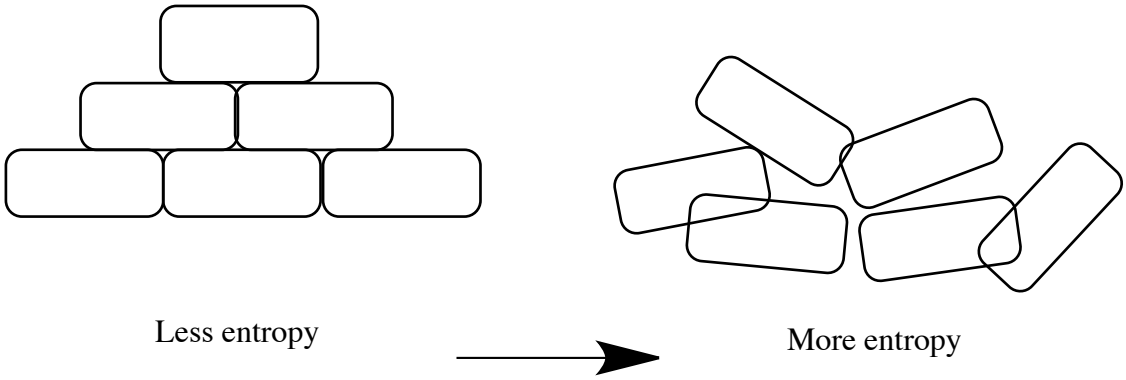
CONCEPT: GIBBS FREE ENERGY AND EQUILIBRIUM

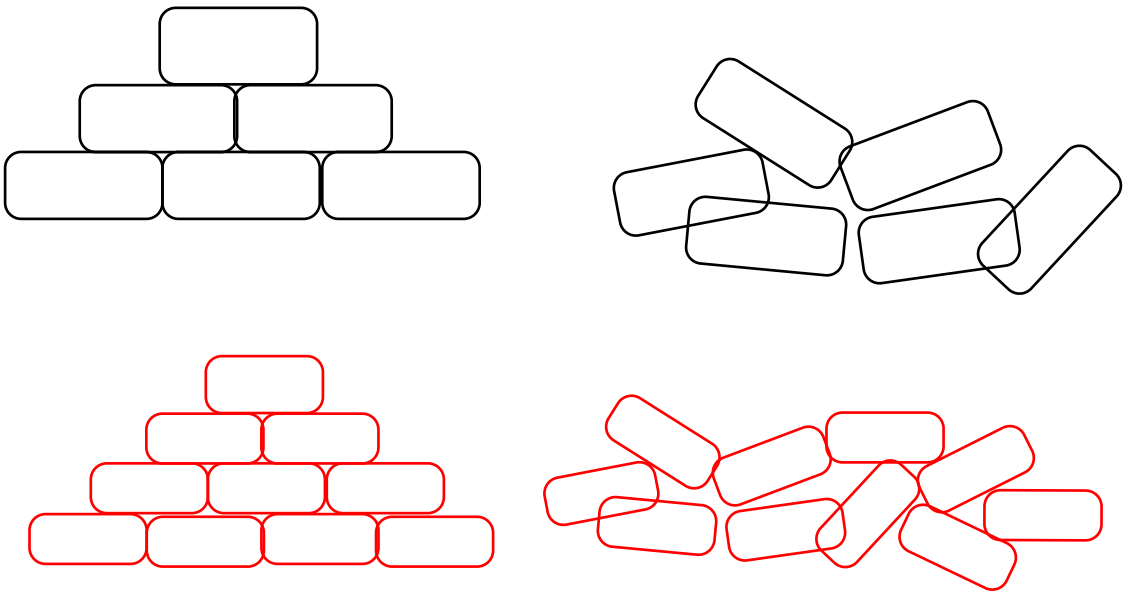
- **Gibbs free energy** (G) is a measure to determine if a chemical reaction will occur *spontaneously*
  - □ Spontaneous reactions are those which are thermodynamically favorable (can occur without outside help)
    - Increase **entropy** (disorder) of the universe
  - □ Gibbs free energy can be calculated at a particular time point (**G**) or as a change occurring during a reaction (**ΔG**)
    - ΔG changes as a reaction moves towards equilibrium
  - □ **Equilibrium** is a state where the chemical reaction equally occurs in forward and reverse
    - Cells do not exist at equilibrium – life depends on having reactions that do not reach equilibrium

