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Neural Networks

Moin Mostakim

What is Neural Network

- A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates.
- Neural networks can adapt to changing input; so the network generates the best possible result without needing to redesign the output criteria.
- The concept of neural networks, which has its roots in artificial intelligence, is swiftly gaining popularity these days.

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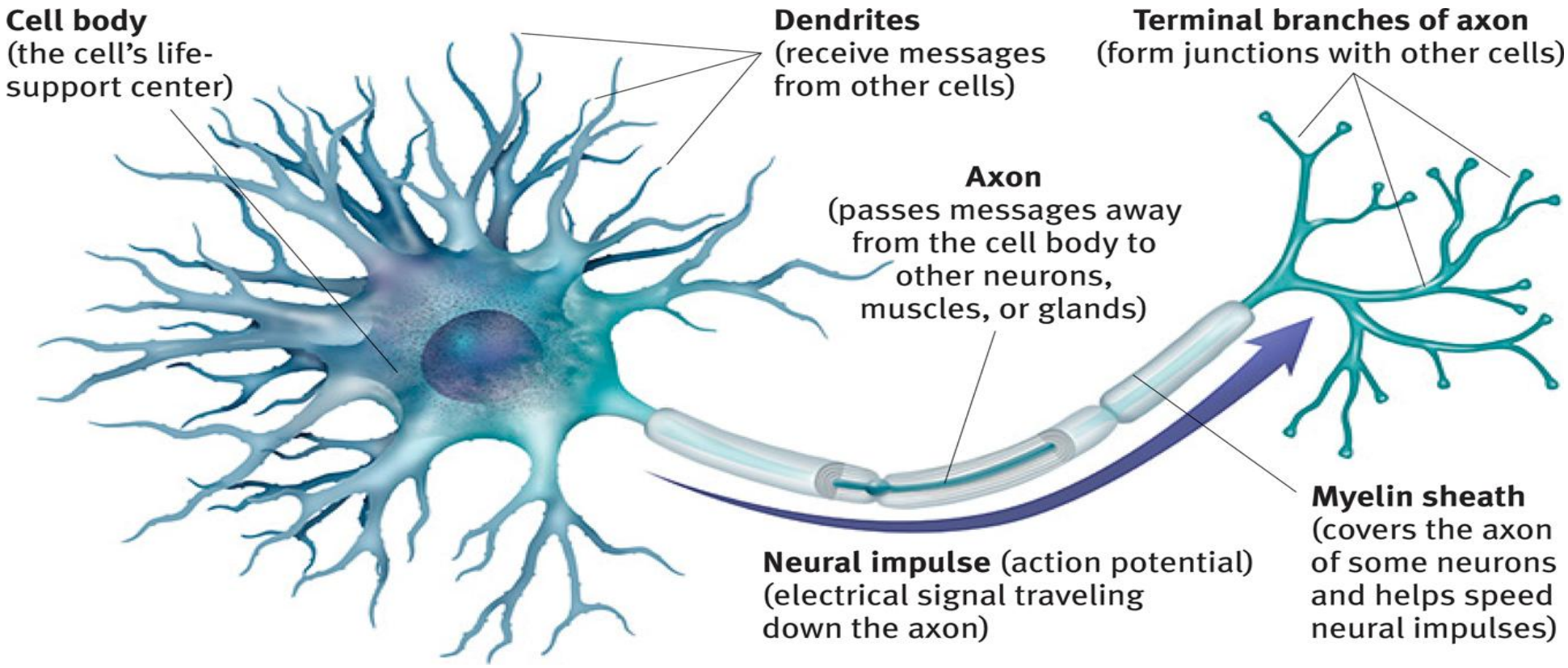
Biological Structure Of Neuron

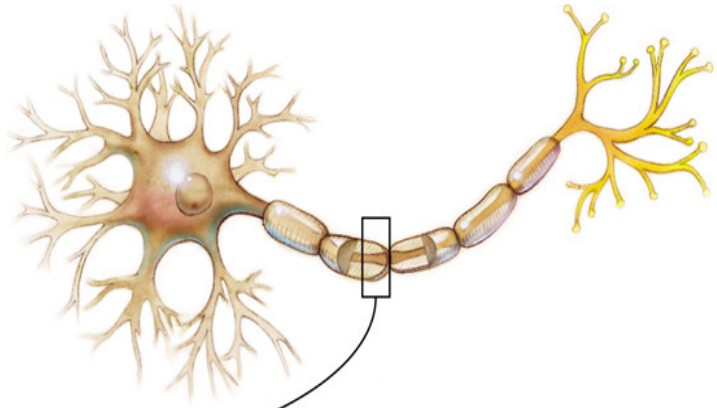
The Structure of a Neuron



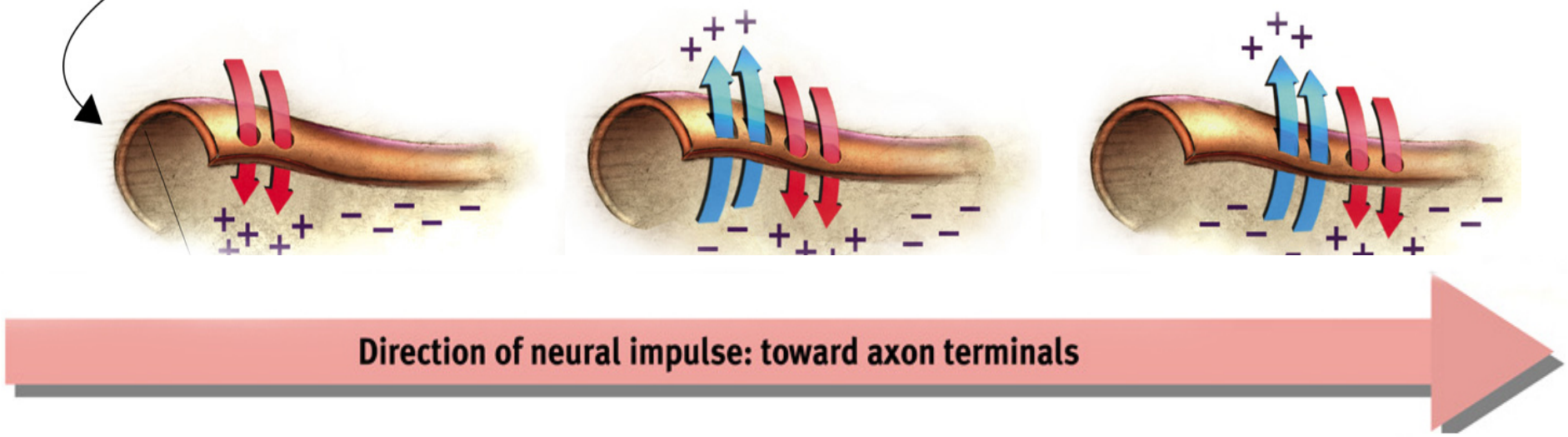
There are billions of neurons
(nerve cells) throughout the body.

