



Neural Networks

Computer Vision

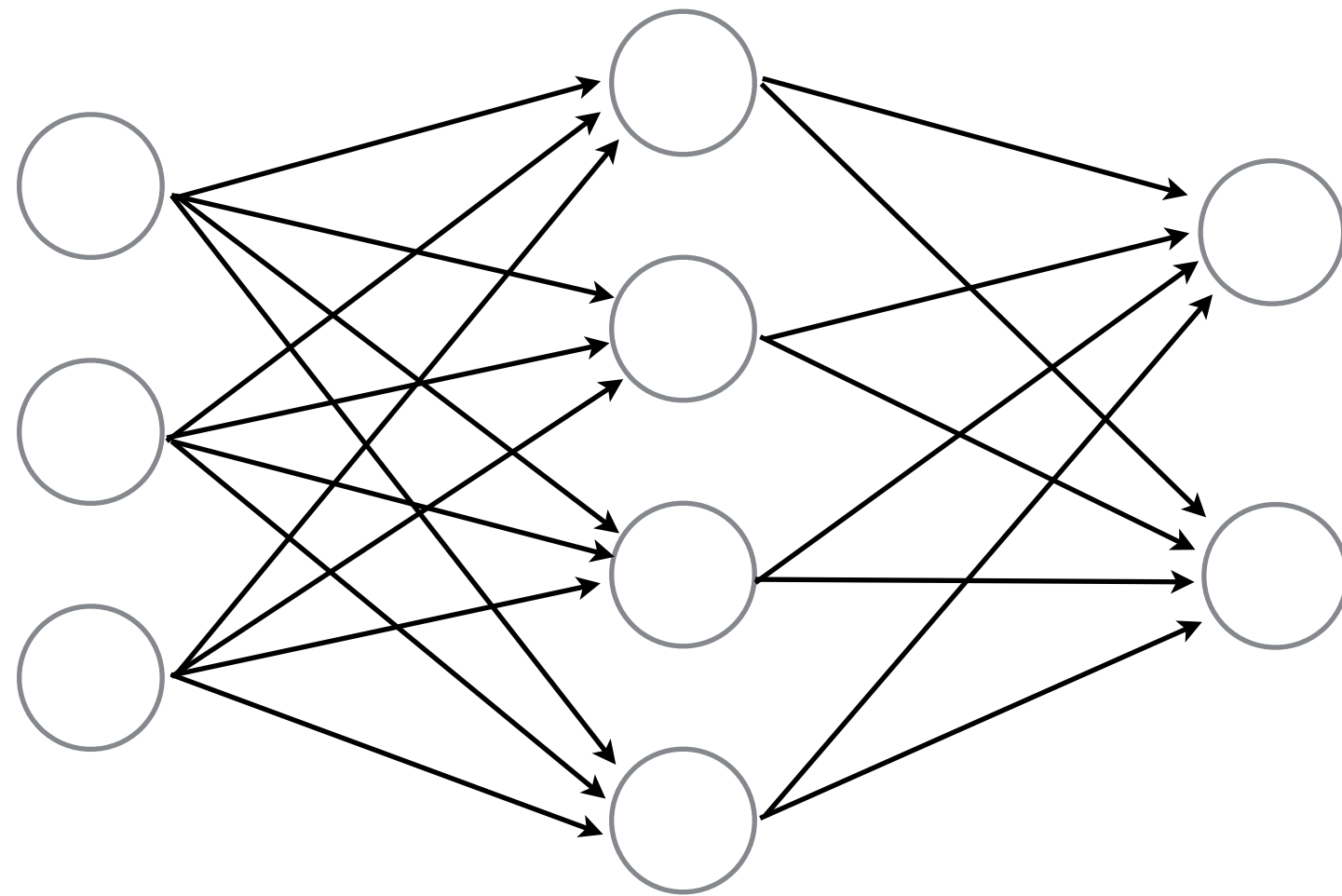
Carnegie Mellon University (Kris Kitani)

Connect a bunch of perceptrons together ...

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Neural Network

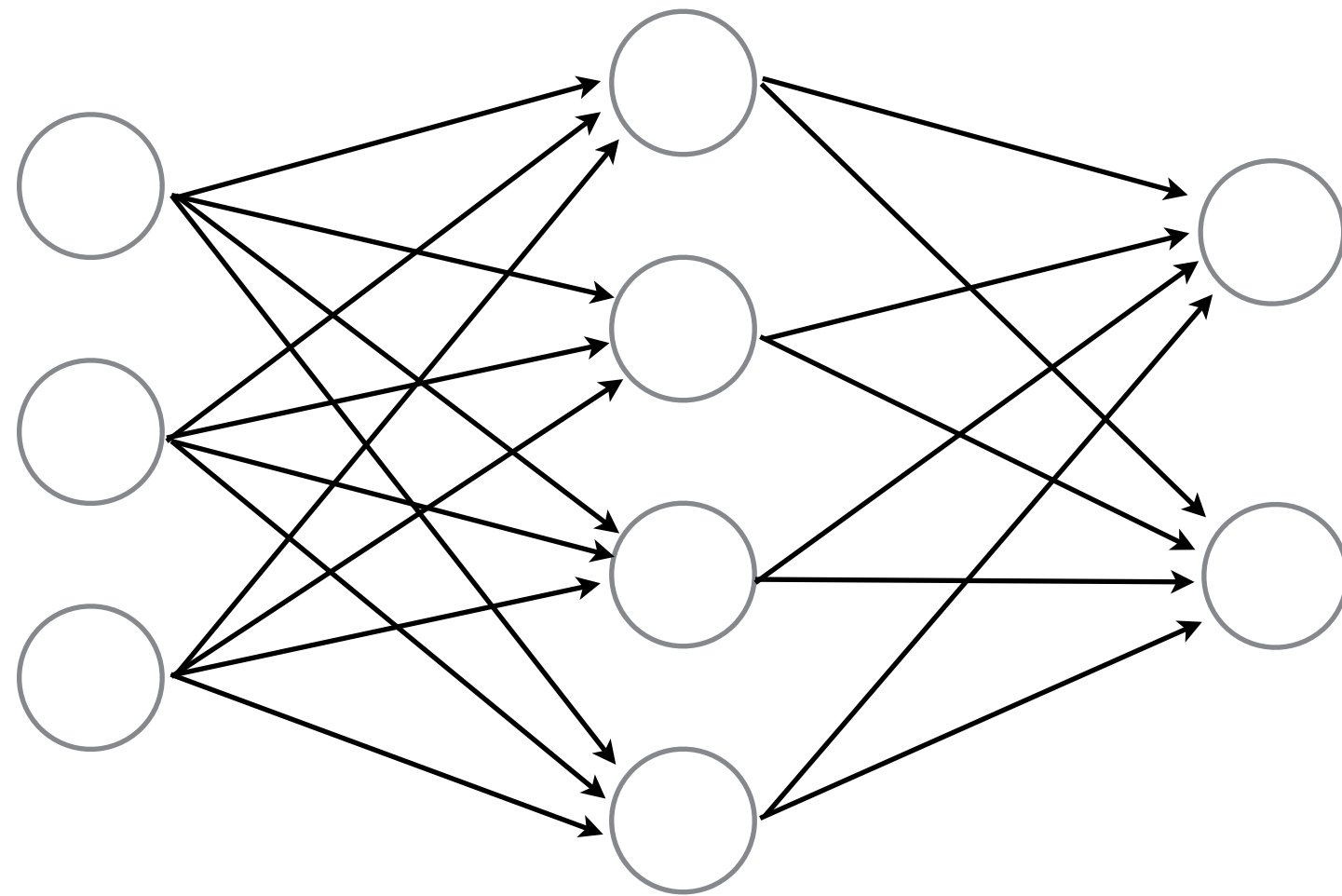
a collection of connected perceptrons



Connect a bunch of perceptrons together ...

