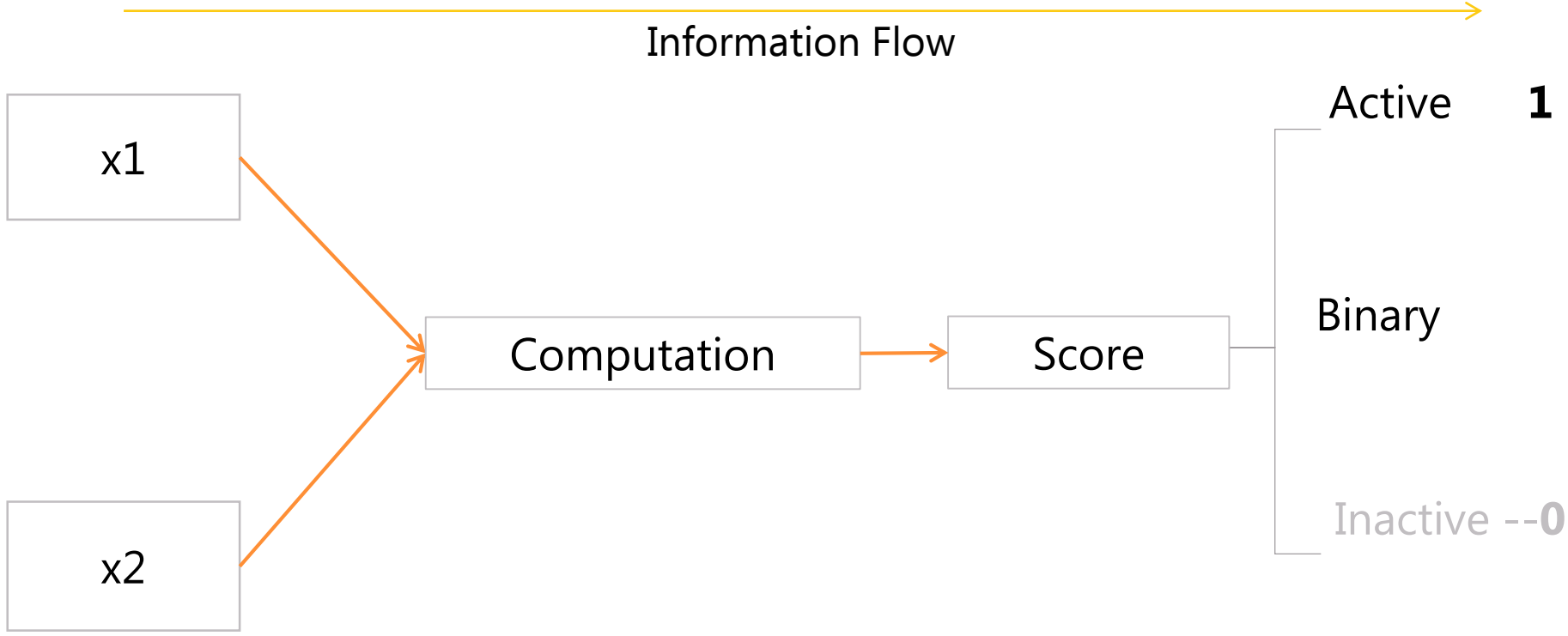
A Single Neuron

In other words, the output of a single neuron can be modeled as **0** or **1**



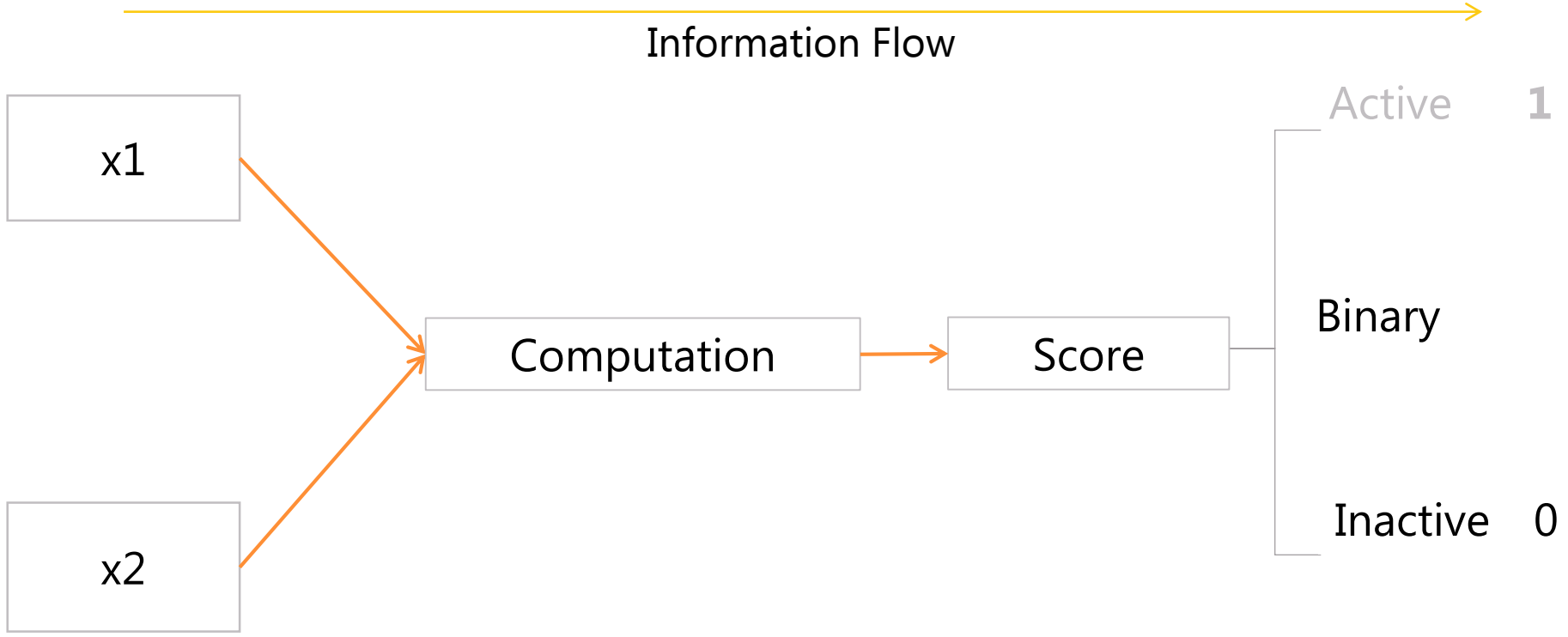
A Single Neuron

