Regulation of Enzyme.

- Allosteric regulation : regulated by reversible noncompetitive inhibitors / activator

(most enzyme which allosterically regulated are constructed from 2 or more subunits each composed of own active site)

→ 효소나 단백질 활성이 원래의 활성부위가 아닌 다른 자리에 물질이 결합함으로써 조절되는 현상.

- Allosteric activators / inhibitors
  - Active form $\xrightarrow{\text{activator}}$ stabilized active form (Allosteric activator)
  - ↕ oscillate
  - Inactive form $\xrightarrow{\text{inhibitor}}$ stabilized inactive form (Allosteric inhibitor)

ex) ATP Generation process
ATP : Allosteric inhibitor
ADP : Allosteric activator
⇒ Feedback inhibition - end product acts like inhibitor.

- Cooperativity : another type of allosteric activation
  - $\xrightarrow{\text{Substrate}}$ one substrate to active site of one subunit locks all subunits in active conformation
  - ex) Hemoglobin O_2 affinity.

U1. The Role of Chemistry in Biology

2. Atoms and molecules

neutron, Proton : $1.7\times10^{-24}g$ = 1 dalton (1 amu)

이온결합에서 NaCl 같은 이온식은 비율만 의미함.
그 자체로 분자 아님.

Isotope	동위원소	vertebrate	척추동물
cation	양이온	thyroid gland	갑상선
anion	음이온	abbreviation (리)	약어, 약도, 단축
dissociate	해리, 분리	urine (유린)	~~요소~~ 오줌.

3 The chemistry of water.

Temperature = Average kinetic E. ≠ Thermal E (Totally up of total volume)

Cal (calorie) = 1g water 1°C ↑ : 1cal = 4.184 J

water → hydrogen bonds.

Specific heat = measure of how well a substance resists changing its temperature when it absorbs or releases heat.

hydrophilic	친수성
hydrophobic	소수성
specific heat	비열
affinity	친화력, 호감

In any aqueous solution at 25°C $[H^+][OH^-] = 10^{-14}$ constantly.

$pH = -\log[H^+]$ Buffer ex) $H_2CO_3 \underset{\text{when pH}\downarrow}{\overset{\text{when pH}\uparrow}{\rightleftharpoons}} HCO_3^- + H^+$ ⇒ most other buffers are also acid-base pairs.

H_2CO_3 ↓ H^+ donor (acid); HCO_3^- ↓ H^+ acceptor (base)

브뢴스테드 로우리 산염기 정의
↳ acid = H^+ donor, base = H^+ acceptor.

CO_2 (air)
↓
$CO_2 + H_2O \rightarrow H_2CO_3$
↓
$H_2CO_3 \Rightarrow H^+ + HCO_3^-$
↓
$H^+ + CO_3^- \rightarrow HCO_3^-$
↑
$CO_3^- + Ca^{2+} \rightarrow CaCO_3$

바다 산성화 되어 H^+ ↑ 되면 $CaCO_3$ 만들어야 할 CO_3^{2-}가 H^+랑 결합해서 HCO_3^-가 만들어짐
∴ 산호, 조개 등 다양한 곳에 쓰이는 $CaCO_3$ 양↓

4. Carbon : The basis of molecular Diversity (tetrahedral : 109.5°), C 있으면 organic

hydrocarbon (C-H) : Energy bank. hydrophobic.

isomer
- Structural : branch / double bond location
- Cis-Trans : double bond don't allow the atoms to rotate freely about the bond axis
- Enantiomers : L.D isomers (mirror)


Cis Trans

chemical groups
- affect molecular shapes : indirectly involve
- functional groups : directly involve in chem reactions.

isomer	이성질체
Enantiomer	거울상 이성질체
functional group	작용기

•Hydroxyl group	carbonyl	carboxyl	Amino	Sulfhydryl	Phosphate	Methyl
$-OH$	$>C=O$	$-C(=O)-OH$ (COOH)	$-N(H)H$ (NH_2)	$-SH$	$O-P(=O)(O^-)-O^-$ (OPO_3^{2-})	$-C(H)(H)-H$ (CH_3)
hydrophilic	hydrophilic	hydrophilic	hydrophilic	hydrophobic	hydrophilic	hydrophobic
Alcohol	Ketone aldehyde	carboxylic acid organic acid	Amine	Thiol	organic phosphate (ATP)	Methylated compounds. Chemically inactive

5. Biological Macromolecules and Lipids. *Polymer

condensation reaction : connects a monomer to another monomer or polymer + with the loss of small molecule (H_2O, NH_3, HCl …)
└ dehydration reaction (반대는 hydrolysis)

condensation	축합
cramp	복통, 경련, 비틀오
hydrolysis	가수분해
analogous	유사한, 닮은.
carbohydrate	탄수화물
saccharide	당, 당류

Four main large biological molecules.

① carbohydrate (탄수화물)

✓ Monosaccharide

multiple of CH_2O (ex. $C_6H_{12}O_6$)

trademarks : >C=O, -OH
~~carboxyl~~ carbonyl   Hydroxyl

3~7 carbon chain.