Action potential

A neural impulse that travels down an axon like a wave



Just as “the wave” can flow to the right in a stadium even though the people only move up and down, a wave moves down an axon although it is only made up of ion exchanges moving in and out.



When does the cell send the action potential?... when it reaches a threshold

How neurons communicate (with each other):

The neuron receives signals from other neurons; some are telling it to fire and some are telling it not to fire.

When the **threshold** is reached, the action potential starts moving.

- Like a gun, it either fires or it doesn't; more stimulation does nothing.
- This is known as the "all-or-none" response.

The action potential travels down the axon from the cell body to the terminal branches.

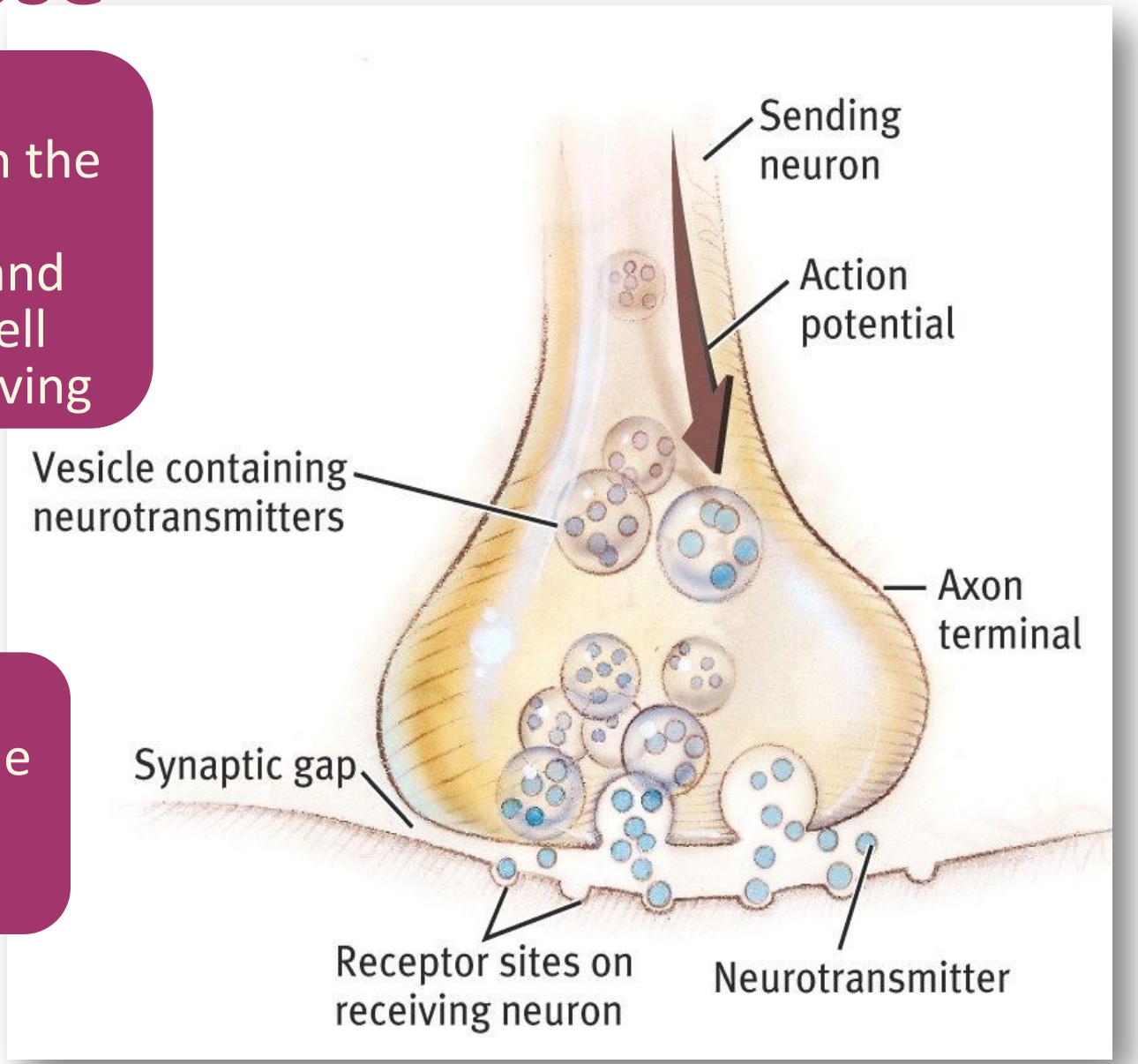
The signal is transmitted to another cell. However, the message must find a way to cross a gap between cells. This gap is also called **the synapse.**

The **threshold** is reached when excitatory ("Fire!") signals outweigh the inhibitory ("Don't fire!") signals by a certain amount.

