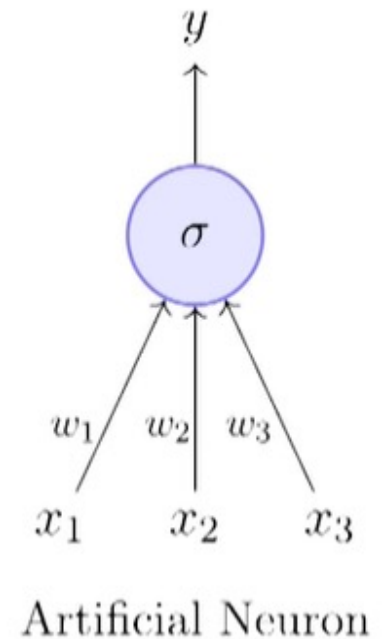


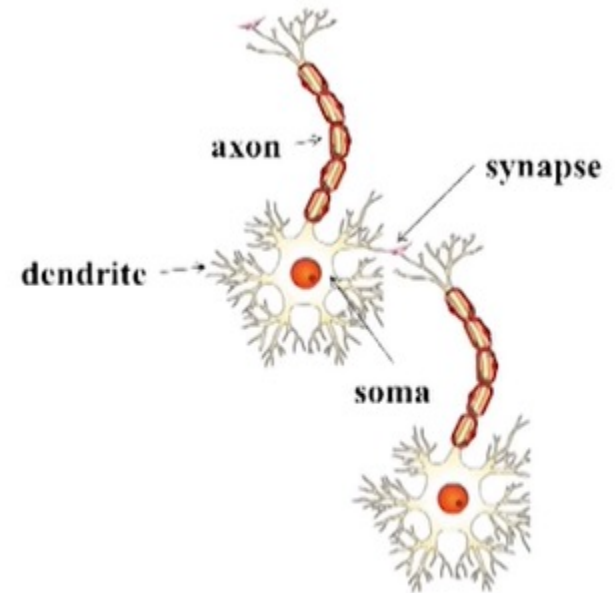
# Neural Networks

- The most fundamental unit of deep neural network is an *artificial neuron*
- Why it is called a neuron?
- Where does the inspiration come from?
- The inspiration comes from biology (neuron)
- *Biological neurons = neural cells = neural processing units*



# Biological Neuron

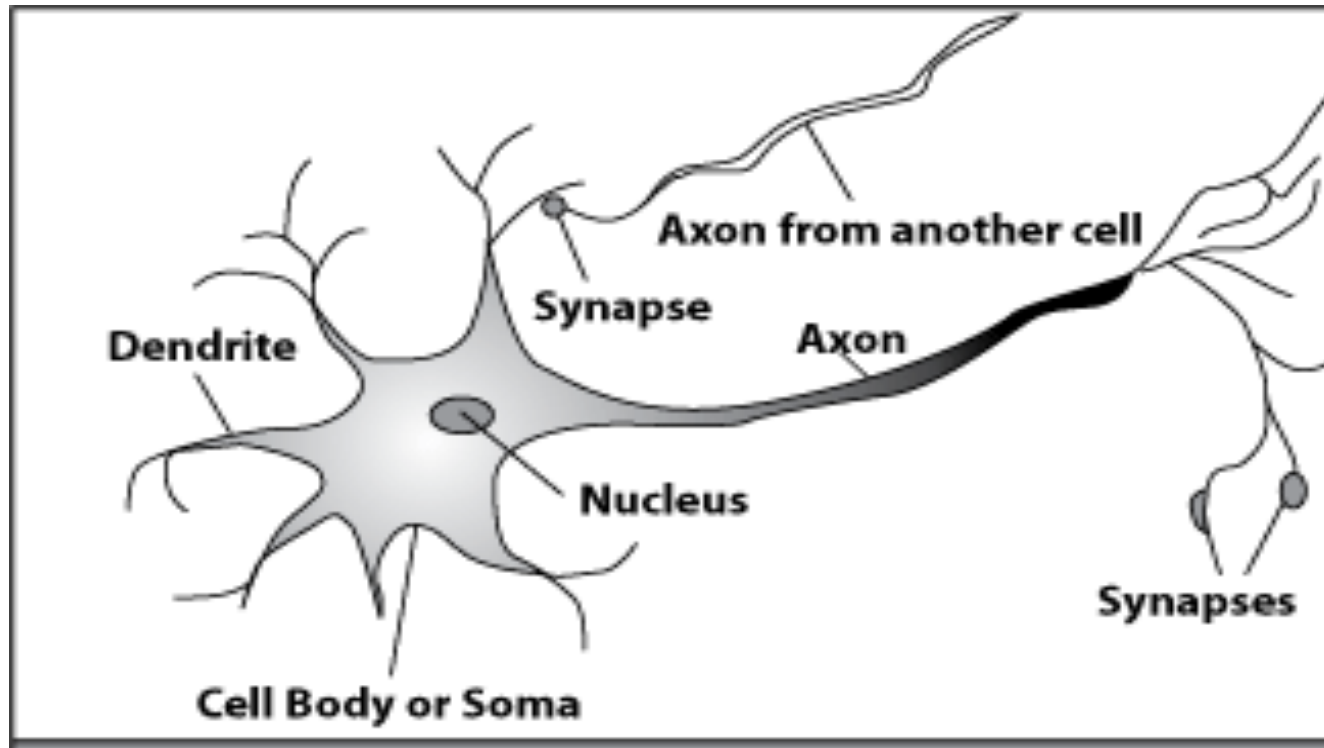
- Dendrite : receives signals from other neurons
- Synapse : point of connection to other neurons
- Soma : processes the information
- Axon : transmits the output of this neuron