Neural Network

a collection of connected perceptrons

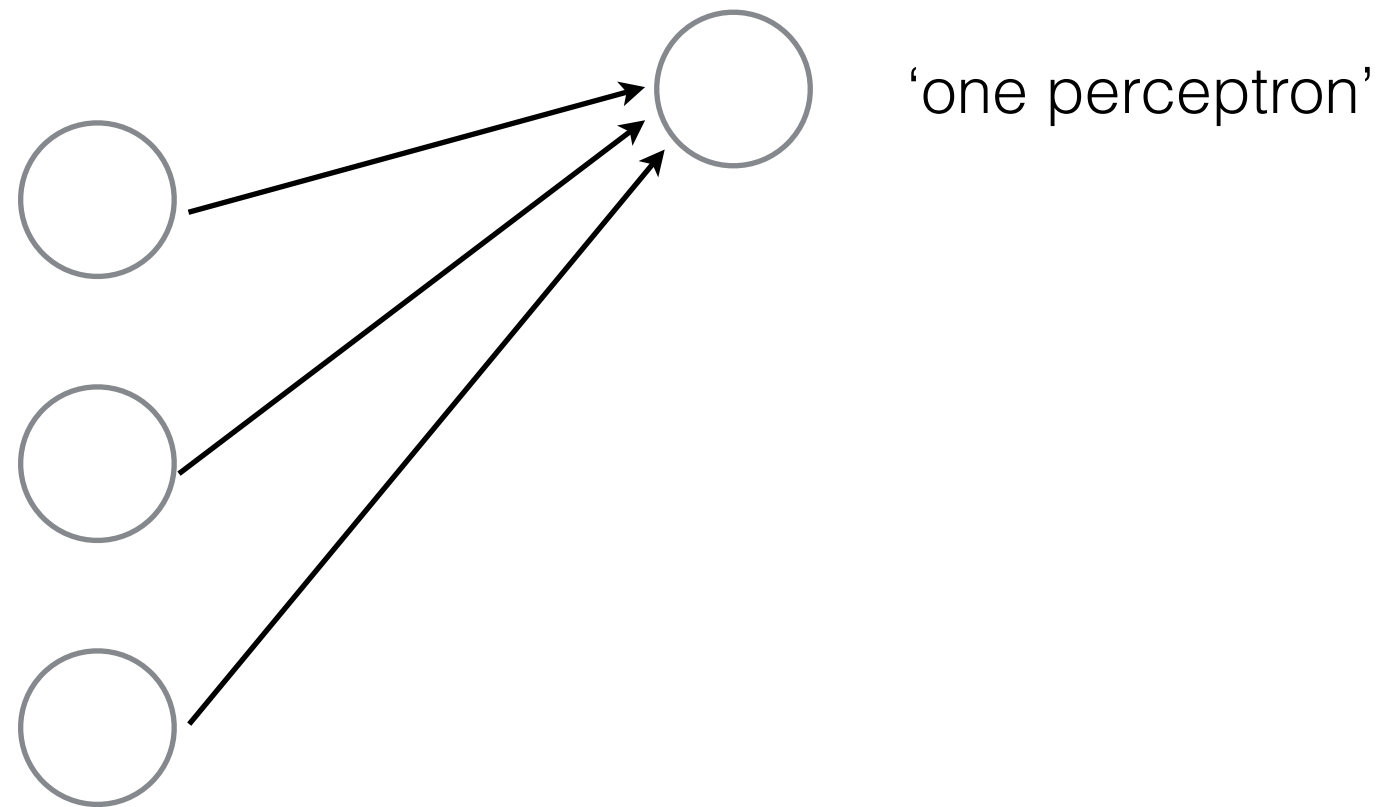


How many perceptrons in this neural network?

Connect a bunch of perceptrons together ...

Neural Network

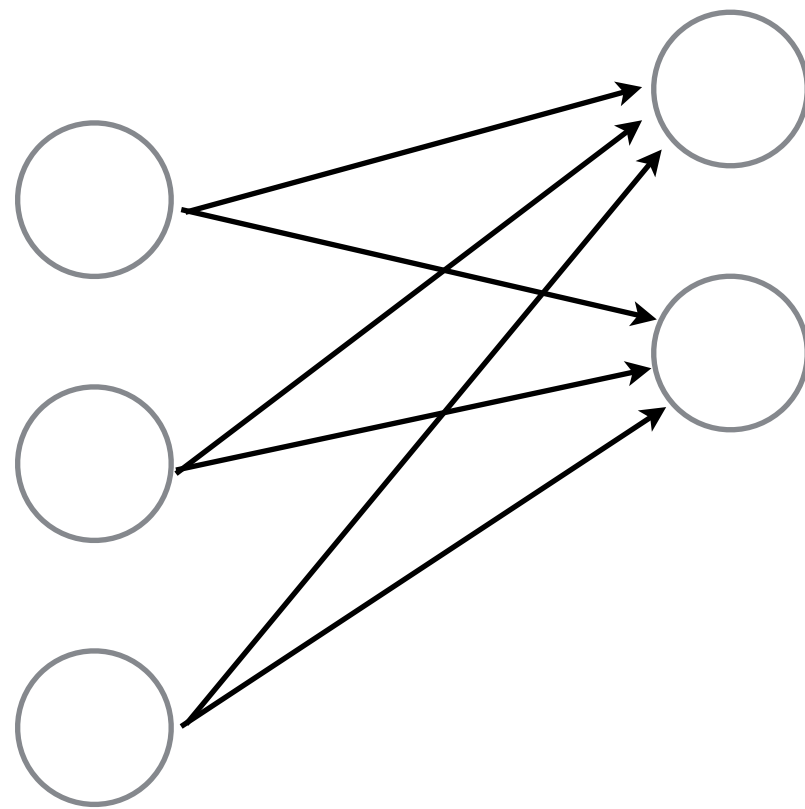
a collection of connected perceptrons



Connect a bunch of perceptrons together ...

Neural Network

a collection of connected perceptrons



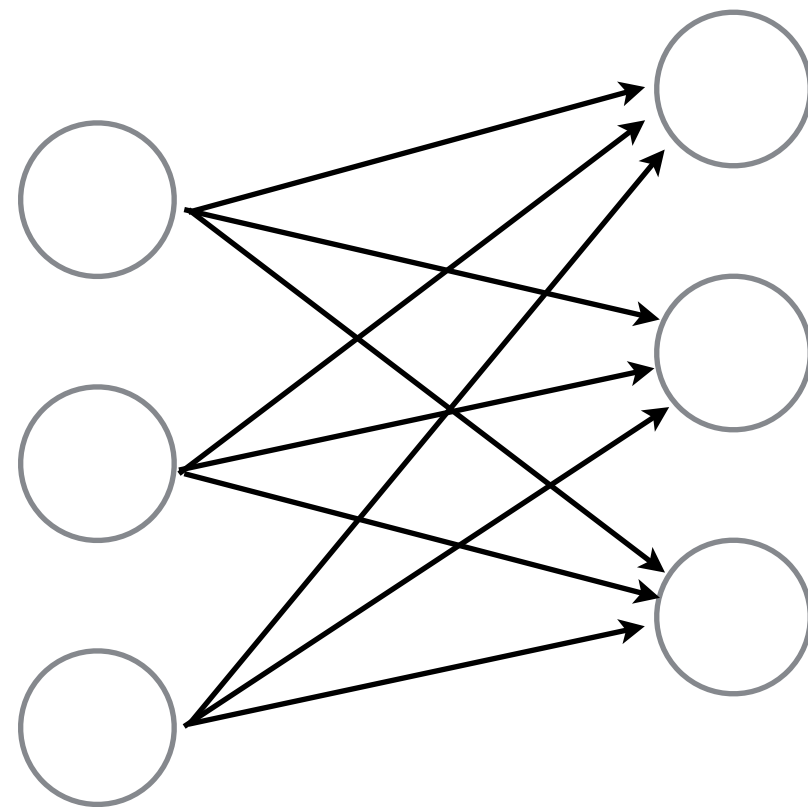
'two perceptrons'



Connect a bunch of perceptrons together ...

