What are Memories? 🤔

Energy unites **Diffusion** and **Associative Memory**

**Diffusion Models vs Associative Memories**

1. Do I have an energy?
2. Is energy bounded from below?
3. \( \frac{dE}{dt} \leq 0 \) everywhere?

↓

Energy is **Lyapunov**

You have an **Associative Memory**

---

**Neurons** are dynamical variables that evolve to minimize their contribution to a global energy. Each neuron has two properties:
1. an internal state \( X \) that evolves in time
2. a convex, scalar Lagrangian function \( L \)

The Lagrangian defines the activations

\[
g = \nabla X L
\]

and the neuron's energy

\[
E = (g^T X) - L
\]

**Synapses** describe relationships between the activations of dynamic variables (neurons)

**Synapses can be any function**, but are often parameterized by weights \( W \)

\[
E = -g^T_m W g_f
\]

Neuron states evolve to descen **total energy**

\[
E = E_{\text{features}} + E_{\text{memories}} + E
\]

---

**IBM Research**

"Uncanny Resemblance of Diffusion & Associative Memory in Memory in Plain Sight"