The Synapse

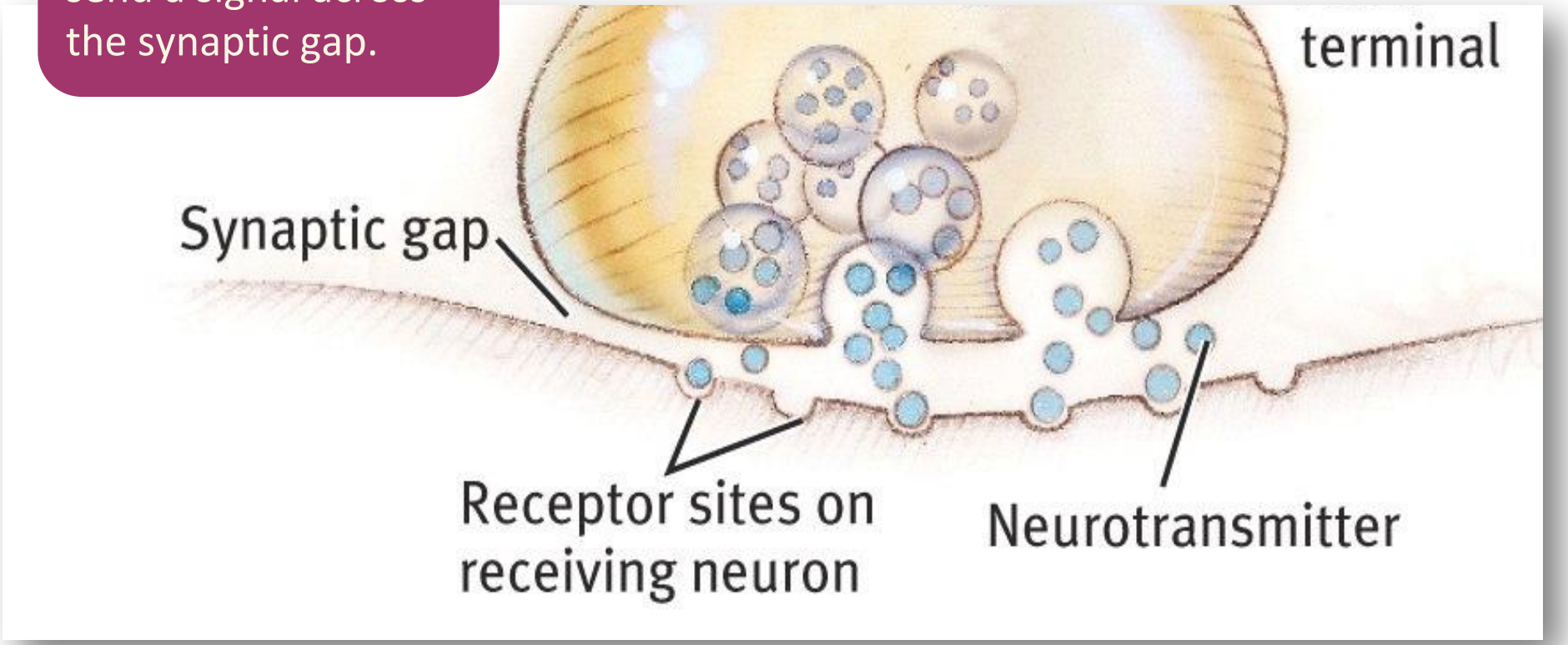
The synapse is a junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron.

The synapse is also known as the "**synaptic junction**" or "**synaptic gap**."



Neurotransmitters

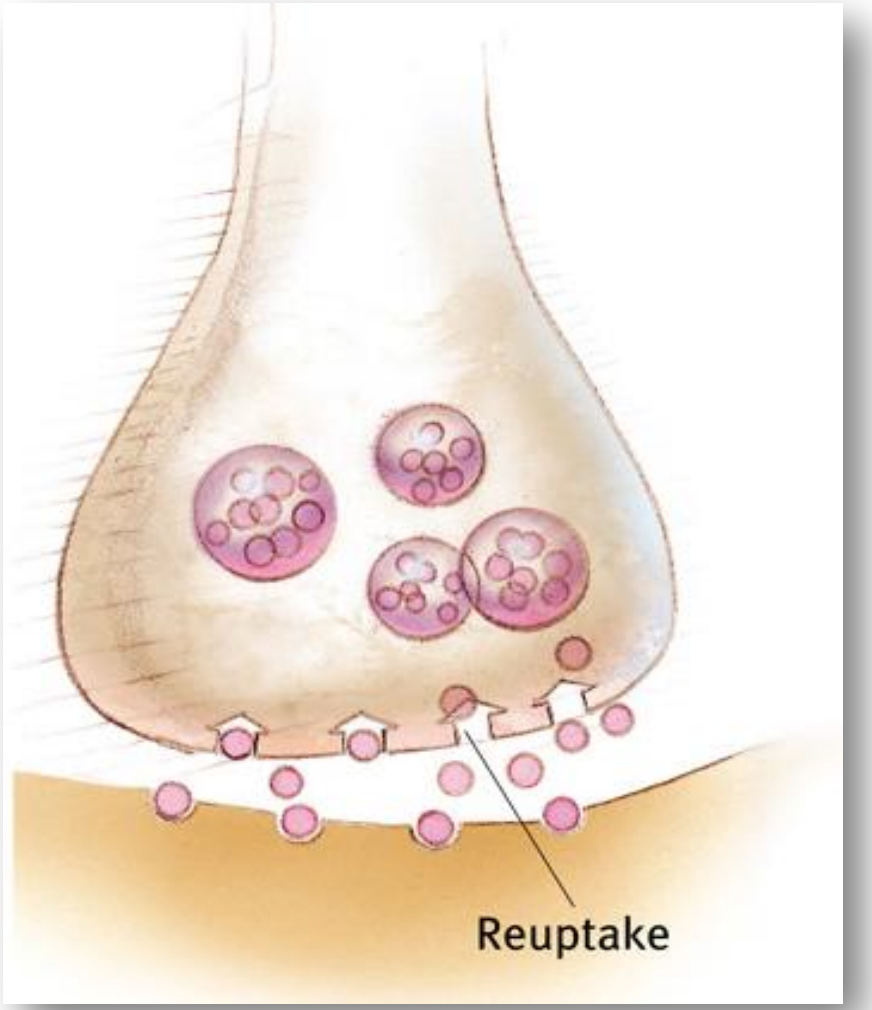
Neurotransmitters are chemicals used to send a signal across the synaptic gap.