If **activated** it produces an output of **1**



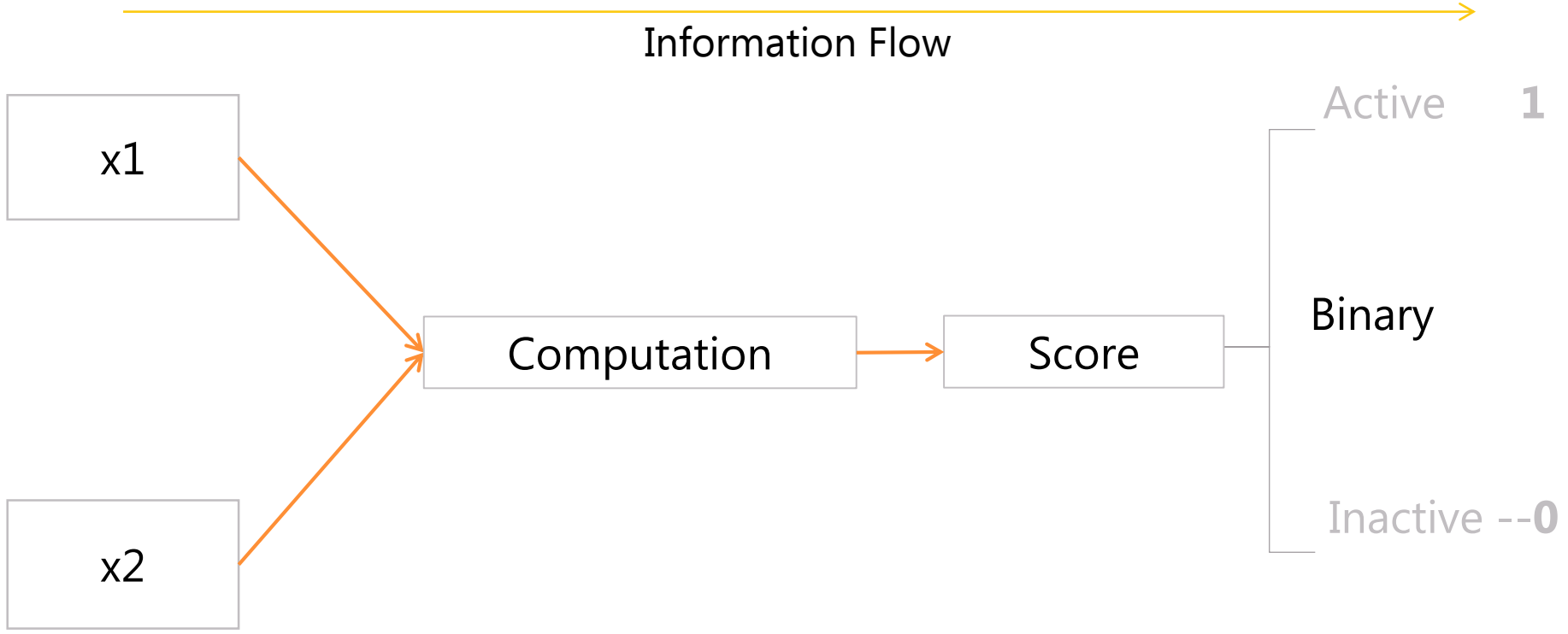
A Single Neuron

If **inactive** it produces an output of **0**



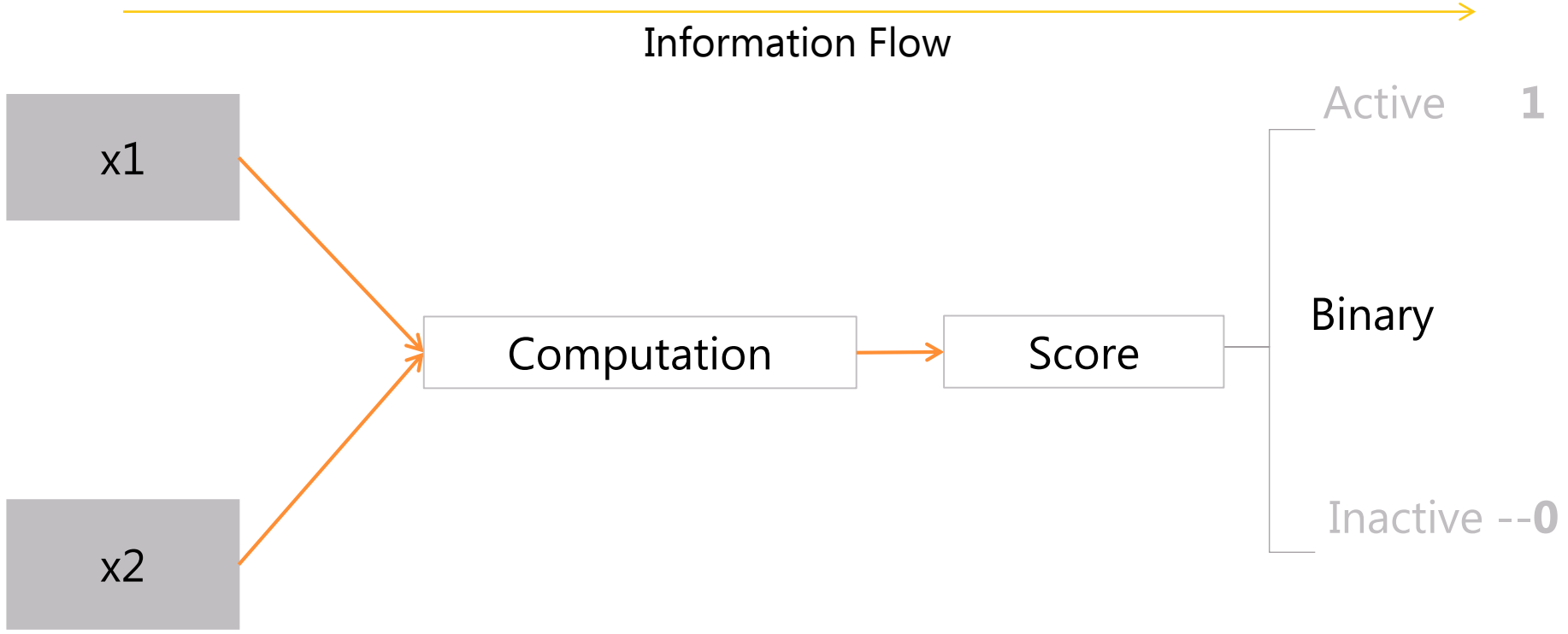
A Single Neuron

How is a neuron activated?



