

*FCEN, UBA*

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# Representation Learning

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Cecilia Garraffo

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# Outline

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- ❖ Representaciones en MLP y CNNs
- ❖ Autodecodificadores
- ❖ Modelos Multimodales
- ❖ Aprendizaje por contraste
- ❖ Series de Tiempo / Transformers
- ❖ Aplicaciones en Astronomia en Rayos-X

## Inteligencia Artificial

La capacidad de una máquina para realizar tareas que requieren razonamiento o aprendizaje humano.

## Machine Learning

La capacidad de una máquina de aprender a tomar decisiones informadas.

## Redes Neuronales

Un tipo de modelo inspirado en el cerebro que procesa información mediante capas de nodos conectados.

## Deep Learning

Redes neuronales con múltiples capas que permiten aprender representaciones complejas de datos.

## Modelos DL Probabilísticos

## IA Generativa

# IA Generativa



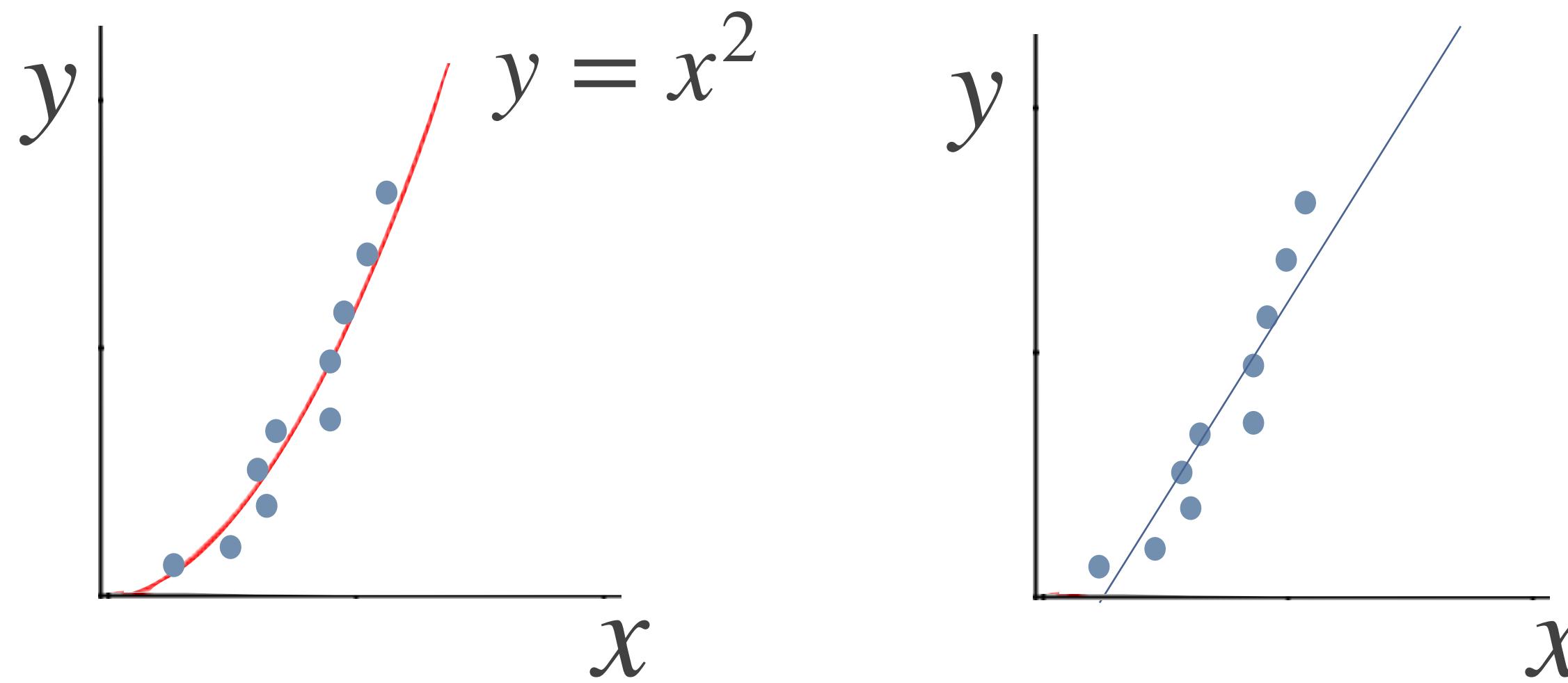
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# Recap

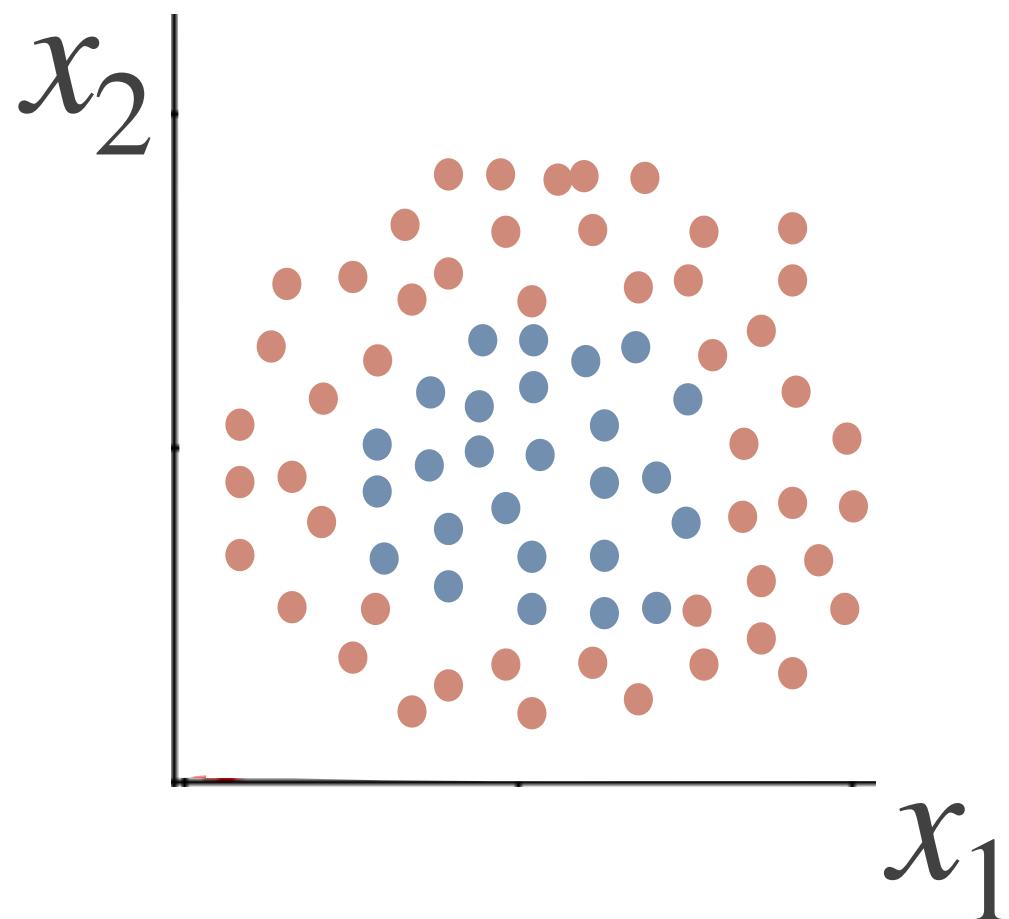
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- ❖ Modelos Semi-supervisados
- ❖ Redes Neuronales Fisicamente Informadas (PINNs)
- ❖ Redes Neuronales Hamiltonianas (HNNs)
- ❖ Redes Neuronales Lagrangianas (LNNs)
- ❖ Redes Equivariantes y bias inductivos

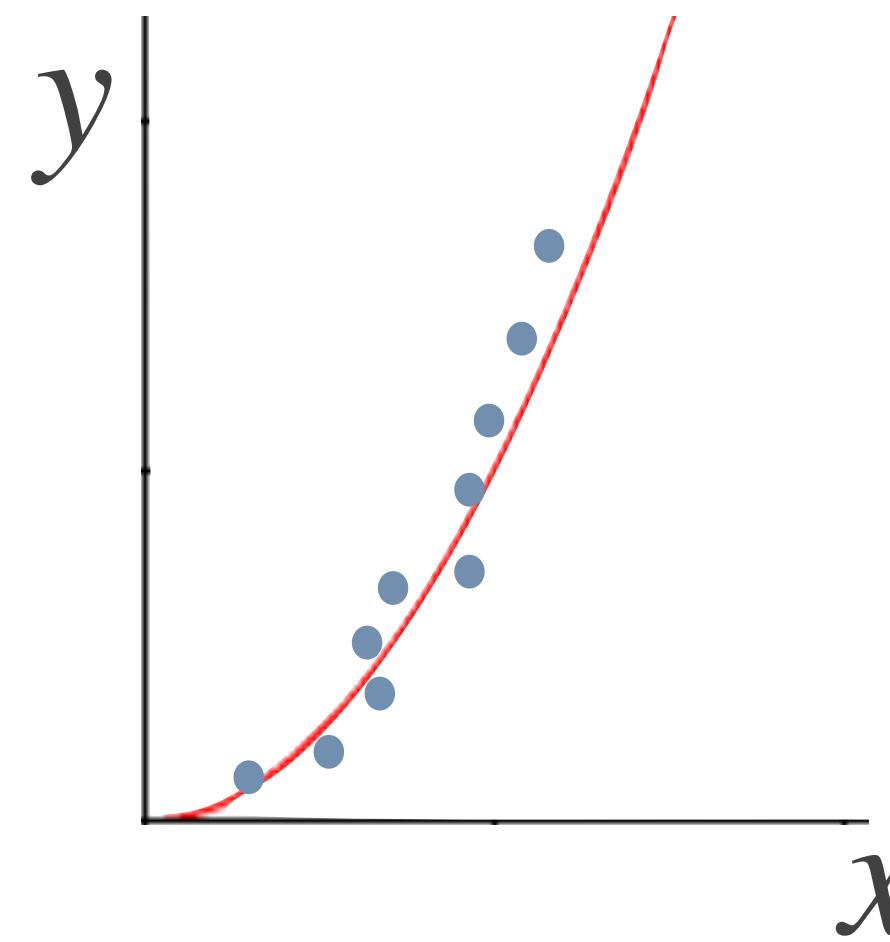
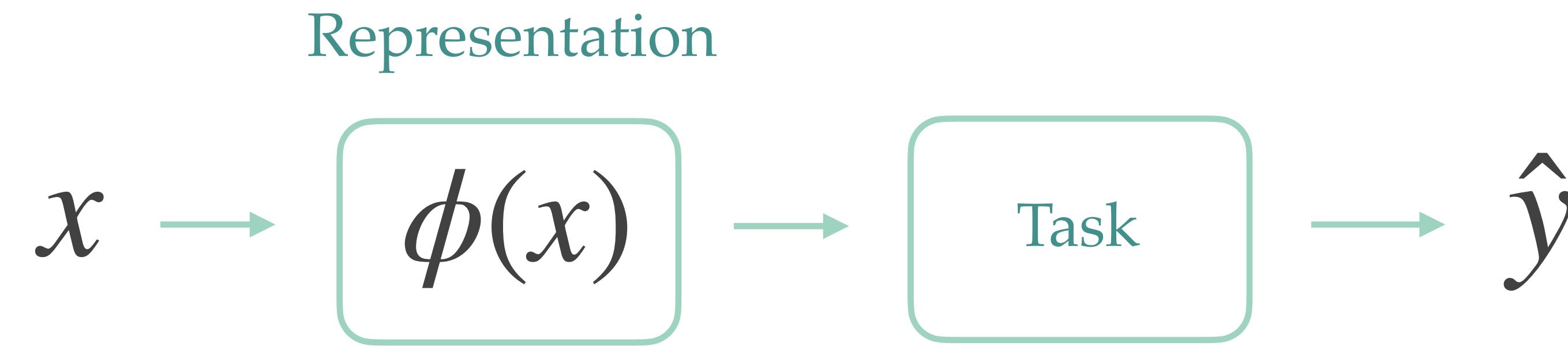
# MLP: Representation Learning



