



# Neural Networks

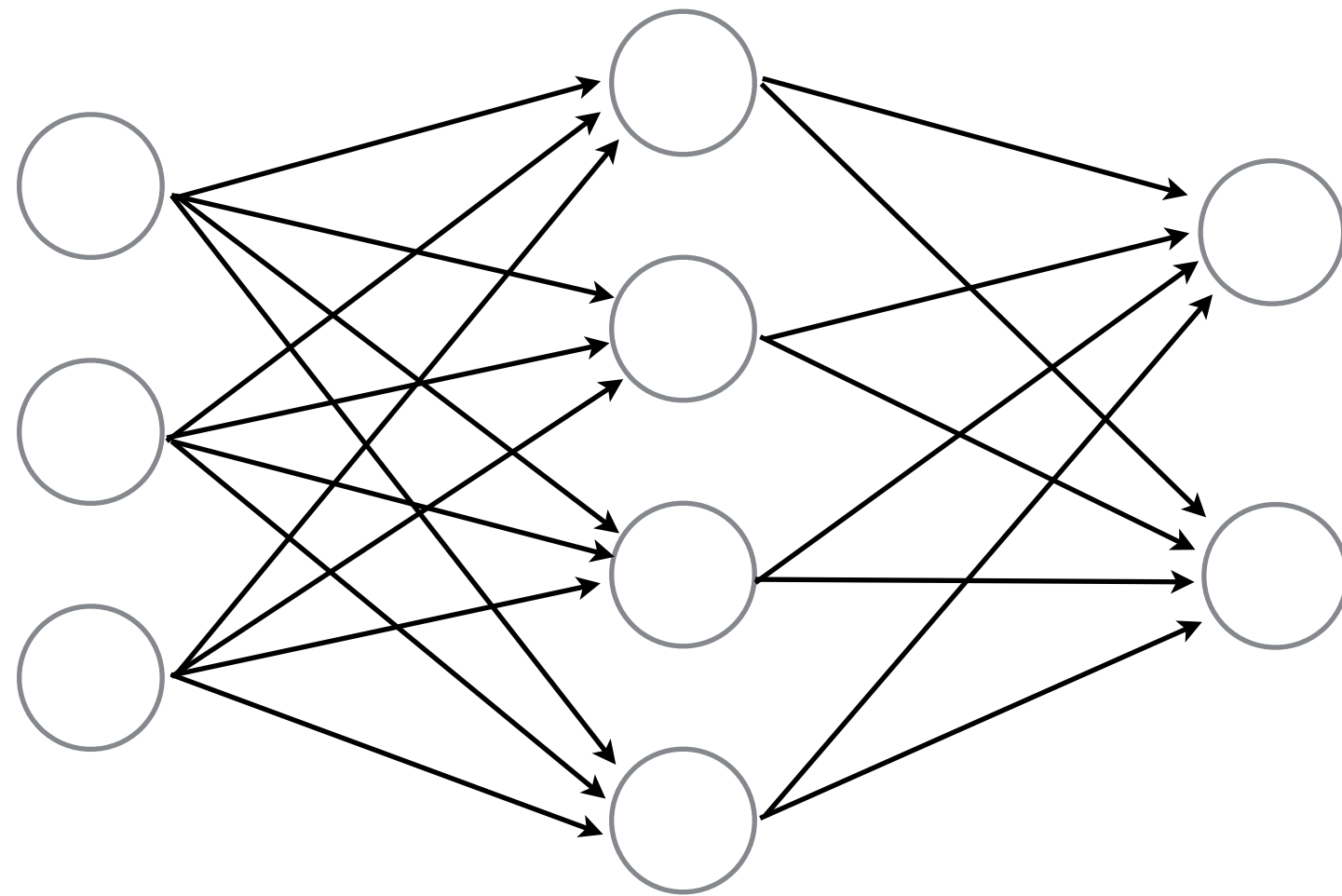
16-385 Computer Vision (Kris Kitani)  
**Carnegie Mellon University**

Connect a bunch of perceptrons together ...

Connect a bunch of perceptrons together ...

