Thermodynamics - study of chemical energy

Why in bio 111?

major goal of living things is controlling chemical reactions

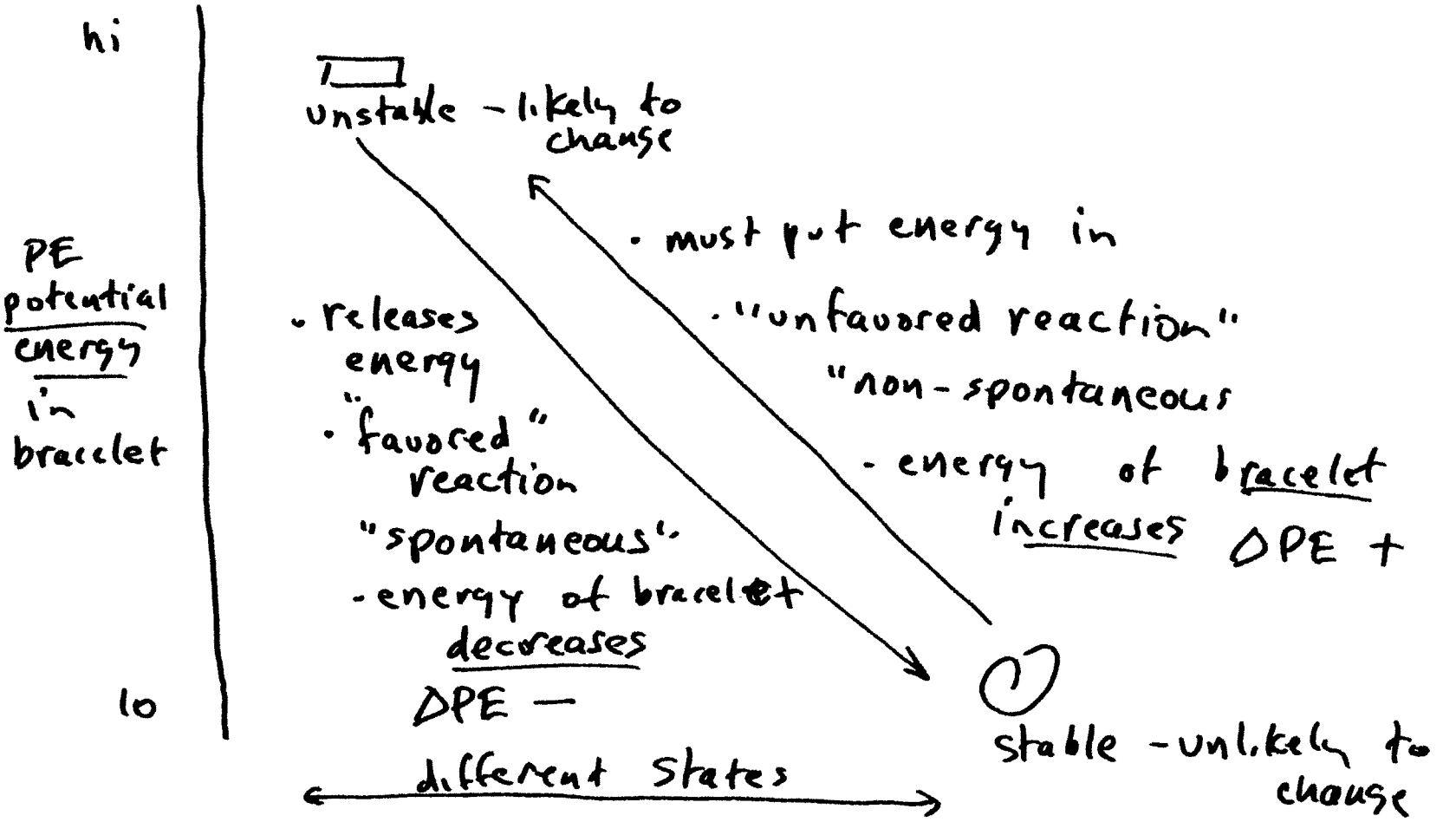
ex I want to digest my lunch into monomers
(1) not to atoms (2) sometime soon

∴ need to control (1) which reactions happen
& (2) how fast

Illustrative example "slap bracelets"

