

Artificial Neural Networks

BIOE 210

Linear Systems

$$\underline{y} = \underline{A} \underline{x}$$

Known

$$\overset{n}{\underline{x}}, \overset{n \times n}{\underline{A}}$$

$$\overset{n \times n}{\underline{A}}, \overset{n}{\underline{y}}$$

$$\overset{n}{\underline{x}}, \overset{n}{\underline{y}}$$

Unknown

$$\overset{n}{\underline{y}}$$

$$\overset{n}{\underline{x}}$$

$$\overset{n \times n}{\underline{A}}$$

Method

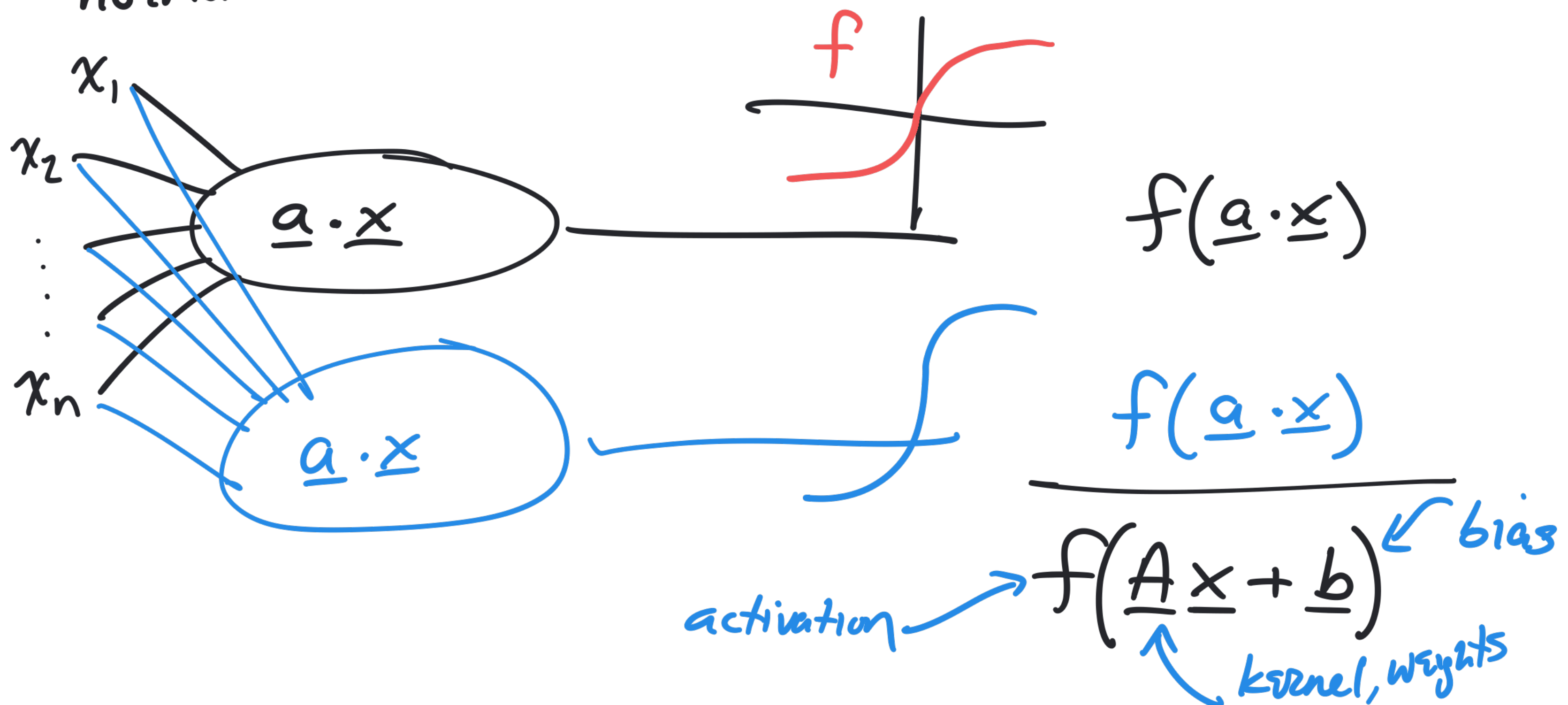
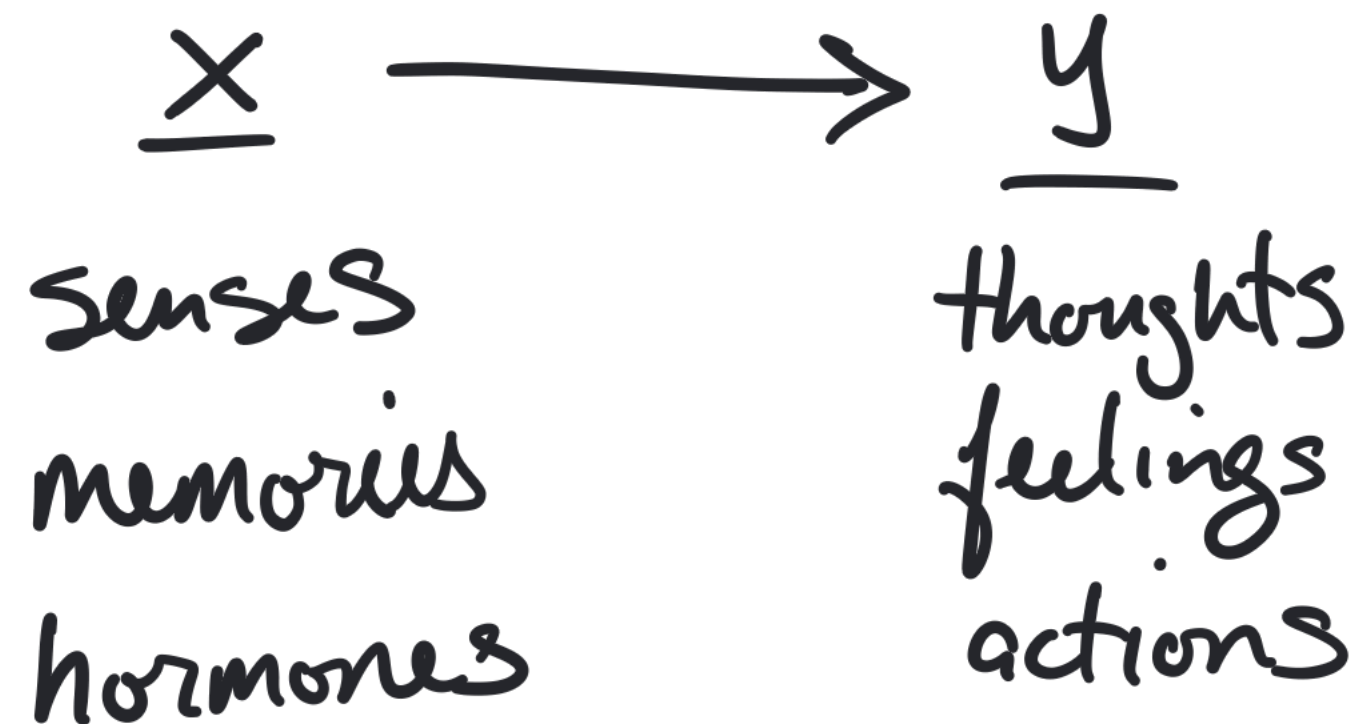
$$\underline{A} \underline{x} \text{ (mult.)}$$

