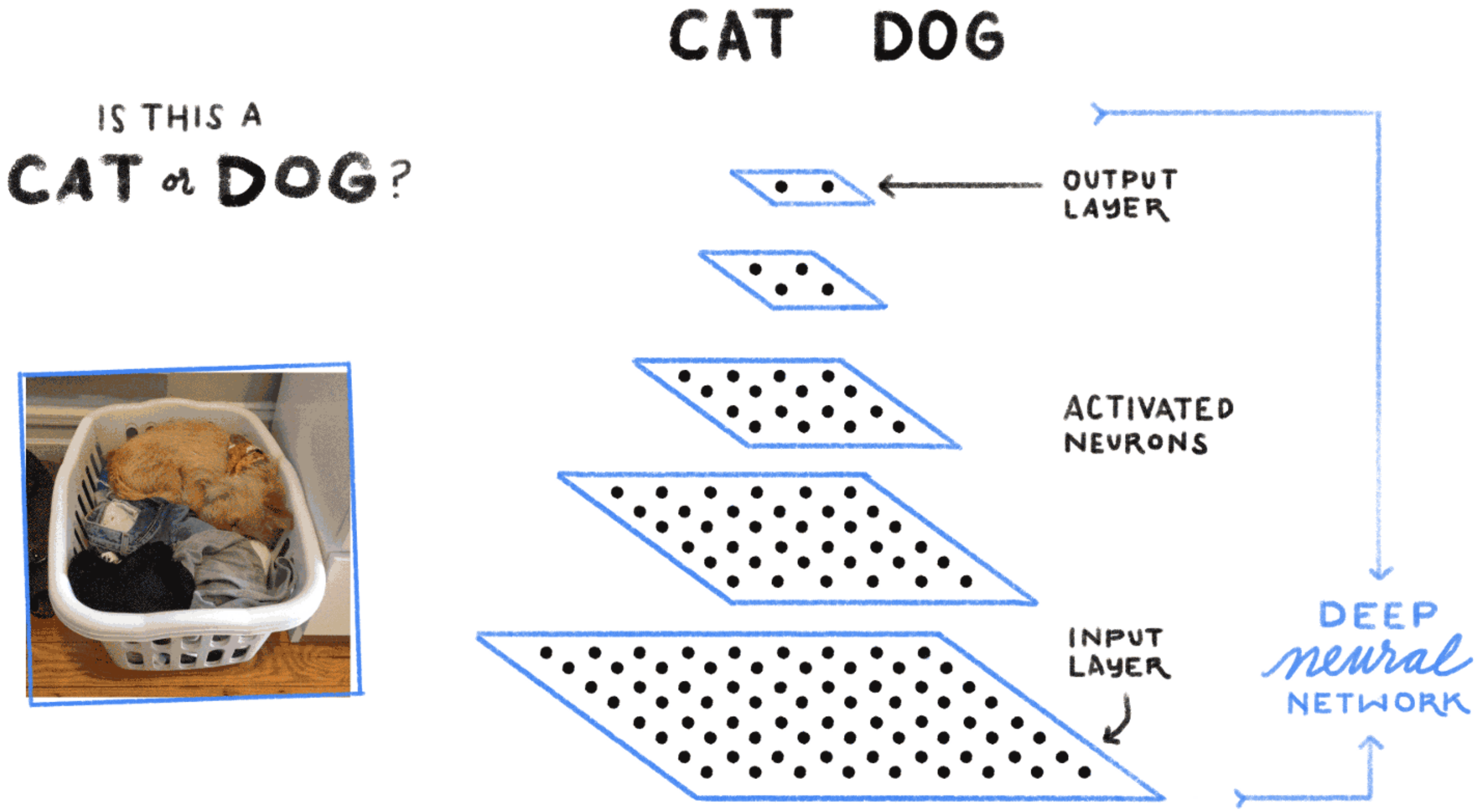
Artificial Neural Networks



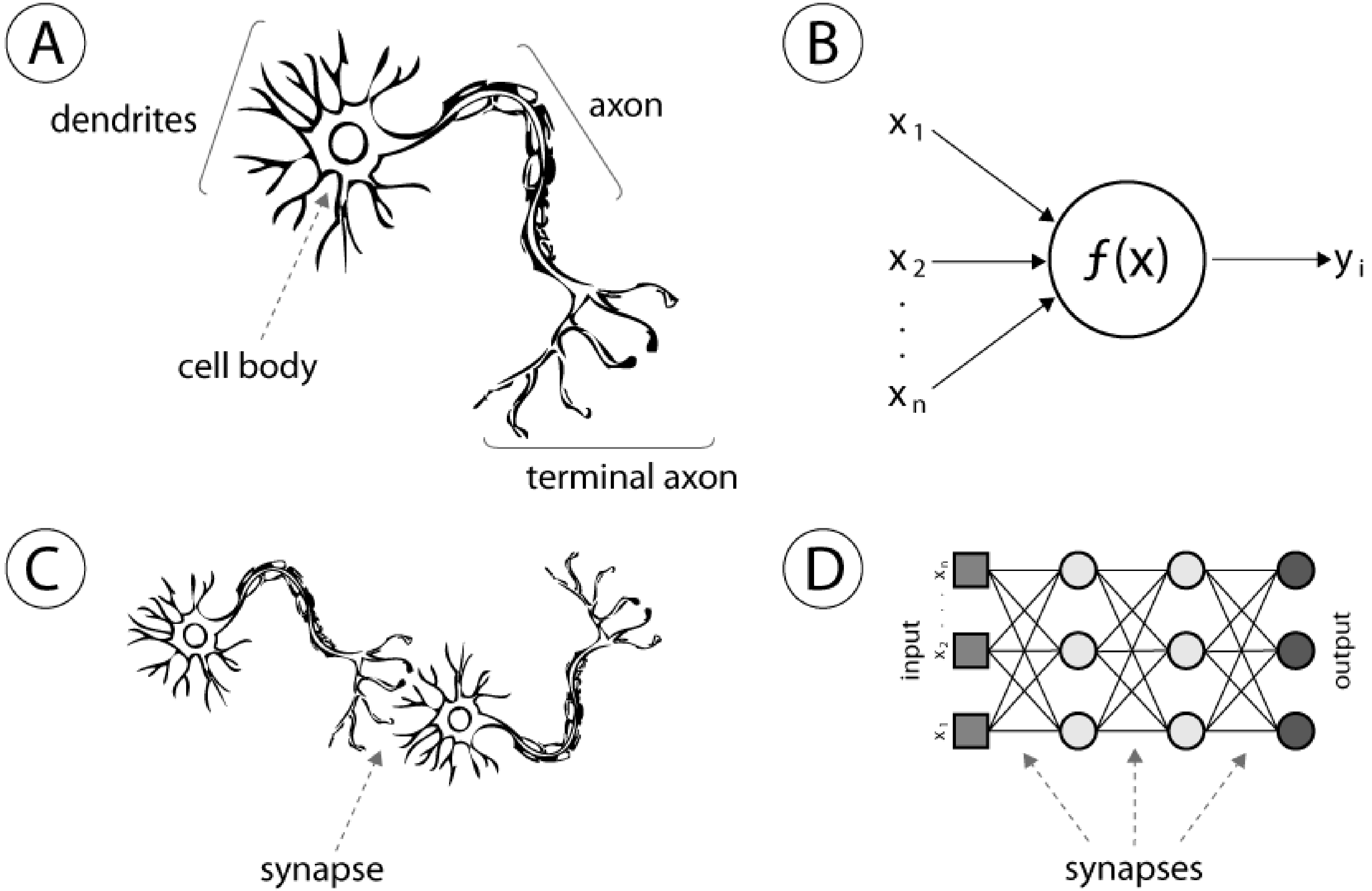
What are they?

Inspired by the Human Brain.

The human brain has about 86 Billion neurons and requires 20% of your body's energy to function.

These neurons are connected to between 100 Trillion to 1 Quadrillion synapses!

What are they?



What are they?

1. Originally developed by Warren McCulloch and Walter Pitts[3] (1943)
2. Started off as an unsupervised learning tool.
   1. Had problems with computing time and could not compute XOR
   2. Was abandoned in favor of other algorithms
3. Werbos's (1975) backpropagation algorithm
   1. Incorporated supervision and solved XOR
   2. But were still too slow vs. other algorithms e.g., Support Vector Machines
4. Backpropagation was accelerated by GPUs in 2010 and shown to be more efficient and cost effective

GPUS

GPUS handle parallel operations much better (thousands of threads per core) but are not as quick as CPUs. However, the matrix multiplication steps in ANNs can be run in parallel resulting in considerable time + cost savings. The best CPUs handle about 50GB/s while the best GPUs handle 750GB/s memory bandwidth.

PNY - NVIDIA GeForce GT 710 VERTO 2GB DDR3 PCI Express 2.0 Graphics Card - Black

2GB DDR3 (64-bit) on-board memory

Plus 192 CUDA processing cores and up to 12.8GB/sec.