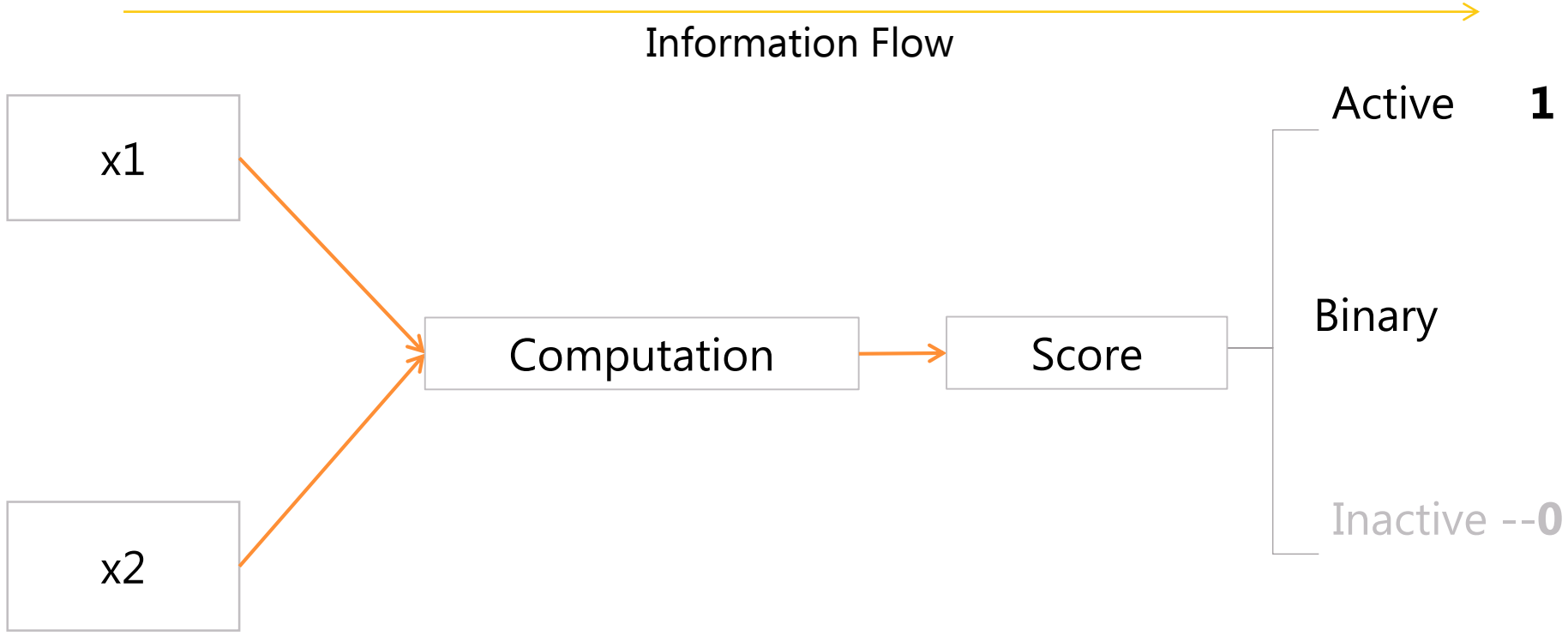
A Single Neuron

Based on inputs **x1** and **x2**, the neuron computes and produces a score

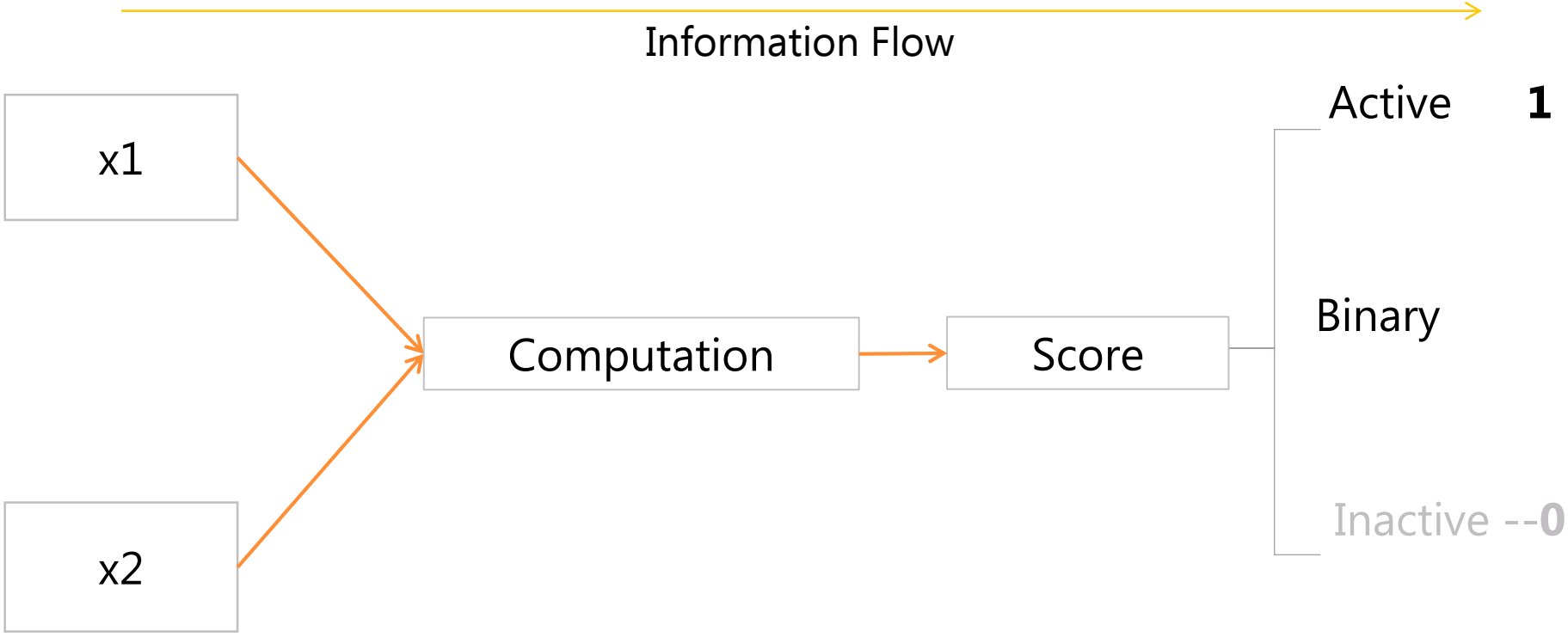


A Single Neuron

If the score is larger than a **threshold value**, the neuron sends out an electrical pulse or an output of **1**