# Neural Network

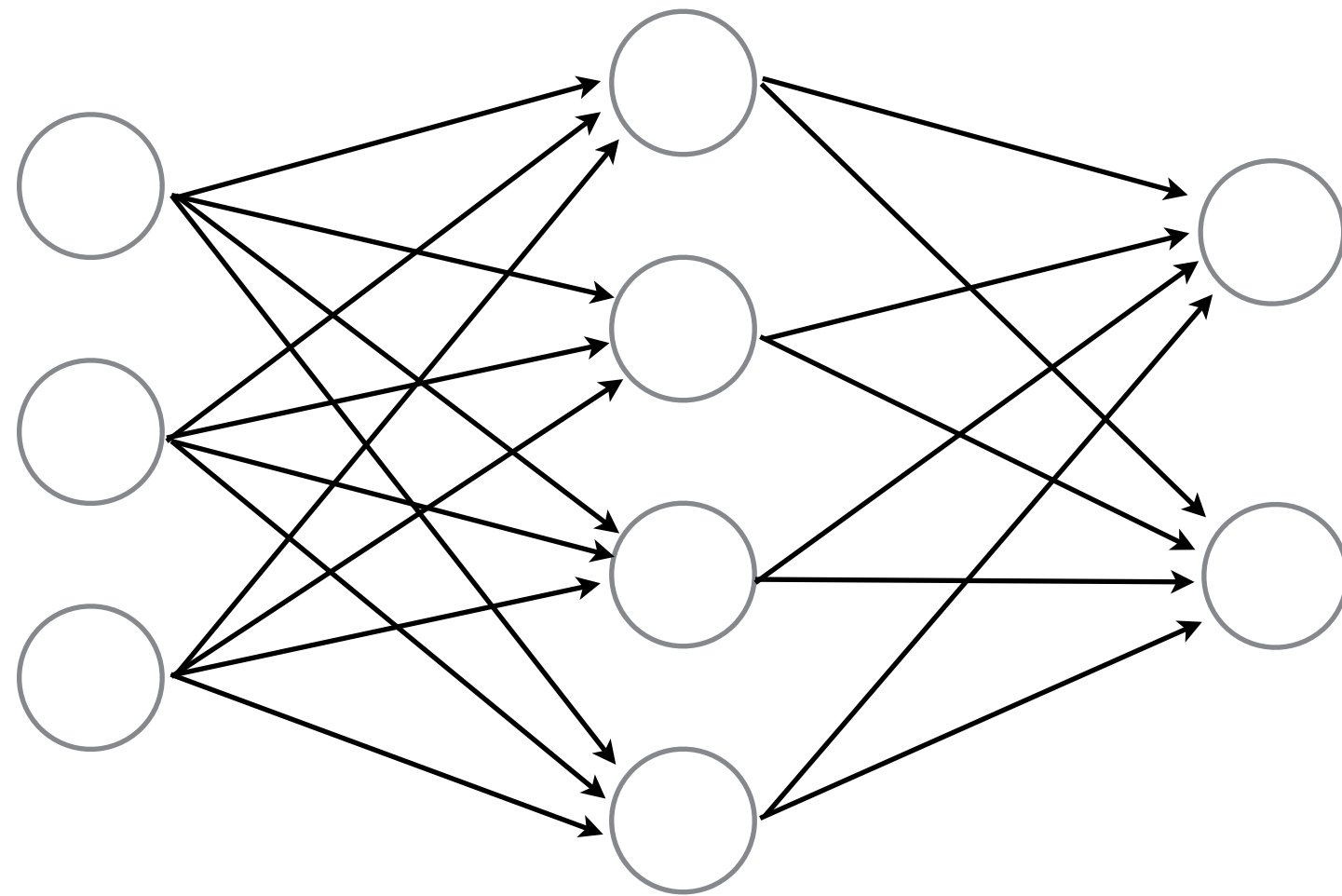
a collection of connected perceptrons



Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons

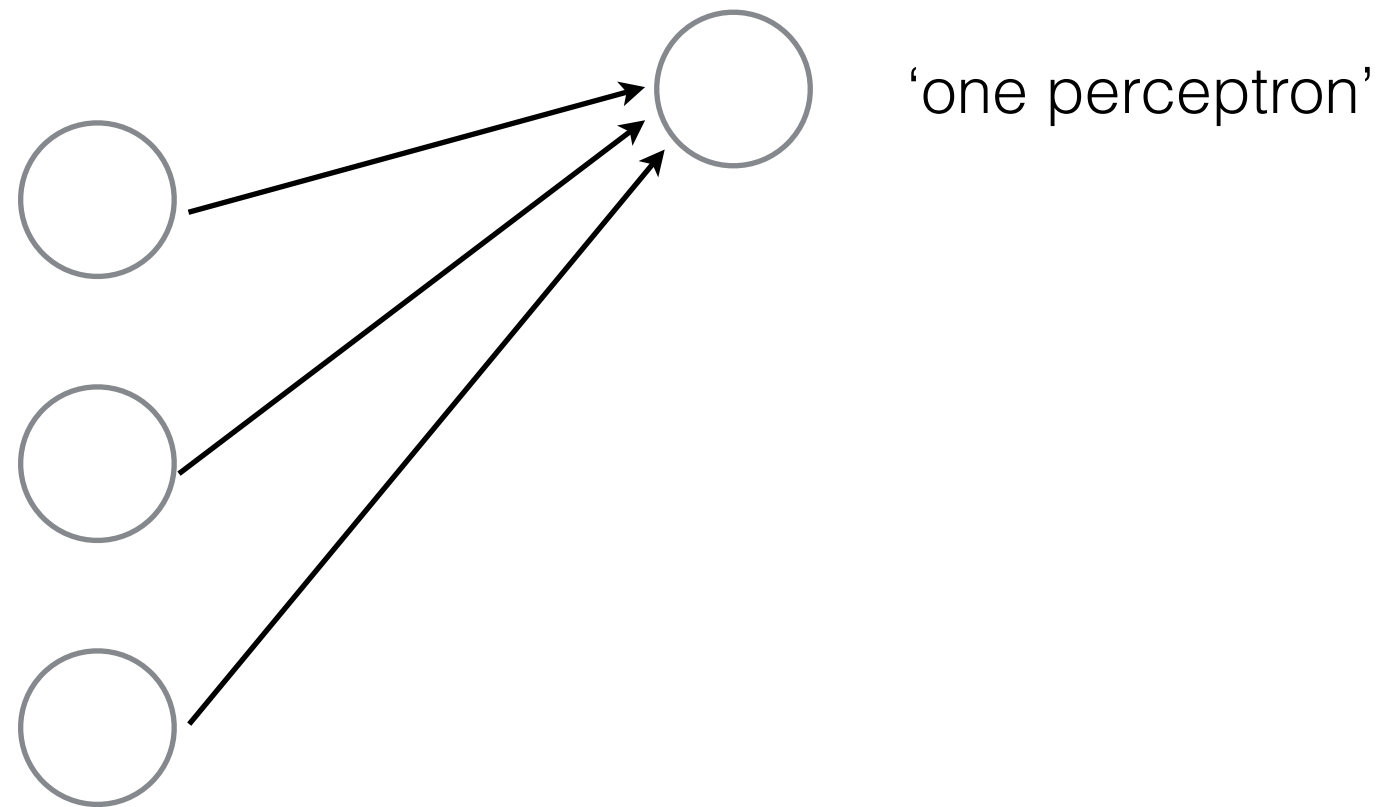


*How many perceptrons in this neural network?*

Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons

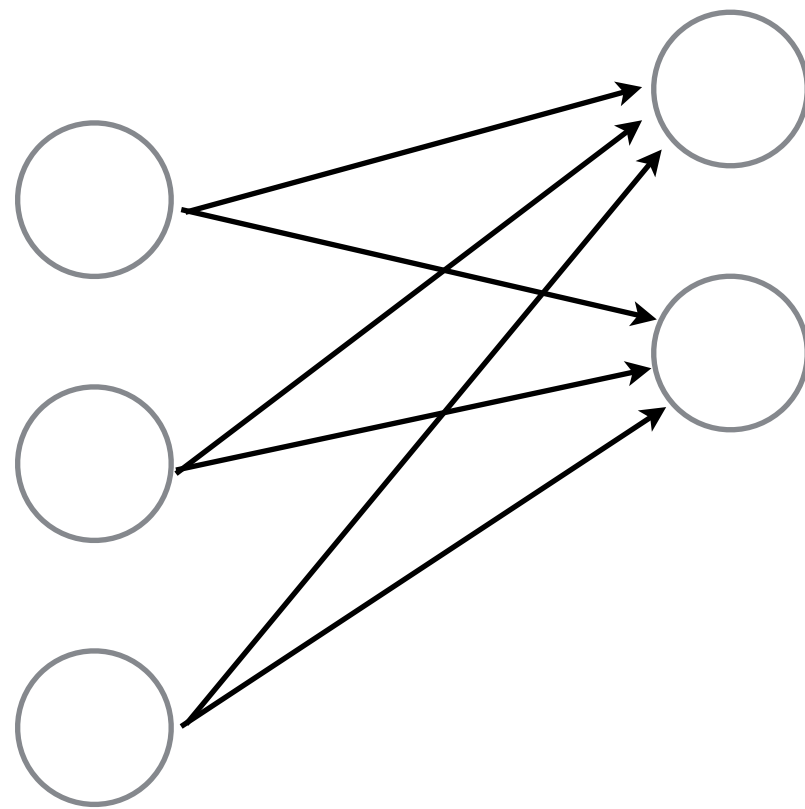




Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons



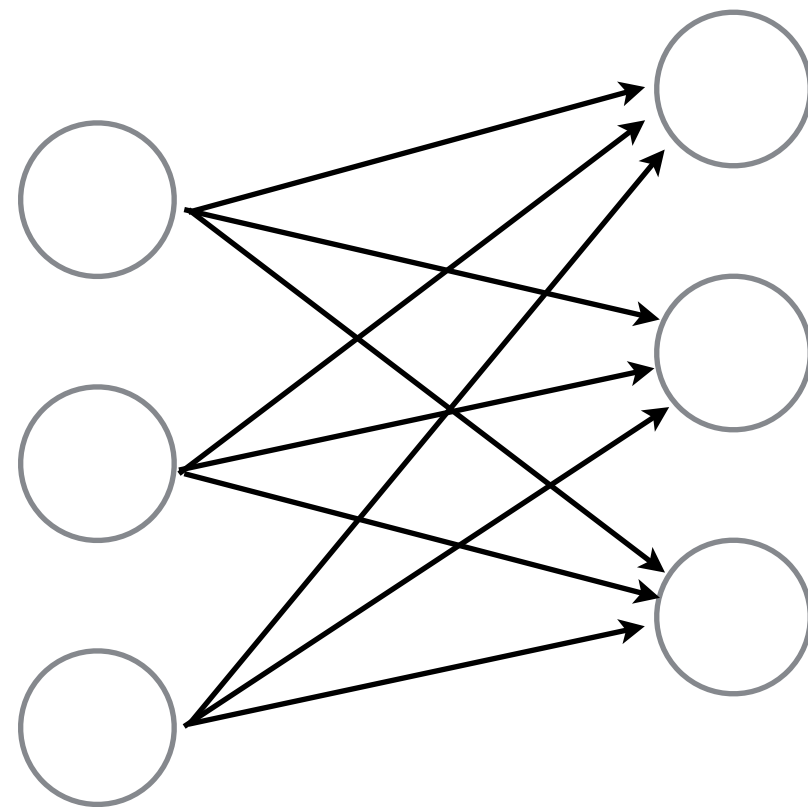
‘two perceptrons’



Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons



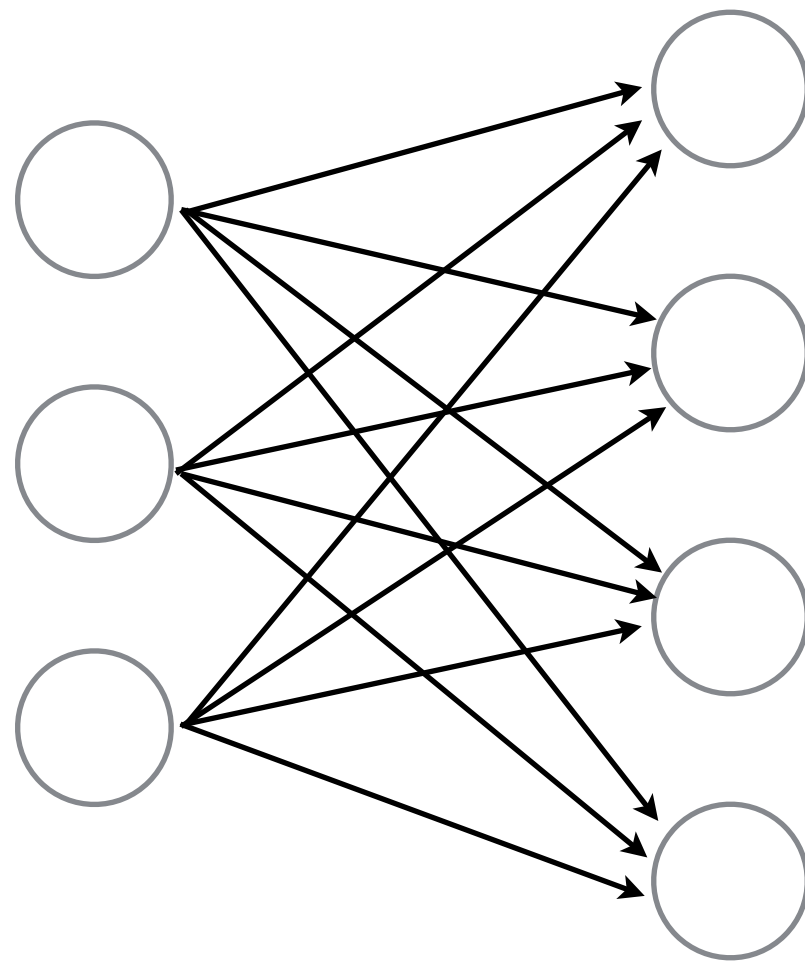
'three perceptrons'



Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons



'four perceptrons'

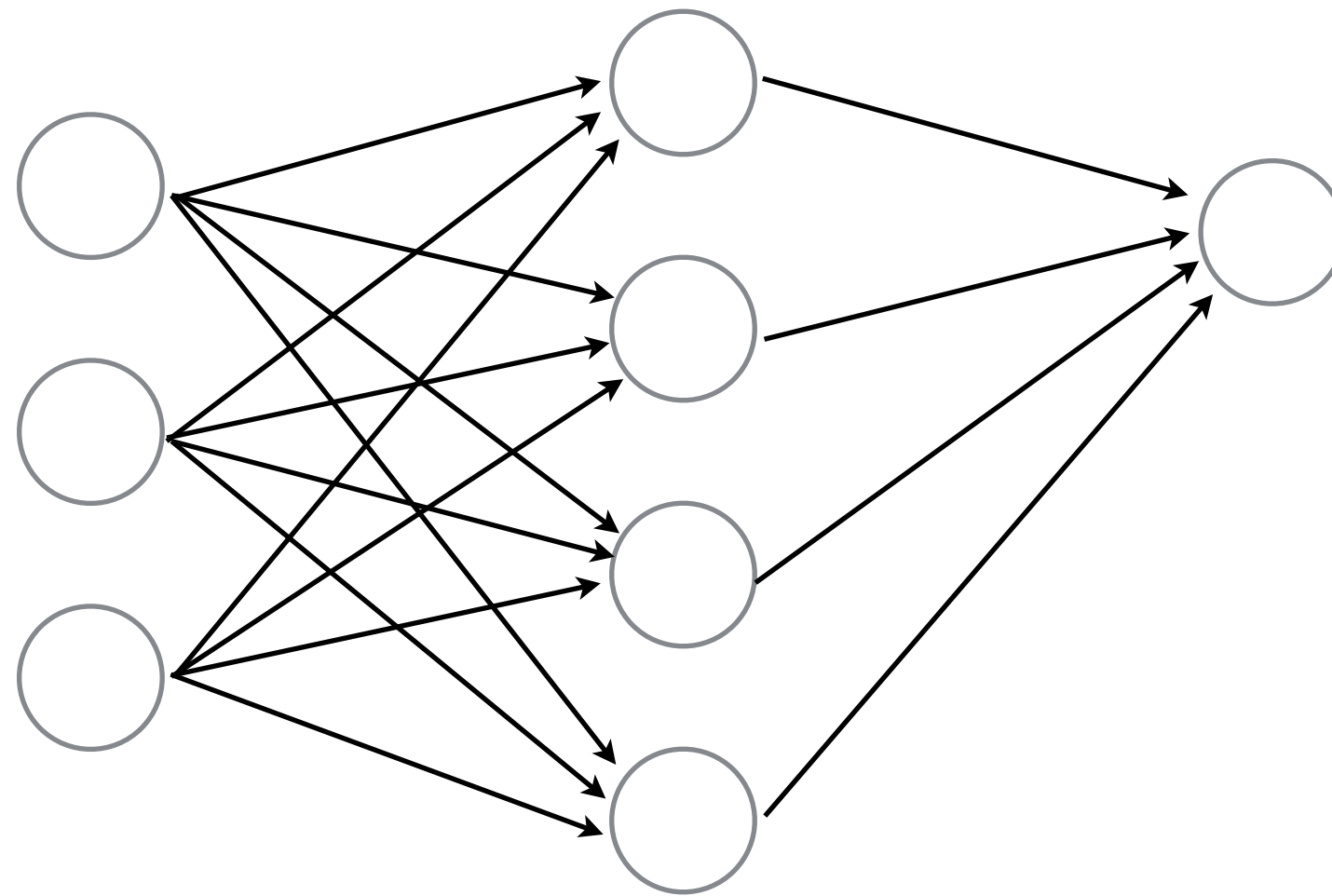




Connect a bunch of perceptrons together ...

# Neural Network

a collection of connected perceptrons



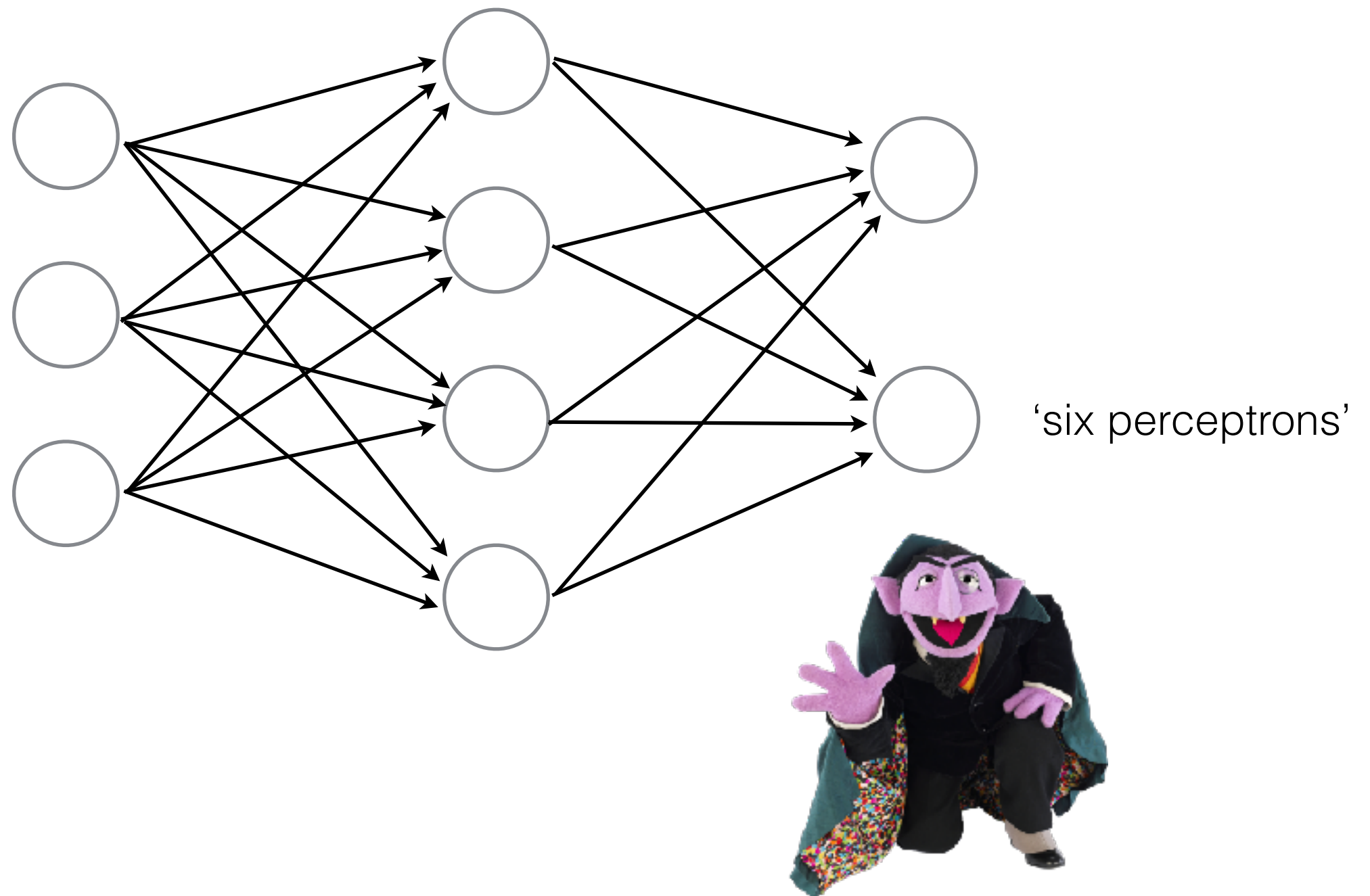
‘five perceptrons’



