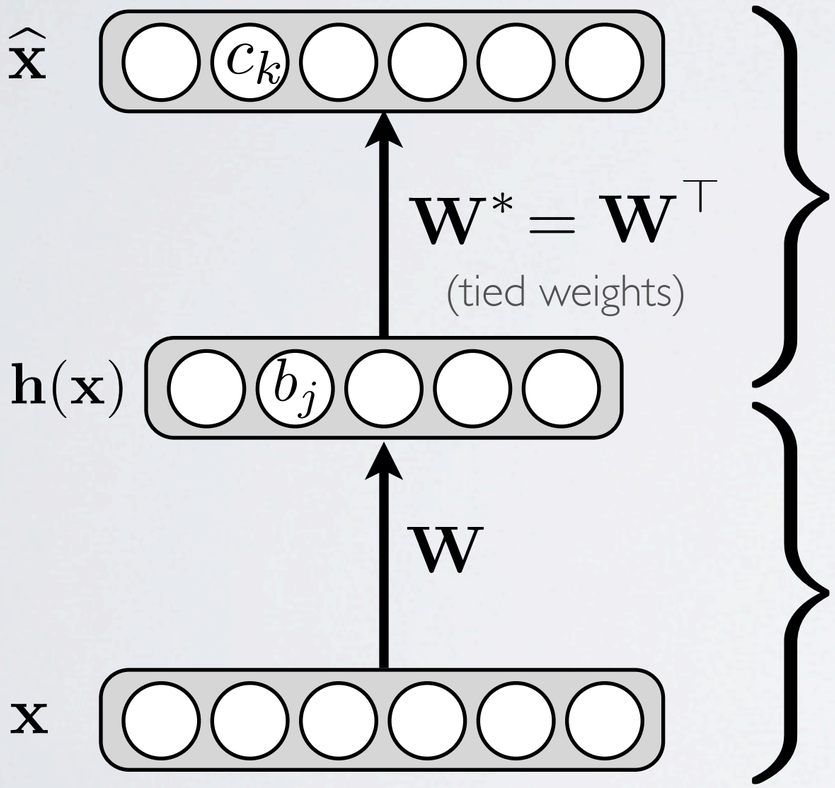
# Neural networks

Autoencoder - undercomplete vs. overcomplete hidden layer

# AUTOENCODER

**Topics:** autoencoder, encoder, decoder, tied weights

- Feed-forward neural network trained to reproduce its input at the output layer




Decoder

$$\begin{aligned}\hat{\mathbf{x}} &= o(\hat{\mathbf{a}}(\mathbf{x})) \\ &= \underbrace{\mathrm{sigm}}_{\text{for binary inputs}}(\mathbf{c} + \mathbf{W}^*\mathbf{h}(\mathbf{x}))\end{aligned}$$

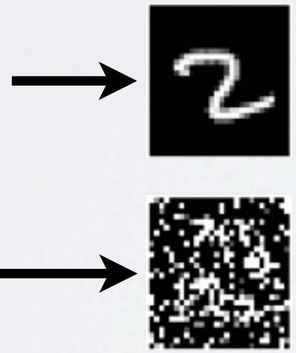
Encoder

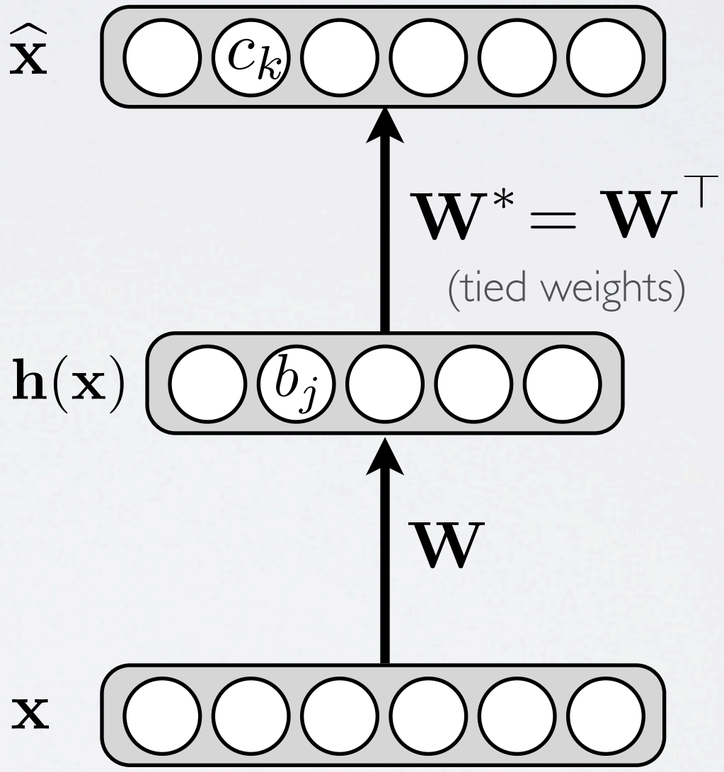
$$\begin{aligned}\mathbf{h}(\mathbf{x}) &= g(\mathbf{a}(\mathbf{x})) \\ &= \mathrm{sigm}(\mathbf{b} + \mathbf{W}\mathbf{x})\end{aligned}$$

# UNDERCOMPLETE HIDDEN LAYER

**Topics:** undercomplete representation

- Hidden layer is undercomplete if smaller than the input layer
  - hidden layer "compresses" the input
  - will compress well only for the training distribution
- Hidden units will be
  - good features for the training distribution
  - but bad for other types of input





# OVERCOMPLETE HIDDEN LAYER

**Topics:** overcomplete representation

- Hidden layer is overcomplete if greater than the input layer
  - no compression in hidden layer
  - each hidden unit could copy a different input component
- No guarantee that the hidden units will extract meaningful structure