Biological Neurons\*

# How do our brains work?

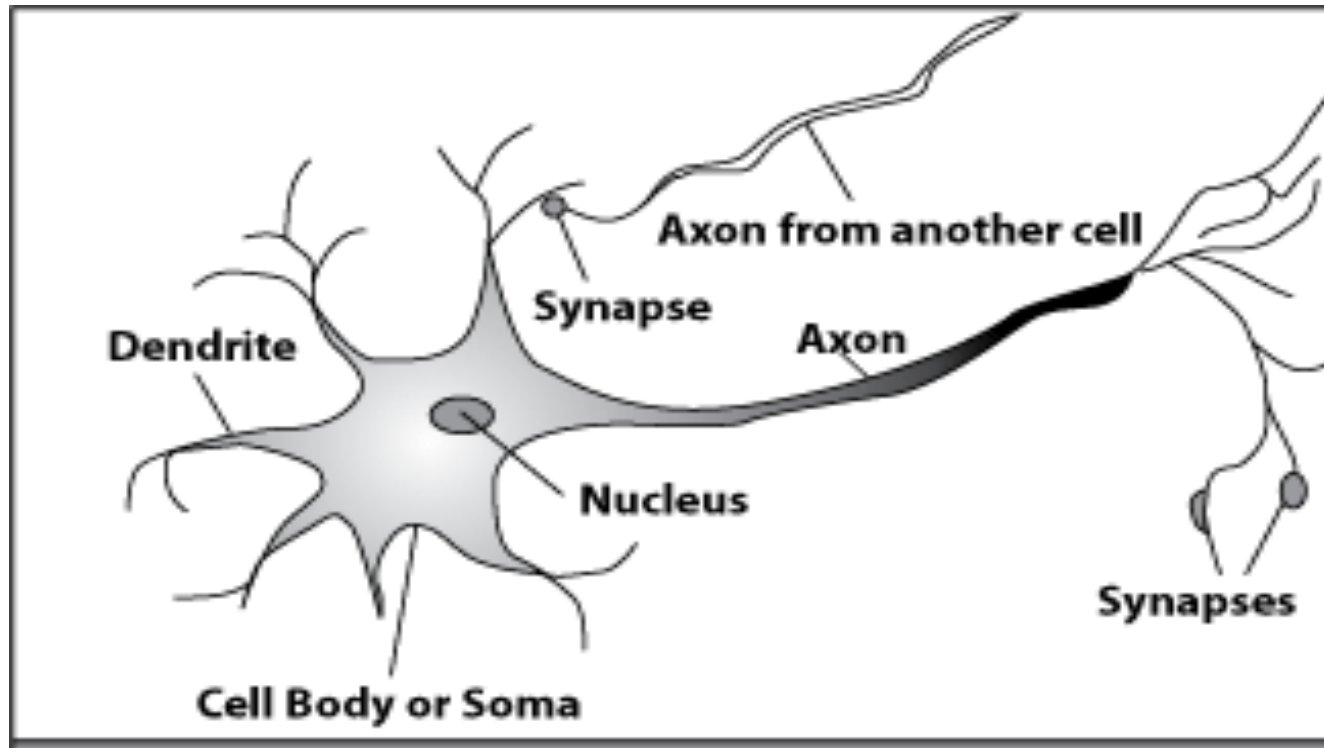
- A processing element



Dendrites: Input  
Cell body: Processor  
Synaptic: Link  
Axon: Output

# How do our brains work?

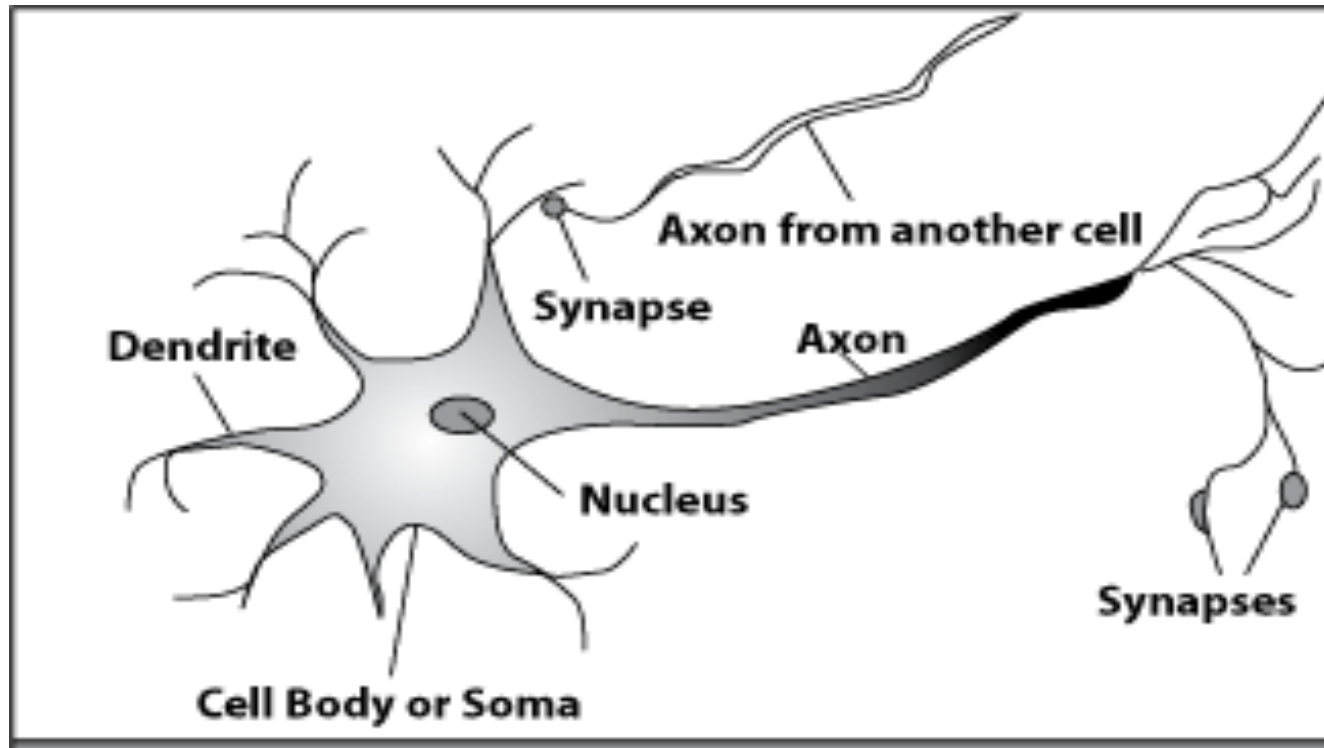
- A processing element



A neuron is connected to other neurons through about *10,000 synapses*

# How do our brains work?

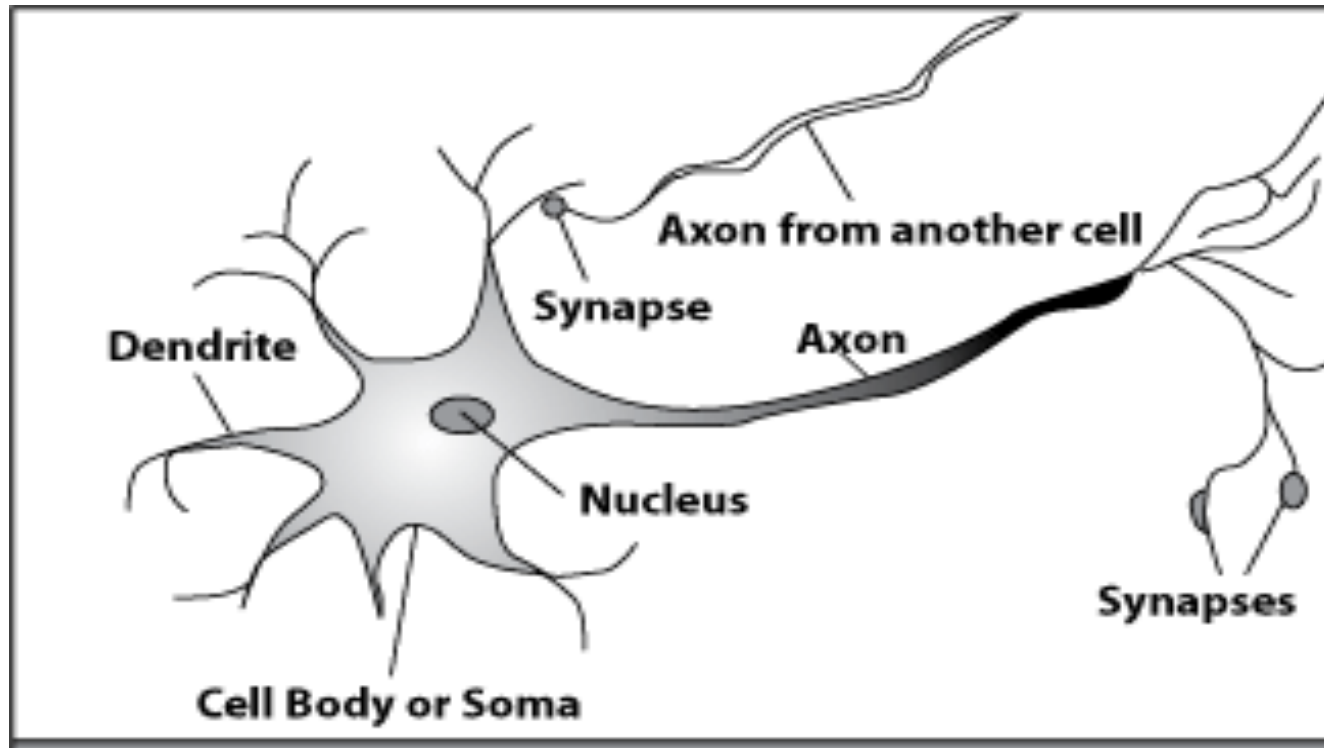
- A processing element