Connect a bunch of perceptrons together ...

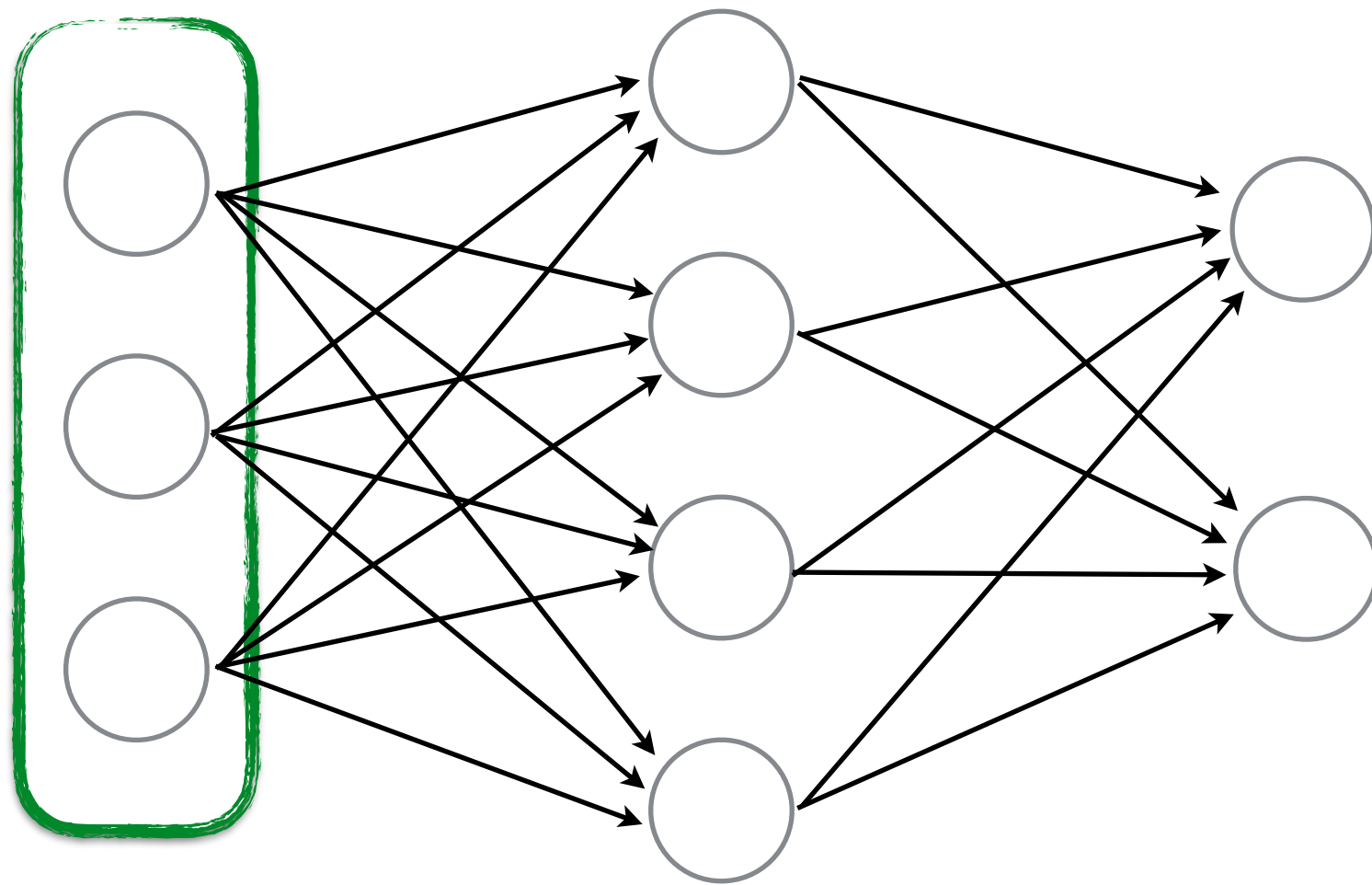
# Neural Network

a collection of connected perceptrons



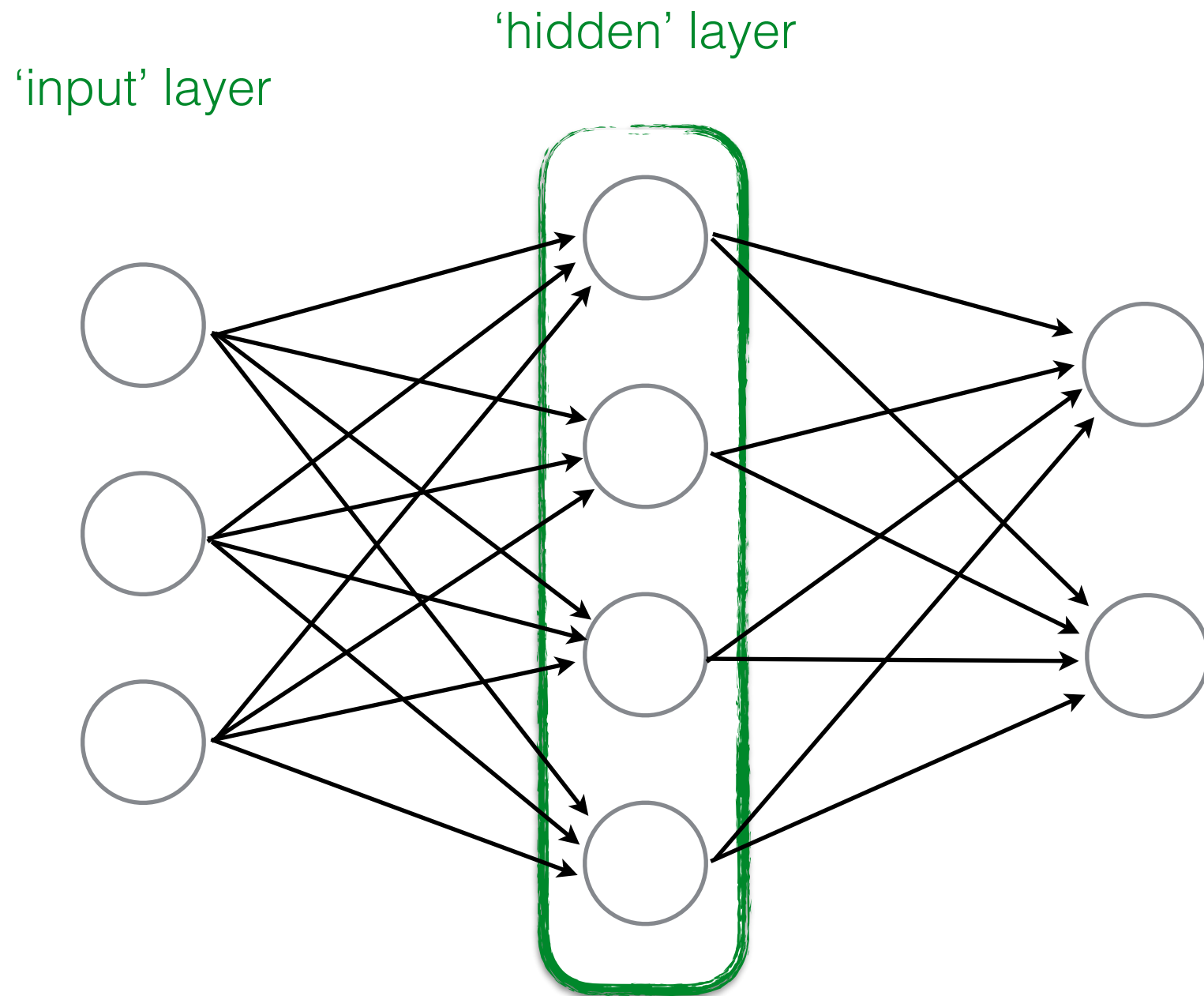
Some terminology...