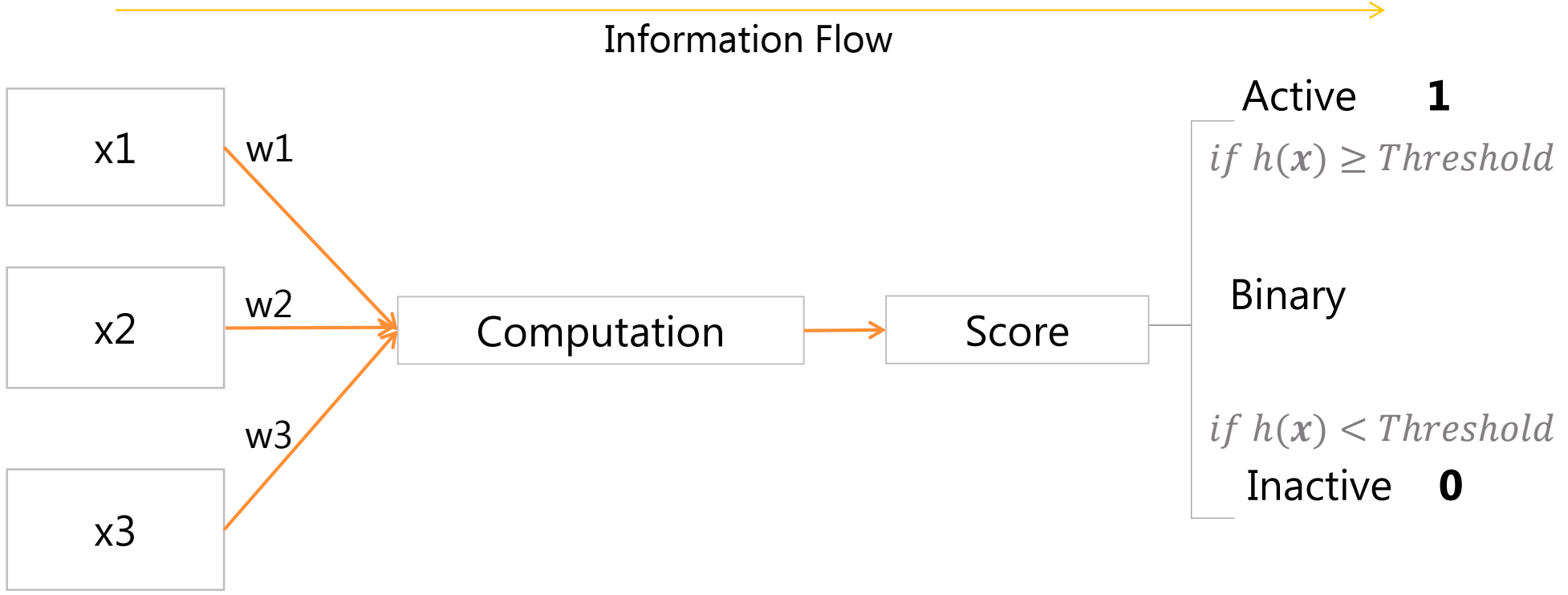
A Single Neuron



This exercise was a demonstration of the mathematical formulation for **perceptrons** and **logistic classifiers**

A Single Neuron

Function h controls whether the neuron will be activated or not based on the inputs and the weights

