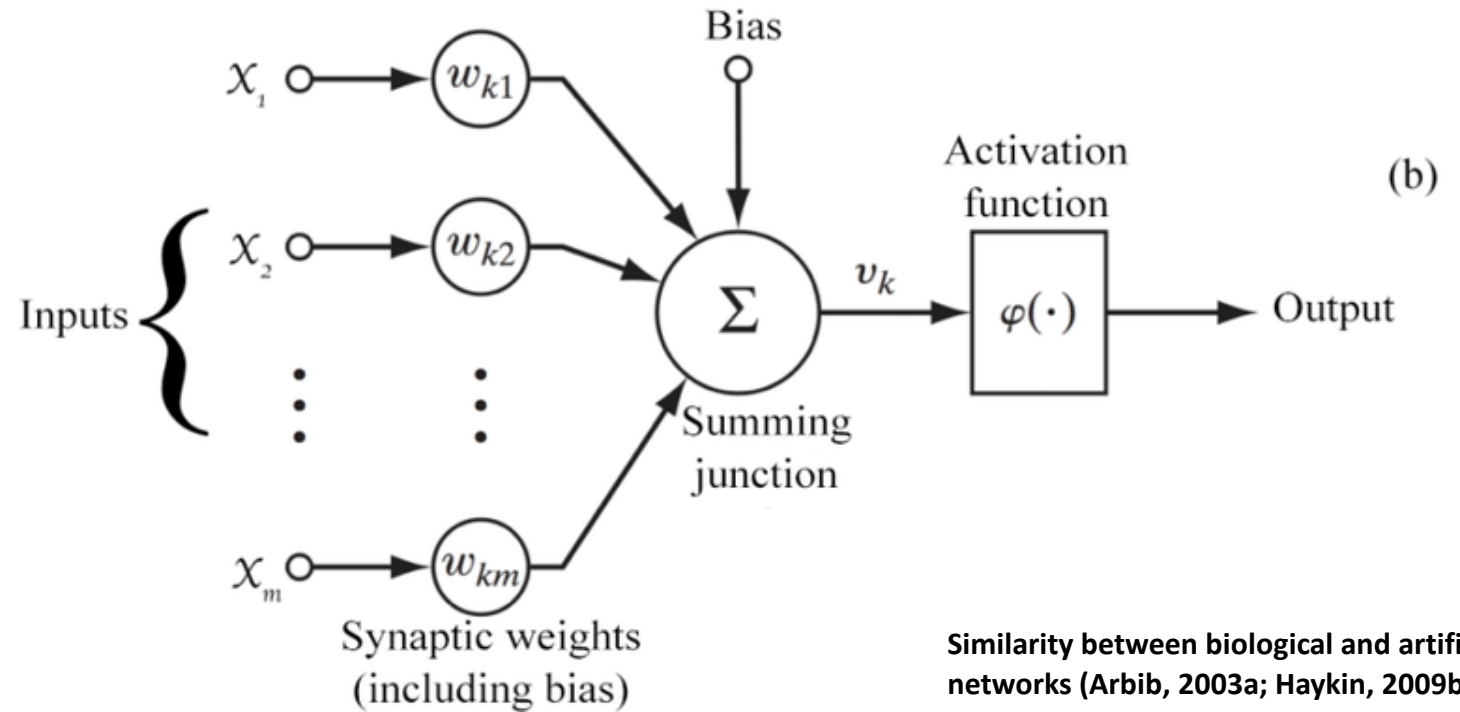
