
# Neural Networks

Fintech

Lesson 13.1

# Class Objectives

By the end of the class, you will be able to:

Explain the concept of neural networks, including how a neuron is related to logistic regression.

Preprocess data for neural network models.

Explain the intuition of how weights of neurons are determined.

List the Python libraries available for building neural networks.

Describe some of the differences between neural networks involving regression versus those involving classification.

Describe the pros and cons of using Keras for building neural networks.

Use the Quick, Draw! web app to experiment with neural network applications.

Implement neural networks with the TensorFlow Keras API.


WELCOME

# What do you think a neural network is?

# Sample Answers

01

It’s a computer representation of a human neuron.

02

It’s a method to create artificial intelligence software.

03

Neural networks are machine learning algorithms that can learn to solve a problem.

# Do you know some cool applications of neural networks?

**Sample Answer:**

Autonomous (self-driving) cars

**Sample Answer:**

Image processing in cancer detection

**Sample Answer:**

Banning inappropriate content on social networks


**Sample Answer:**

Automated trading based on artificial intelligence

# Questions?

# Homework Preview

# The venture capital industry uses data and models to determine how to make investments.

# Homework Preview

In this homework assignment, you will:

- Take on the role of a venture capital analyst.
- Use models to quantify the factors that lead to investing success and to evaluate future deals.
- Create a neural network model that will predict whether an applicant will become a successful business.

You will learn how to build, evaluate, and optimize deep neural networks by using a “model-fit-predict” pattern.

# Questions?

# What Is a Neural Network?

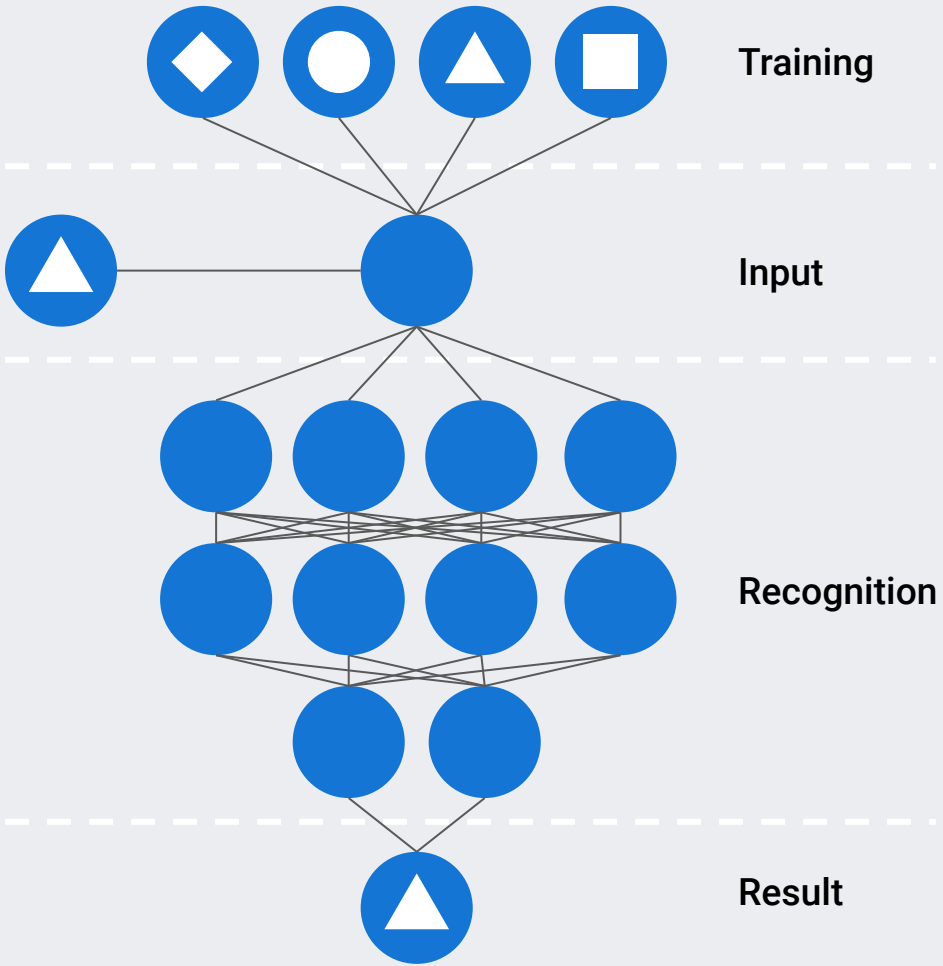
# What Is a Neural Network?

Neural networks, also known as artificial neural networks (ANN), are a set of algorithms that are modeled after the human brain.

# What Is a Neural Network?

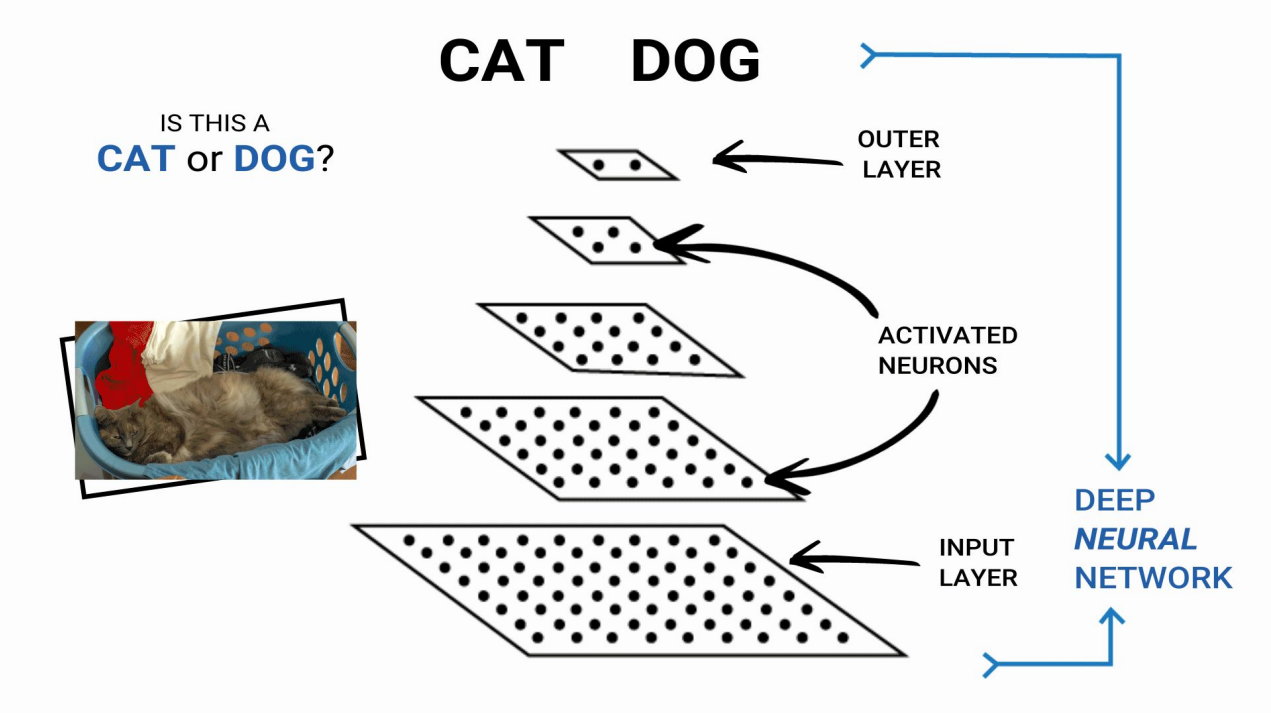
Neural networks are an advanced form of machine learning that:

- Recognizes patterns and features of input data
- Provides a clear quantitative output



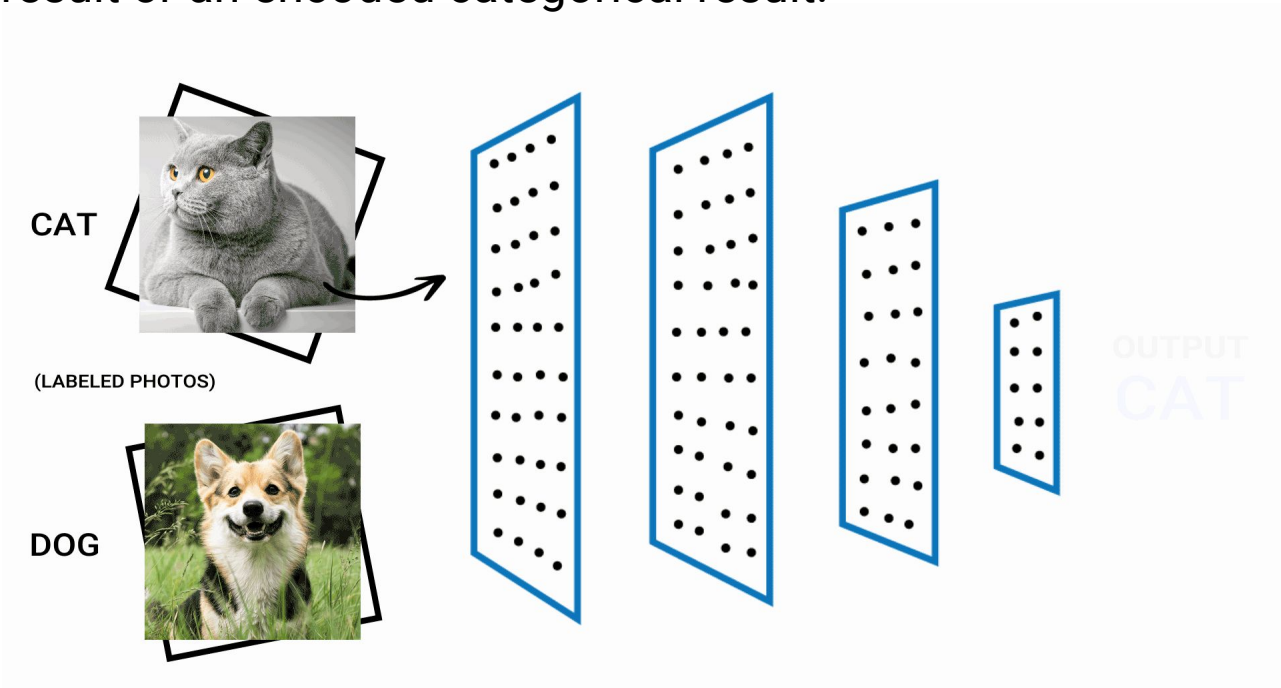
# What Is a Neural Network?

In its simplest form, a neural network contains layers of neurons that perform individual computations.



# What Is a Neural Network?

These computations are connected and weighed against one another until the neurons reach the final layer. In the final layer, the neurons return either a numerical result or an encoded categorical result.



Using a neural network instead of a traditional statistical or machine learning model provides many advantages.

# Advantages of Neural Networks

**Neural networks can detect complex relationships within datasets.**

**Neural networks are versatile.**

They can be used to predict future shopping behavior based on credit card transactions or to assess a loan applicant's likelihood of defaulting on a loan based on their application.

**Neural networks have greater tolerance for messy data.**

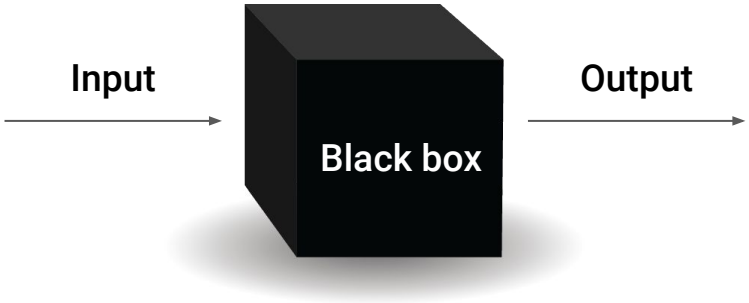
They can learn to ignore noisy characteristics within a large dataset.

There are two primary disadvantages of using a neural network.

# Disadvantages of Neural Networks

**Neural network algorithms can be too complex for humans to understand.**

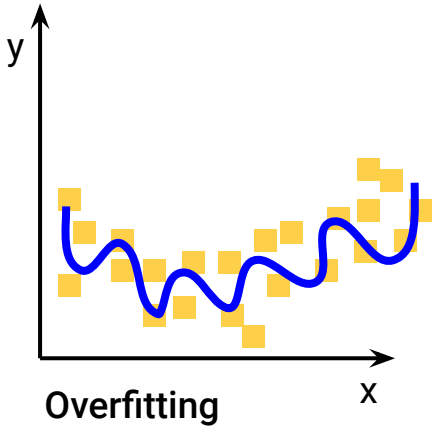
This is an example of something known as a **“black box” problem**, where the inputs are not visible to the user, and the resulting output cannot be traced back to discover the logic that was used.



# Disadvantages of Neural Networks

**Neural networks are more likely to overfit the data.**

**Overfitting** occurs when a model gives too much importance to patterns within the training data that are not found in the test data. This results in a model learning the training data so well that it cannot create generalizations about other data.



Fortunately, we can use different model designs and optimization techniques to compensate for and negate both of these disadvantages.

# Neural Networks in Finance

Neural networks serve multiple purposes in the finance industry:

- Fraud detection
- Risk management
- Money laundering prevention
- Algorithmic stock trading

# Fraud Detection

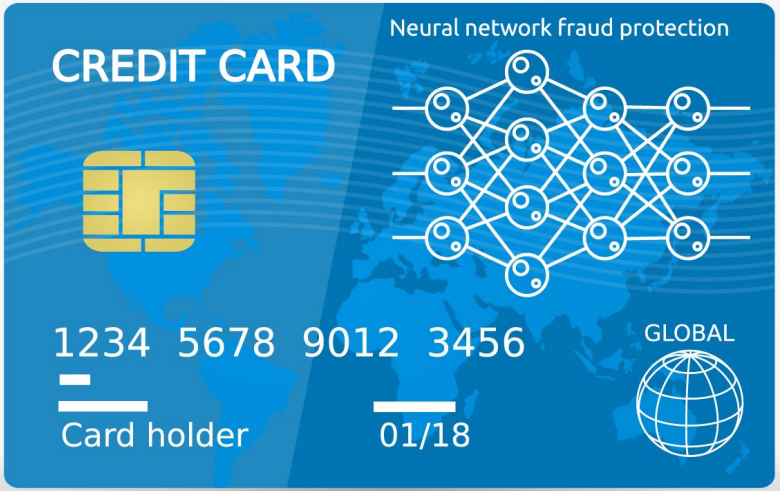
$118 billion worth of credit card transactions are incorrectly identified as fraud and declined every year.

Neural networks can efficiently evaluate the characteristics of a credit card transaction or loan application, allowing financial firms to predict fraud with more accuracy.

This saves time and money.

