# APS360 Fundamentals of AI

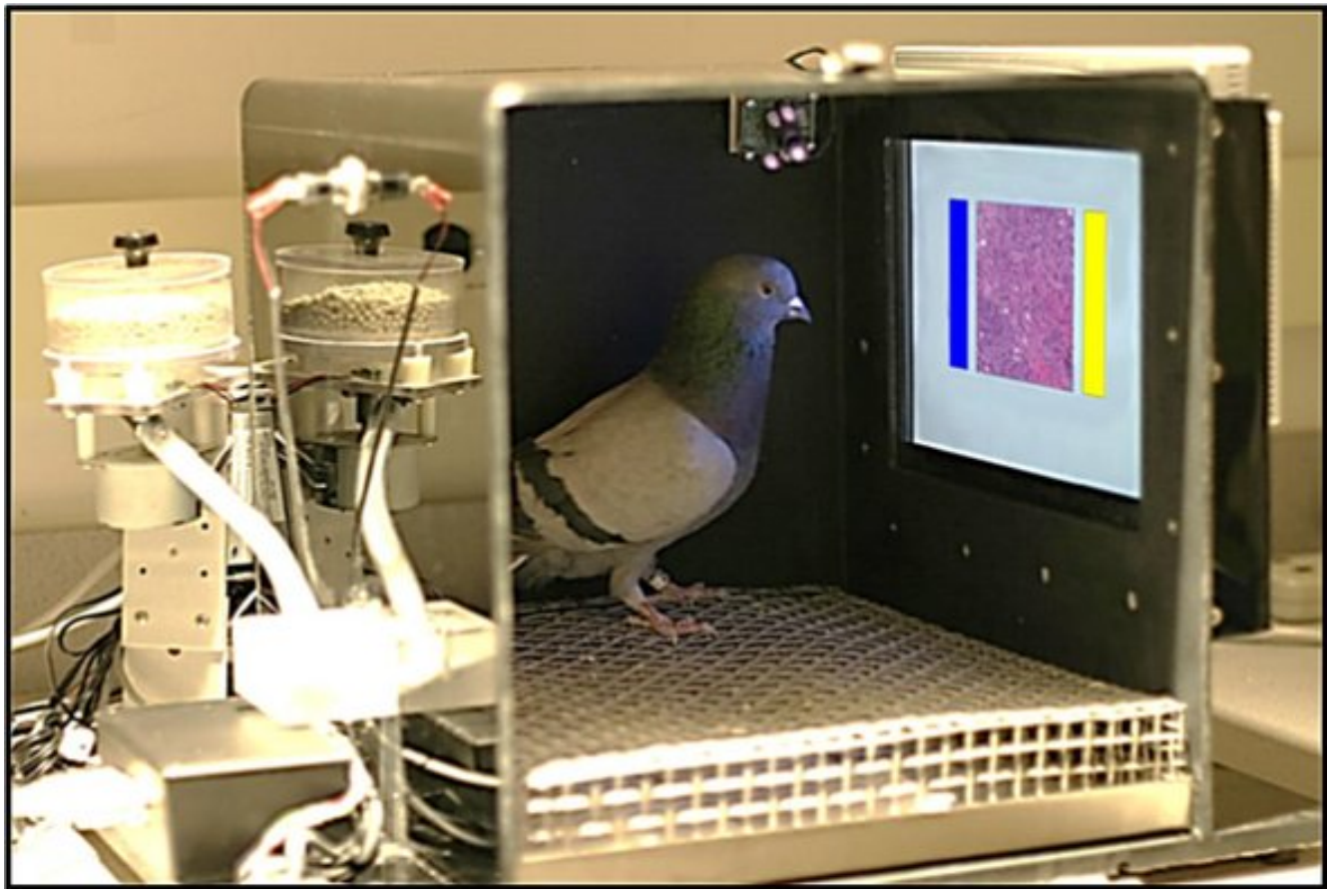
Lisa Zhang

Lecture 2; Jan 10, 2019

# Agenda

- Biological motivation of neural networks
- Train our first neural network
- Training and test sets

# Using Pigeons to Detect Cancer



A new study suggests that the common pigeon can reliably distinguish between benign versus malignant tumors and, in doing so, could help researchers develop better cancer screening technologies.

https://www.scientificamerican.com/article/using-pigeons-to-diagnose-cancer/

# Training Pigeons

https://www.youtube.com/watch?v=flzGjnJLyS0

1. Show an image of a magnified biopsy to a pigeon
2. Pigeon pecks at one of two answer buttons (cancer or not-cancer)
3. If pigeon picks correctly, reward pigeon with a tasty food pellet

# Training an Artificial Neural Network

We need to answer similar questions:

1. How will we reward the pigeon/network?
2. How do we train the pigeon/network quickly and efficiently?
3. How do we know the pigeon/network didn't just memorize the photos?
4. Are there ethical issues in trusting a pigeon/network to detect cancer?