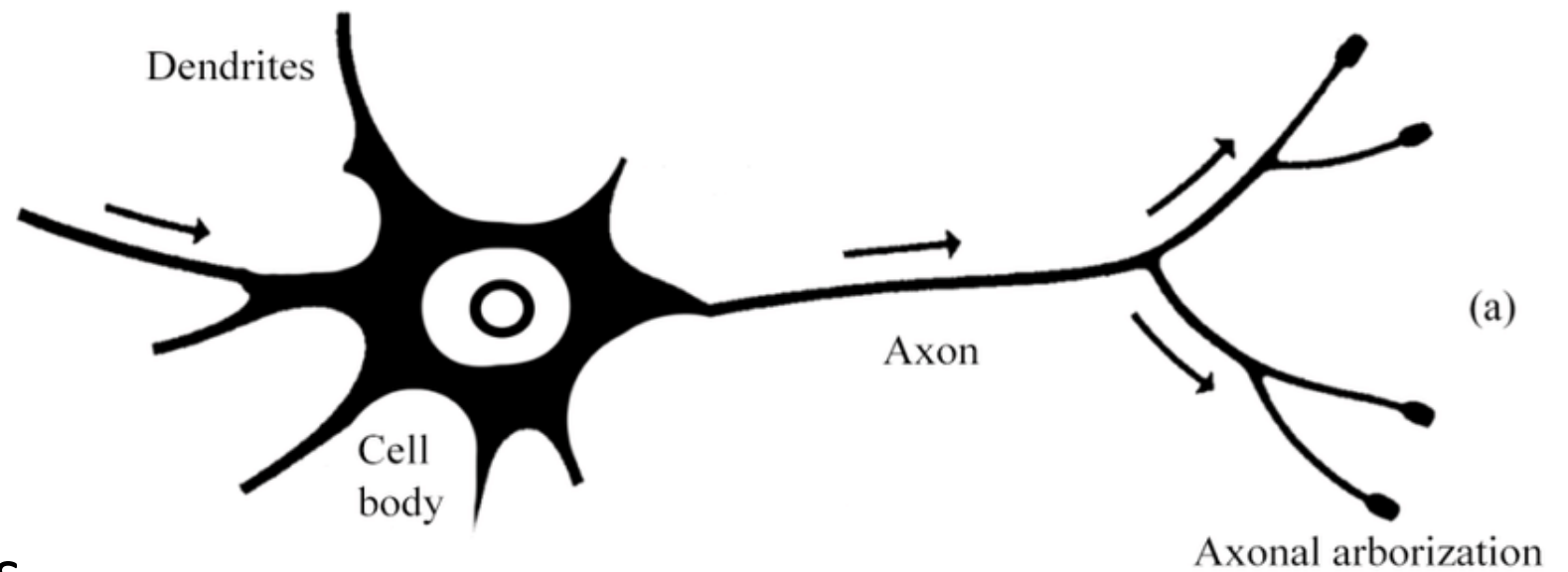