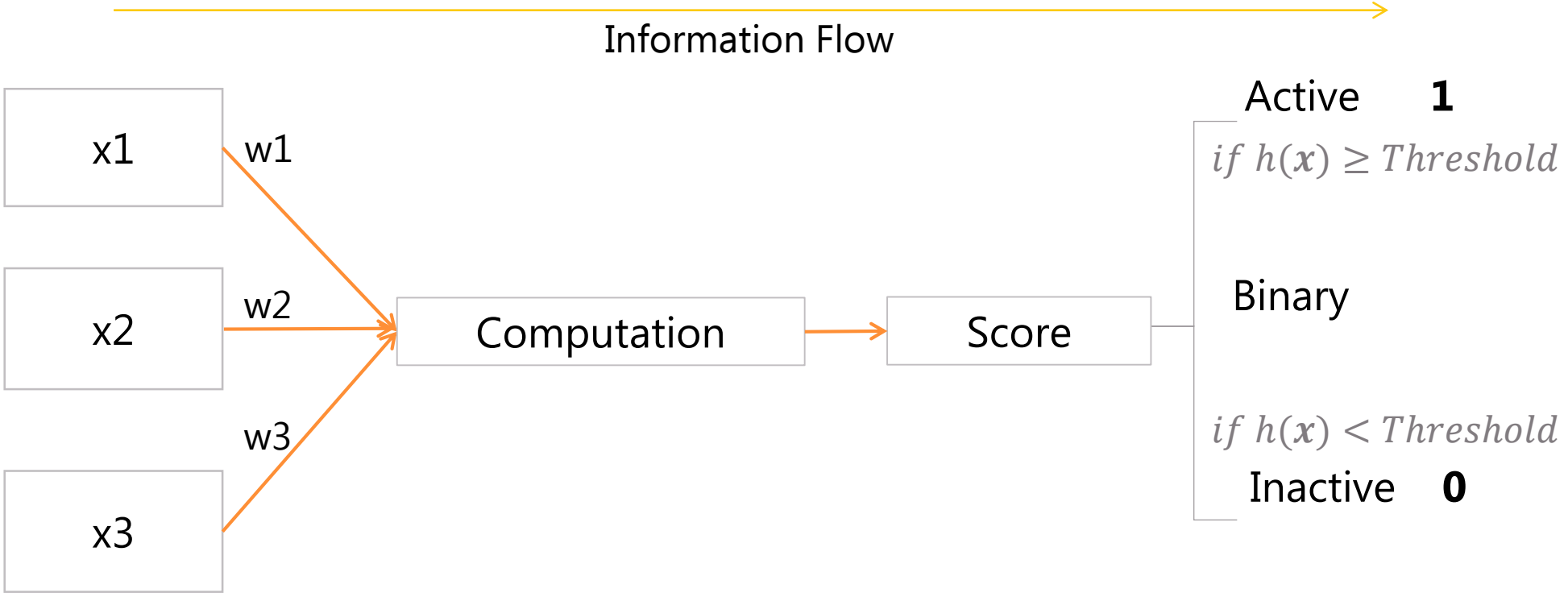


$\boldsymbol{h}(\,)$ **: Activation Function**

$$Output = \begin{cases} 0, & if h(\boldsymbol{x}) < Threshold \\ 1. & if\ h(\boldsymbol{x}) \geq Threshold \end{cases}$$

A Single Neuron

This function is therefore also known as a neuron's **activation function**



$\boldsymbol{h}(\,)$ **: Activation Function**

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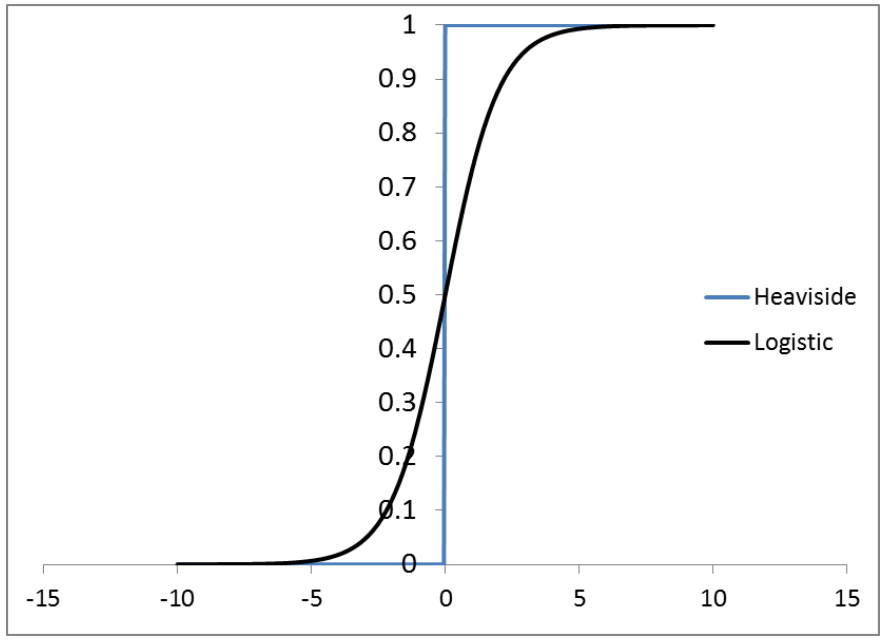
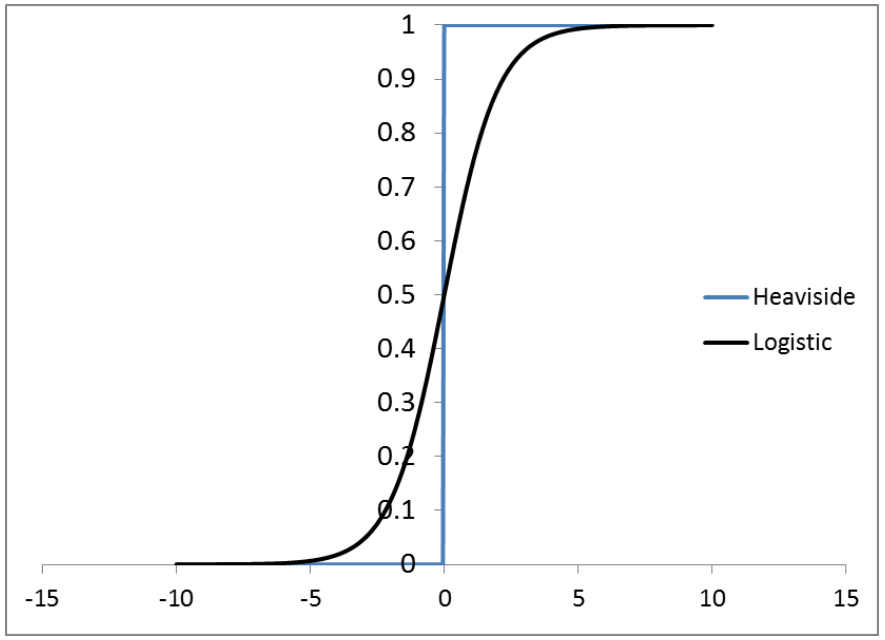
Activation Function: Heaviside vs. Sigmoid