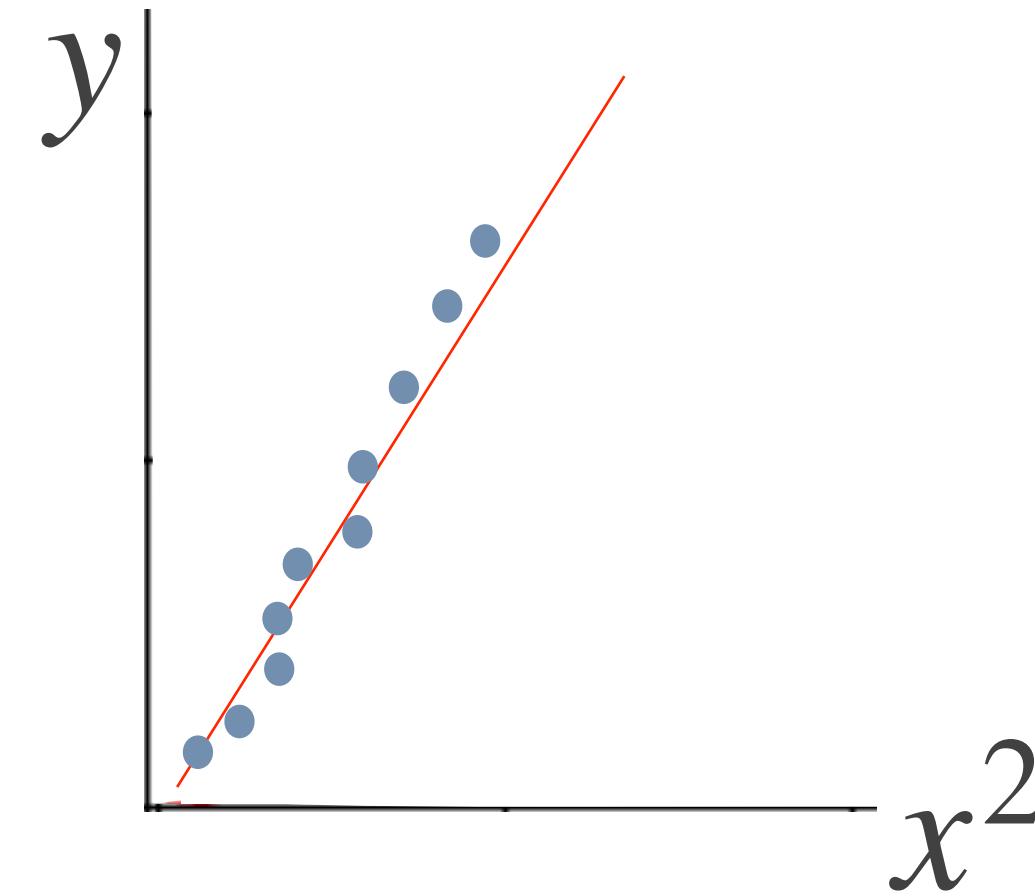
# MLP: Representation Learning



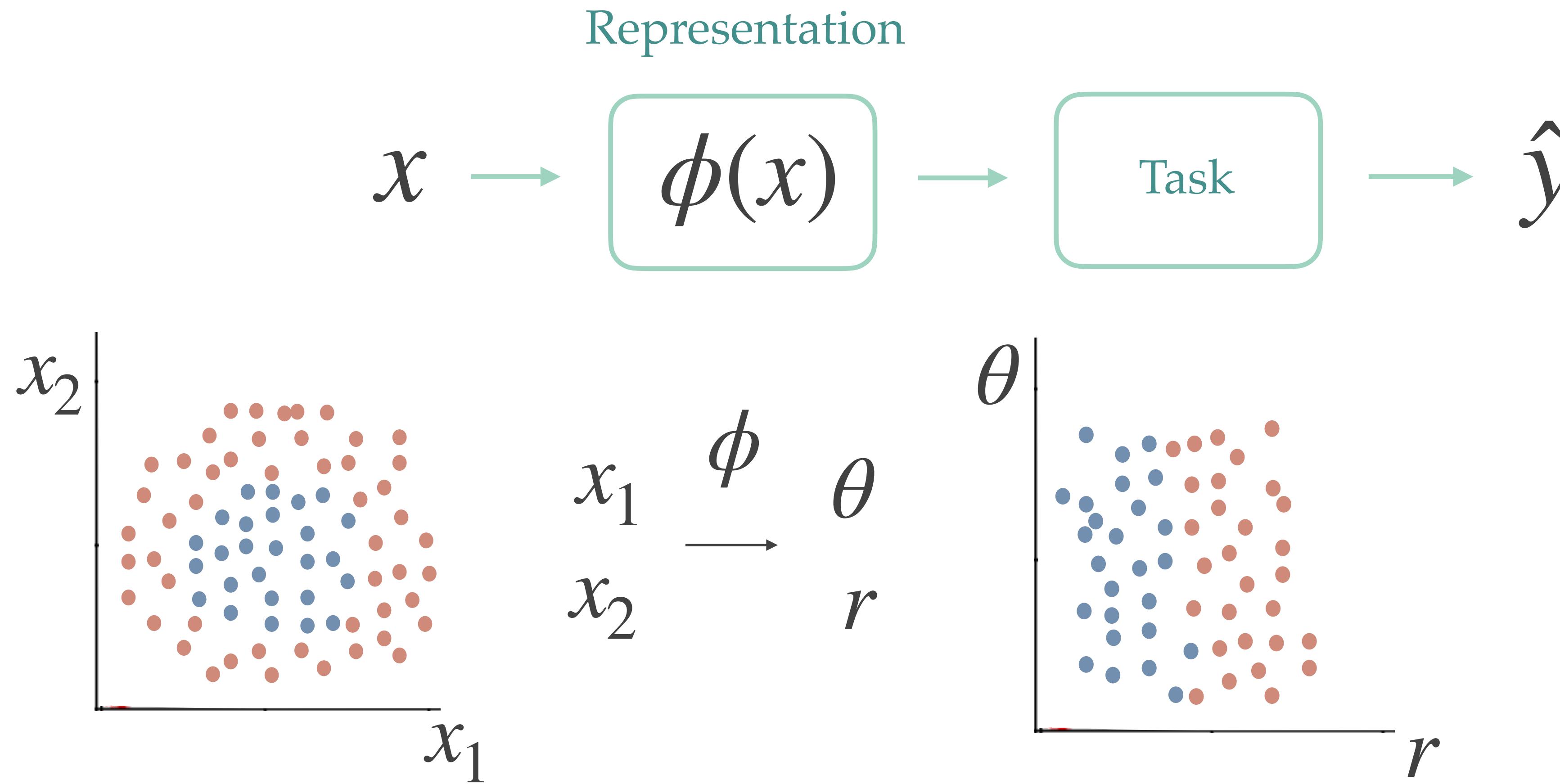
# MLP: Representation Learning



$$\phi(x) = x^2$$



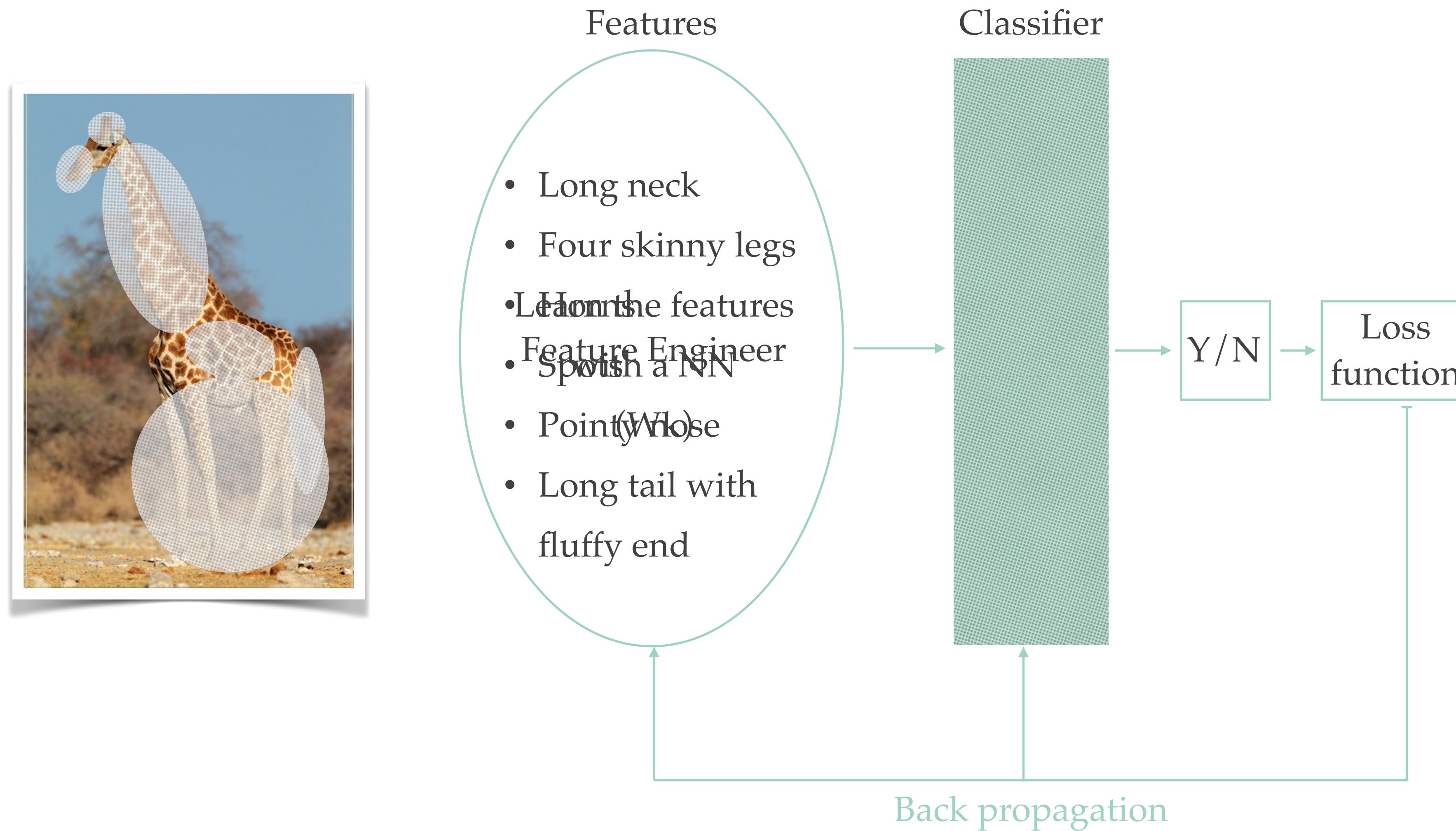
# MLP: Representation Learning



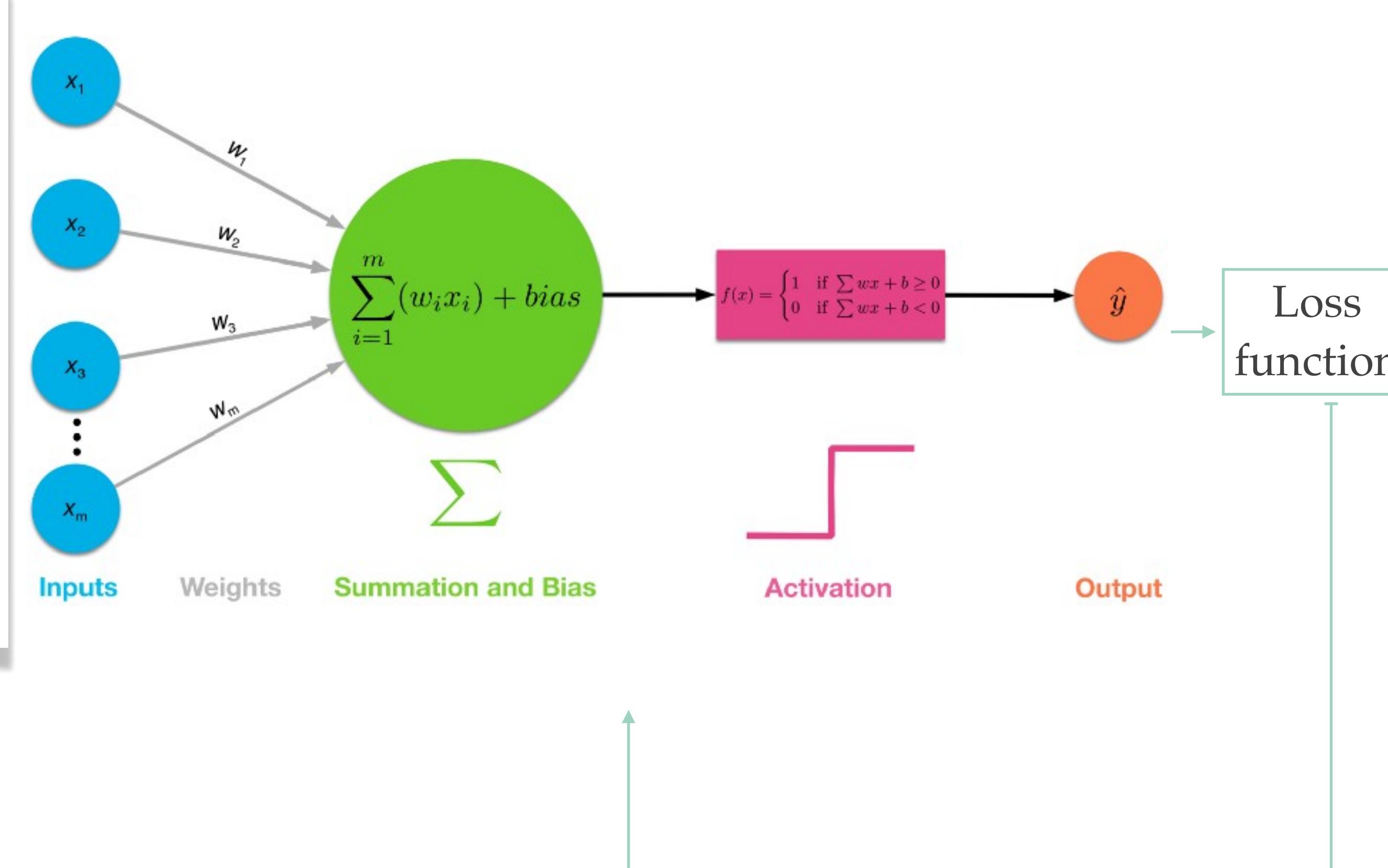
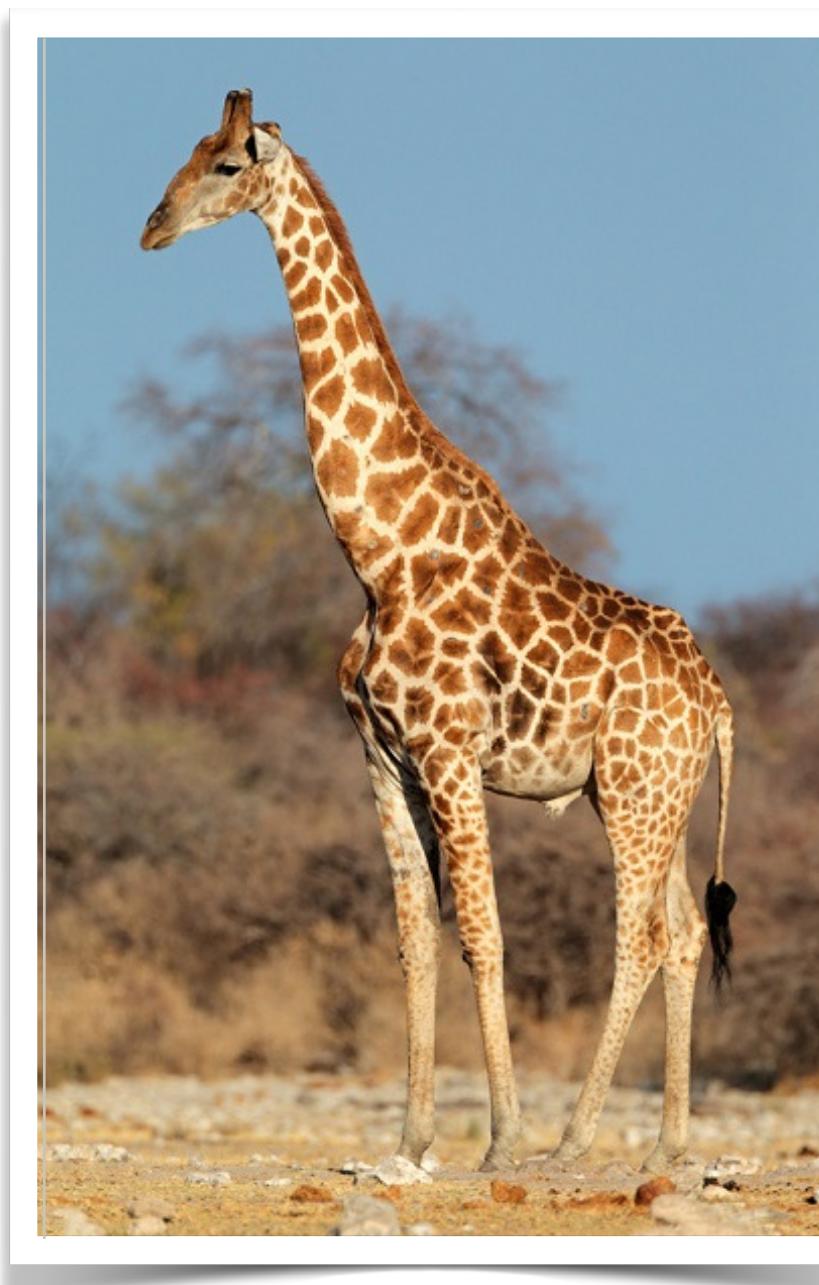
# MLP: Representation Learning



# CNNs: Representation Learning



# Image Analysis: Representation Learning



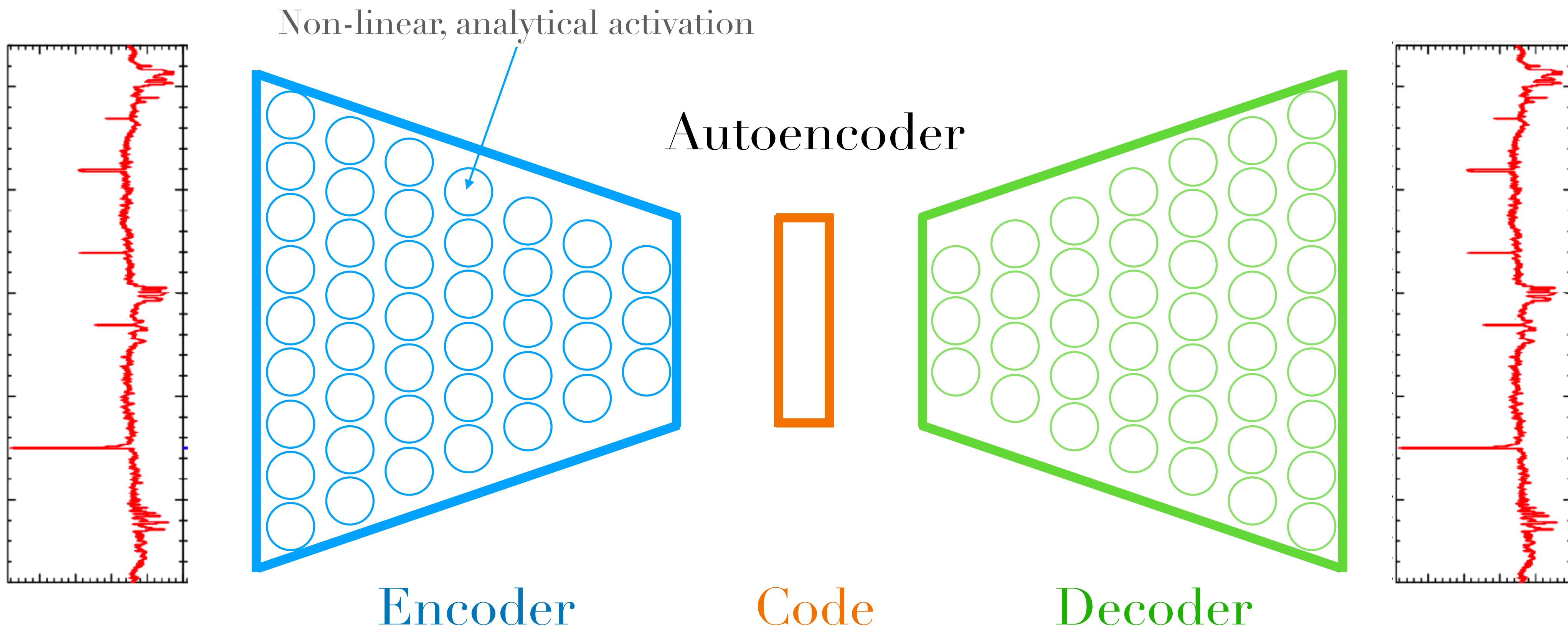
Back propagation

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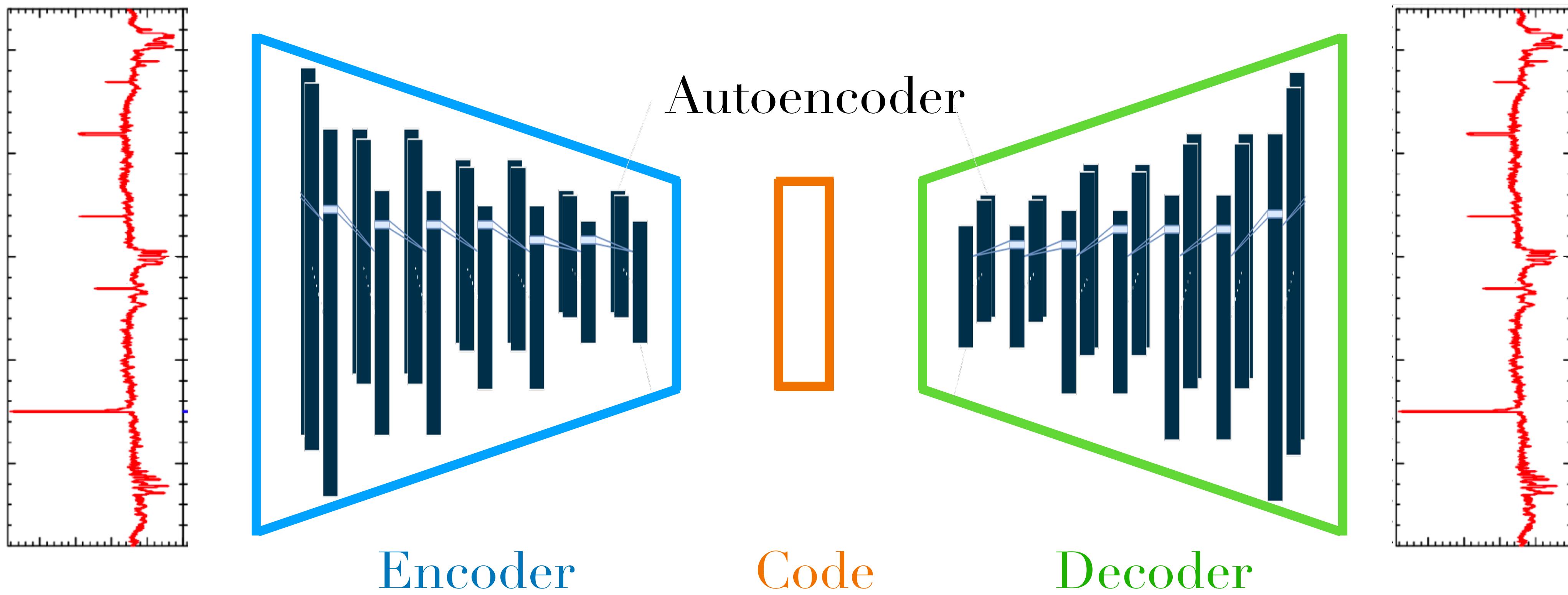
# Arquitecturas

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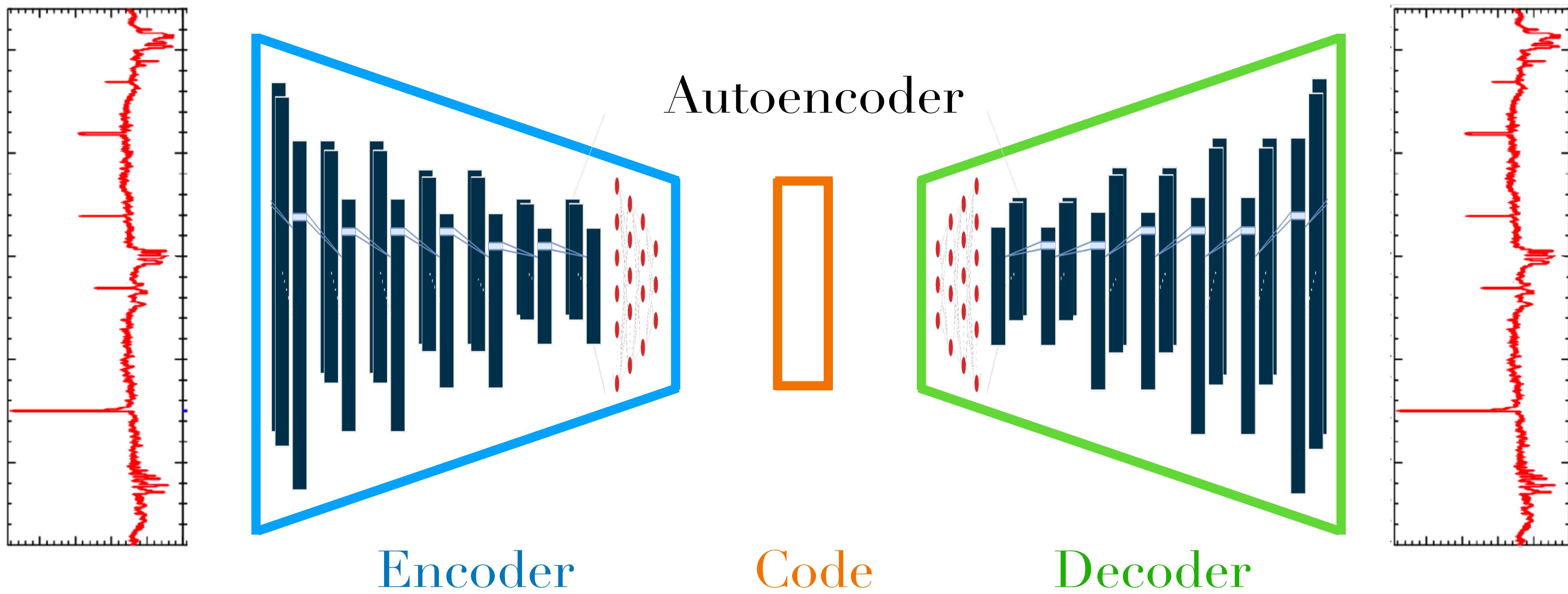
# Architectures: Autoencoder