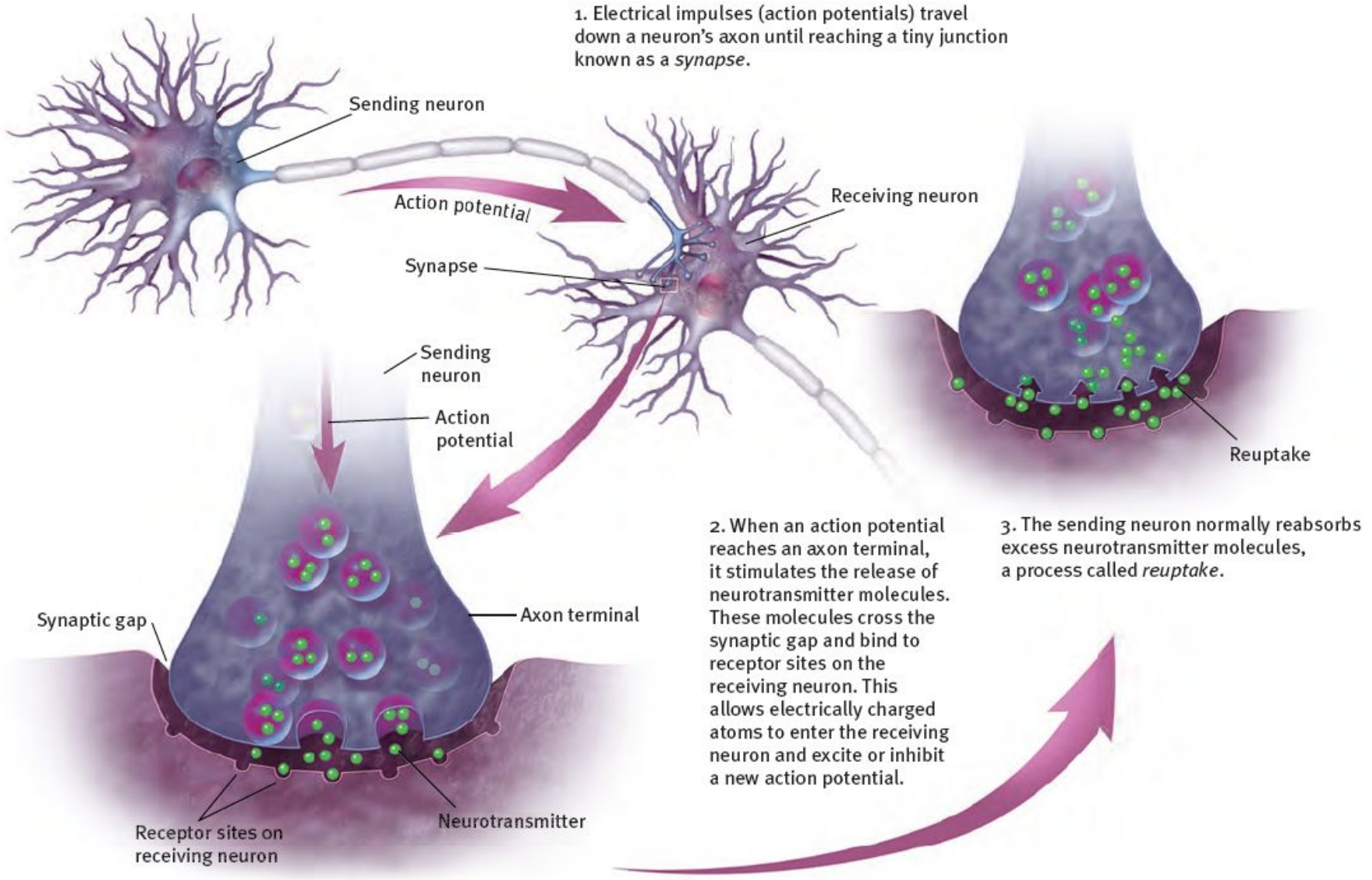
Reuptake:
Recycling Neurotransmitters [NTs]

Reuptake:

After the neurotransmitters stimulate the receptors on the receiving neuron, the chemicals are taken back up into the sending neuron to be used again.



Neural Communication:
Seeing all the Steps Together



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Brief History of Neural Network

Brief History Of Neural Networks

1943

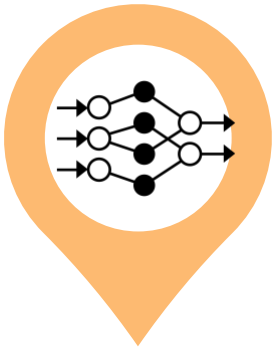
Warren McCulloch

Walter Pitts, wrote a paper on how neurons might work. They modeled a simple neural network with electrical circuits.

1949

Donald Hebb

Reinforced the concept of neurons in his book, The Organization of Behavior. It pointed out that neural pathways are strengthened each time they are used.



1950

Nathanial Rochester

IBM research laboratories led the first effort to simulate a neural network

1956

Dartmouth

Provided a boost to both artificial intelligence and neural networks. This stimulated research in AI and in the much lower level neural processing part of the brain.

1957

John von Neumann

Suggested imitating simple neuron functions by using telegraph relays or vacuum tubes.

Brief History Of Neural Networks

1958

Frank Rosenblatt

Began work on the Perceptron. He was intrigued with the operation of the eye of a fly. The Perceptron, which resulted from this research, was built in hardware and is the oldest neural network still in use today. A single-layer perceptron was found to be useful in classifying a continuous-valued set of inputs into one of two classes. The perceptron computes a weighted sum of the inputs, subtracts a threshold, and passes one of two possible values out as the result.

1959

Widrow and Hoff

Developed models they called ADALINE and MADALINE. These models were named for their use of Multiple ADAptive LINear Elements. MADALINE was the first neural network to be applied to a real-world problem. It is an adaptive filter which eliminates echoes on phone lines. This neural network is still in commercial use

1981

Progress on neural network research halted due fear, unfulfilled claims, etc. until 1981. This caused respected voices to critique the neural network research. The result was to halt much of the funding. This period of stunted growth lasted through 1981

1982

Minsky & Seymour

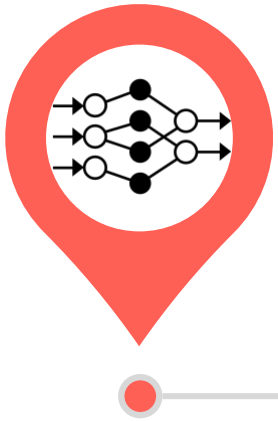
Papert proved the Perceptron to be limited in their book, Perceptrons

1982

John Hopfield

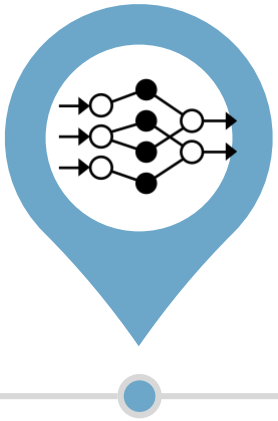
His approach to create useful devices; he was likeable, articulate, and charismatic.