EXAMPLE: Ordered and disordered blocks model a spontaneous reaction



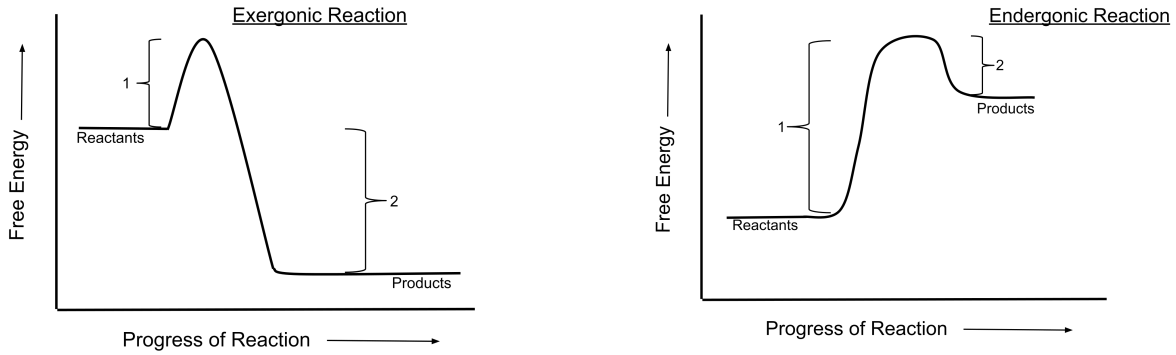
- ΔG and the **standard free energy change (ΔG°)** measure spontaneity of chemical reactions
  - □ ΔG calculates spontaneity for a reaction in a single direction with known concentrations of products and reactants
    - Used to measure real life reactions and is highly sensitive to reactant and product concentrations
  - □ ΔG^{o} calculates spontaneity for a reaction occurring in standard conditions
    - Temperature = 25°C and Pressure = 1atm
    - Used to compare thermodynamics of many reactions because its not sensitive to concentrations

EXAMPLE: Model demonstrating the need for the standard free energy change formula



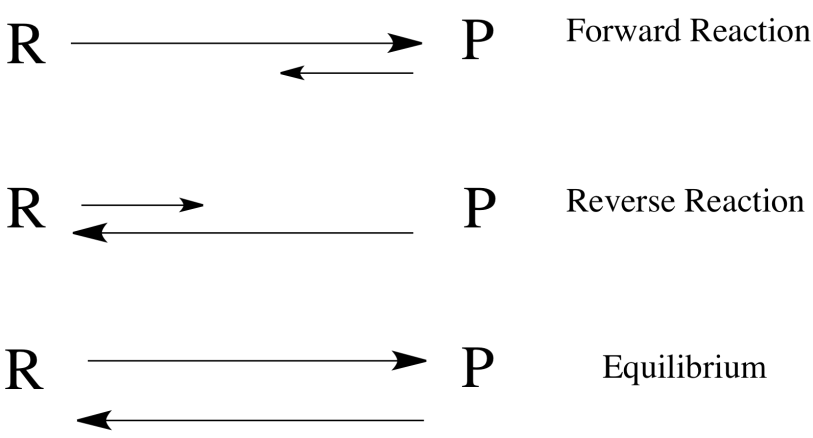
- Chemical reactions can be classified as *exergonic* (energy releasing) or *endergonic* (energy absorbing)
  - □ **Exergonic** reactions are more thermodynamically favorable
    - ΔG will be *negative* because free energy of products is lower than free energy of reactants
  - □ **Endergonic** reactions are less thermodynamically favorable
    - ΔG will be *positive* because free energy of products is higher than free energy of reactants
  - □ At equilibrium $\Delta G=0$ and no NET reactions occur

EXAMPLE: Graphs of exergonic and endergonic reactions



- Measurements of free energy can also provide information on distance to equilibrium
    - The **Equilibrium constant** (K_{eq}) is a ratio of products to reactants
        - Measures how far a reaction needs to proceed before being at equilibrium
    - K_{eq} can also provide information on directionality of the reaction
        - K_{eq}> 0.5 then there are more products – reaction will proceed in reverse
        - K_{eq}<0.5 then there are more reactants – reaction will proceed forward
        - At equilibrium K_{eq}=0.5 and no reactions occur
    - **Steady state** refers to concentration stability of reactants and products (NOT the same as equilibrium)
        - Nutrients that are continually flowing into the cell and being used up are at steady state, not equilibrium

EXAMPLE: Ratio of reactants and products determines the directionality of the reaction



PREVIOUS CLUTCH VIDEOS:
- Click here for an explanation of the Gibbs free energy equation terms
- Click here for a review of calculating Gibbs free energy
- Click here for a review of the relationship between Gibbs free energy and equilibrium