Neural Network

a collection of connected perceptrons



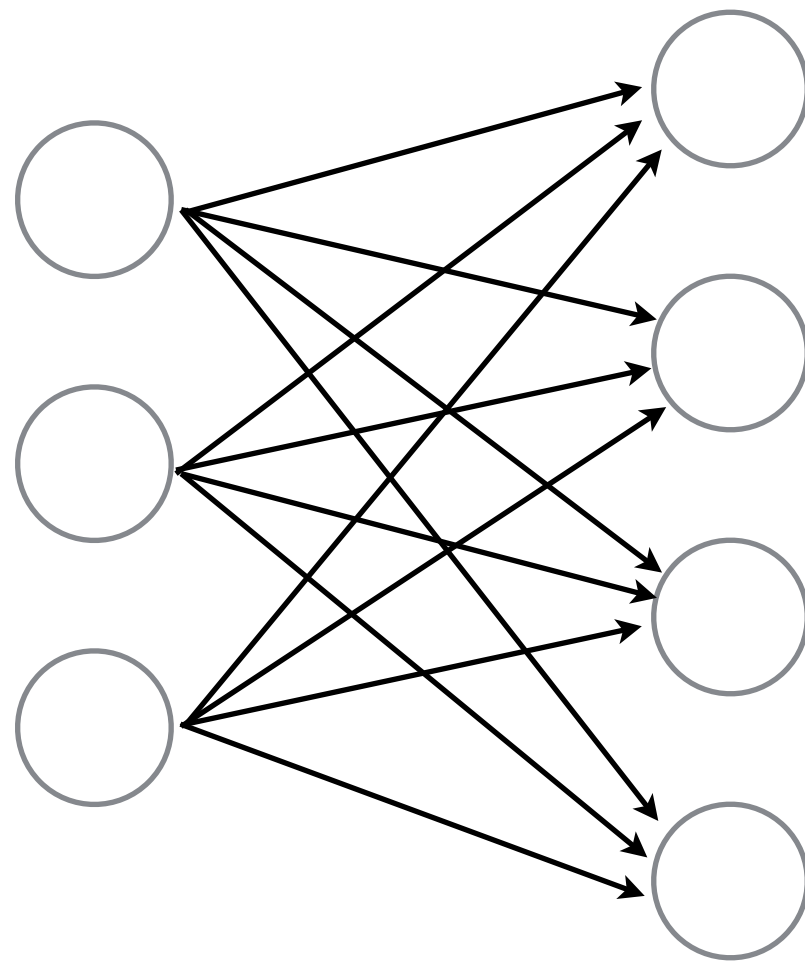
'three perceptrons'



Connect a bunch of perceptrons together ...

Neural Network

a collection of connected perceptrons



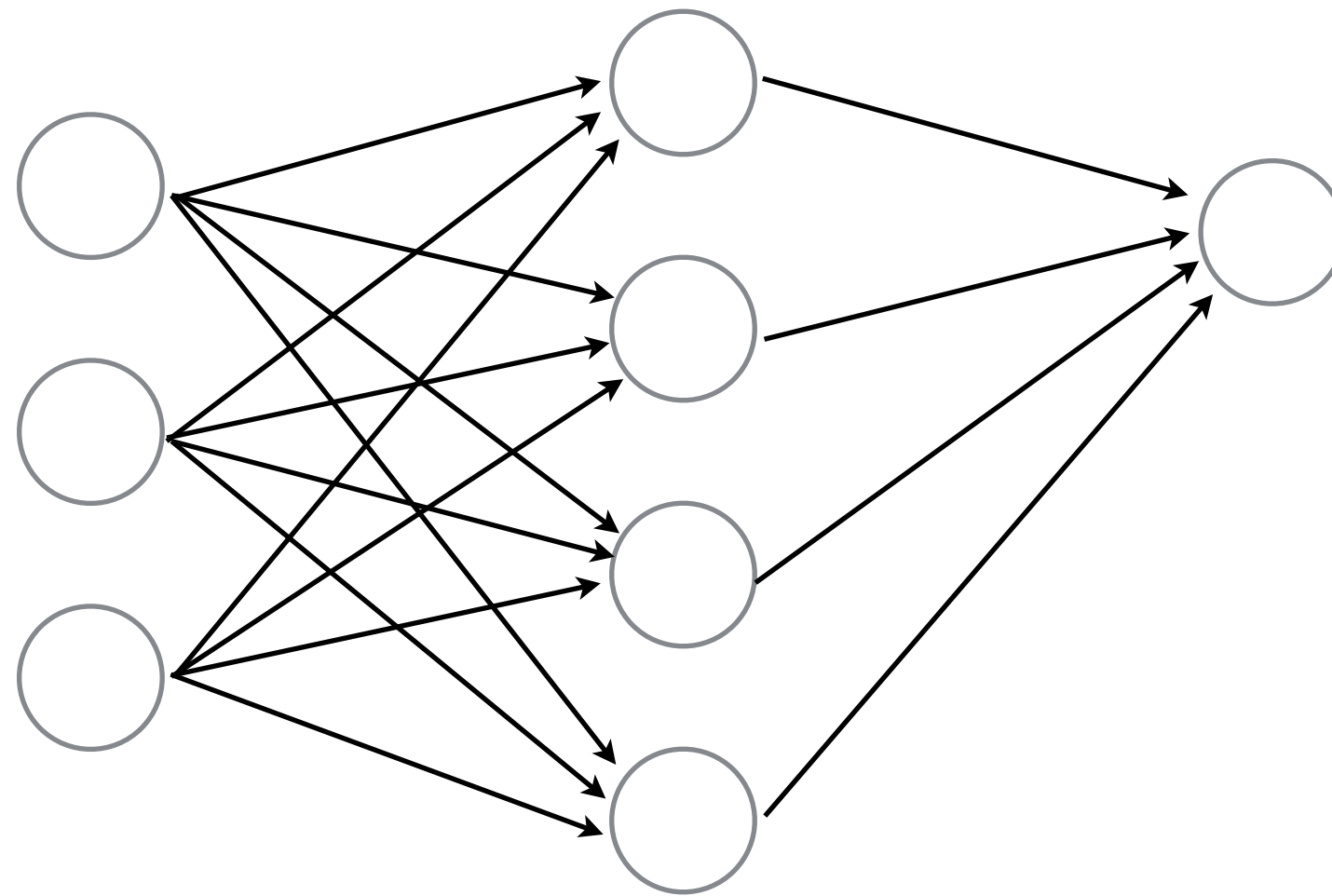
'four perceptrons'



Connect a bunch of perceptrons together ...

Neural Network

a collection of connected perceptrons



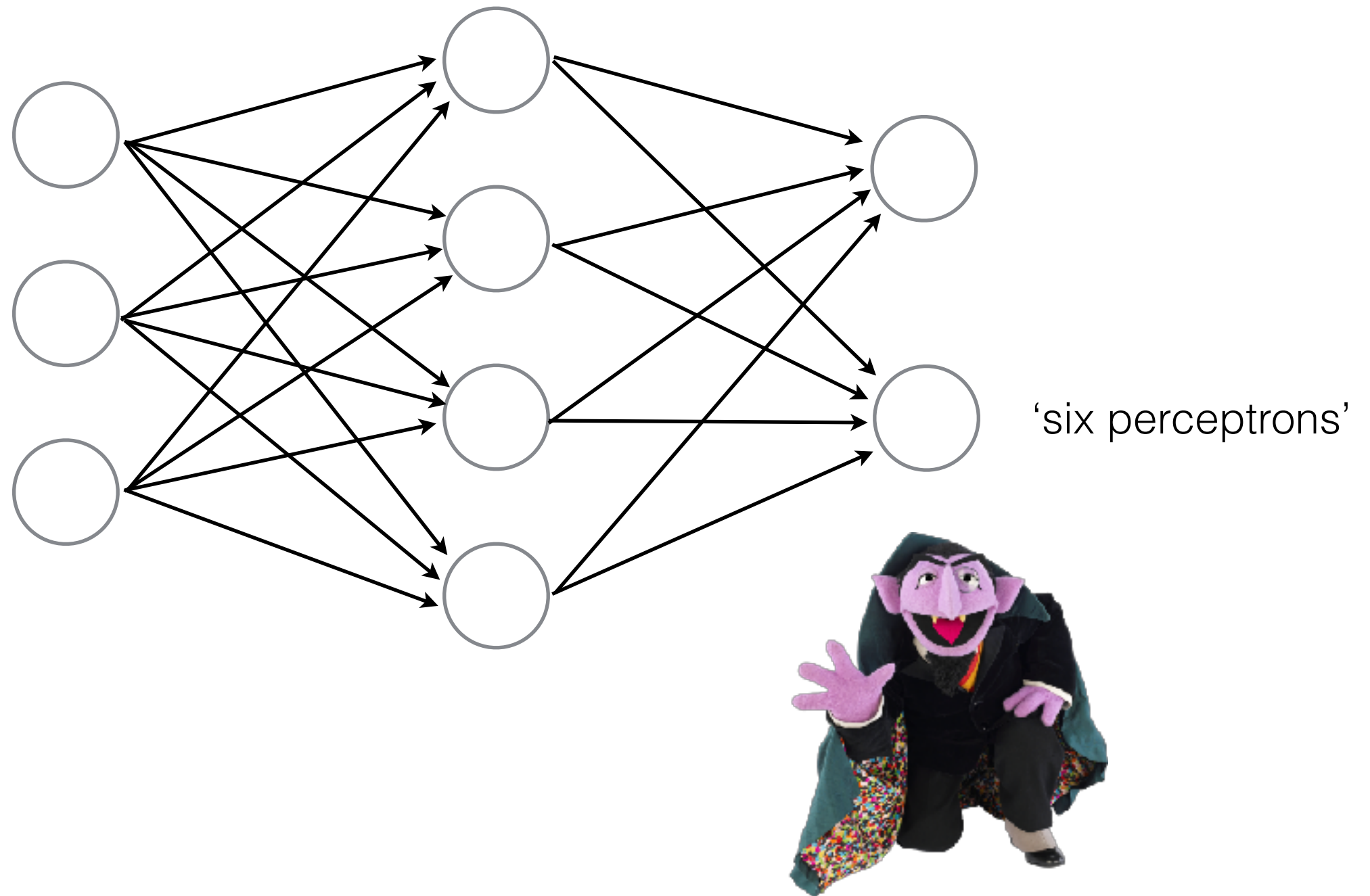
‘five perceptrons’