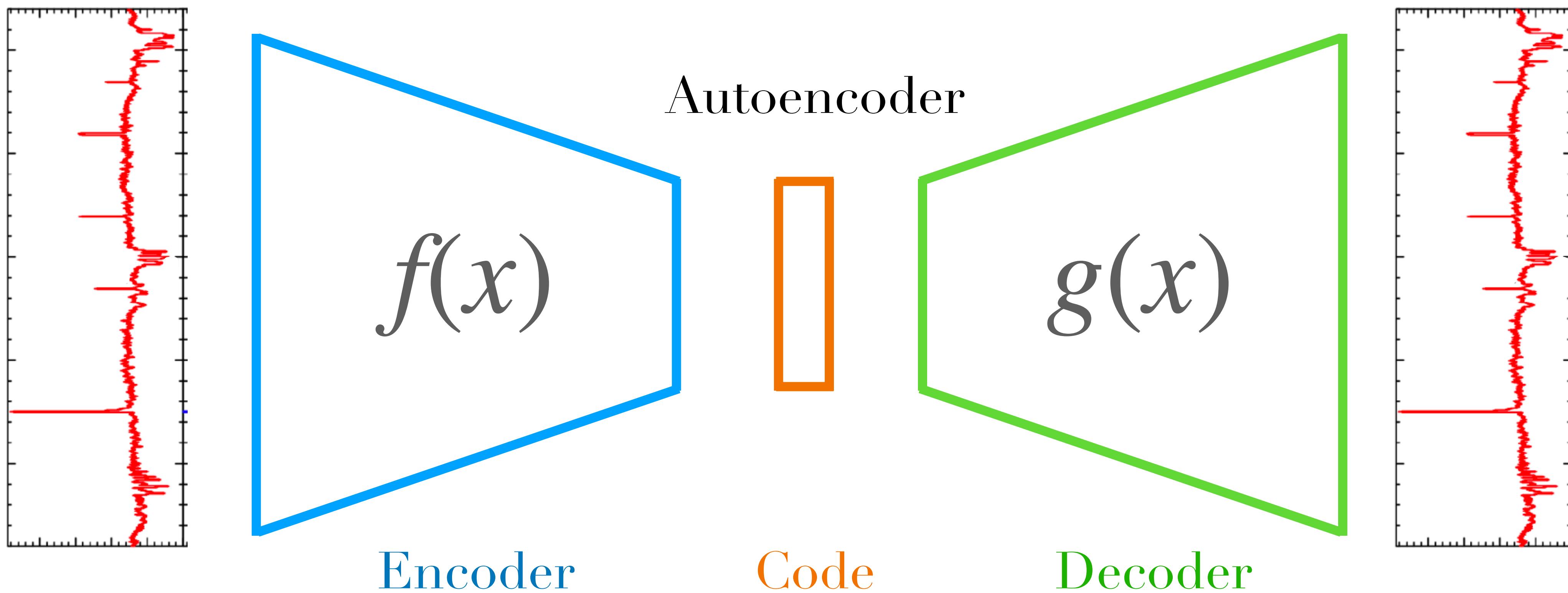
# Architectures: Autoencoder



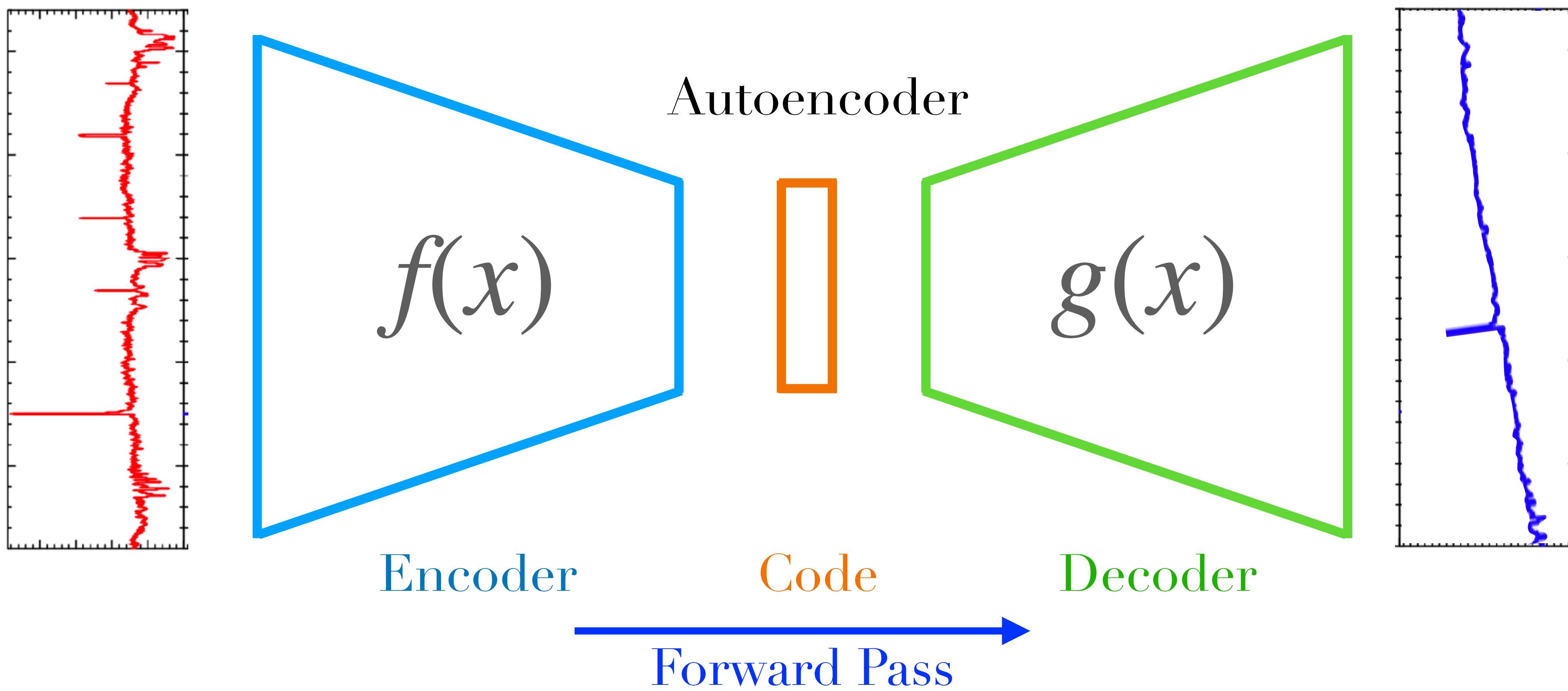
# Architectures: Autoencoder



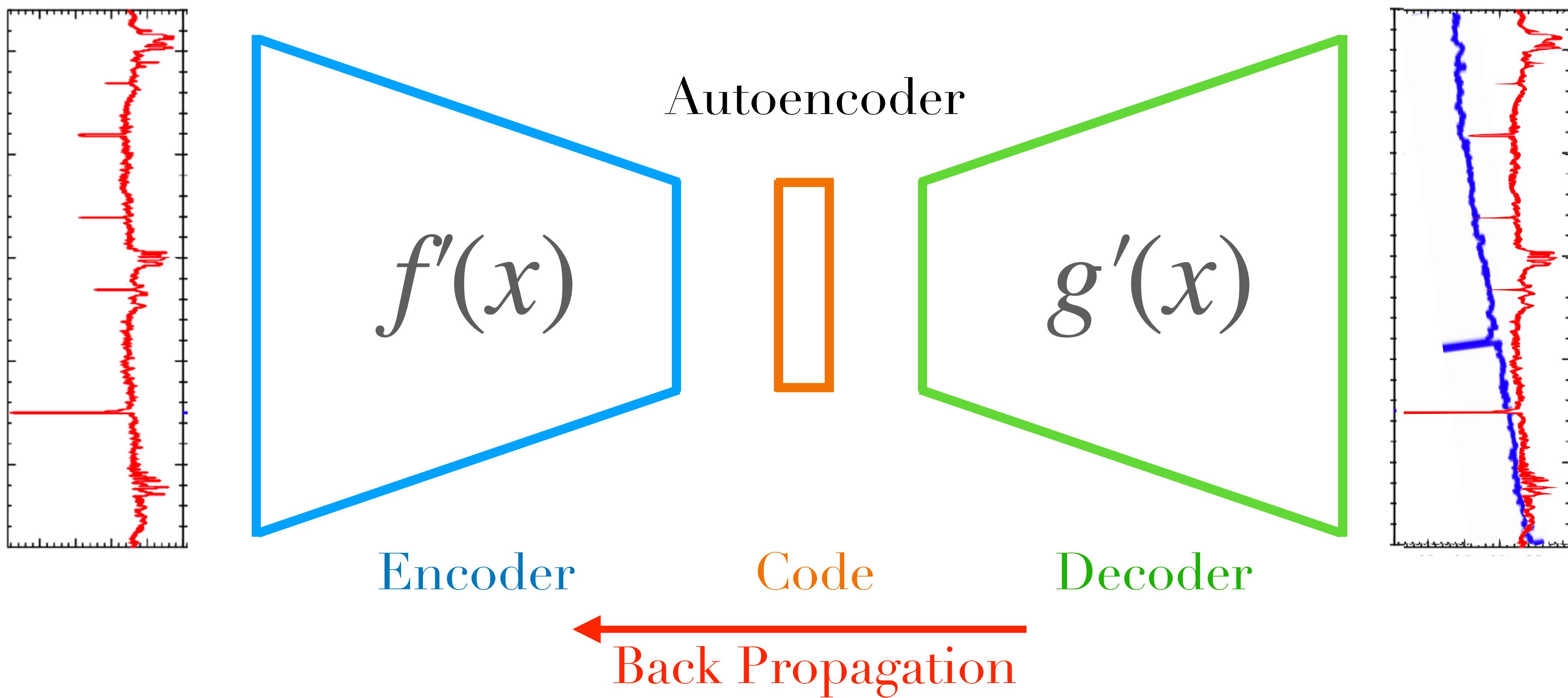
# Architectures: Autoencoder



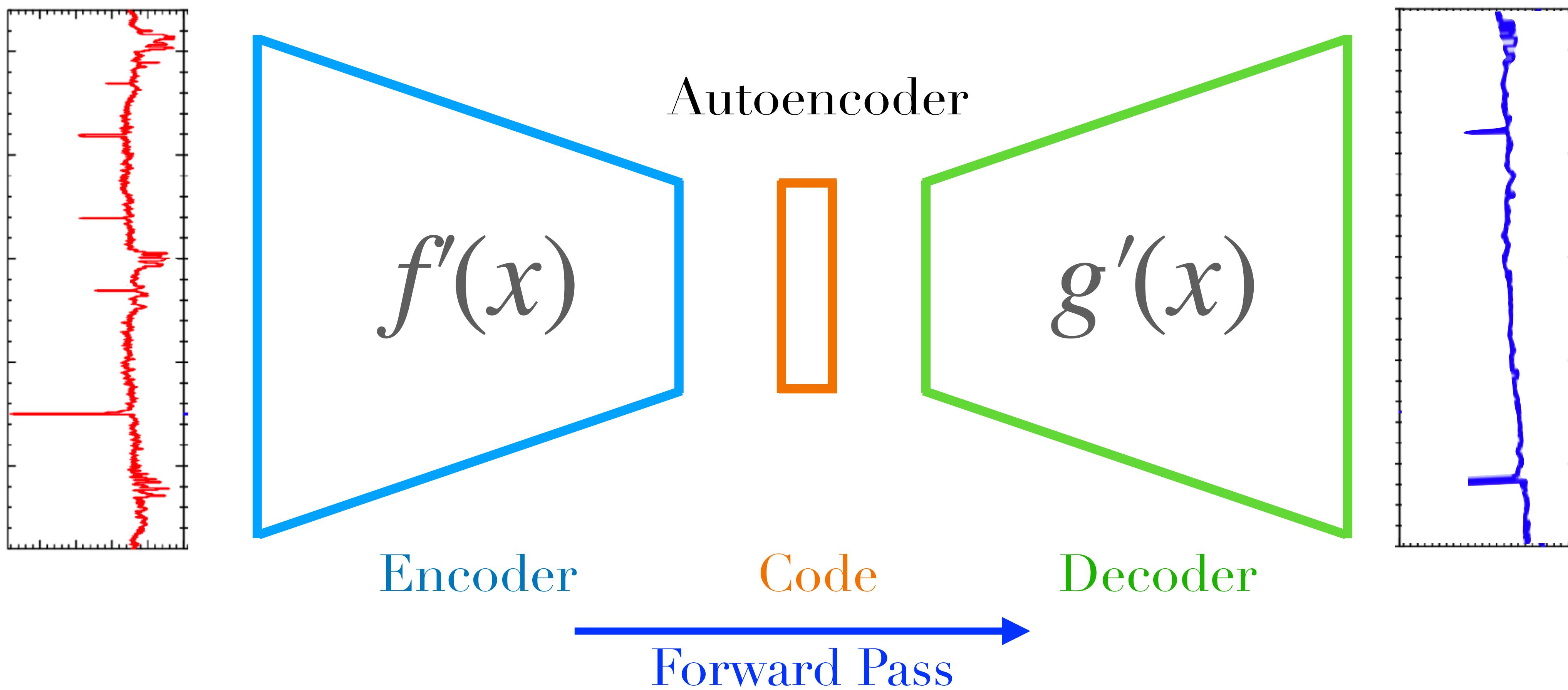
# Architectures: Autoencoder



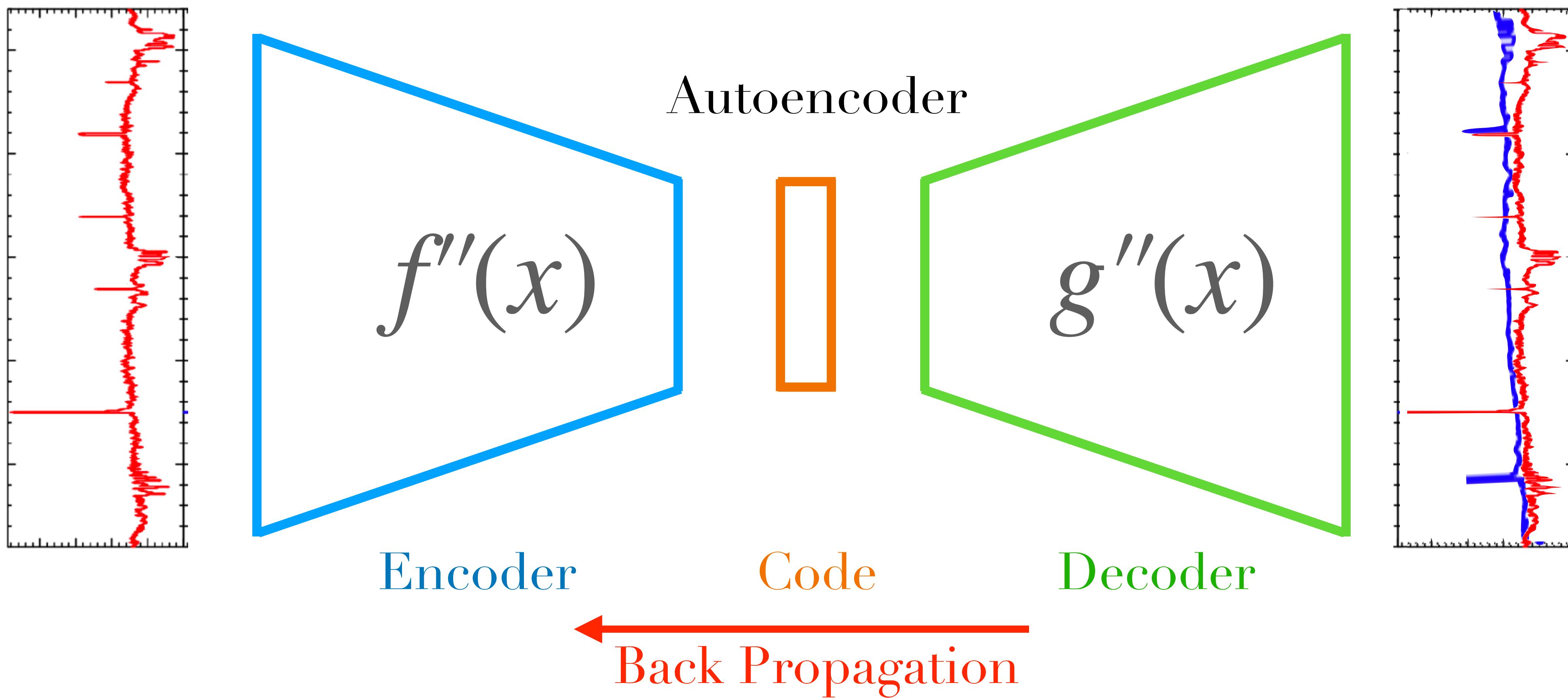
# Architectures: Autoencoder



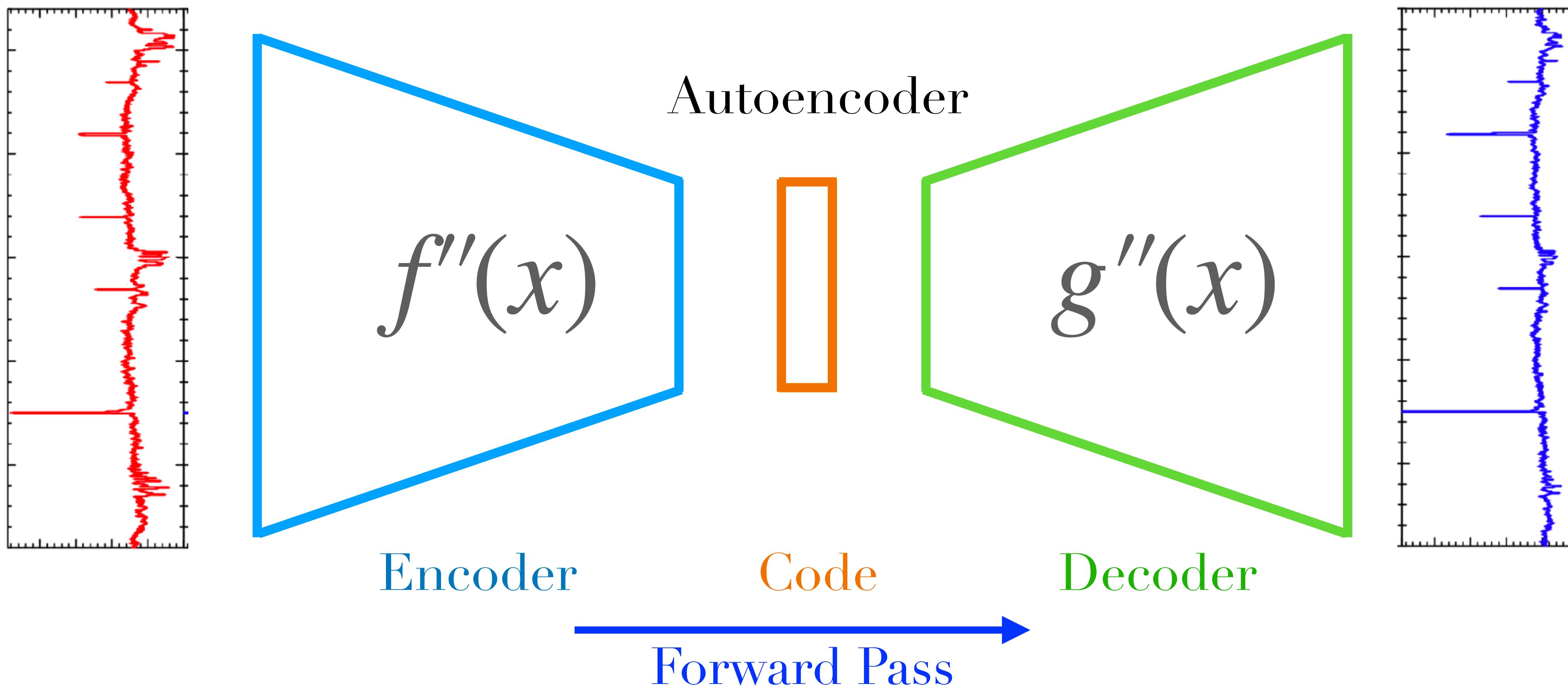
# Architectures: Autoencoder



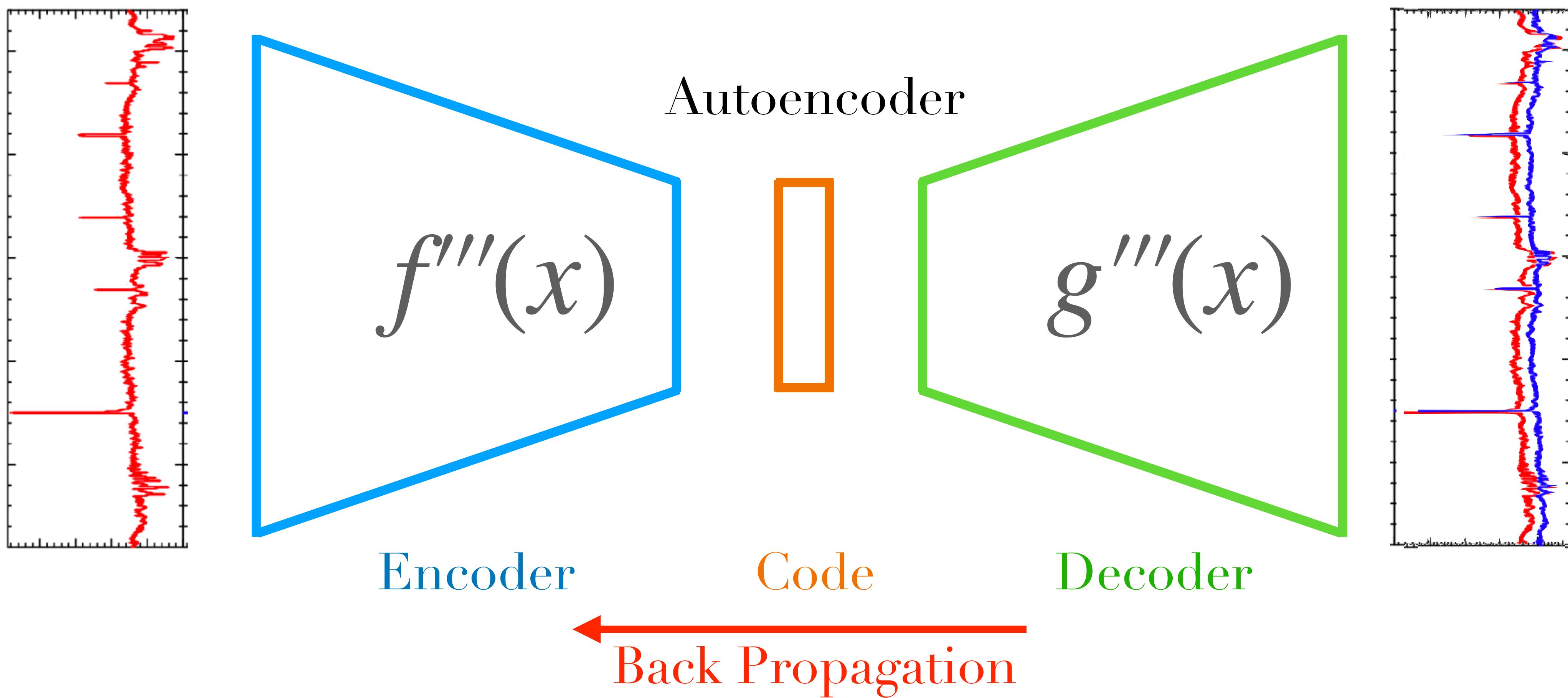
