Learning Machine Learning

A primer on simple feedforward artificial neural networks

B.09

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What's a NN?

- A machine learning algorithm
- Modeled after the brain
- Solves computational problems

Properties of NN

1. Evolutionary
2. Computationally parallel
3. Uses math to learn

Calculus!

The Neuron

This is a neuron.

The Neuron

It holds a number between 0 and 1.

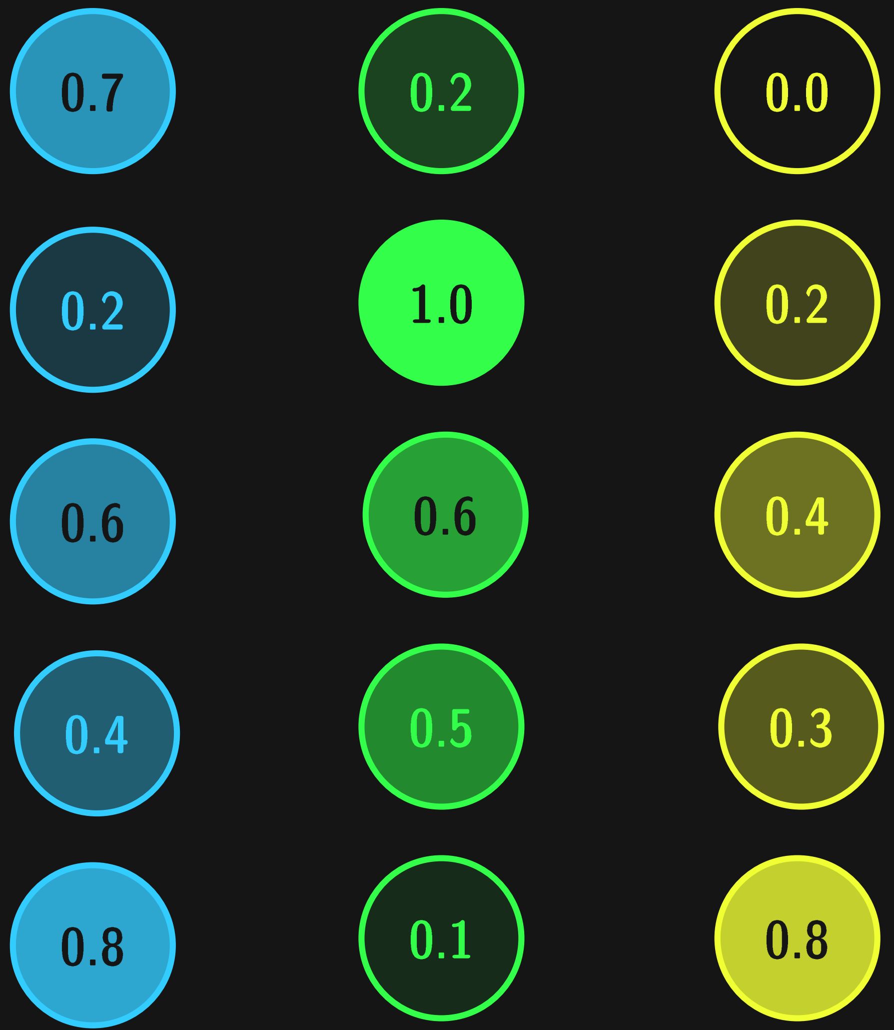
The Neuron

This number is called its activation.

The Layer

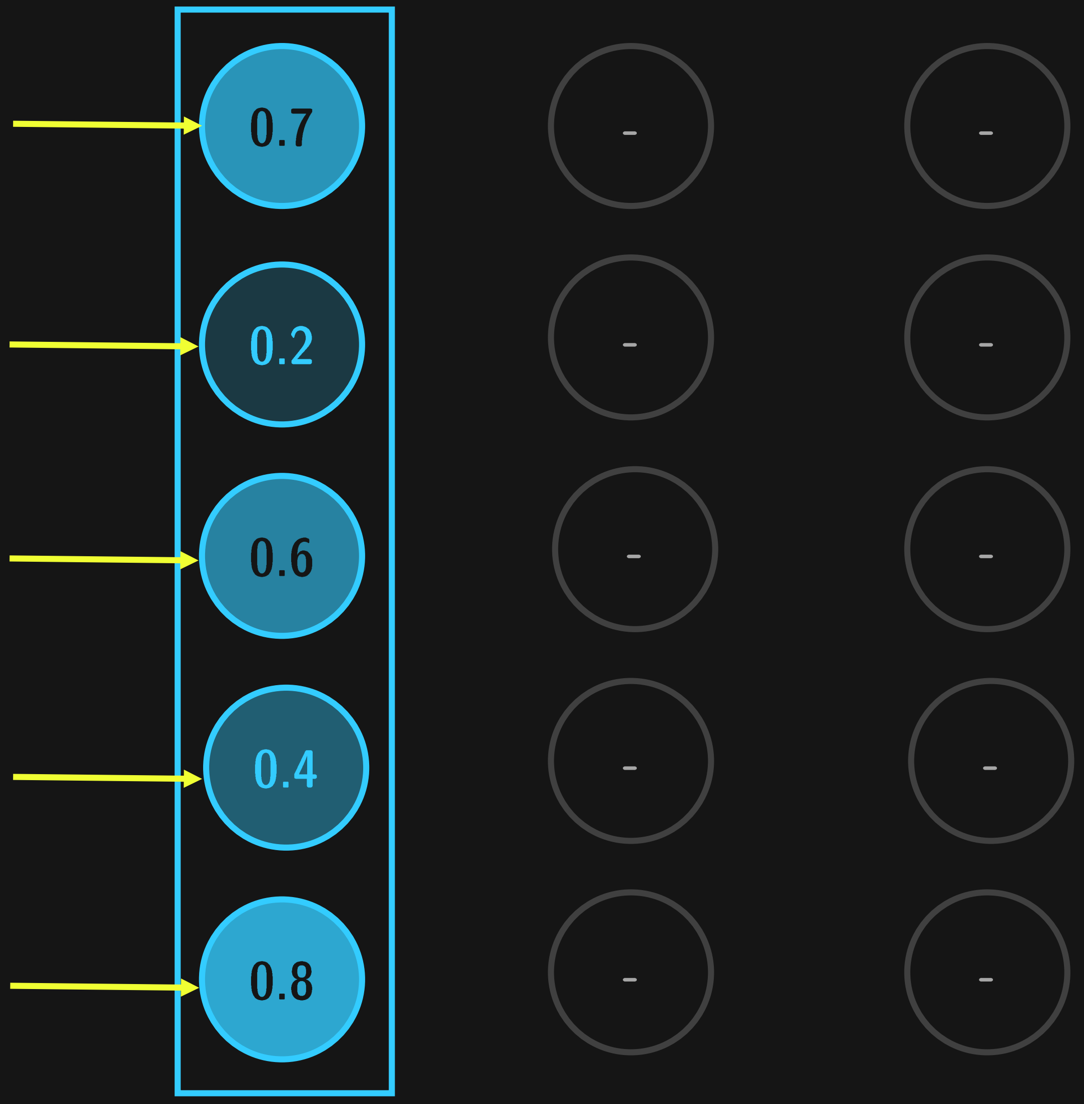
This is a layer of neurons, each with their own activation.

The Network



Many layers make up a neural network.

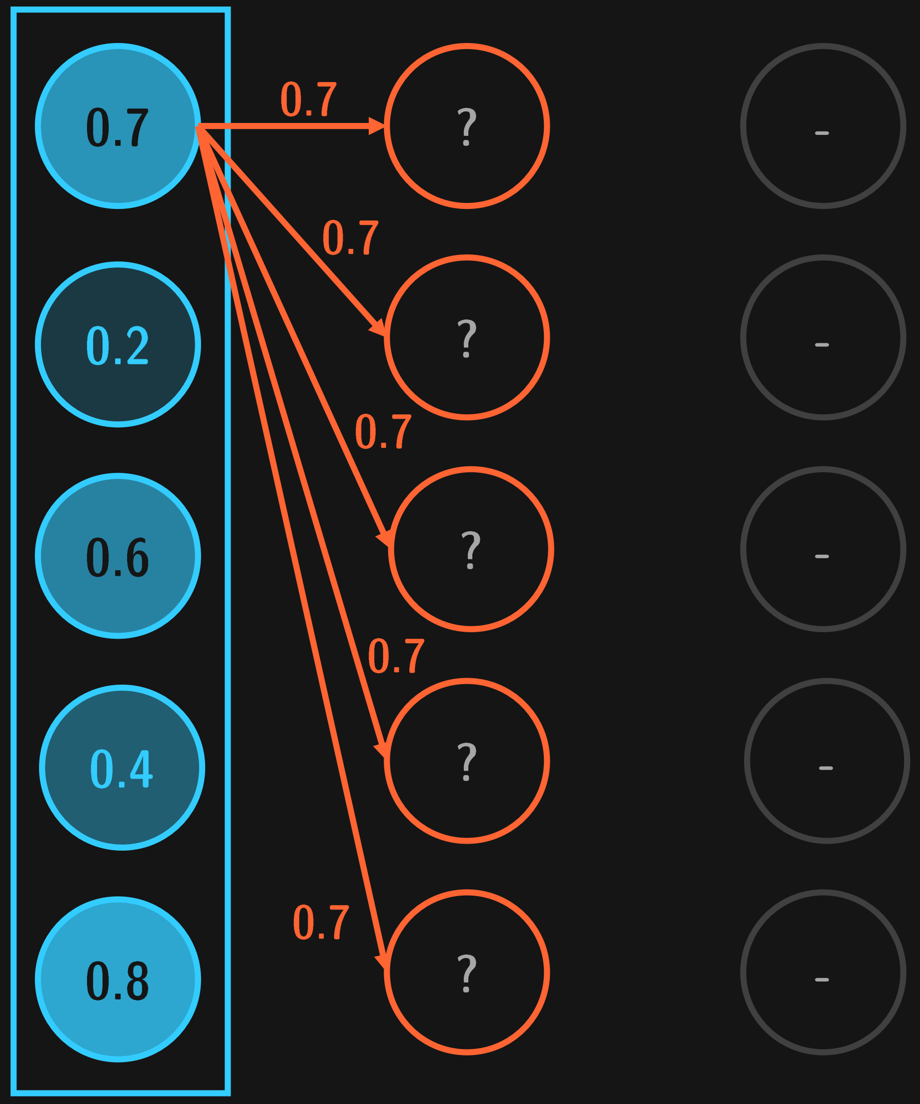
Kinds of Layers



This is the input layer.

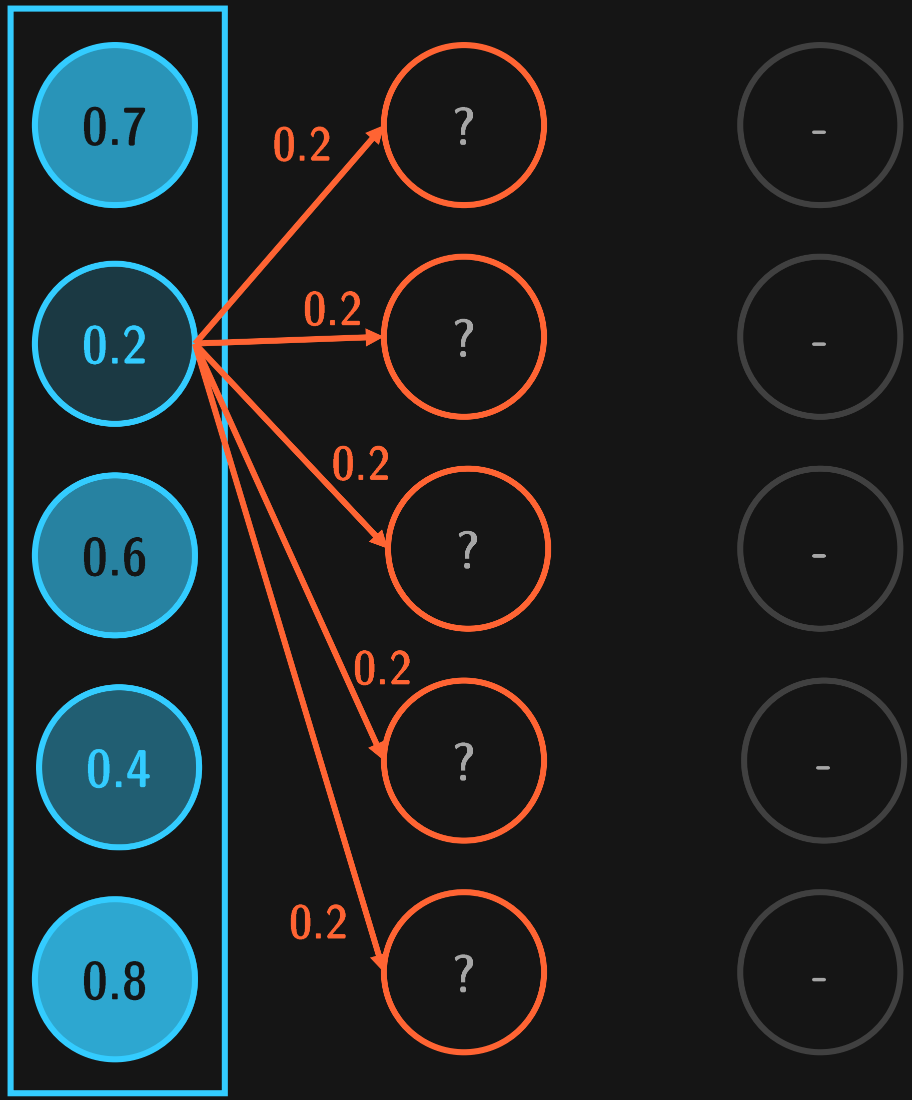
It receives numbers from the training data...

