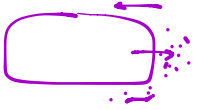


DISCUSS PURCELL → DO THE BACTERIUM BUS EXERCISE

- FOR THE BACTERIUM, THE WATER IS SAND-SIZED → IMAGINE TRYING TO PUSH A BUS THROUGH SAND.



- FOR A PROTEIN, WATER IS EVEN LARGER.

- UNLESS IT IS HIGHLY DYNAMIC → SLAMMED INTO BY WATER. IMAGINE BEING VIOLENTLY SHAKEN IN A BALL PIT FILLED WITH SOFTBALLS. TOTALLY RANDOM

[SHOW WATER MOVIE]

PROBLEM: WHERE DOES ORDERED BIOLOGY COME FROM?

EXAMPLE: -VESICLES MOVING, SMOOTHLY AND DIRECTIONALLY

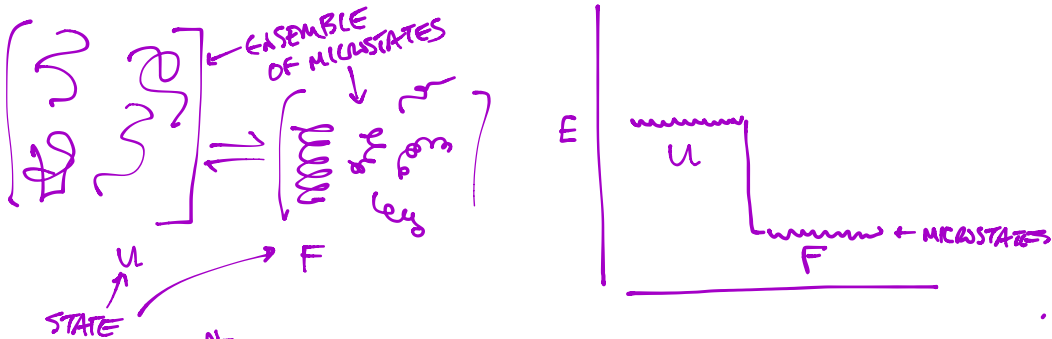
[SHOW VALE VIDEO] (BIOLOGY)

[SHOW SMOOTH ANIMATION] (MOLECULAR)

[SHOW DRUNK WALK] (MOLECULAR ✓✓)

HOW DO WE LINK ACROSS THESE SCALES?

SIMPLER THAN KIESEL:



$$P_F = \frac{\sum_{i=1}^{N_F} N_i f_i}{Q} \leftarrow \text{SUM ALL MICROSTATES}$$

$P_F = \frac{N_F \langle H(F) \rangle}{Q}$
 ↑
 HOW MANY WAYS TO BE FOLDED
 AVERAGE FAVORABILITY OF BONDS IN FOLDED STATE

$$\frac{P_F}{P_U} = \frac{N_F \cdot W_F}{N_U \cdot W_U}$$

$$\ln\left(\frac{P_F}{P_U}\right) = \ln\left(\frac{N_F \cdot W_F}{N_U \cdot W_U}\right)$$
$$= \ln\left(\frac{N_F}{N_U}\right) + \ln\left(\frac{W_F}{W_U}\right)$$

$$-RT \ln\left(\frac{P_F}{P_U}\right) = -RT \ln\left(\frac{N_F}{N_U}\right) - RT \ln\left(\frac{W_F}{W_U}\right)$$

$$\Delta S^\circ \cong RT \ln\left(\frac{N_F}{N_U}\right) \leftarrow \text{DIFF IN \# MICROSTATES}$$

$$\Delta H^\circ \cong -RT \ln\left(\frac{W_F}{W_U}\right) \leftarrow \text{DIFF IN BONDS}$$

$$\Delta G^\circ \cong -RT \ln\left(\frac{P_F}{P_U}\right) \leftarrow \text{DIFF IN TOTAL PROB OF U VS F}$$

$$\Delta G^\circ = -T\Delta S^\circ + \Delta H^\circ$$

↑ AVERAGES CORRECTLY OVER MICROSCOPIC DISORDER TO REVEAL MACROSCOPIC ORDER

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