- Popular activation functions: **Heaviside Function** and **Sigmoid Function**
- Popular choice of **threshold** for Logistic Activation Function is **0.5**
- The threshold can be increased or decreased as desired

Heaviside vs. Sigmoid: Key Differences

Step function makes an abrupt jump when the value of x increases even by a small number



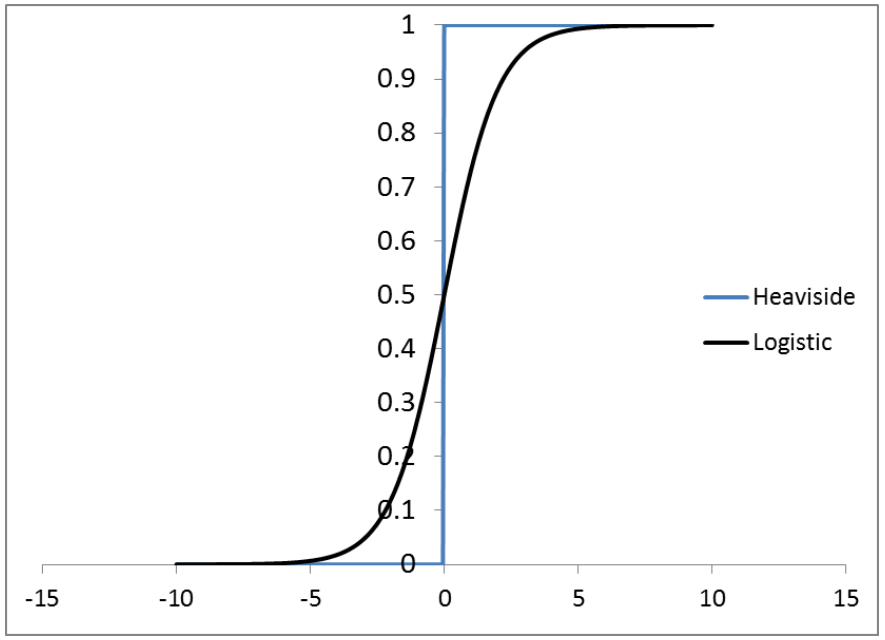
- At -0.1, the neuron with the step function won't be activated
- When **x** becomes 0.1, the neuron is activated

x	Heaviside	Logistic
-0.1	0	0.48
0.1	1	0.52

The Logistic Activation Function

- Smooth logistic curve:
  - ❑ Goes from negative **x** values to positive **x** values
  - ❑ No sudden jumps or changes as values increase

- Produces a continuous real valued score for the value of **x**



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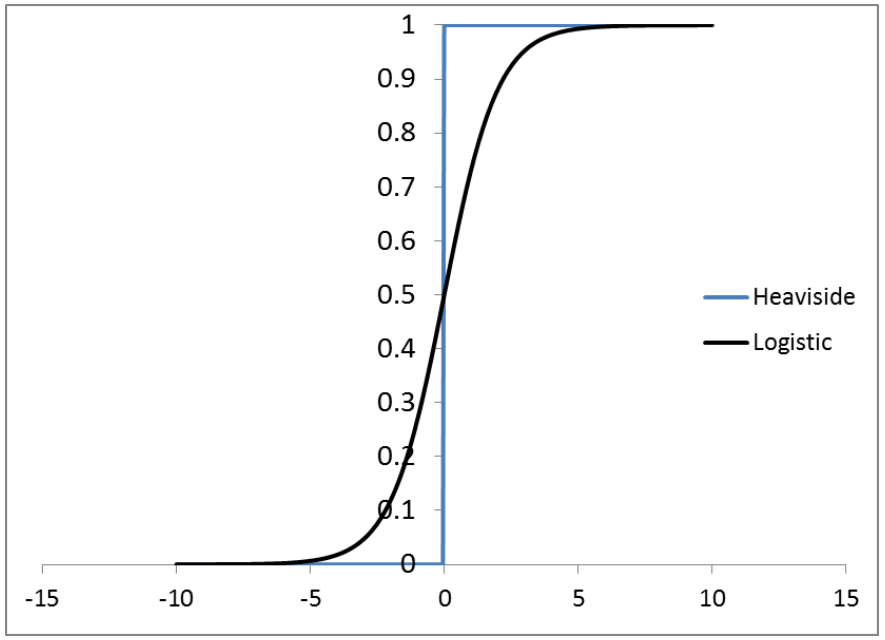
The Logistic Activation Function

Advantage #1: Logistic activation function thresholds and logistic classifier thresholds, are malleable

- Popular choice: 0.5
- Severe class imbalance: With rare class (1%), a threshold of 0.5 does not work