$$\underline{A}^{-1} \underline{y}$$

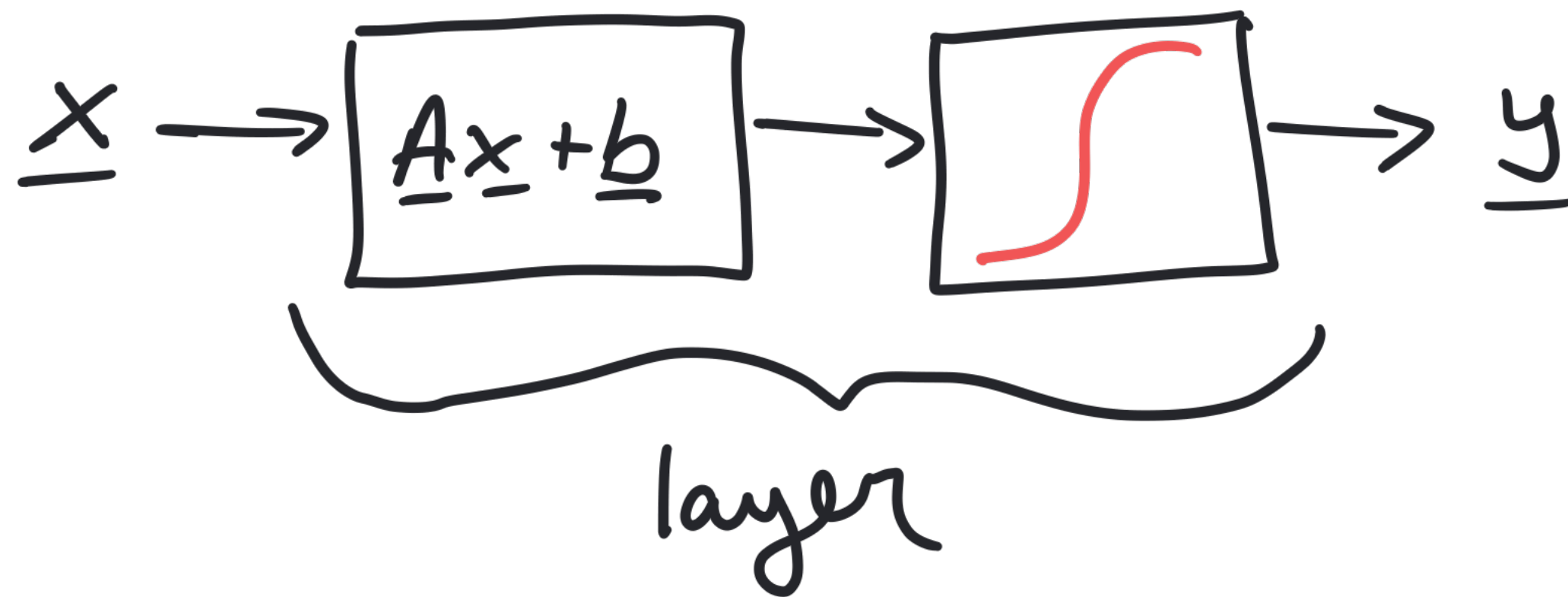
$$\underline{A}^+ \underline{y}$$

Neural
Network

How do biological systems learn?