Brief History Of Neural Networks



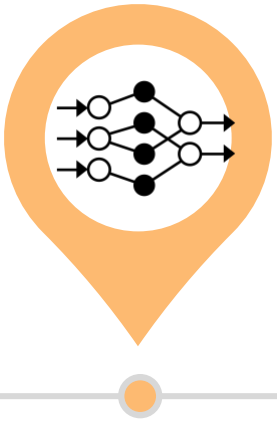
1982

US-Japan Joint Conference on Cooperative/ Competitive Neural Networks at which Japan announced their Fifth-Generation effort resulted US worrying about being left behind. Soon funding was flowing once again.



1985

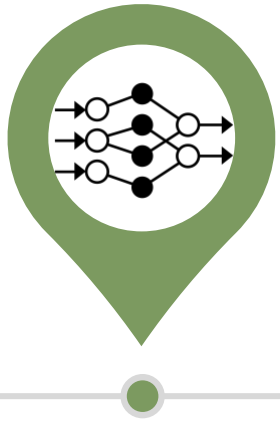
American Institute of Physics began what has become an annual meeting - Neural Networks for Computing. By 1987, the Institute of Electrical and Electronic Engineer's (IEEE) first International Conference on Neural Networks drew more than 1,800 attendees.



1997

Schmidhuber & Hochreiter

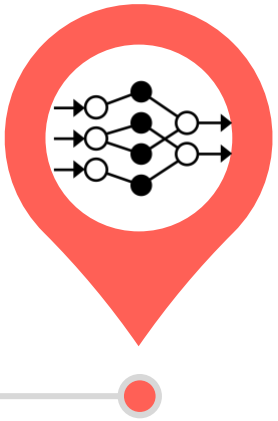
A recurrent neural network framework, Long Short-Term Memory (LSTM) was proposed



1998

Yann LeCun

Gradient-Based Learning Applied to Document Recognition.



Now

Several other steps have been taken to get us to where we are now; today, neural networks discussions are prevalent; the future is here! Currently most neural network development is simply proving that the principal works. This research is developing neural networks that, due to processing limitations, take weeks to learn.

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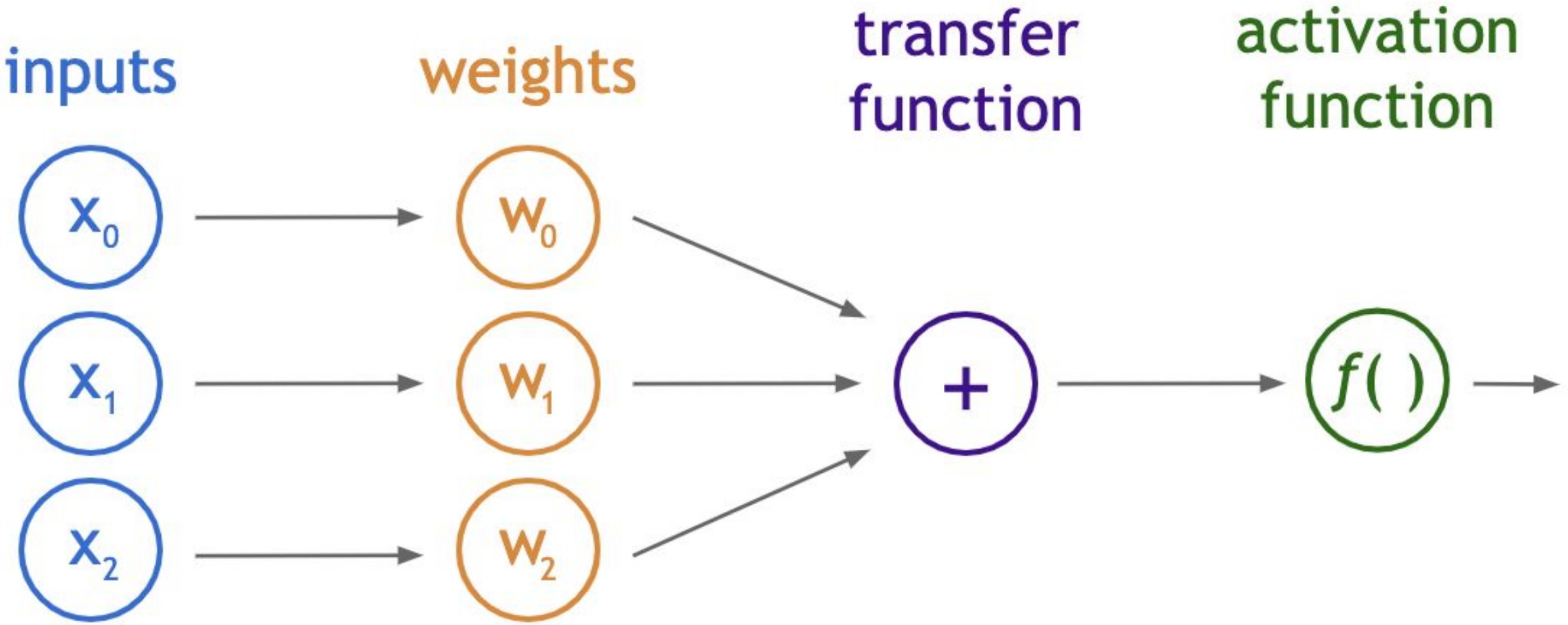
Components of Neural Network