# Risk Management

The banking sector, insurance industry, and stock exchanges are all building more robust and efficient techniques for credit management by using neural networks.



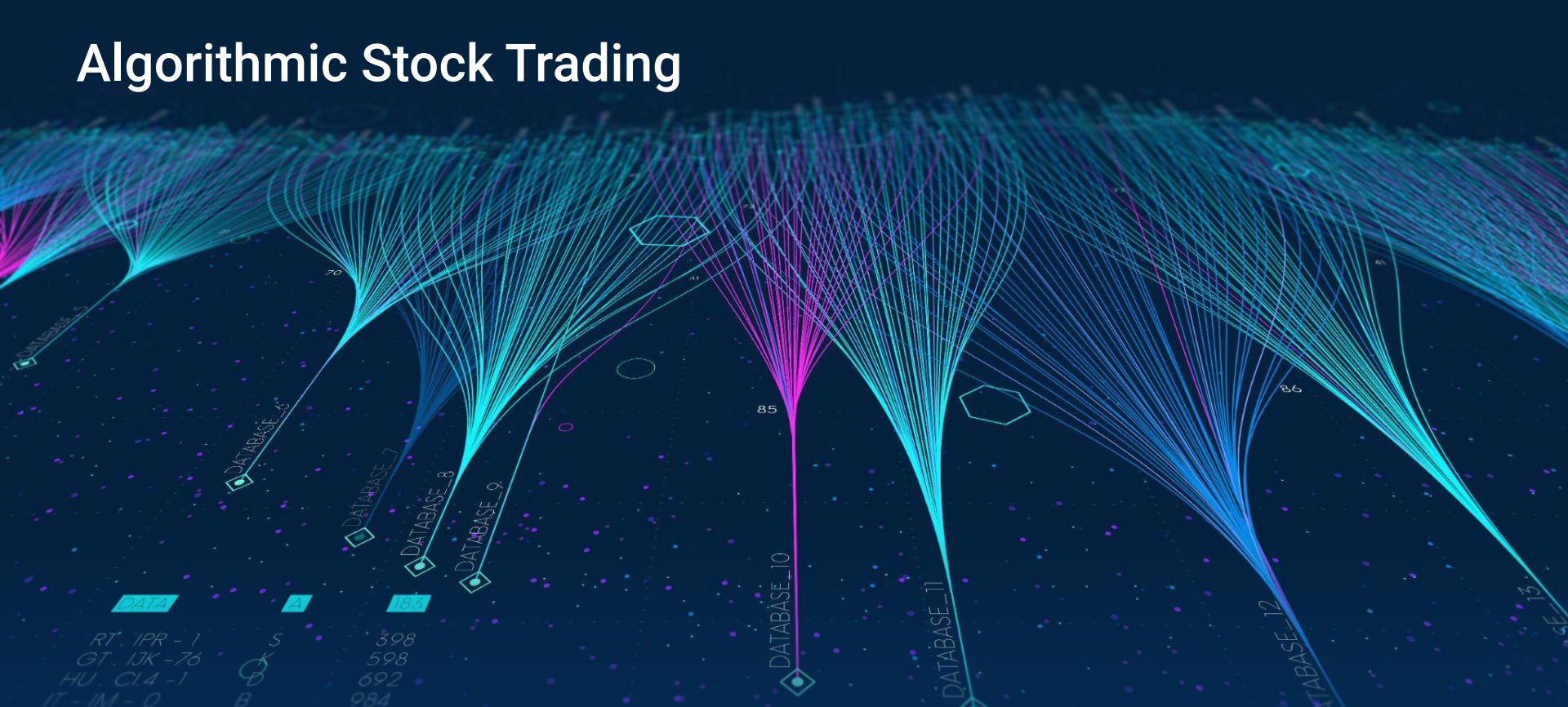
# Money Laundering Prevention

A United Nations study estimates that money laundering activity around the world accounts for 2–5% of annual global GDP.

Financial institutions now use neural nets as a tool in their fight against financial crime.

https://www.unodc.org

# Algorithmic Stock Trading

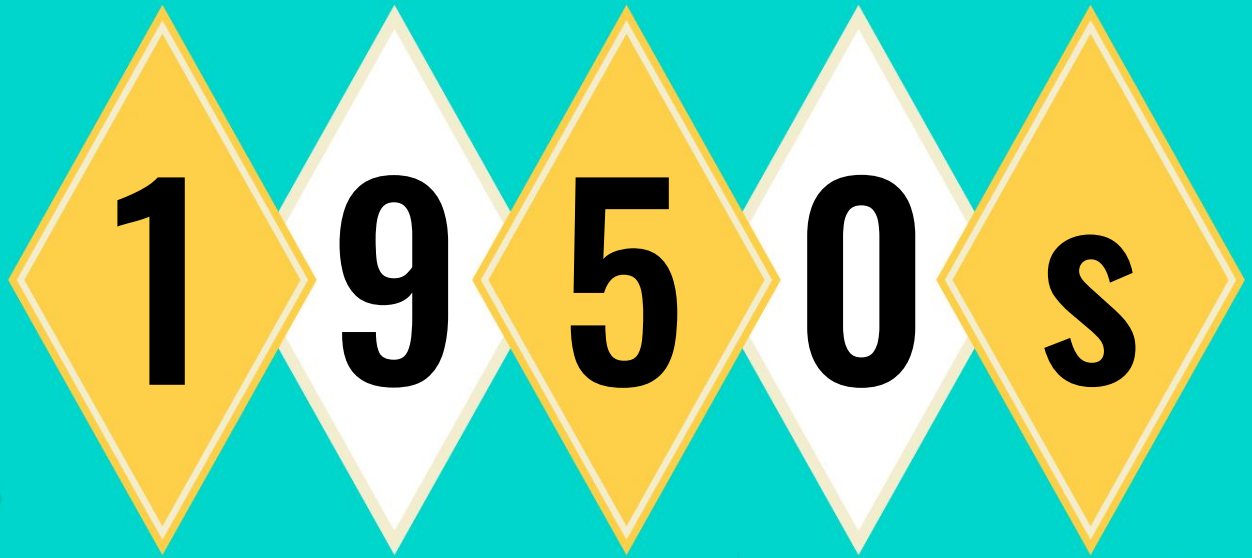



Thanks to trading algorithms that incorporate neural networks,
you can automate your trading strategies and increase your trading profits.

Before we get into the code, let's review the components of a neural network and how they work together to learn.

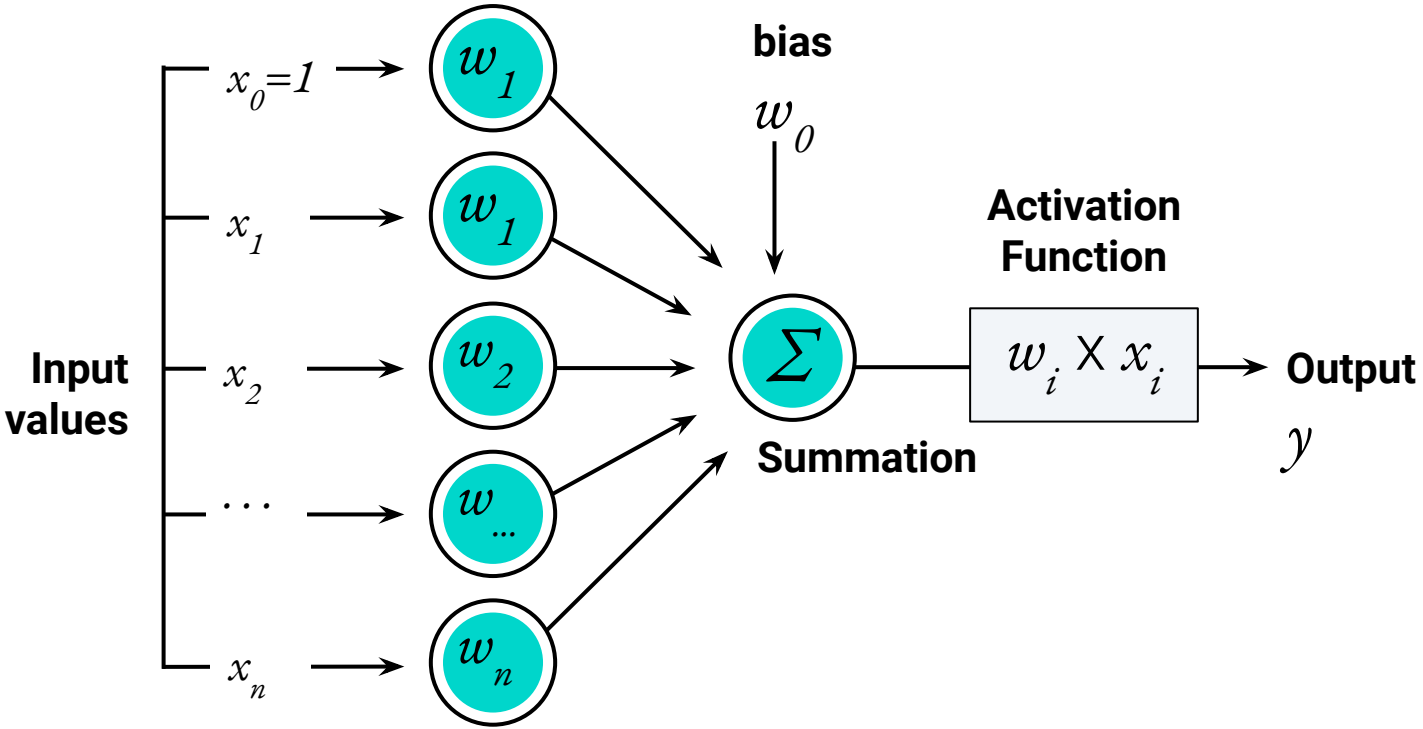
# Perceptron,
# the Computational Neuron

Artificial neural networks have become popular in recent years. But, the original design for a computational neuron, known as a **perceptron**, dates back to the late



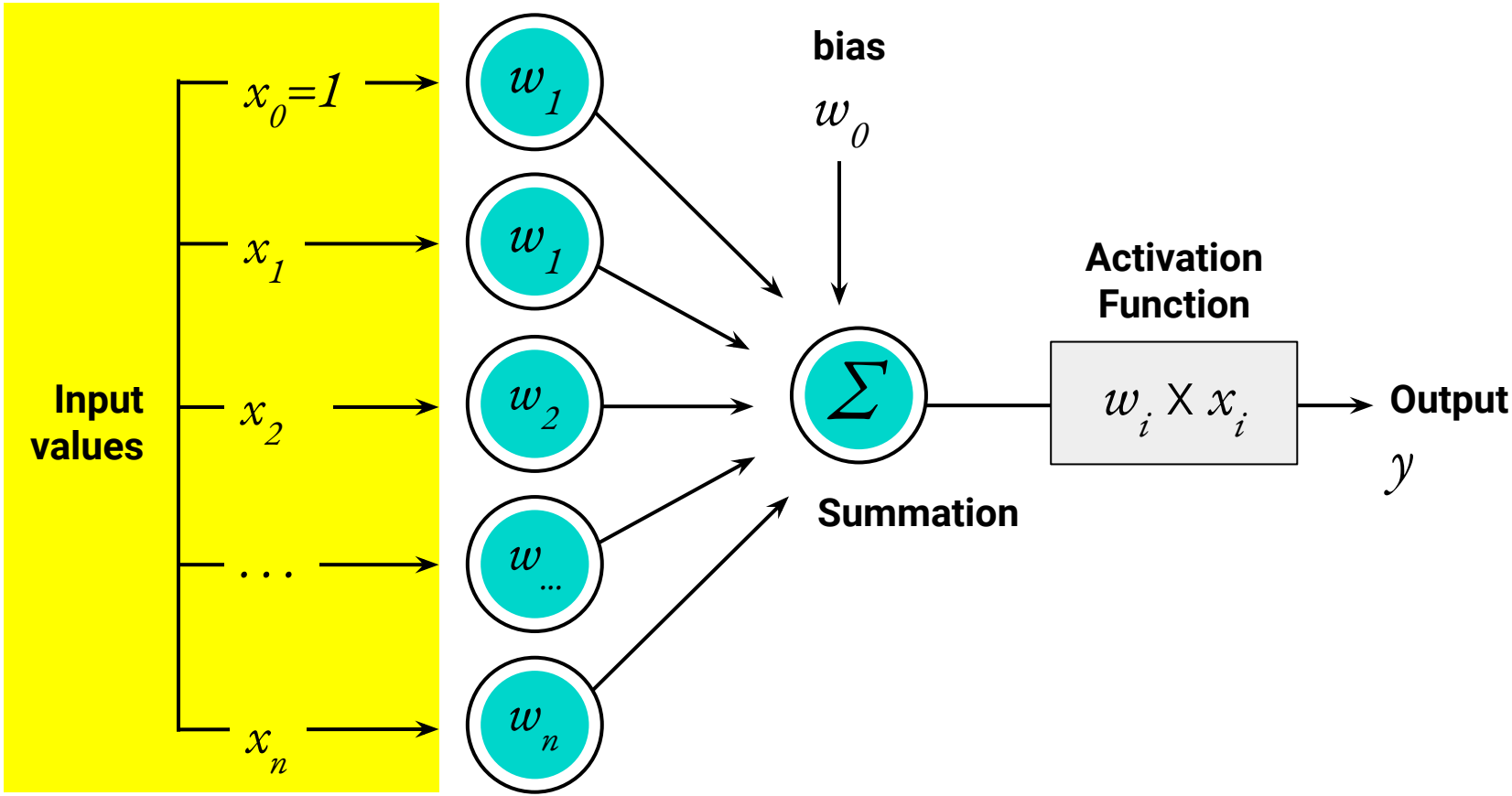
# Meet the Perceptron

The **perceptron model** mimics a biological neuron by receiving input data, weighting the information, and producing a clear output.