The Artificial Neural Network

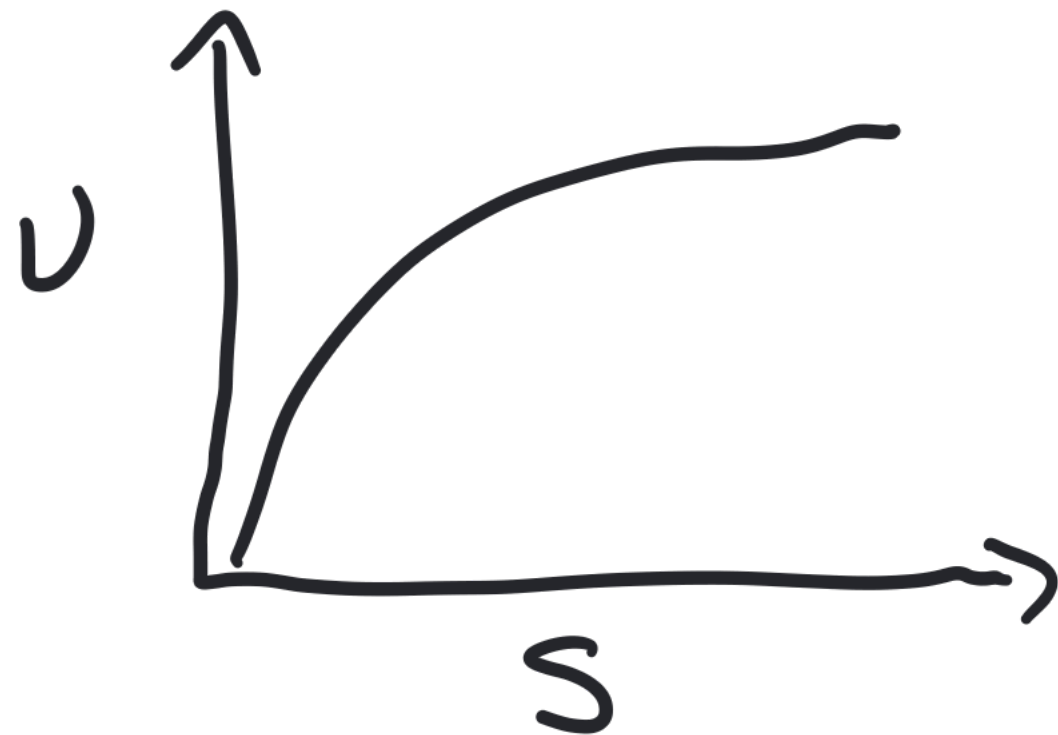


$$\text{Error} = \sum (y_{\text{pred}} - y_{\text{true}})^2$$

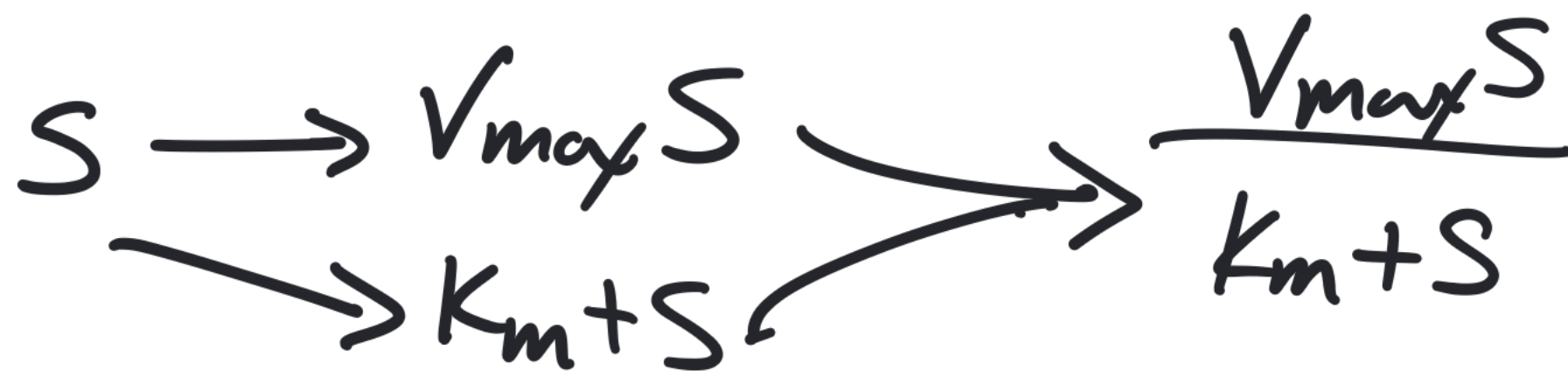
Minimize the error by tuning
"learning" the parameter values. ($\underline{A}, \underline{b}$)

- NN are not convex
- Always find local min.
- Easily overfit.

Example: Michaelis-Menten Kinetics



$$v = \frac{V_{max} S}{K_m + S}$$



Feature
Engineering

A diagram showing the fraction $\frac{V_{max} S}{K_m + S}$ being formed from its numerator and denominator.

Feature Engineering

$$\underline{x} \longrightarrow \underline{y}$$

$$\underline{x} \xrightarrow{NN} \underline{\phi} \xrightarrow{NN} \underline{y}$$

Deep Neural
Network

$$\underline{x} \longrightarrow \underline{\phi_1} \longrightarrow \underline{\phi_2} \longrightarrow \dots \longrightarrow \underline{\phi_n} \longrightarrow \underline{y}$$



hidden layers

neurons in a
layer is the # of "nodes"

← depth
↑ width
nodes

Why ANN in a Linear Algebra class?

- NN are based on $\underline{A}\underline{x} + \underline{b}$
- Training are based on L.A.
 - GPUs
- NN are "workhorse" of A.I.
 - A.I. is built in the language of L.A.