A neuron receives input from other neurons. Inputs are combined.

# How do our brains work?

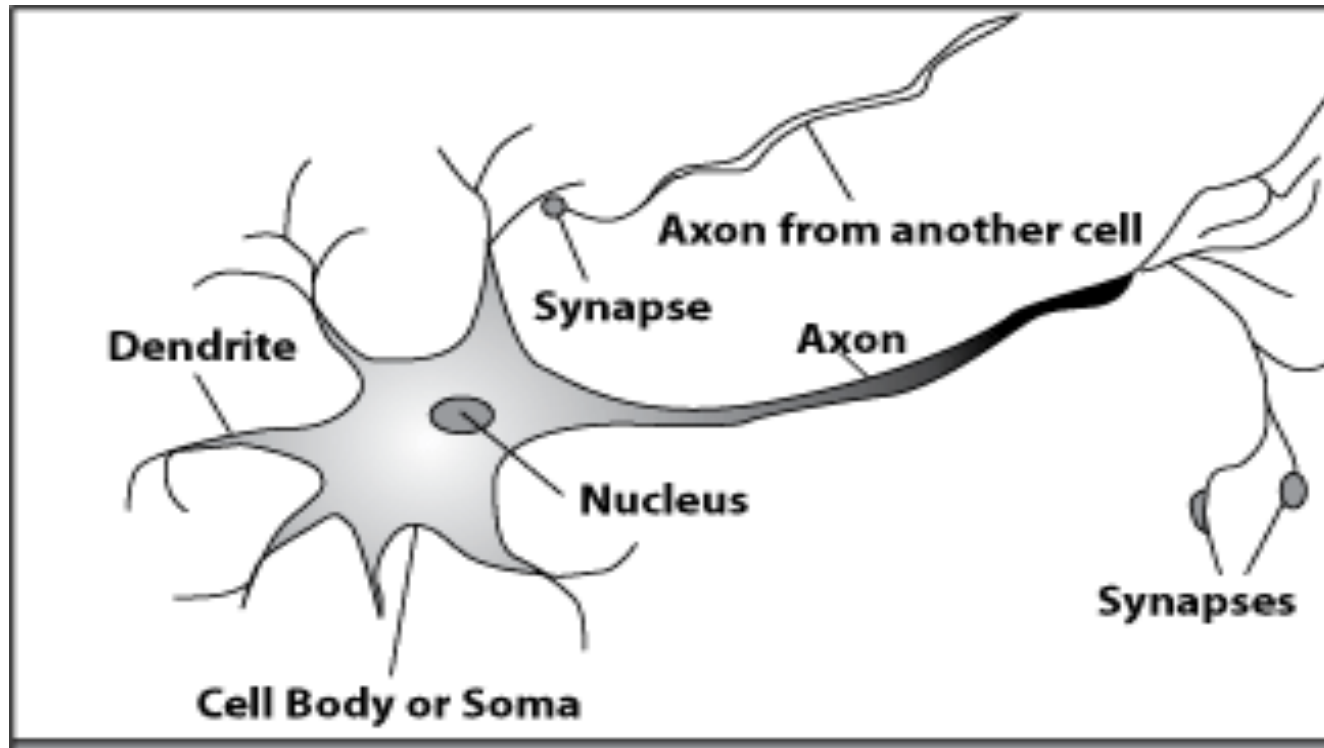
- A processing element



Once input exceeds a critical level, the neuron discharges a spike - an electrical pulse that travels from the body, down the axon, to the next neuron(s)

# How do our brains work?

- A processing element

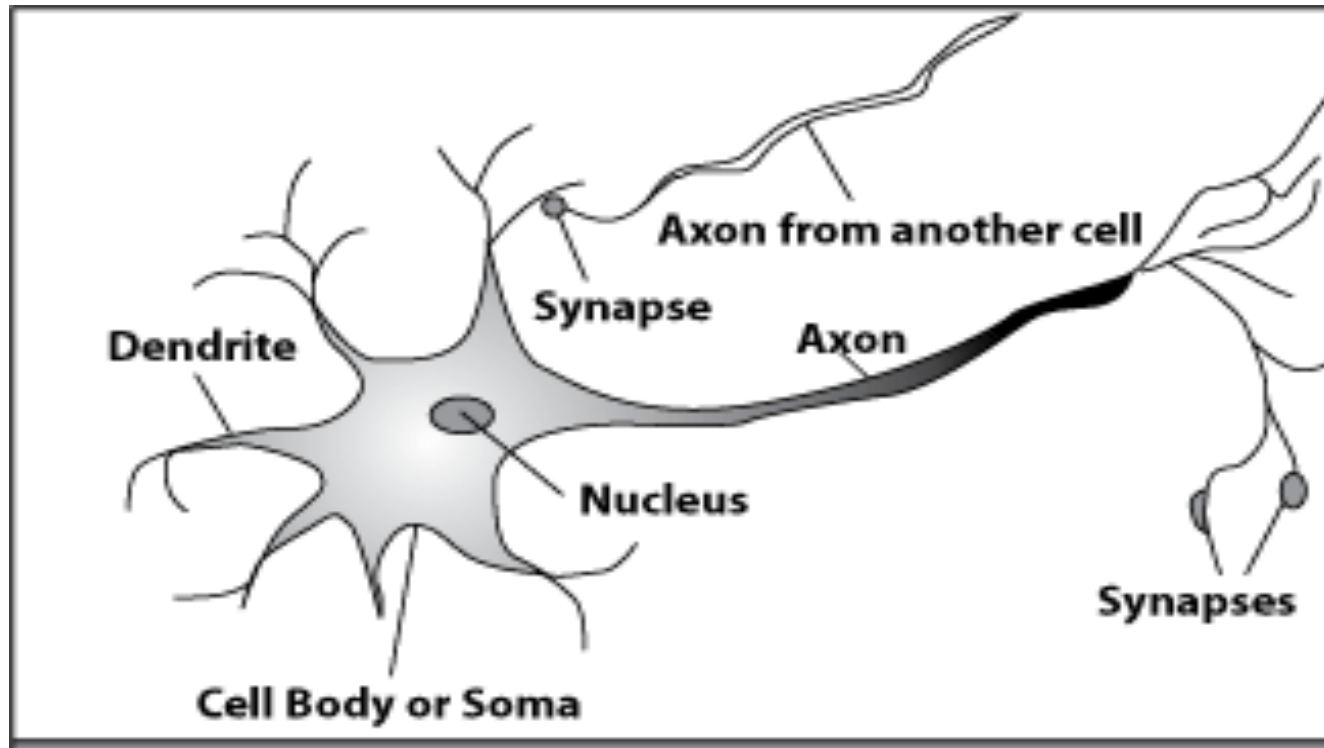


The axon endings almost touch the dendrites or cell body of the next neuron.