# Architectures: Autoencoder



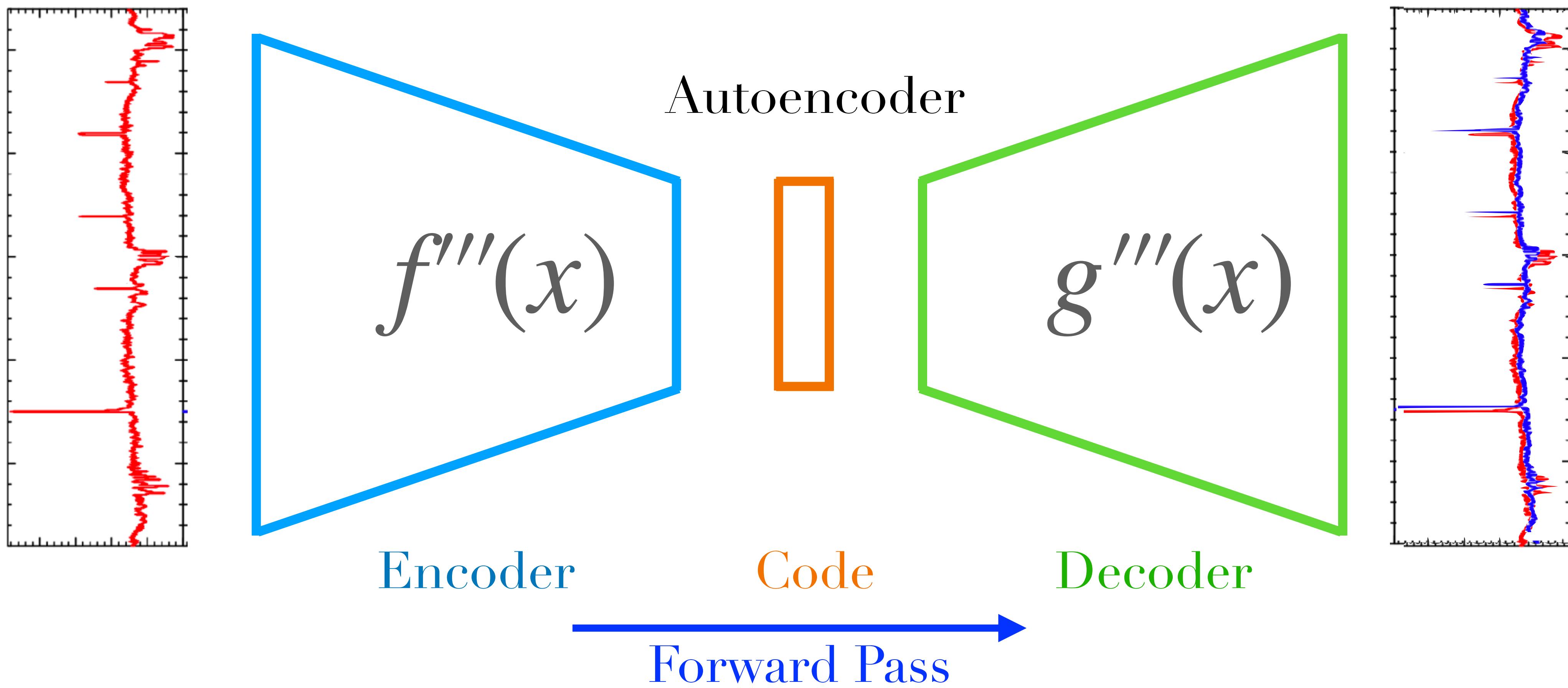
# Architectures: Autoencoder



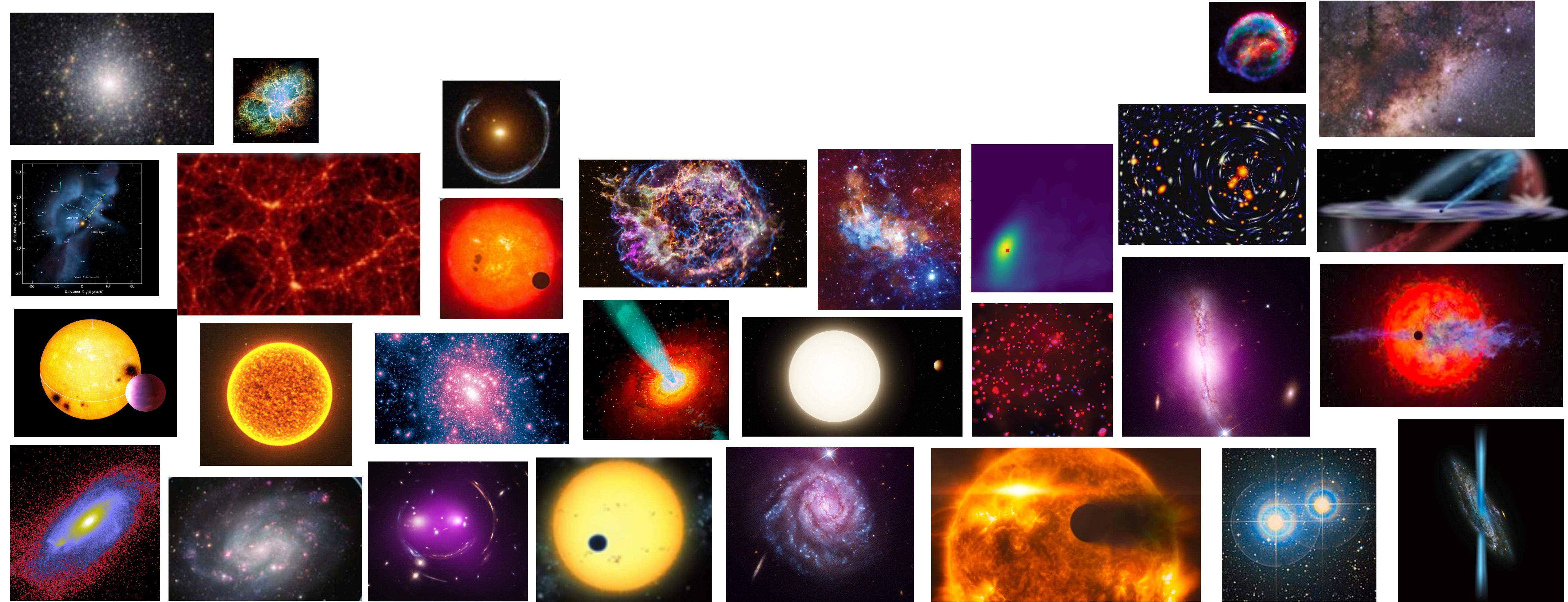
# Architectures: Autoencoder



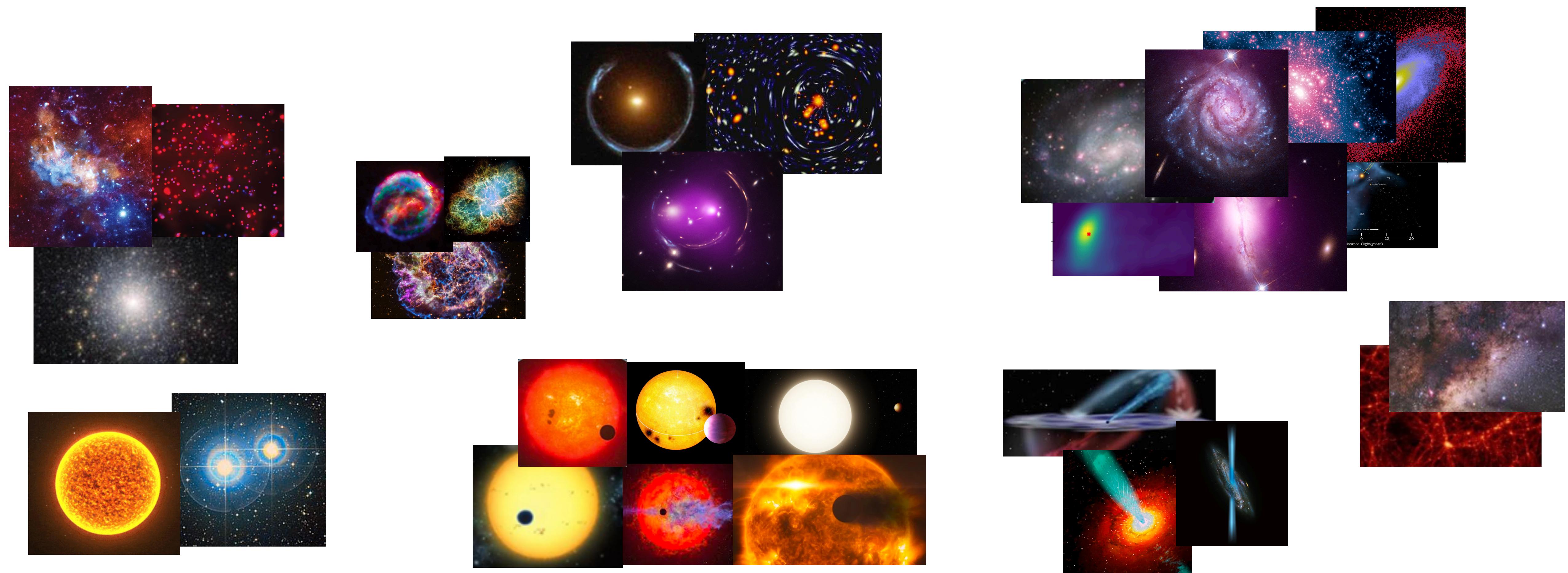
# Architectures: Autoencoder



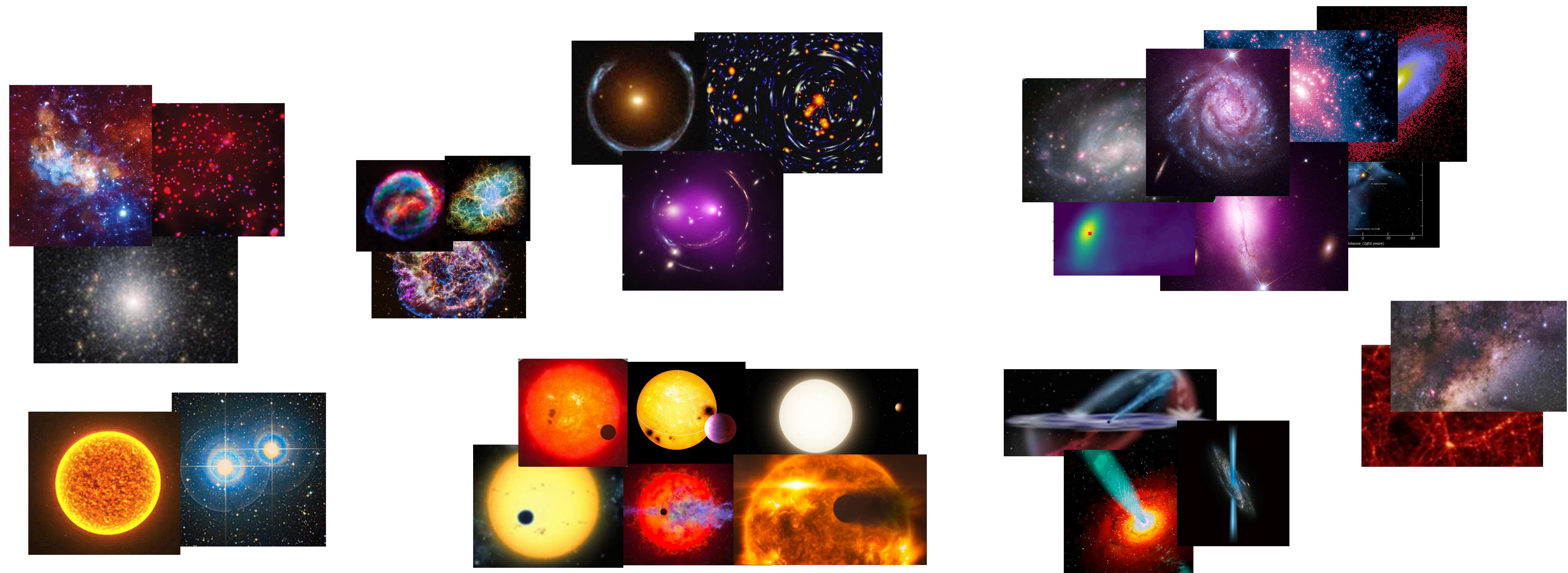
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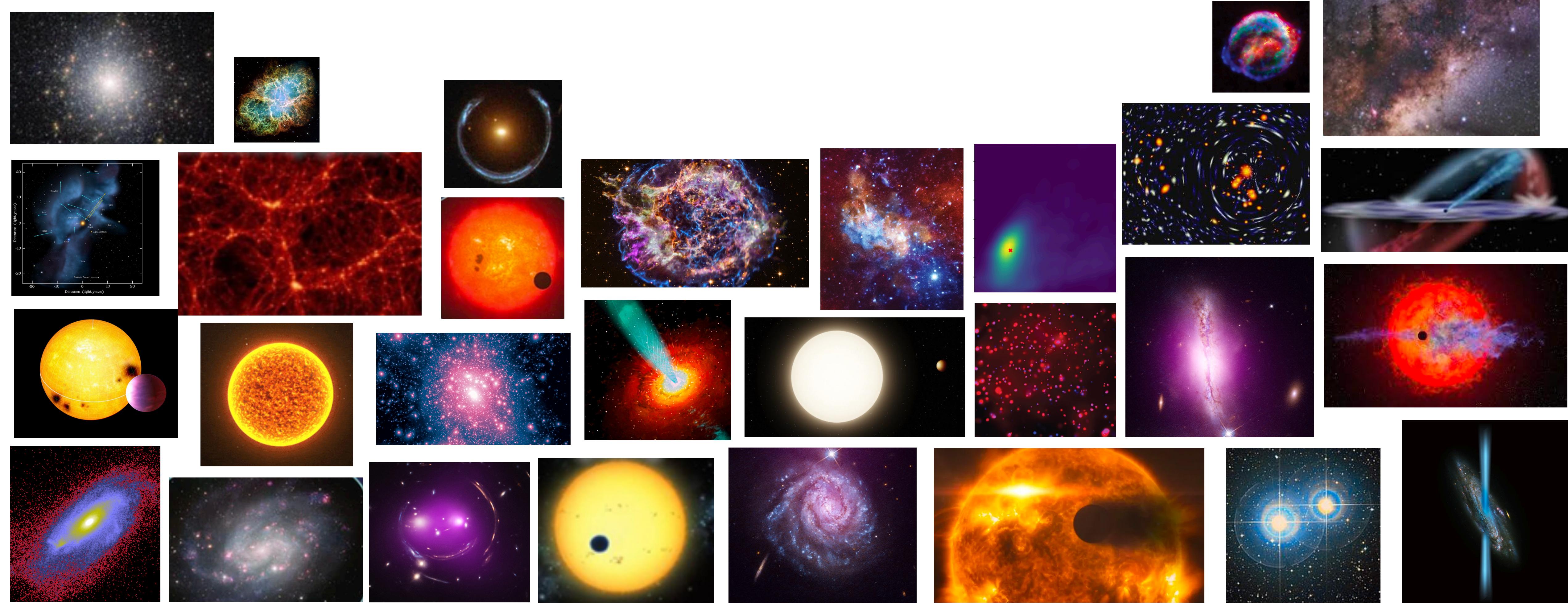
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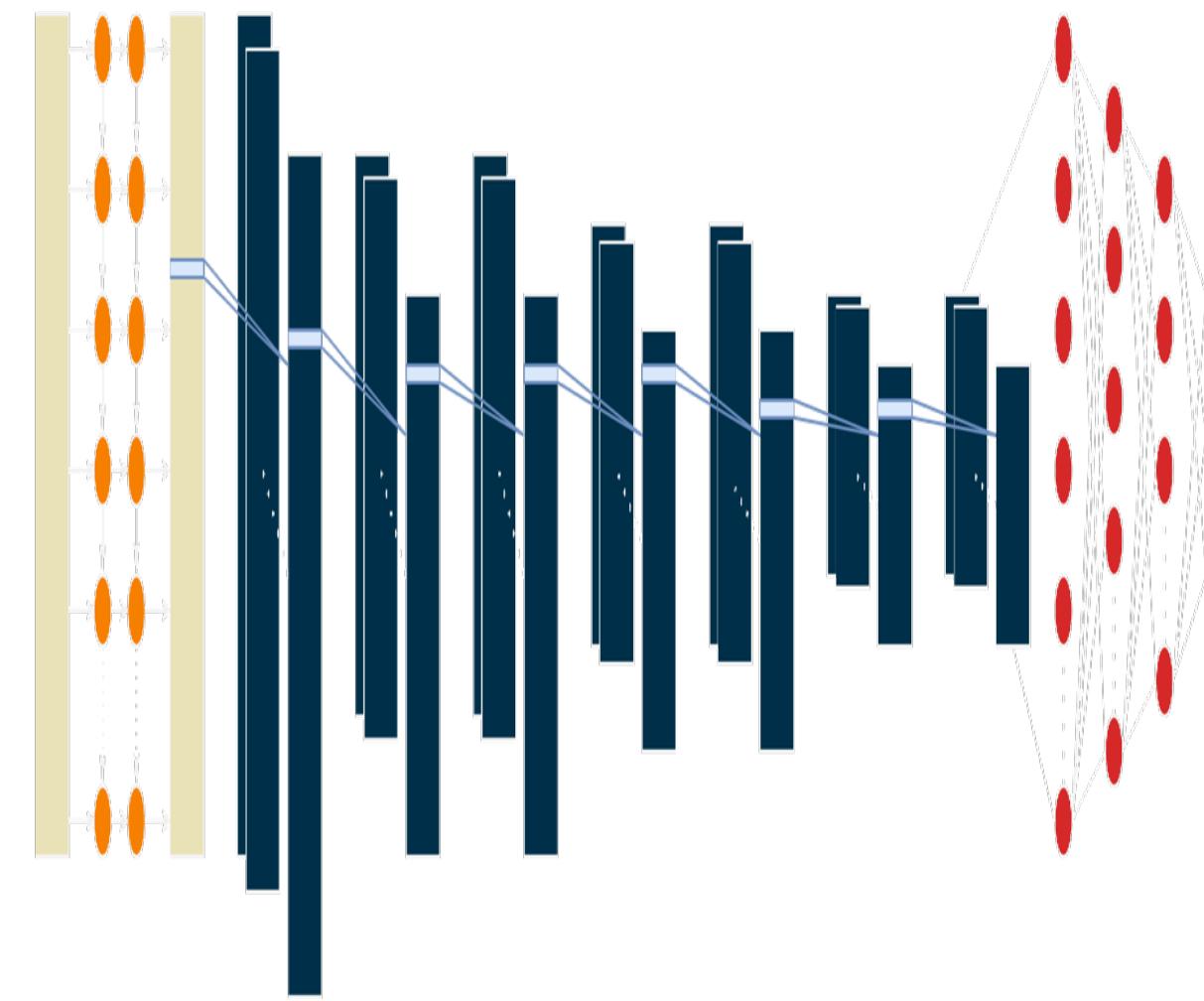
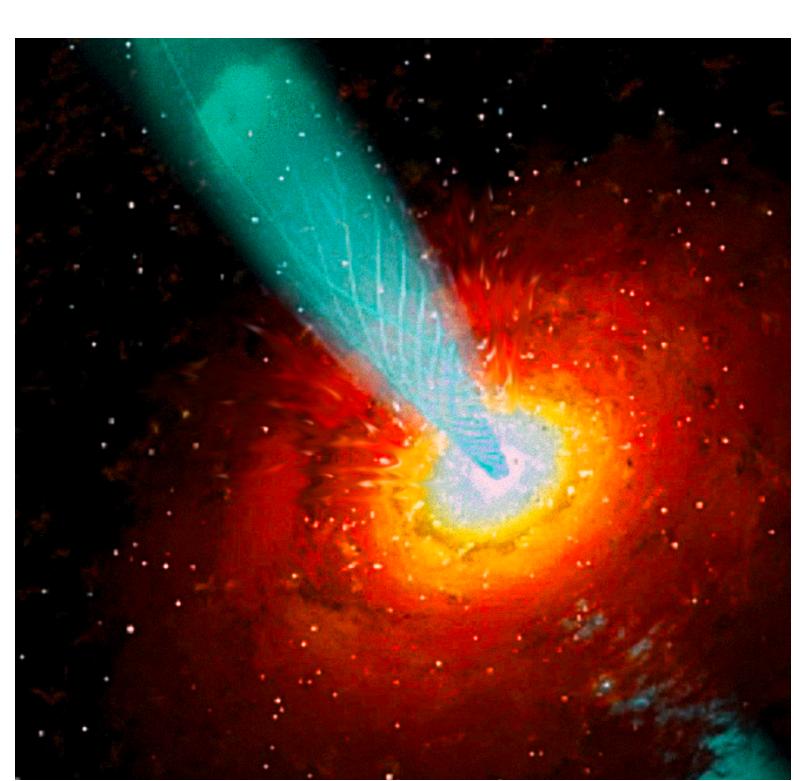
# Buscando lo inesperado