- Glucose, Galactose. Fructose.
  α β

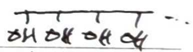
✓ disaccharide

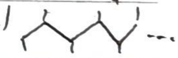
1 Maltose = Glucose × 2
3 Sucrose = Glucose + Fructose
2 Lactose = Glucose + Galactose

✓ Polysaccharide

- storage polysaccharide
  - starch
    - amylose : unbranched
    - amylopectin : somewhat branched
  - glycogen : extensively branched (1~6 linkage) (usually in liver, muscle)
    - *more free ends
      - available for breakdown
- structural polysaccharide.
  (starch : all α-glucose - largely helical)
  Cellulose : all. β-glucose : straight never branch
  Chitin - exoskeletons

← Some hydroxyl groups on its glucose mono are free to hydrogen bond with the hydroxyl of other cellulose lying parallel.
⇒ make group : ~~micro fibers~~ microfibrils

α는 소화가능 
OH OH OH OH

β는 × (섬유질) 

② Lipids (hydrophobic)

✓ Fats (≠ polymer)

Majorly long term E storage.

Glycerol + 3 Fatty acids

dehydration reaction
↓
Ester linkage (-COO)
(hydroxyl (OH) + carboxyl (COOH))

Fatty acids: hydrocarbon (C-H) : nonpolar / hydrophobic.

Saturated Fats
- No double bonds between carbons
  animal fats. / packed.

Unsaturated Fats
- cis double bonds
   prevent packing
- trans double bonds
  

impede	방해하다.
deposit	퇴적하다 예금하다.
Phospholipid	인지질

✓ Phospholipids

Glycerol + 2 Fatty acids + Phosphate group + α
hydrophobic   hydrophilic

→ in water, self-assemble into double layer (bilayer)

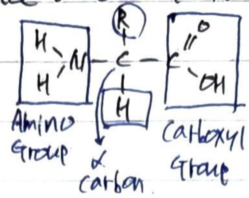
✓ steroids (ex. cholesterol)

- 붙은 Chemical group 따라 종류 달라짐

① Protein set of 20 amino acids + Peptide bond → Polypeptide ≠ Protein = twisted, folded, coiled Polypeptides.

(Carboxyl + amino) → H_2O (탈수) (소화)

↳ common structure



R: Side chain (R Group)

Amino acids (20)

1. Nonpolar side chains (hydrophobic)

Glycine (Gly, G) H

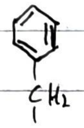
Alanine (Ala, A) CH_3

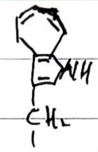
Valine (Val, V) CH_3 CH_3 / CH

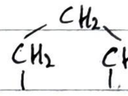
Leucine (Leu, L) CH_3 CH_3 / CH / CH_2

Isoleucine (Ile, I) CH_3 / CH_2 / CH_3 CH

Methionine (Met, M) CH_3 / S / CH_2 / CH_2

Phenylalanine (Phe, F)


Tryptophan (Trp, W)


Proline (Pro, P)


2. Polar ~~chain~~ side chains (hydrophilic)

Serine (Ser, S) OH / CH_2

트레오닌 Threonine (Thr, T) OH CH_3 / CH

Cysteine (Cys, C) SH / CH_2 weak polar : sometimes nonpolar

Tyrosine (Tyr, Y)


Asparagine (Asn, N) NH_2 C=O / CH_2

Glutamine (Gln, Q) NH_2 C=O / CH_2 / CH_2

3. Electrically charged side chains (hydrophilic)

- Acidic (negatively charged)

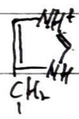
Aspartic acid (Asp, D) O^- C=O / CH_2

Glutamic acid (Glu, E) O^- C=O / CH_2 / CH_2

- Basic (positively charged)

라이신 Lysine (Lys, K) NH_3^+ / CH_2 / CH_2 / CH_2 / CH_2

Arginine (Arg, R) NH_2 / C=NH_2^+ / NH / CH_2 / CH_2 / CH_2

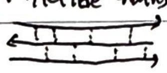
Histidine (His, H)


H>N-OOOO-C(=O)OH
Amino end Carboxyl end
N-terminus C-terminus

- Levels of Protein Structure

1. Primary structure : Linear chain of Amino Acids.

2. Secondary structure { α helix : hydrogen bonds between every 4th amino acids
β Pleated sheet : β strands Polypeptide chains



: Regions stabilized by hydrogen bonds between Atoms of the polypeptide backbones.

Oxygen atom (-), Hydrogen atom (+)
N

3. Tertiary structure : three dimensional shape stabilized by interaction between side chains (R Groups)

- hydrophobic interaction - 소수성 side chain 들이 core of Protein 에서 cluster 하면 Van der Waals interaction 이 help hold them together.