Connect a bunch of perceptrons together ...

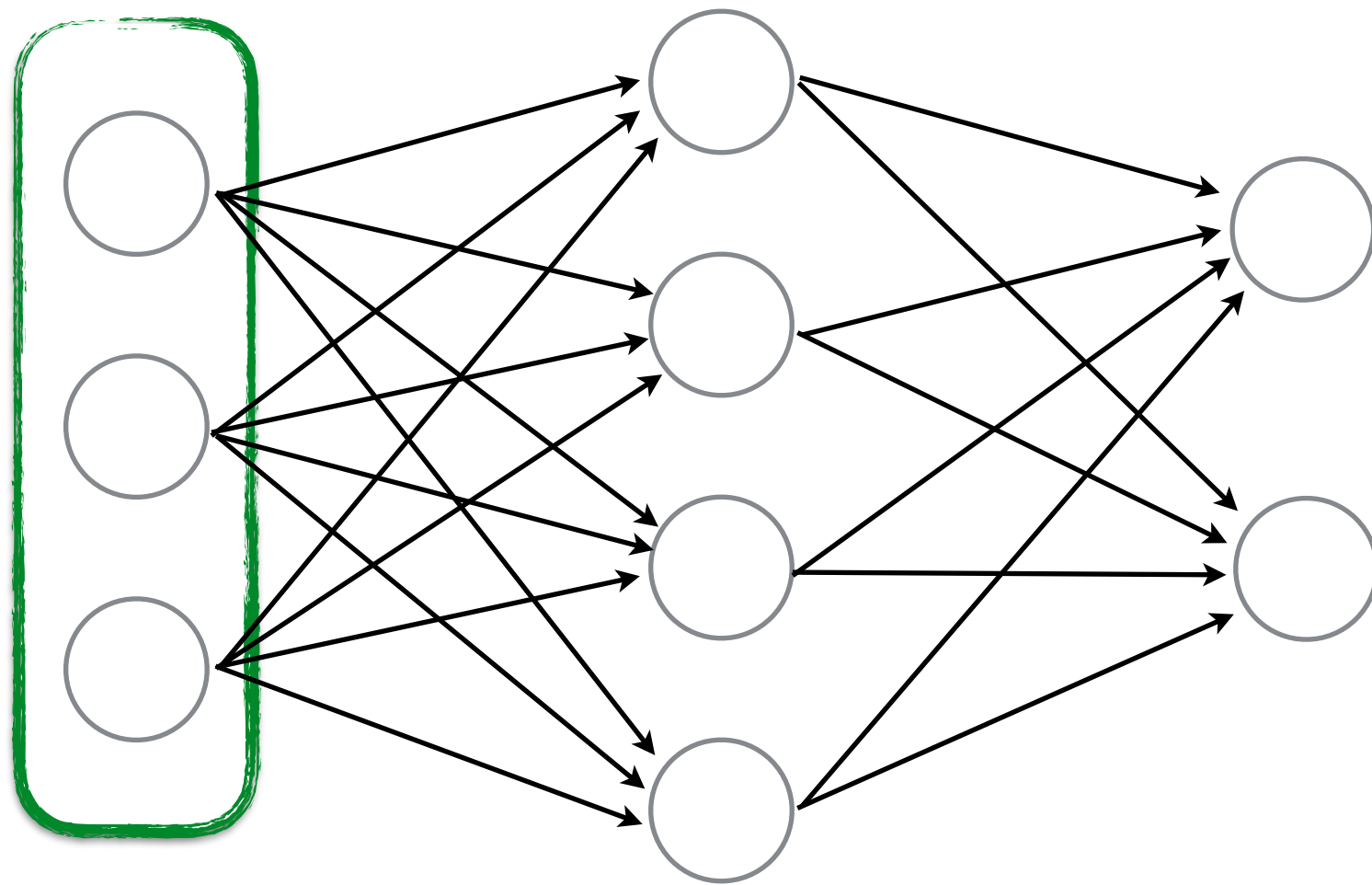
Neural Network

a collection of connected perceptrons



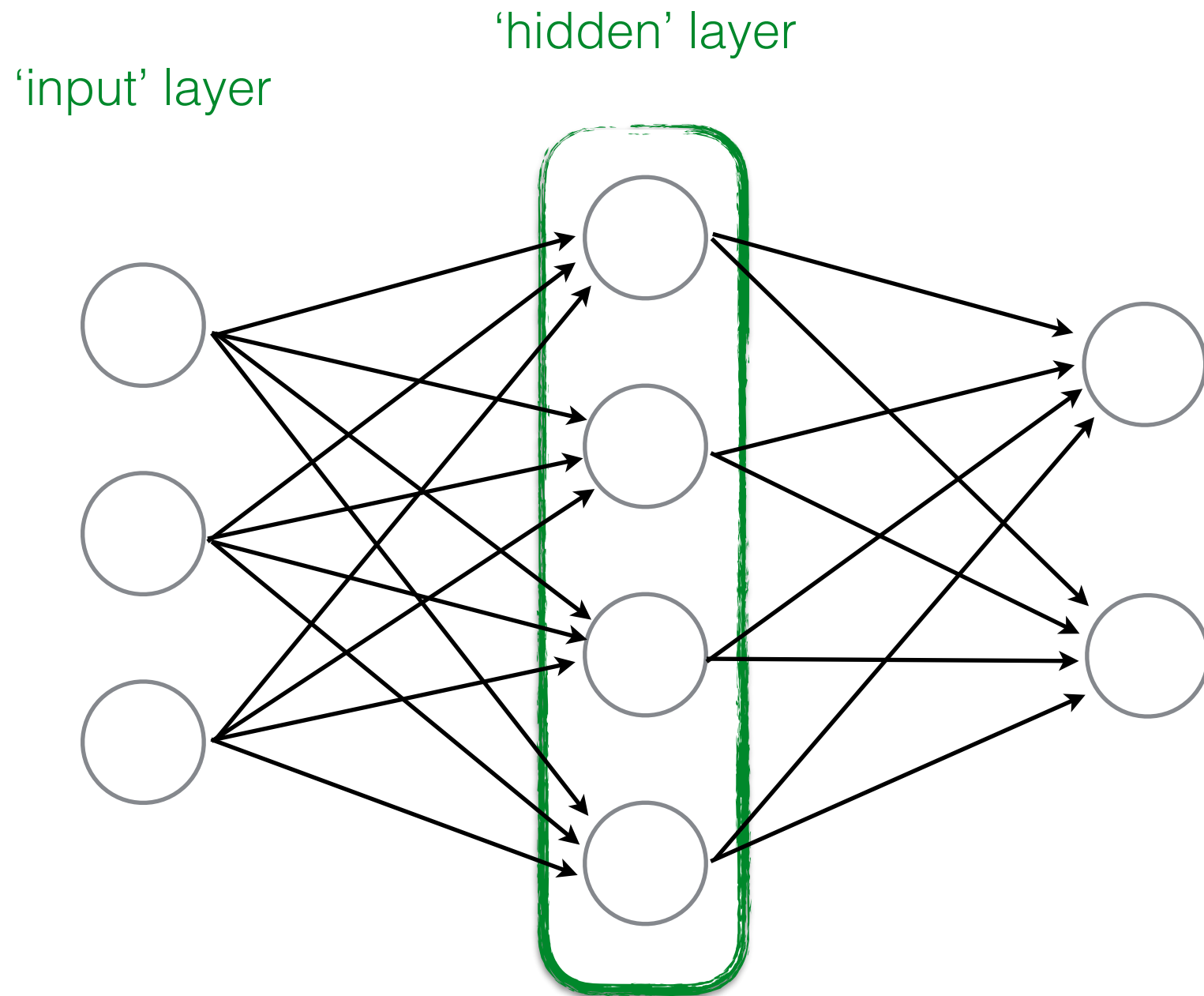
Some terminology...