'input' layer



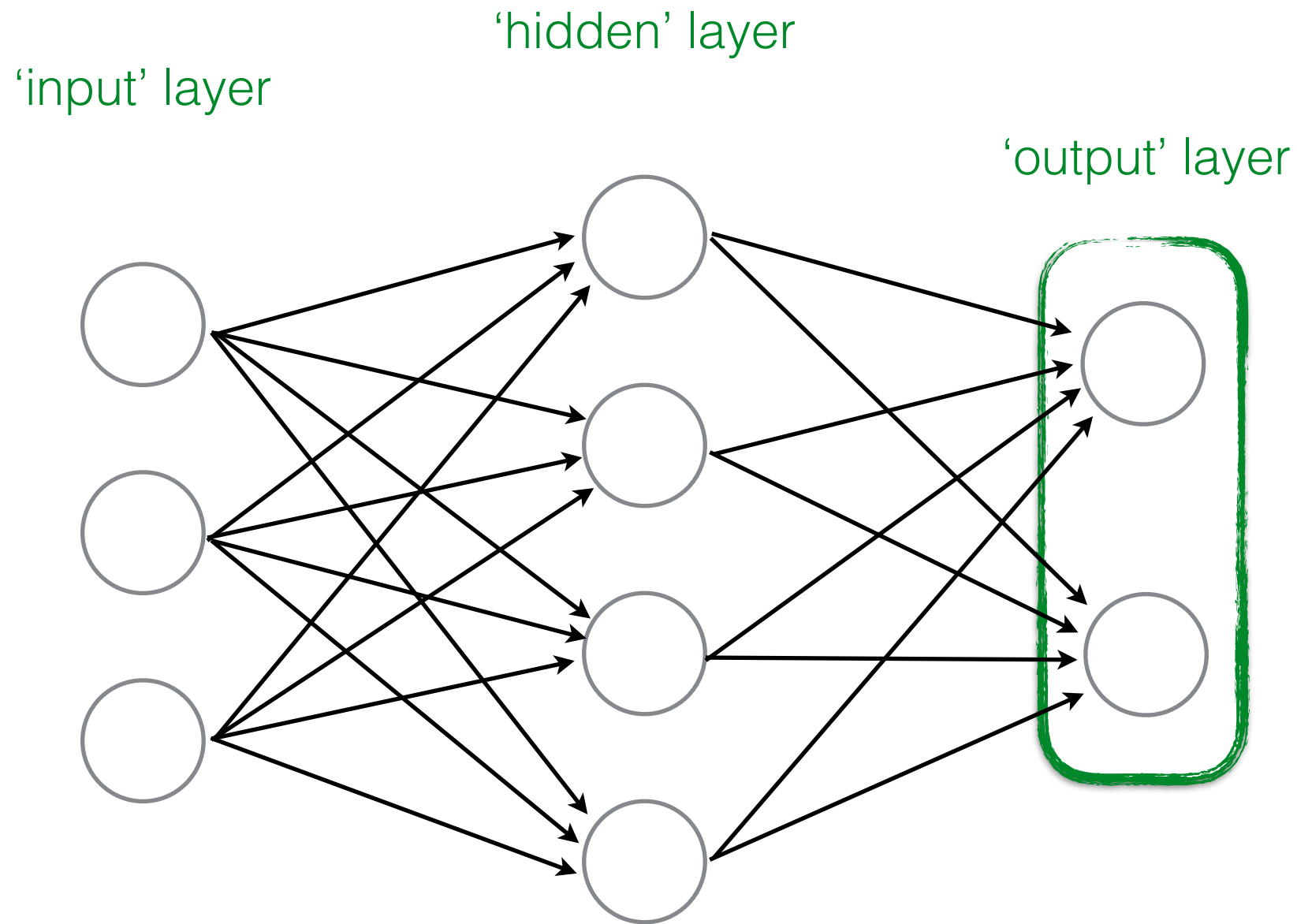
...also called a **Multi-layer Perceptron** (MLP)

Some terminology...



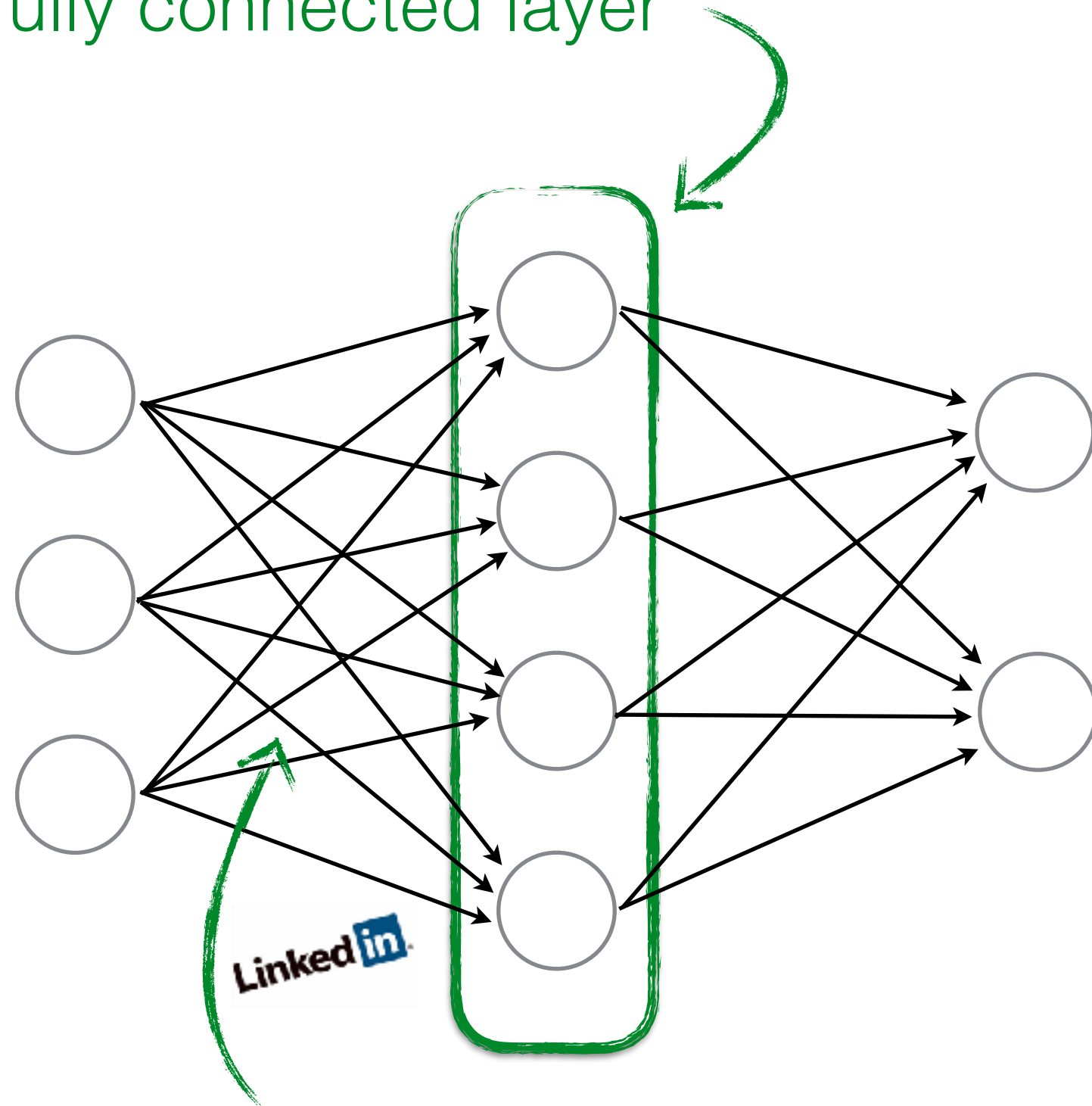
...also called a **Multi-layer Perceptron** (MLP)

Some terminology...