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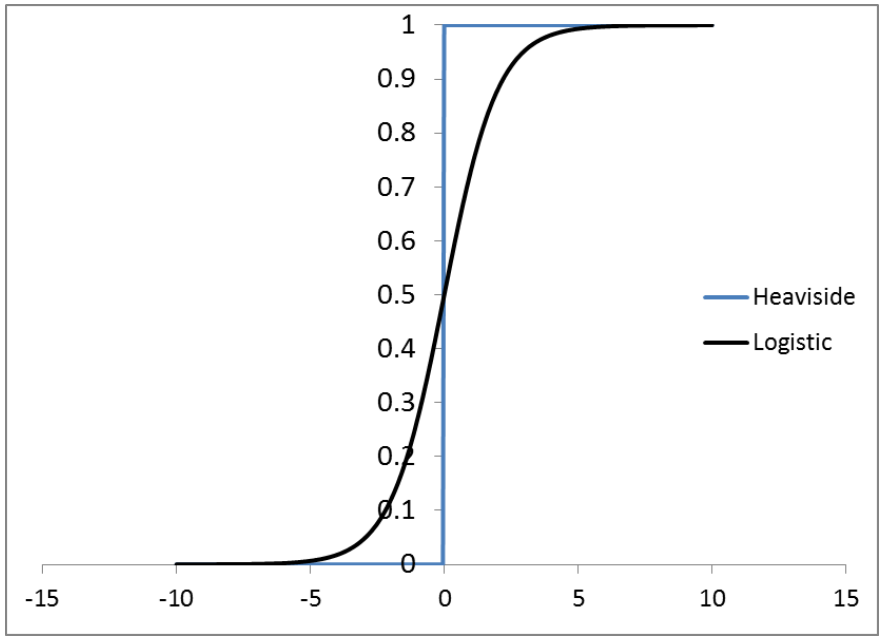
The Logistic Activation Function

- With binary classification of 1000 observations:
  - ❑ Class 1 occurs only 10 times, the rest are all 0's
  - ❑ Class 1 occurs for only 1% of data



- A 0.5 threshold does not work for logistic classifiers
- In such cases neither the choice of error measure nor the misclassification rate) work

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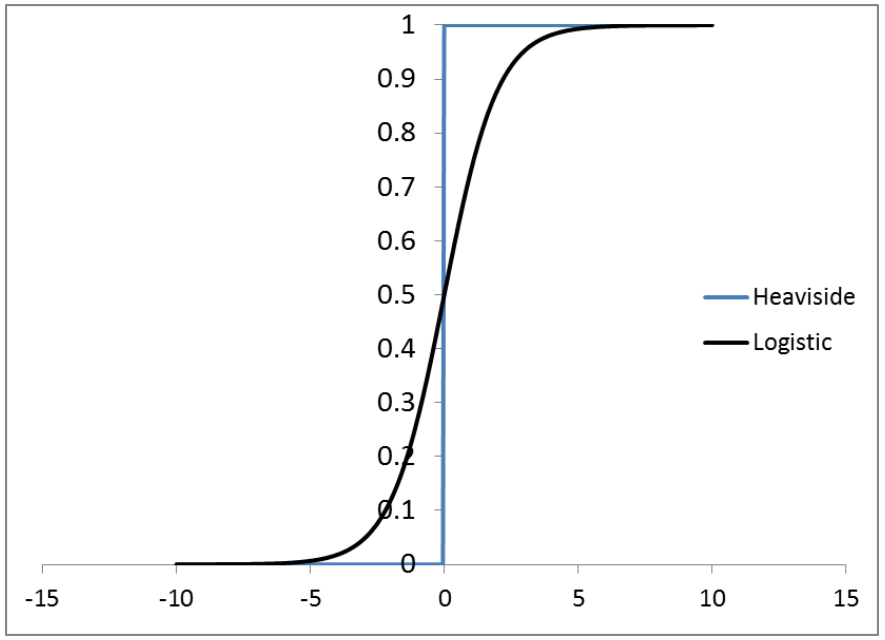
0.1	1	0.52

The Logistic Activation Function

- From a mathematical perspective:
  - ❑ The logistic curve is a continuous function
  - ❑ The step function is a discontinuous one



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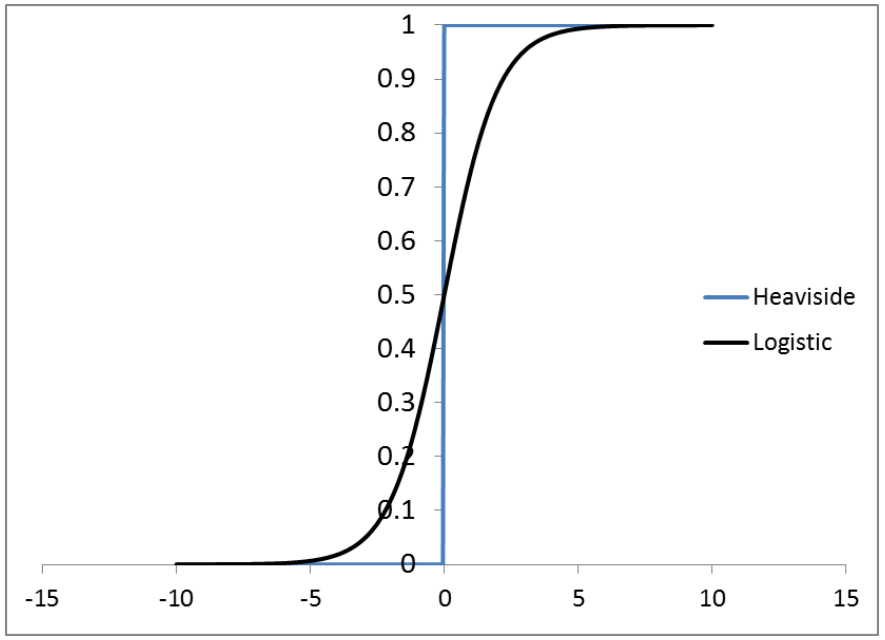
The Logistic Activation Function

Advantage #2: The logistic function output score has a direct probabilistic interpretation