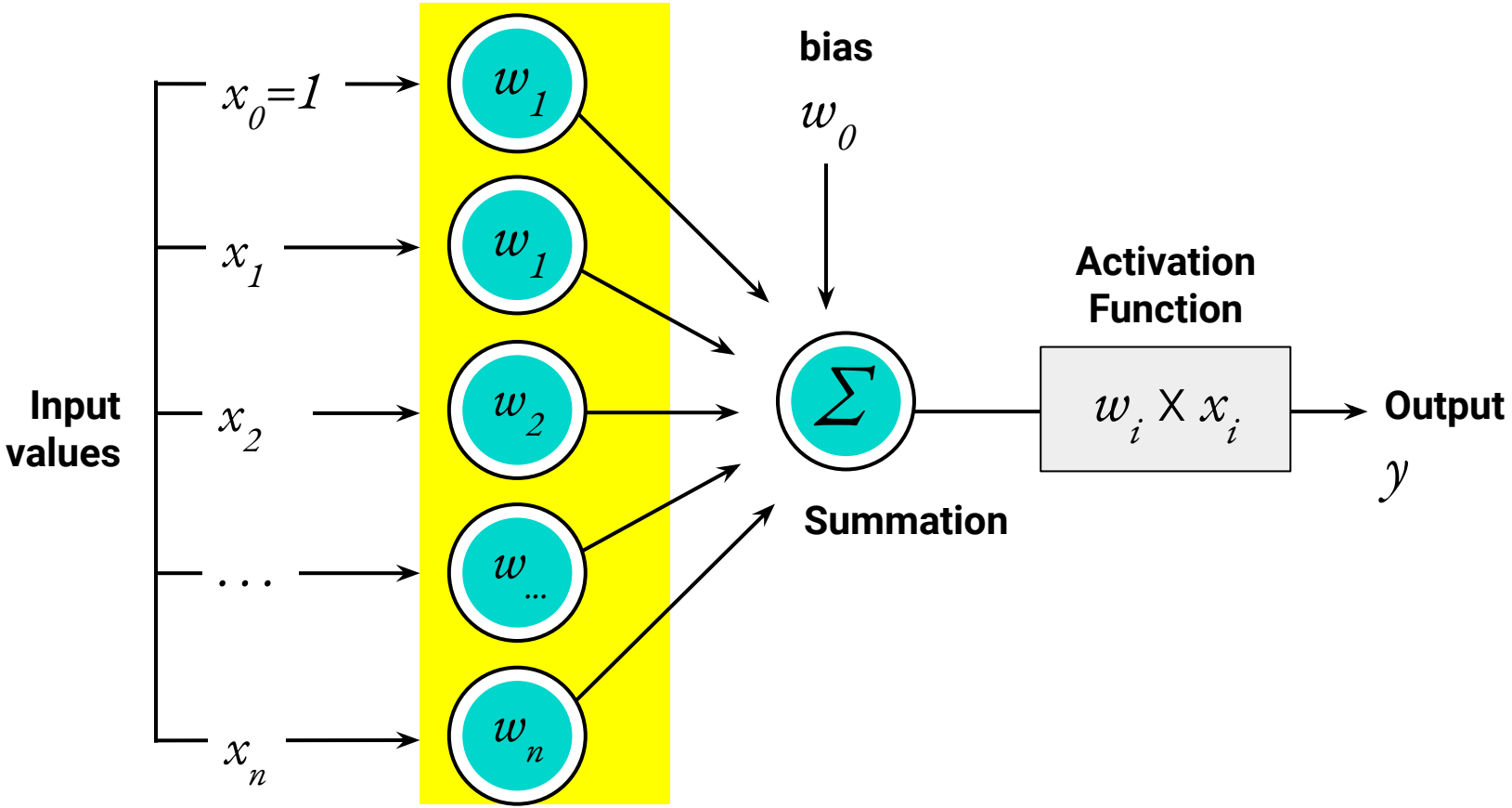


The perceptron model has four major components.

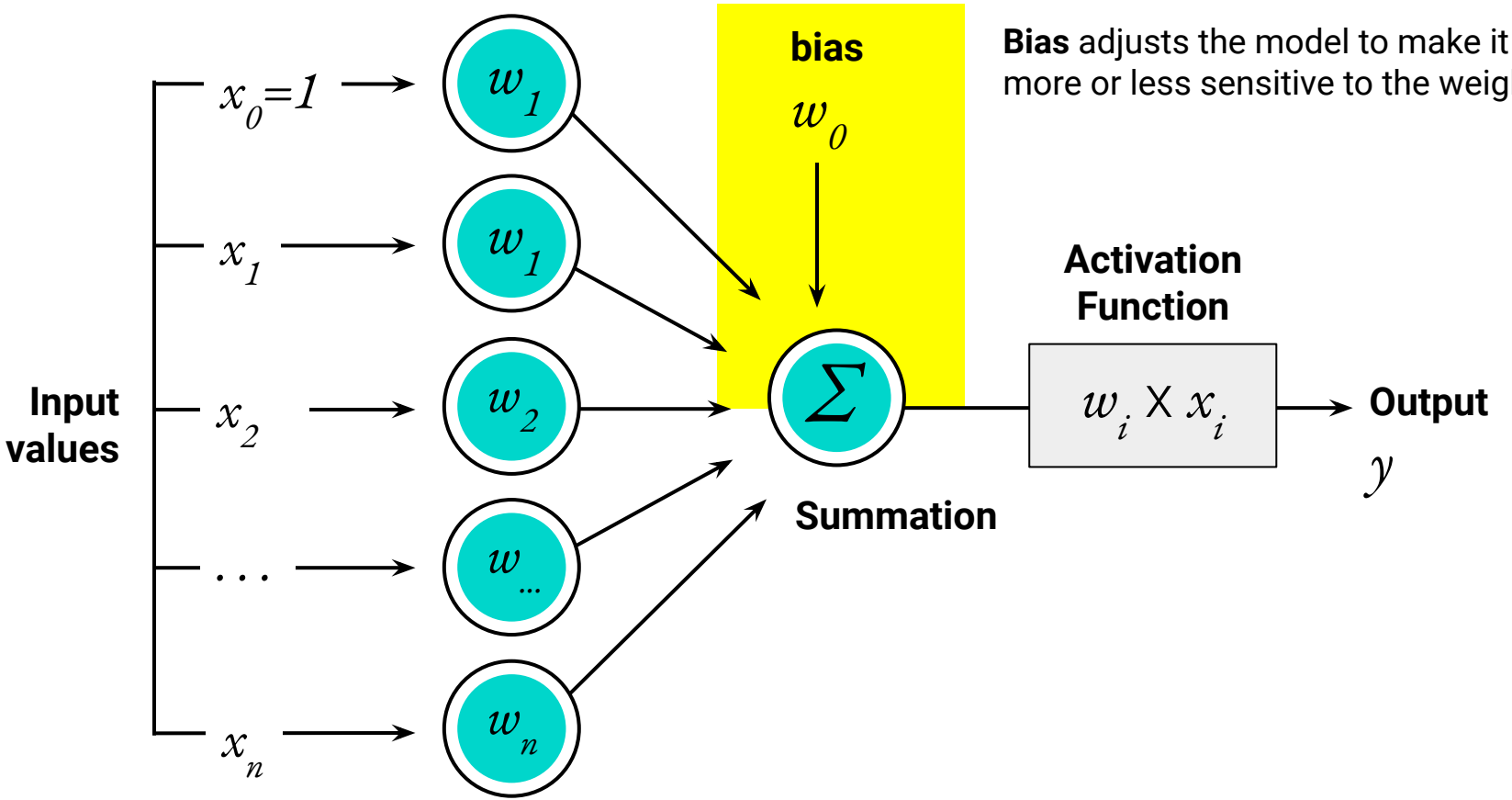
# Input Values (shown as *x*'s)



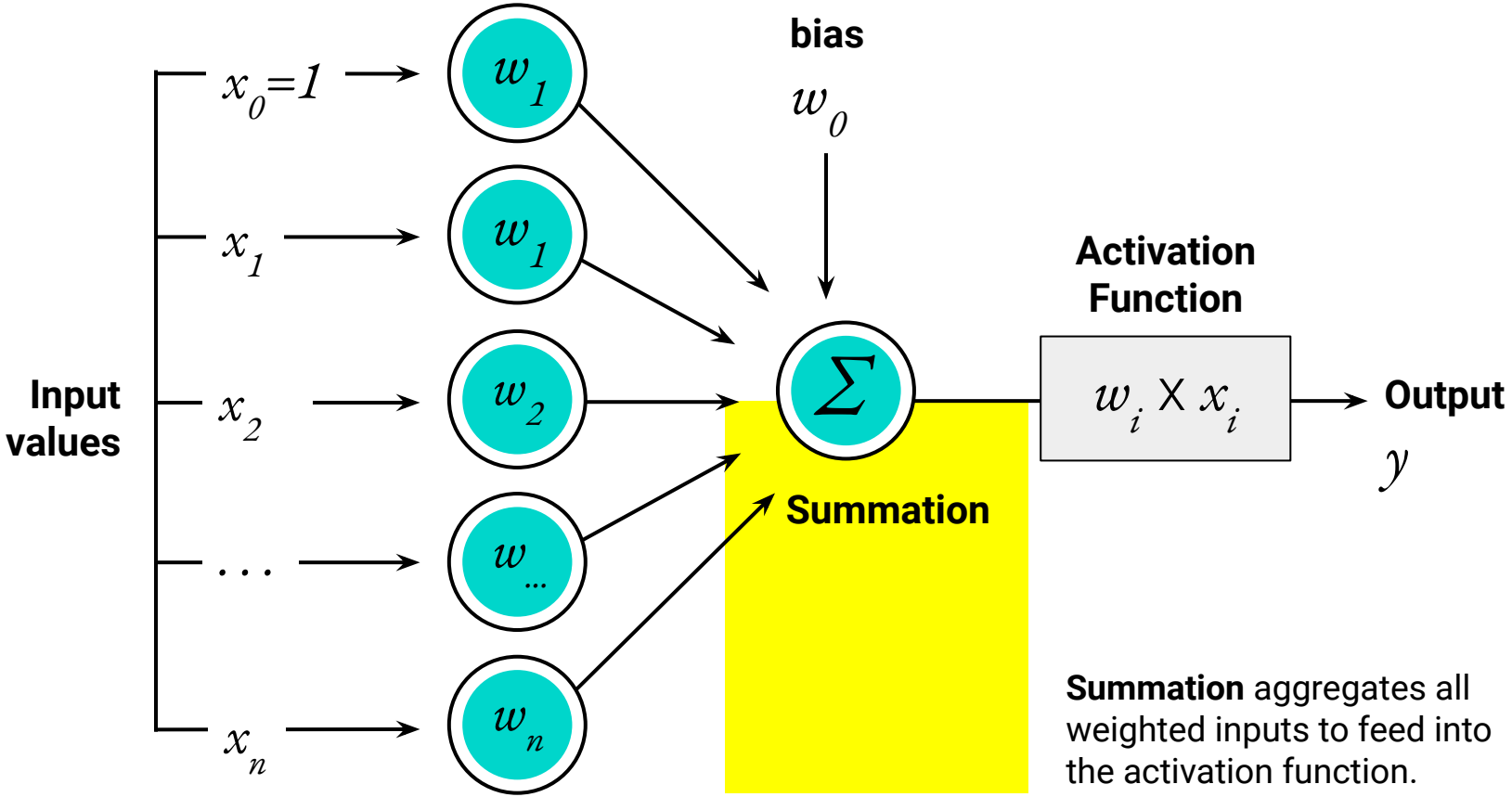
# Weight Coefficients (denoted as *w*'s)



# A Constant Value Called Bias



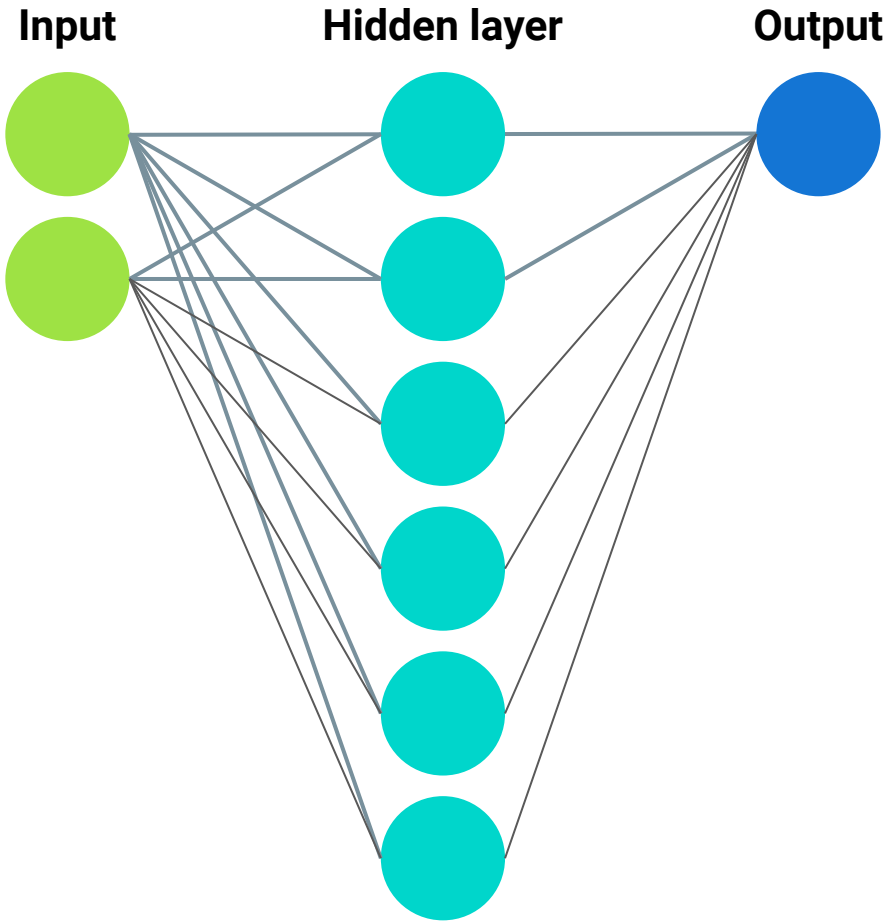
# Net Summary Function (the Summation)




**Summation** aggregates all weighted inputs to feed into the activation function.

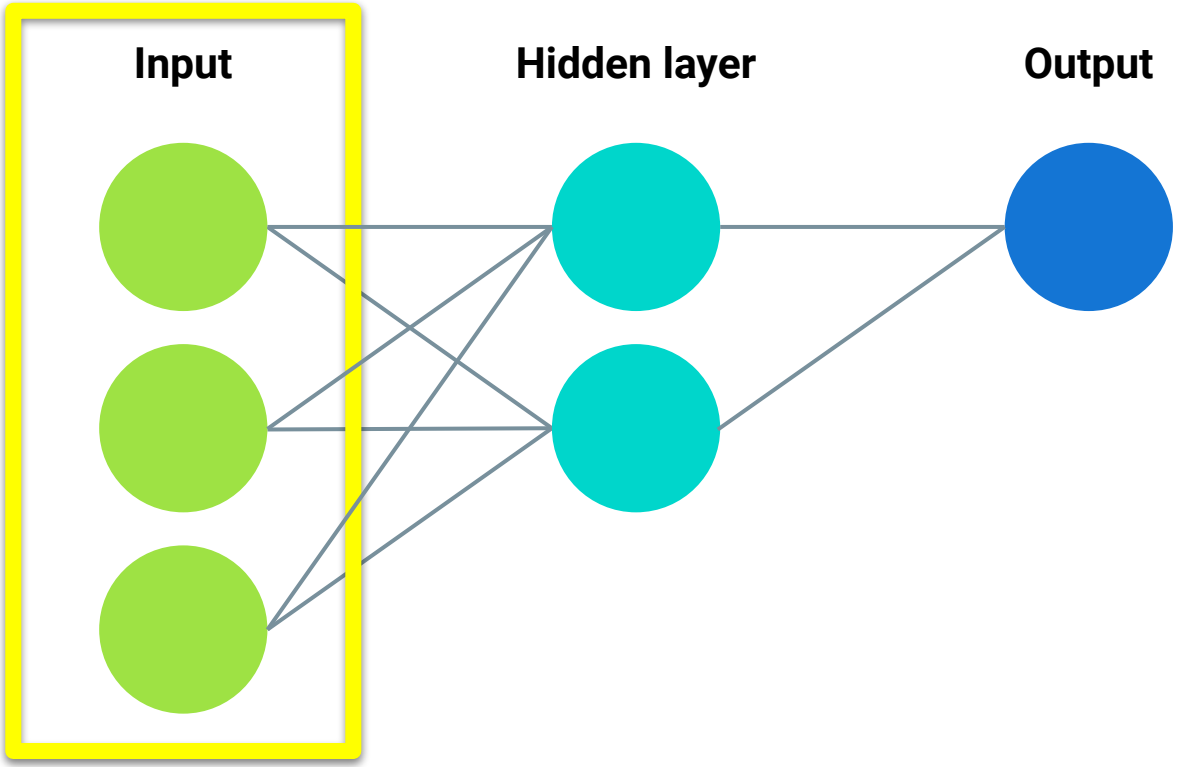
# The Neural Network

A modern neural network model is a structure composed of several connected perceptrons that learn from input data to produce an output.