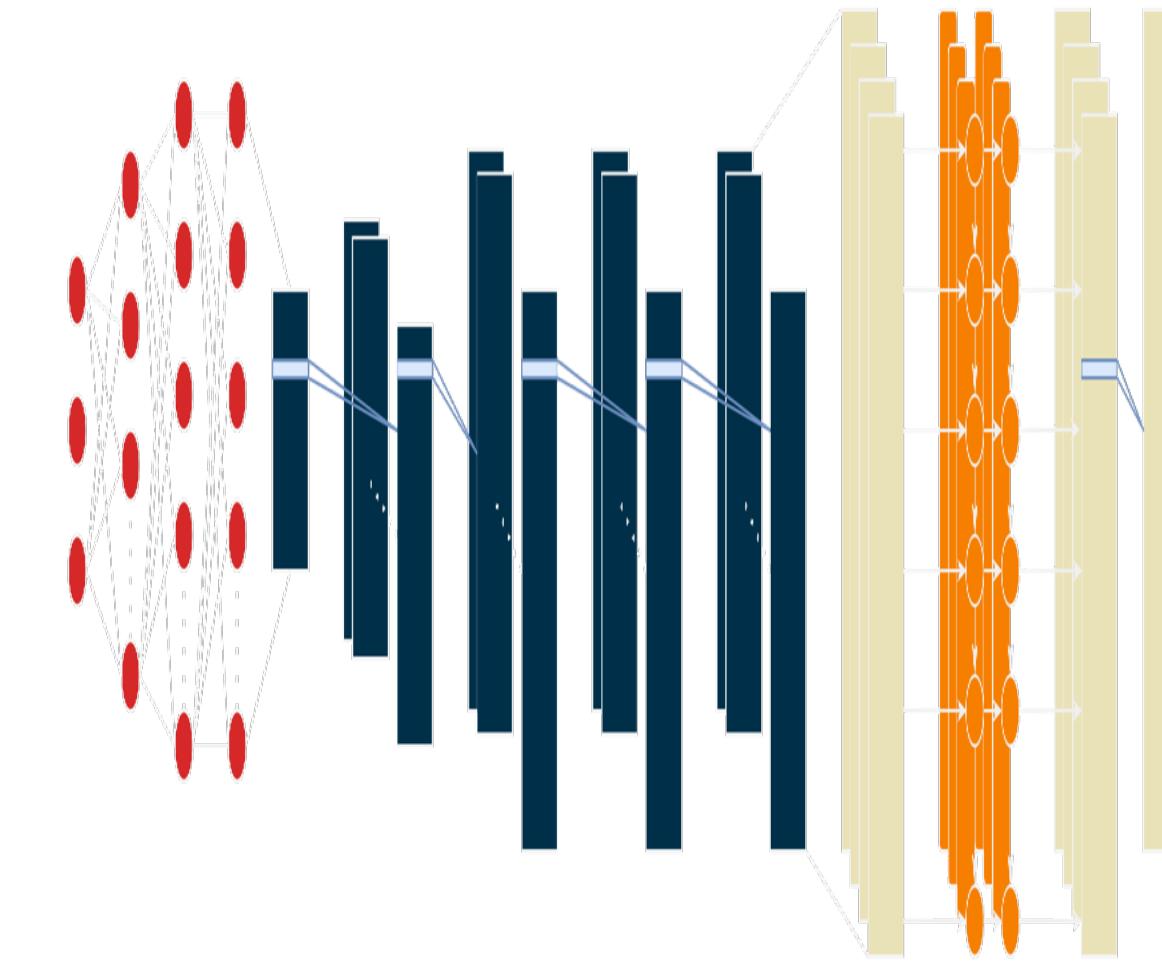
# Representation Learning



# Representation Learning: Unsupervised

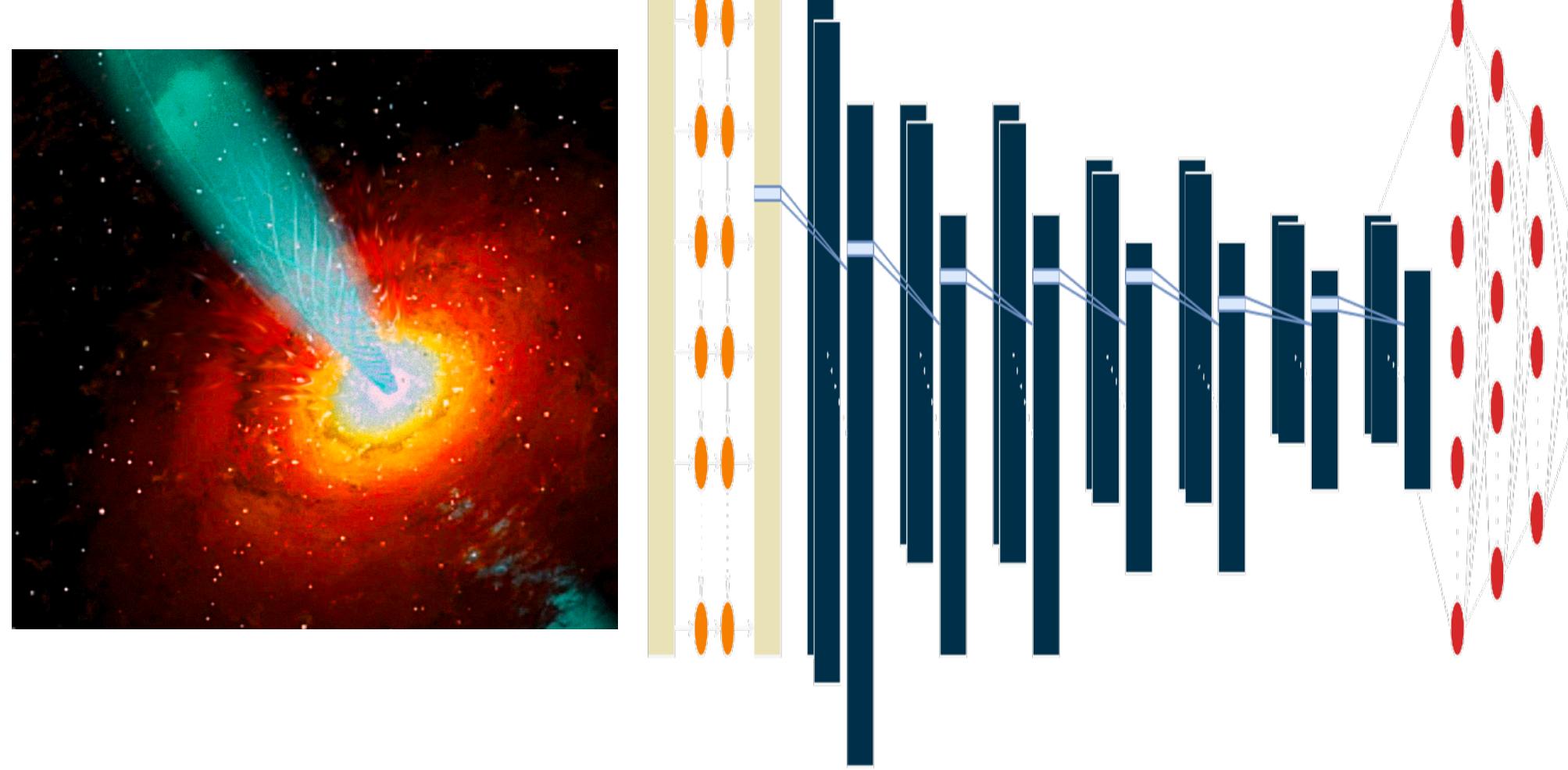


Encoder

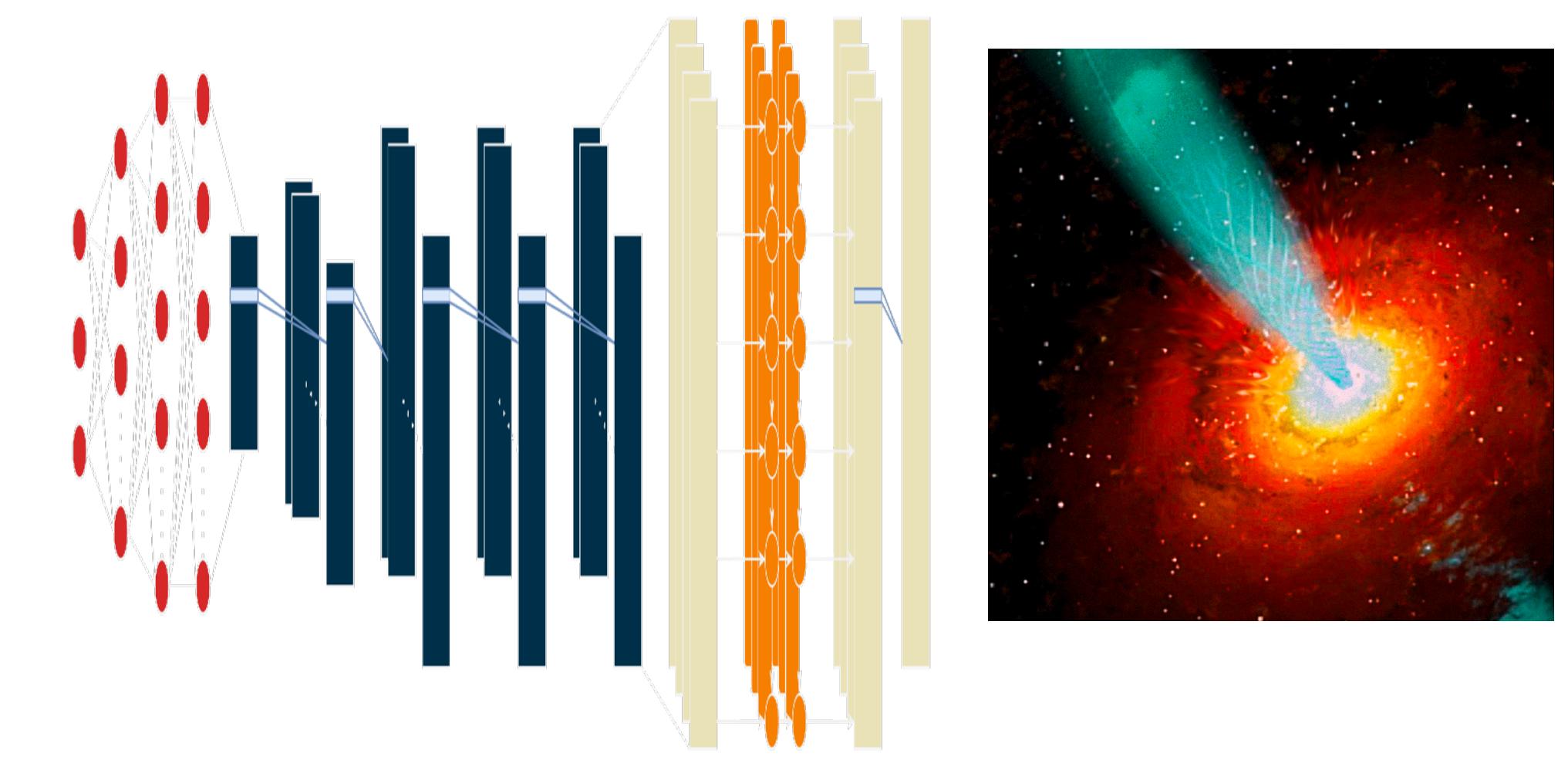


Decoder

# Representation Learning: Unsupervised

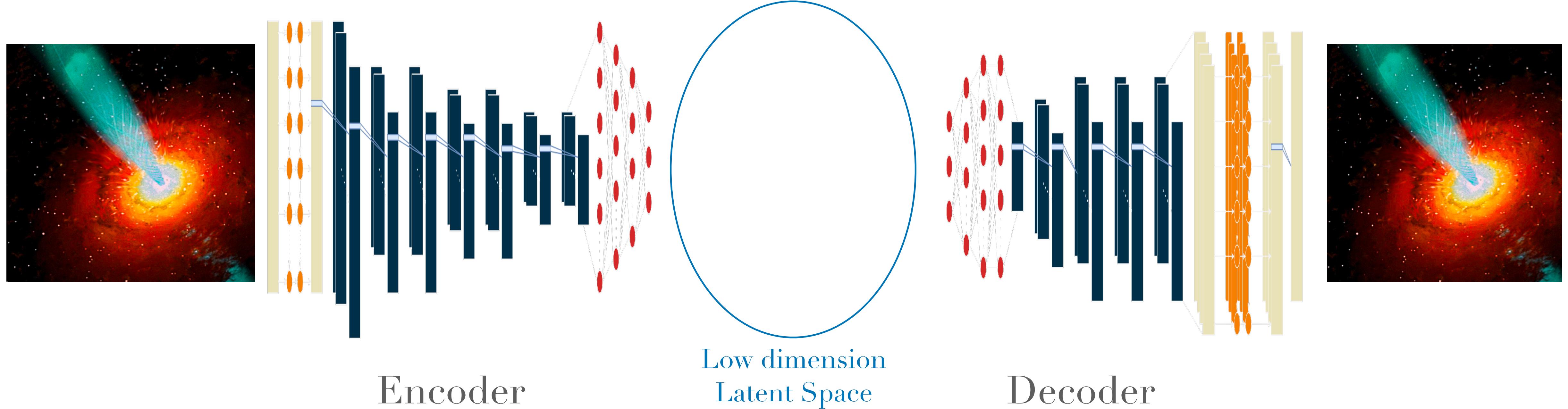


Encoder

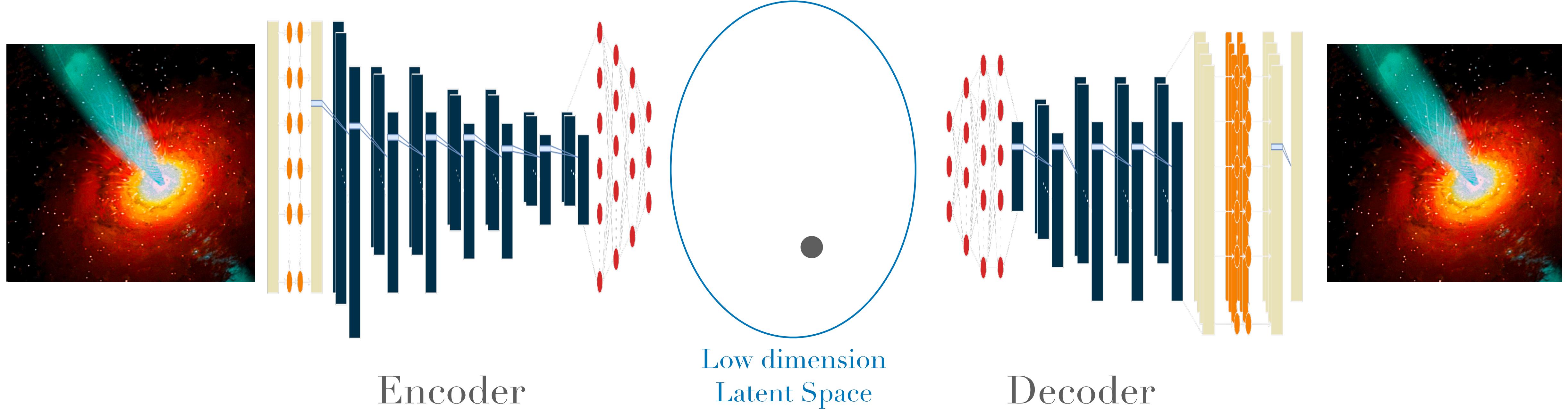


Decoder

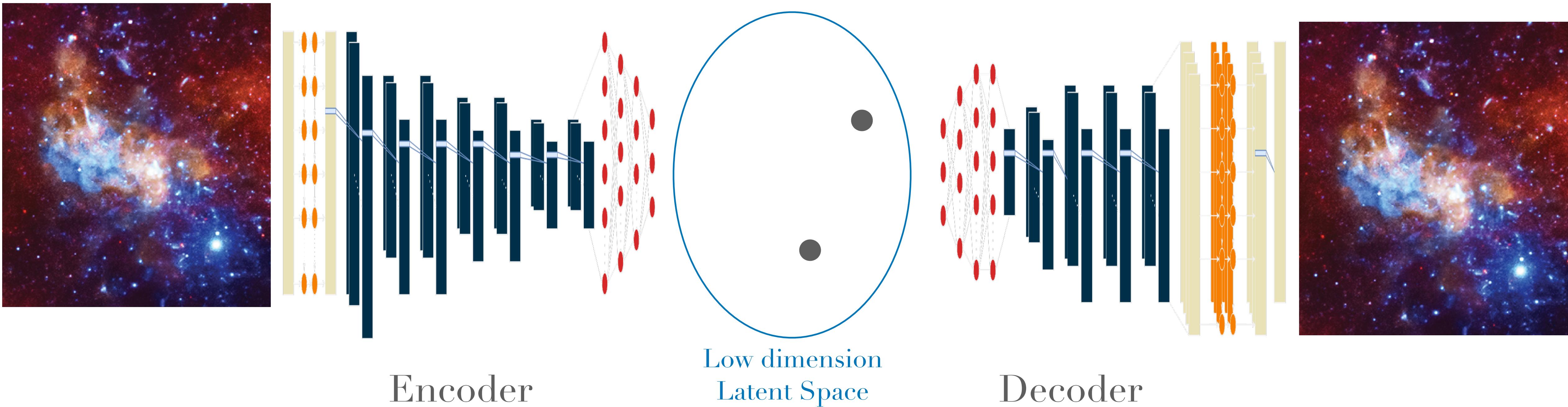
# Representation Learning: Unsupervised



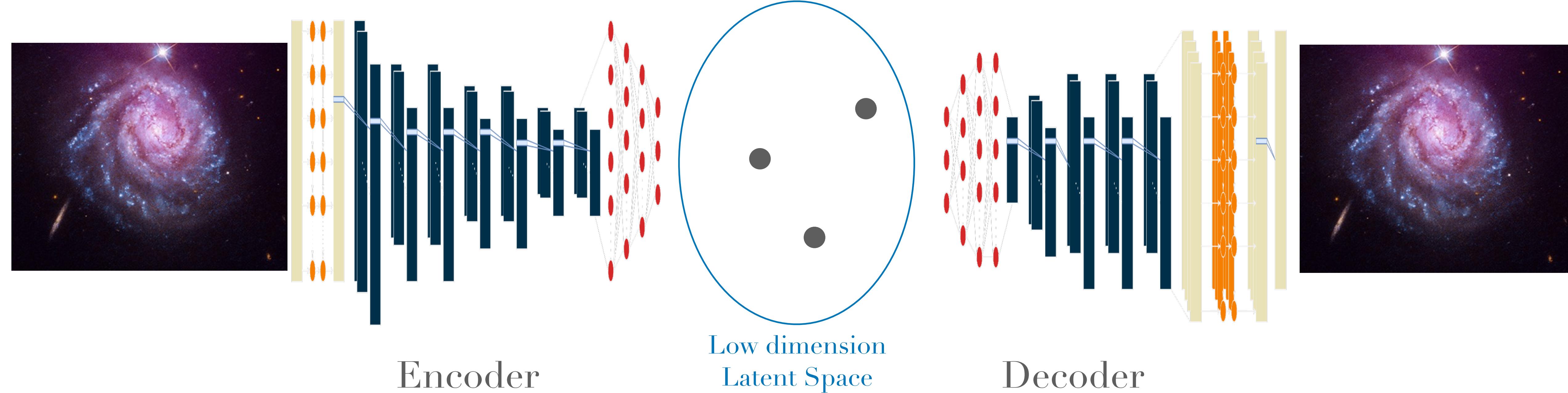
# Representation Learning: Unsupervised



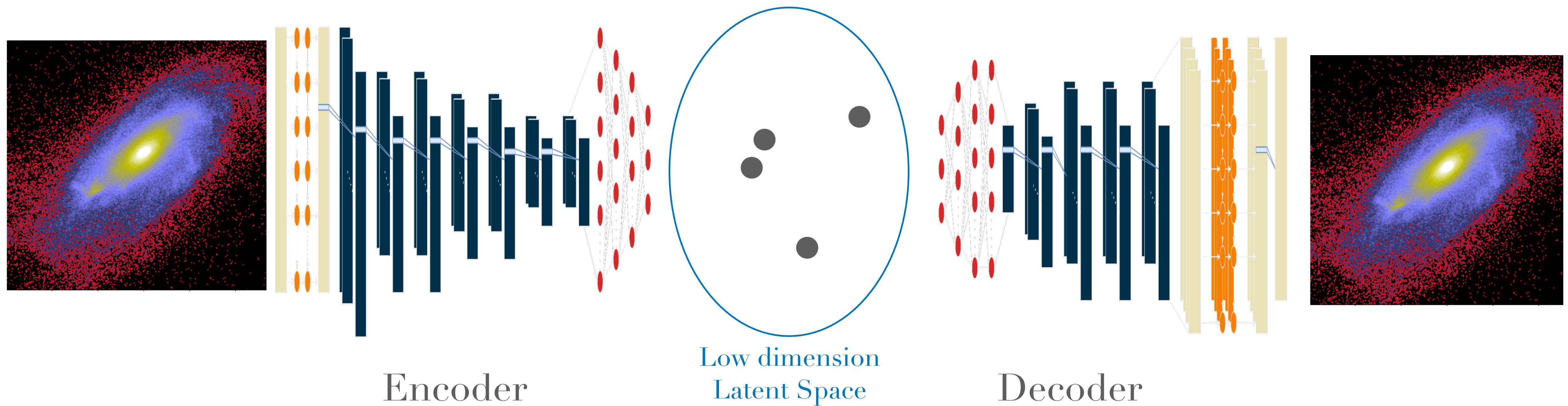
# Representation Learning: Unsupervised



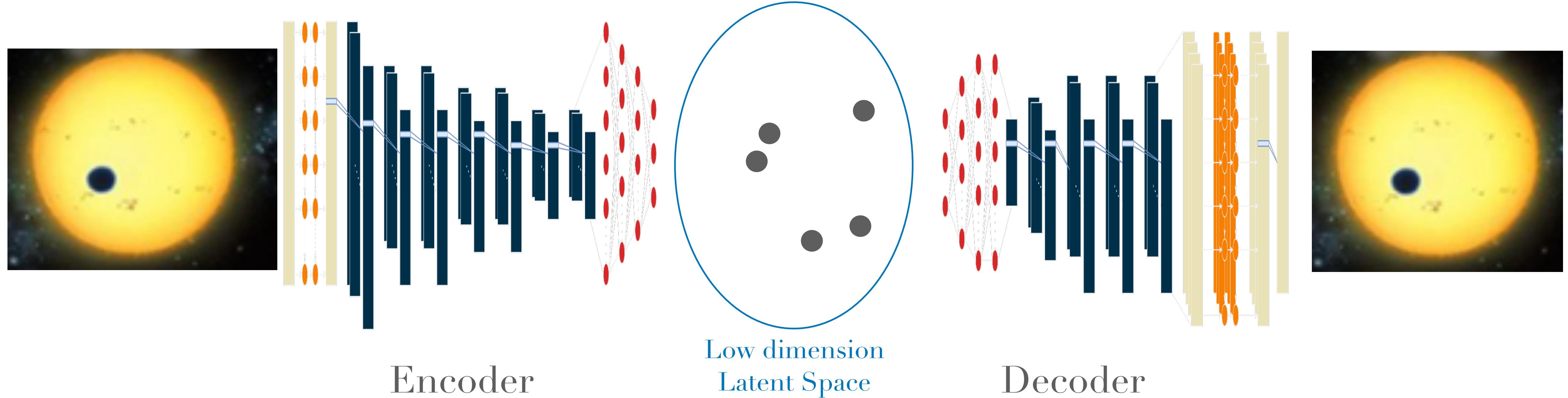
# Representation Learning: Unsupervised



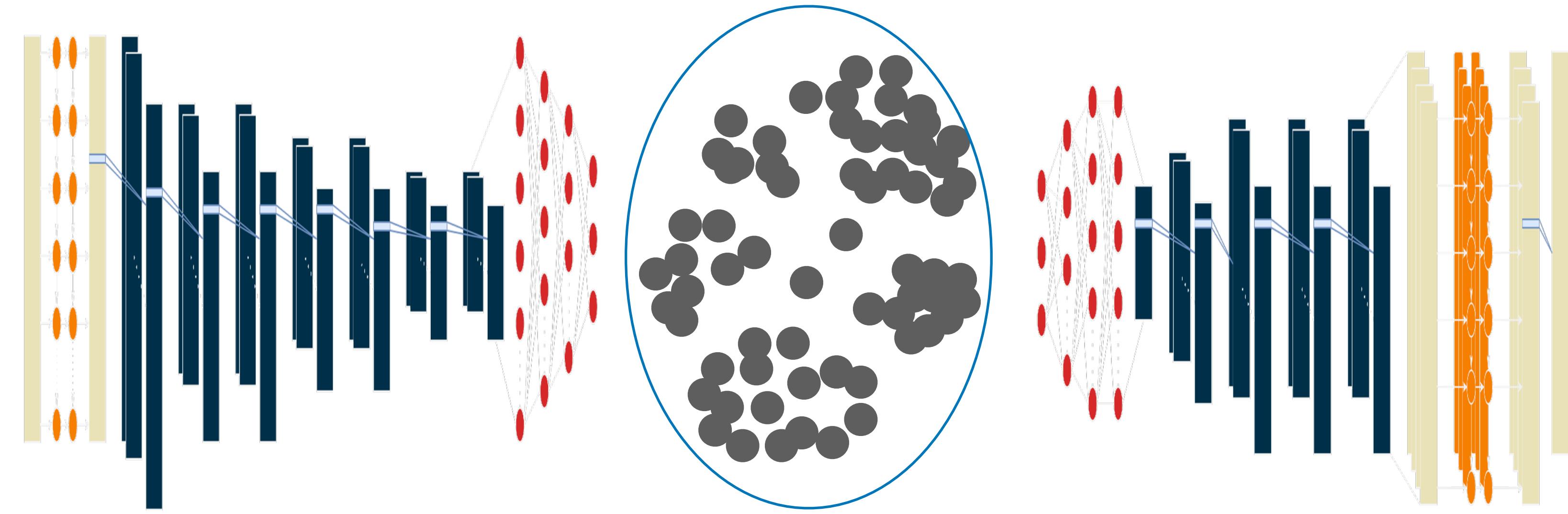
# Representation Learning: Unsupervised



# Representation Learning: Unsupervised



# Representation Learning: Unsupervised



Encoder

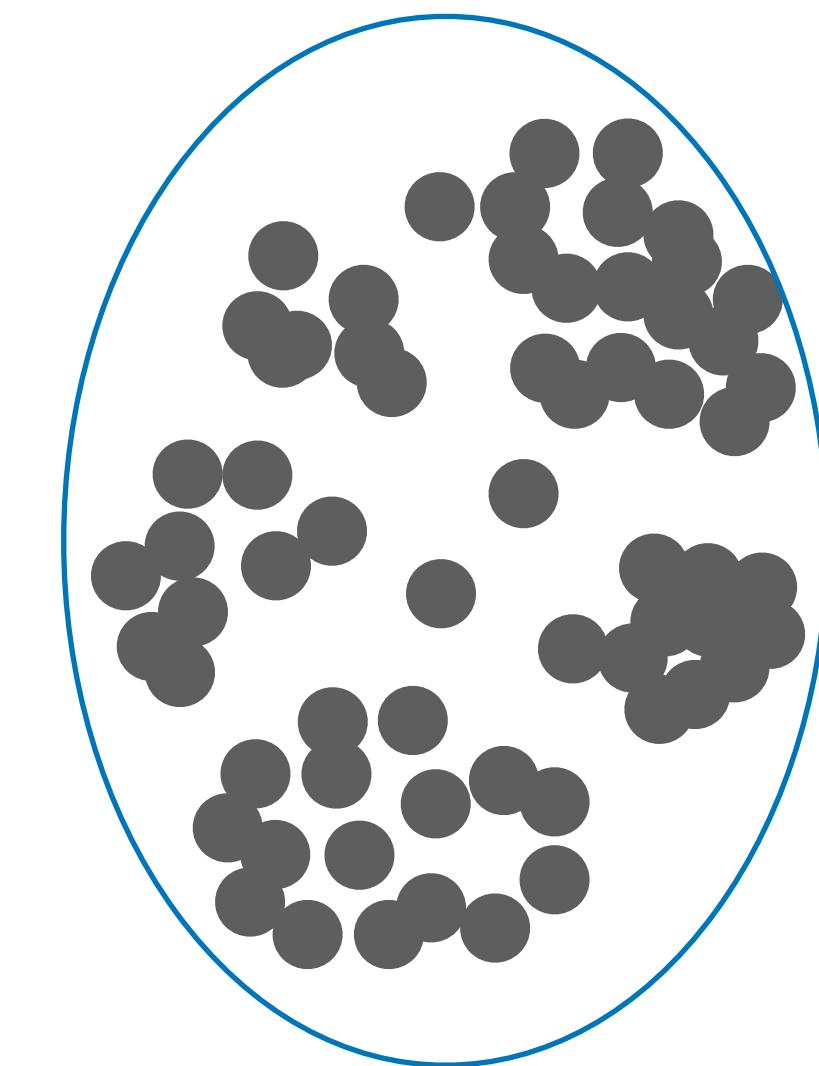
Decoder



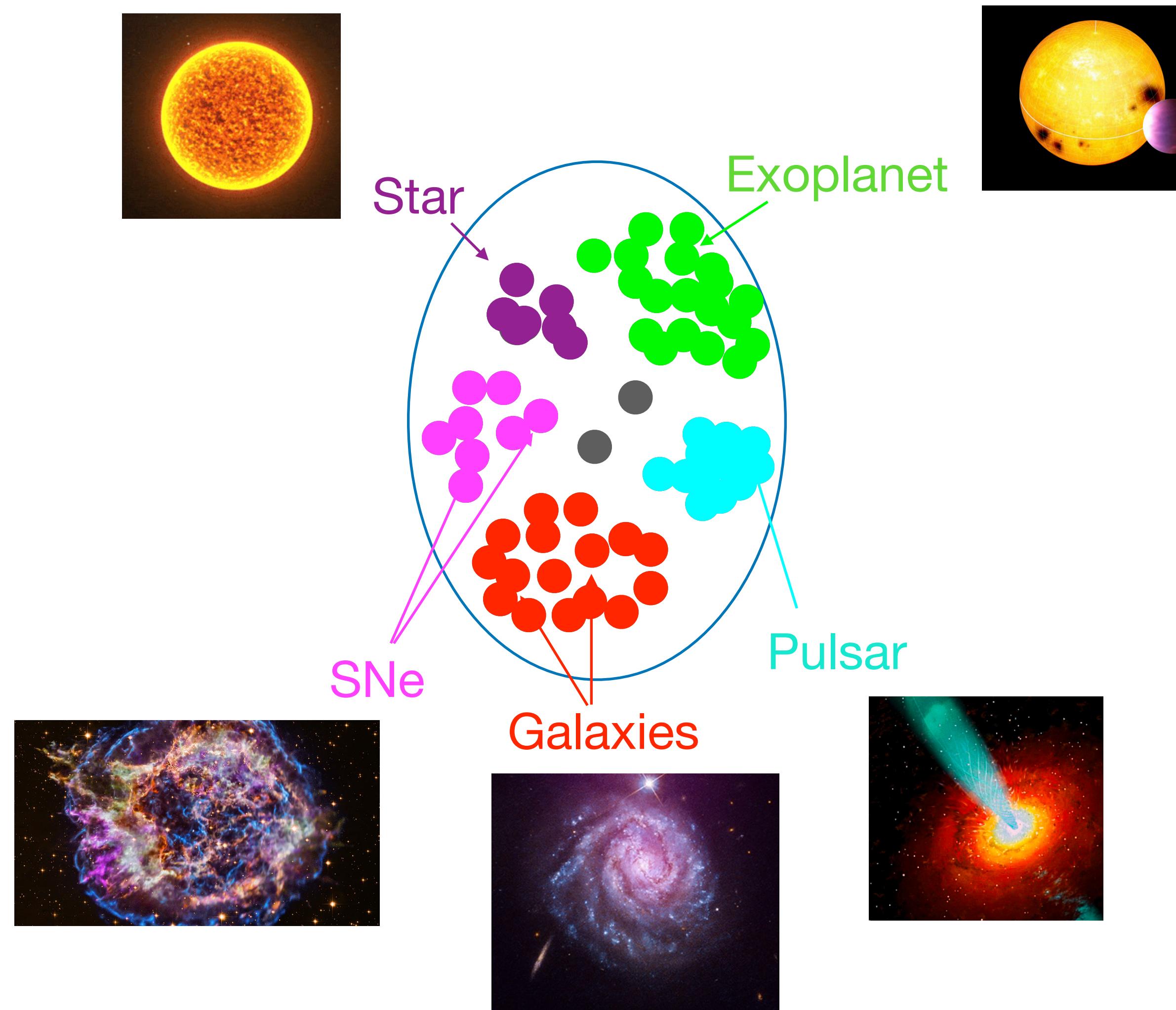
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# Representation Learning: Unsupervised