Kinds of Layers



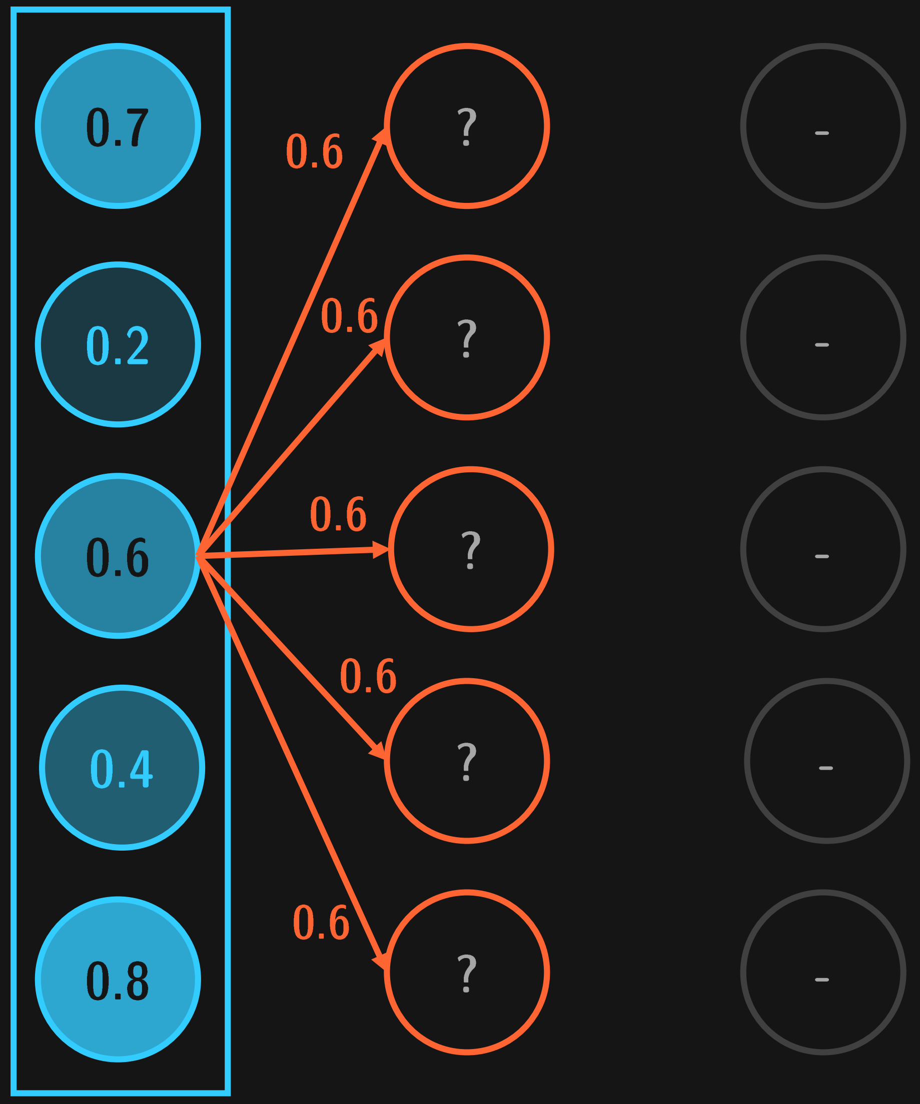
...and passes them on.

Kinds of Layers



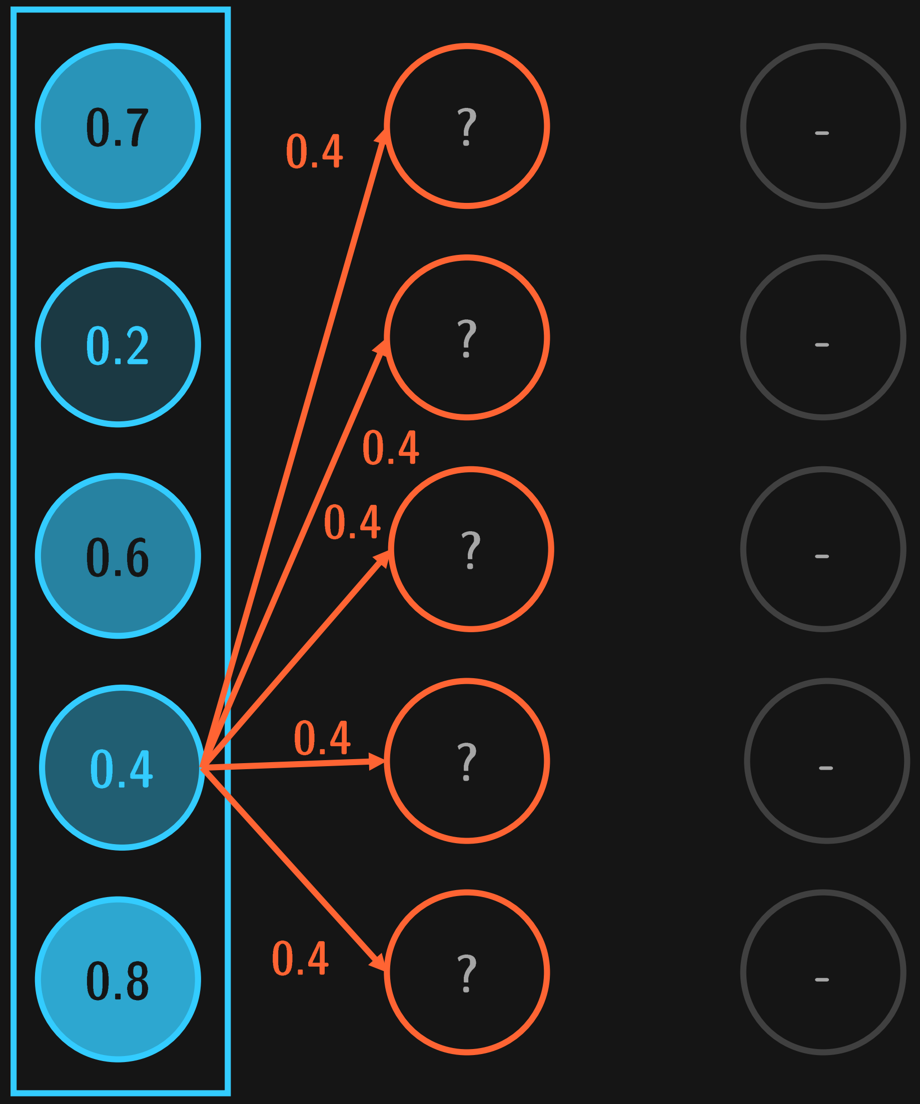
...and passes them on.

Kinds of Layers



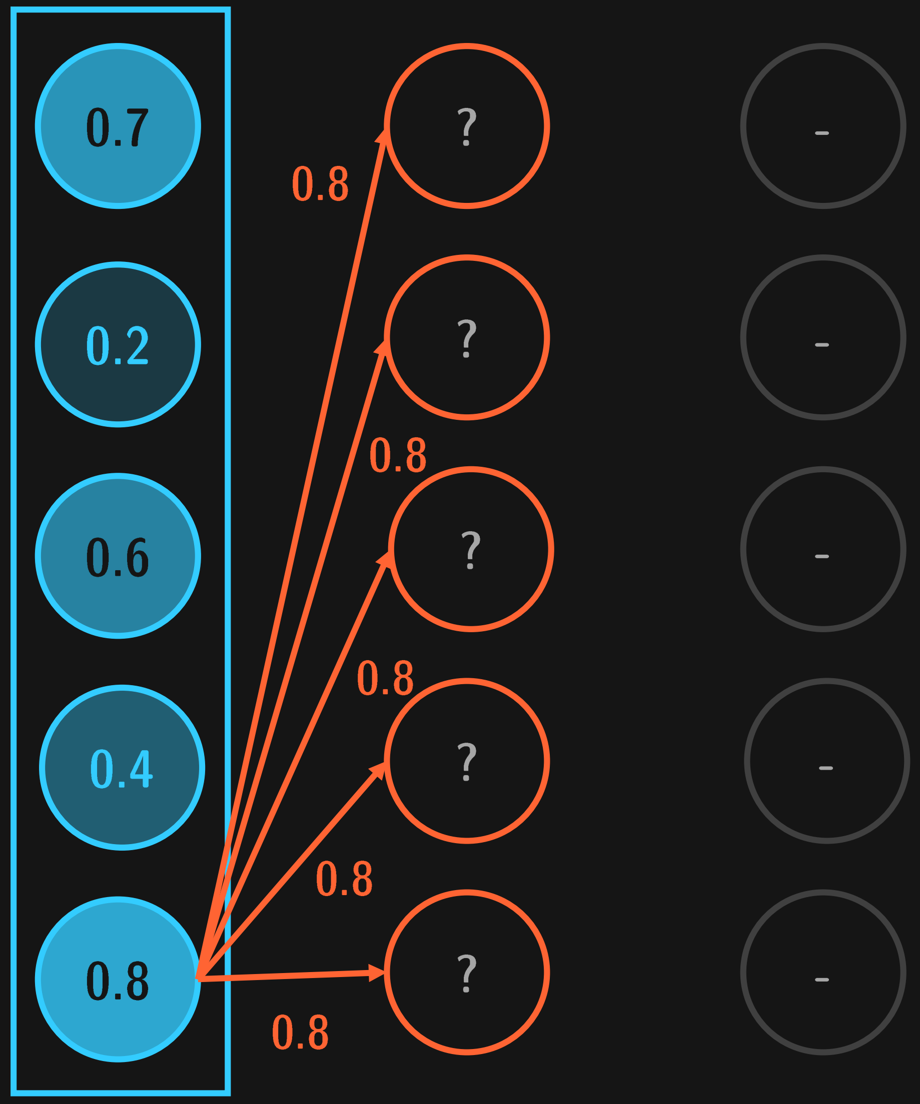
...and passes them on.

Kinds of Layers



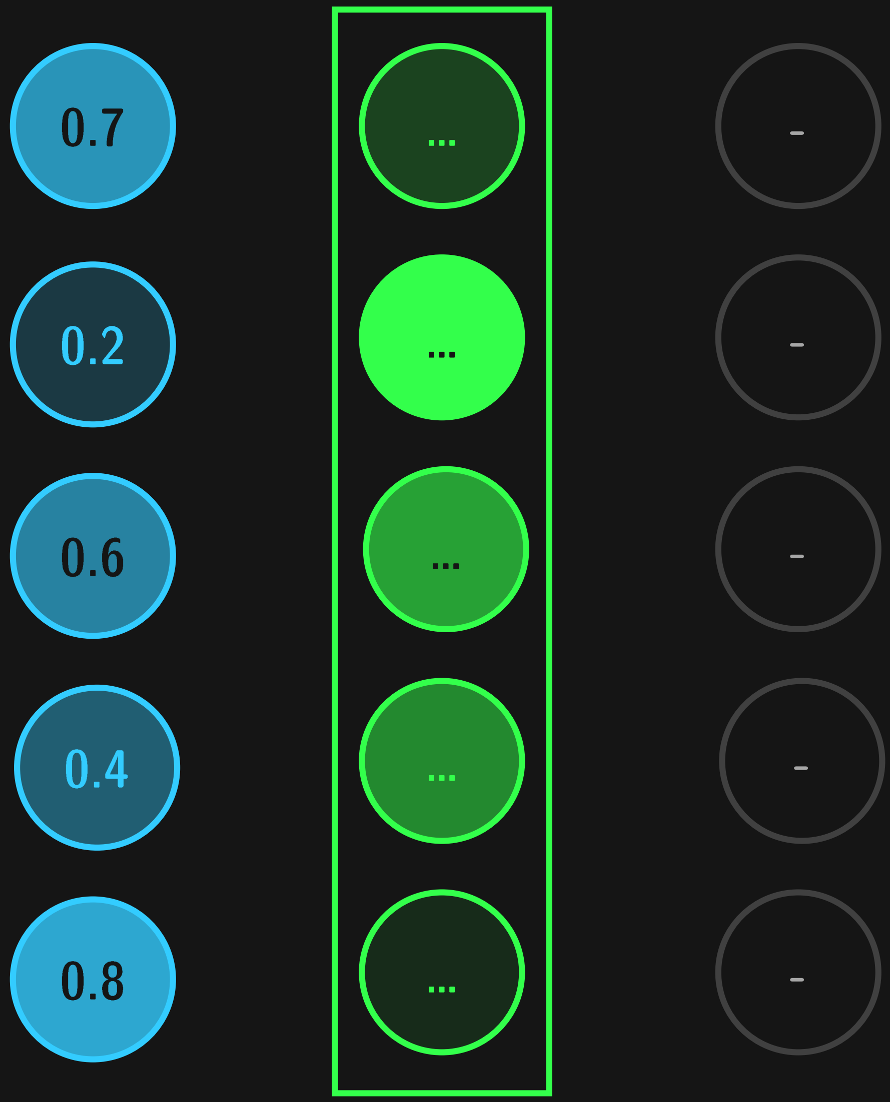
...and passes them on.

Kinds of Layers



...and **passes them on.**

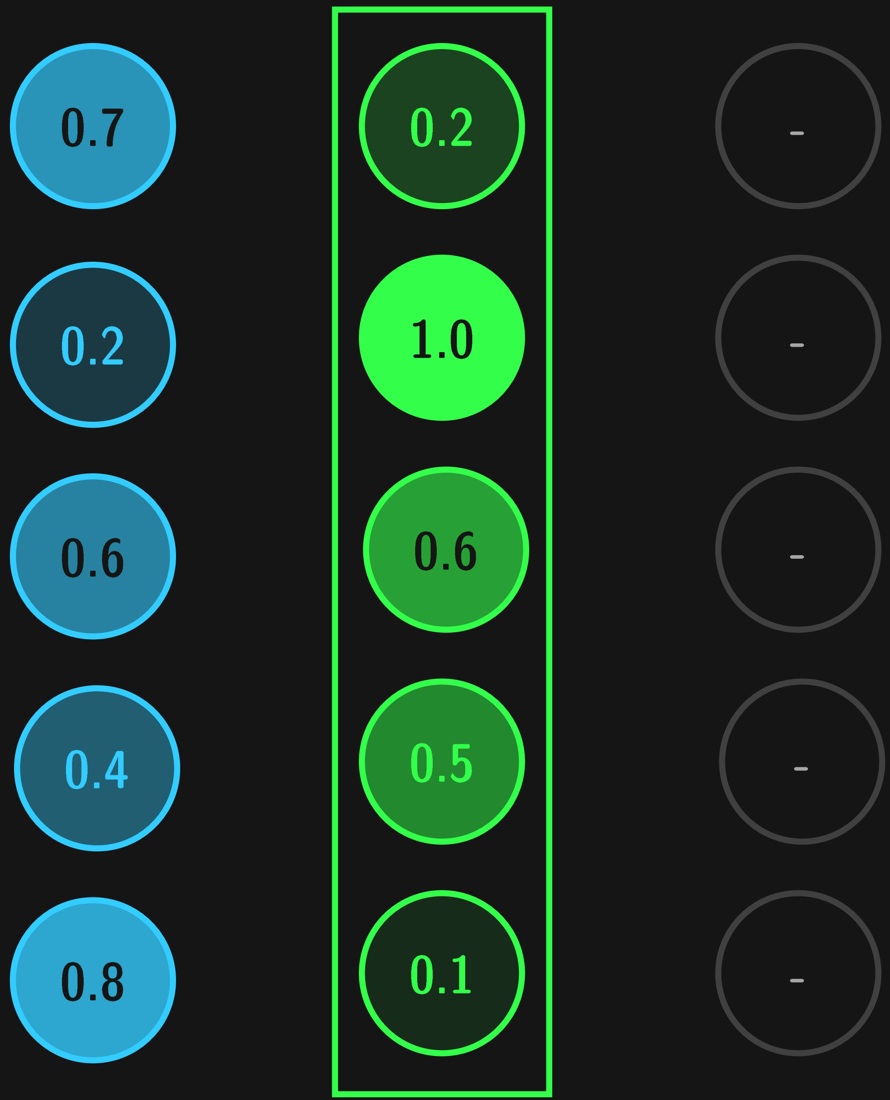
Kinds of Layers



This is a hidden layer.