# How do our brains work?

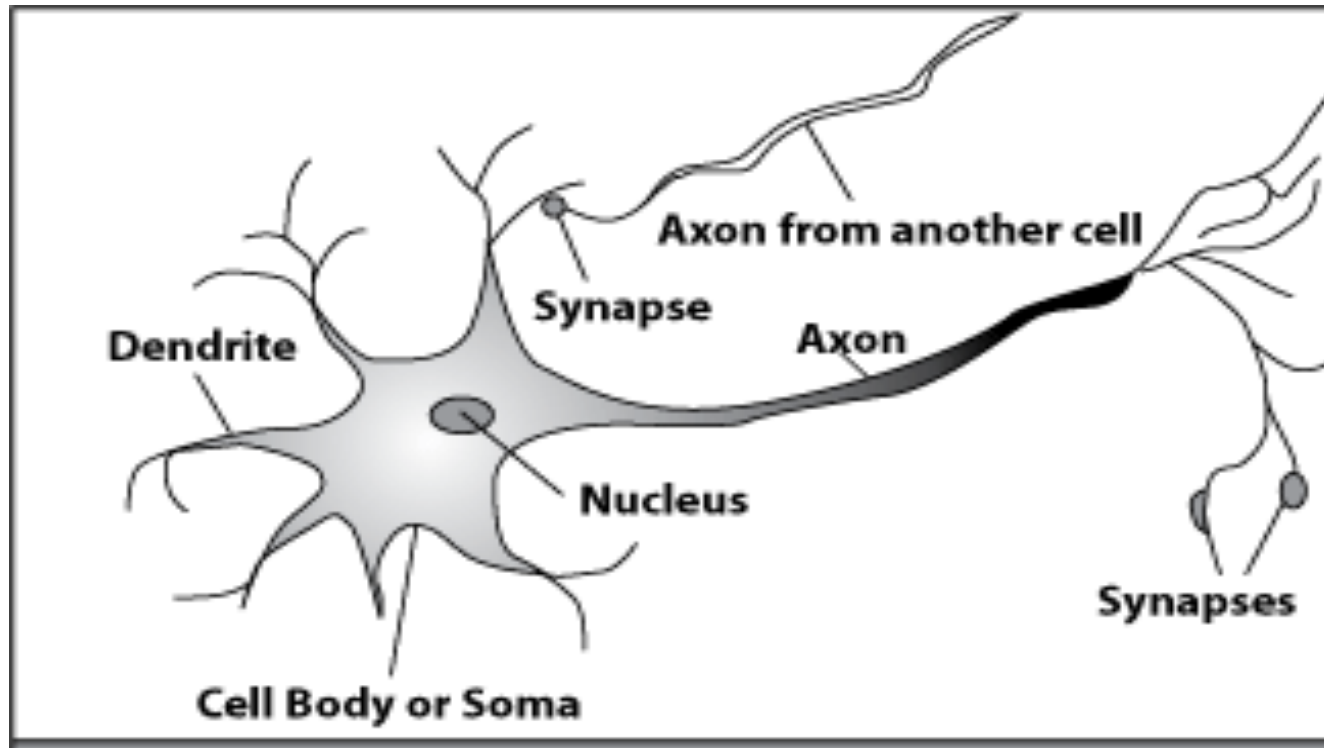
- A processing element



Transmission of an electrical signal from one neuron to the next is effected by neurotransmitters.

# How do our brains work?

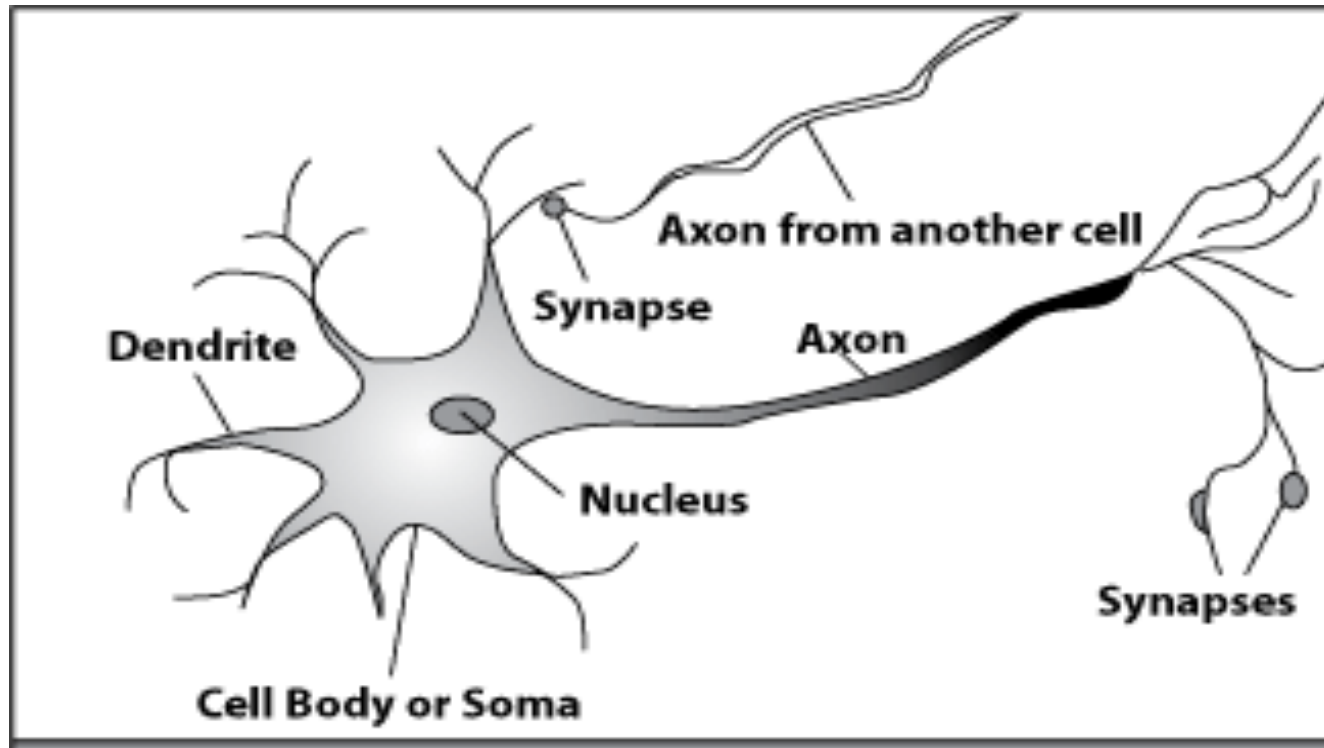
- A processing element



Neurotransmitters are chemicals which are released from the first neuron and which bind to the Second.