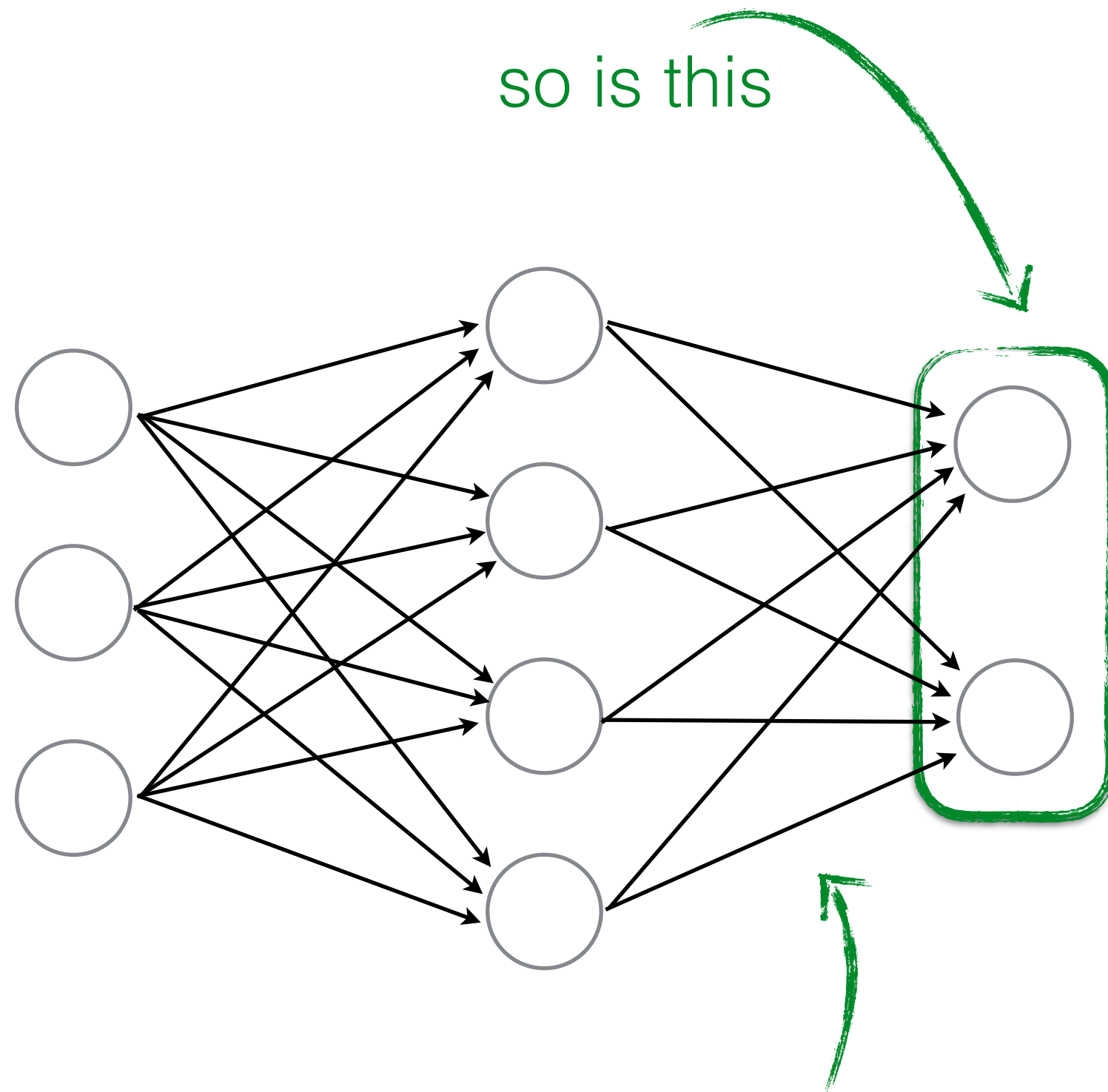
...also called a **Multi-layer Perceptron** (MLP)

this layer is a  
'fully connected layer'