- hydrogen bonds between polar side chains

- ionic bonds between positively, negatively charged side chains

- covalent bonds : disulfide bridge (S-S)
two cysteine monomers (sulfhydral group -SH)

4. Quaternary structure : Association of two or more polypeptides
ex) collagen, Hemoglobin.

※ Protein Structure 영향 : secondary, tertiary structure
chemical, physical Env
(denaturation 변성가능)

But 가장 근본적인 것은 Primary. (sequence of Amino acids)

⑧ nucleic acids
- DNA Deoxyribonucleic acid → Determine primary structure of polypeptide
- RNA ribonucleic acid

Gene Expression : DNA → mRNA → Protein.
Ribosome.
convey genetic instructure from nucleus to cytoplasm.

Polynucleotides → nucleotides
- 5'C sugar (Pentose) → Deoxyribose (DNA) -H, Ribose (RNA) -OH
- Nitrogenous base (1,2 rings) on 1'C
- Phosphate group (1~3개)

nucleoside : 1개일때 nucleotide (nucleoside monophosphate)

N tends to take up H^+, so base.

Pyrimidine (1 ring)
- Cytosine (C), Thymine (T), Uracil (U) RNA

Purine (2 ring)
- Adenine (A), Guanine (G)

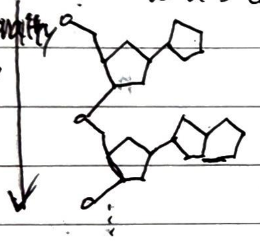
Nucleotide polymer → ~~condensational~~ condensation reaction.

Phosphodiester linkage : phosphate group that covalently links sugars of two Nucleotides

-<sugar — phosphate> = backbone!

5' end - Phosphate attached to a 5' carbon

directionality $5' \to 3'$



3' end - (-OH) hydroxyl group on a 3' carbon.

∨ DNA
antiparallel 5' 3' / 3' 5'
A-T
G-C hydrogen bonds.

2X Polynucleotides (strands) double helix.

∨ RNA - single strand but complementary base pairing can occur.
- two RNA
- one RNA → tRNA (bring Amino acids to Ribosome during the synthesis of polypeptides)

6- Energy and Life.

Gibbs free energy ΔG : T.P 일정할때 portion of a system's E that can perform work.

$\Delta G = \Delta H - T\Delta S$ (T - kelvin, ΔS - entropy change, ΔH - Enthalpy change)

$\Delta G = G_{final} - G_{initial}$

$\Delta G < 0$: spontaneous process.

G↑ : instable → G↓ : stable.

catabolic	이화작용
anabolic	동화작용
respire	호흡하다.
agitate	교란하다. 휘젓다.
substrate	기질

- Exergonic (E out, $\Delta G < 0$) Reaction.
- Endergonic (E in, $\Delta G > 0$) Reaction

∨ breaking of bonds requires energy

"Energy stored in bonds" is short hand for the potential energy that can be released when new bonds are formed after the original bonds break.

ATP's Role [Energy coupling
One of the nucleoside triphosphates used to make RNA

$ATP + H_2O \rightarrow ADP + \text{Ⓟ}_i + E$ ($\Delta G = -7.3$ kcal/mol)

hydrolysis

not from bond itself.

ATP regeneration

E from Catabolism (cellular respiration) → $ATP + H_2O$ / $ADP + \text{Ⓟ}_i$ → ATP hydrolysis to $ADP + \text{Ⓟ}_i$ ⇝ E for cellular work

<Energy coupling>

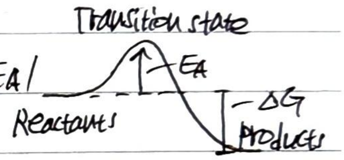
ATP→ADP로 생성된 E로 Endergonic 반응을 일으킴.

→ Glutamic acid + ATP → Glu-Ⓟ + ADP → Glutamine + ADP + Ⓟ_i

< phosphorylated intermediate >

Enzyme = macromolecule that acts as catalyst.

Activation Energy (E_A)

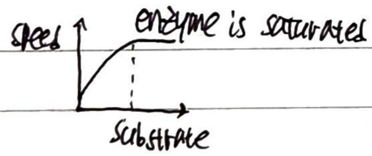


Enzyme selectively speed up a reaction, not as heat.

↳ substrate specificity of Enzymes (기질 특이성) → it results from enzyme (Protein)'s shape.

Enzyme + substrate → Enzyme-substrate complex → Enzyme + products
(active site - bind to substrate)

Enzyme ≠ stiff structure ⇒ enzyme dance and take shape very short time
+ substrate enter to active site, enzyme change shape due to interaction with substrate and enzyme.
⇒ Induced fit.



Cofactor (nonprotein helpers) { inorganic : metal atom / organic : coenzyme (Vitamin)

Enzyme inhibitors (many poisons) { irreversible / reversible : compete for admission into the active site. - competitive inhibitor
noncompetitive inhibitor - impede enzymatic reactions by binding to another part of enzyme. (change shape of enzyme)

Toonitini