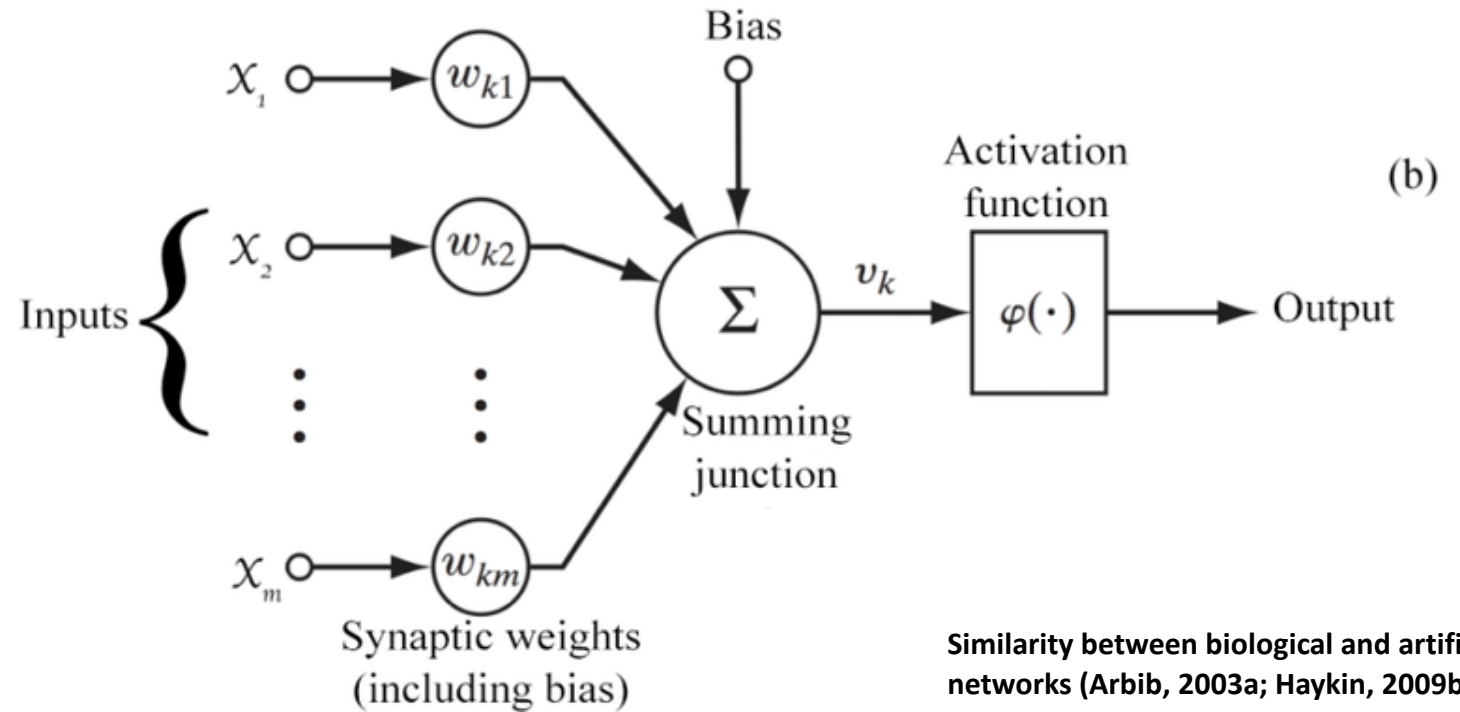
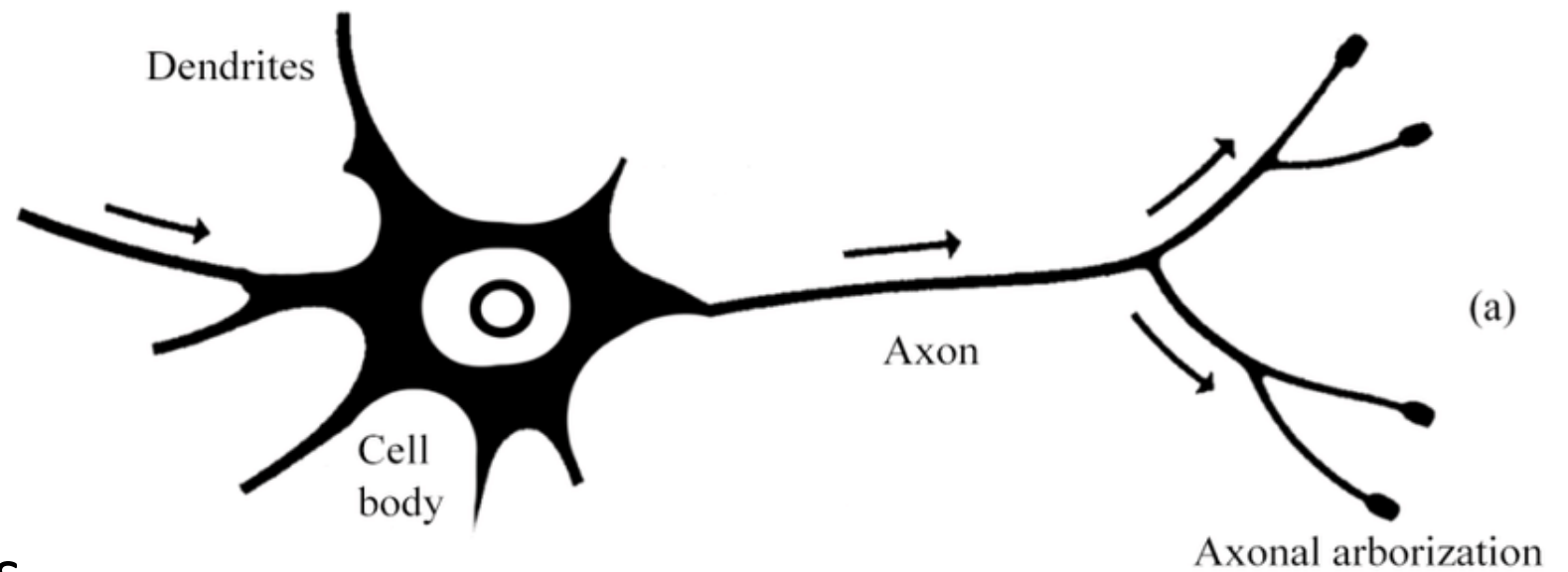