2 states : ▭ straight ◎ coiled

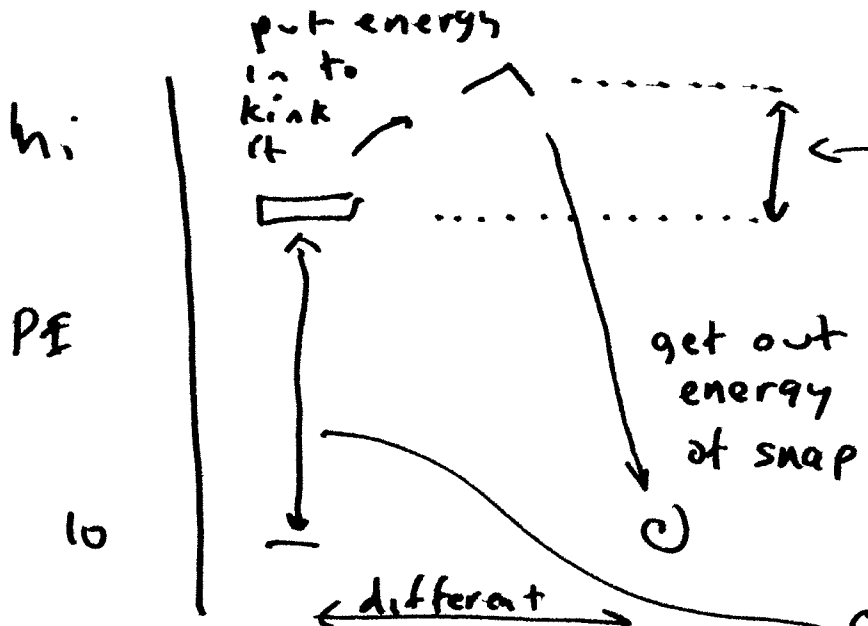
Δ (delta)
= change in



Q: if ▭ → ⊙ is favored - why doesn't it snap in your hand?

A: need to "put a kink in it" to start it off

∴ transient 3rd state - kinked ⌃ - where on chart?



← Activation energy (E_A)
required to overcome reaction barrier
* controls reaction rate

overall energy - controls which direction is favored / unfavored

Rate * not ~~how~~ how fast each bracelet snaps
but how often bracelets snap

3 situations

real world
temperature
absolute zero

① box sitting still : rate = 0

② box shaking a little : rate = low — warm

③ box shaking a lot : rate = high — hot

why? more shaking ⇒ more ▭ have enough energy to kink & then snap ⇒ faster rate

∴ heating increases rate of ~~all chemical reactions~~ favored reaction

Q: can heat make unfavored rxn happen?

A: NO - heat energy is not ~~usef~~ useful here

heat is random motion

more shaking won't G ⟶ ⬭

Connection to real world

"potential energy in bracelets" = "chemical potential energy in molecules"

= Gibbs' free energy "G" $\Delta G-$ = favored

$\Delta G+$ = unfavored

ex. rusting iron (hot packs)

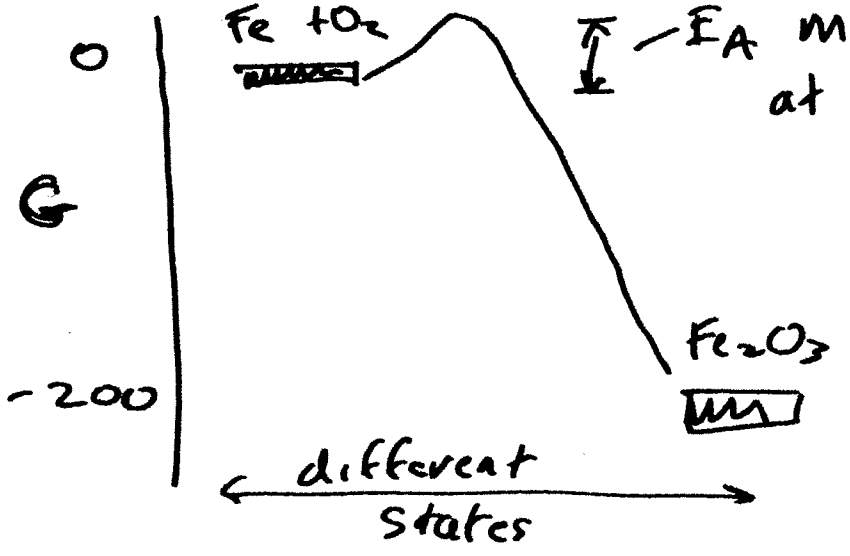
reactants ⟶ products $\Delta G = -200$ kcal/mol (units)

$Fe + O_2 \longrightarrow Fe_2O_3$

iron red rust

ΔG = change in free energy

$-$ ∴ favored



E_A means that rxn happens slowly at room temp

→ favored

← unfavored

rules for ΔG

① reverse reaction has reverse sign of ΔG

$Fe_2O_3 \longrightarrow Fe + O_2 \quad \Delta G + 200$ kcal/mol

∴ unfavored

② ΔG's can be added

$Fe + O_2 \longrightarrow Fe_2O_3 \quad \Delta G -200$

$+ \quad Fe_2O_3 + O_2 \longrightarrow Fe_3O_4$ black rust $\quad \Delta G -70$

$Fe + O_2 \longrightarrow Fe_3O_4 \quad \Delta G -270$