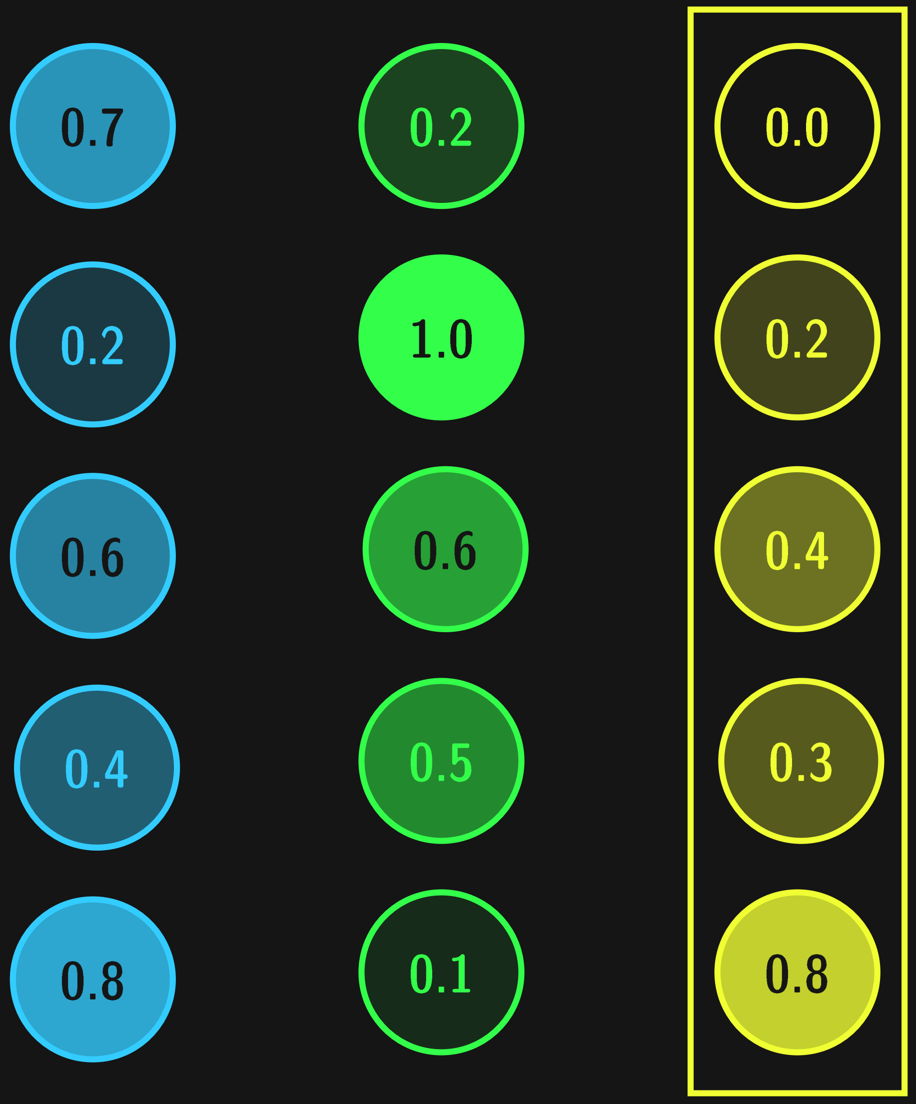
It processes all info from the input layer...

Kinds of Layers



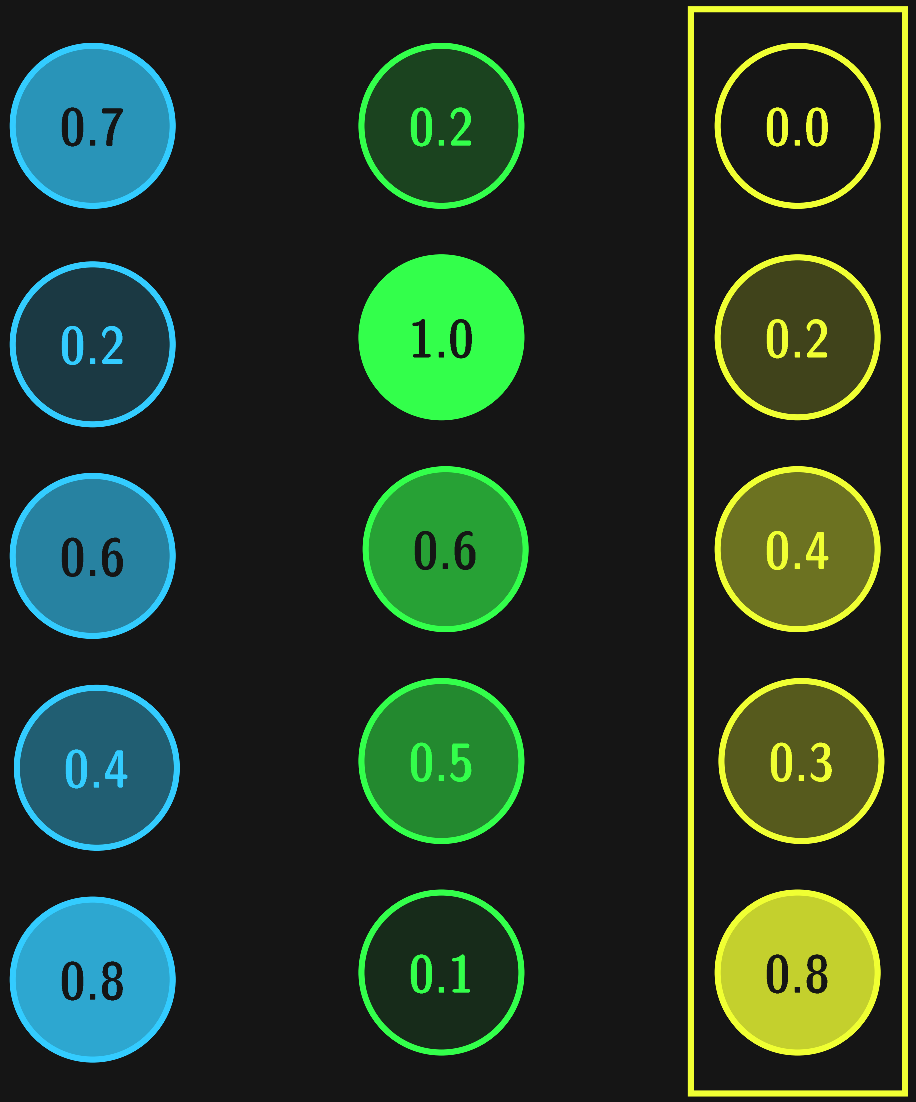
and comes up with an activation for each neuron using a certain math function.

The Network



This is the output layer.

The Network



It computes its activation just like the hidden layers...

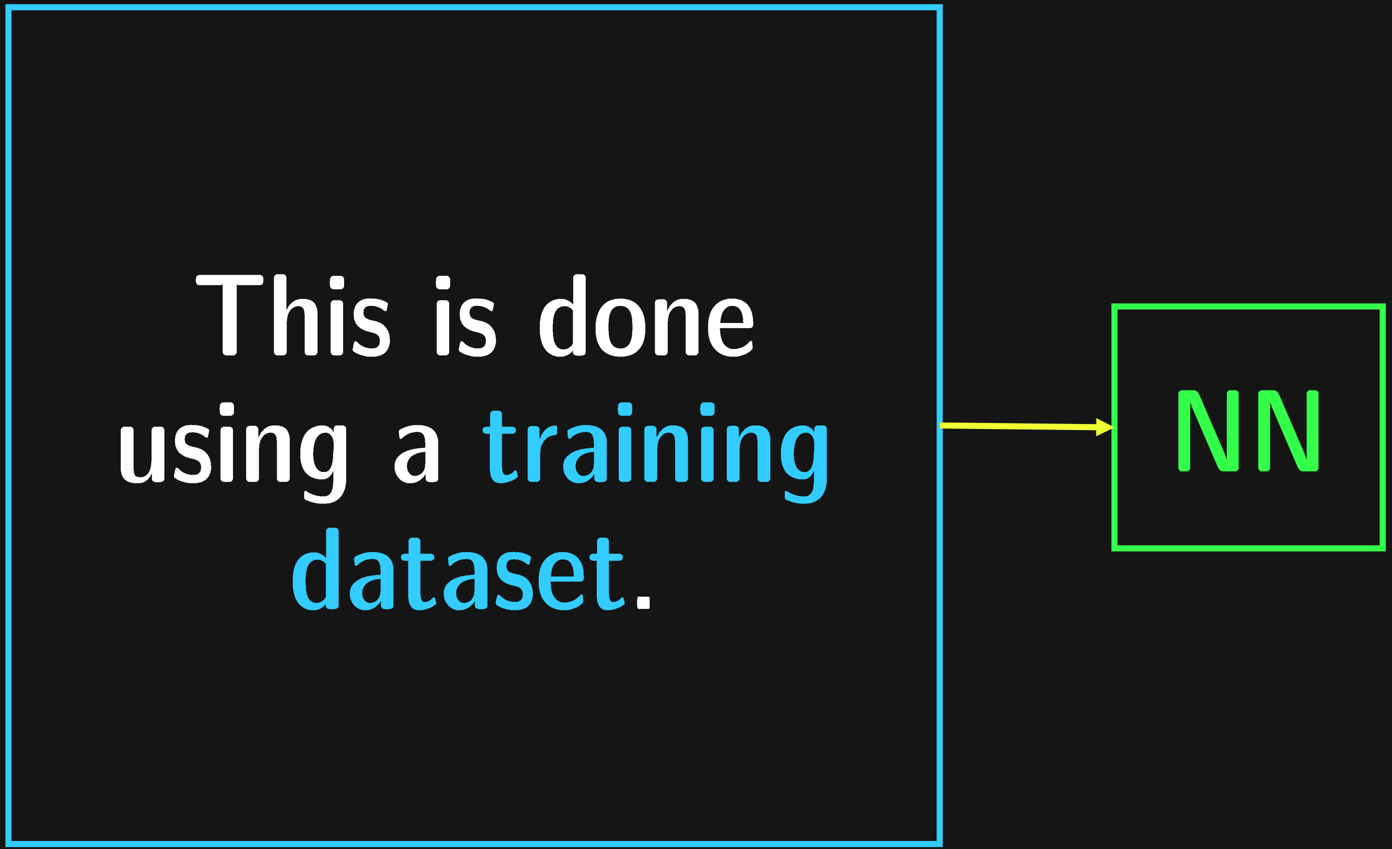
The Network

...except that their activations are the outputs of the network.

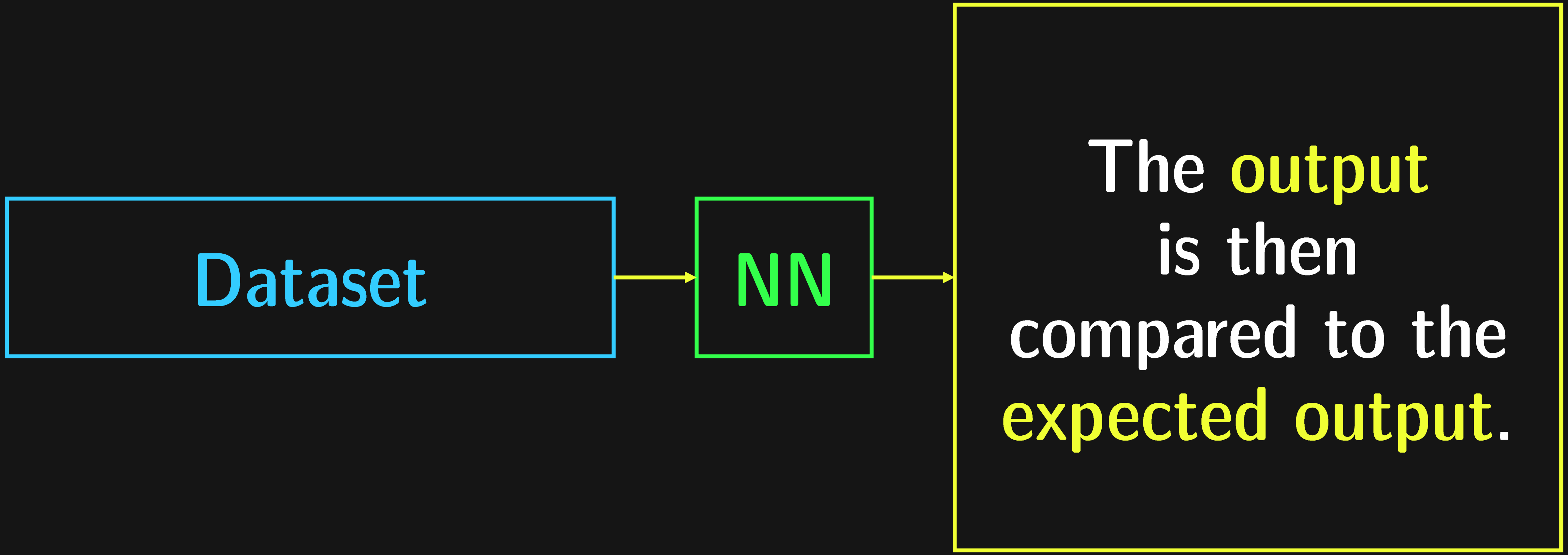
Training

Every neural network is trained, just like a brain.

Training



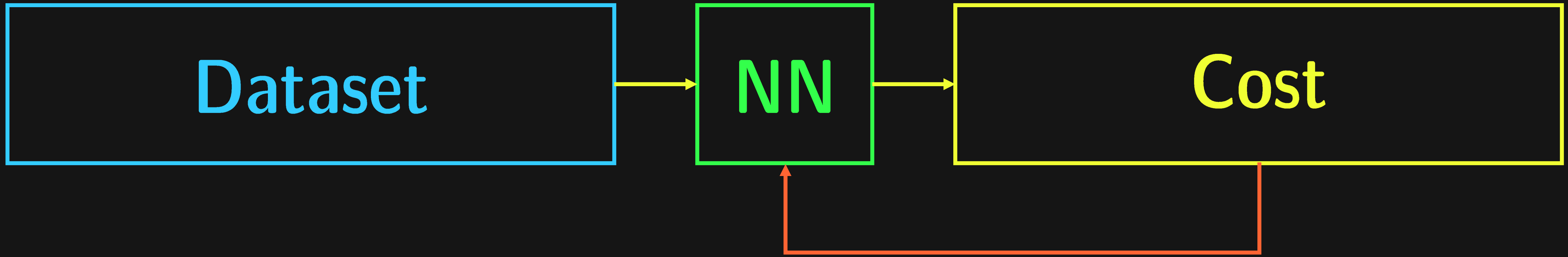
Training


Dataset
NN
The output is then compared to the expected output.

Training

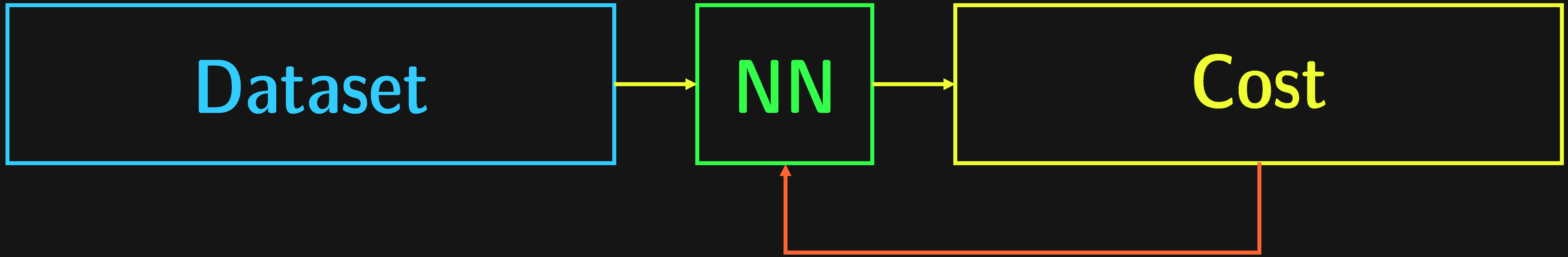
Dataset → NN → From there, the NN's "untrainedness", or **cost**, is obtained.