all pairwise neurons between layers are connected



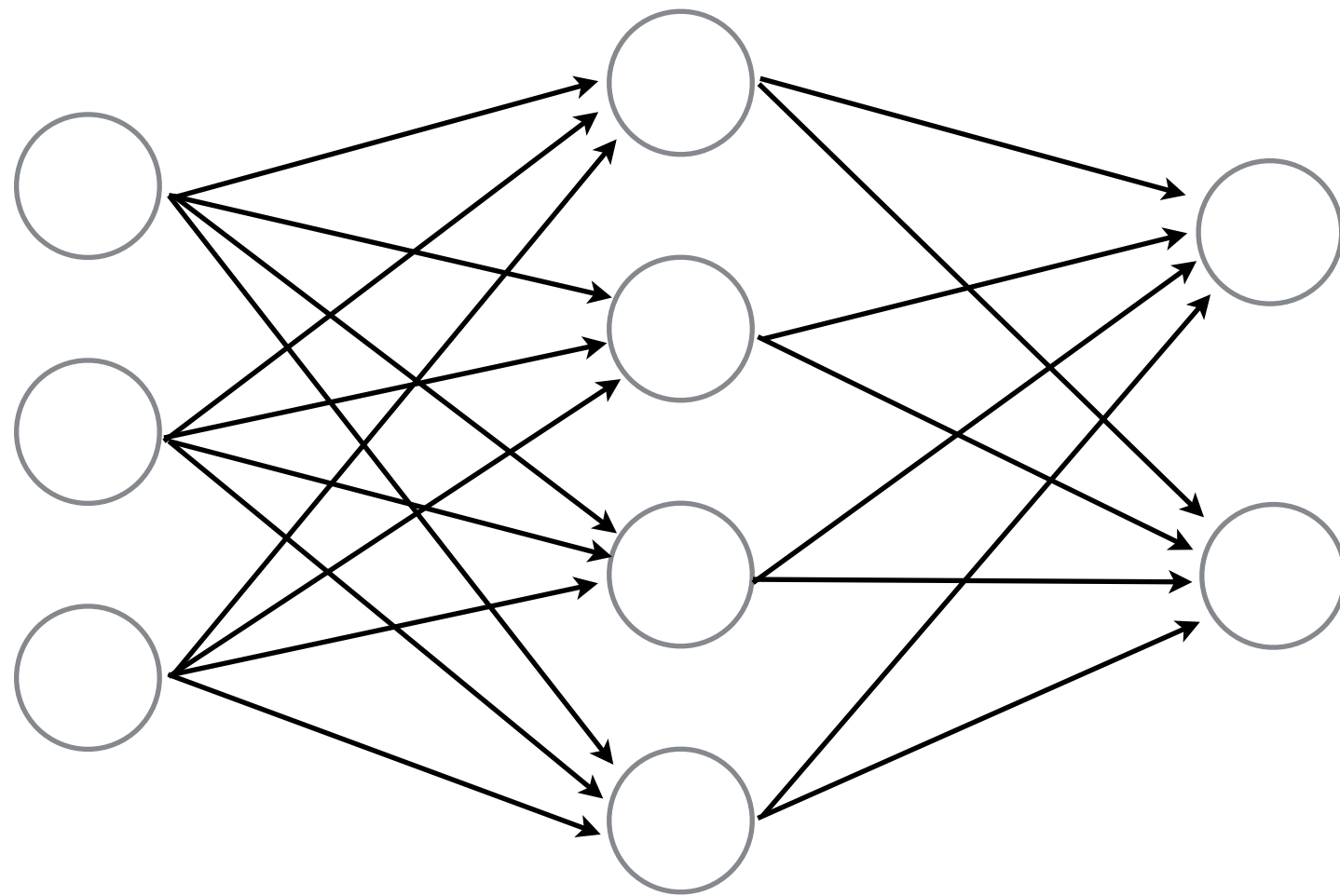


so is this

all pairwise neurons between layers are connected

*How many neurons (perceptrons)?*

*How many weights (edges)?*

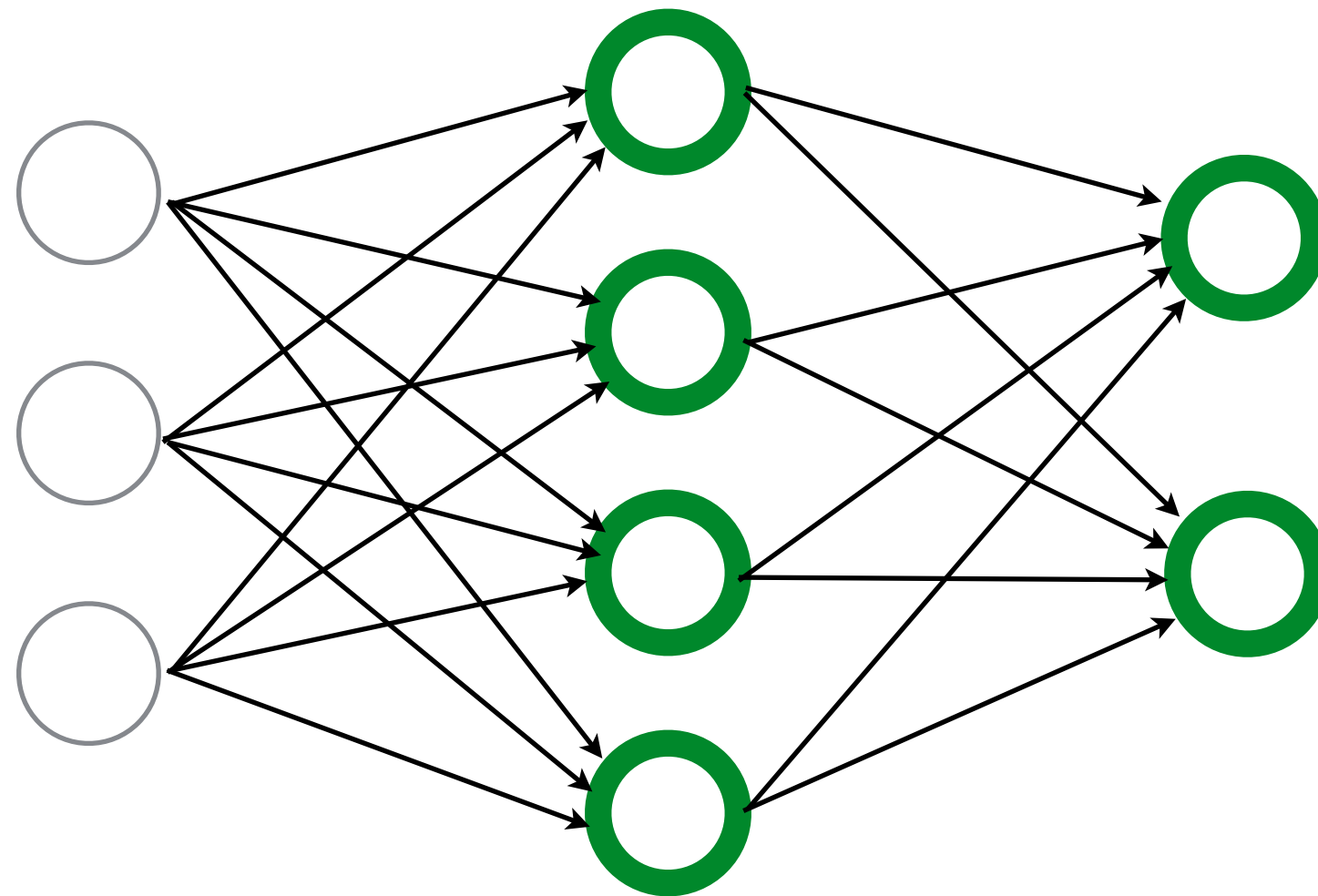


*How many learnable parameters total?*

*How many neurons (perceptrons)?*

$$4 + 2 = 6$$

*How many weights (edges)?*



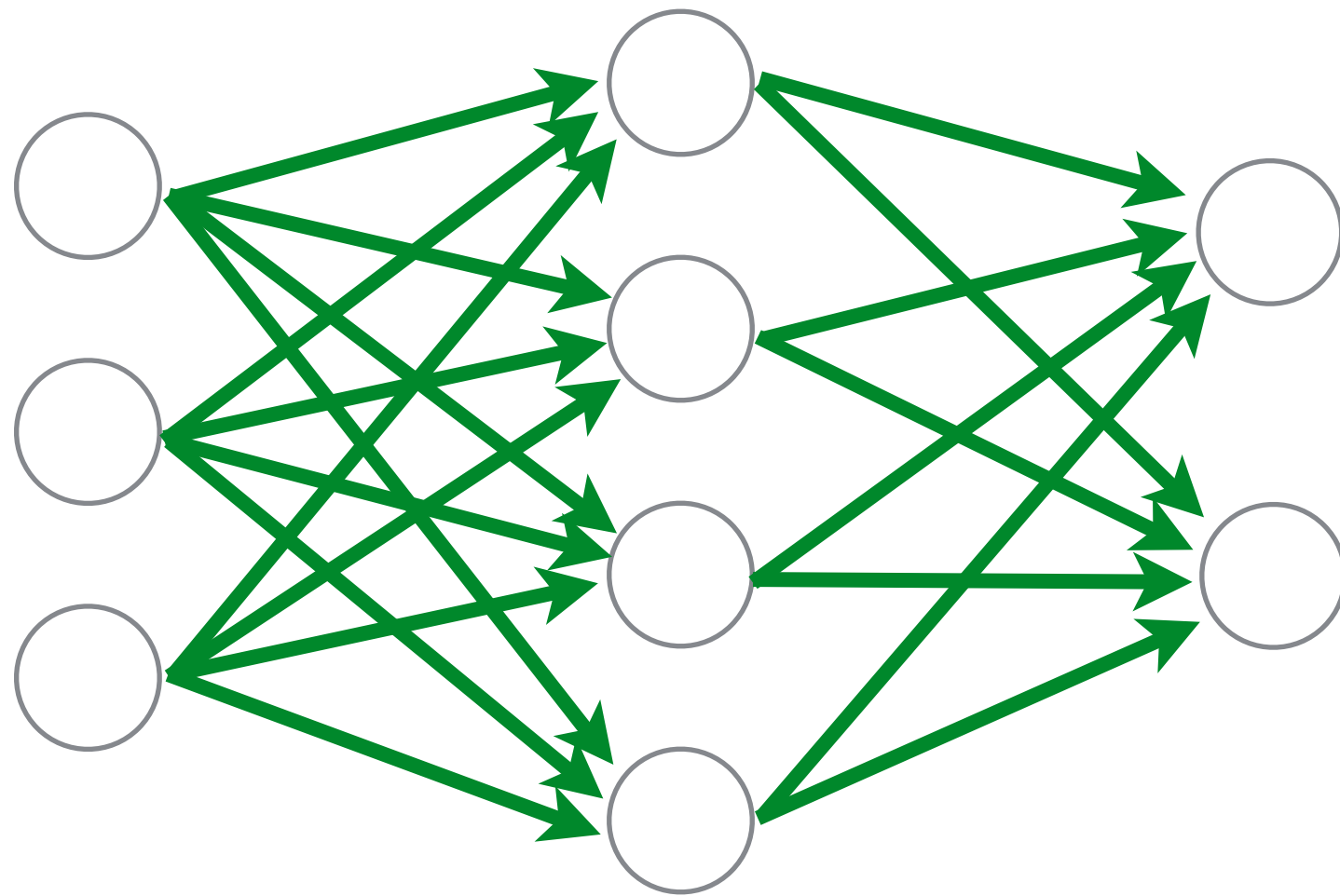
*How many learnable parameters total?*

*How many neurons (perceptrons)?*

$$4 + 2 = 6$$