'input' layer



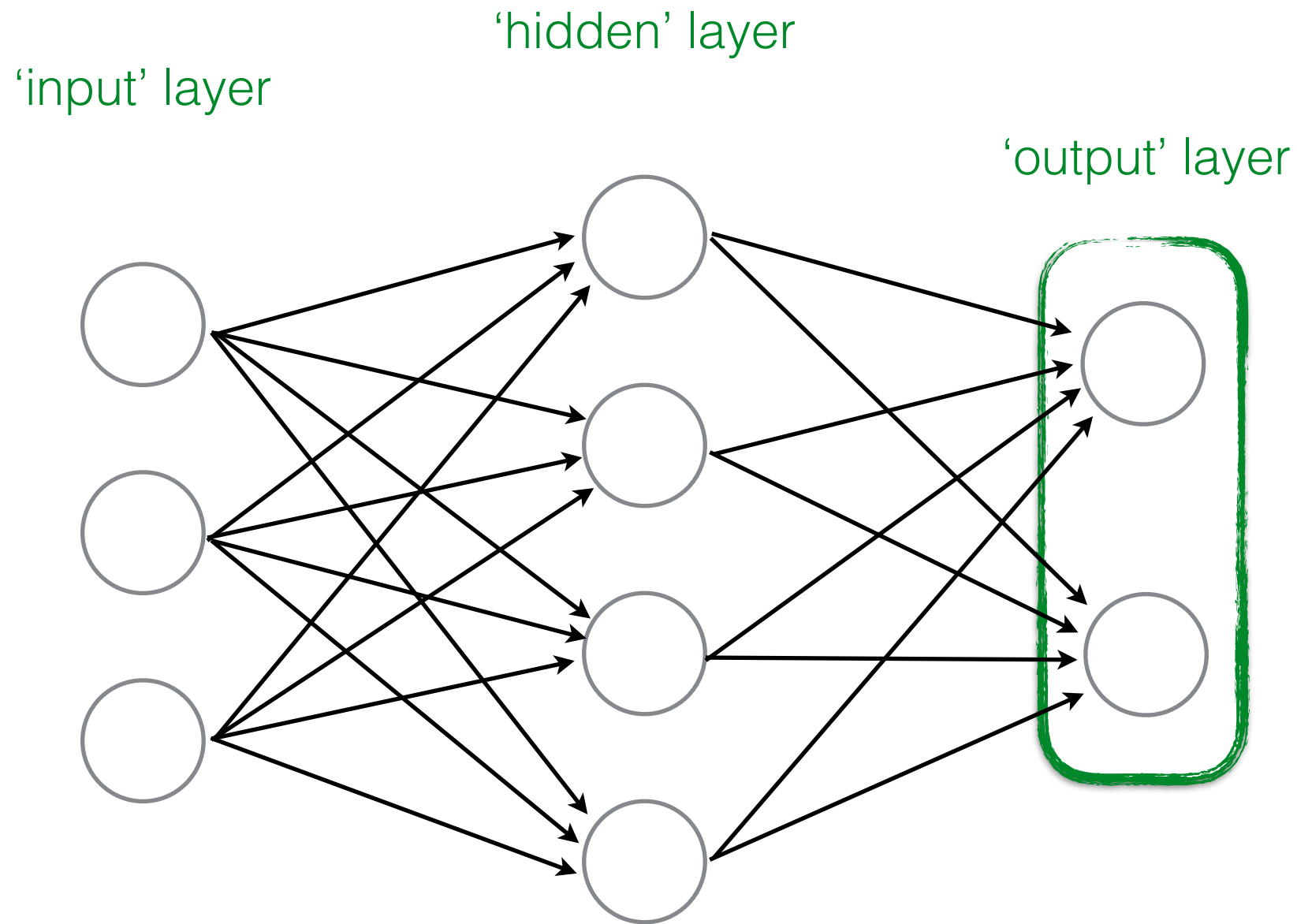
...also called a **Multi-layer Perceptron** (MLP)

Some terminology...



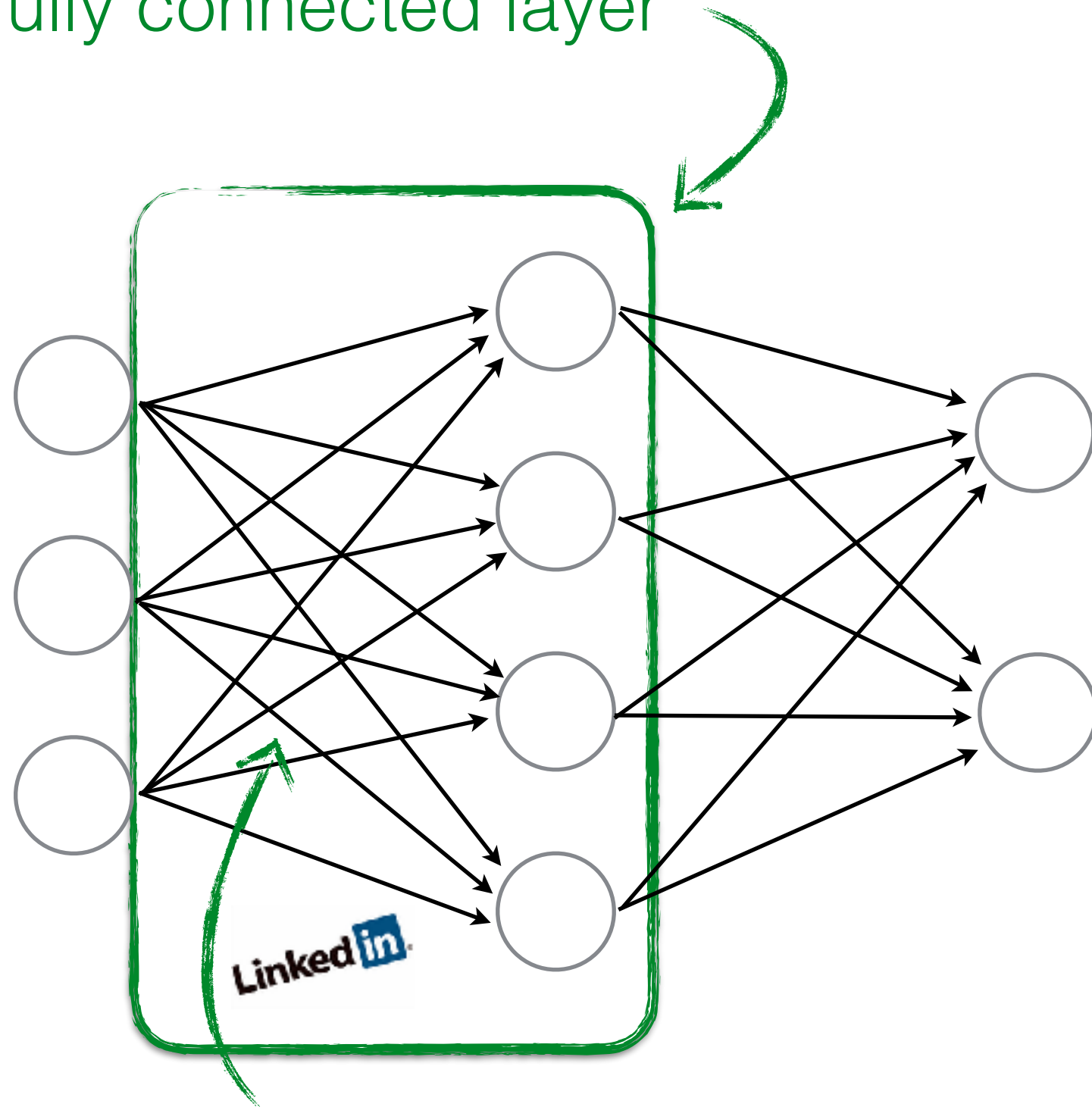
...also called a **Multi-layer Perceptron** (MLP)

Some terminology...