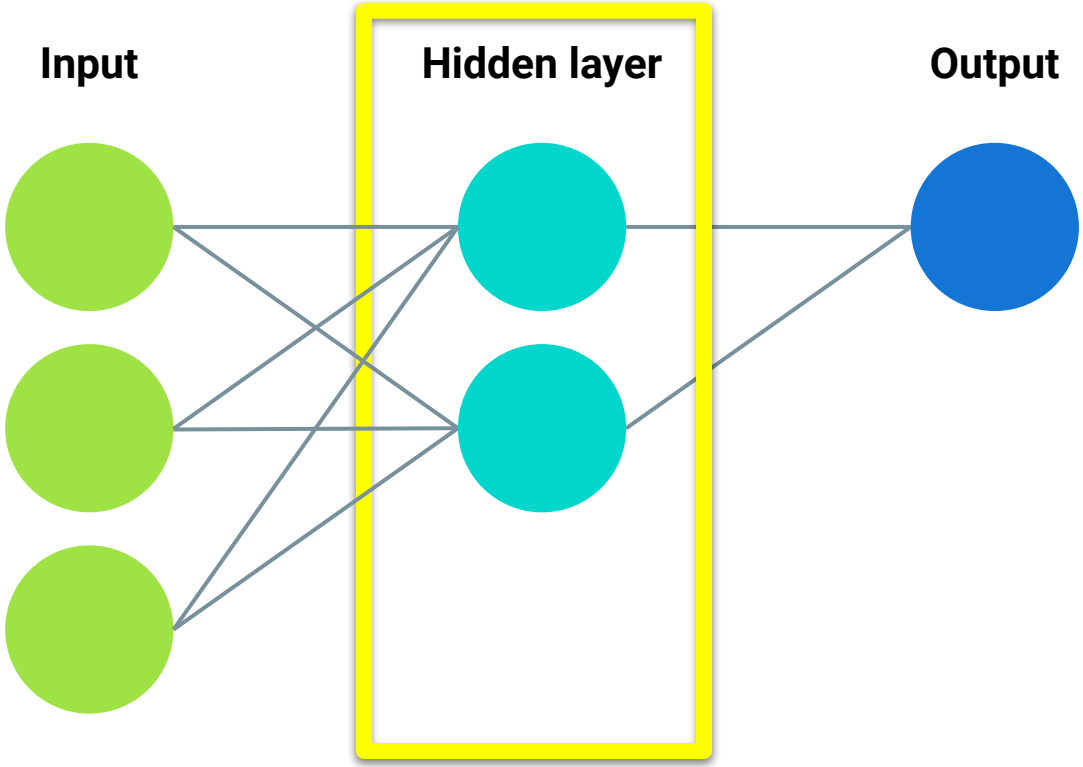
# The Structure of a Neural Network

An **input layer** of input values transformed by weight coefficients



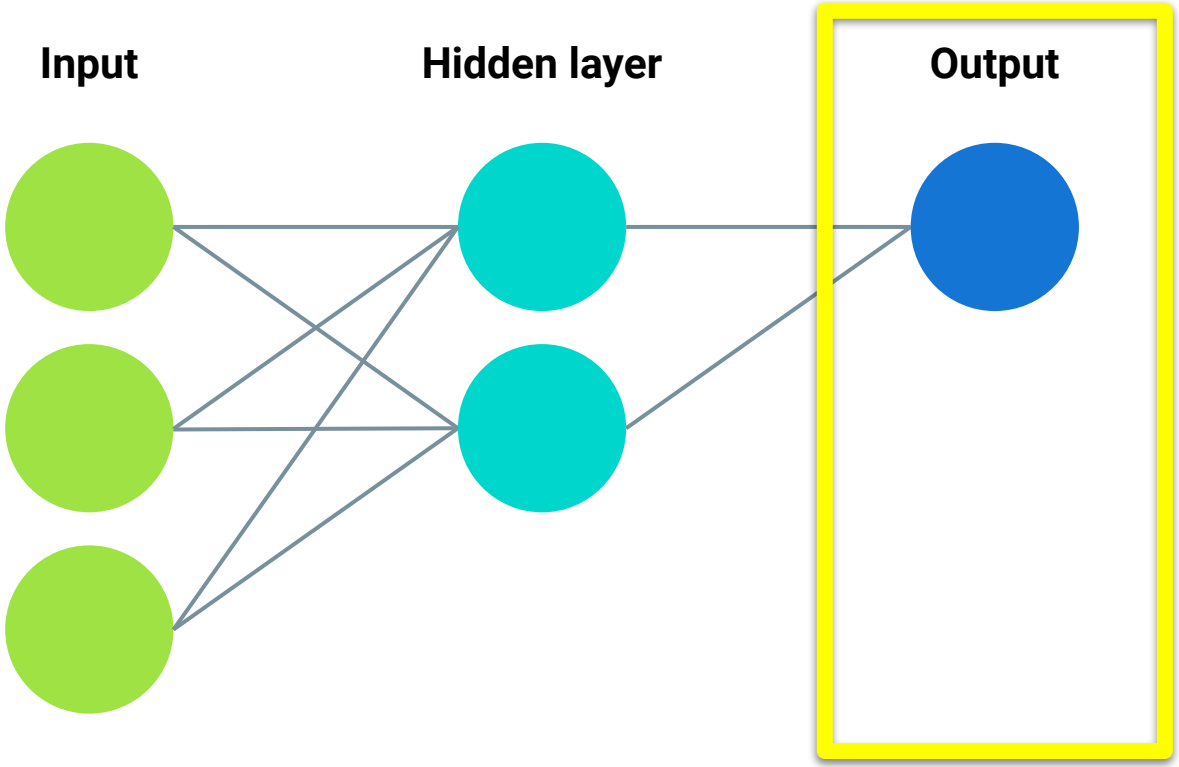
# The Structure of a Neural Network

A single **hidden layer** that can contain a single neuron or multiple neurons



# The Structure of a Neural Network

An **output layer** that reports the outcome of the value



# Activation Functions

# Activation Functions

Neural networks link neurons that process input together to produce a clear, quantitative output.

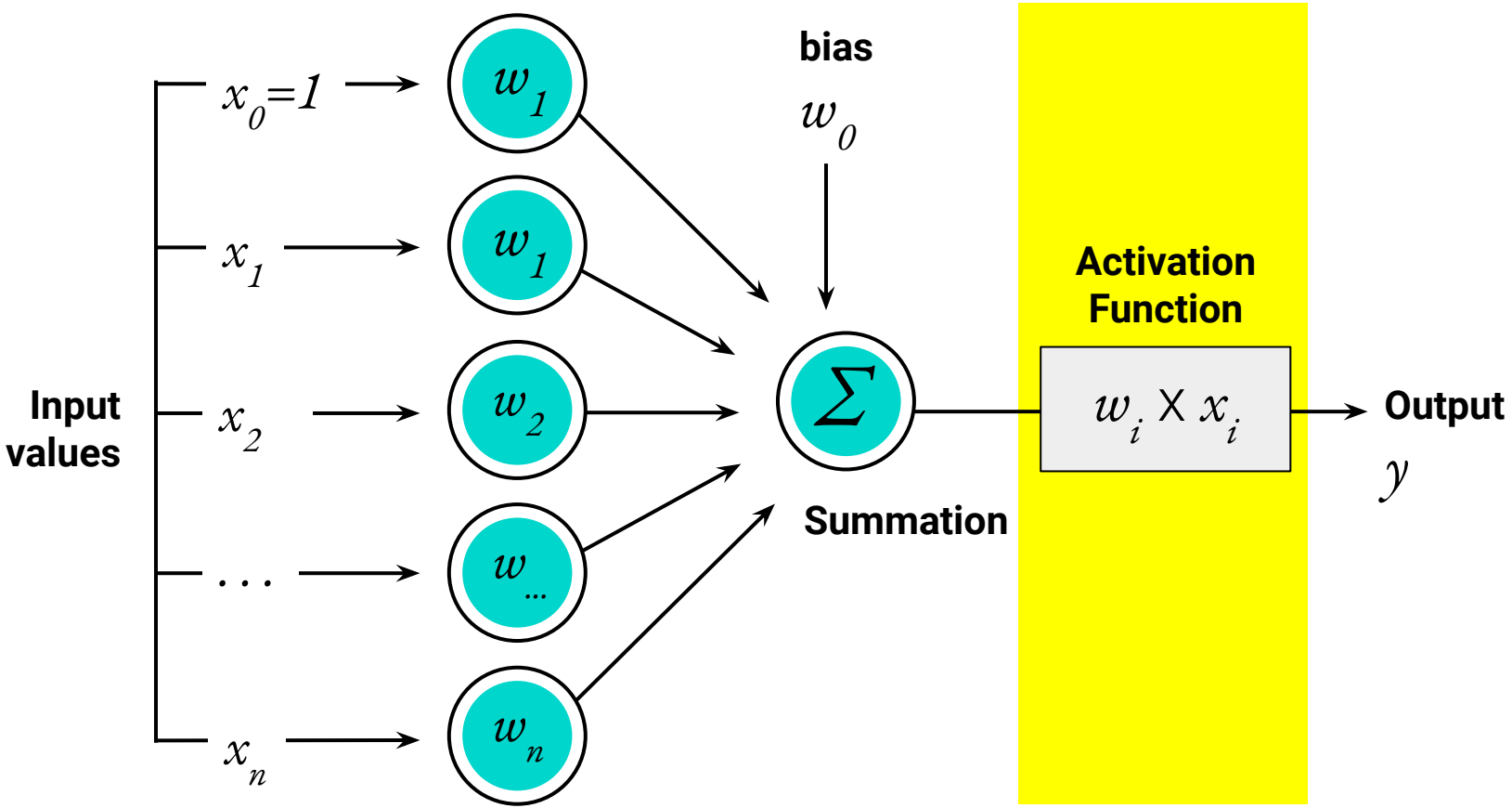
An **activation function** combines all these outputs into a single classifier or regression model.

When building a model, we apply the activation function to the end of each neuron (each individual perceptron model).

This mathematical function transforms each neuron's output into a quantitative value.

The quantitative output value becomes the input value for the next layer in the neural network model.

# Activation Function (Transformation After Summation)

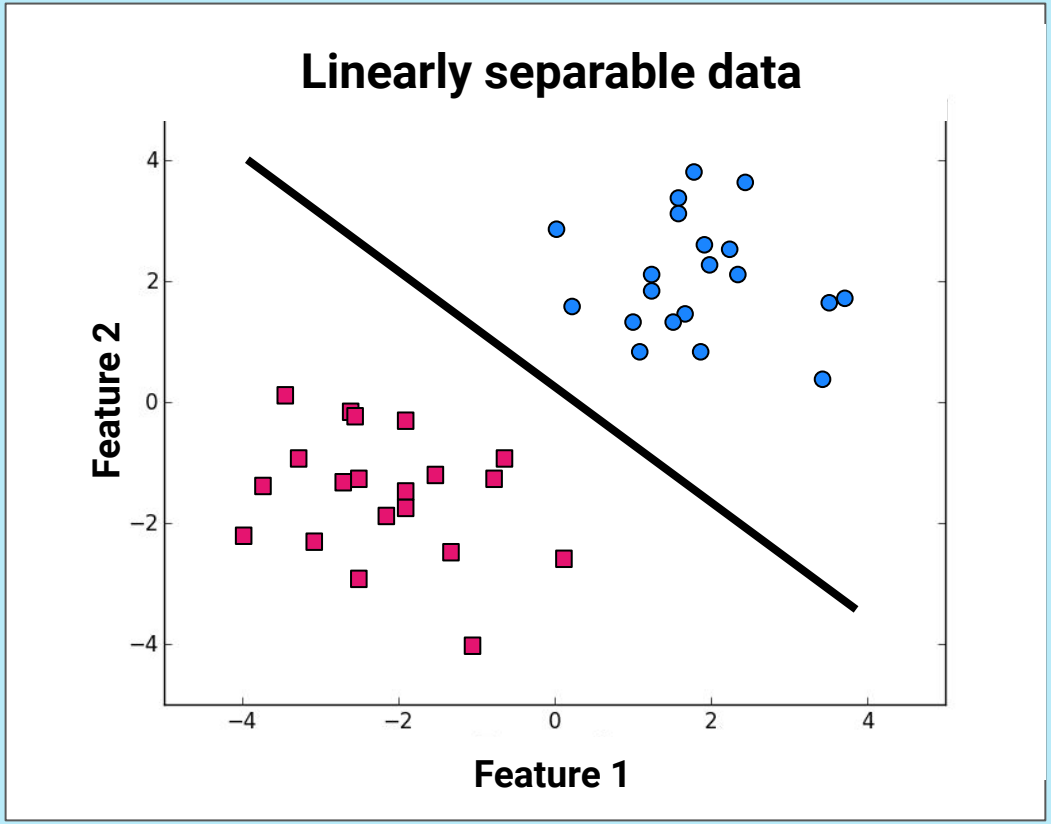


A wide variety of activation functions exist, and each has a specific purpose.

However, most neural networks will use one of the following activation functions.