Training



The neural network then attempts to minimize this cost...

Training

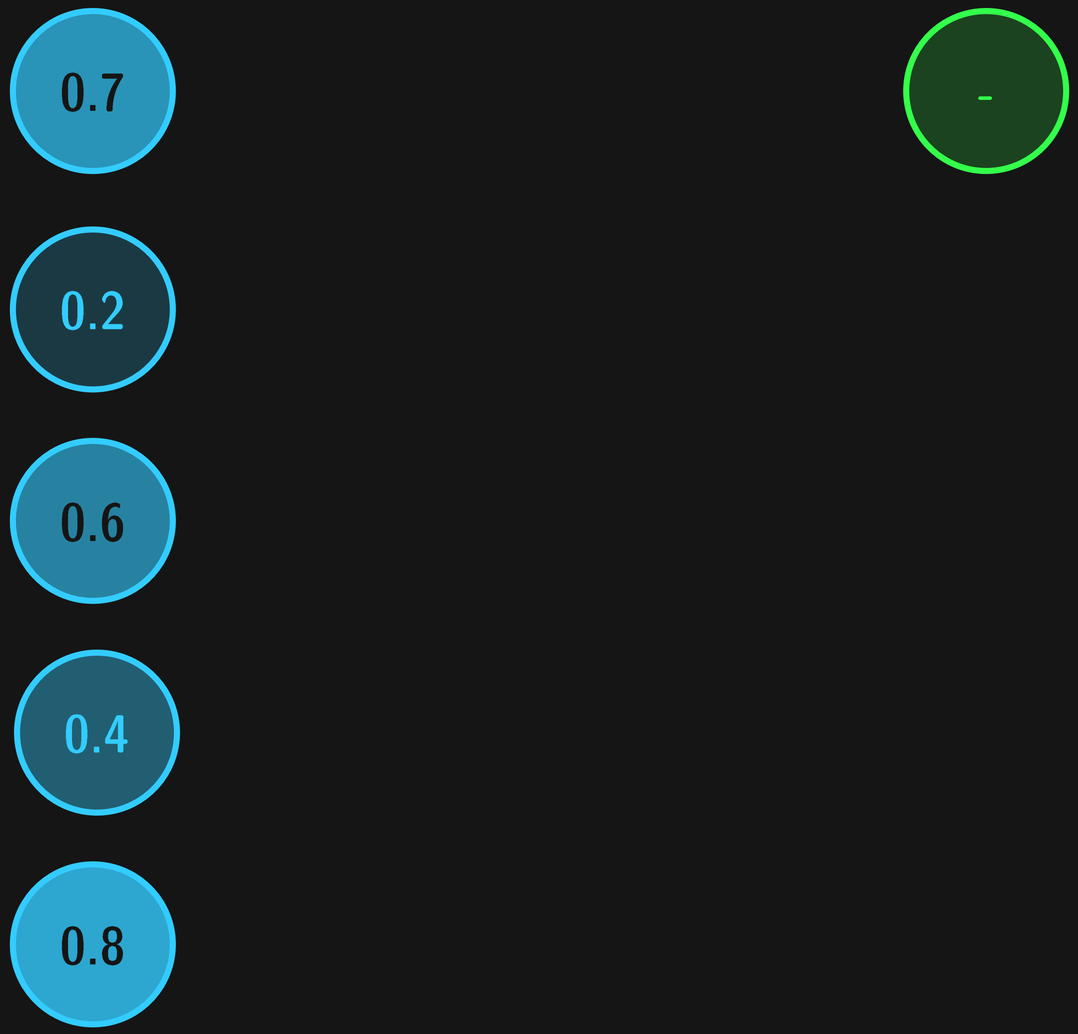


...in a process called
backpropagation.

How Neurons Work

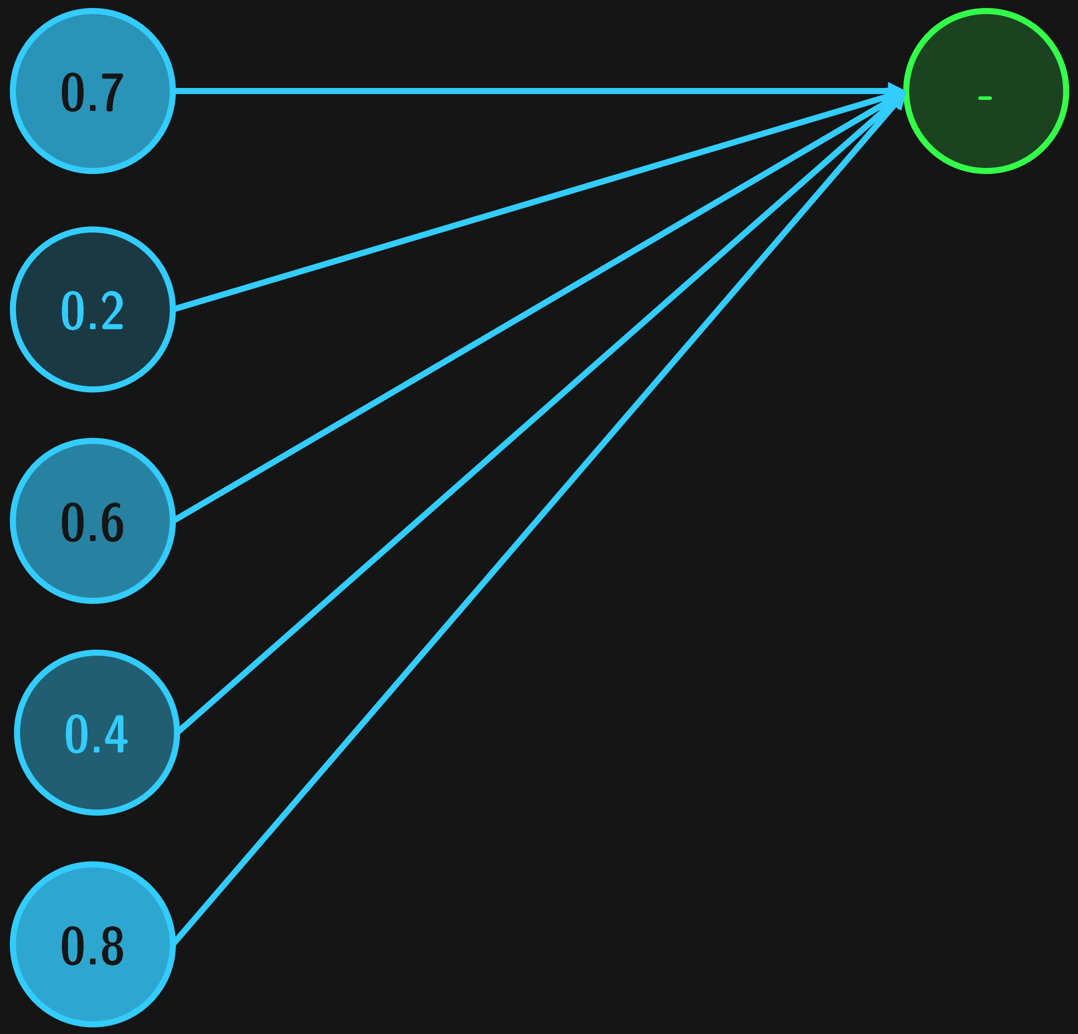
How does a neuron decide what number to store in it?

How Neurons Work



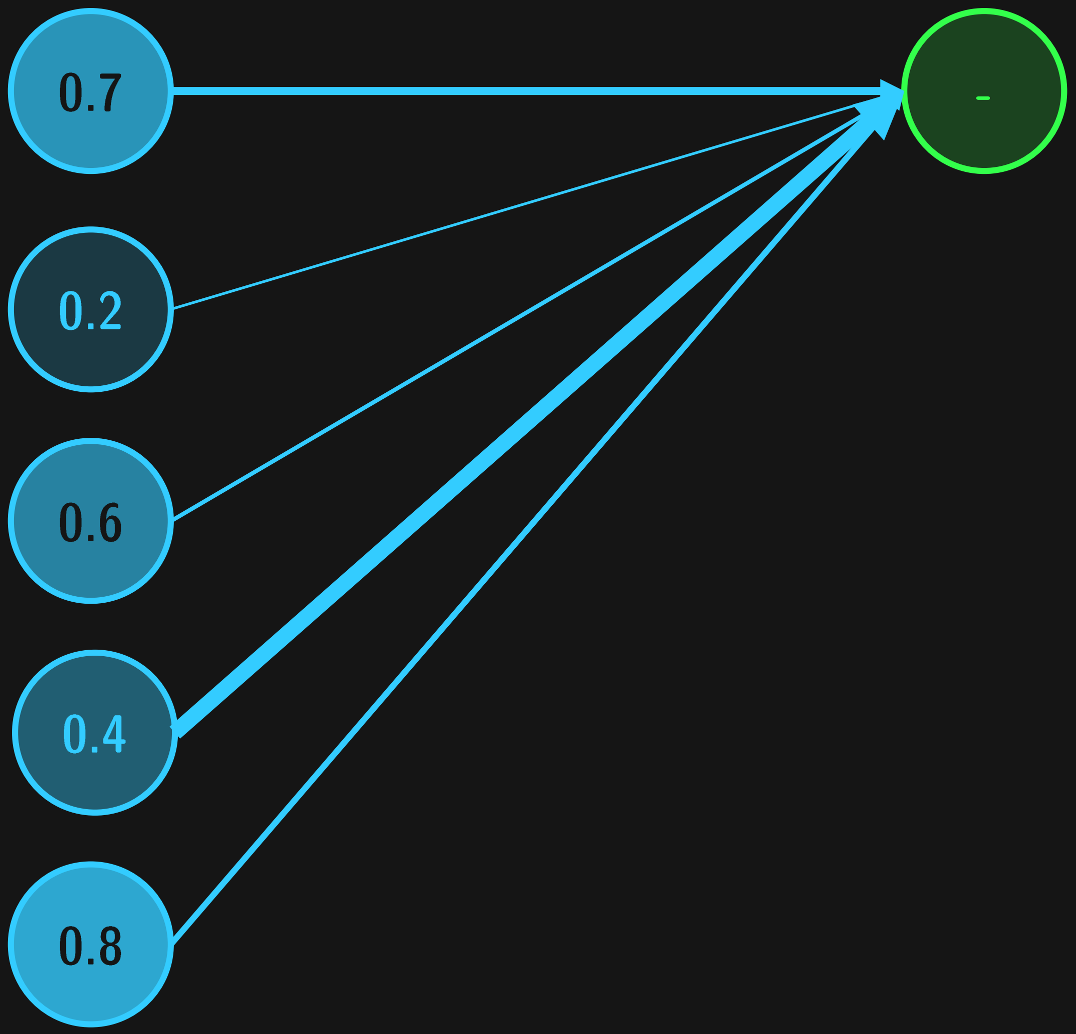
Focus on the green neuron.

How Neurons Work



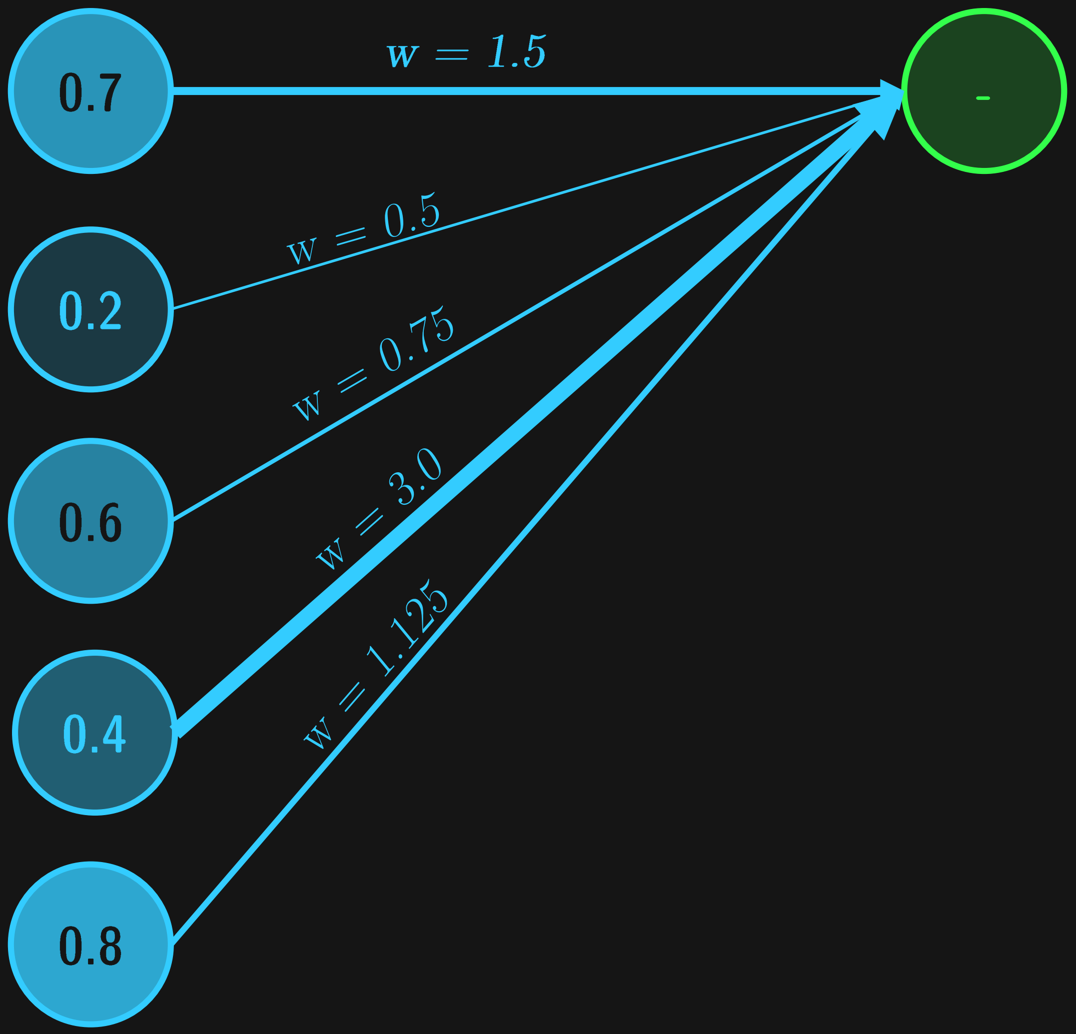
It takes **inputs** from each **input neuron**.

