

## 1. Organic and biological

有机物的性质：杂化方式 (hybridization), 极性 (polar), 溶解性 (solubility),  
官能团 (functional groups), 化学反应 (reaction),  
立体异构 / 顺反异构 / 手性异构 (isomerism)  
unequal electrons (electron negativity 电负性).

① polarity ↓ influence → solubility (溶解性) like dissolves like.

melt and boiling points influence { dipole-dipole interaction (偶极作用)  
(hydrogen bond)  
(partially negative / positive charge)

### ② organic classification (有机物分类)

Hydrocarbons (烃类): Alkanes, Alkenes, Alkynes, Aromatic hydrocarbon

C: 1~4 gas  
5~12 gasoline  
13+ solid

Methane, Ethane, Propane, butane.

Pentane, hexane, heptane.

Most important reaction: combustion (燃烧反应)

Aromatic Hydrocarbons have  $\pi$  ring, containing localized

more likely to have substitution reaction and delocalized electrons.

Alcohols (醇类): mixable with water.

Ethers (醚类): not mixable with water.

used as solvents for organic reactions.

Ketones (酮类): used extensively as solvents. acetone (丙酮) dissolves in water

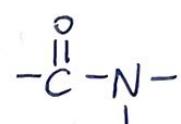
Aldehydes (醛类): Many are natural flavourings. and many organic compounds

Carboxylic Acids (羧酸): weakly acidic.

important in manufacturing polymers.

Esters (酯类): saponification (皂化反应) Decomposition of Ester.

Amides (胺: 氨基被取代分子) Amines (氨基化合物) acid catalyst and water

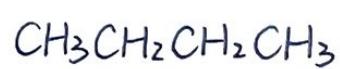


Addition reaction 加成反应.

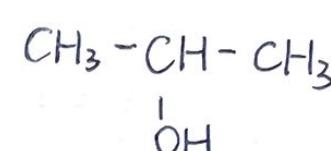
Substitution reaction 取代反应.

Chirality (手性): achiral (非手性的).

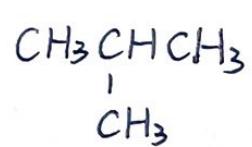
- ① enantiomers (对映异构体) have same physical and chemical properties when reacting with ~~nonpolar~~ nonchiral reagents.
- ② enantiomers rotate plane-polarized light in opposite directions.
- ③ A collection containing only one enantiomeric form of a chiral molecule is called Enantiomer Enantiopure or Optically Pure.
- ④ 判断 R(D), S(L) 手性的方法.



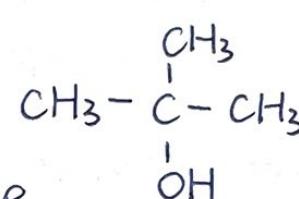
butane.



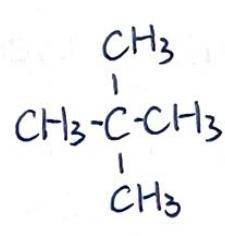
2-propanol.



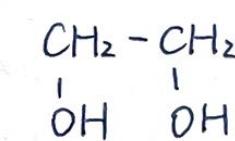
2-Methylpropane.  
isobutane



2-Methyl-2-propanol.



2,2-Dimethylpropane.



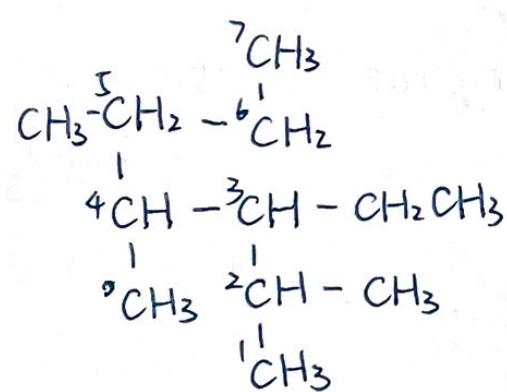
1,2-Ethandiol.

~~n-pentane~~.

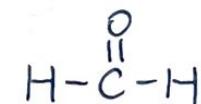
neopentane.



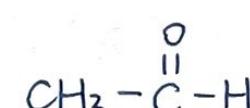
1,2-Ethanediol.