$ **PRICE MATCH** GUARANTEE

$59.99

AMD - 1600 Six-Core 3.2 GHz Desktop Processor - White

Model: YD1600BBAEBOX **SKU:** 6091101

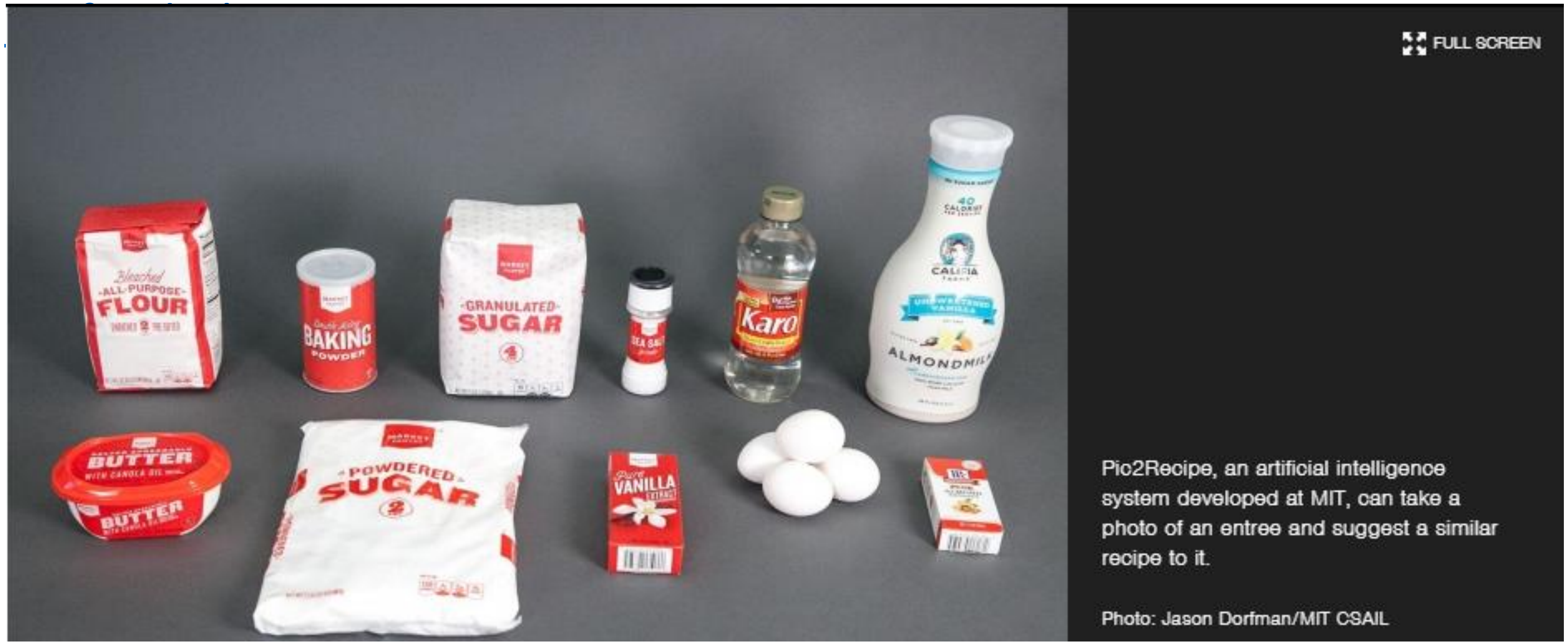
$ **PRICE MATCH** GUARANTEE

$189.99

	Google	**Stanford**
Number of cores	1K CPUs = 16K cores	3GPUs = 18K cores
Cost	$5B	$33K
Training time	week	week