How Neurons Work



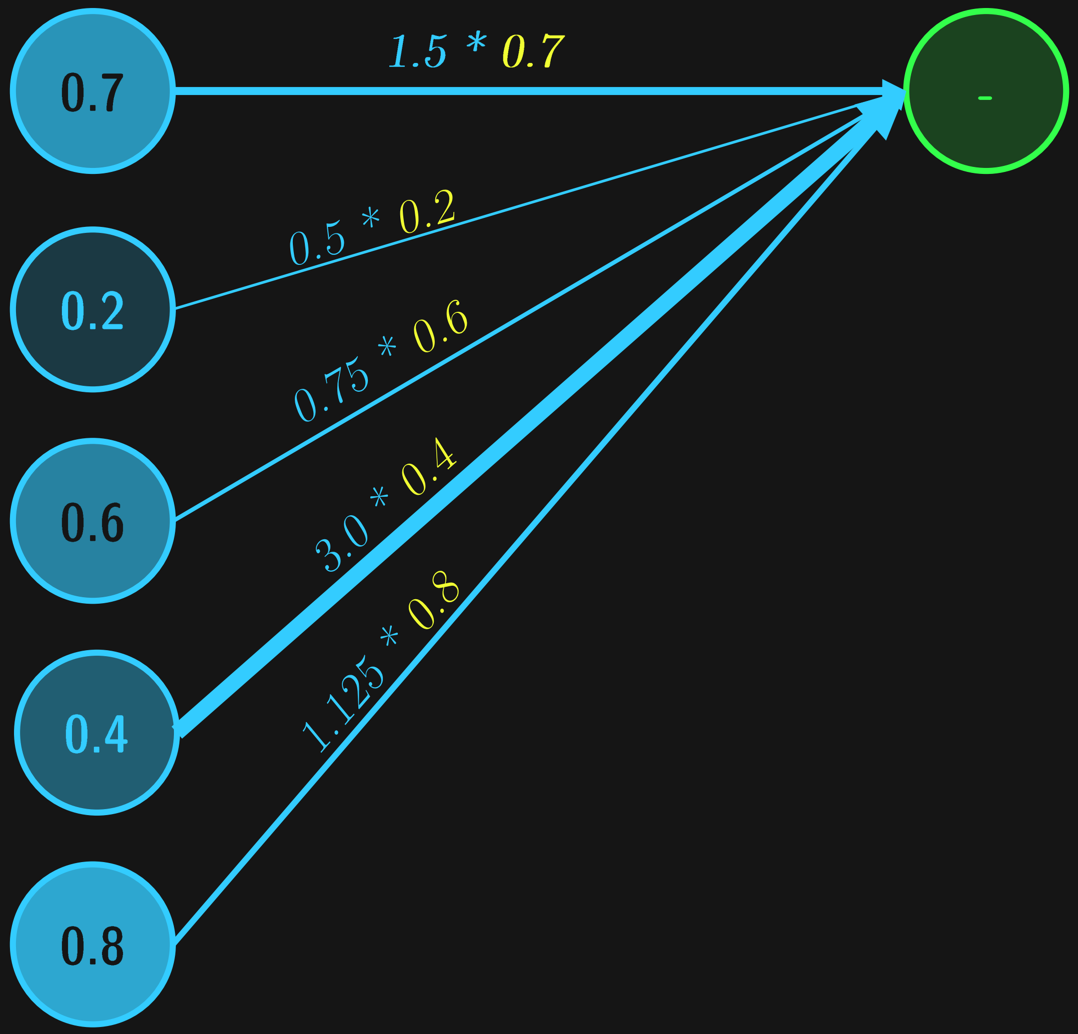
But values some inputs over others.

How Neurons Work



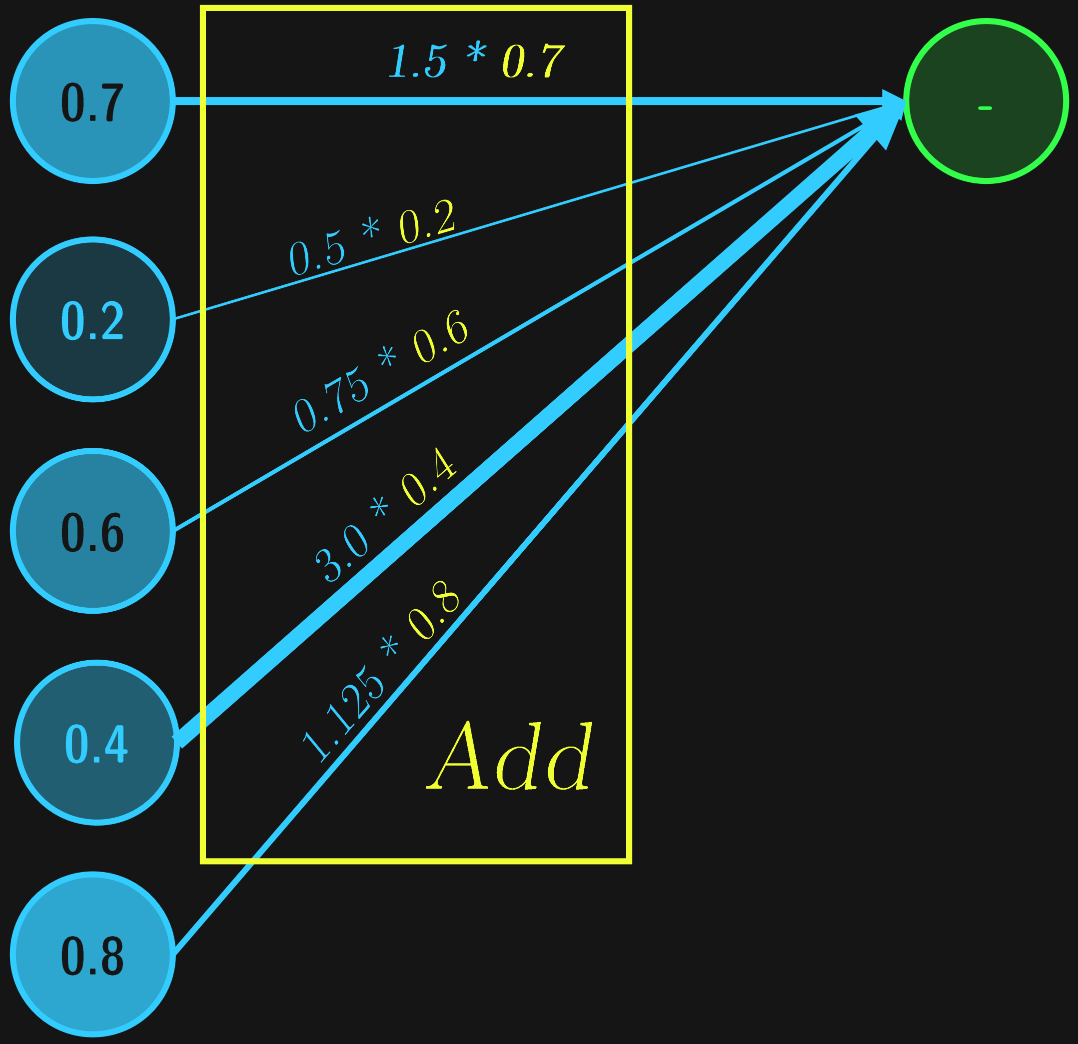
Each link carries a **weight** (w)

How Neurons Work



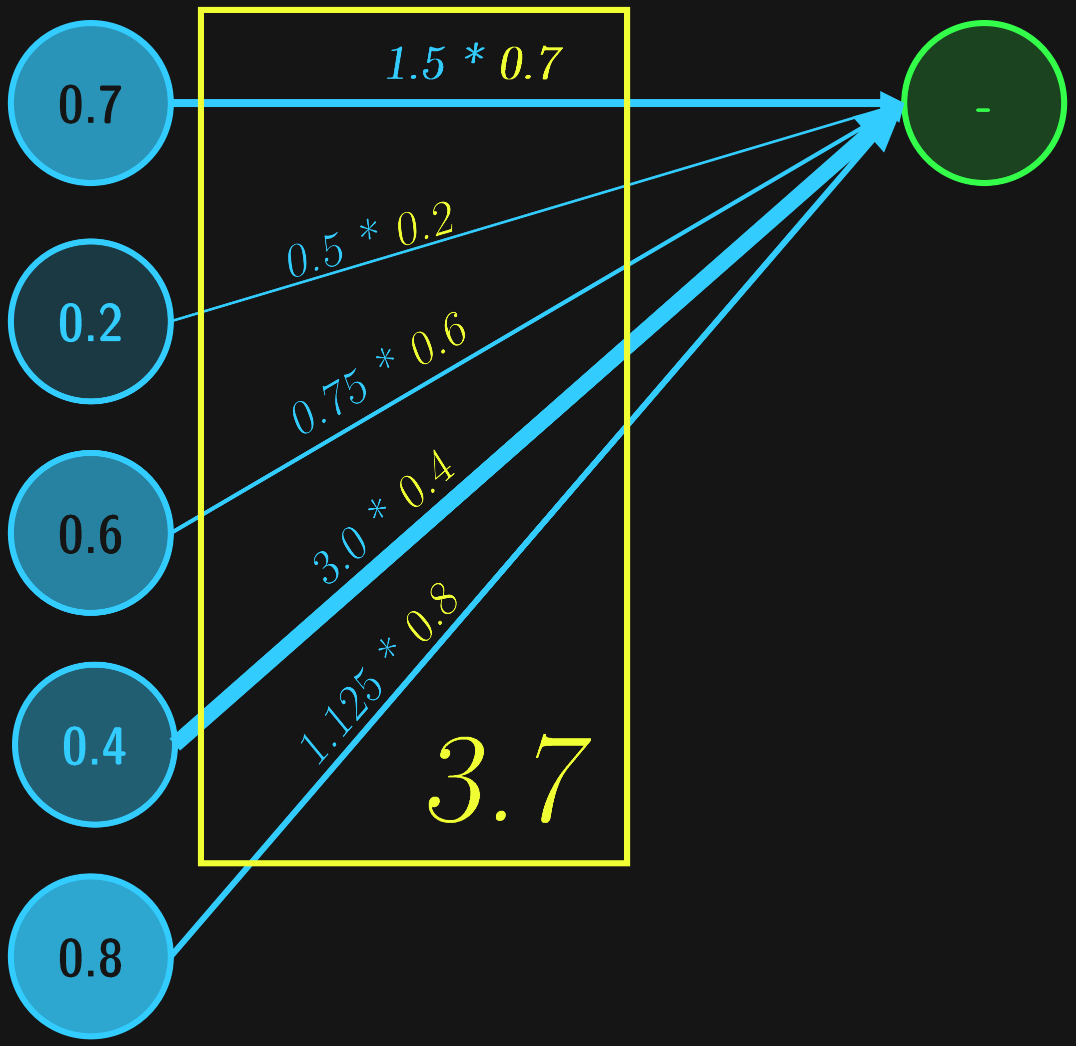
which the neuron multiplies with each **input activation** (A_{in})

How Neurons Work



And then adds the products together.

How Neurons Work

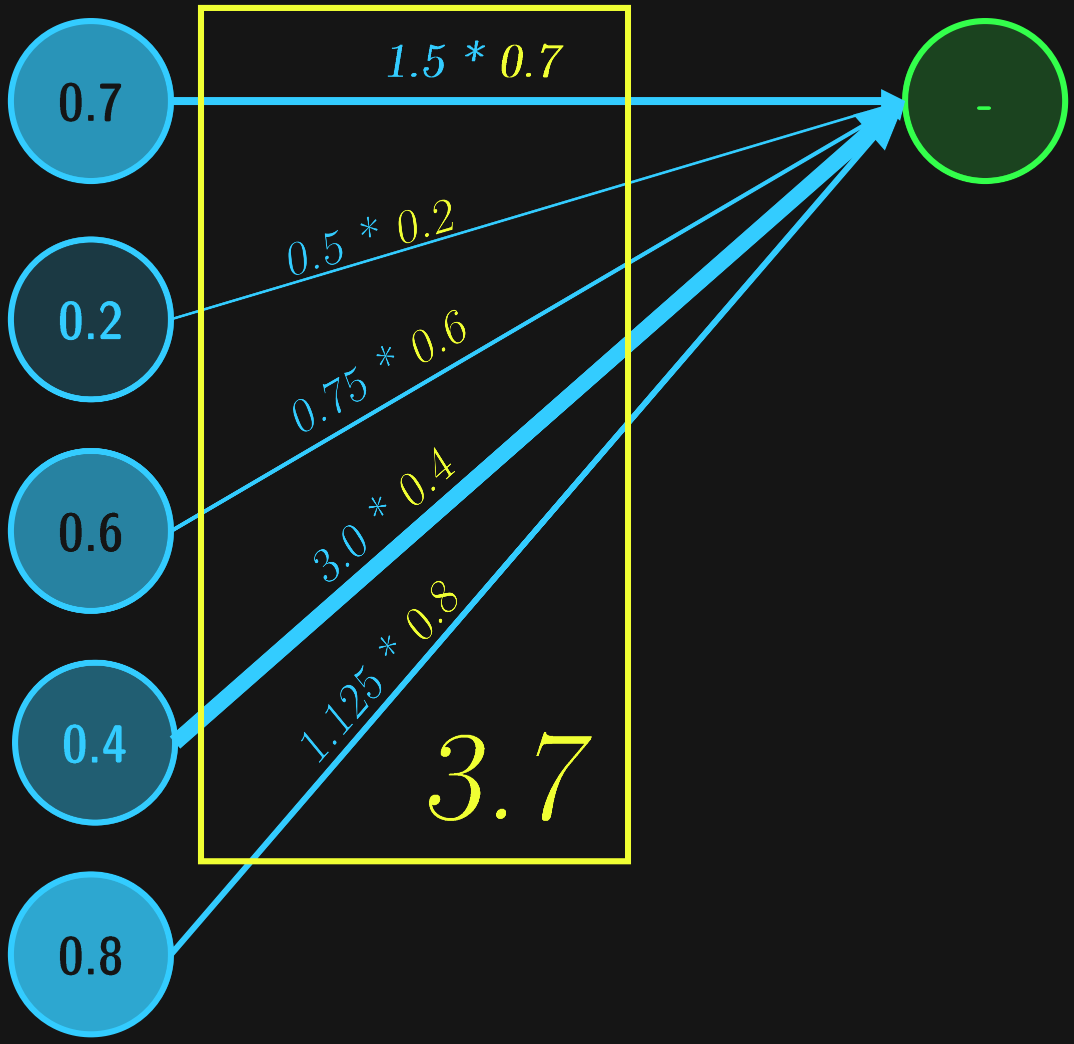


But wait...

$$\sum wA_{in} = 3.7$$

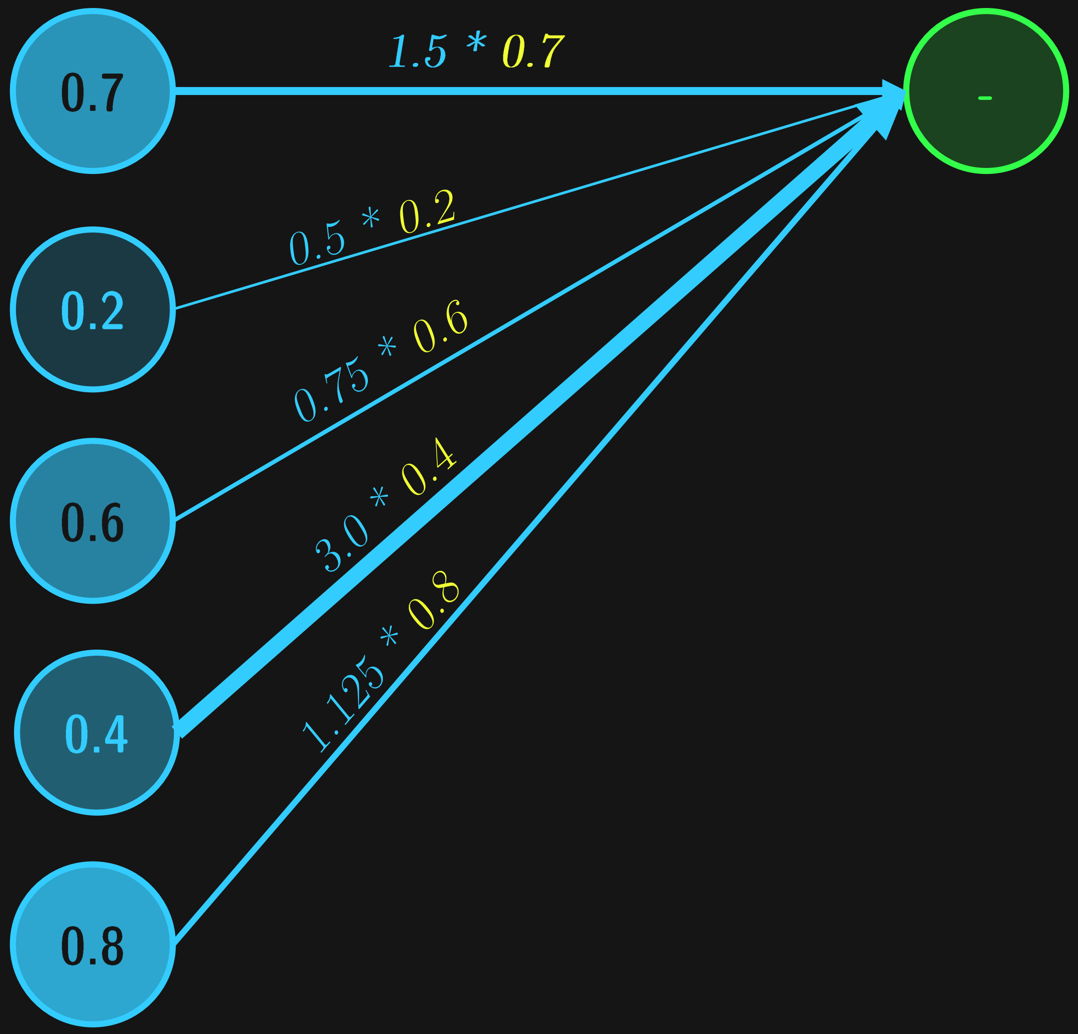
That's not between 0 and 1!