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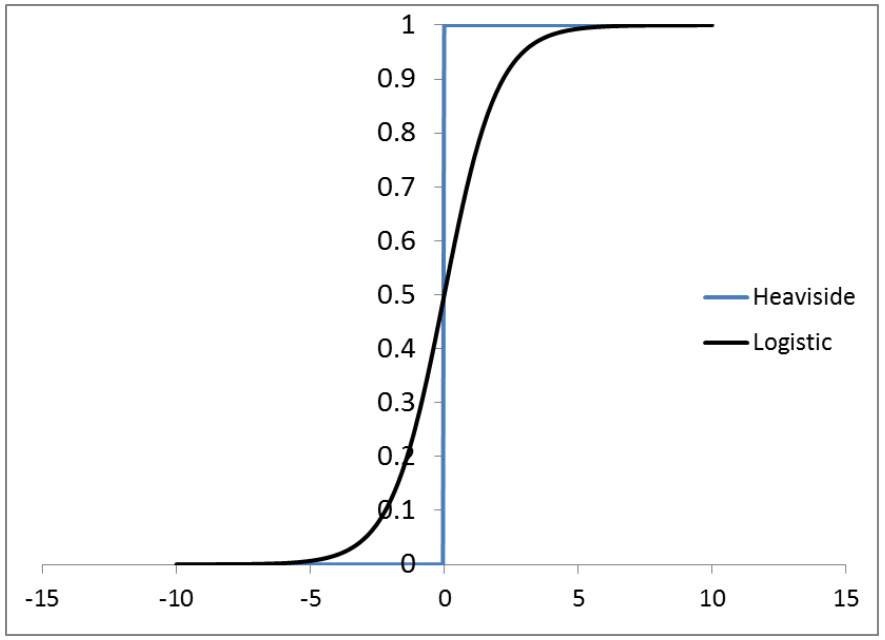
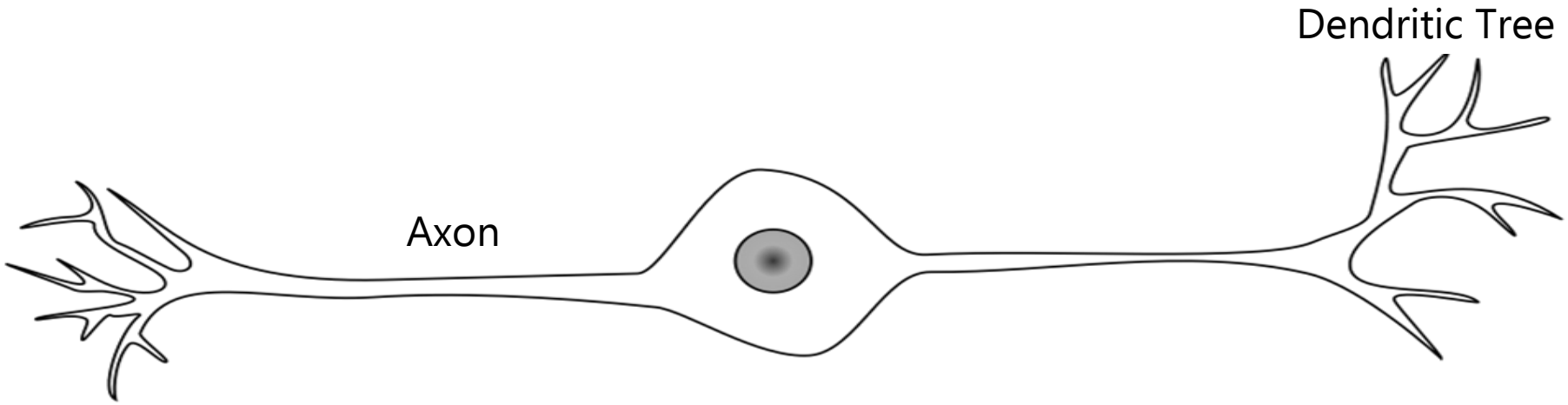
The Logistic Activation Function



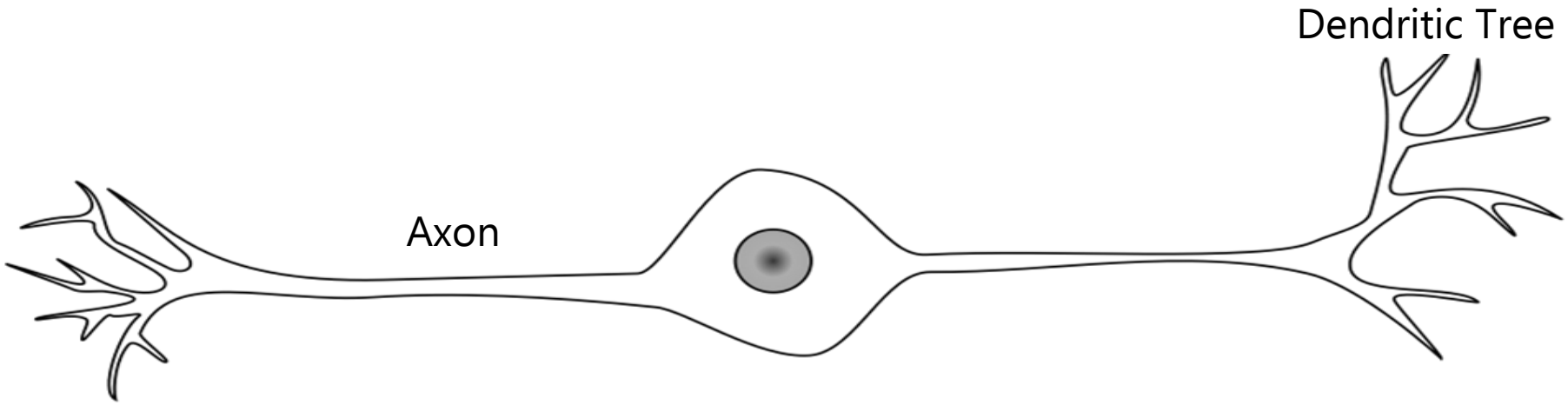
- The Logistic function is one of many functions in the family of Sigmoid curves
- There are other functions as well
- Later in the course, we will take a brief look at the different options available to us

Review



- Single neurons can make yes/no decisions based on computations
- Features are assigned weights, which are determined from the data at hand
- Single neurons have an **Activation Function**

Review



- **Activation Function**: Triggers neurons to release an electrical pulse through the axon
- Single neurons compute linearly or almost linearly separable data
- Binary problems are linearly separable when a straight line separates two classes

Recap

- A Single Neuron
- Activation Function: Heaviside vs. Sigmoid
- Heaviside vs. Sigmoid: Key Differences
- The Logistic Activation Function
- Review

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