# How do our brains work?

- A processing element



This link is called a synapse. The strength of the signal that reaches the next neuron depends on factors such as the amount of neurotransmitter available.

# Artificial Neural Network

- An artificial neural network consists of a pool of simple processing units which communicate by sending signals to each other over a large number of weighted connections.

# Artificial Neural Network

- A set of major aspects of a parallel distributed model include:
  - a set of processing units (cells).
  - a state of activation for every unit, which equivalent to the output of the unit.
  - connections between the units. Generally each connection is defined by a weight.
  - a propagation rule, which determines the effective input of a unit from its external inputs.
  - an activation function, which determines the new level of activation based on the effective input and the current activation.

# Artificial Neural Network

- an external input for each unit.
- a method for information gathering (the learning rule).
- an environment within which the system must operate, providing input signals and \_ if necessary \_ error signals.

# Why Artificial Neural Networks?

- There are two basic reasons why we are interested in building artificial neural networks (ANNs):
- **Technical viewpoint:** Some problems such as character recognition or the prediction of future states of a system require massively **parallel and adaptive processing**.
- **Biological viewpoint:** ANNs can be used to replicate and simulate components of the human (or animal) brain, thereby giving us insight into **natural information processing**.

# Artificial Neural Networks

- The “building blocks” of neural networks are the **neurons**.
  - also referred as **units** or **nodes**.
- Basically, each neuron
  - receives **input** from many other neurons.
  - changes its internal state (**activation**) based on the current input.
  - sends **one output signal** to many other neurons, possibly including its input neurons (recurrent network).



# Artificial Neural Networks

- Information is transmitted as a series of electric impulses, so-called **spikes**.
- The **frequency** and **phase** of these spikes encodes the information.
- In biological systems, one neuron can be connected to as many as **10,000** other neurons.
- Usually, a neuron receives its information from other neurons in a confined area, its so-called **receptive field**.

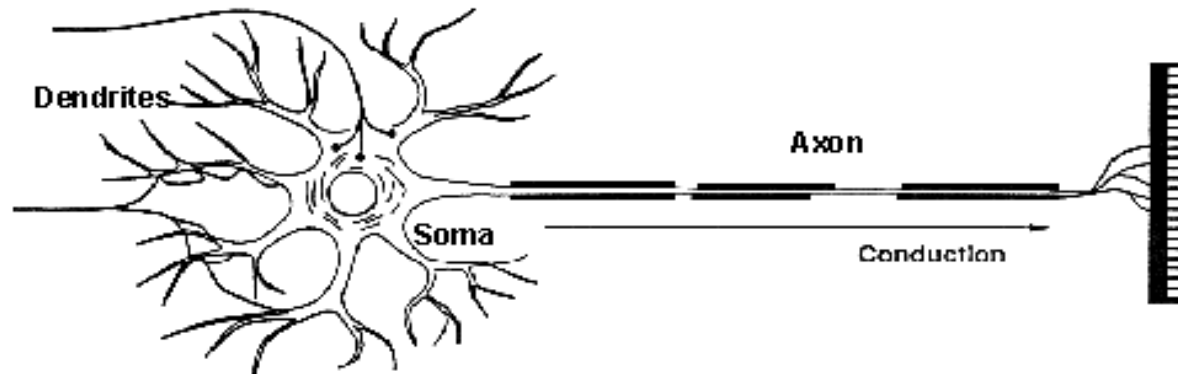
# How do ANNs work?

- An artificial neural network (ANN) is either a **hardware implementation** or a **computer program** which strives to simulate the information processing capabilities of its biological exemplar. ANNs are typically composed of a great number of interconnected artificial neurons. The artificial neurons are simplified models of their biological counterparts.
- ANN is a technique for solving problems by constructing software that works like our brains.