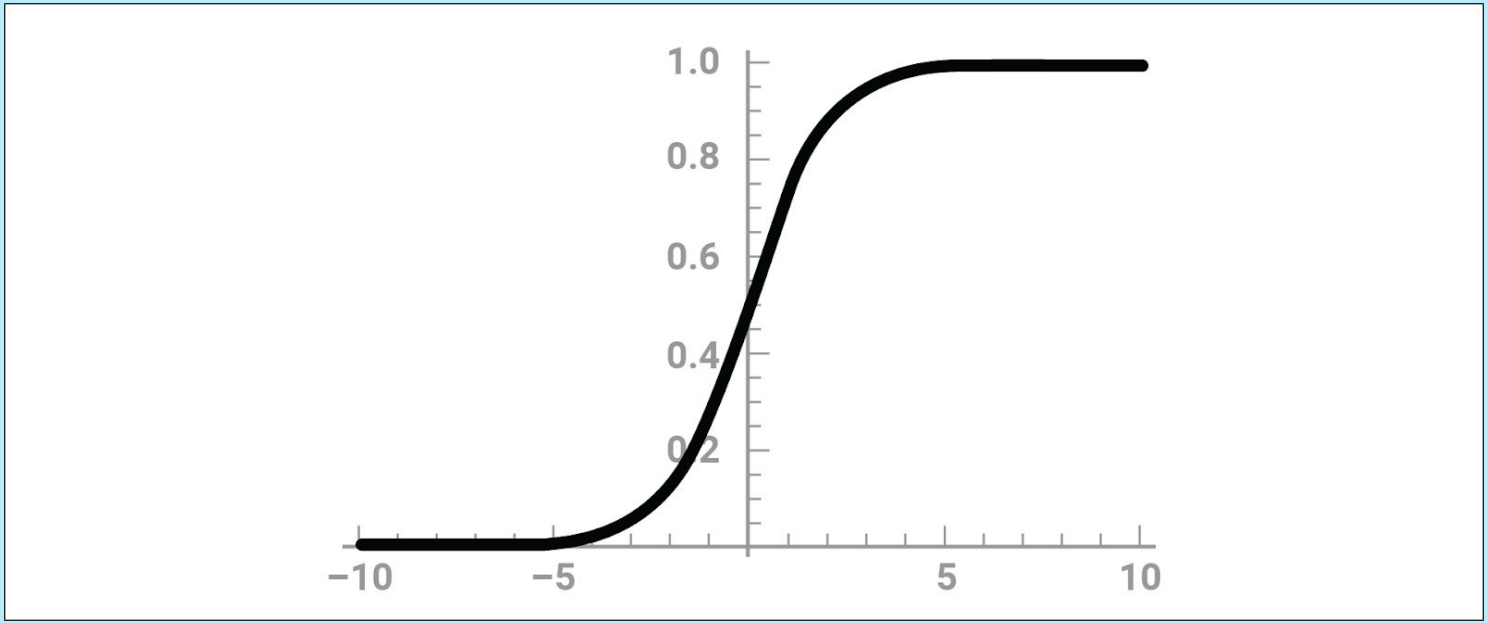
# Linear Function

The linear function returns the sum of the weighted inputs without transformation.



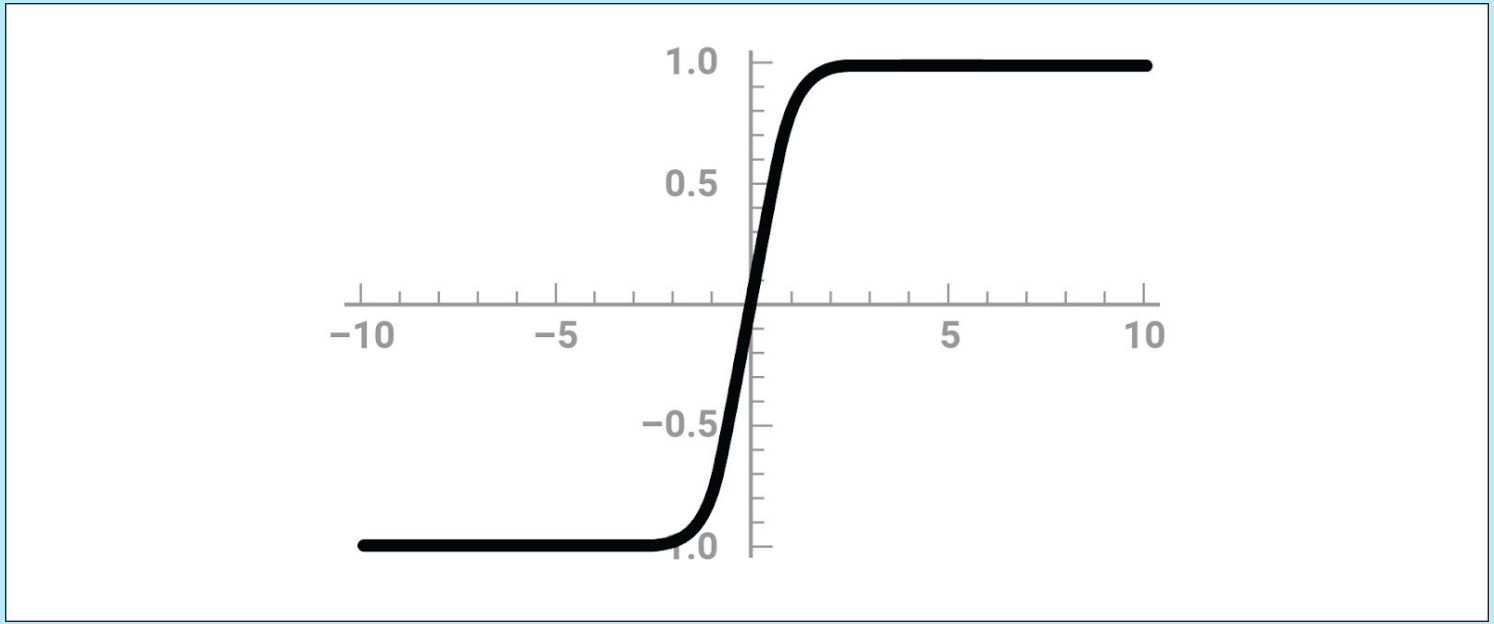
# Sigmoid Function

The sigmoid function transforms the neuron’s output to a range between 0 and 1, which is especially useful for predicting probabilities. A neural network that uses the sigmoid function will output a model with a characteristic S-curve.



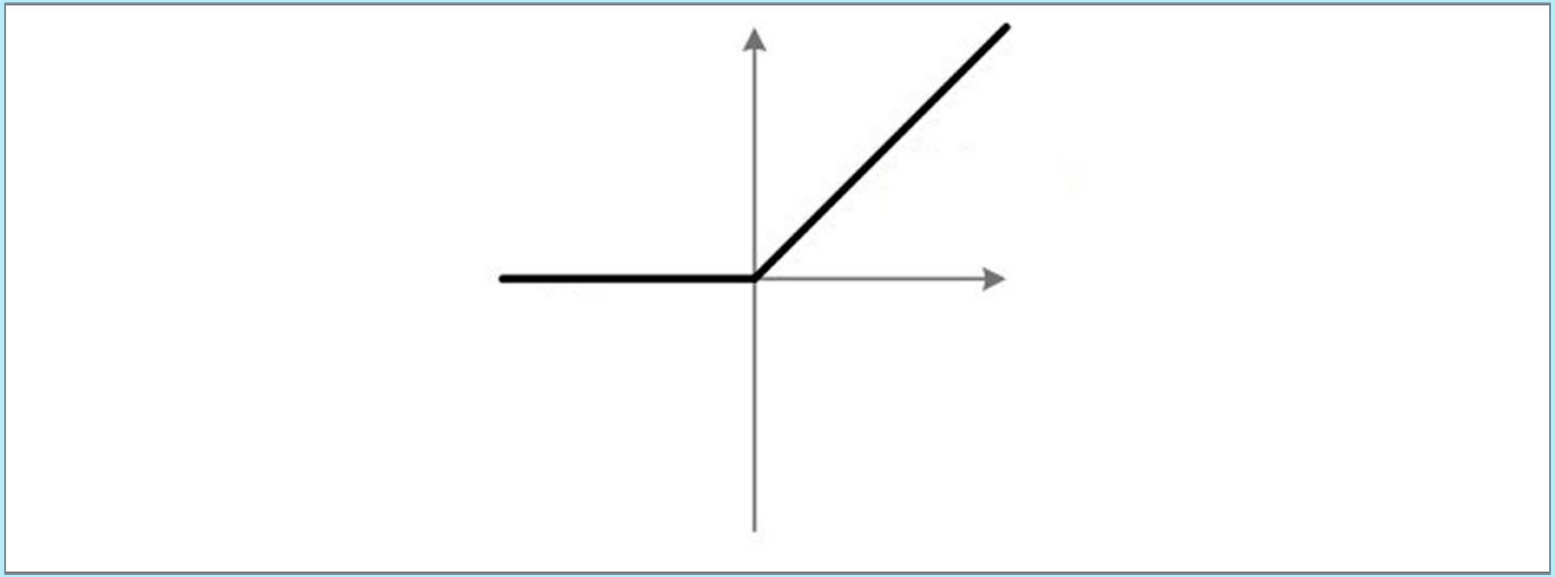
# Tanh Function

The tanh function transforms the output to a range between −1 and 1.
The output for a model using a tanh function also forms a characteristic S-curve.
It’s primary use is classifying data into one of two classes.



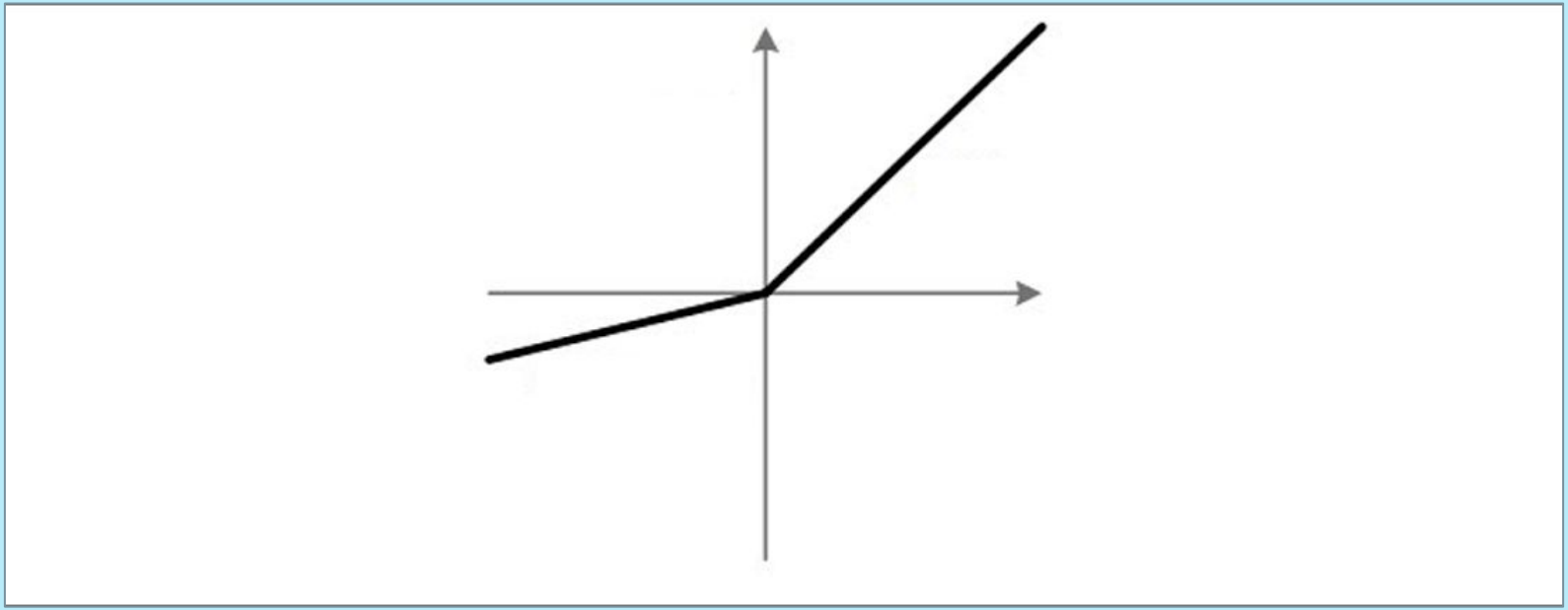
# Rectified Linear Unit (ReLU)

The rectified linear unit (ReLU) function returns a value from 0 to infinity. This activation function transforms any negative input to 0. It is the most commonly used activation function in neural networks due to its faster learning and simplified output. However, it is not always appropriate for simpler models.



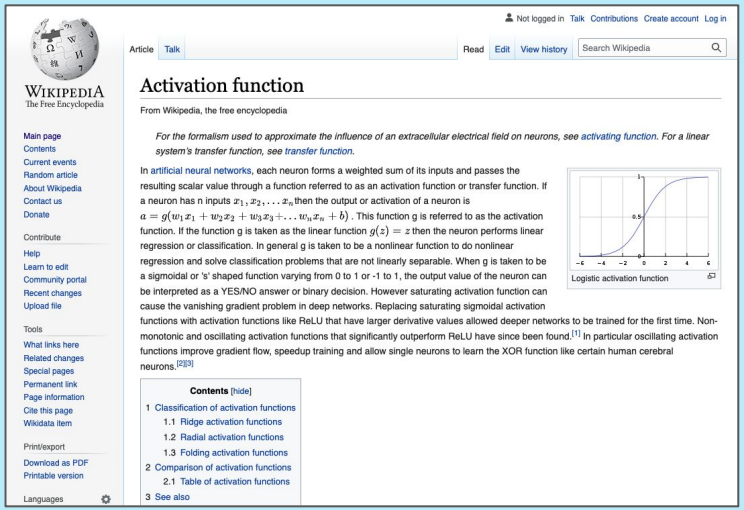
# Leaky ReLU Function

The leaky ReLU function is an alternative to the ReLU function, which can sometimes work better. Instead of transforming negative input values to 0, it transforms them into much smaller negative values.