Introduction to Neural Networks

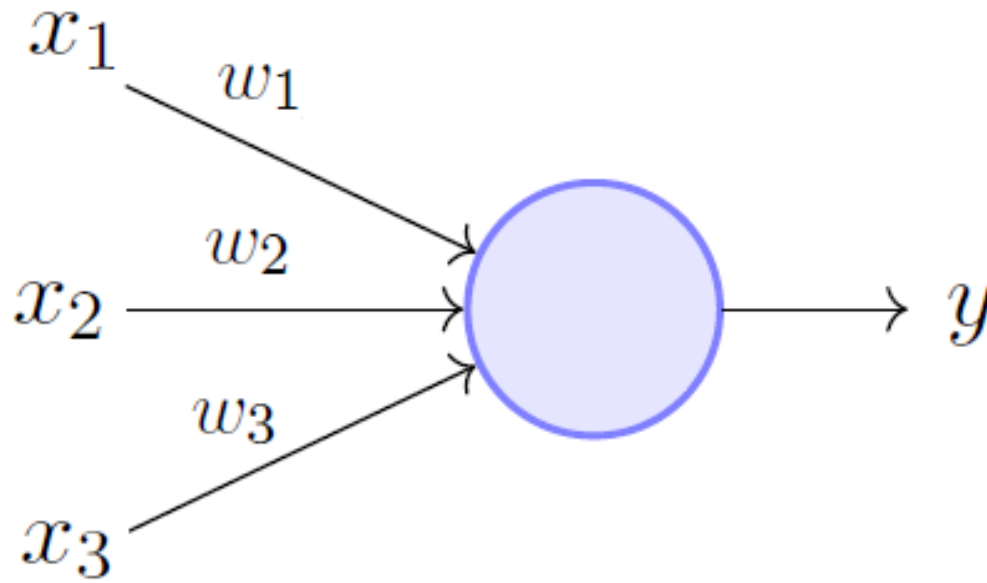
Garrett M. Dancik, PhD

- 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



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

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

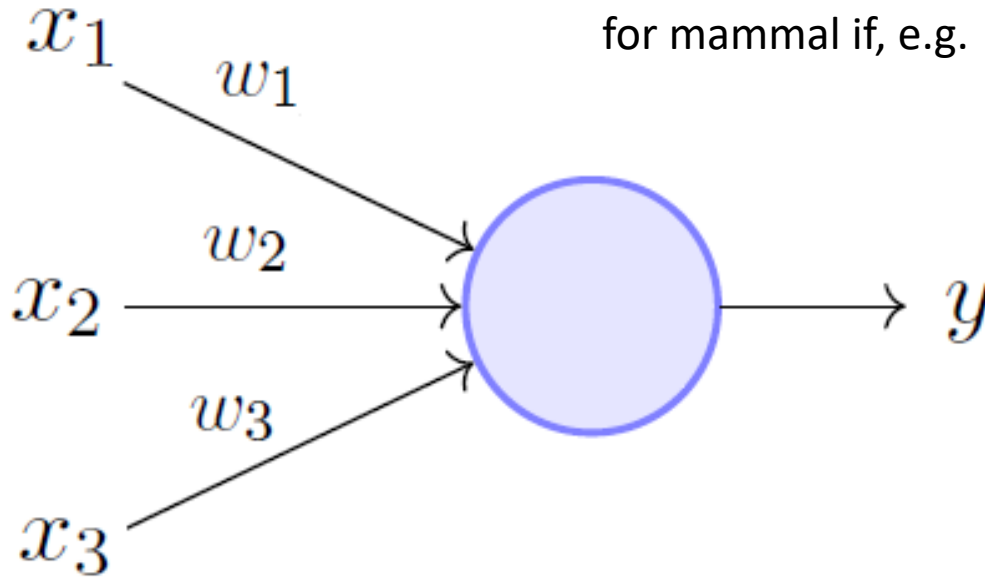
A perceptron consists of a single neuron that "fires" if the sum of its weighted inputs exceeds a threshold (i.e., the bias term, b)

Perceptron

Warm-blooded
(Y = 1, N = 0)

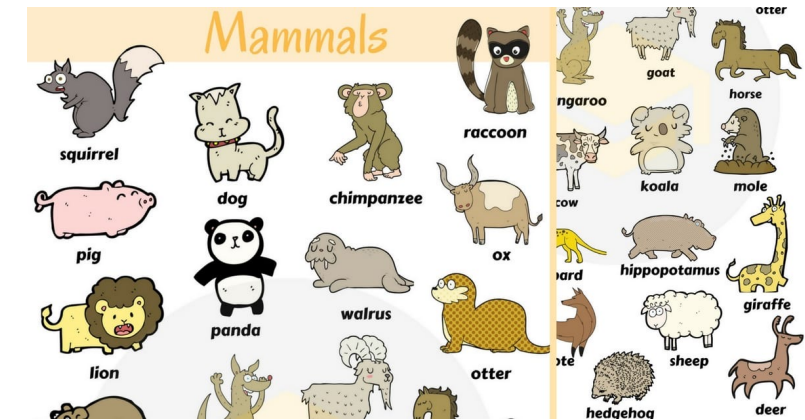
Fur
(Y = 1, N = 0)

Hair
(Y = 1, N = 0)



If we expect mammals to be warm-blooded and to either have fur *or* hair, then we might output "Yes" for mammal if, e.g. $x_1 + .5x_2 + .5x_3 > 1.3$