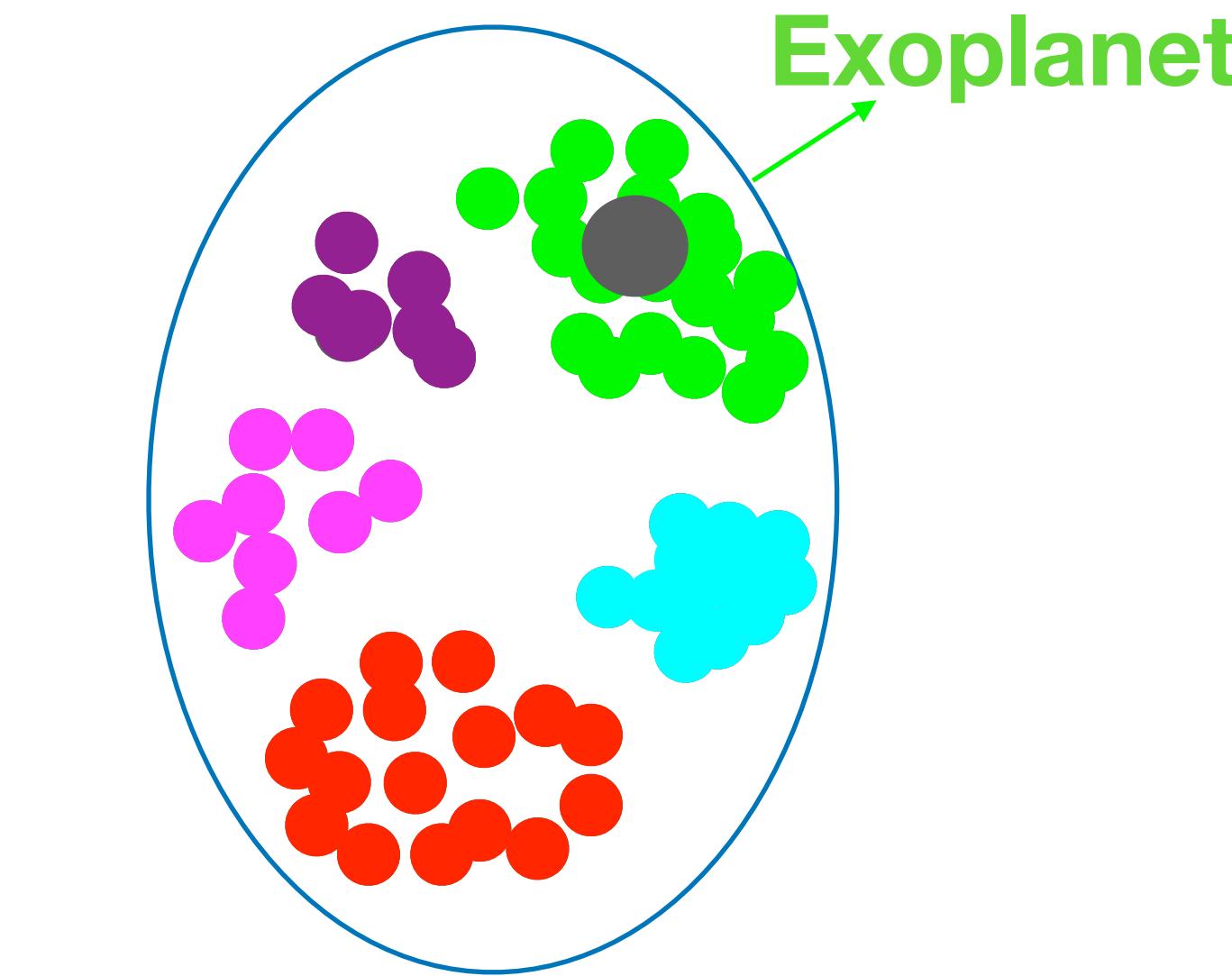
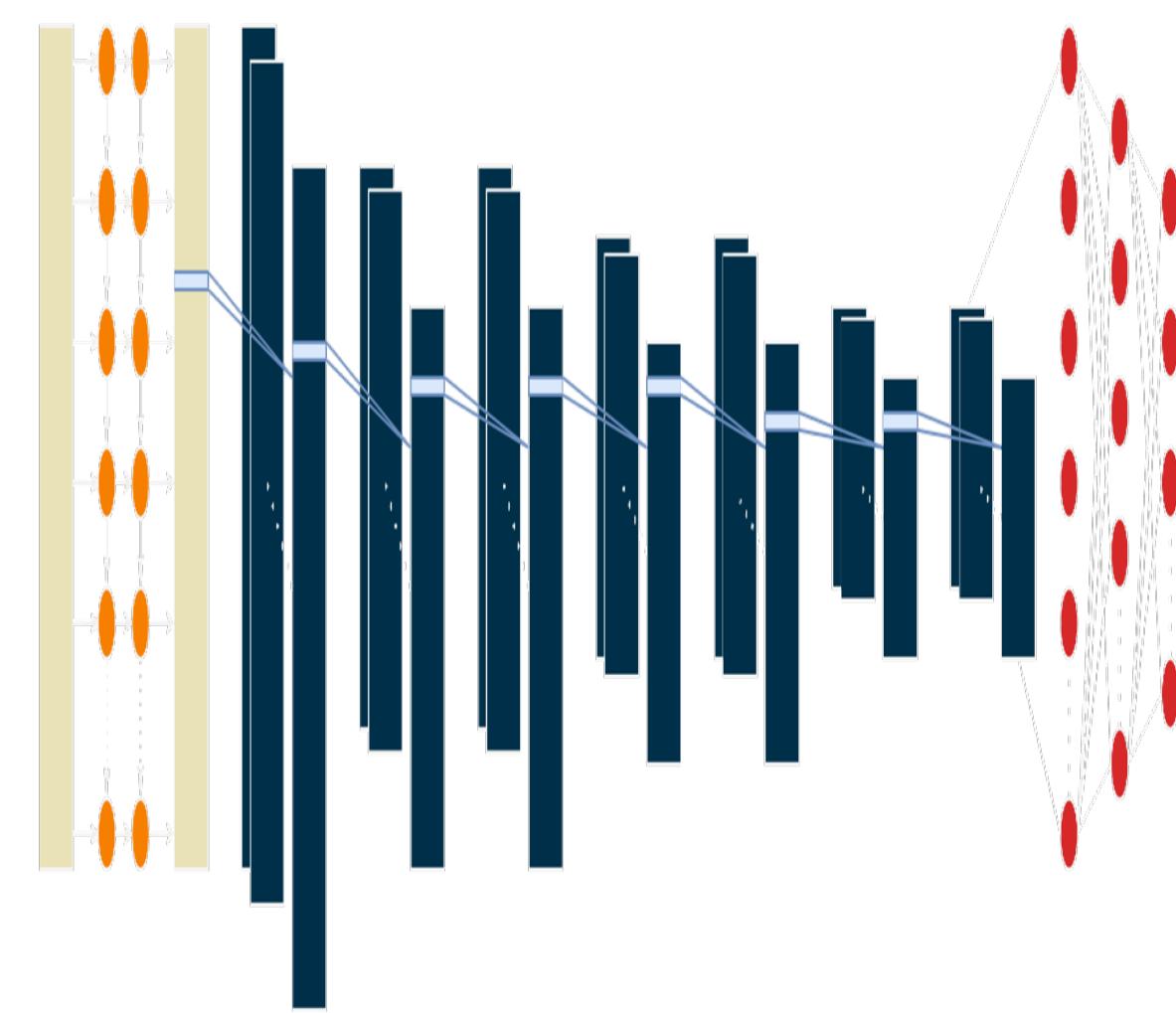
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# Representation Learning: Self-Supervised



# Representation Learning: Self-Supervised



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# Contrastive Learning: InfoNCE Loss

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# Contrastive Learning: InfoNCE Loss

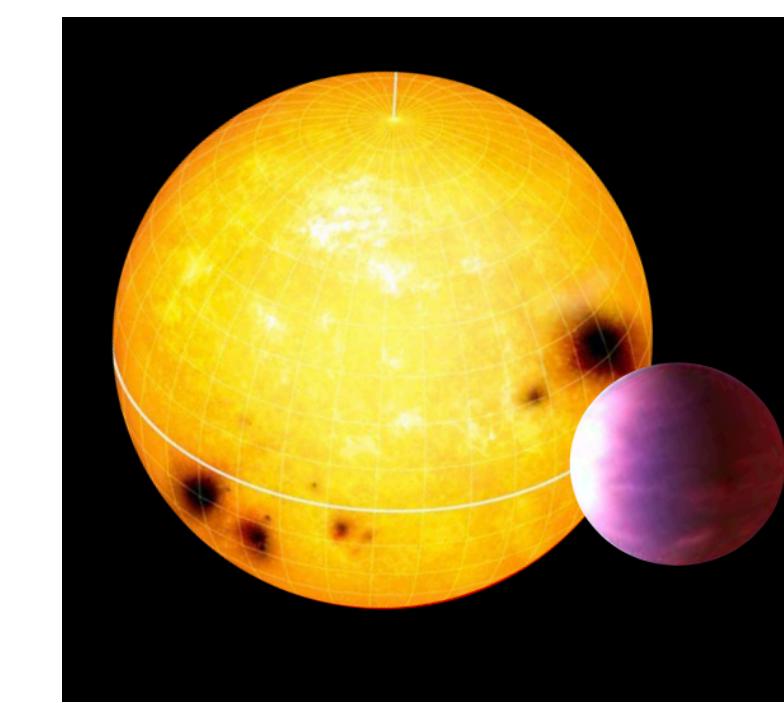
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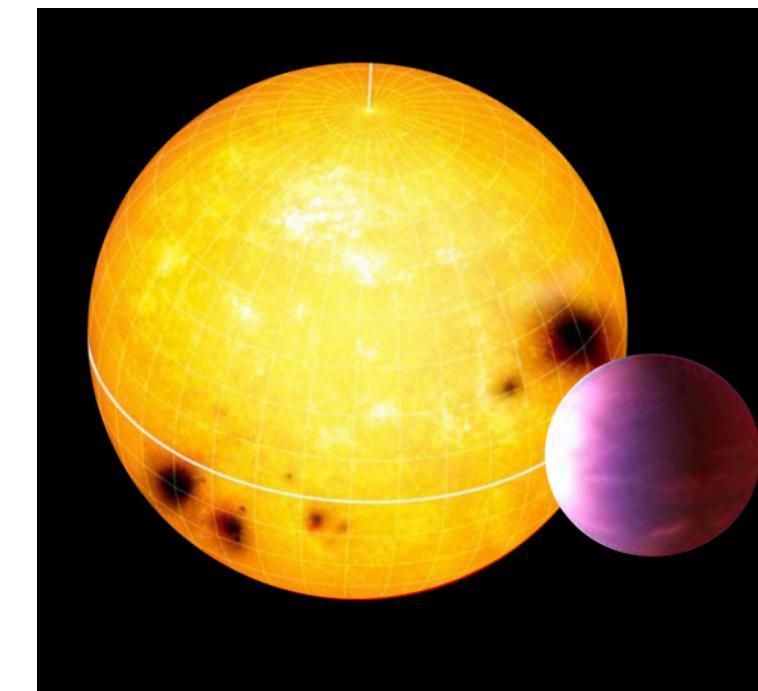
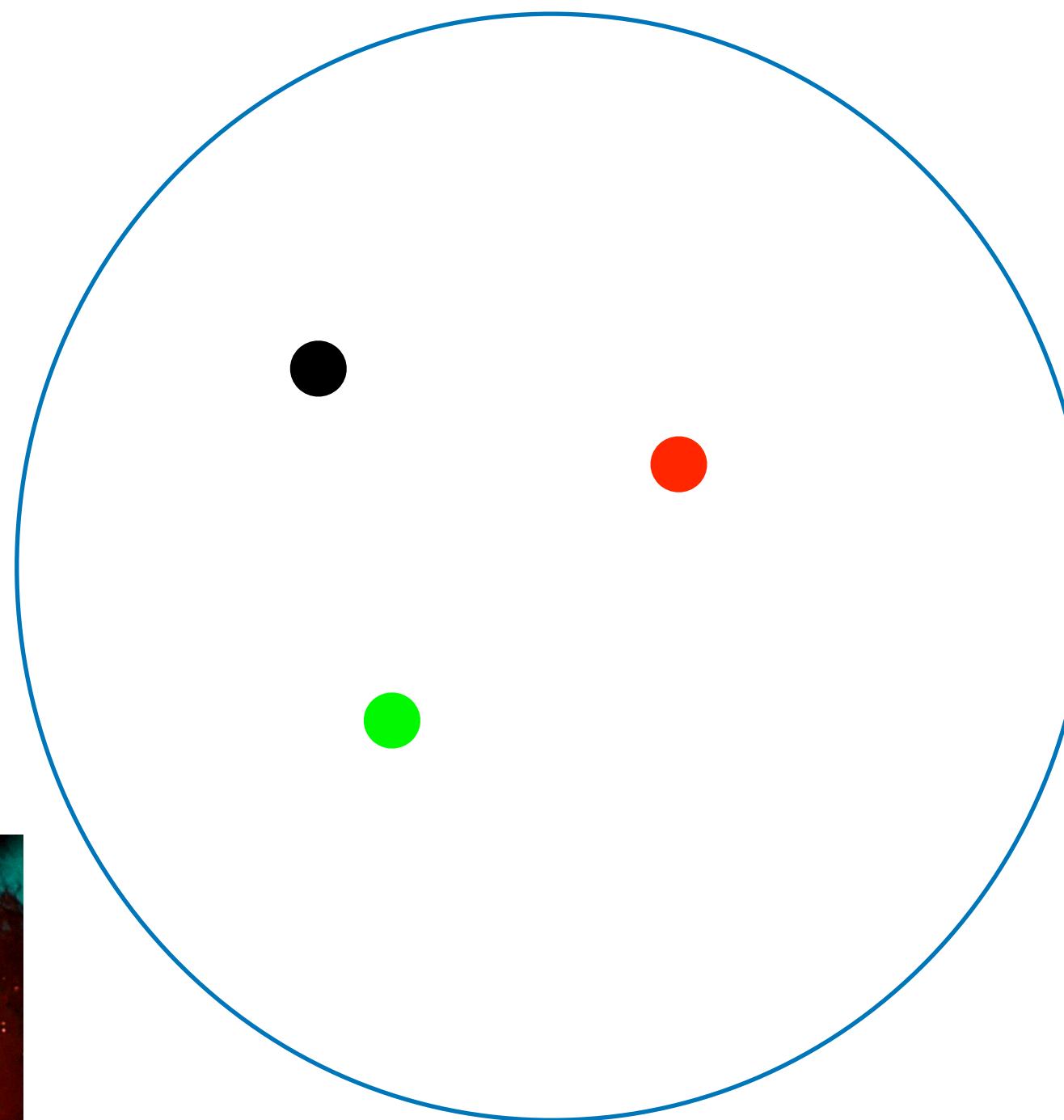
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# Contrastive Learning: InfoNCE Loss

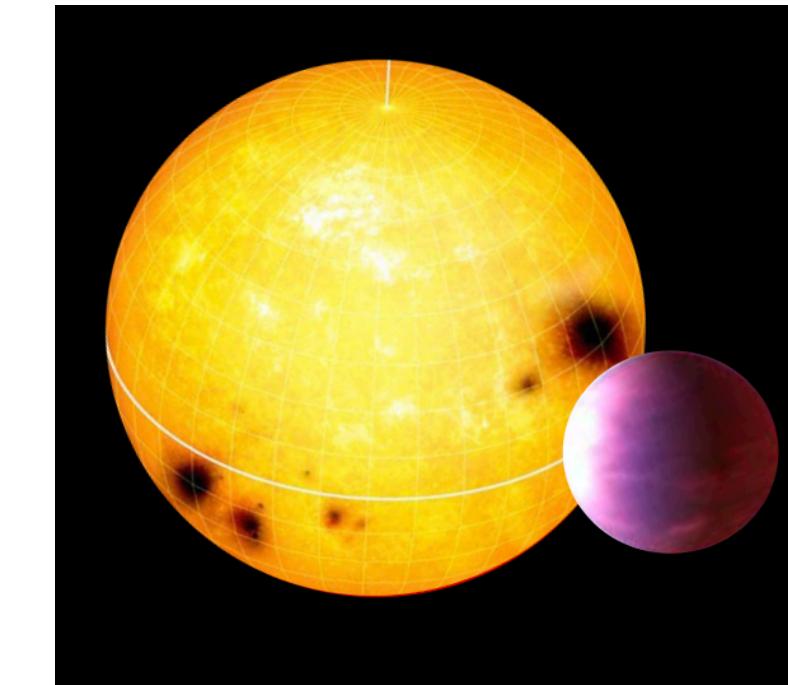
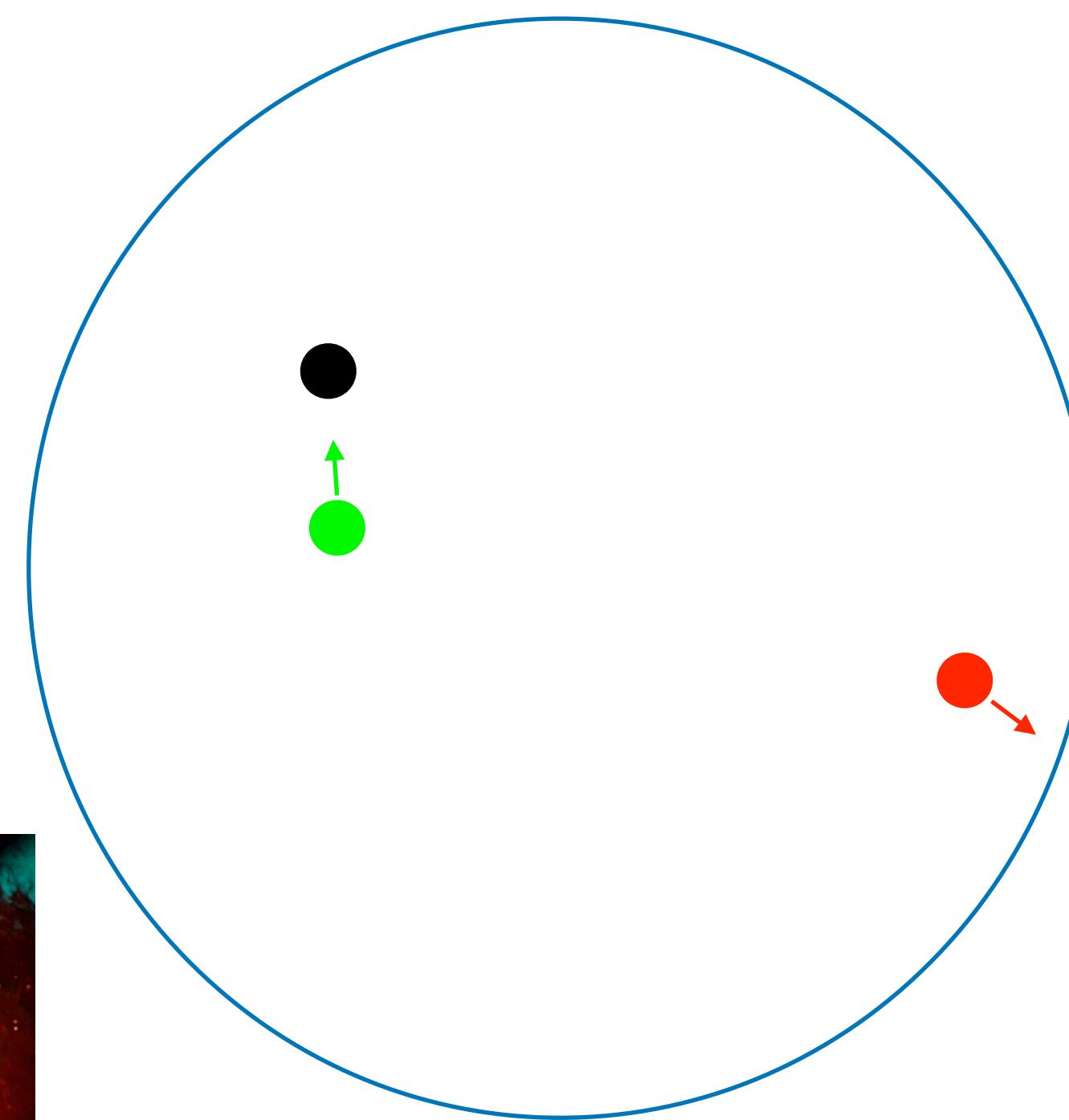
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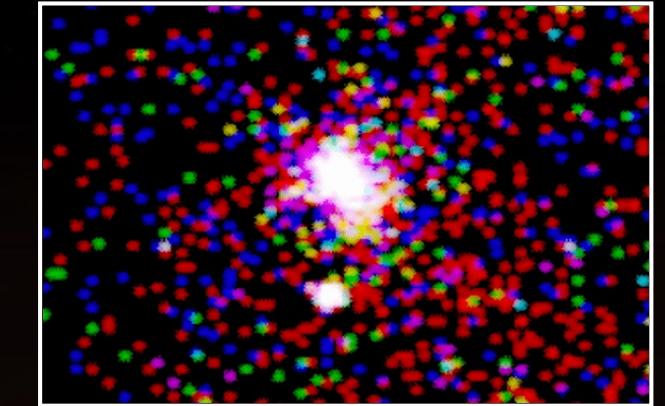
# Contrastive Learning: InfoNCE Loss