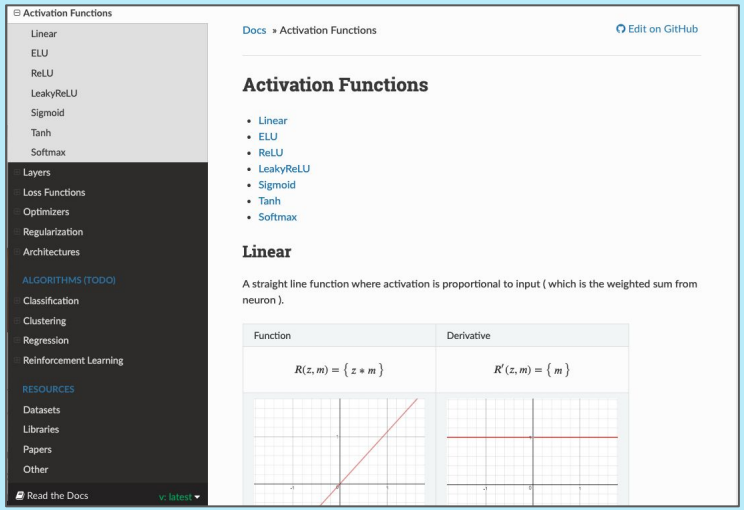


# Deep Dive

When designing a neural network, developers usually test different activation function combinations. You can learn more about the formulas and the mathematical fundamentals behind each function from:




[Wikipedia article]




[ML Glossary's Activation Function]

# Neural Networks Are Cool!

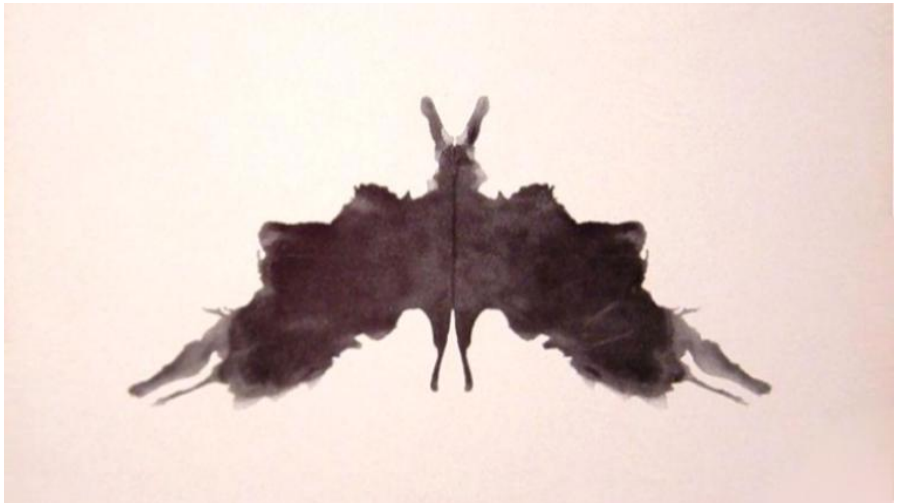
# Neural Networks

What do you see in this image?

Rorschach Blot

# Neural Networks

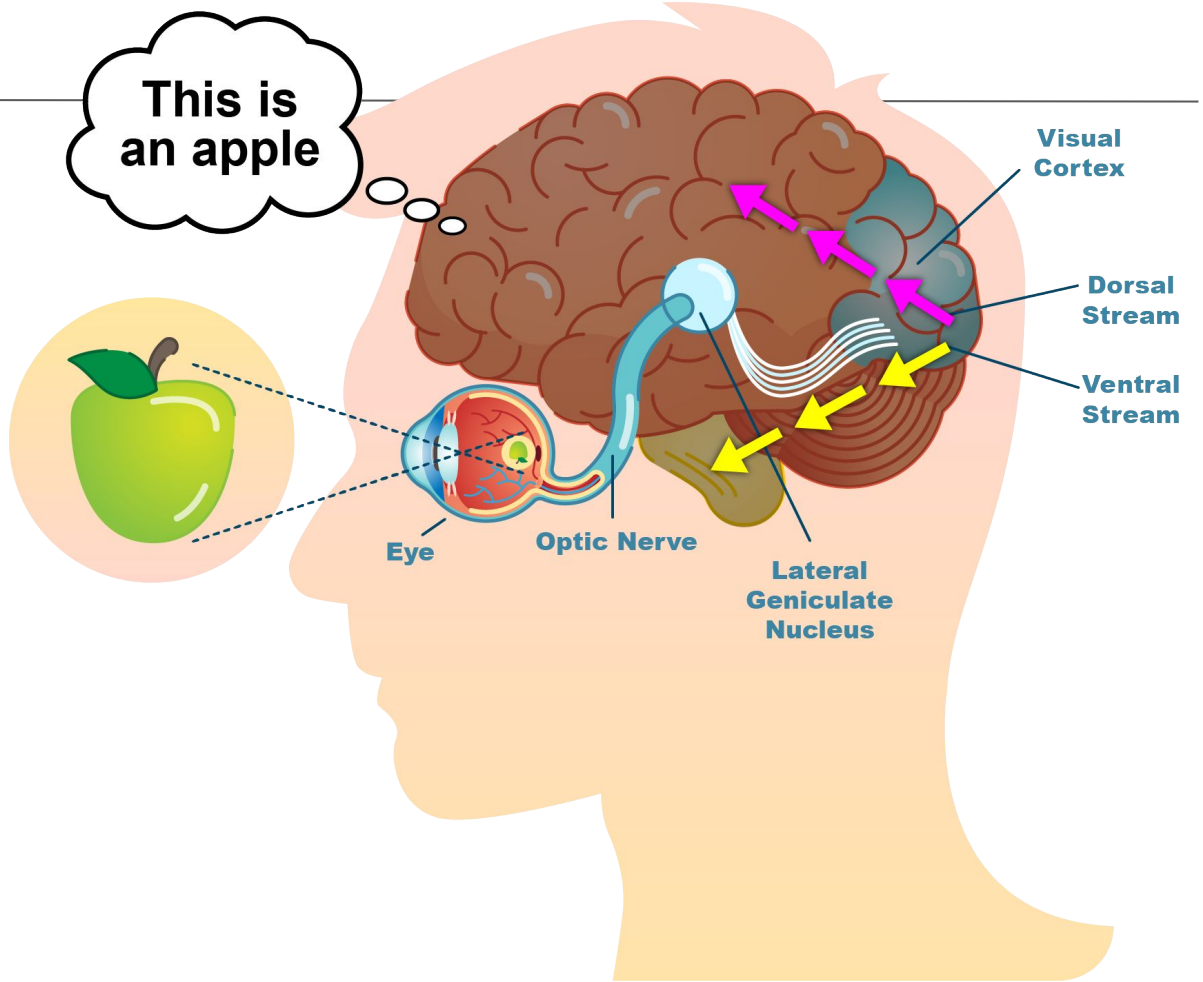
We can find similarities between this image and a real object because our brain uses thousands of neuron connections to find a match between the visual input and a mental representation of an object.



# Neural Networks

How our brain works:

In order to recognize an image, our brain uses thousands of neuron connections to find a match between the visual input and a mental representation of an object.

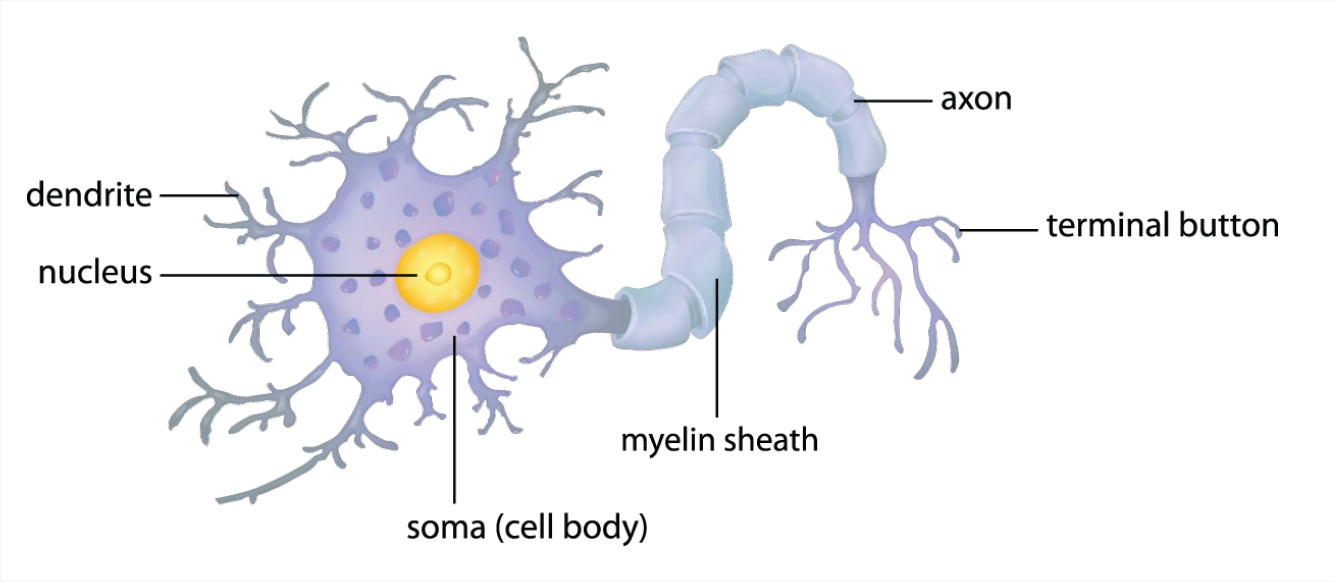


# Neural Networks

The ability of the brain to process information and make predictions or interpretations is what inspired neurophysiologists and mathematicians to start the development of artificial neural networks (ANN).

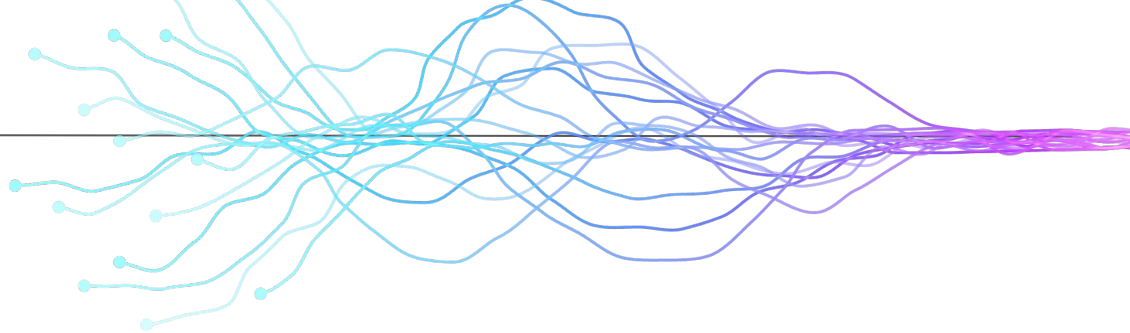
In the same way that biological neurons receive input signals through the dendrites, an ANN receives input variables and processes them by using an activation function.

The output of an ANN is similar to the neuron nucleus in the brain.



# Neural Networks

## The History of Neural Networks:



**1943**

Neurophysiologist **Warren McCulloch** and mathematician **Walter Pitts** wrote a paper on how neurons might work.

**1949**

**Donald Hebb** wrote *The Organization of Behavior*, which pointed out the fact that neural pathways are strengthened each time they are used.

**1959**

**Bernard Widrow** and **Marcian Hoff** of Stanford developed models called ADALINE and MADALINE.

**1962**

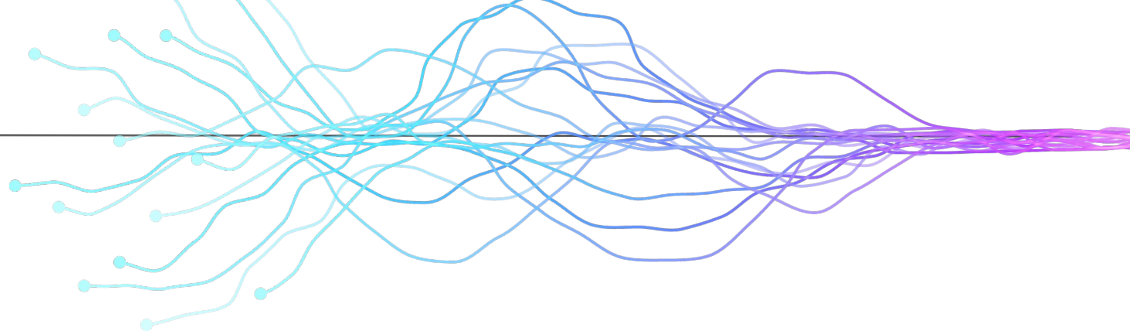
**Widrow** and **Hoff** developed a learning procedure that examines the value before the weight adjusts it (i.e., 0 or 1) according to the rule: Weight Change = (Pre-Weight line value).

**1972**

**Teuvo Kohonen** and **James A. Anderson** each developed a similar network independently of one another. They both used matrix mathematics to describe their ideas but did not realize that what they were doing was creating an array of analog ADALINE circuits.

(Source)

# Neural Networks



## The History of Neural Networks:
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### 1982

**John Hopfield** of Caltech presented a paper to the National Academy of Sciences. His approach was to create more useful machines by using bidirectional lines. Previously, the connections between neurons was only one way.

### 1982

Joint US-Japan conference on **Cooperative/ Competitive Neural Networks**. Japan announced a new Fifth Generation effort on neural networks, and US papers generated worry that the US could be left behind in the field.

### 1986

Three independent groups of researchers, including **David Rumelhart**, a former member of Stanford's psychology department, came up with similar ideas which are now called back propagation networks.

### 1997

A recurrent neural network framework, LSTM was proposed by **Jürgen Schmidhuber** and **Sepp Hochreiter**.

### Now

Neural networks discussions are prevalent; the future is here!

**Examples:**
self driving cars, algorithmic trading, robo advisors, customized marketing offers.

(Source 1; Source 2)

# Applications of Neural Nets

Neural networks are here to stay, and their applications become more common every day.

# Applications of Neural Nets

Companies like Google and Tesla are using neural networks to develop self-driving cars.

