Why Stat Mech?

Newton → classical mechanics (laws of motion for single particles)

Laplace → Clockwork Universe
Everything predictable from Newton's laws

Microscopic laws of motion

But difficult to apply to 10^{23} particles macroscopically

So

Thermodynamics → Phenomenological

e.g. P, V, T → no analog in microscopic description

Eqn. of state $PV = RT$

But can we derive this from 1st principles?

→ Stat. Mech.

Emergent phenomena → Arrow of time

$$S = k_B \ln \Omega \quad \text{(Boltzmann)}$$

In isolated system, S evolves to become max.

Non-interacting systems → Elementary Stat Mech

Interacting system → Phase transitions and critical phenomena

e.g. spontaneous magnetization

Discrete symmetry model: Ising

No phase transition in 1D (Bethe-Peierls)
Phase transition in $\geq 2D$ (Onsager – 2D)
Renormalization group (Wilson) (Electoral College)
Coarsening in Schelling model

Continuous Symmetry XY model : No phase transition in 1D or 2D

(Mermin-Wagner Theorem)

Kosterlitz-Thouless transition (vortex-Antivortex binding)

Flocking in Vicsek model

Disordered Systems → spin glass frustration

Structural balance

Breakdown of ergodicity Rugged energy landscape

Frustration Local minima vs. global minima

{Neural Network, SAT} Traveling Salesman problem, Protein folding

Non-equilibrium phenomena – Pattern formation in Chemical system

Absorbing state → Cooperation – Defects

Numerics (schelling's game)

Pre-requisite: To be dealt with in initial classes

Elementary prob (Binomial, Gaussian, CLT)

MB, BE, FD (Asset Exchange Model)

Partition fn. & free energy of a non-interacting system

Counting microstates