# Today

1. Build an artificial pigeon – or rather, an *artificial pigeon brain*
2. Decide how to reward the artificial pigeon
3. Decide how to train the artificial pigeon
4. Determine how well our artificial pigeon performs the classification task

# How do pigeons work?

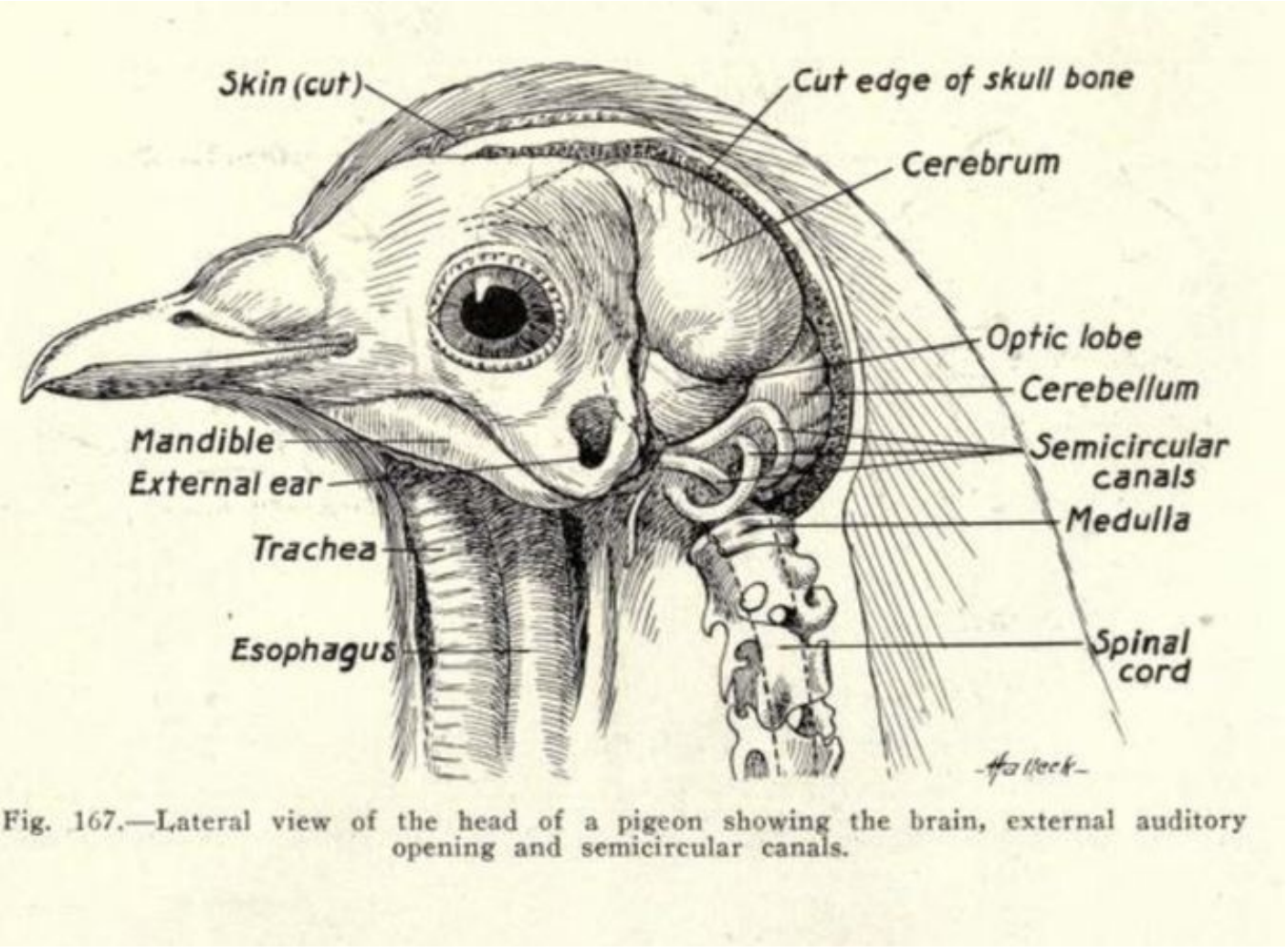
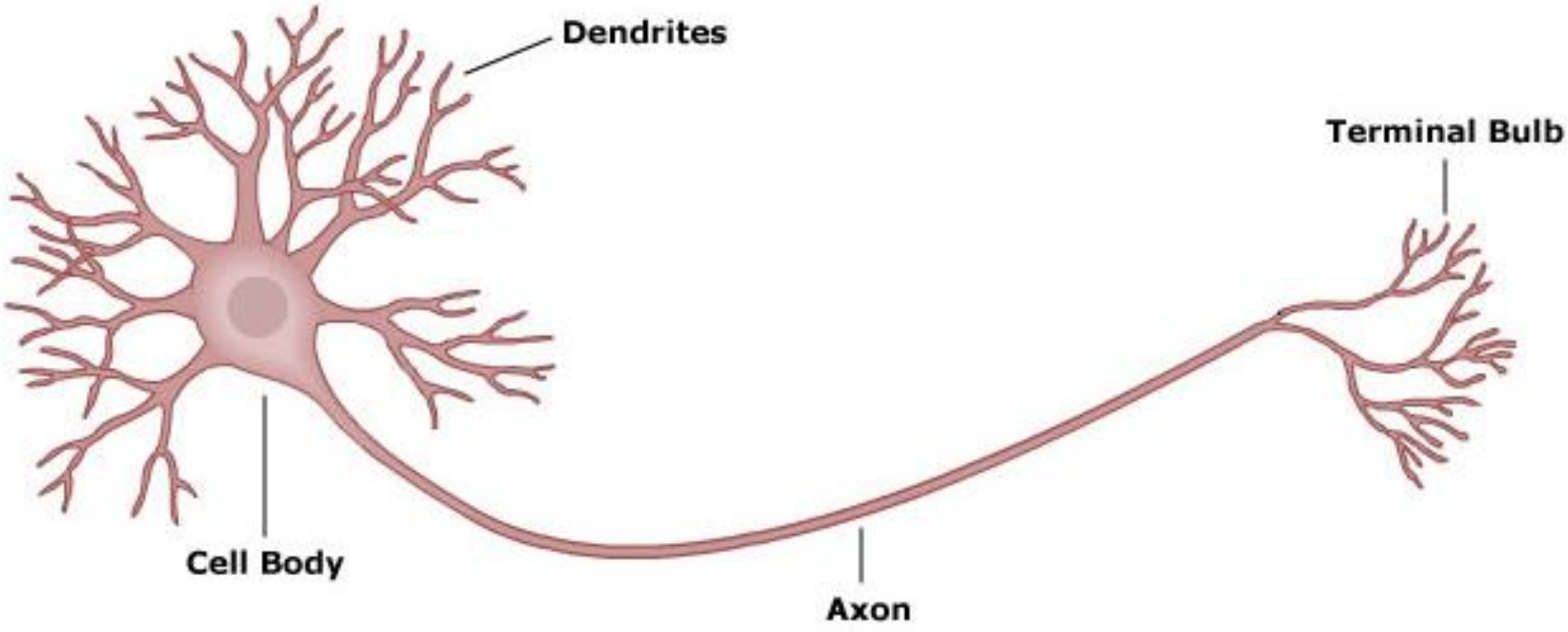