# Introduction to Neural Networks

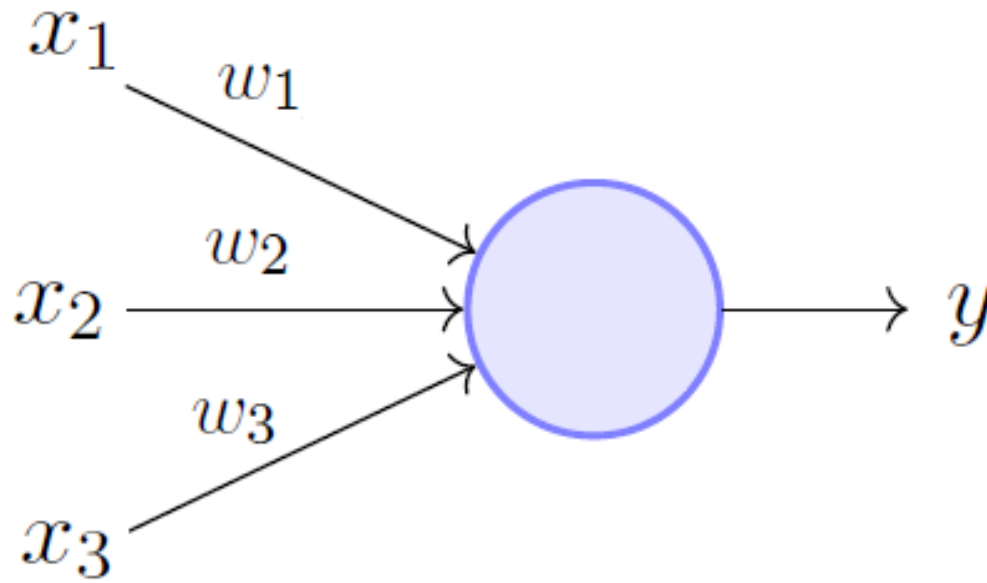
Garrett M. Dancik, PhD

- Artificial neural networks (ANNs) are inspired by biological neural networks
- A neuron receives inputs, and *fires* if its inputs exceed a threshold



Similarity between biological and artificial neural networks (Arbib, 2003a; Haykin, 2009b).