WAYMO

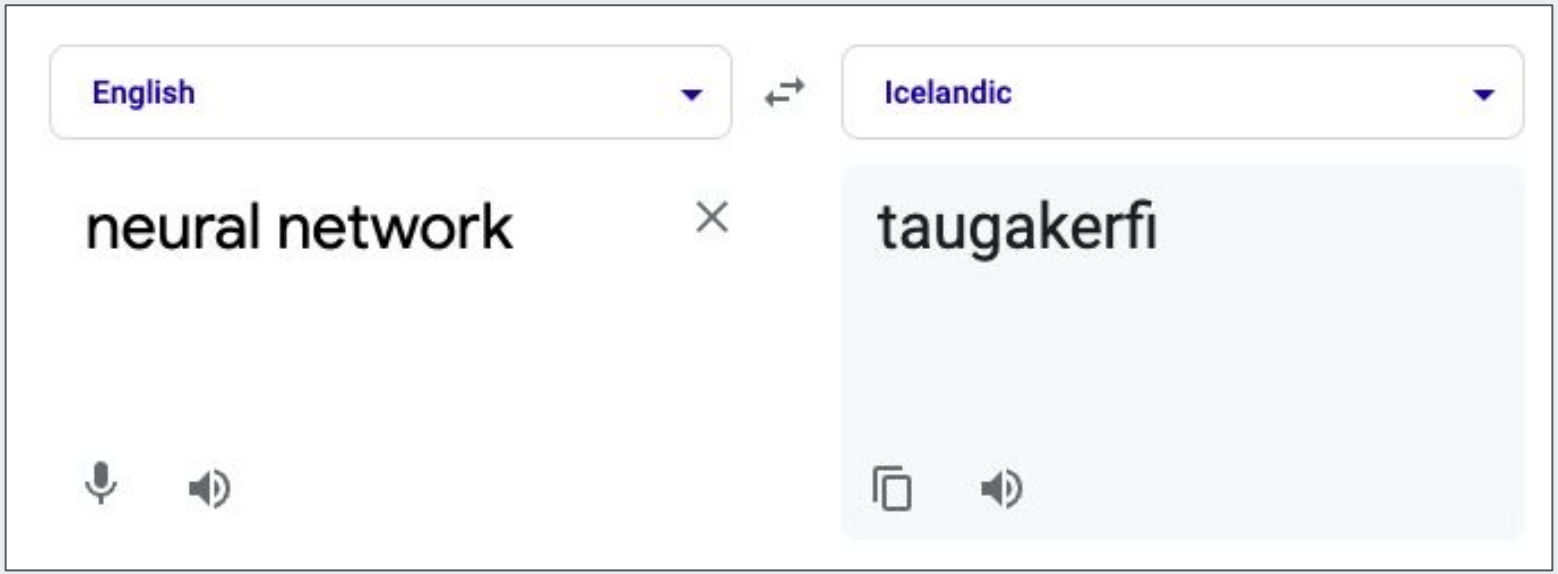
TESLA

https://waymo.com/

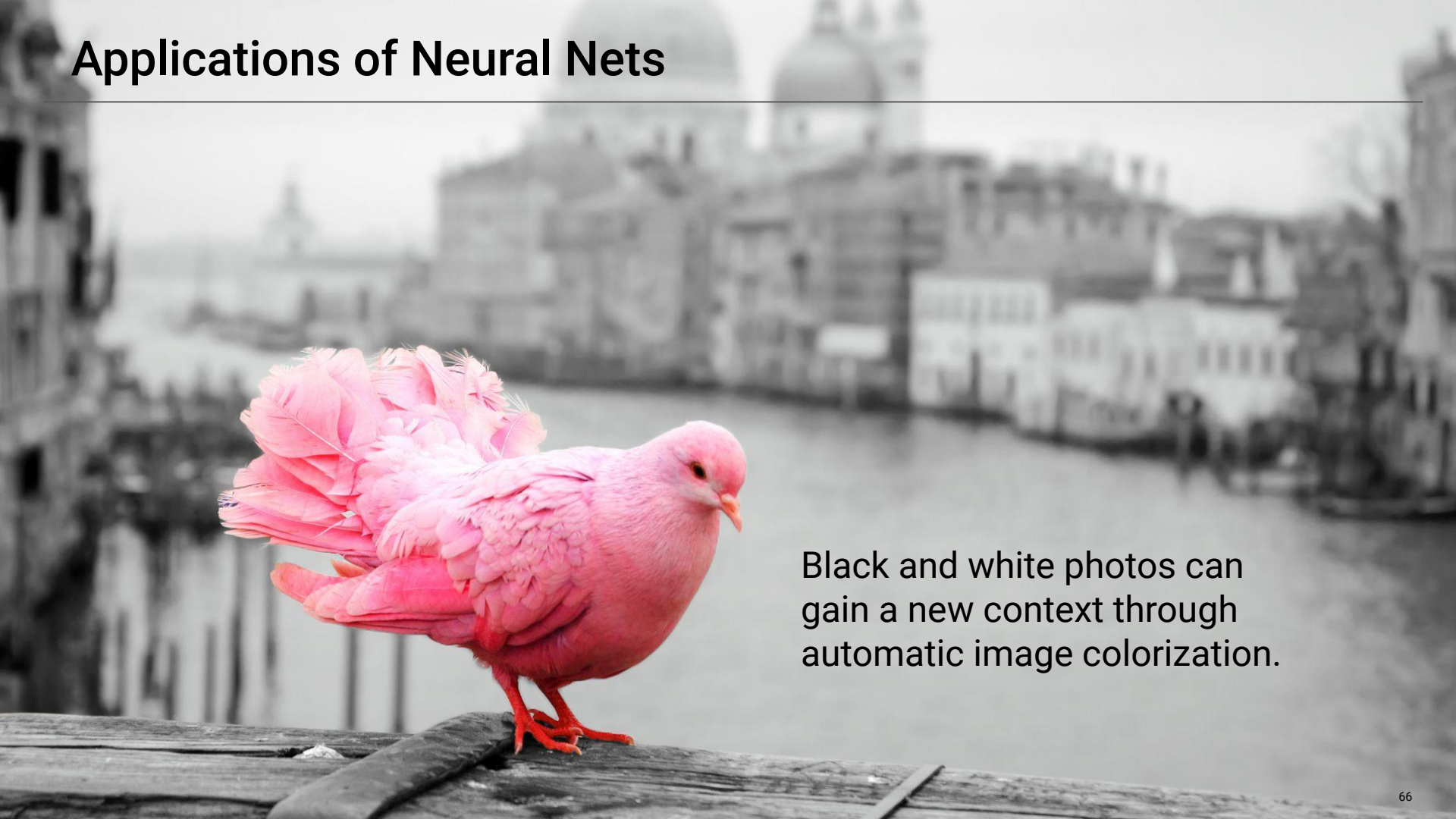
https://www.tesla.com/

# Applications of Neural Nets

The power of neural networks allows you to communicate in any language thanks to automated tools that can perform real-time translation (Google Translate, Skype, etc.).



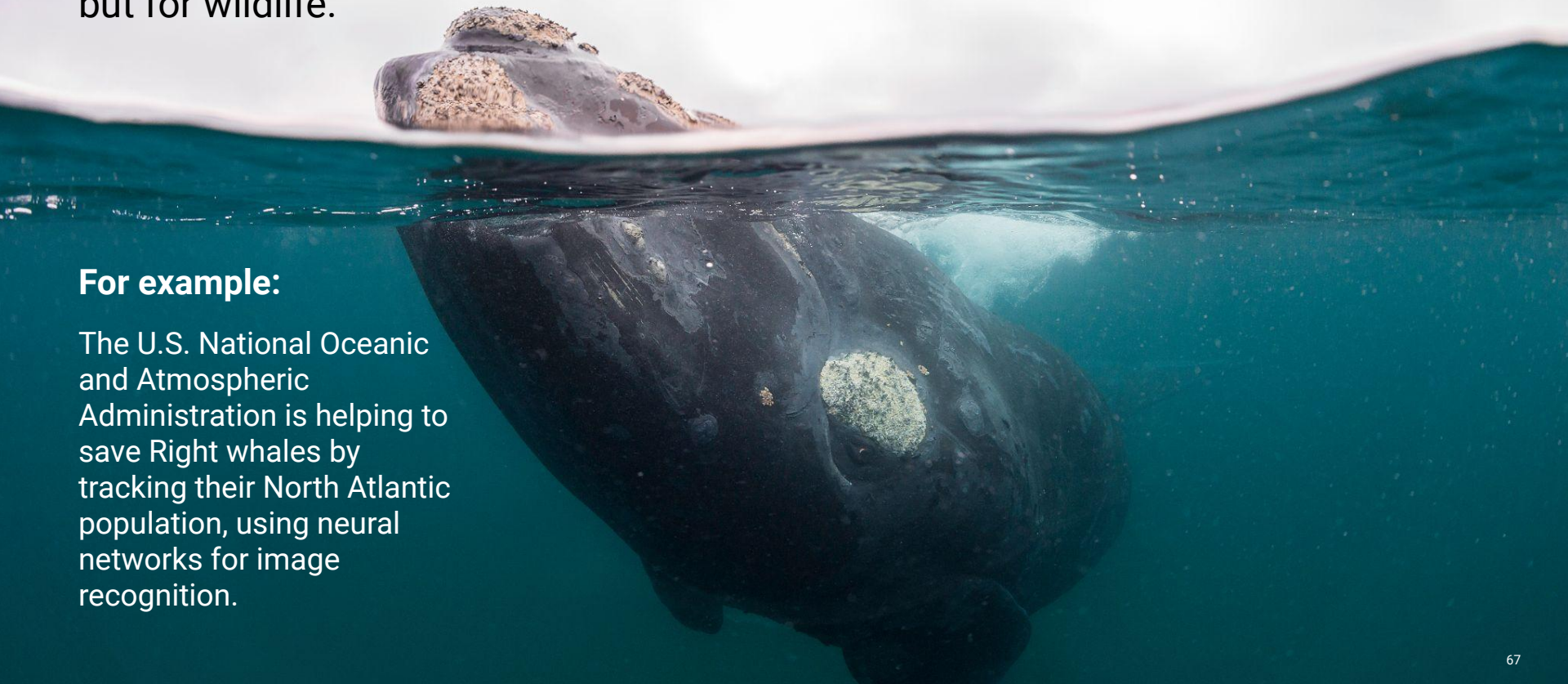
# Applications of Neural Nets



Black and white photos can gain a new context through automatic image colorization.

# Applications of Neural Nets

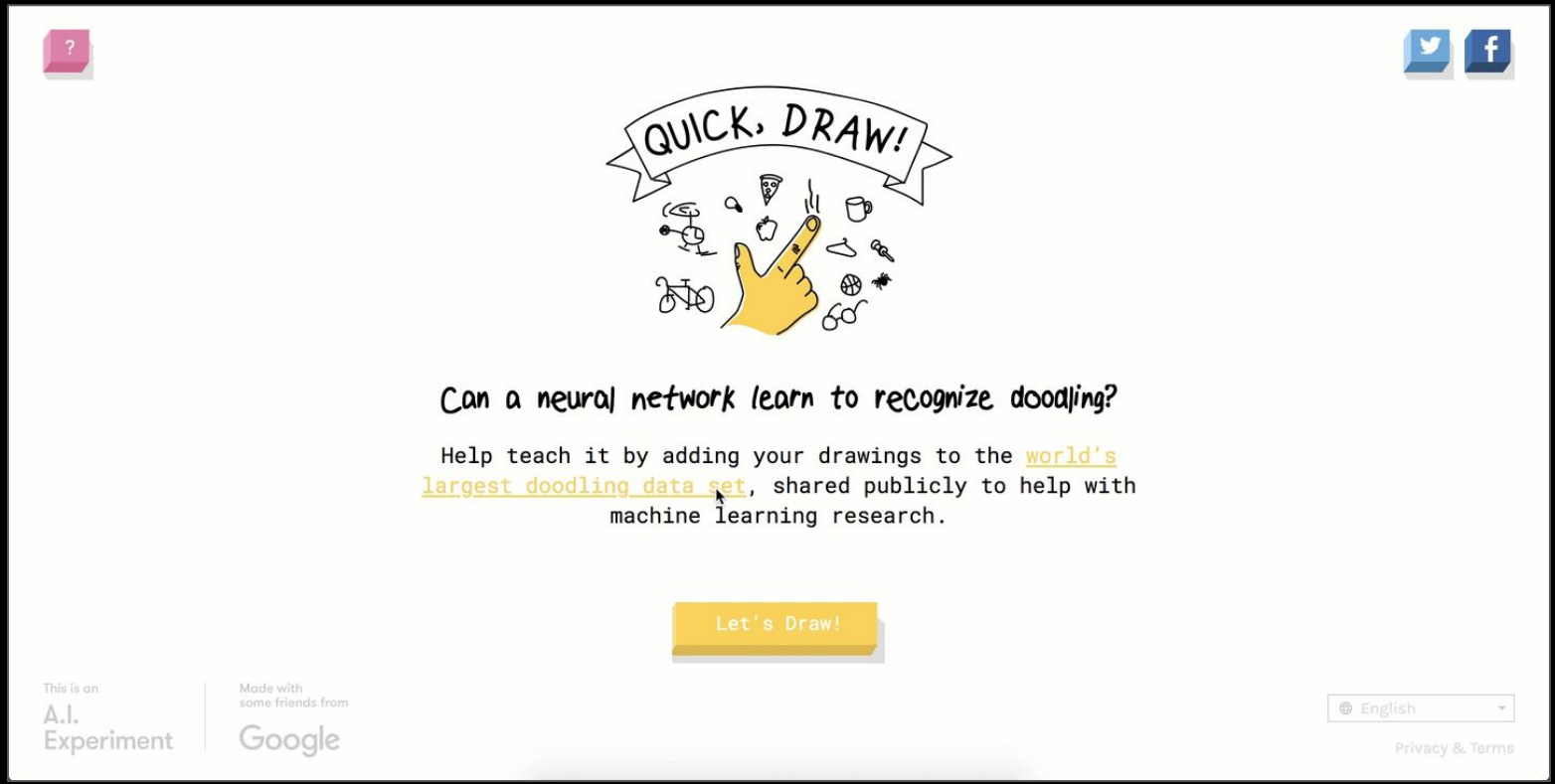
Neural networks are also used to help create a better world, not only for humans but for wildlife.



**For example:**

The U.S. National Oceanic and Atmospheric Administration is helping to save Right whales by tracking their North Atlantic population, using neural networks for image recognition.

# Let’s play a short game powered by neural networks to illustrate how clever such models can be.




https://quickdraw.withgoogle.com/

Let’s visit the [Google AI Experiments website] and select an experiment to try.

# Questions?

# Creating a Neural Network

# Creating a Neural Network

There are two ways to code a neuron:

01 The hard way (code from scratch)

You can do all the math and code it from scratch using Python, Pandas, and NumPy.



02 The easy way (API or framework)

You can use an industry-standard API or framework to speed up your implementation and focus your efforts on improving your model.

This allows you to spend more time learning about the business problem you want to solve.

# Creating a Neural Network

We are going to use TensorFlow and Keras to build our neural networks.

## TensorFlow

TensorFlow is an open-source platform for machine learning that allows us to run our code across multiple platforms in a highly efficient way.

## Keras

Keras is an abstraction layer on top of TensorFlow that makes it easier to build models. You can relate this to using Plotly Express to create charts instead of using the more verbose Matplotlib library.

# Creating a Neural Network

## Why TensorFlow?

- Machine learning library
- Used to build neural networks
- Runs on multiple platforms
- Supports distributed computing
- Allows detailed fine-tuning

# Creating a Neural Network


Why Keras?

- An API designed for human beings
- Runs on top of TensorFlow, CNTK, or Theano
- Facilitates to turn models into products
- Has broad adoption in the industry and the research community

# Keras + TensorFlow

Keras allows interaction with TensorFlow through a simplified interface
Model → Fit → Predict (with a few other steps)

```
from keras.models import Sequential

model = Sequential()
```

```
# x_train and y_train are Numpy arrays, just like in the Scikit-Learn API.
model.fit(x_train, y_train, epochs=5, batch_size=32)
```

```
classes = model.predict(x_test, batch_size=128)
```

# Keras + TensorFlow

There are two types of models in Keras.