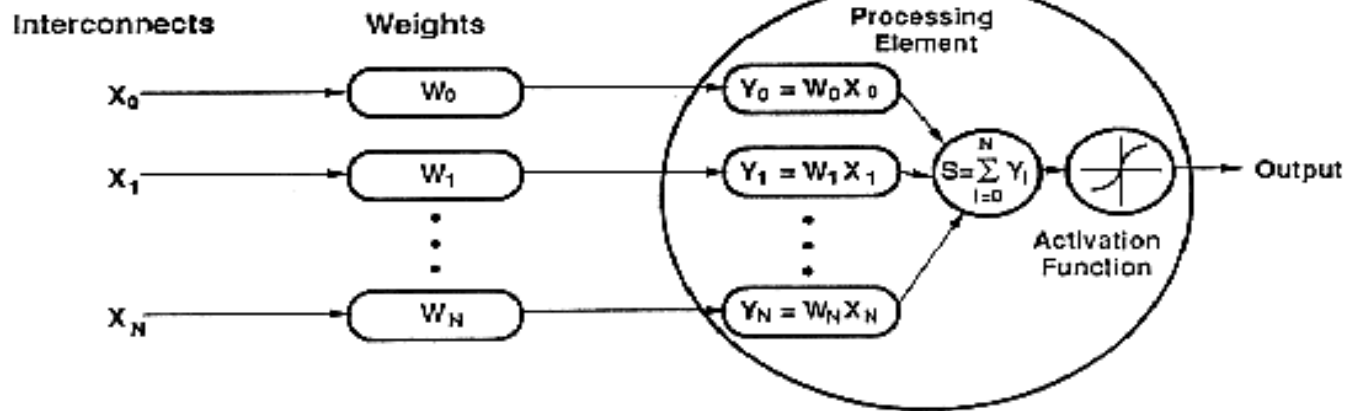


# How do ANNs work?

## Biological Neuron



## Artificial Neuron

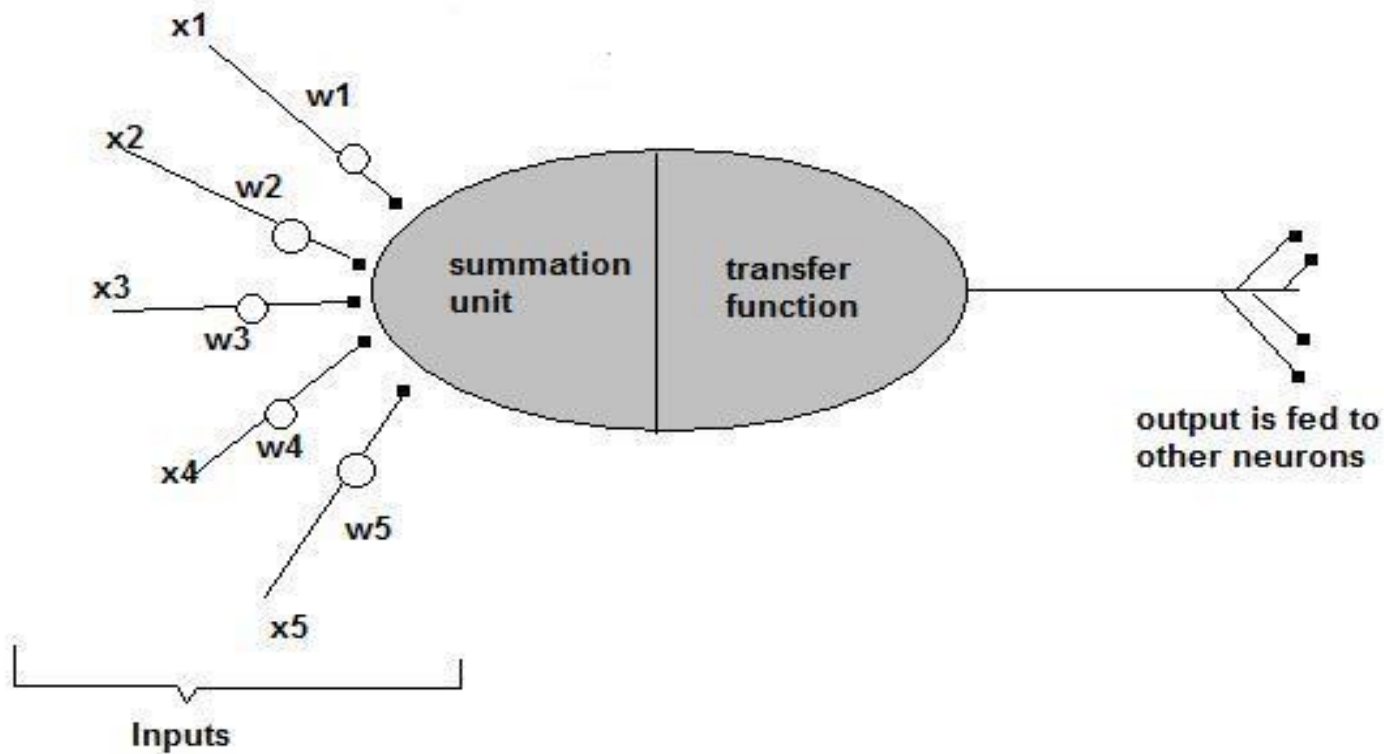


An artificial neuron is an imitation of a human neuron

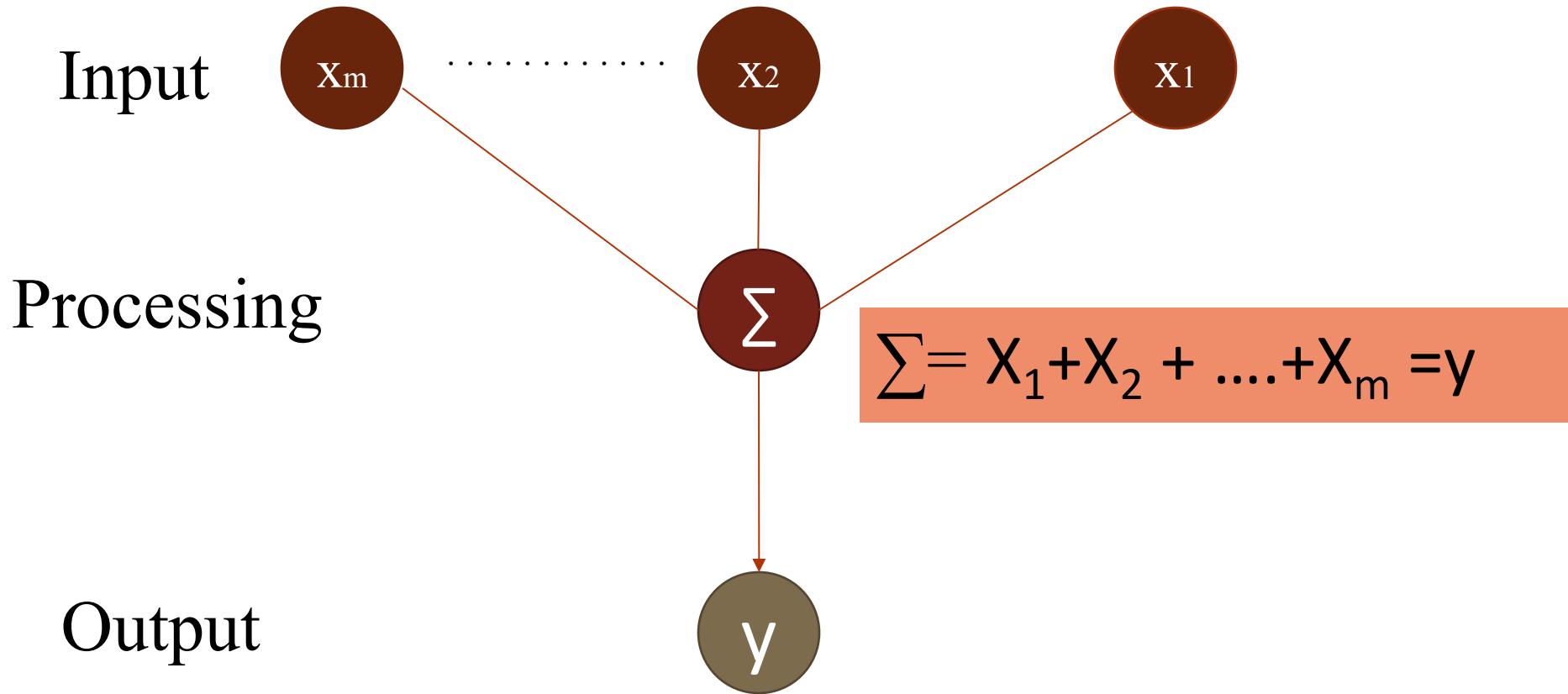
# How do ANNs work?

- Now, let us have a look at the model of an artificial neuron.