# Perceptron

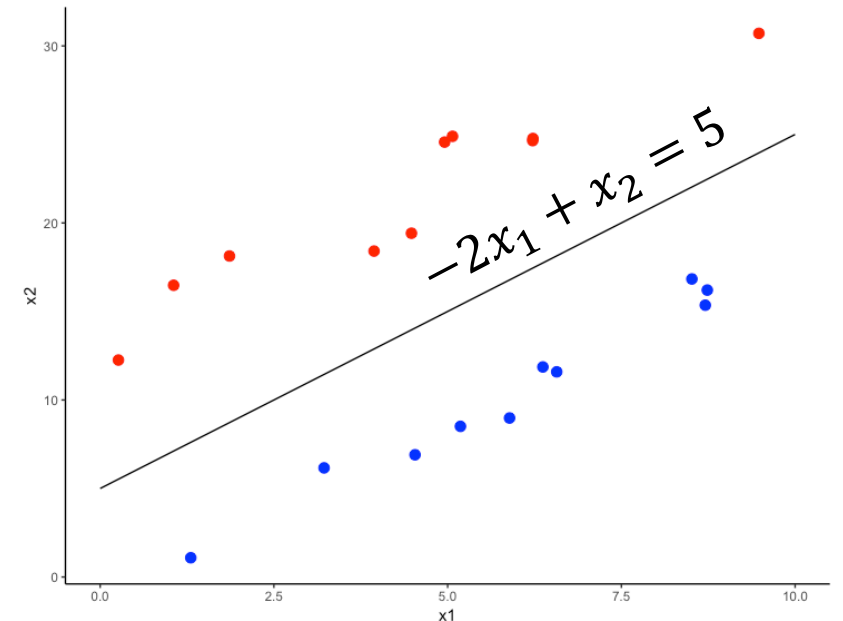
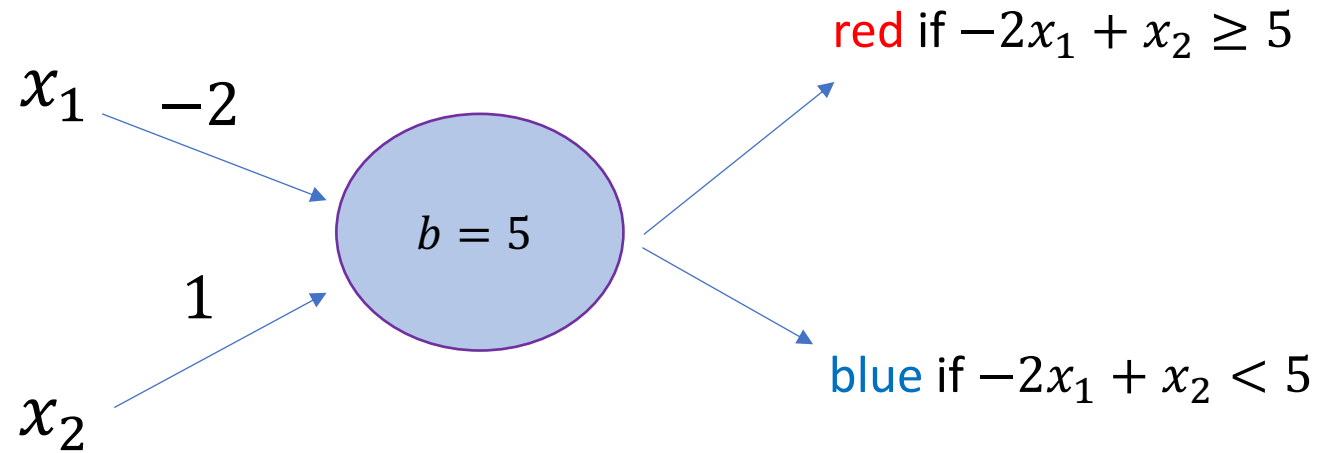


$$\begin{cases} 0 & \text{if } \sum w_i x_i < b \\ 1 & \text{if } \sum w_i x_i \geq b \end{cases}$$