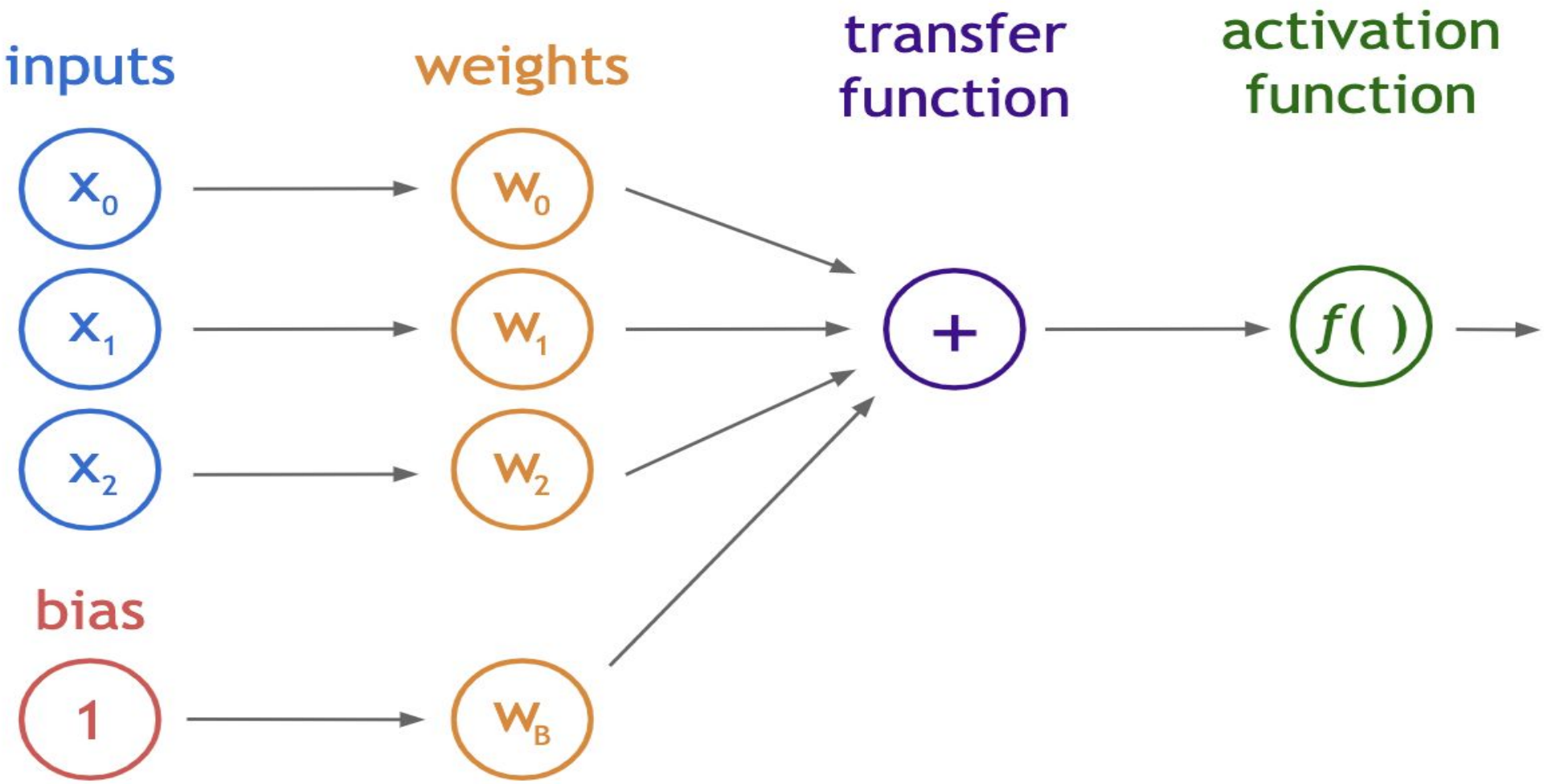
Major Components

- Inputs
- Weights
- Transfer Function
- Activation Function
- Bias

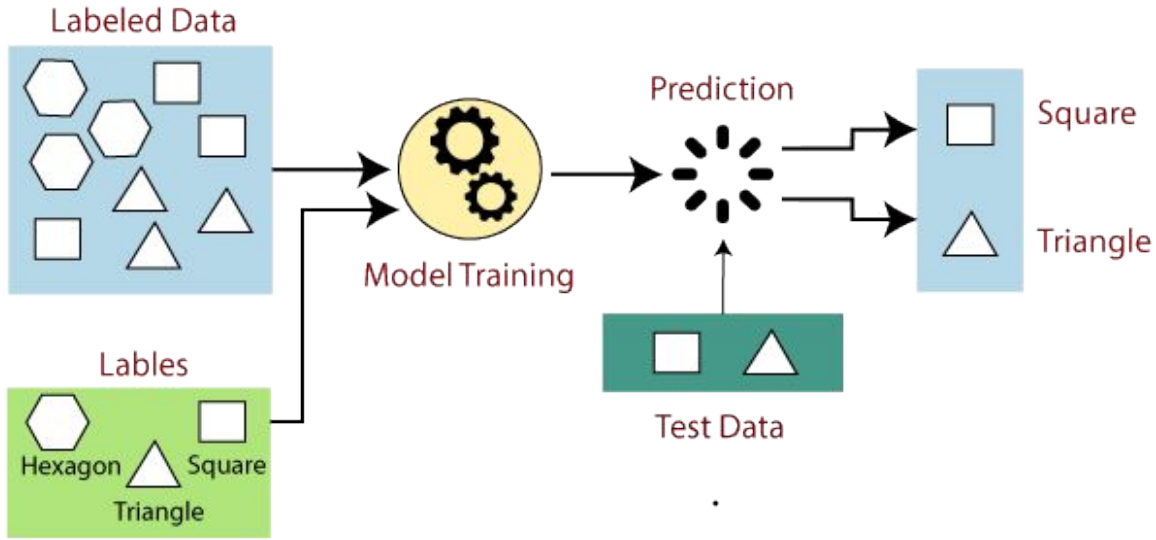
Without Bias

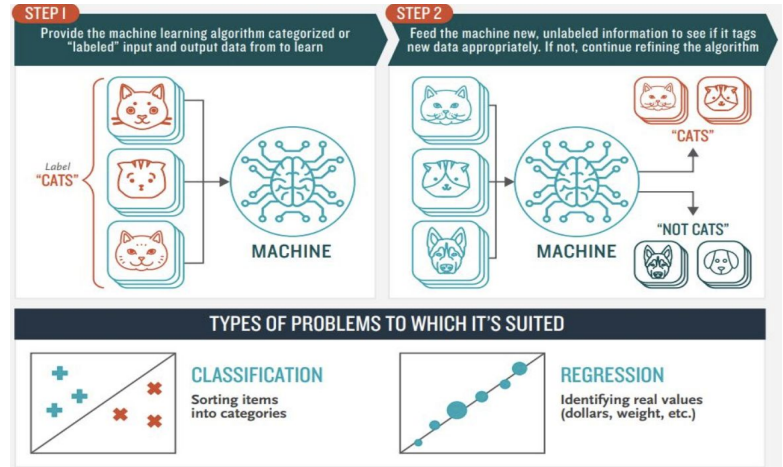


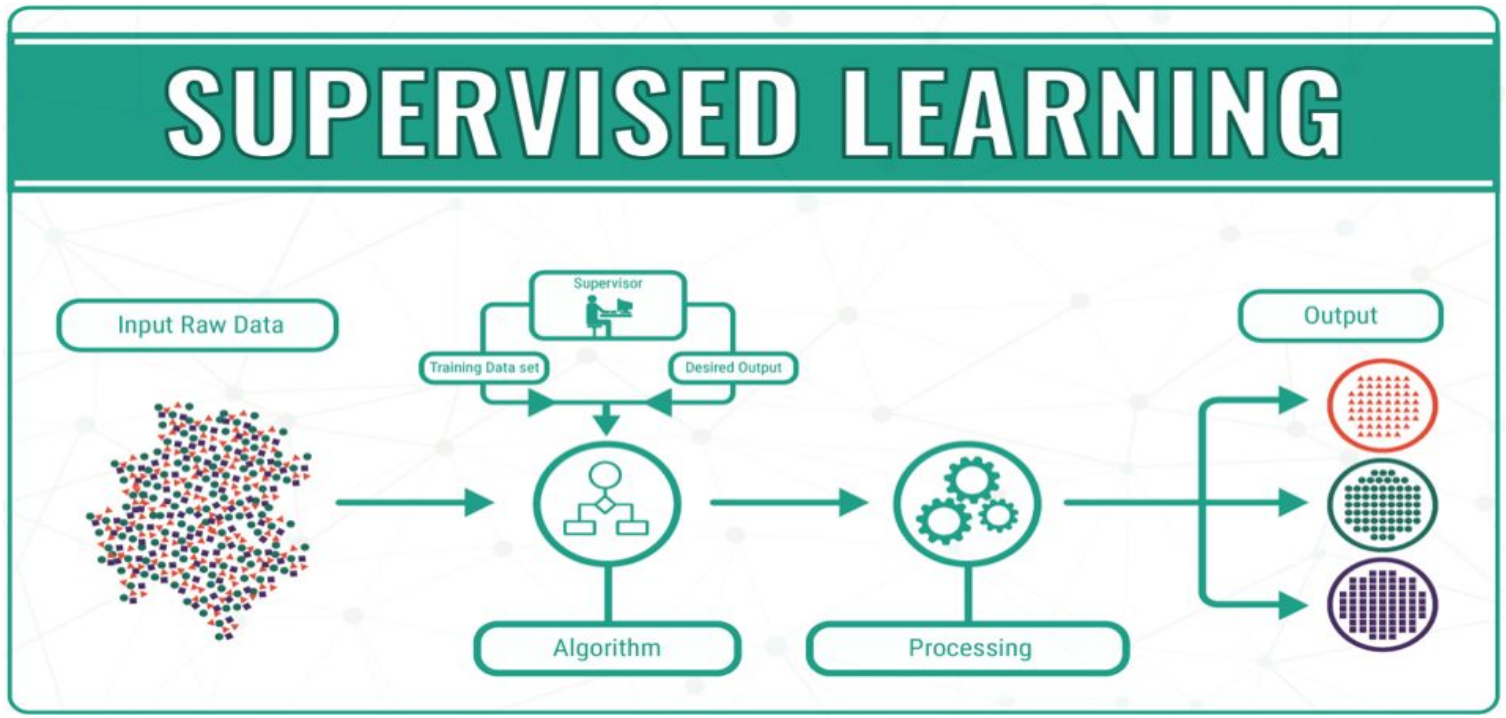
With Bias


inputs
weights
transfer function
activation function
x_0
x_1
x_2
bias
1
w_0
w_1
w_2
w_B
+
$f( )$

Supervised Domain


Labeled Data
Lables
Hexagon
Square
Triangle
Model Training
Prediction
Square
Triangle
Test Data


STEP 1
Provide the machine learning algorithm categorized or "labeled" input and output data from to learn
Label "CATS"
MACHINE
STEP 2
Feed the machine new, unlabeled information to see if it tags new data appropriately. If not, continue refining the algorithm
"CATS"
"NOT CATS"
MACHINE
TYPES OF PROBLEMS TO WHICH IT'S SUITED
CLASSIFICATION
Sorting items into categories
REGRESSION
Identifying real values (dollars, weight, etc.)


SUPERVISED LEARNING
Input Raw Data
Supervisor
Training Data set
Desired Output
Algorithm
Processing
Output