Fig. 167.—Lateral view of the head of a pigeon showing the brain, external auditory opening and semicircular canals.

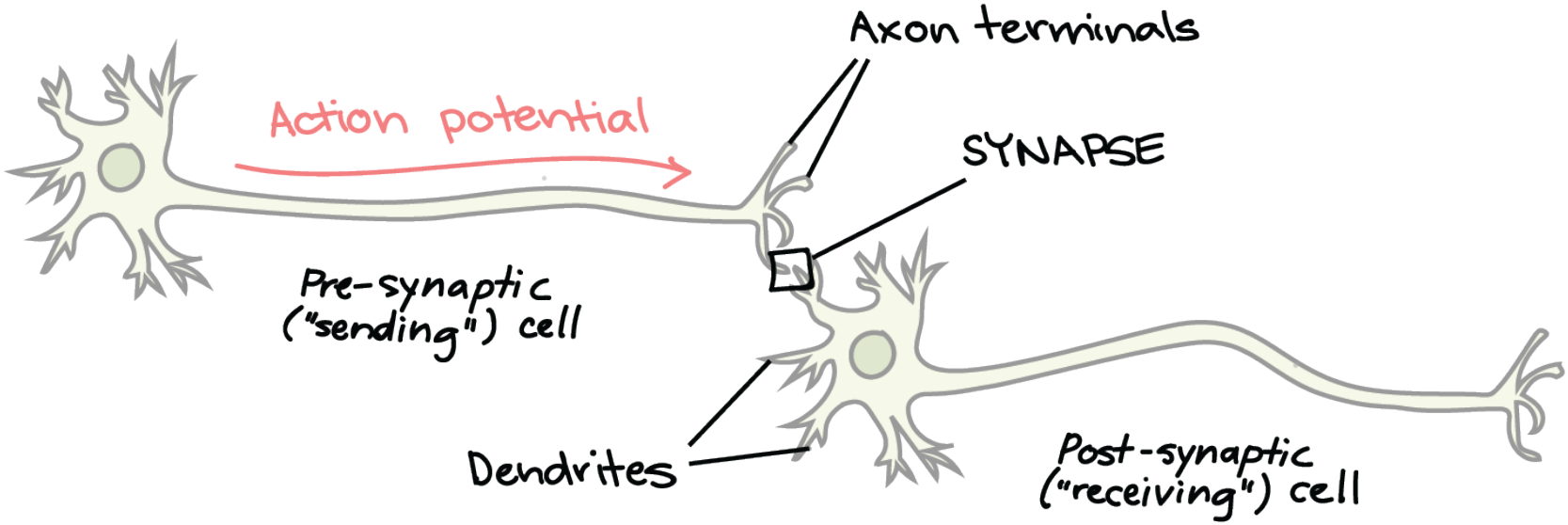
# Neuron



# Neuron Anatomy

- The **dendrites**, which are connected to other cells that provides information.
- The **cell body**, which consolidates information from the dendrites.
- The **axon**, which is an extension from the cell body that passes information to other cells.
- The **synapse**, which is the area where the axon of one neuron and the dendrite of another connect.

# Synapse


Axon terminals
Action potential
SYNAPSE
Pre-synaptic
("sending") cell
Dendrites
Post-synaptic
("receiving") cell

# Synapse

- Small voltage difference between inside and outside of cell
- When a neuron receives "information" in its dendrites, the voltage difference along that part of the cell lowers.
- If the total activity in a neuron's dendrites lowers the voltage difference enough, the entire cell *depolarizes* and the cell **fires**.
- The voltage signal spread along the axon and to the synapse, then to the next cells.

# Neural Decoding

What does it mean when a particular neuron fires?

Neuron can fire in response to...

- retinal cells
- certain edges, lines, angles, movements
- hands and faces (in primates)
- specific people like Jennifer Aniston (in humans)

# Grandmother Cell

- A neuron that represents a complex but specific concept or object
- Its existence is contested

