



### F. The Epistemological Point

#### WHY TIME AVERAGING FAILS

**ERGODIC SYSTEM:**

- No hidden memory
- All trajectories explore same states
- Time avg  $\rightarrow$  Ensemble avg as  $T \rightarrow \infty$
- Inference: just measure longer

**NON-ERGODIC SYSTEM:**

- Hidden state H carries memory
- H constrains which states are visited
- Time avg  $\rightarrow$  H-dependent value
- Inference: measuring longer doesn't help!

#### THE BIOLOGICAL CASE:

If sub-Landauer structure (epigenetic marks, conformational states, developmental history) encodes memory that you cannot observe:

- $\rightarrow$  Your time averages are **BIASED**
- $\rightarrow$  The bias depends on **HISTORY**
- $\rightarrow$  You cannot detect the bias
- $\rightarrow$  "Just collect more data" doesn't fix it

This is why non-ergodicity breaks the classical inference toolkit.