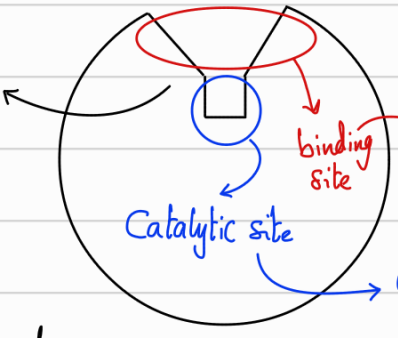
Enzymes

→ Except ribozymes

→ Proteins that catalyze, accelerate, speed up, increase the rate of chemical reactions

- Small amount
- Unconsumed, unchanged
  - So, they can be used repeatedly

- Affinity → strength of binding
- Specificity → The preference to bind a molecule
  - most proteins are specific
  - Albumin is non-specific



bind, orient and stabilize the interactions with substrates (reactants)

Catalyze, carry out the reaction

Active site must be specific with high affinity, by:

1) Compitable 3D shape
2) proper interactions with substrate
   - determined by the primary structure (amino acid sequence) of the enzyme

Active site
- small
- must bind the substrate on 3 differant points to recognize chirality (isomers)
- Internal, and exclude water
- Interactions are non-covalent (weak) but multiple (high affinity)

Binding between Substrate and active site:

1) Lock and key model ⇝ fits directly
2) Induced fit ⇝ induce conformational changes

Glucokinase bind Glucose (lock and key) and ATP (induced fit)

Free energy

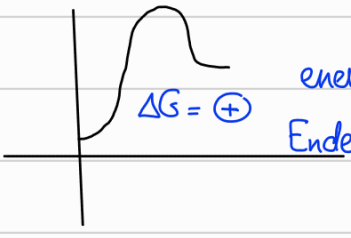
potential energy stored in bonds

→ Free energy change (ΔG) is energy available for the reaction ($\Delta G = G_{Products} - G_{Reactants}$)

No net input

Release energy

Exergonic, Spontaneous



energy is needed

Endergonic, Non-Spontaneous

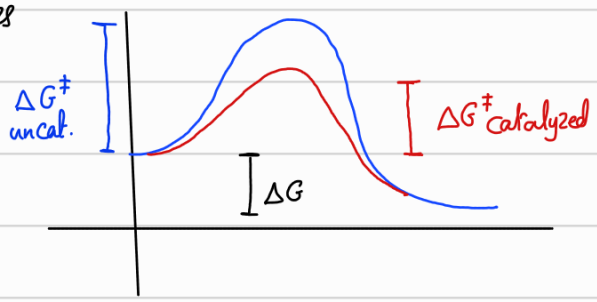
☆ When ΔG = zero → Equilibrium (Rate forward reaction = Rate Backward reaction)

☆ Any reversible reaction ($\Delta G_{forward} = \Delta G_{backward}$) and opposite in charge

Transition state (ES) ⇝ intermediate between substrates and products with highest energy unstable with maximum strained bonds

Activation energy ($\Delta G^{\ddagger}$): $G_{Transition\ state} - G_{substrates}$

Enzymes decrease activation energy but doesn't affect free energy change (ΔG)



Mechanisms of catalysis:

1) Bond strain ⇝ bonds become weaker (vulnerable) and broken easier, such as lysozymes
2) Acid / base catalysis ⇝ involve proton transfer, such as serine proteases (trypsin, chymotrypsin Elastase)
3) Covalent catalysis ⇝ formation of covalent bond such as serine proteases

Types of interactions with active site
- binding site → only non covalent
- catalytic site → Covalent or non covalent

Enzymes Classifications

1) Oxidoreductase ⇝ oxidation Reduction Reaction

Dehydrogenase
- ☆ transfer electrons in the form of H^- or H atom
- ☆ Require NAD^+, FAD, FMN
- ☆ Example: Glutathione reductase

Oxidase
- ☆ transfer H into O_2
- ☆ produce H_2O_2 Hydrogen peroxide

Oxygenase
- ☆ introduce Oxygen
- Monooxygenase ⇝ 1 O atom → Produce H_2O
- Dioxygenase ⇝ 2 O atoms → X H_2O

Peroxidase
- Oxidation of substrate using H_2O_2 as reactants
- ☆ Glutathione peroxidase → Protect the body from ROS

2 Glut ⇌ (Peroxidase / Reductase NADP) Glut-S-S-Glut

2) Transferase

Kinase
Transfer a phosphate from (ATP, GTP....) to a substrate

such as: phosphofructokinase

Fructose 6-phosphate → Fructose 1,6 bisphosphate

Transaminase
Transfer amino group

Convert amino acids ⇌ Keto acids

Amino acids	Keto acids
Aspartate	Oxaloacetate
Alanine	Pyruvate
Glutamate	α-ketoglutarate

Synthase
Transfer monomers to build polymers

Such as Glycogen synthase

3) Hydrolase ⇝ Cleavage reactions using water
→ such as protease, lipases, Glycosidase

4) Lyase ⇝ Cleavage without using water

Dehydrases
Remove H_2O (product)
form double bond
Such as enolase

Decarboxylase
Remove Carboxyl
produce CO_2

Synthase
Citrate synthase

Aldolase
break fructose 1,6-bisphosphate
into Glyceraldehyde 3-phosphate
and Dihydroxyacetone phosphate

5) Isomerase

Isomerase ⇝ Rearrange bonds
Mutase ⇝ move phosphate

6) Ligase (synthetase)

Join molecules using ATP, GTP .....
such as Carboxylase

Abzymes

⇝ antibodies used as enzymes, produced against transition state analogs
→ such as abzymes Similar to Cocaine esterase

Ribozymes

→ Non protein enzymes (RNA + protein)
catalysis → RNA splicing and protein synthesis
→ stabilize and enhance the activity of RNA