Applications

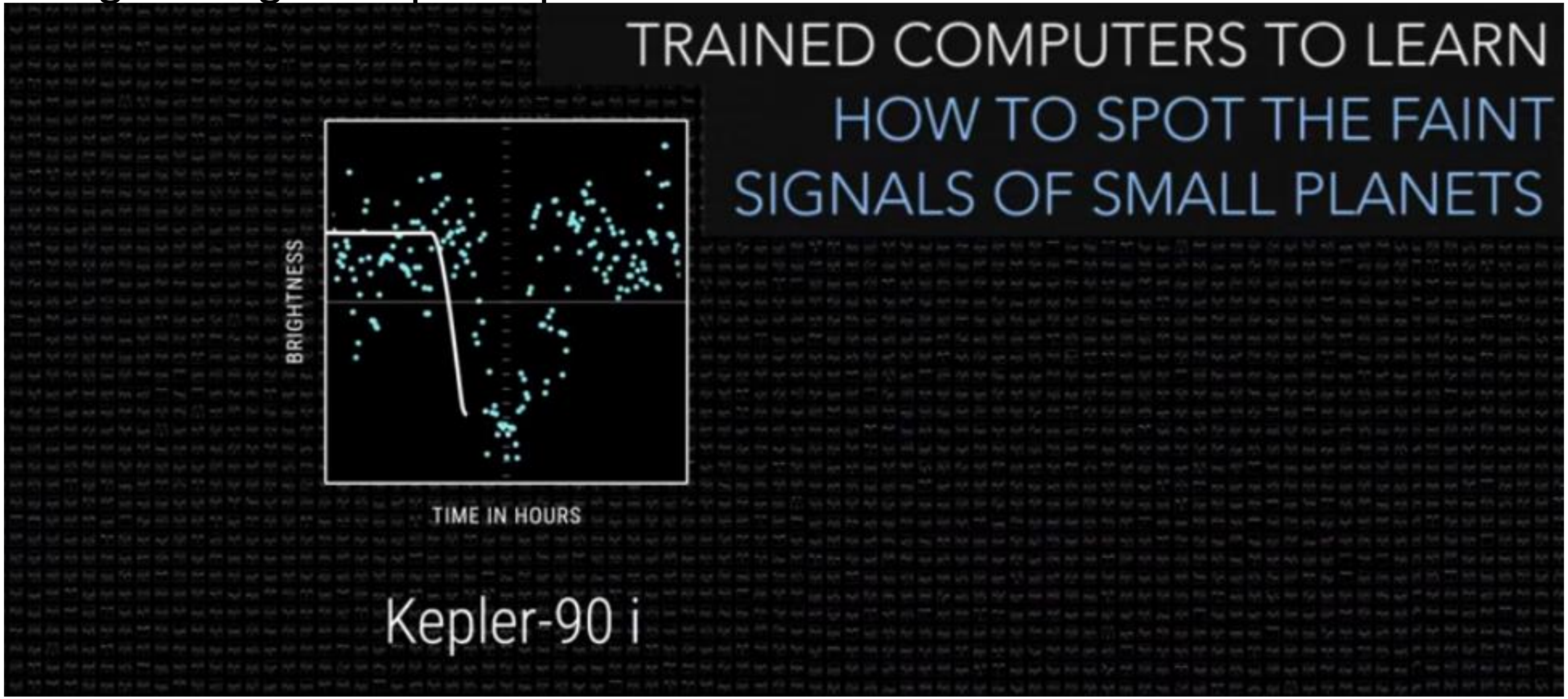
http://news.mit.edu/2017/artificial-intelligence-suggests-recipes-based-



Applications

https://www.nasa.gov/press-release/artificial-intelligence-nasa-data-used-to-discover-eighth-planet-circling-distant-star

Images of light drop compared and new ones found.