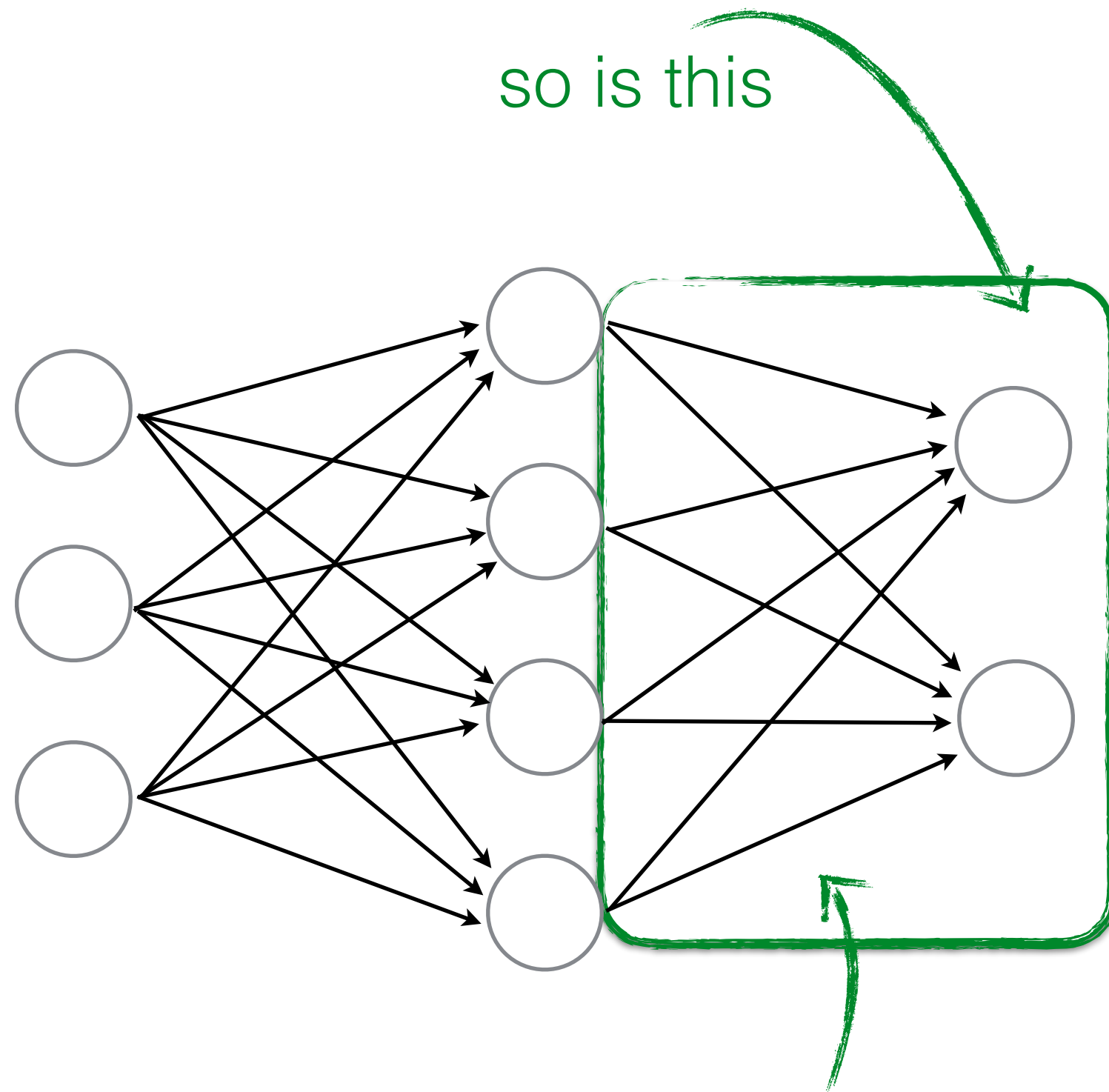


...also called a **Multi-layer Perceptron** (MLP)

this layer is a
'fully connected layer'



all pairwise neurons between layers are connected

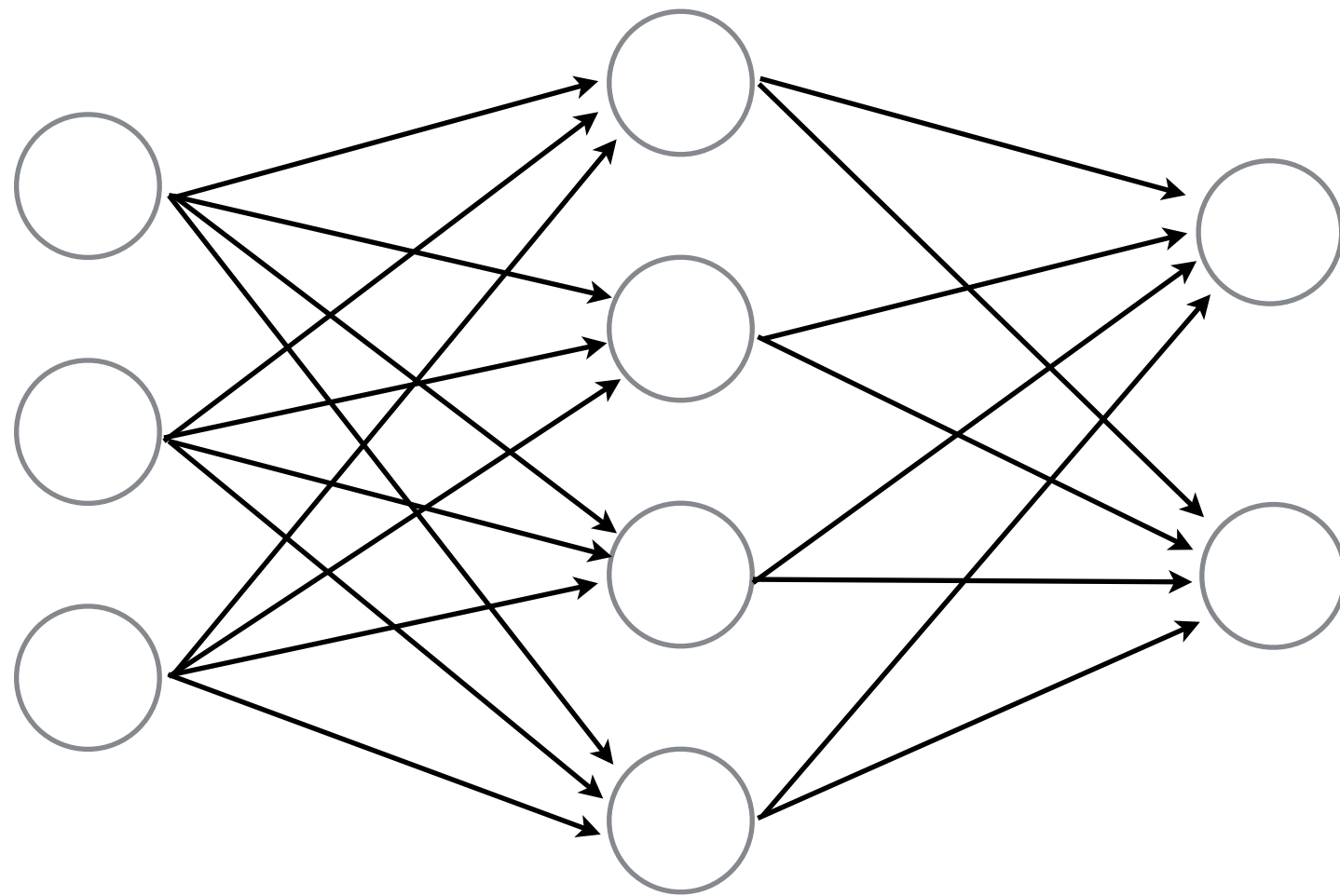


so is this

all pairwise neurons between layers are connected

How many neurons (perceptrons)?