$$\sum w_i x_i = w_1 x_1 + w_2 x_2 + w_3 x_3$$

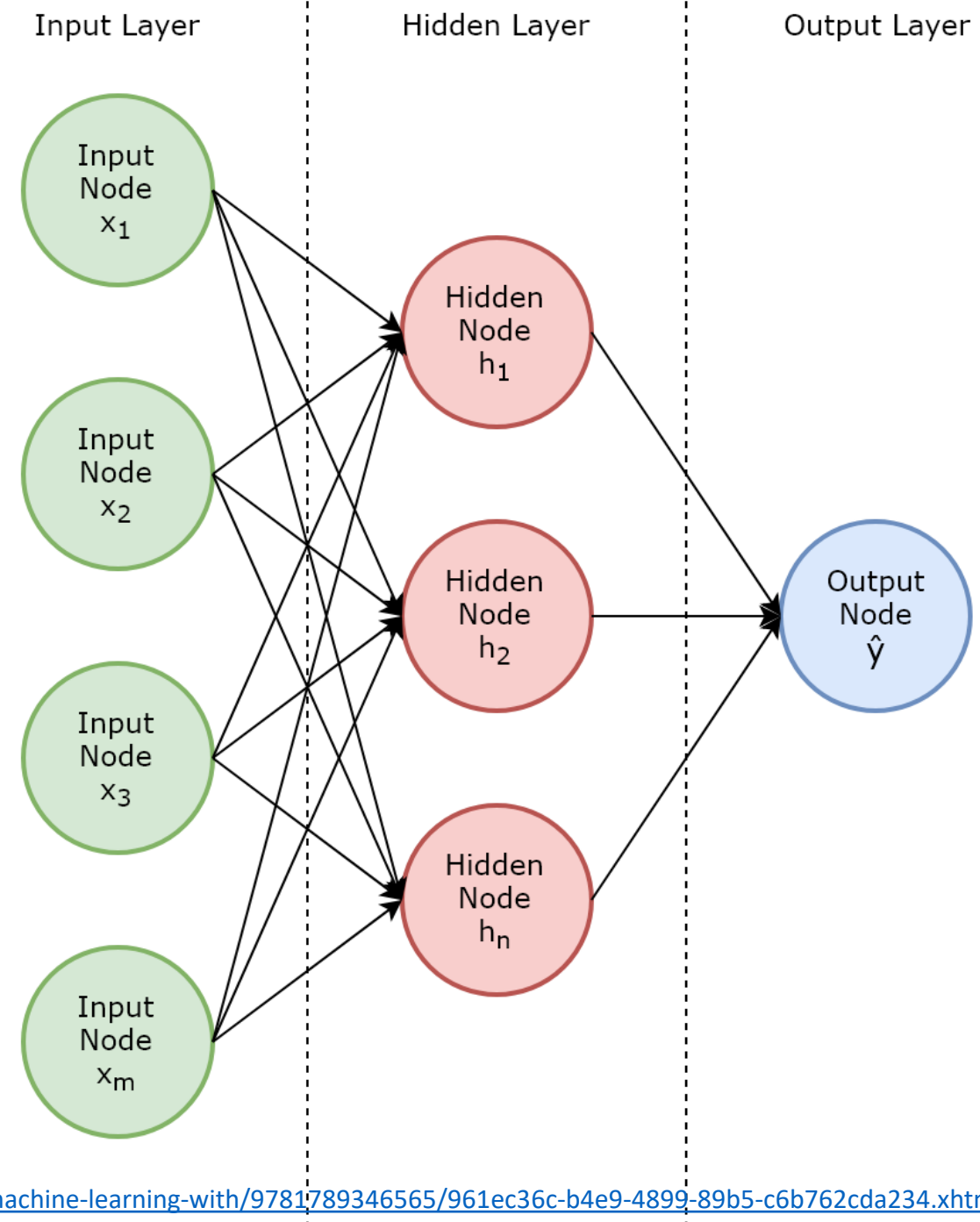
A perceptron consists of a single neuron that "fires" if the sum of its weighted inputs exceeds a threshold (i.e., the bias term,  $b$ )

# A single perceptron is a linear classifier



# Multilayer perceptron

- Consists of an input layer, 1 or more hidden layers, and an output layer
- Is fully connected: each node in a layer connects to all nodes in the next layer
- Each hidden node uses a non-linear activation function that outputs a value between 0 and 1 (rather than either a 0 or 1)
- Can learn non-linear relationships
- Is a type of feedforward artificial neural network (the signal only moves forward)



# Training neural networks

- The weights and bias terms are updated during the training process in order to optimize a loss (or cost) function, which measures the performance of the fitted model (the goal is to minimize the loss)
- For classification, *cross entropy loss* is used.
- An *epoch* refers to one forward pass of each training sample in a *batch*, and one backward pass (to update the weights and bias terms)
- General overview: [https://www.youtube.com/watch?v=sZAlS3\\_dnk0](https://www.youtube.com/watch?v=sZAlS3_dnk0)