How Neurons Work



So we squish all real numbers into a range from 0 to 1!

How Neurons Work

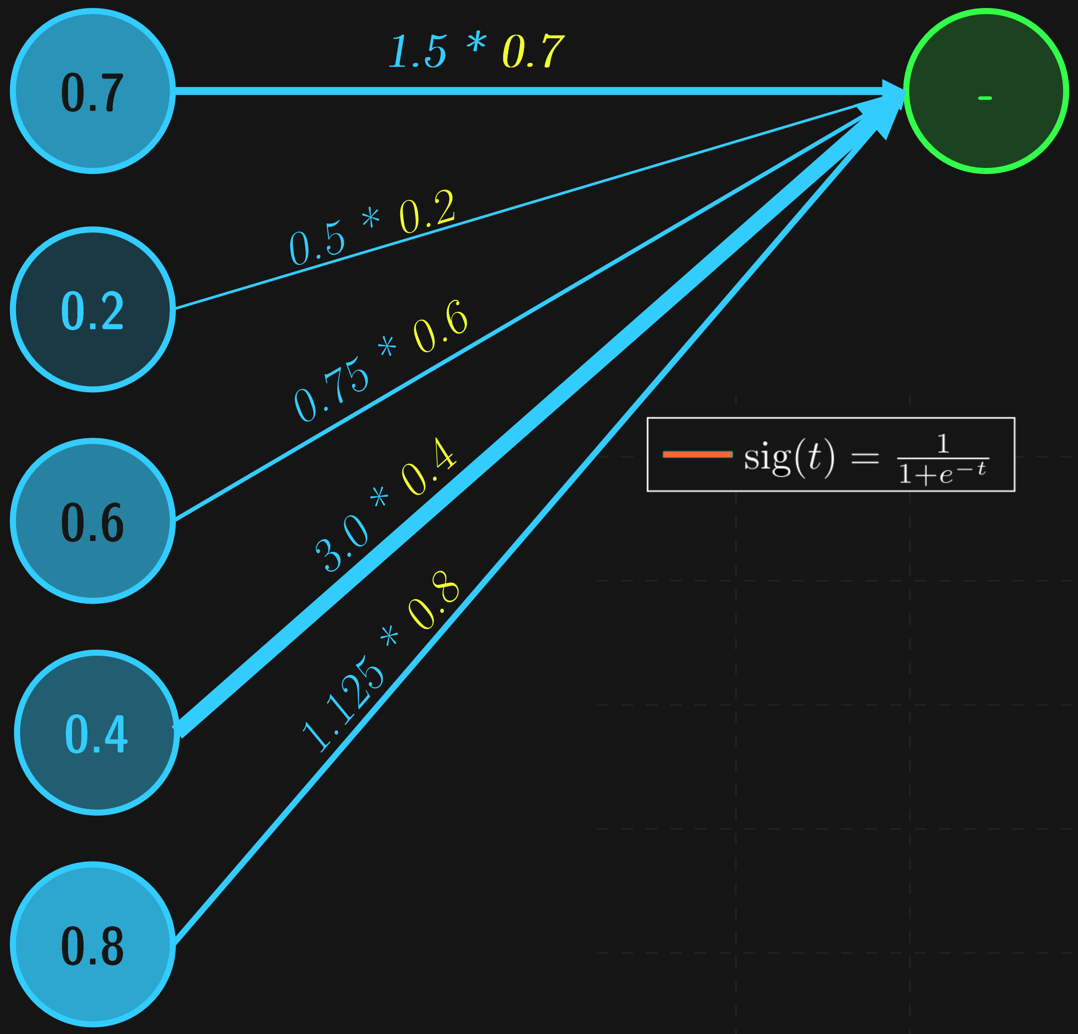


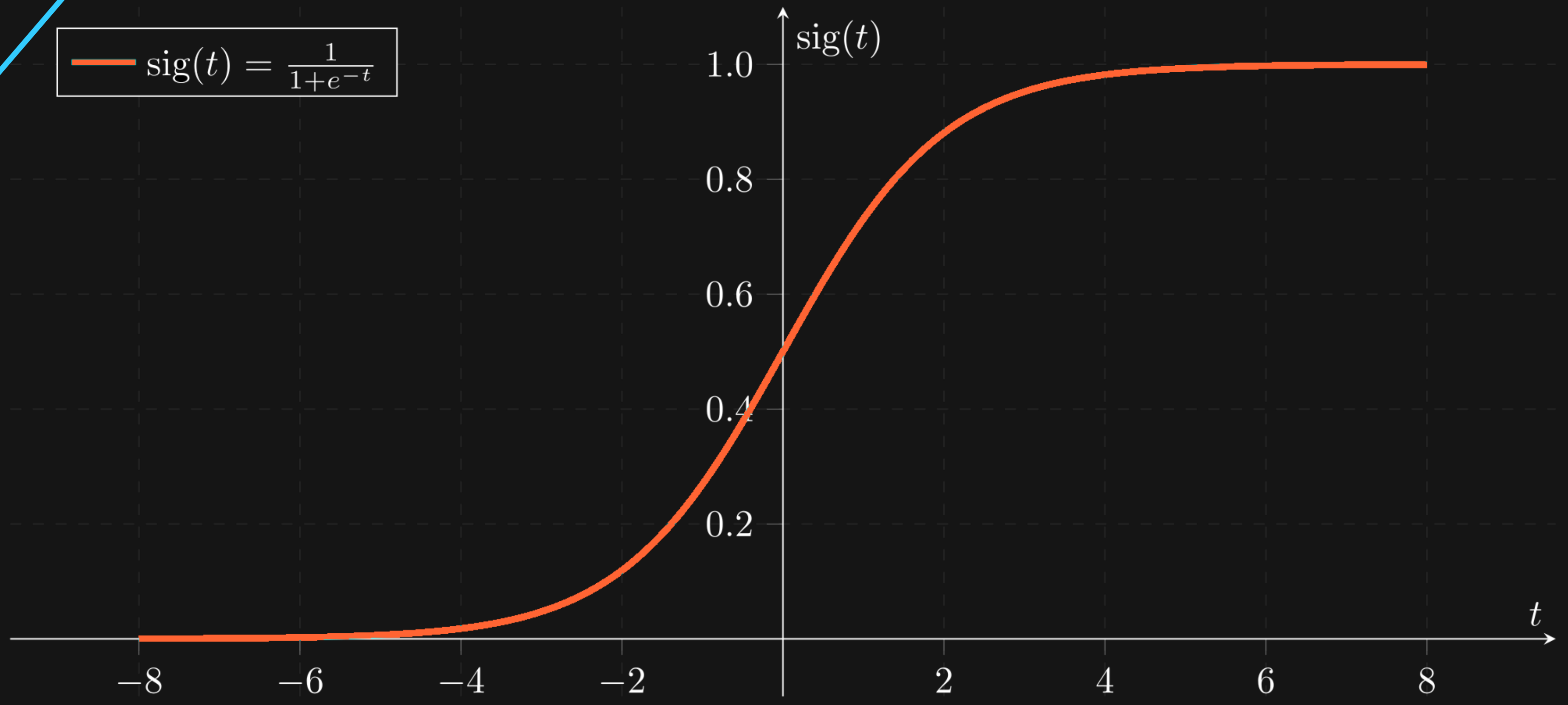
Enter the Sigmoid function.