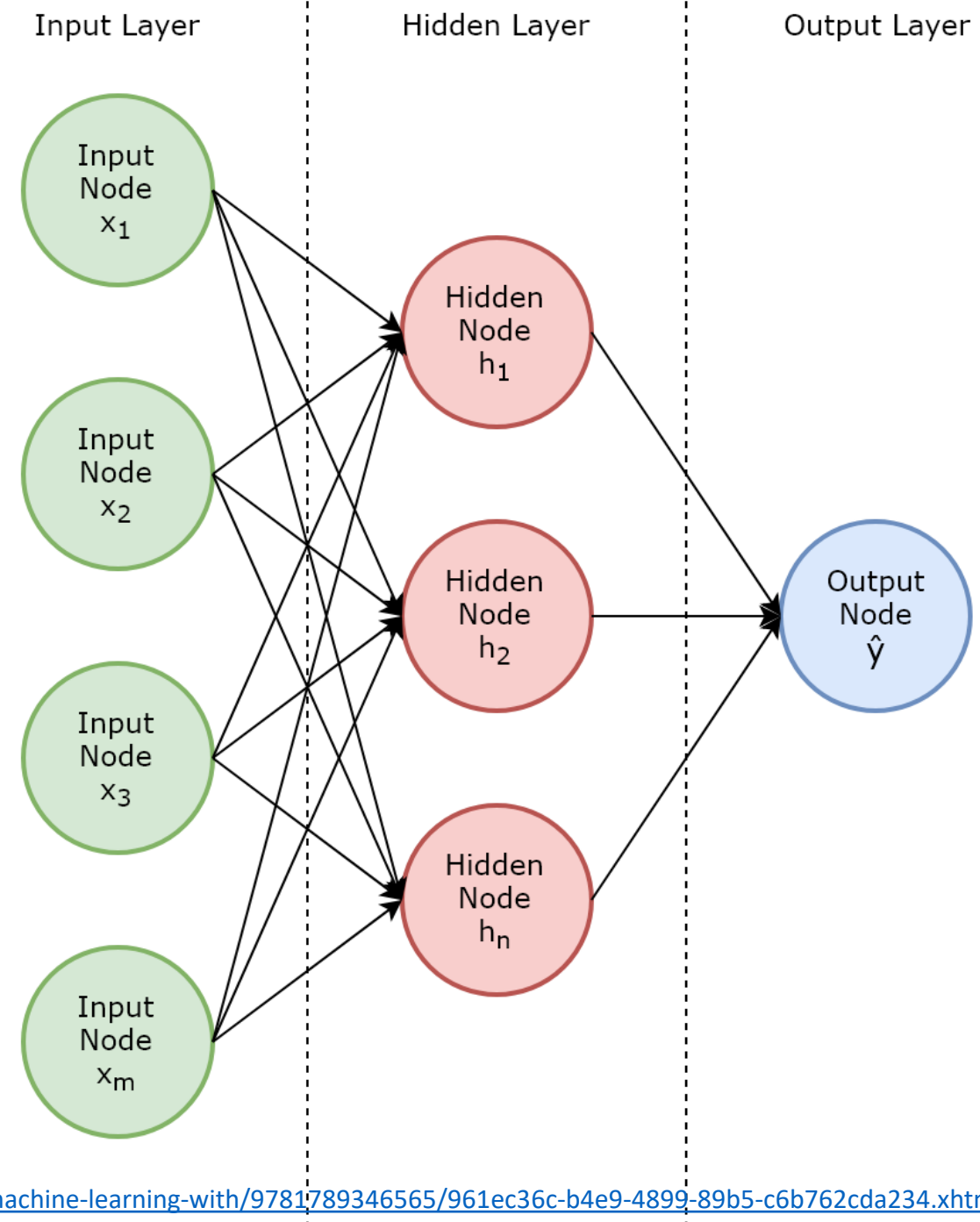
Mammal
(Yes or No)



Input	Score	Output (Mammal?)
Warm-blooded, no fur, no hair	1	No (score is NOT > 1.3)
Not warm-blooded, hair only	0.5	No (score is NOT > 1.3)
Warm-blooded, fur, no hair	1.5	Yes (score is > 1.3)

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