How many weights (edges)?

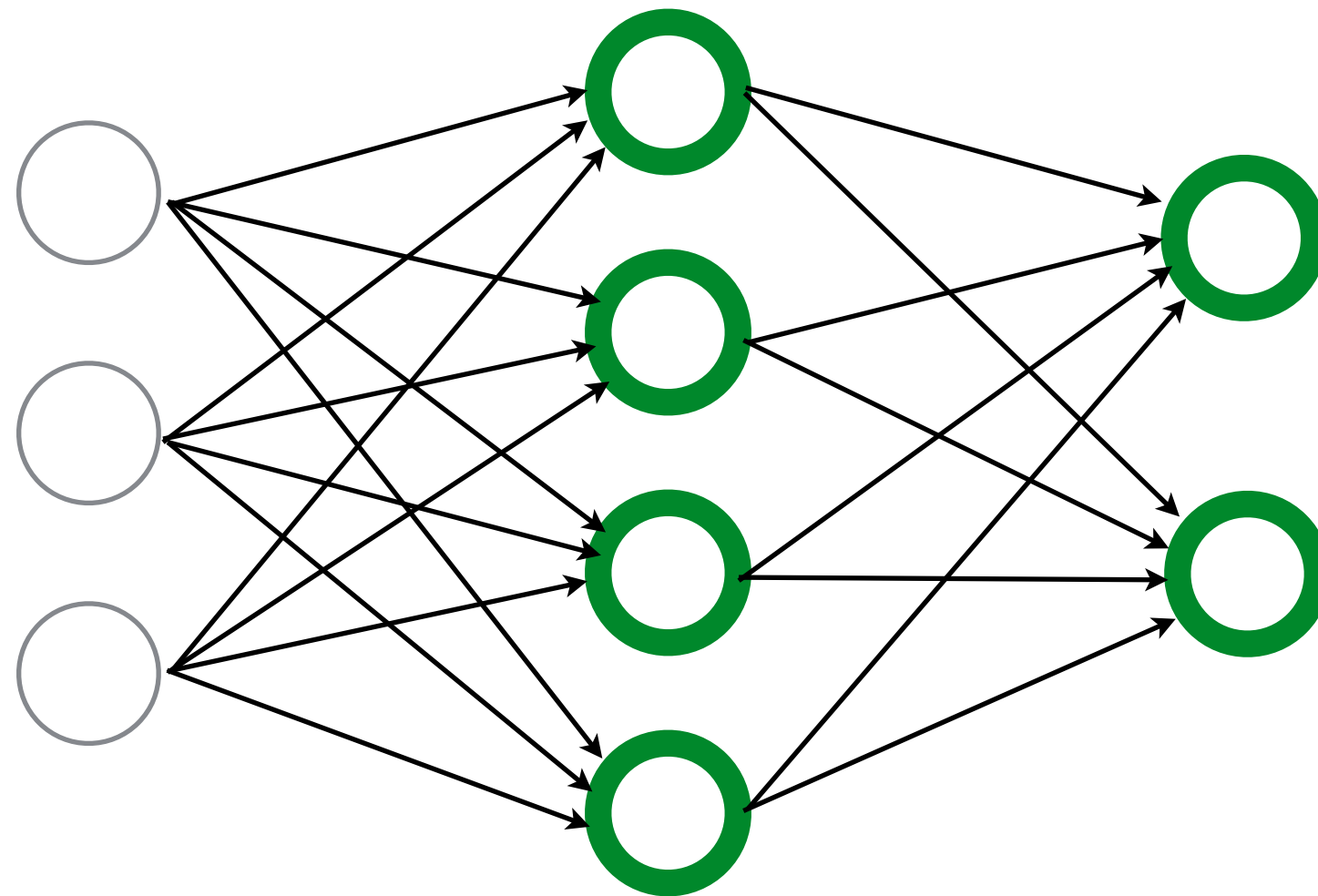


How many learnable parameters total?

How many neurons (perceptrons)?

$$4 + 2 = 6$$

How many weights (edges)?



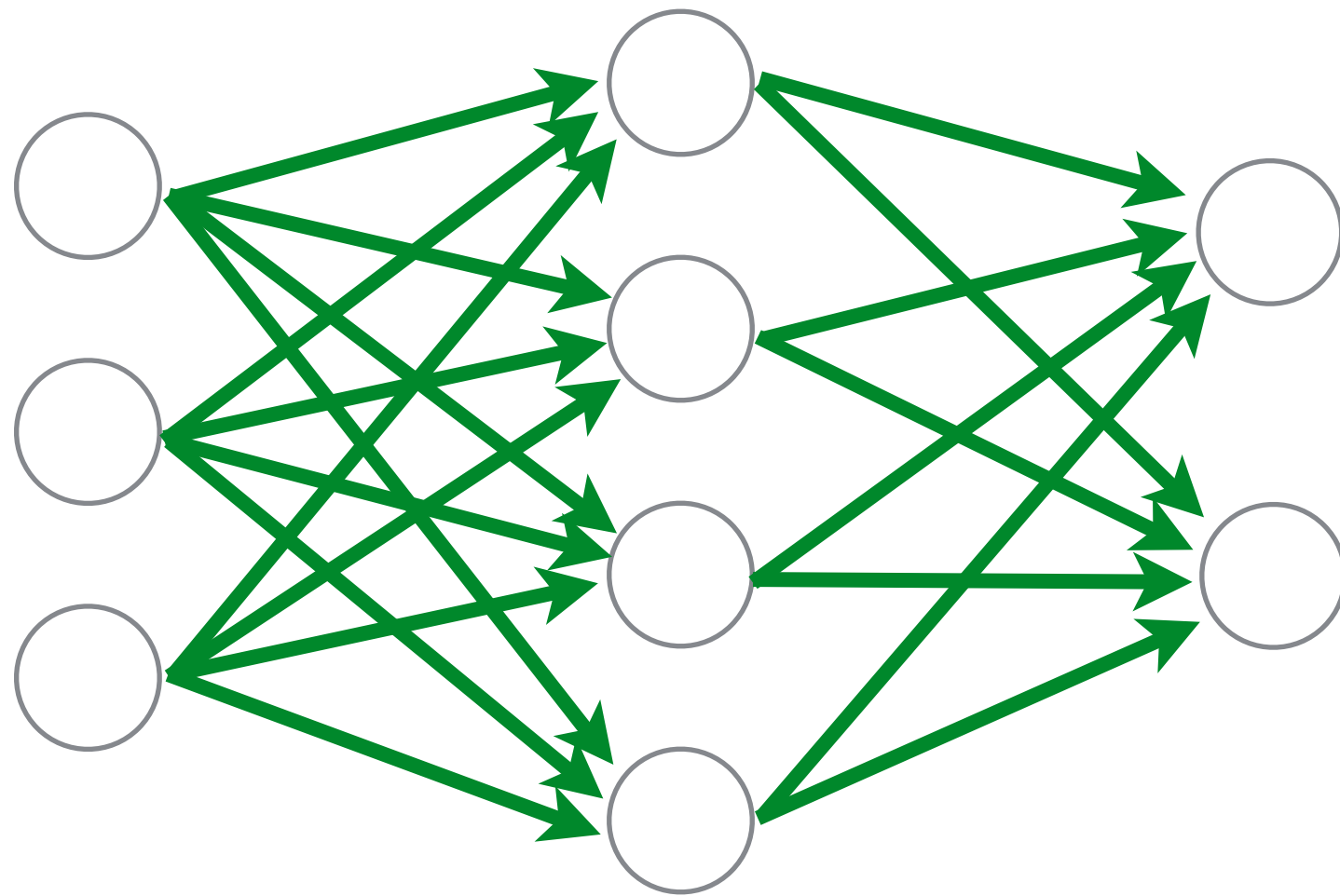
How many learnable parameters total?