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

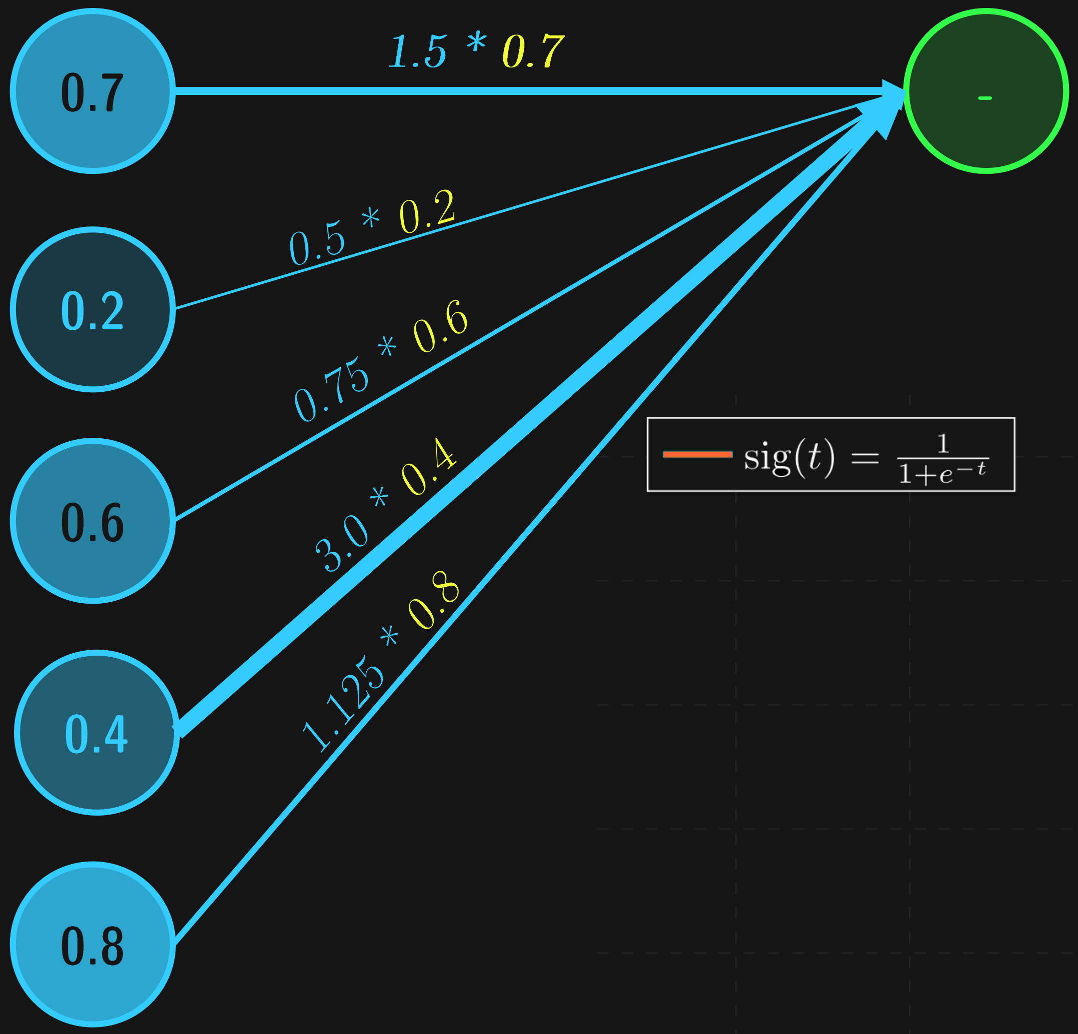
How Neurons Work

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

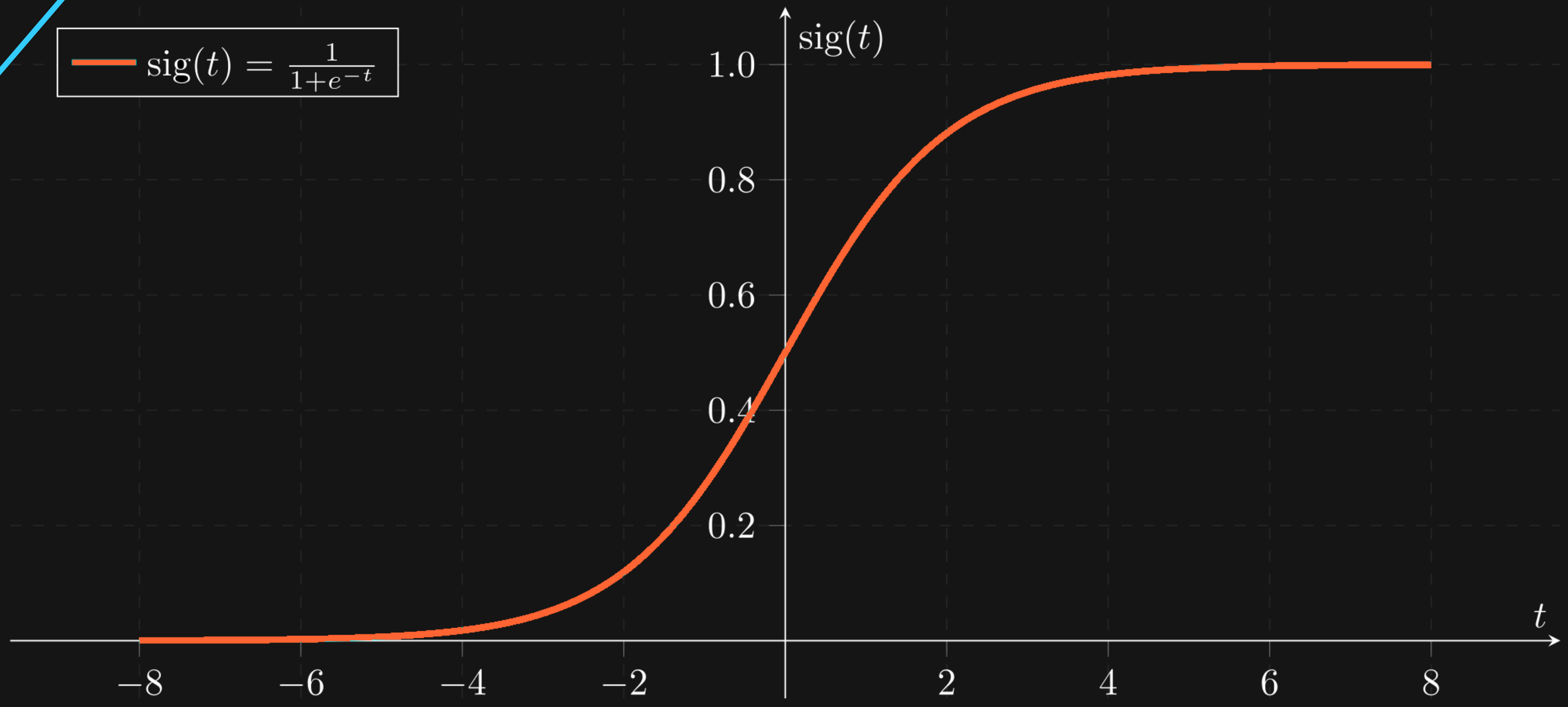




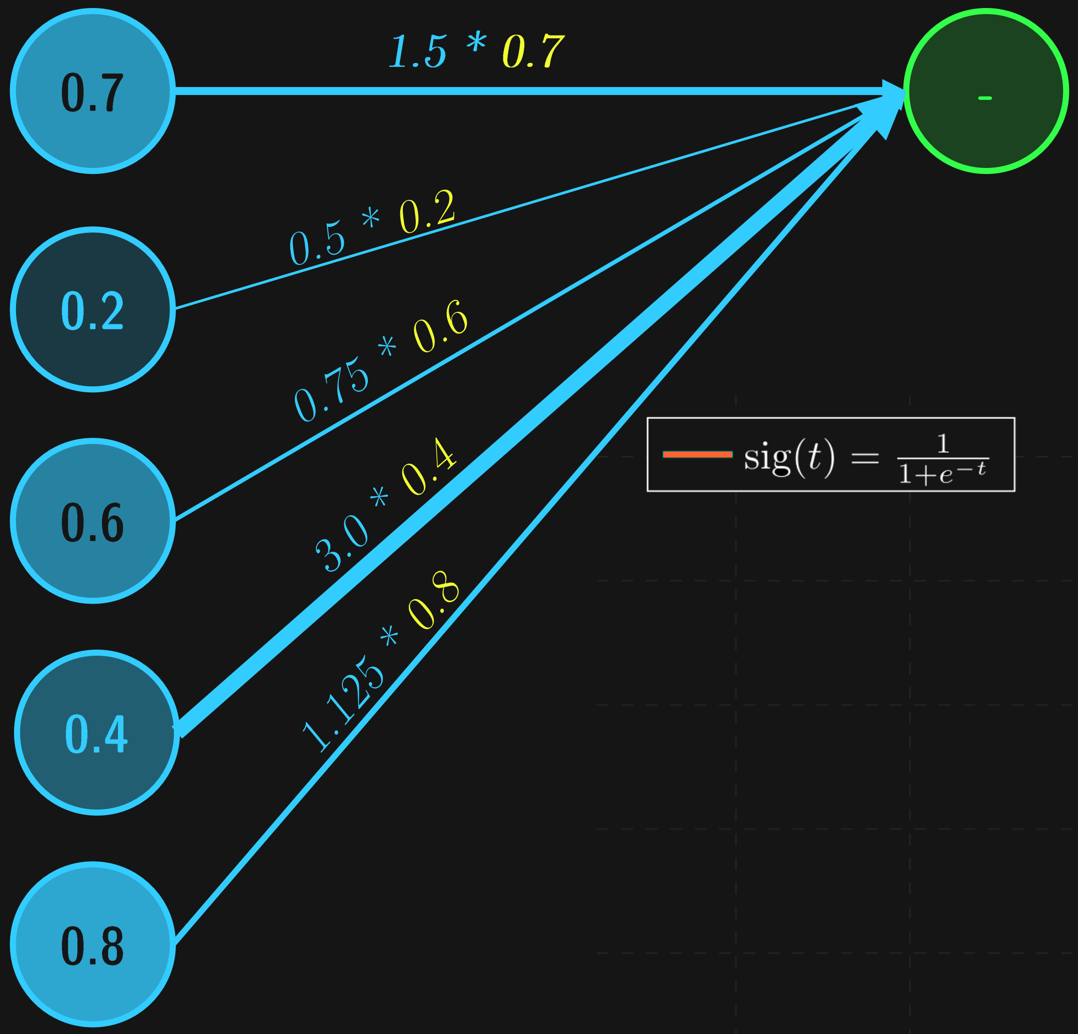
How Neurons Work



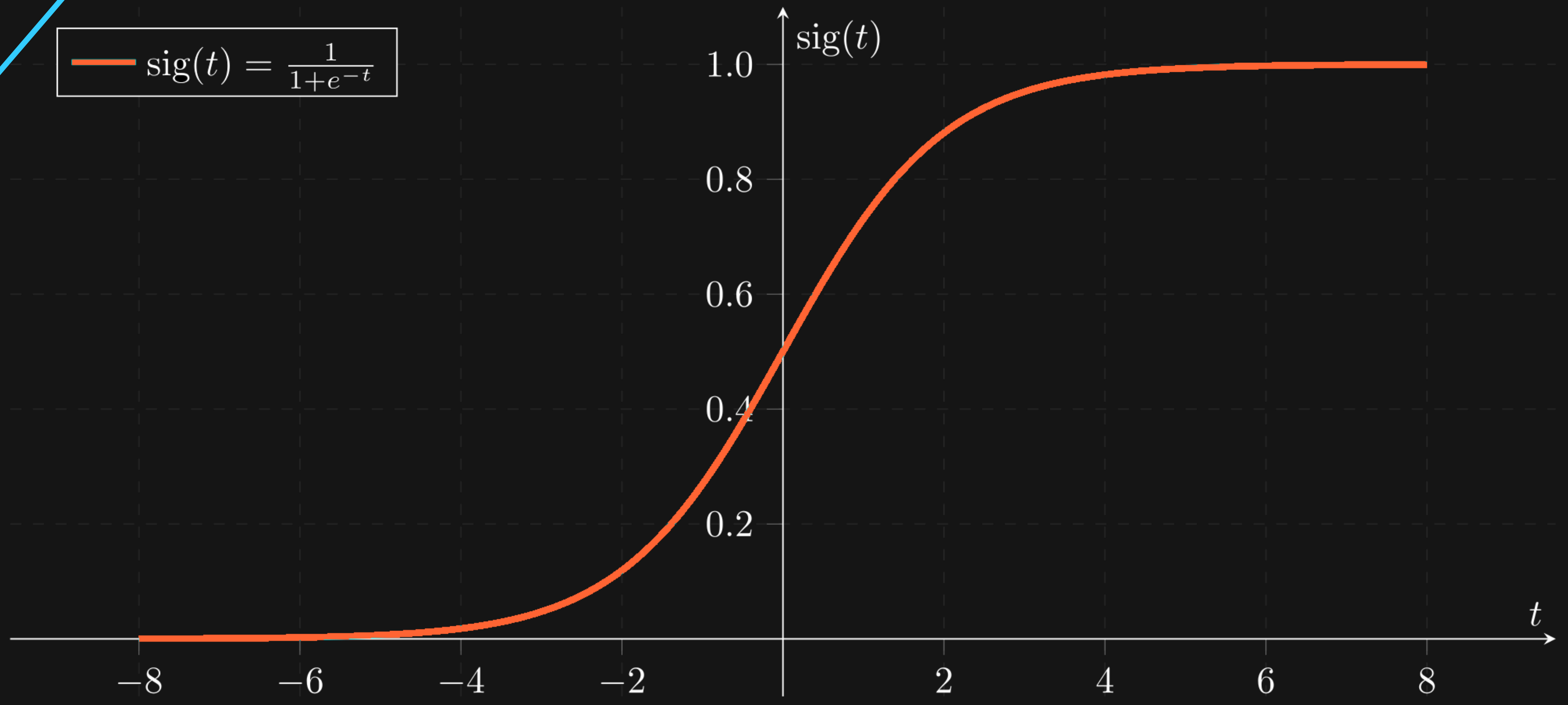
As $x \to \infty$, $\sigma(x) \to 1$



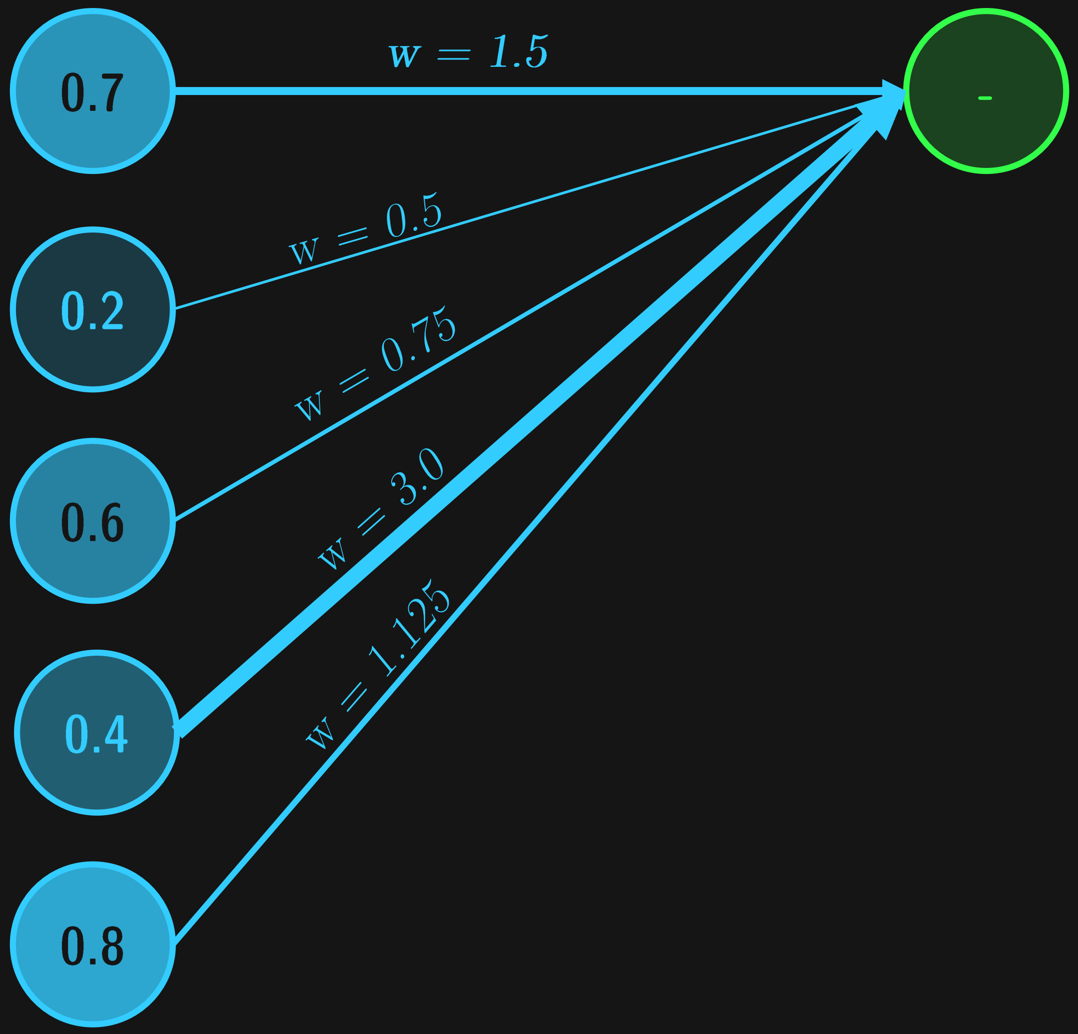
How Neurons Work



As $x \to -\infty$, $\sigma(x) \to 0$



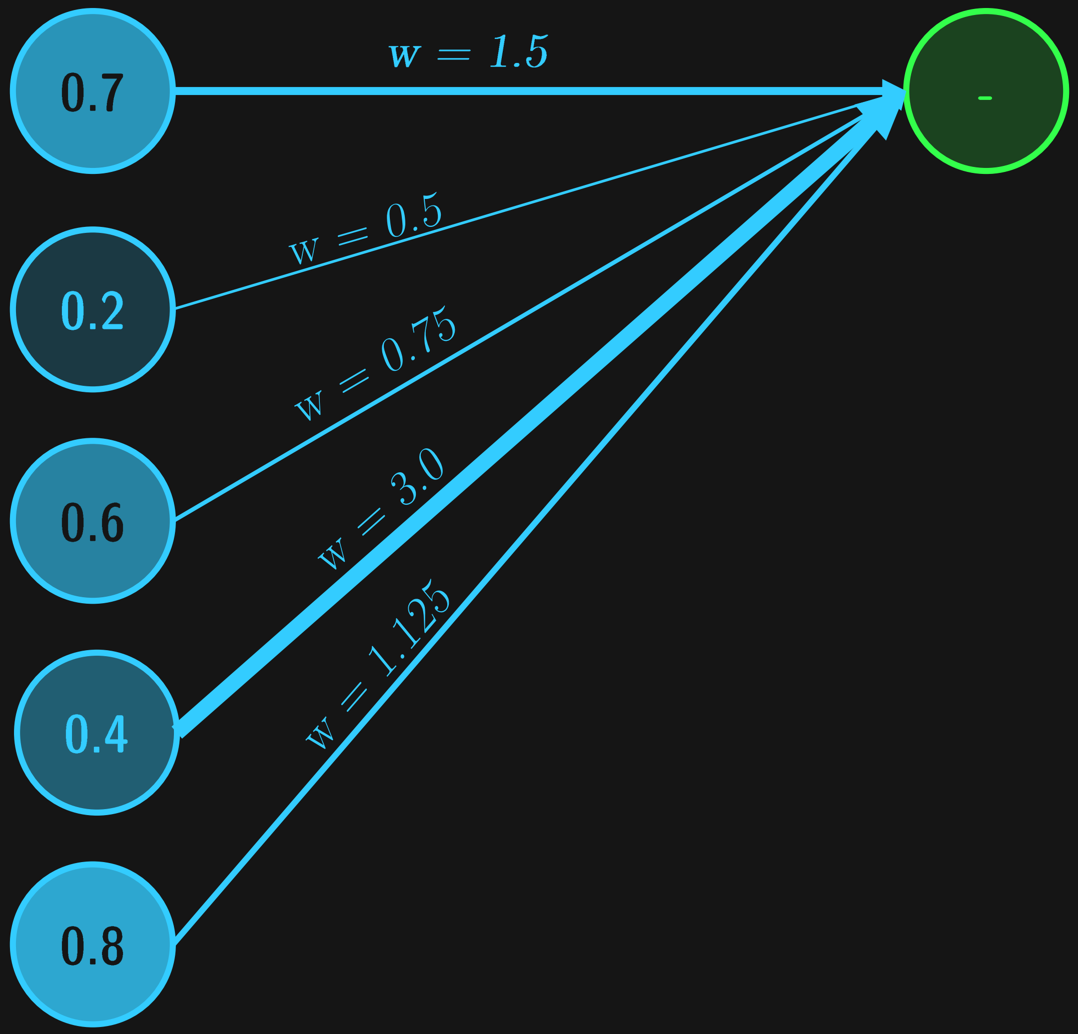
How Neurons Work



So our formula now looks like this.