## A Single Neuron

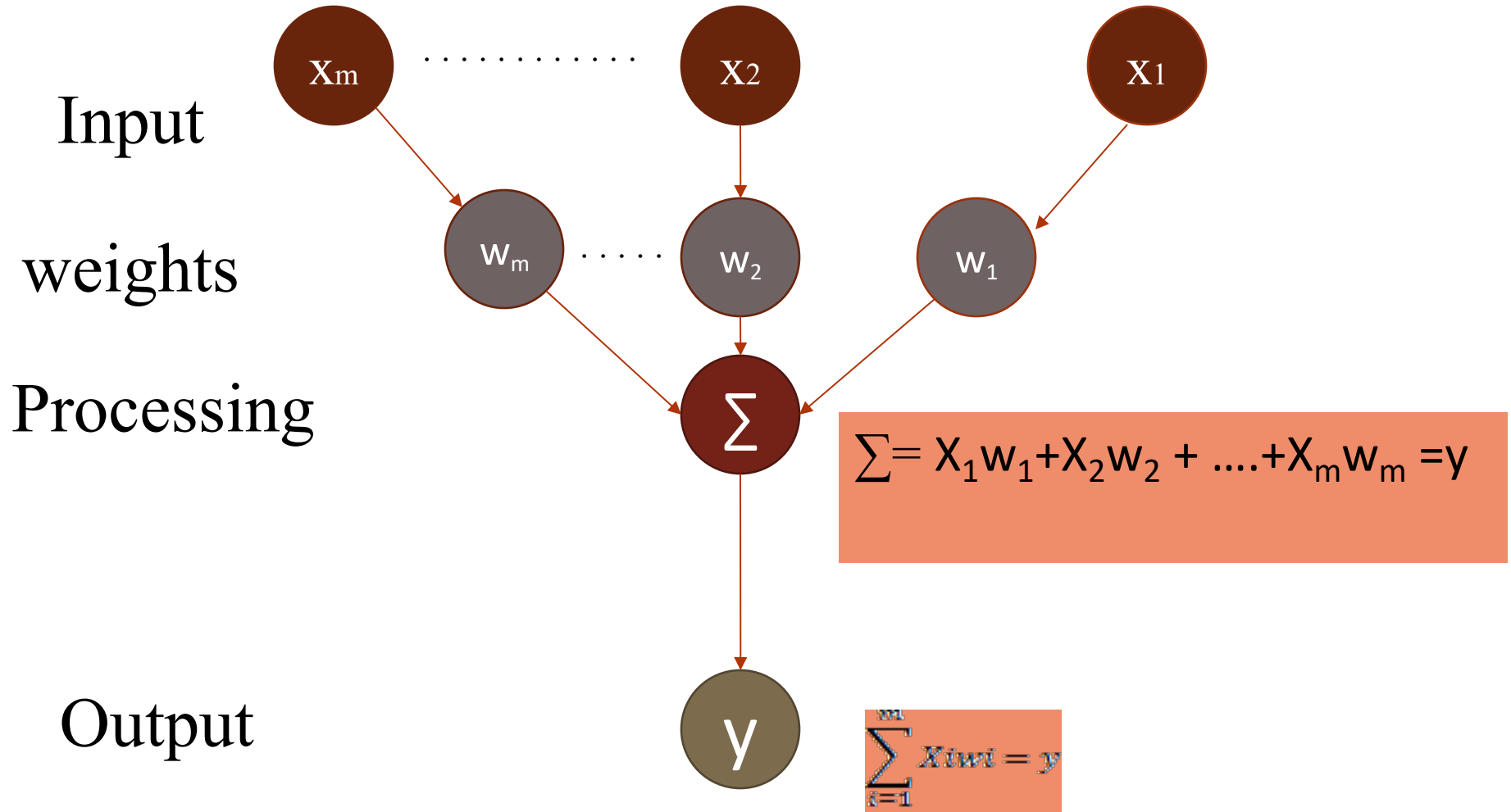


# How do ANNs work?



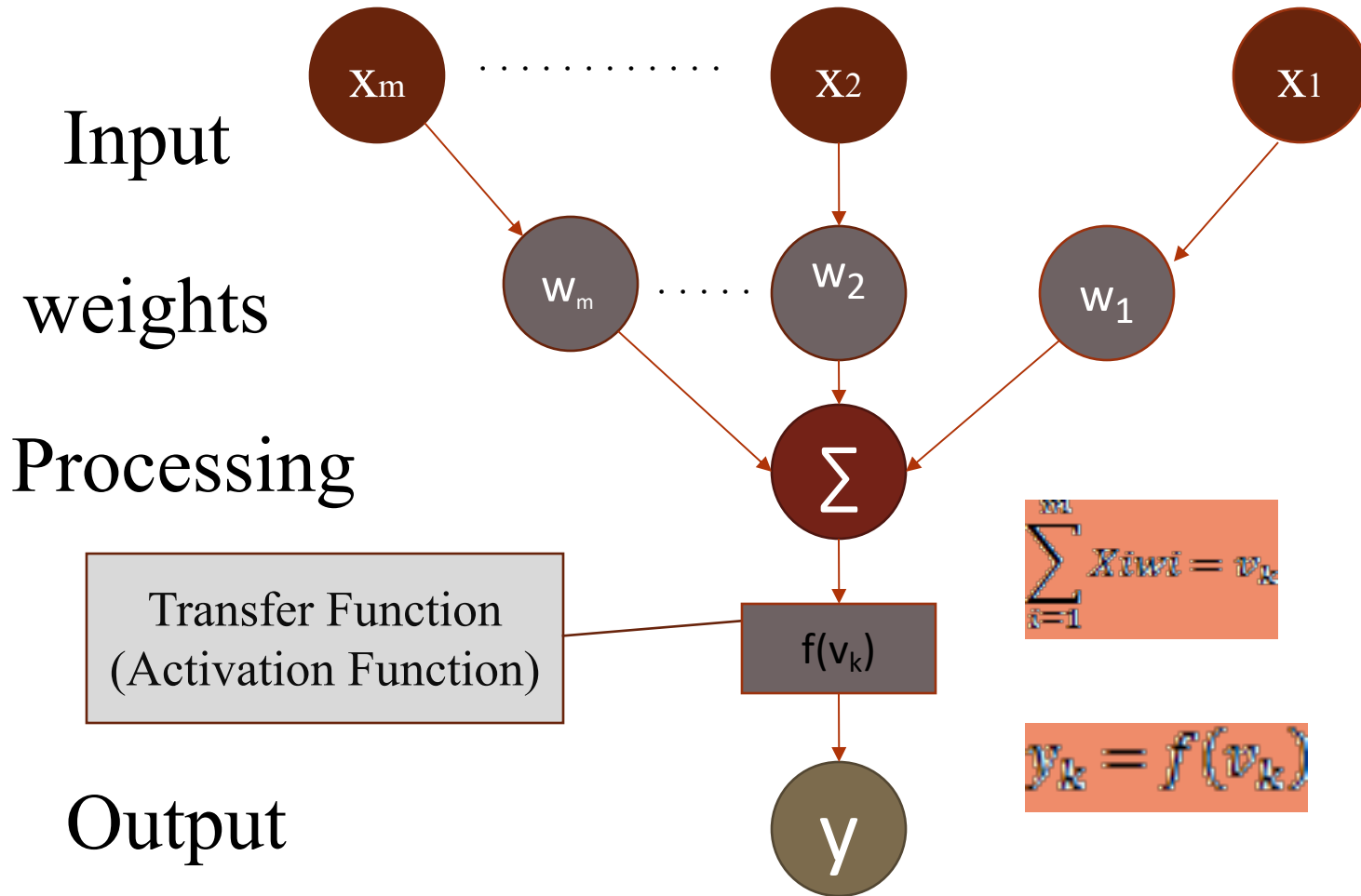
# How do ANNs work?