How many neurons (perceptrons)?

$$4 + 2 = 6$$

How many weights (edges)?

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



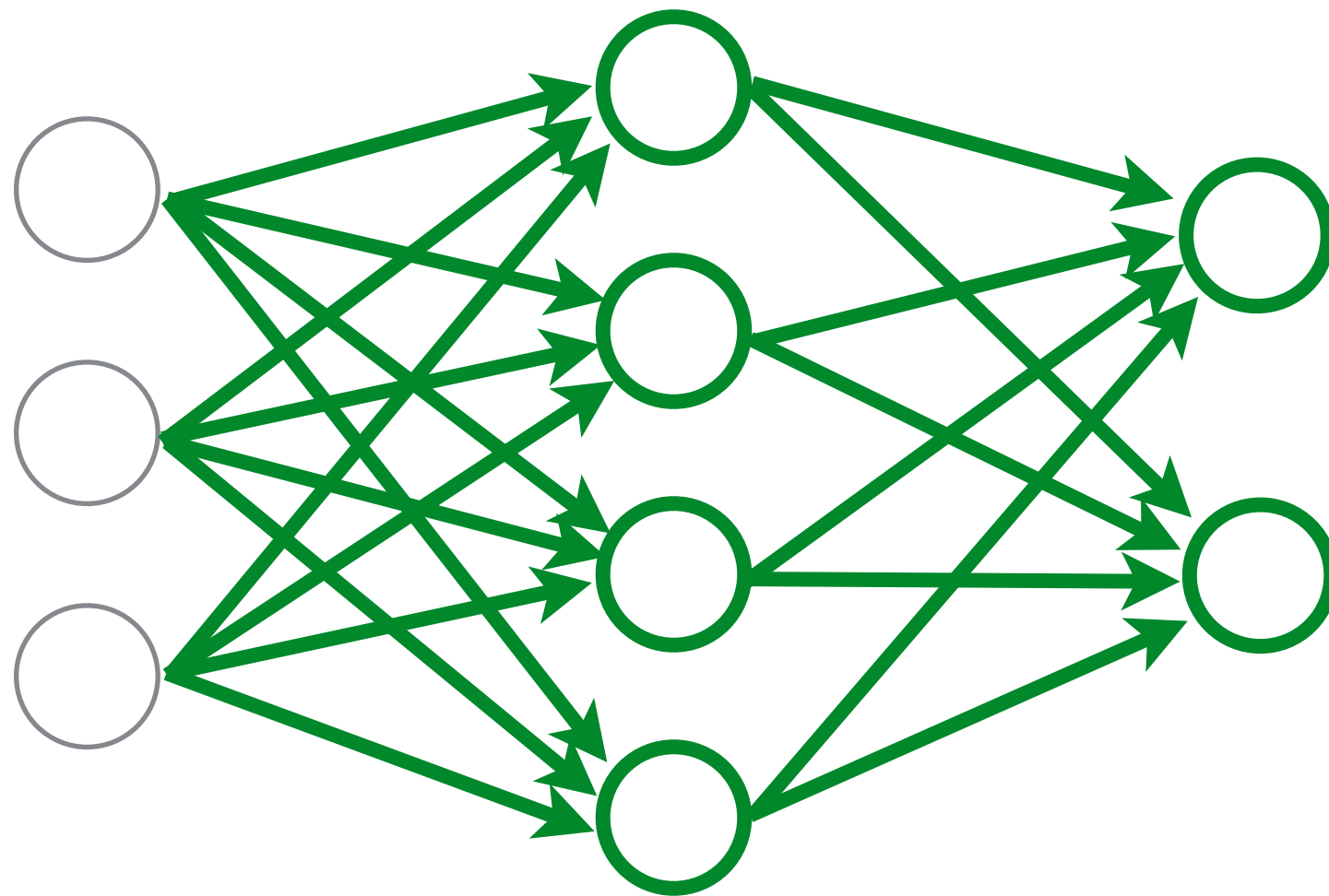
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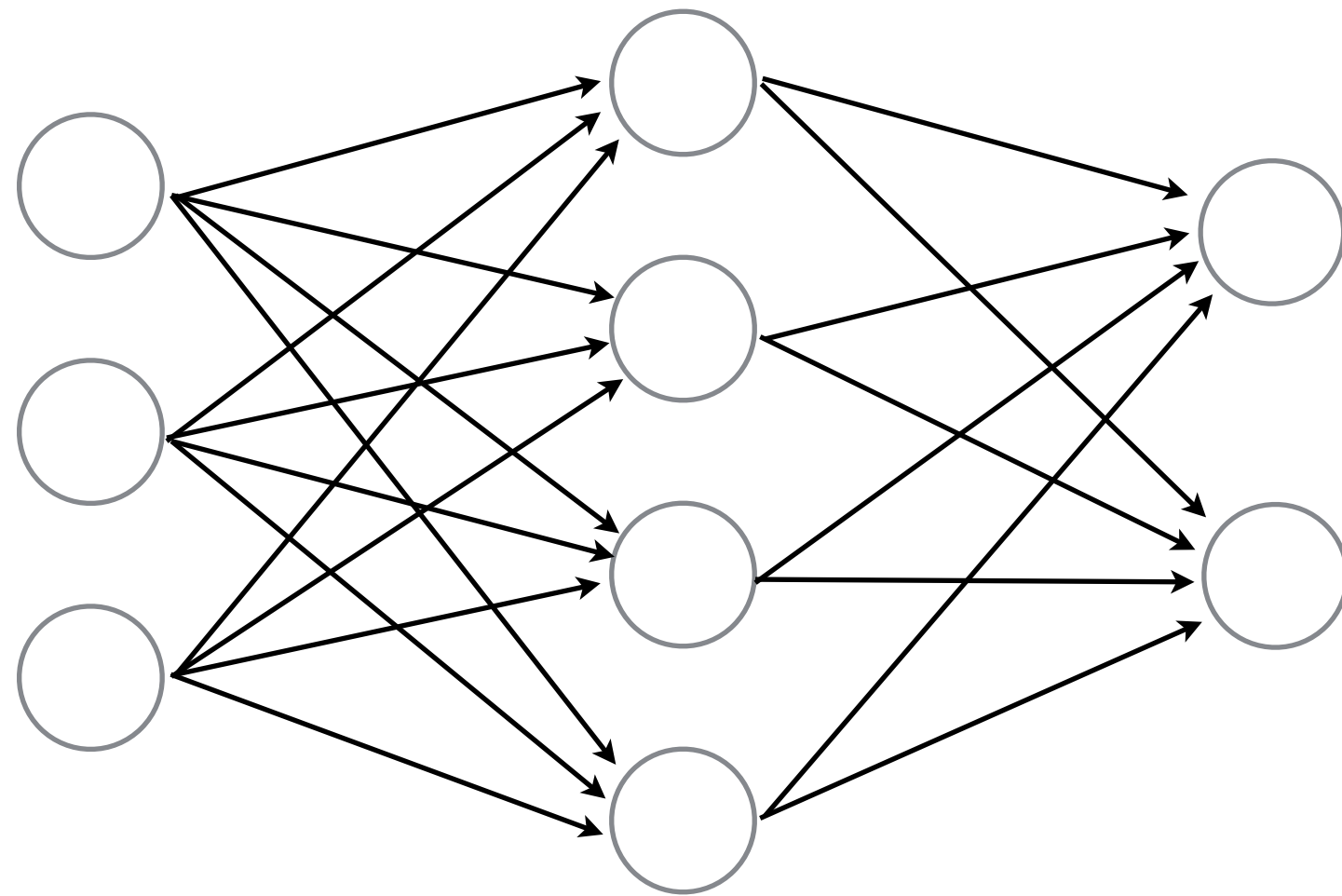


How many learnable parameters total?

$$20 + 4 + 2 = 26$$

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