Idea behind them

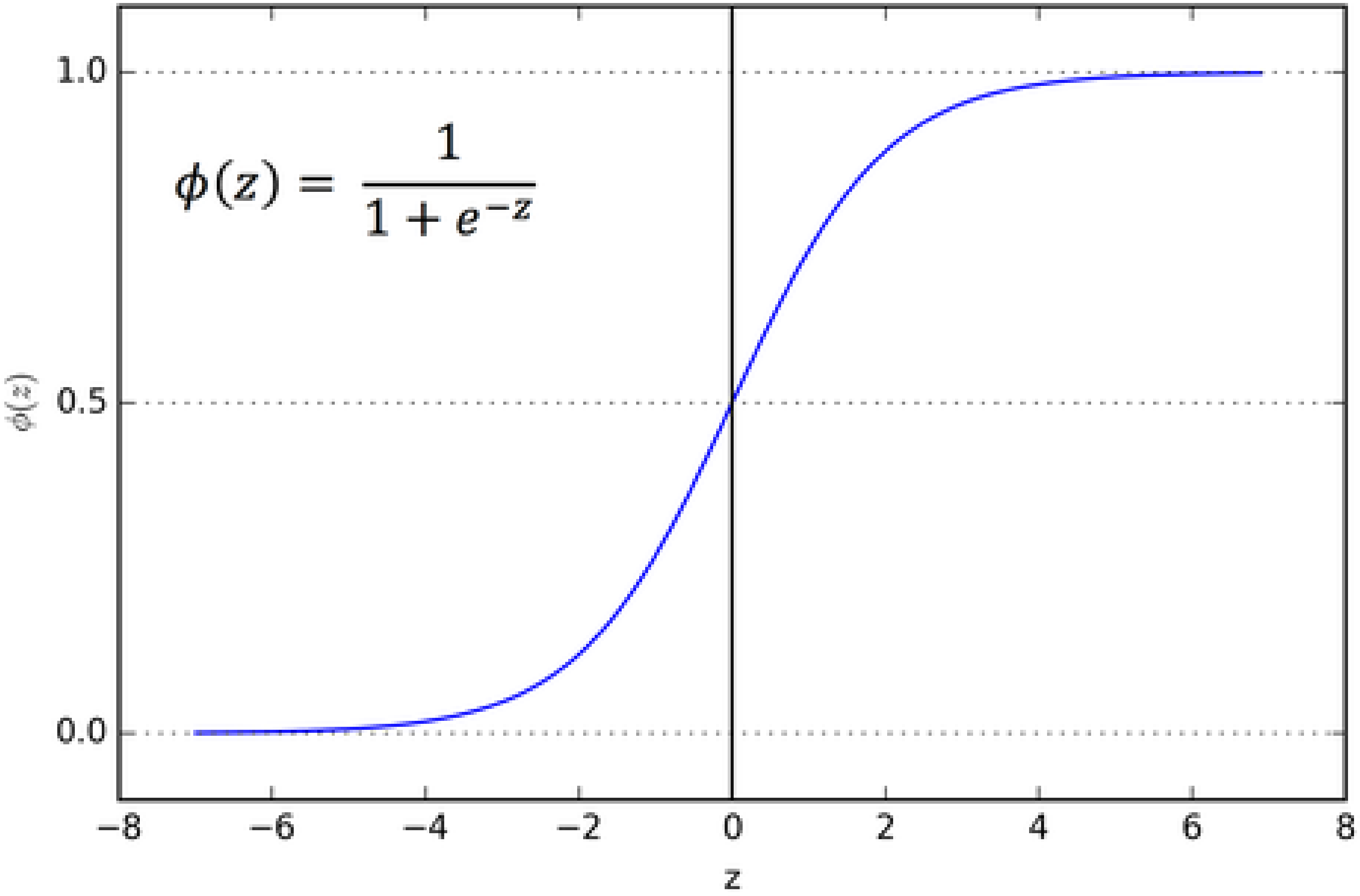
1. Obtain some structured data (always a good idea ☺).
2. Use some subset of that data as training
3. Feed each training example through the network
   1. Calculate the error for each training example
   2. Update the weights for each neuron to minimize the error using Gradient Descent (Back Propagation)
   3. Feed in the data again until you reach the desired % error or trials run out
   4. If you reached % error or trials stop and go to the next training input
      1. Else (Back Propagation)

An example

Forward Propagation

1. Assign random weights to the synapses
2. Feed in the training data
3. Calculate the hidden layers neurons from the inputs and the weights using an activation function
4. Calculate the output from the hidden layer neurons and the output weights
5. Calculate the error from what is expected

Activation Function



Forward propagation

Back propagation

We need to adjust the weights to minimize the error

Back propagation

Back Propagation

$$\left(\frac{f}{g}\right)' = \frac{f'\,g - f\,g'}{g^2}$$

An excel example

Derivative of the sigmoid

Let's denote the sigmoid function as $\sigma(x) = \frac{1}{1+e^{-x}}$.

The derivative of the sigmoid is $\frac{d}{dx}\sigma(x) = \sigma(x)(1-\sigma(x))$.

Here's a detailed derivation:

$$
\begin{aligned}
\frac{d}{dx}\sigma(x) &= \frac{d}{dx}\left[\frac{1}{1+e^{-x}}\right] \\
&= \frac{d}{dx}\left(1+\mathrm{e}^{-x}\right)^{-1} \\
&= -(1+e^{-x})^{-2}(-e^{-x}) \\
&= \frac{e^{-x}}{(1+e^{-x})^2} \\
&= \frac{1}{1+e^{-x}} \cdot \frac{e^{-x}}{1+e^{-x}} \\
&= \frac{1}{1+e^{-x}} \cdot \frac{(1+e^{-x})-1}{1+e^{-x}} \\
&= \frac{1}{1+e^{-x}} \cdot \left(\frac{1+e^{-x}}{1+e^{-x}} - \frac{1}{1+e^{-x}}\right) \\
&= \frac{1}{1+e^{-x}} \cdot \left(1 - \frac{1}{1+e^{-x}}\right) \\
&= \sigma(x) \cdot (1-\sigma(x))
\end{aligned}
$$