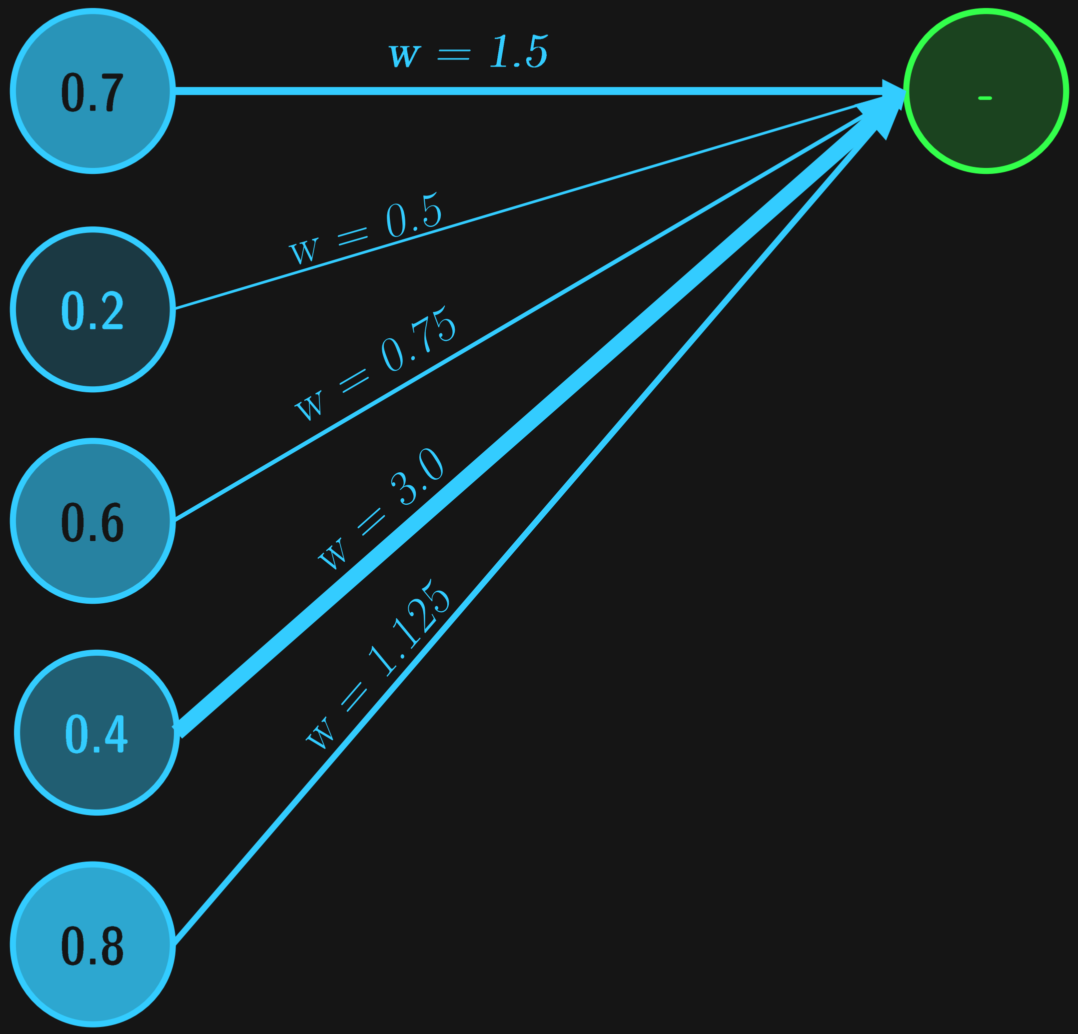
$$A_{out} = \sigma\left(\sum wA_{in}\right)$$

How Neurons Work



But that's not all.

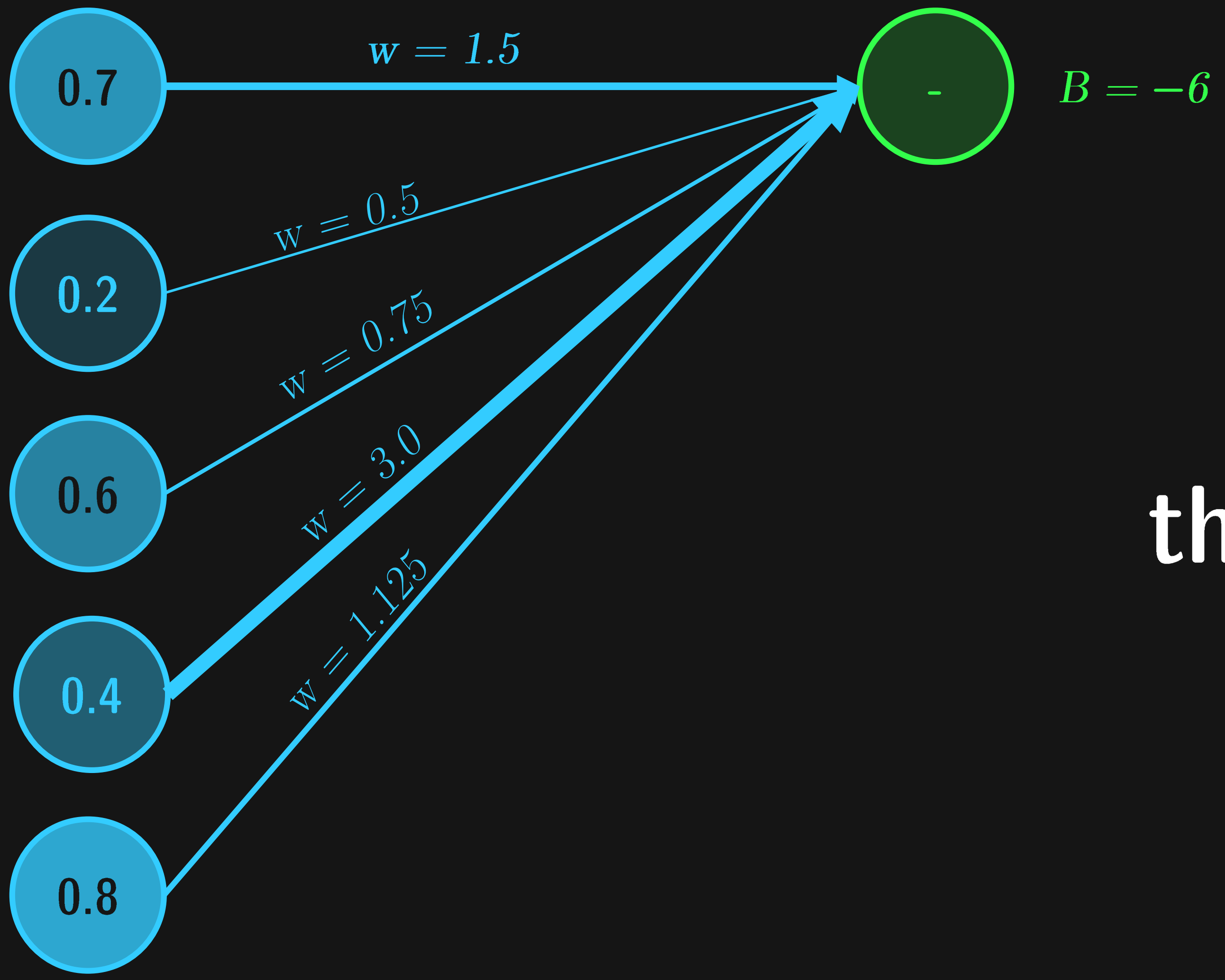
How Neurons Work



But that's not all.

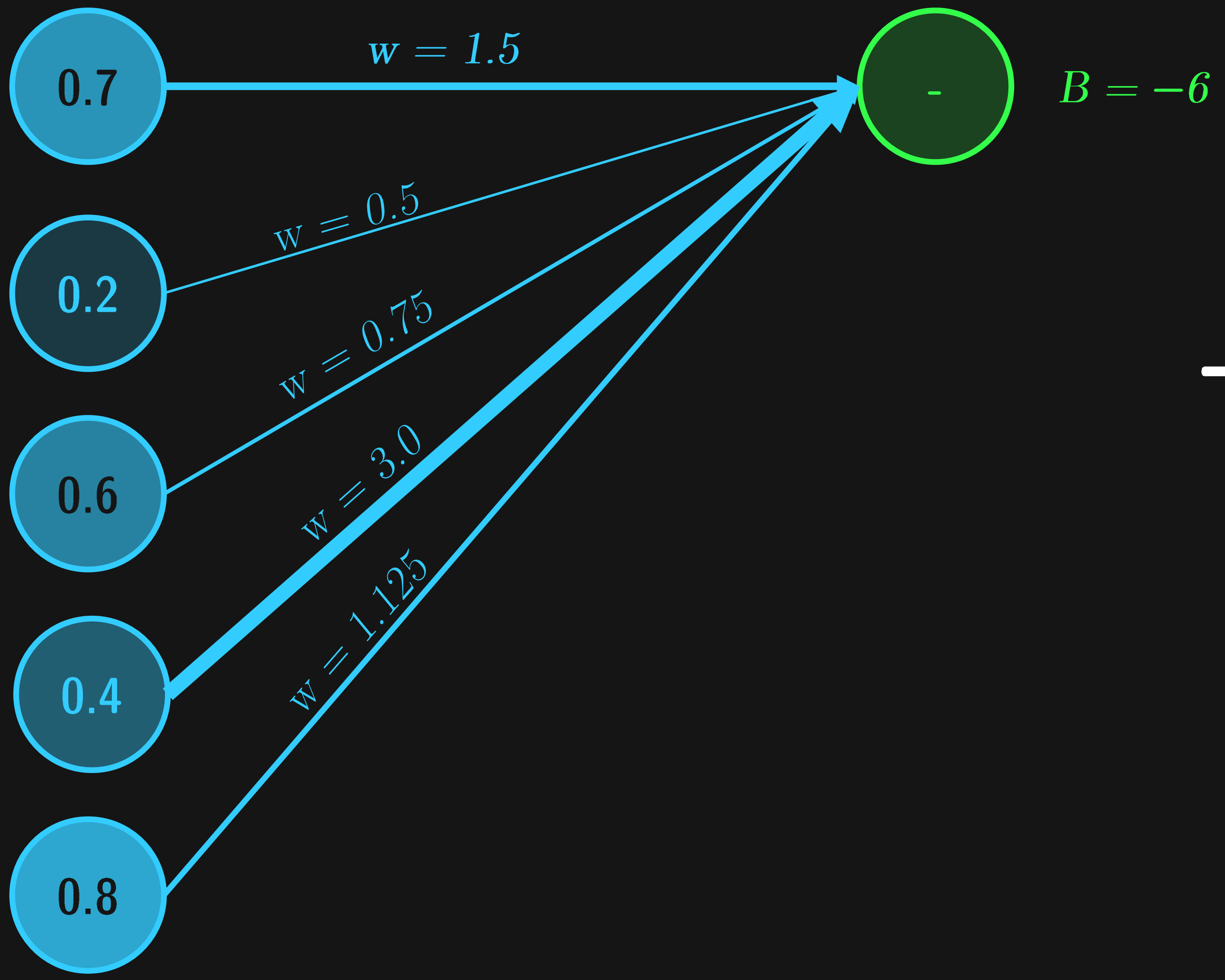
What if the green neuron needed to be even harder to please?

How Neurons Work



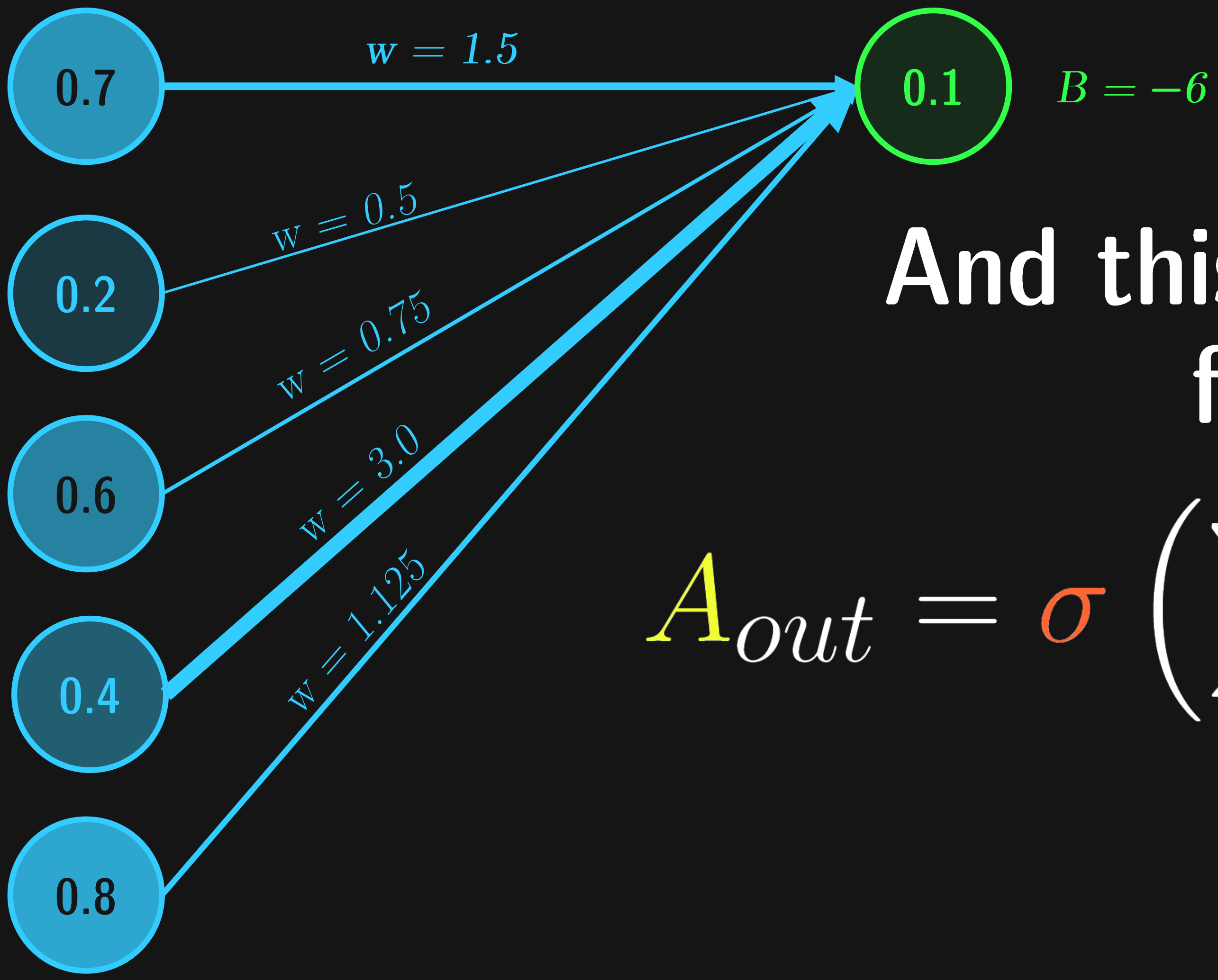
...in other words,
that it needed to be
biased?

How Neurons Work



This can be easily added to the formula as bias!

How Neurons Work



And this is how each neuron finds its value.

$$A_{out} = \sigma\left(\sum w_{in} A_{in} + B_{in}\right)$$

HNW: Extra

This equation applies to all neurons in the network.

$$A_{n,L+1} = \sigma\left(\sum_{n=1}^{n_L} w_{n,L} A_{n,L} + B_{n,L}\right)$$