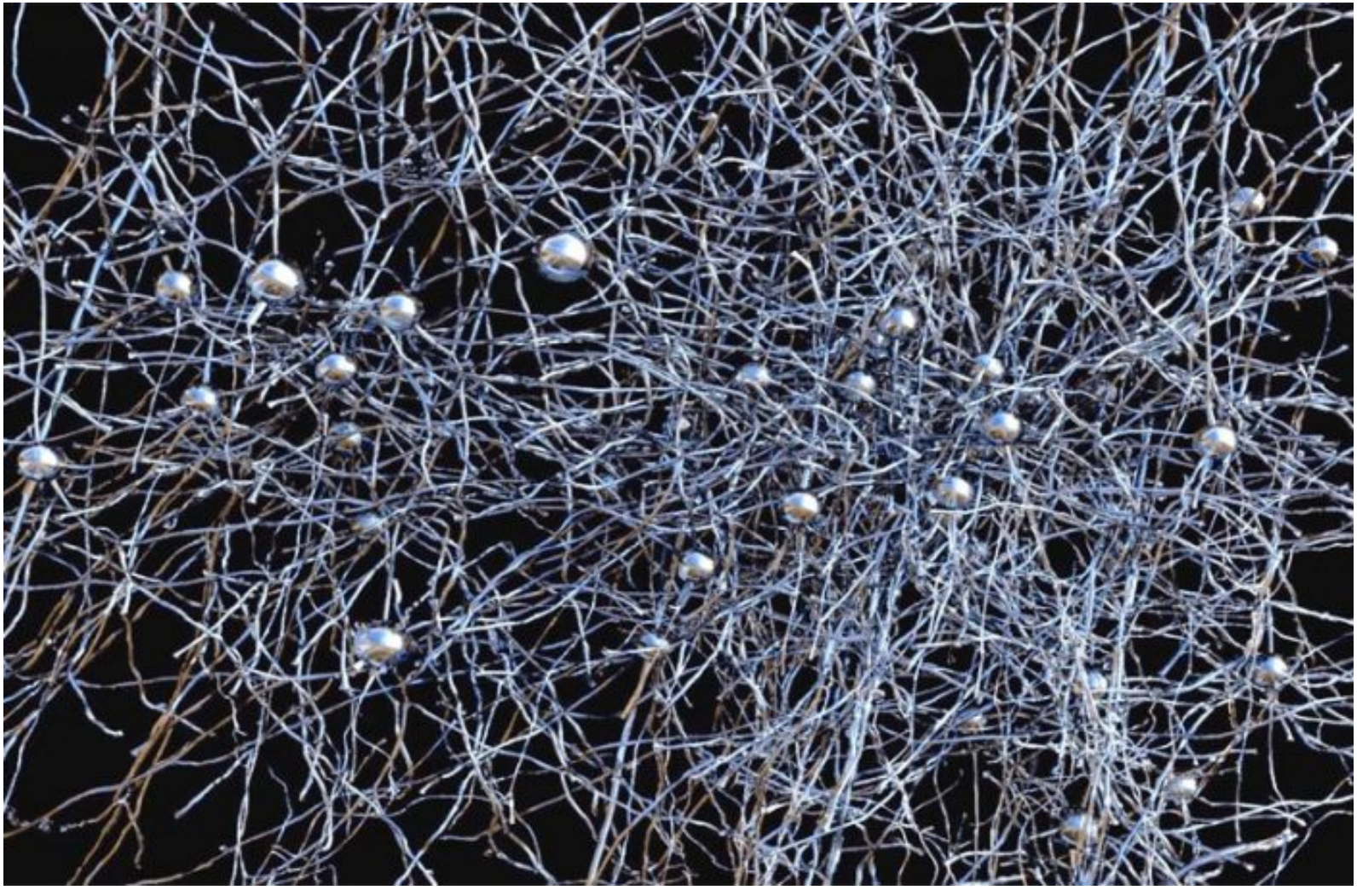
# Distributed encoding

The idea that neuron firing patterns encode information only in a **distributed** fashion

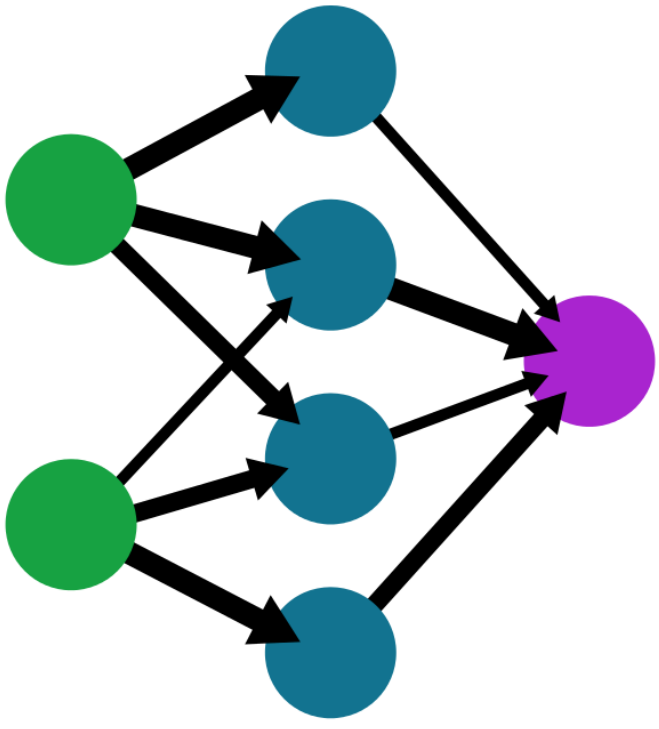
# Artificial Pigeon Brain

- Start with an **output** "grandmother cell" that represent the concept that we want to predict.
- Also, start with **input** neurons that activate with each pixel
- Connect input to outputs

# Biological Neuron Connectivity



# Artificial Neuron Connectivity



- add a **hidden layer** that don't have specific meaning
- **fully-connected, feed-forward network**

# Modelling Individual Neurons

- $a_{01}$ = the neurons **activation** of an input layer neuron
- $a_{11}$ = the neuron activation of a hidden layer neuron

$$a_{11} = \sigma\left(b_{11} + \sum_i w_{i1} a_{0i}\right)$$

- $w_{0i}$ = a **weight** summarizing the connectivity of neurons $0i$ and 11
- $b_{11}$ = a **bias** summarizing the activation requirement of the neuron 11

Let's build a "pigeon" in PyTorch!