*How many weights (edges)?*

$$(3 \times 4) + (4 \times 2) = 20$$



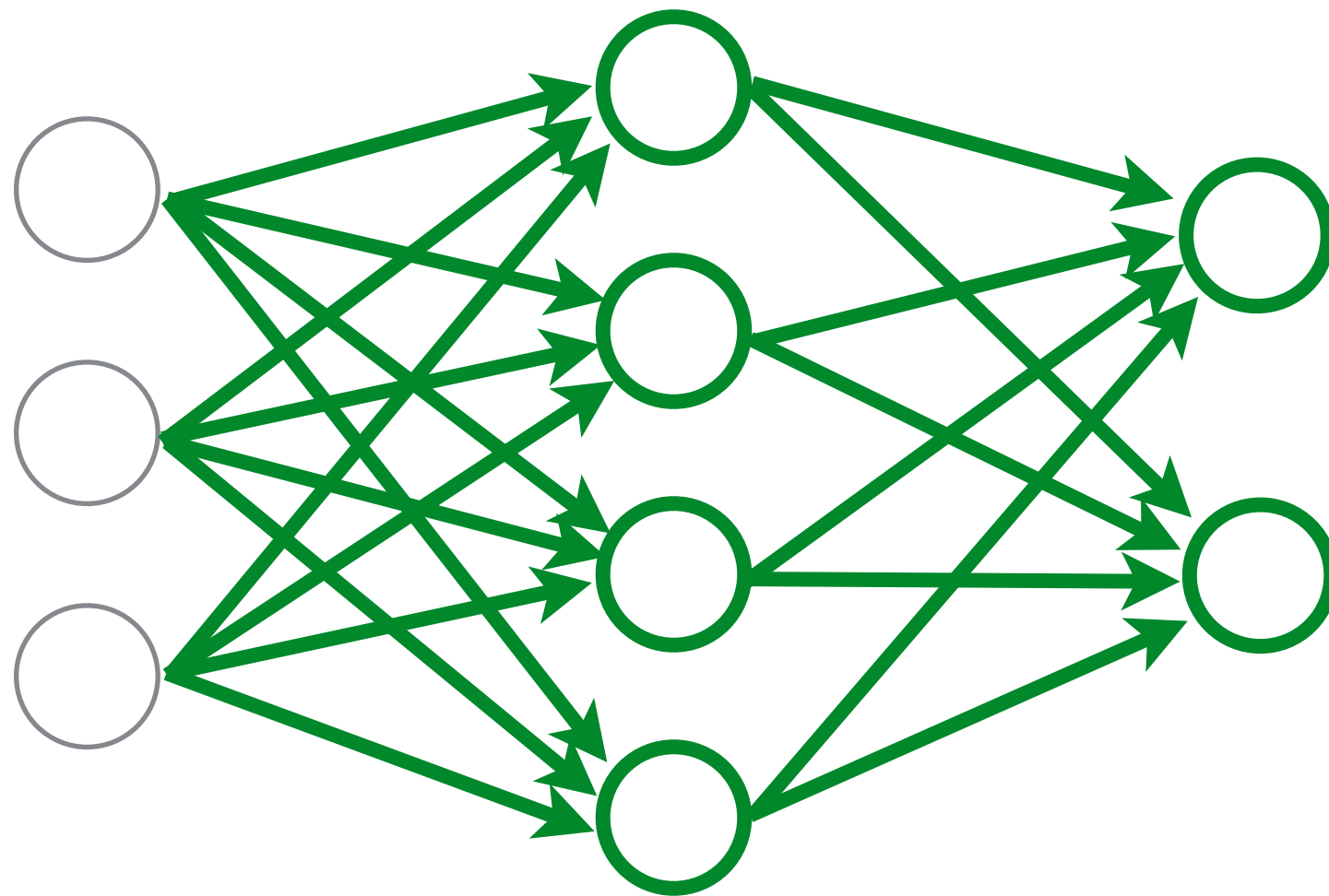
*How many learnable parameters total?*

*How many neurons (perceptrons)?*

$$4 + 2 = 6$$

*How many weights (edges)?*

$$(3 \times 4) + (4 \times 2) = 20$$

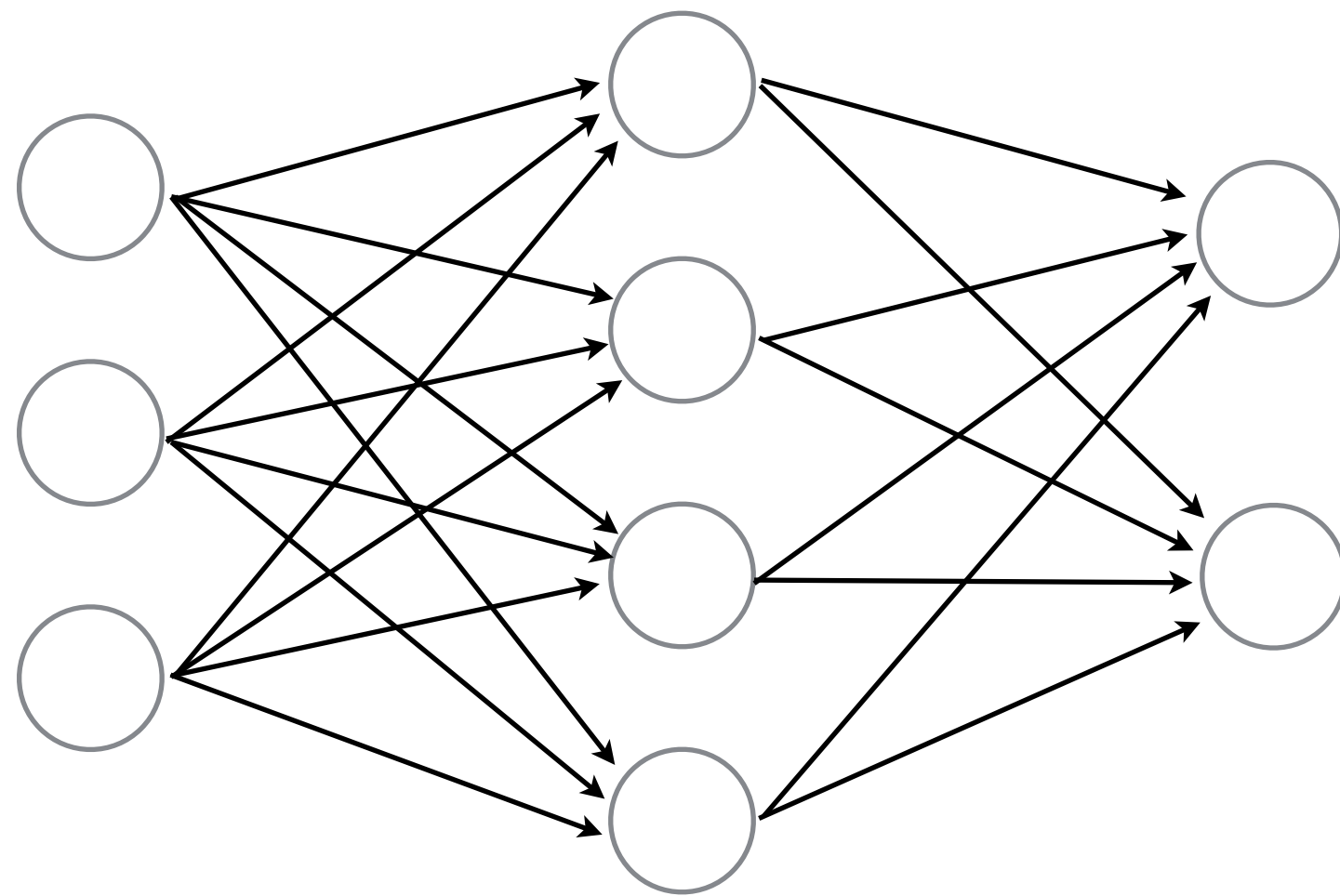


*How many learnable parameters total?*

$$20 + 4 + 2 = 26$$

bias terms

performance usually tops out at 2-3 layers,  
deeper networks don't really improve performance...



...with the exception of **convolutional** networks for images