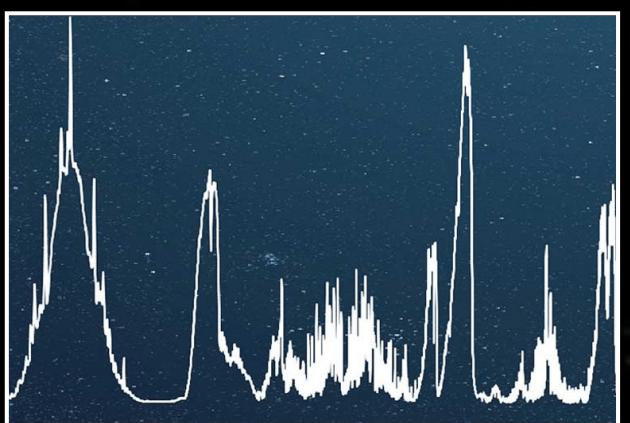
# Contrastive Learning: InfoNCE Loss



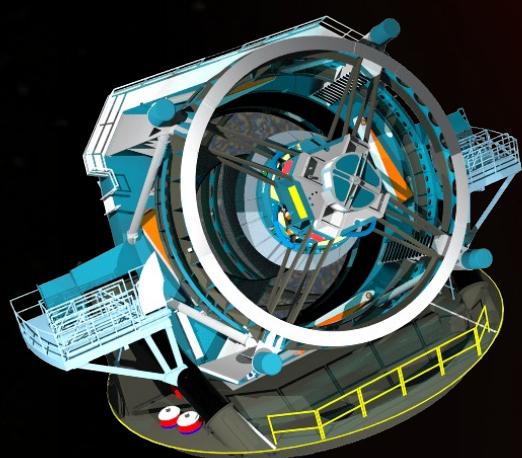
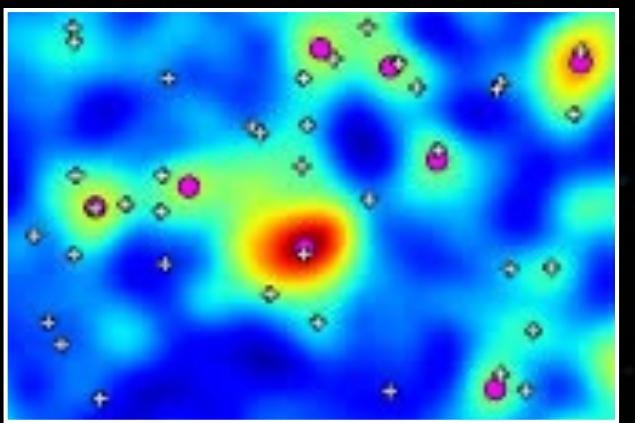
$$\mathcal{L}_i = - \log \frac{\exp \left( \text{sim}(z_i, z_j)/\tau \right)}{\sum_{k=1}^N \exp \left( \text{sim}(z_i, z_k)/\tau \right)}$$



**Chandra**



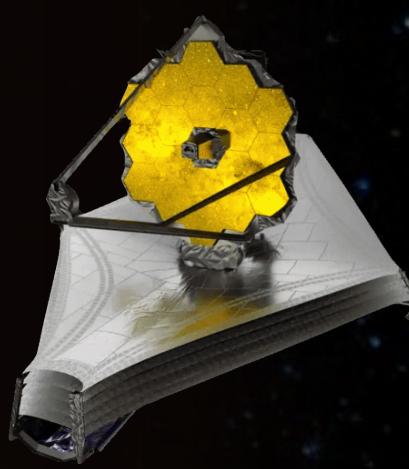
**Roman**



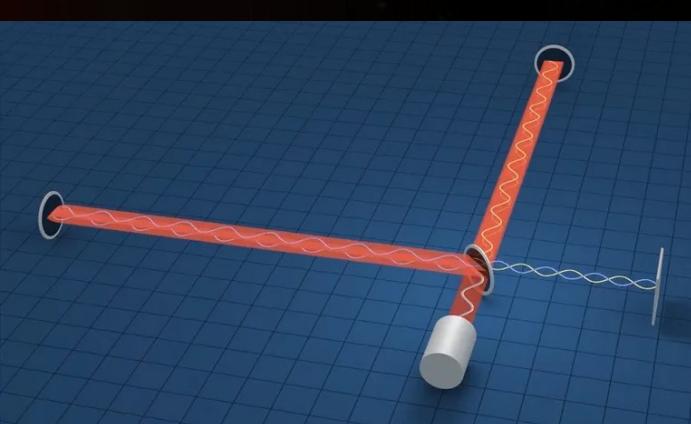
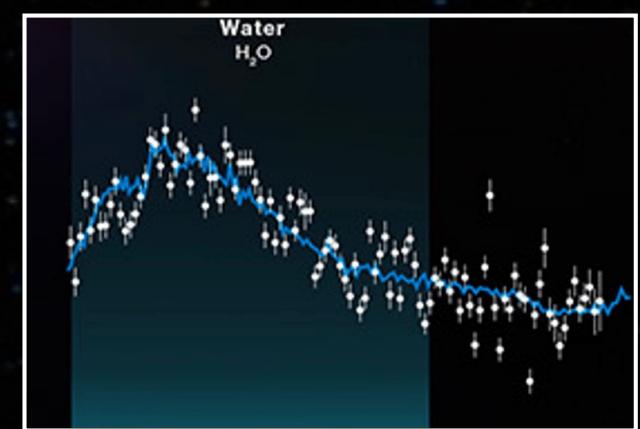
**Rubin**



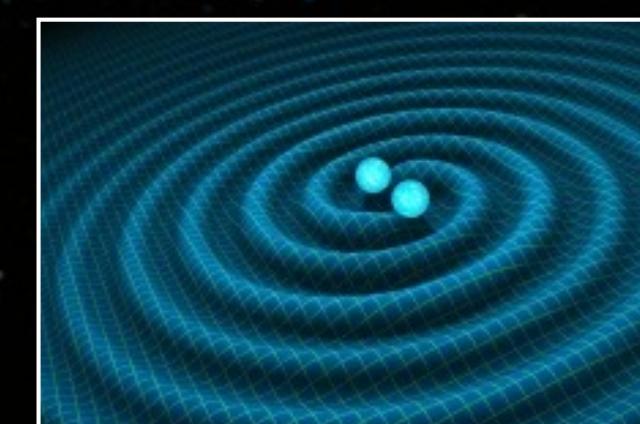
**Event Horizon  
Telescope**



**Webb**

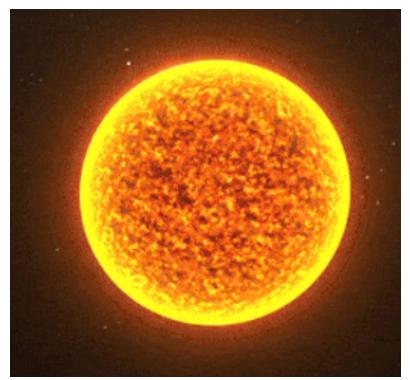


**LIGO**

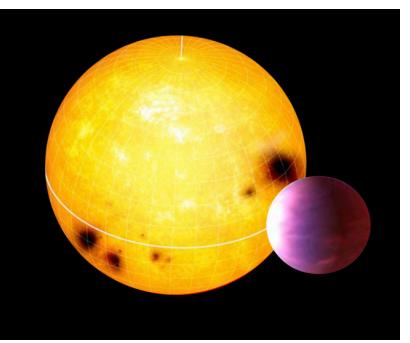


# Multi-Modal AI Models: Aligning Representations with Contrastive Learning

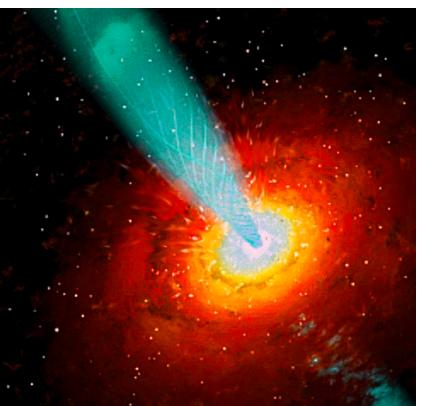
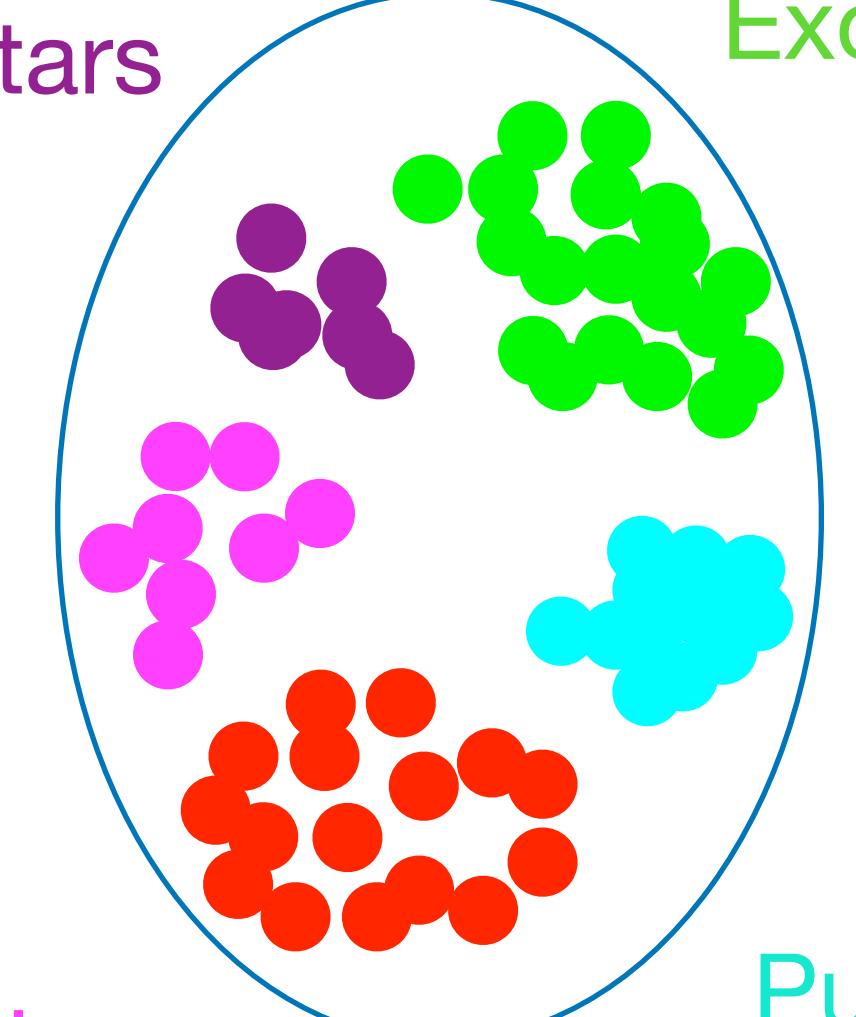
## Image Representation



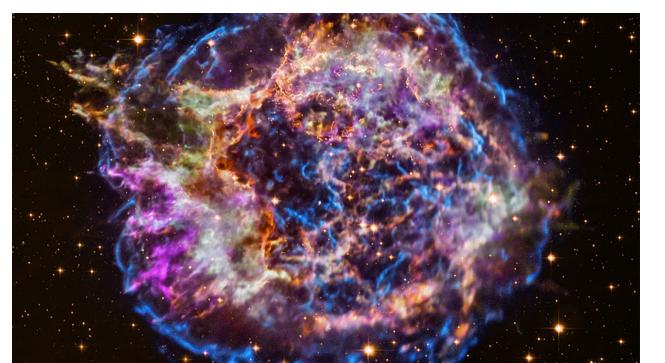
Stars



Exoplanets



Pulsars

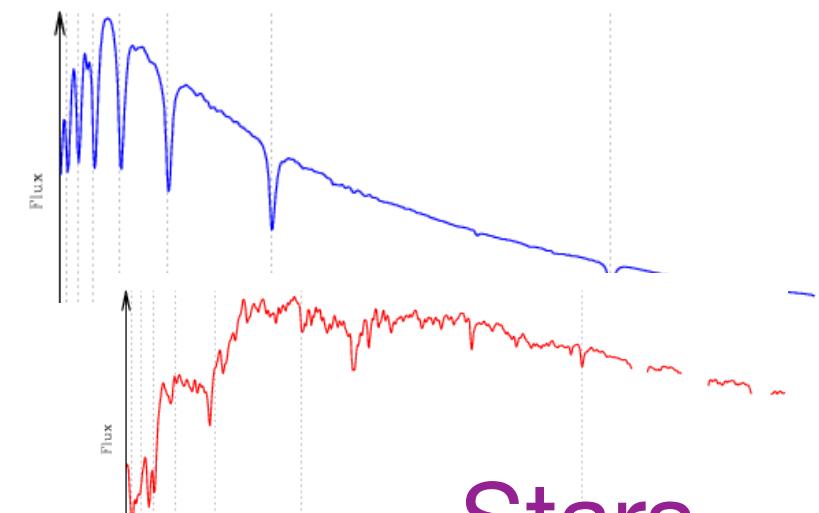


SNe

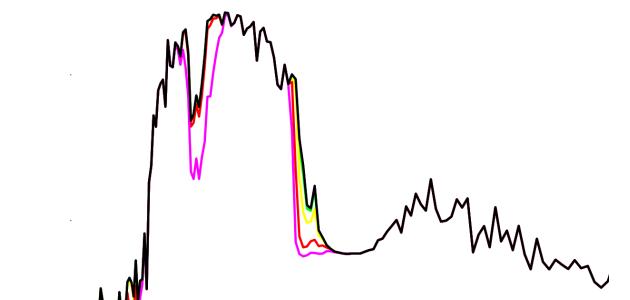
Galaxies



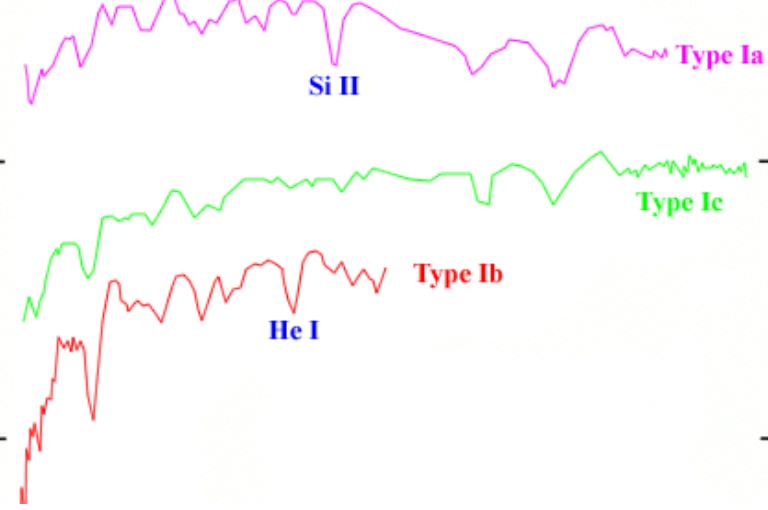
## Spectra Representation



Stars

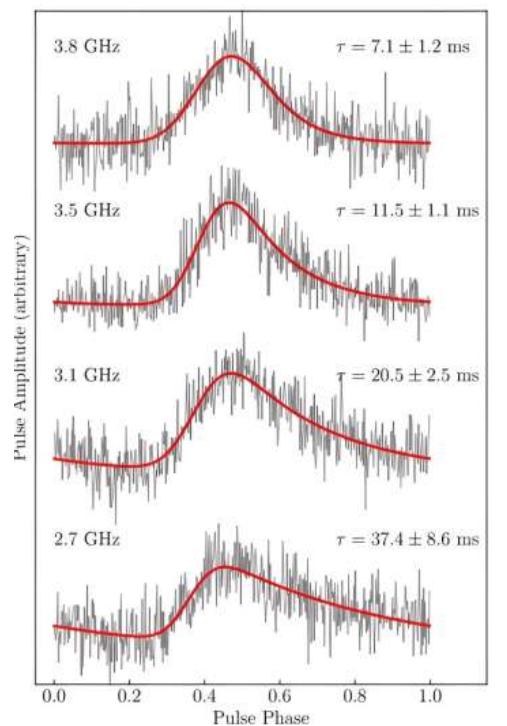


Exoplanets



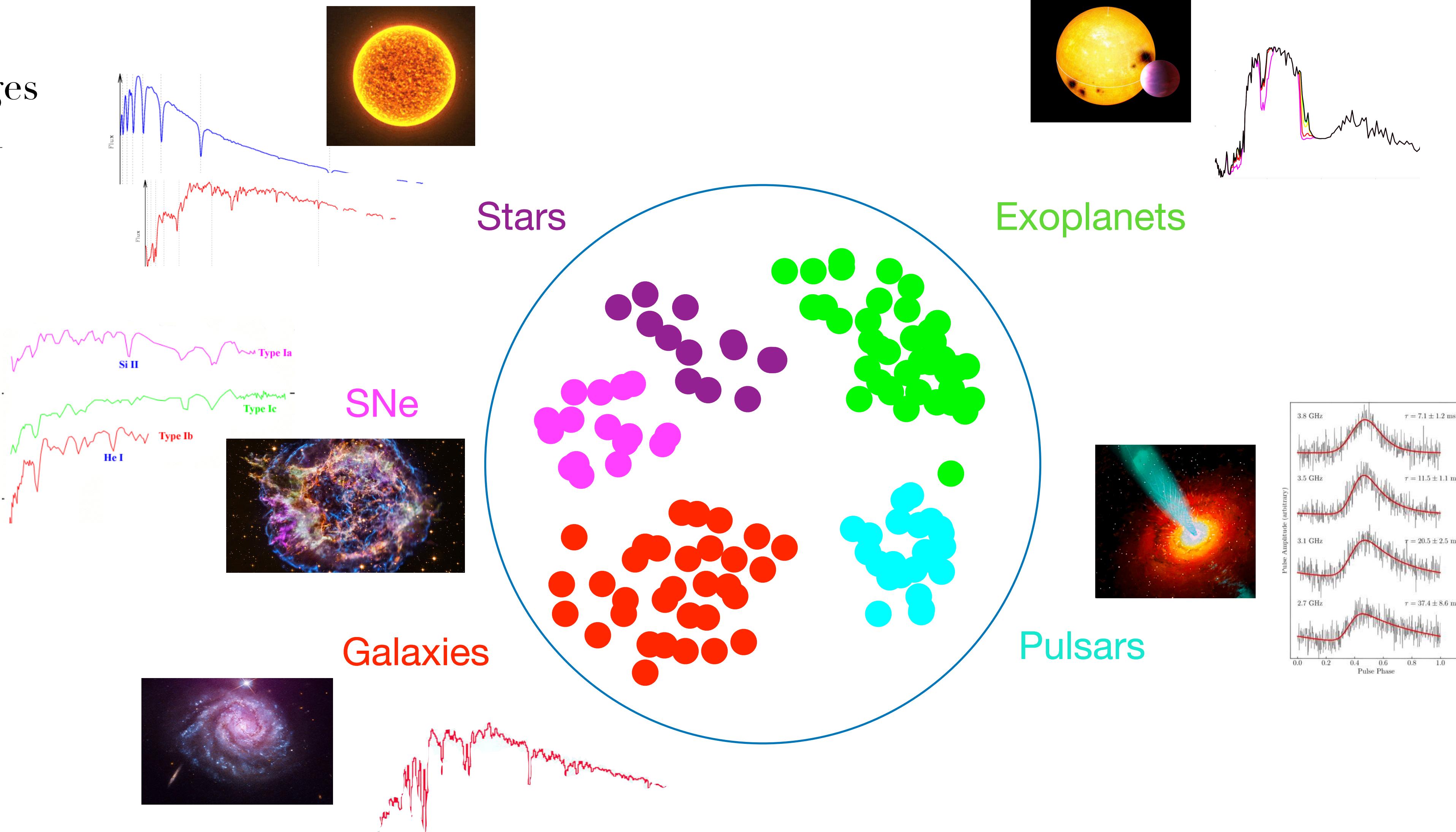
SNe

Galaxies



Pulsars

# Multimodal Spectra + Images Representation



# Representation Learning:



# Representation Learning: Cross Retrieval



# Representation Learning: Bimodal Analysis



# Representation Learning: Multimodality

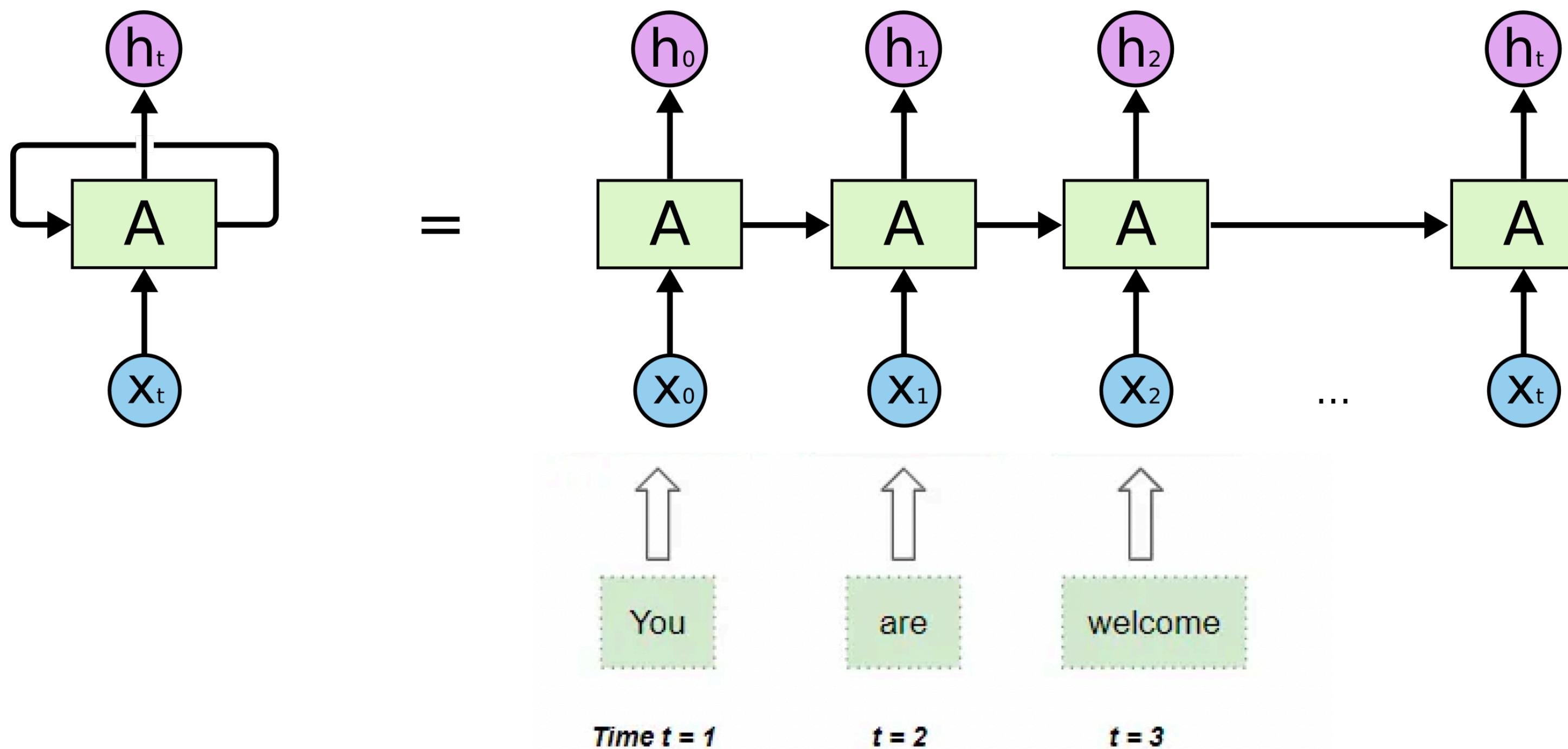


# Representation Learning: Multimodality



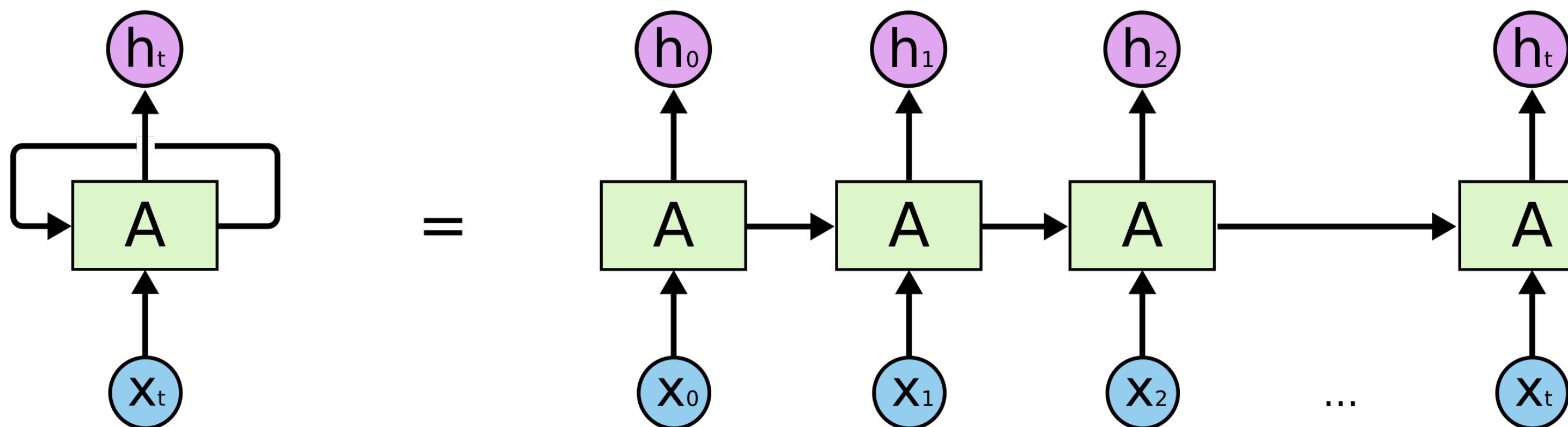
# Types of (deep) networks: Time Series

## Recurrent Neural Networks



# Types of (deep) networks: Draw Backs

## Recurrent Neural Networks



- Vanishing and exploding gradients —> difficult to train
- Can't connect words that are far away—> no context learning
- One word a time —> computationally expensive