01 Sequential model

The **sequential** model is a linear stack of layers in which data flows from one layer to the next.

02 Functional model

The functional `model` class allows us to create sophisticated and more customizable models.

**We'll use the `sequential` model with the `Dense` class to add layers to the neural network.**

# Instructor Demonstration

## Creating a Neural Network in Keras

# Questions?

# Activity: Preventing Credit Card Defaults, Part 1

In this activity, you will use Keras and several features (variables) to build a neural network model that predicts whether a credit card customer will default on their debt.

Suggested Time:

20 minutes

# Time’s Up! Let’s Review.

# Questions?


Countdown timer

15:00

(with alarm)

# Building, Fitting, and Predicting a Neural Network Model

Defining the neural network's structure is like designing blueprints for a house, and compiling the model is like building the house.

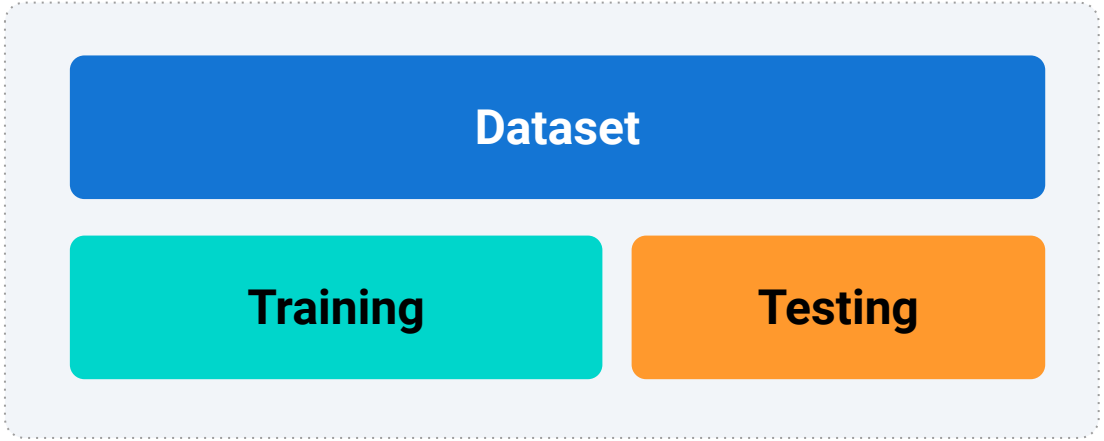
To compile and fit a model, we need to specify loss and optimization functions.

# Building, Fitting, and Predicting a Neural Network Model

When we train our neural network model on a dataset, we pass our training dataset through the model multiple times.

The loss function allows us to observe how the model's performance changes over each iteration.

We can then determine when the model reaches maximum performance (after a specific number of iterations).



# How a Neural Network Optimizes

# Building, Fitting, and Predicting a Neural Network Model

When we fit the model, we also want to keep track of two evaluation metrics:

## Accuracy

- We use model predictive accuracy (`accuracy`) for classification models that are designed to answer “whether or not” questions.
- A higher accuracy value indicates more accurate predictions, and the highest possible accuracy value is 1.
- We would use a classification model to predict if a borrower is likely to default on a loan.

## Mean squared error (MSE)

- We use MSE (`mse`) for regression models in which we're trying to predict some continuous outcome, like the percentage stock return for the next day.
- As the MSE gets closer to 0, the model’s predictions become increasingly accurate.

# Mean Squared Error (MSE)

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$

$\mathrm{MSE}$ = mean squared error

$Y_i$ = observed values

$n$ = number of data points

$\hat{Y}_i$ = predicted values

# Instructor Demonstration

## Building, Fitting, and Predicting a Neural Network Model

# Questions?

# Instructor Demonstration

## Review Preventing Credit Card Defaults, Part 2 Solutions

# Questions?

# Activity: Preventing Credit Card Defaults, Part 2

In this activity, you will continue working on the neural network model you created in the previous activity. You'll compile, fit, and evaluate a model that predicts credit card defaults.

Suggested Time:

20 minutes

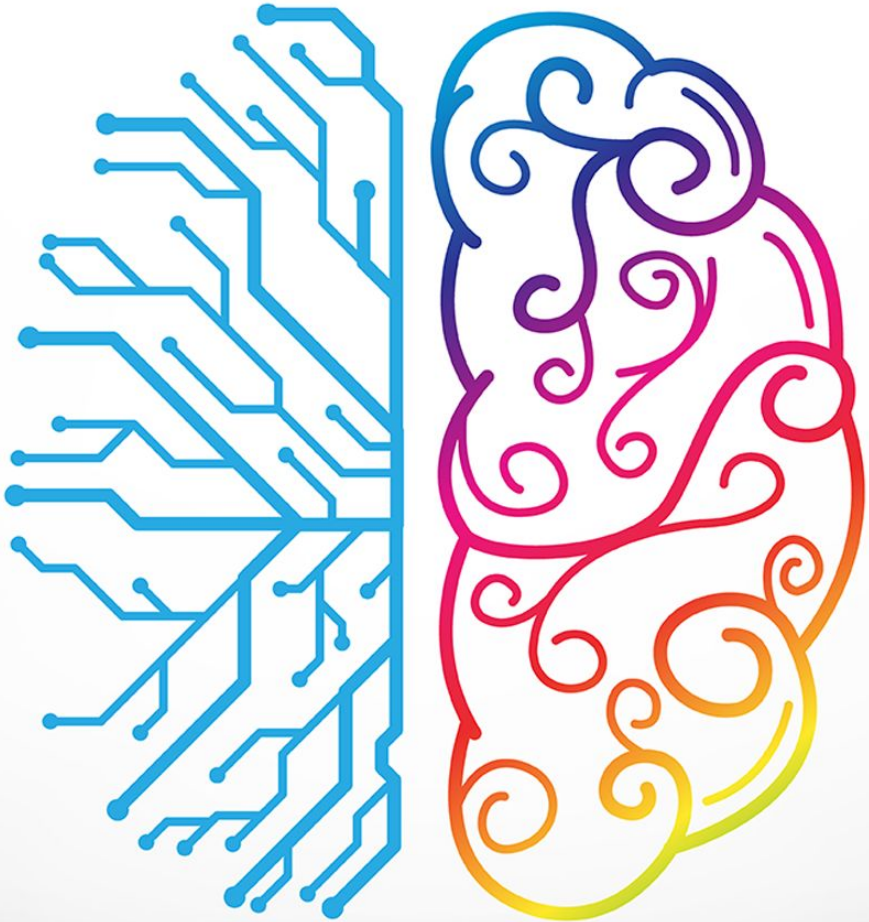
# Time's Up! Let's Review.

# Questions?


Recap

Modeling neural networks
is part art and part science.

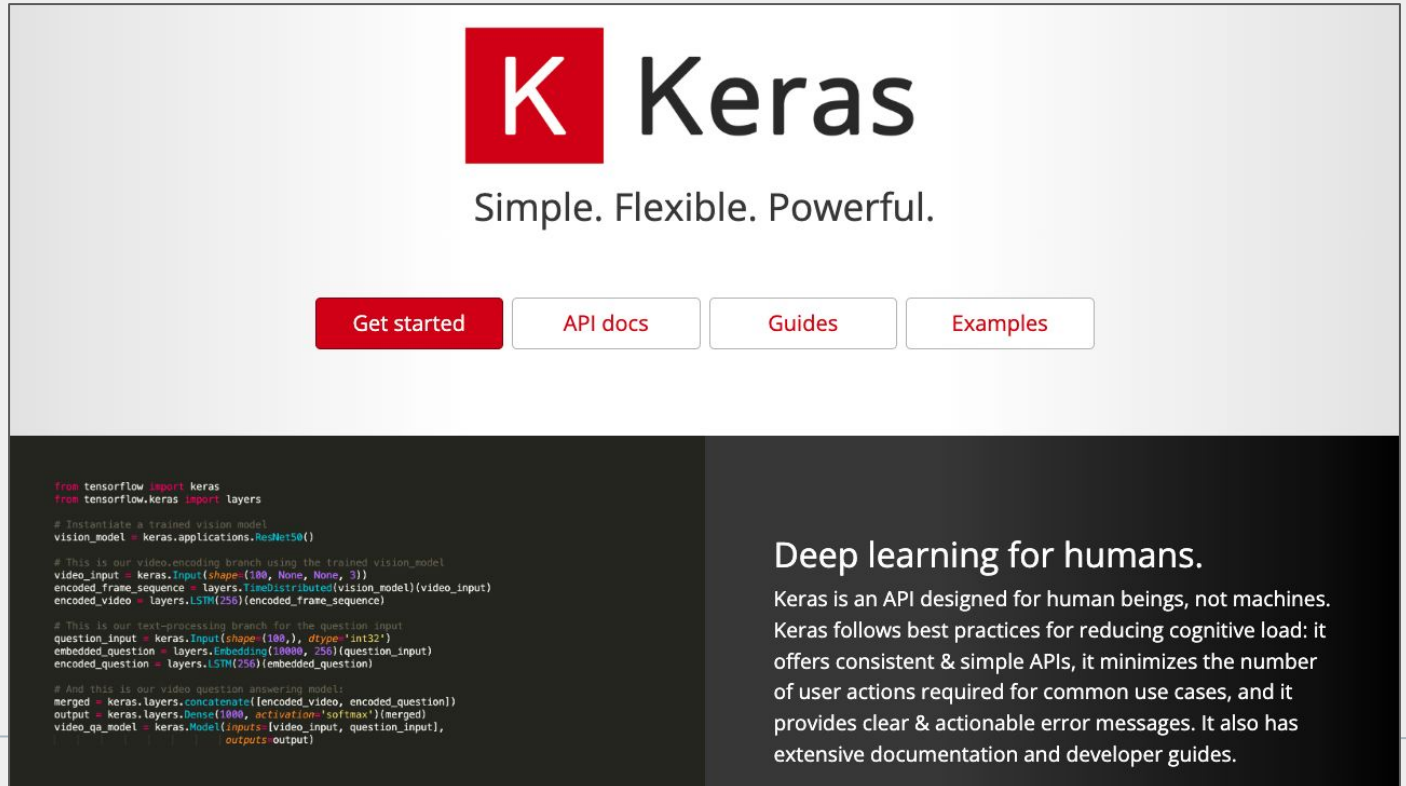
Be patient while defining models.



There are several frameworks
for implementing neural networks.

# Recap

Keras is a business-class framework that you can use for prototyping or deploying production models.

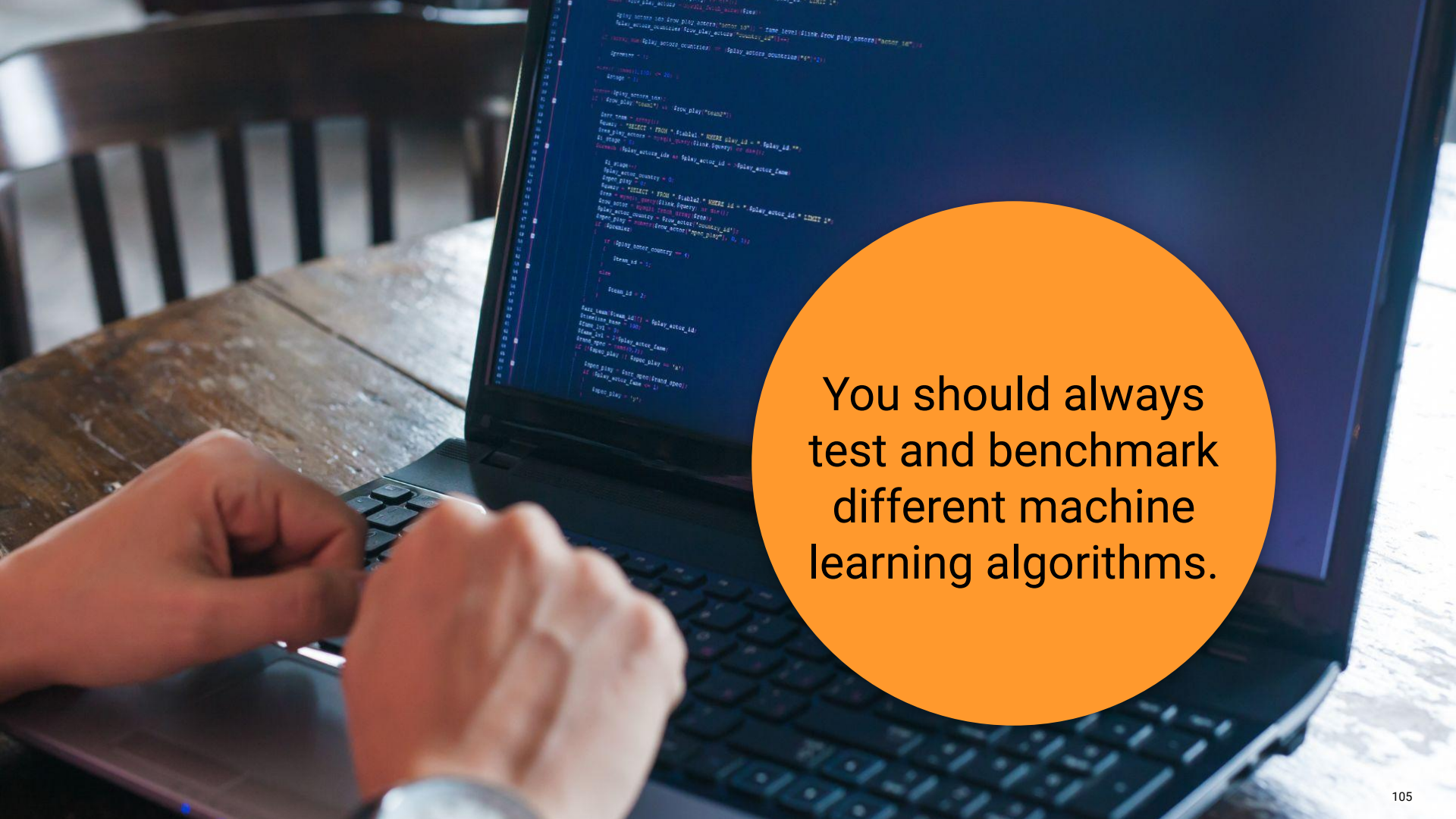



https://keras.io/

# Mastering neural networks takes time.

Thanks to frameworks like Keras, you don’t need a PhD to start using neural networks to solve real-world problems.

Neural networks are not a
universal best solution.


You should always test and benchmark different machine learning algorithms.

Congratulations! You've learned new skills that will add value to your professional portfolio.

# Questions?


The End