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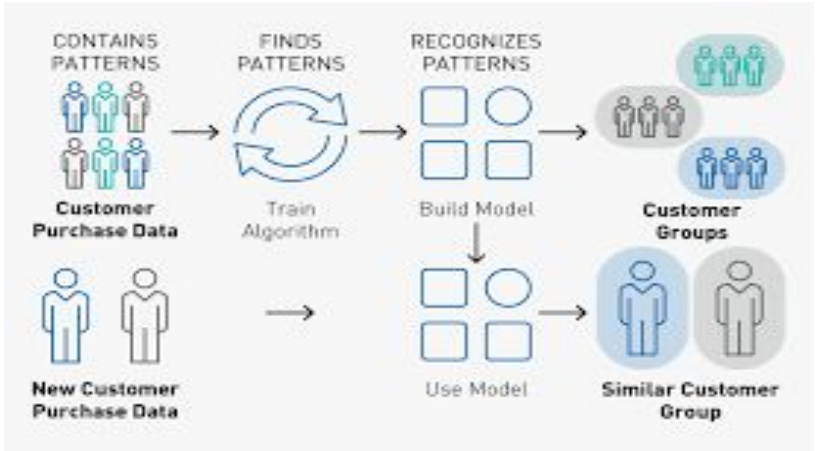
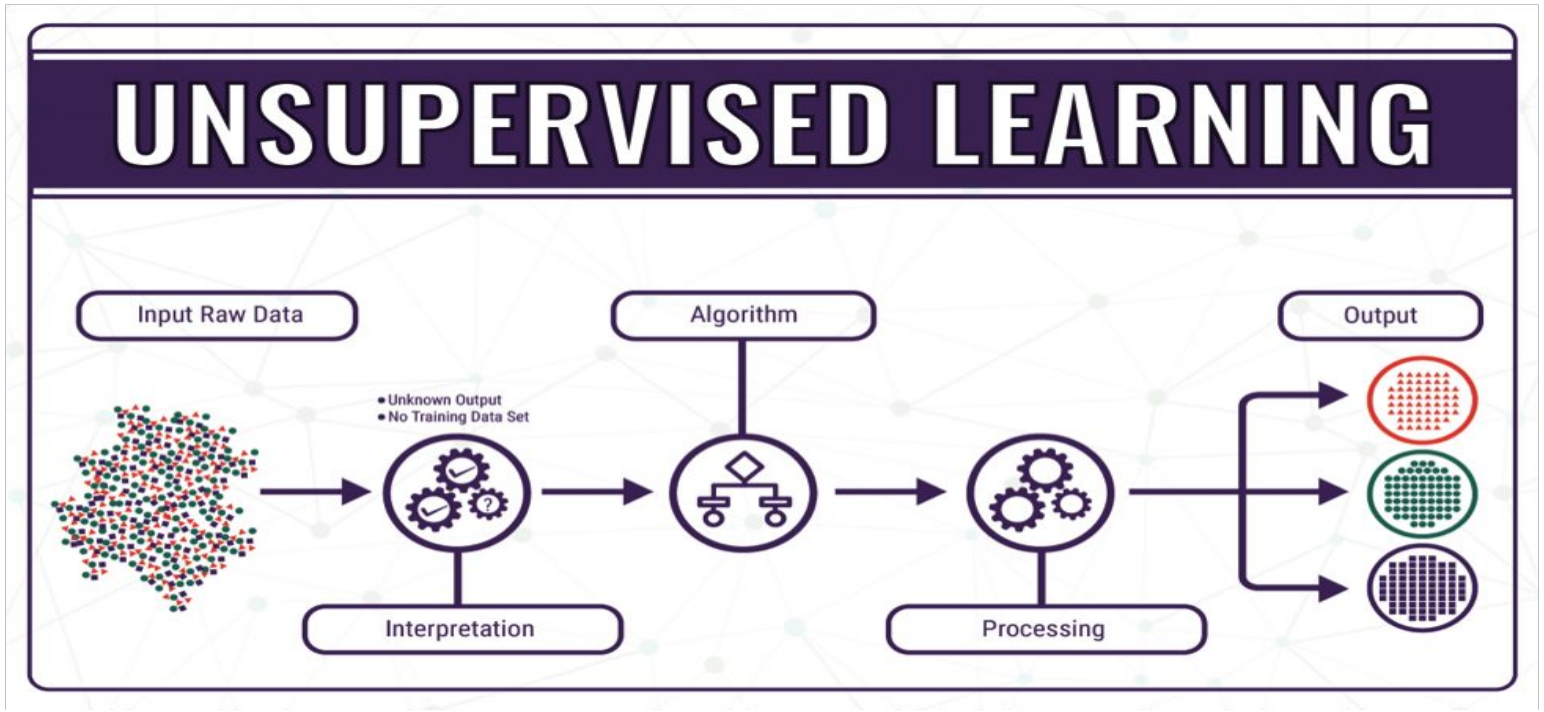
Unsupervised Domain


CONTAINS PATTERNS
FINDS PATTERNS
RECOGNIZES PATTERNS
Customer Purchase Data
Train Algorithm
Build Model
Customer Groups
New Customer Purchase Data
Use Model
Similar Customer Group


UNSUPERVISED LEARNING
Input Raw Data
Unknown Output
No Training Data Set
Algorithm
Output
Interpretation
Processing

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Neural Network Applications

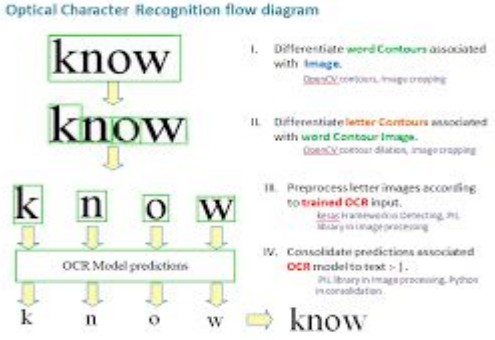
Applications of Neural Networks

Figure 1: An example of NER application on an example text

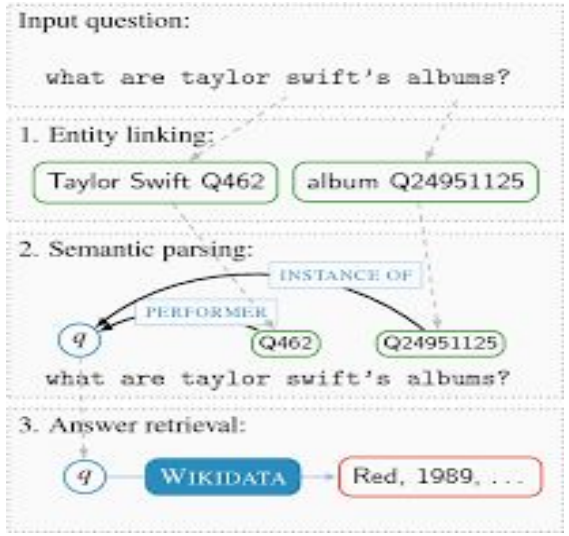
Named Entity Recognition (NER)

Machine Translation

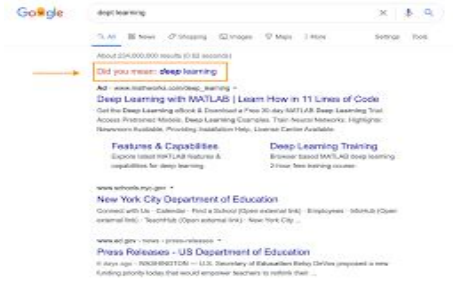
Text Classification and Categorization



Character Recognition



Semantic Parsing and Question Answering

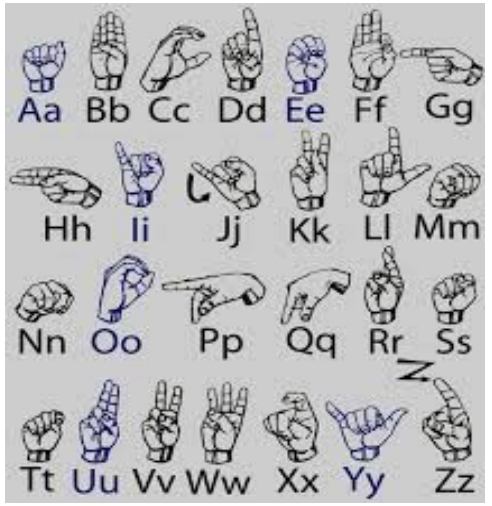


Spell Checking

Applications of Neural Networks

Part-of-Speech Tagging

Paraphrase Detection



Sign Language Detection