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# Transformers

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## Attention Is All You Need

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**Jakob Uszkoreit\***  
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**Llion Jones\***  
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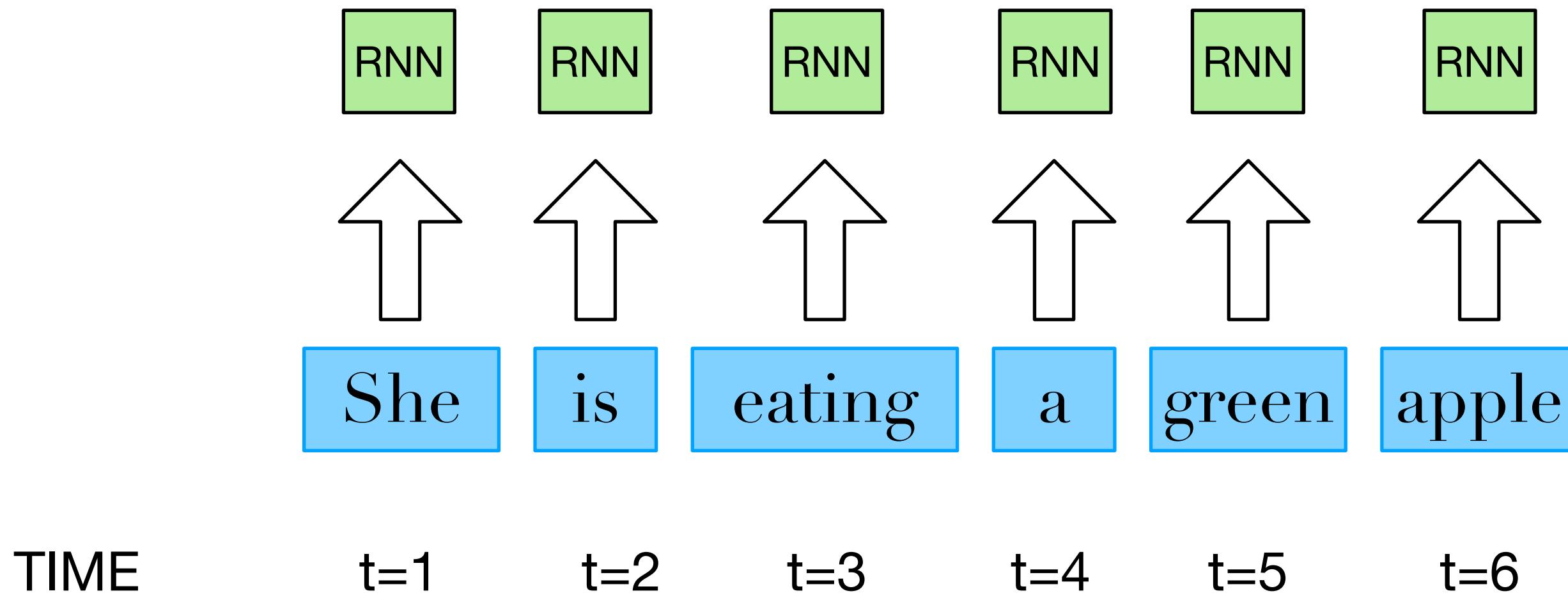
**Aidan N. Gomez\* †**  
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**Łukasz Kaiser\***  
Google Brain  
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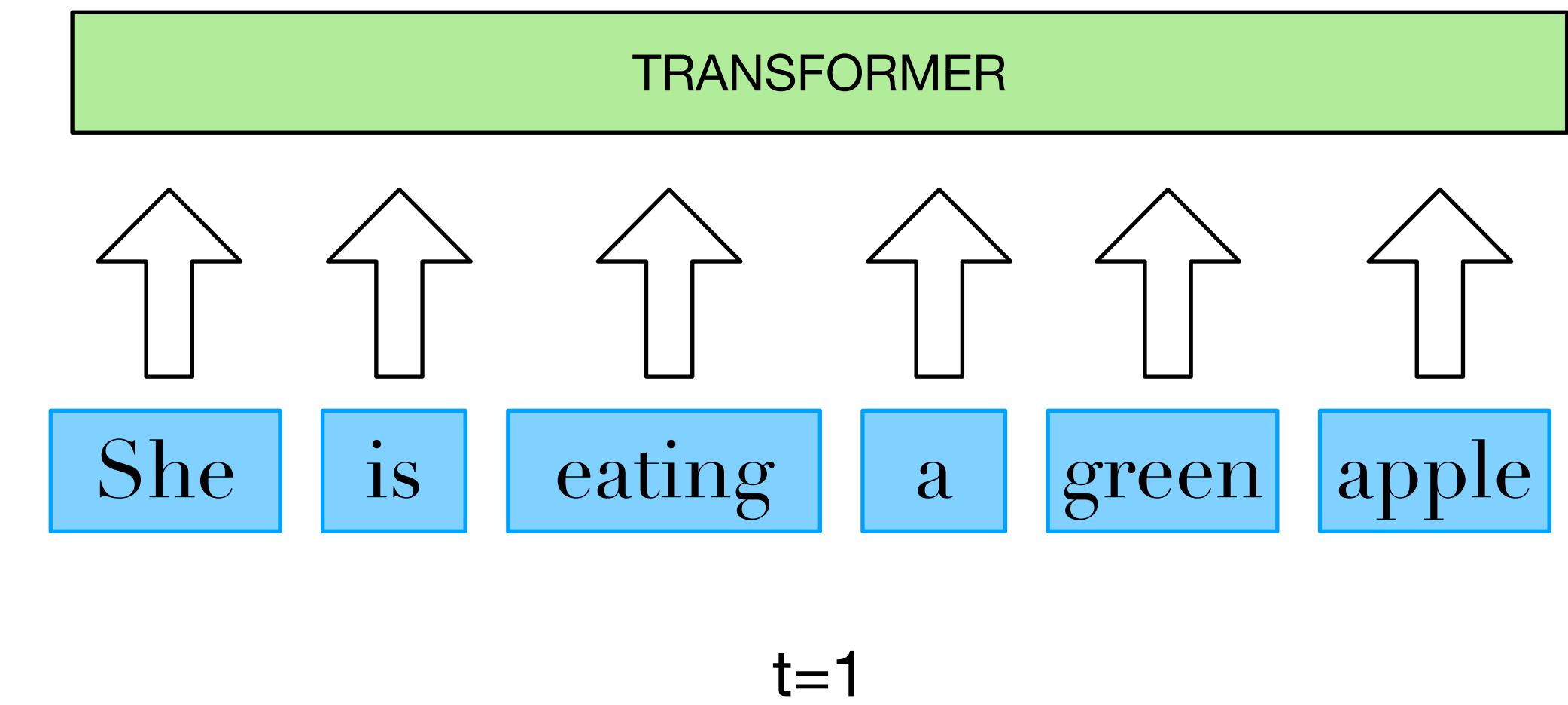
**Illia Polosukhin\* ‡**  
[illia.polosukhin@gmail.com](mailto:illia.polosukhin@gmail.com)

# Transformers

## Recurrent Neural Networks

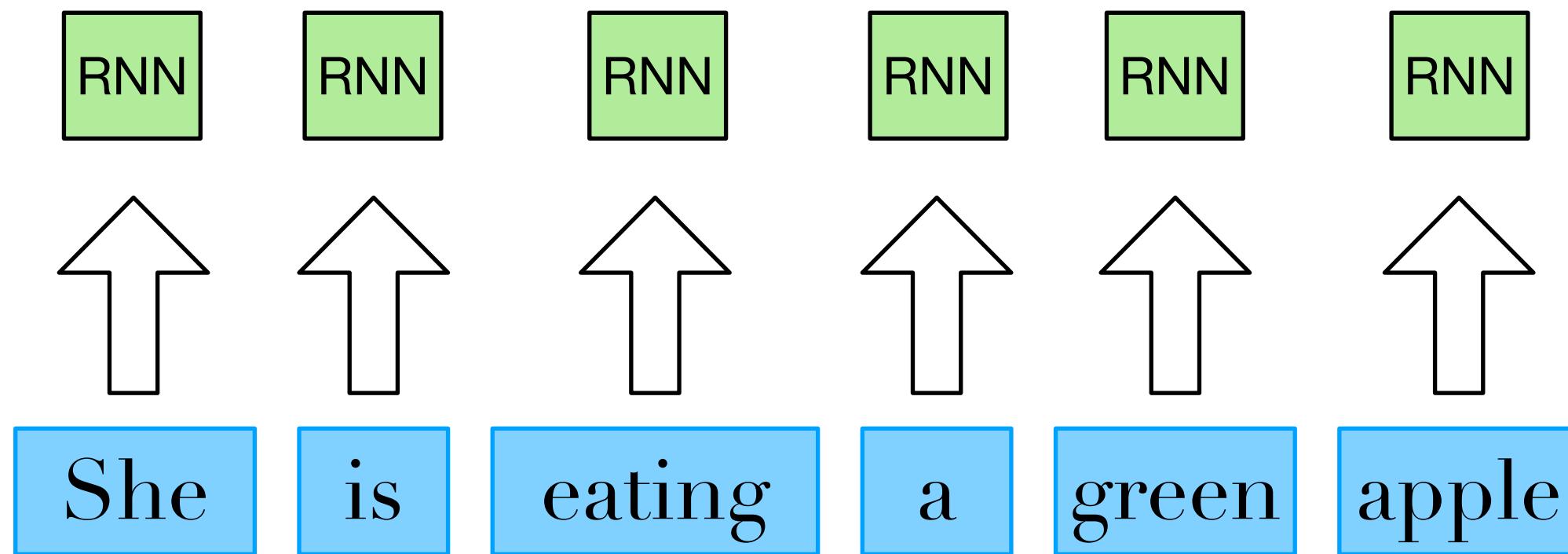


## Transformers

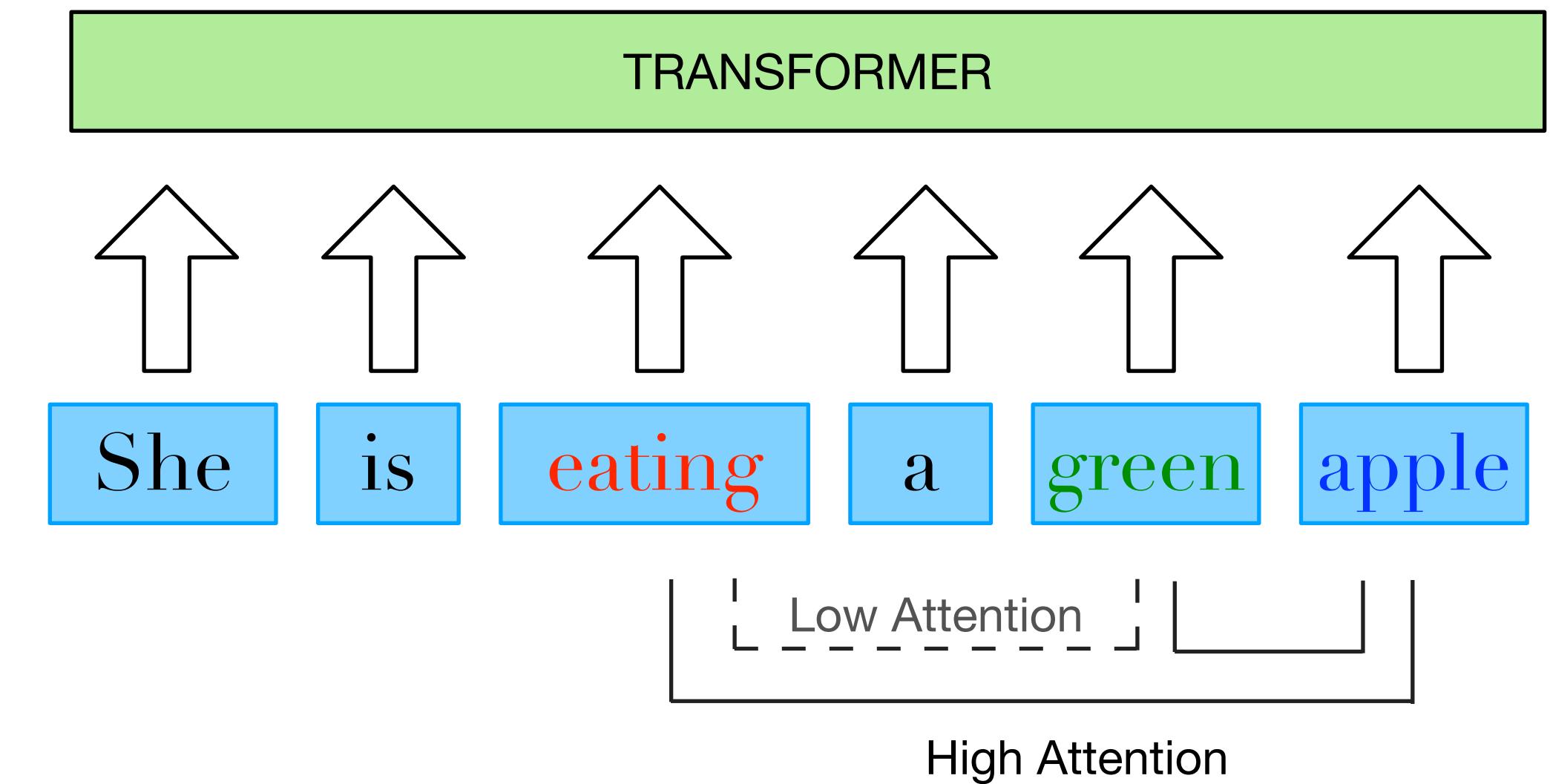


# Transformers

## Recurrent Neural Networks

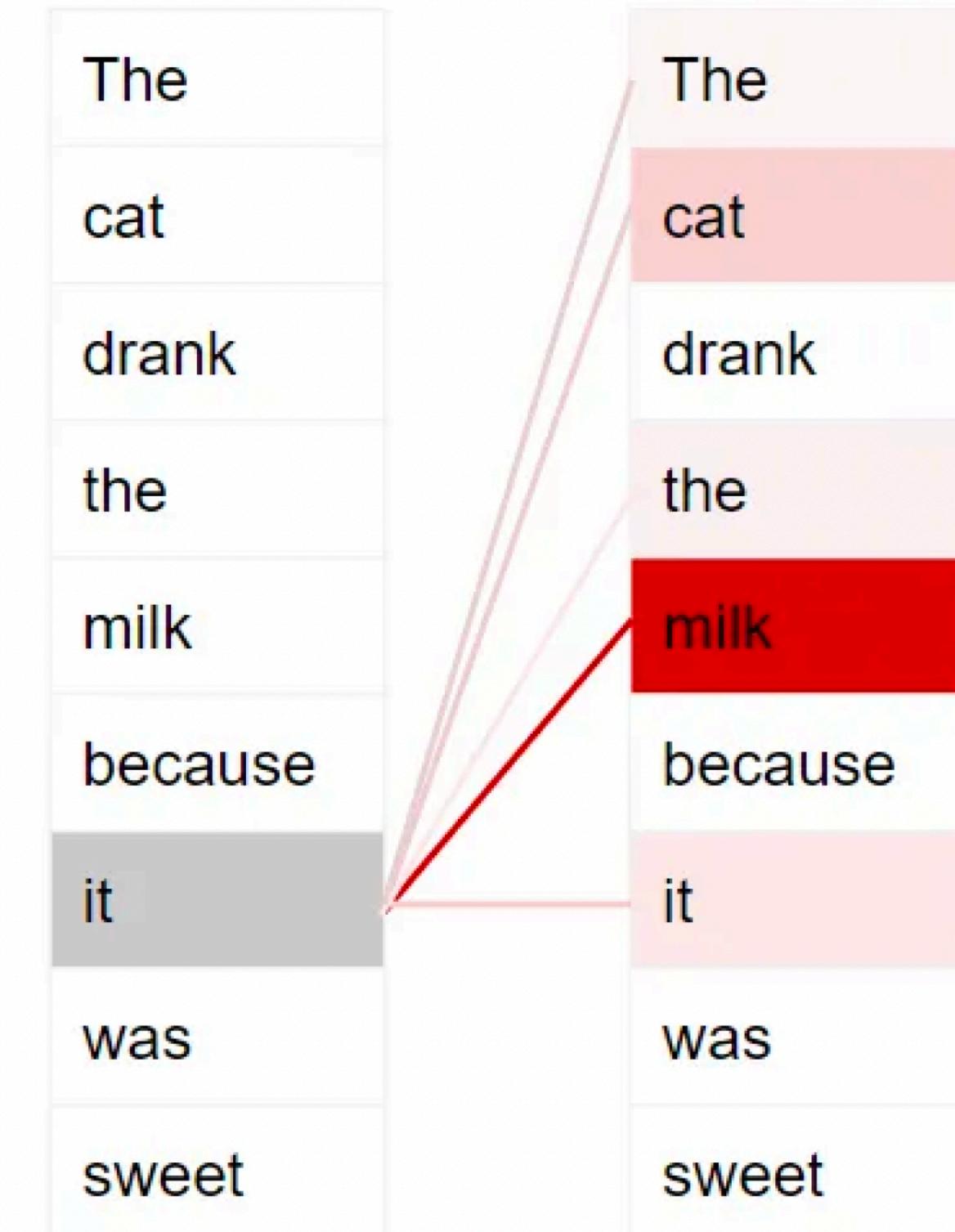
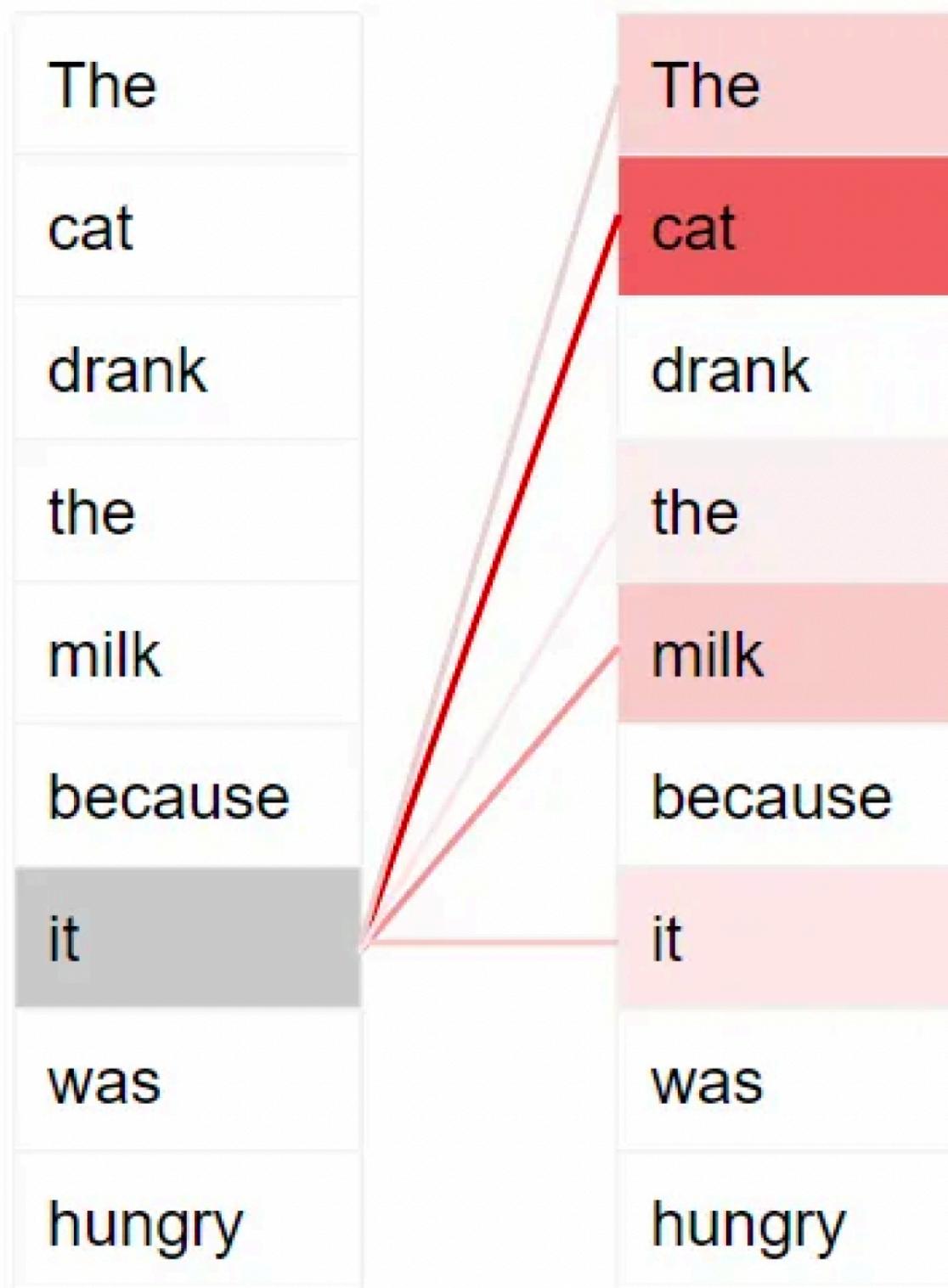


## Transformers



# Transformers

“The cat drank the milk because it was hungry”



“The cat drank the milk because it was sweet”

# Representation Learning