Not all inputs are equal

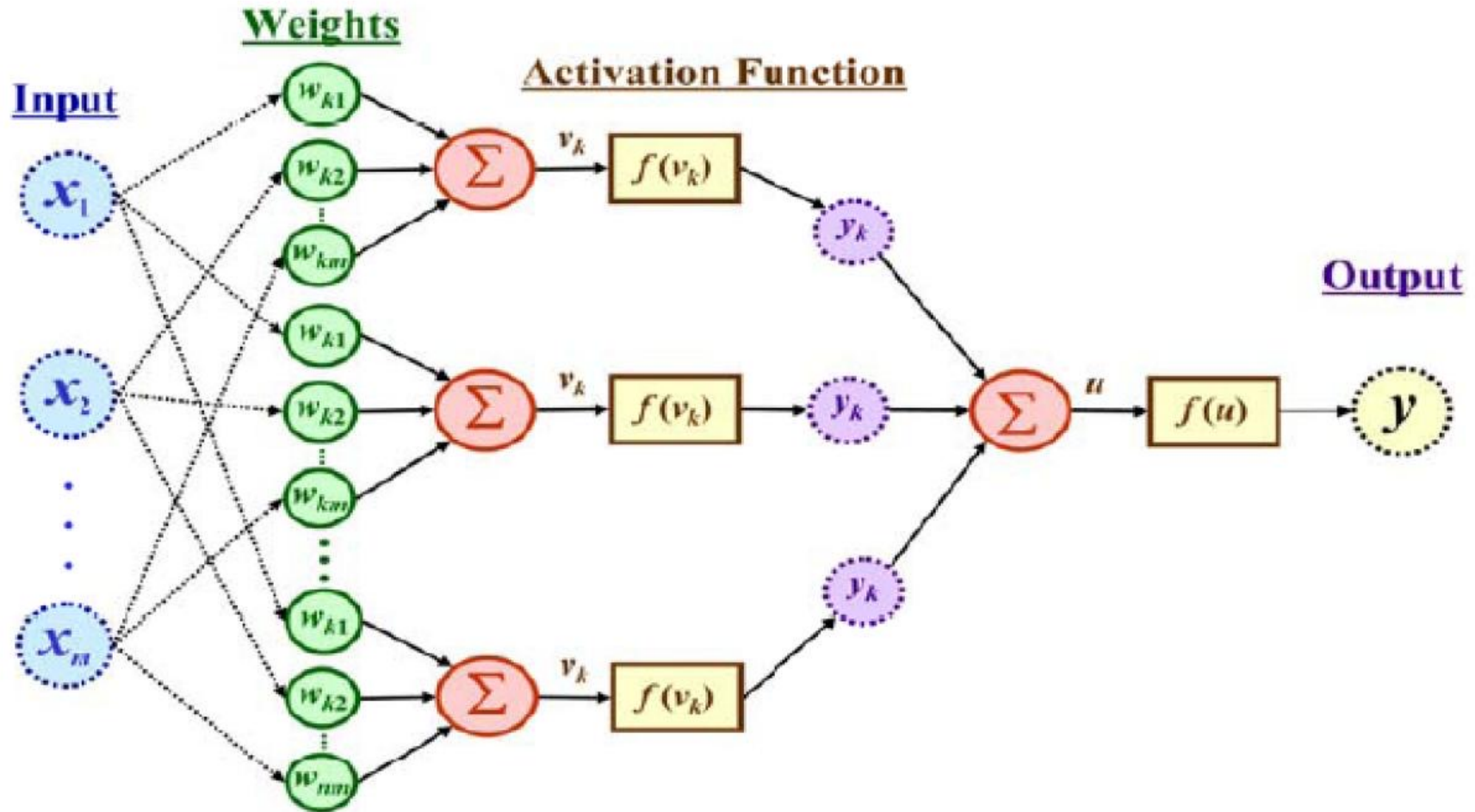


# How do ANNs work?

The signal is not passed down to the next neuron verbatim

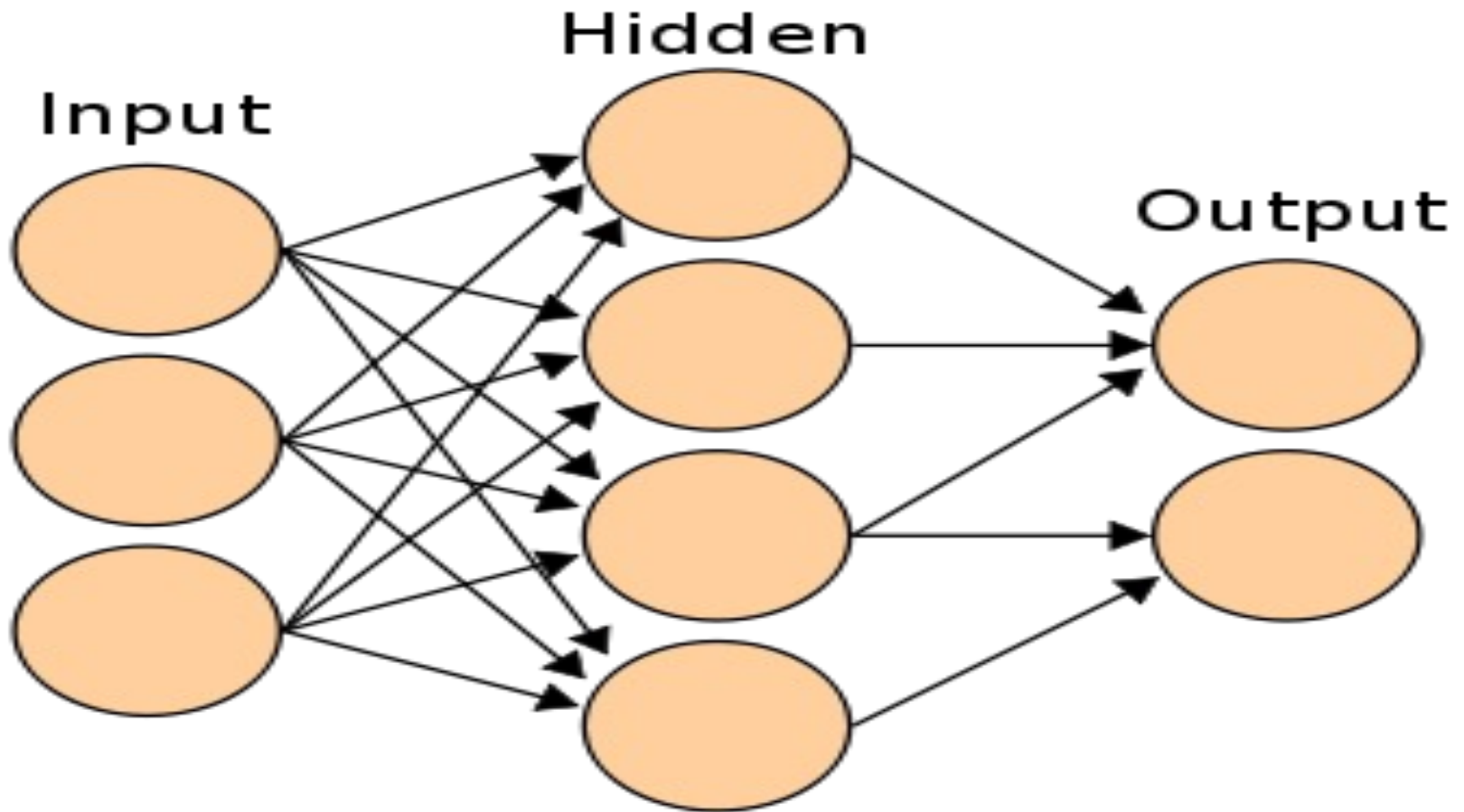


The output is a function of the input, that is affected by the weights, and the transfer functions





# Three types of layers: Input, Hidden, and Output



# Artificial Neural Networks

- An ANN can:
  1. compute *any computable* function, by the appropriate selection of the network topology and weights values.
  2. learn from experience!
    - Specifically, by trial-and-error

# Learning by trial-and-error

## Continuous process of:

### ➤ Trial:

Processing an input to produce an output (In terms of ANN: Compute the output function of a given input)

### ➤ Evaluate:

Evaluating this output by comparing the actual output with the expected output.

### ➤ Adjust:

Adjust the *weights*.