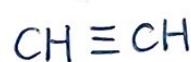
2,4,5-Trimethyl-  
-Ethyl-heptane.  
3-Ethyl-2,4,5-  
trimethyl heptane.



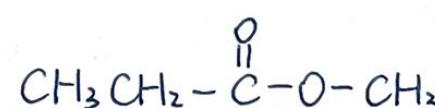
Methanal.  
甲 醛



Ethanal.  
乙 醛



Alkyne



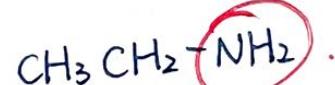
Methyl Propanoate.

Methyl Ethanoate.

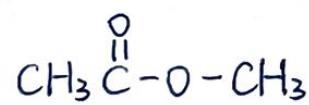
(Methyl Acetate)



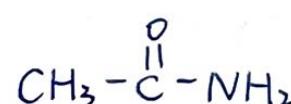
Dimethyl ether.



Ethylamide.



Methyl Acetate.



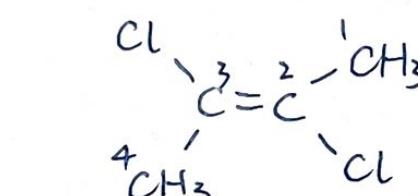
Acetamine.



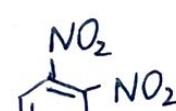
Ethanoic acid.

~~Acetacid.~~

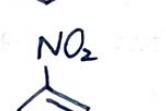
Acetic acid



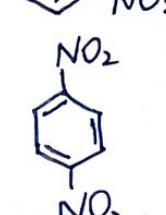
trans-2,3-Dichloro-  
-Dichloro-2-butene.



ortho-Dinitrobenzene.



meta-Dinitrobenzene.

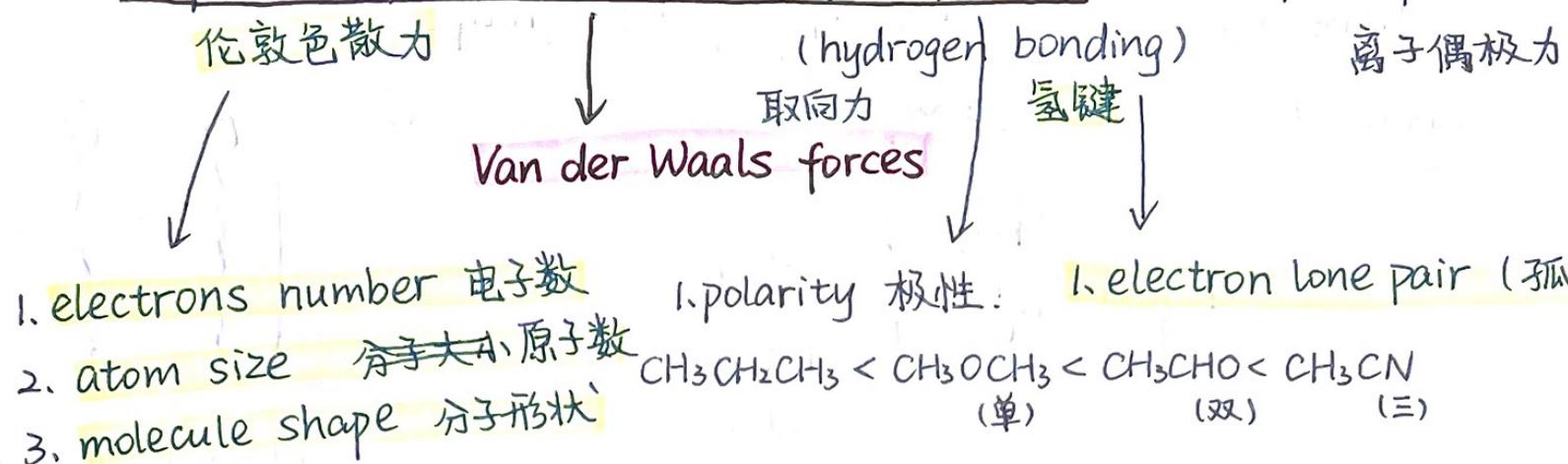


para-Dinitrobenzene.

## 2. Liquids and intermolecular forces.

### ① Intermolecular forces

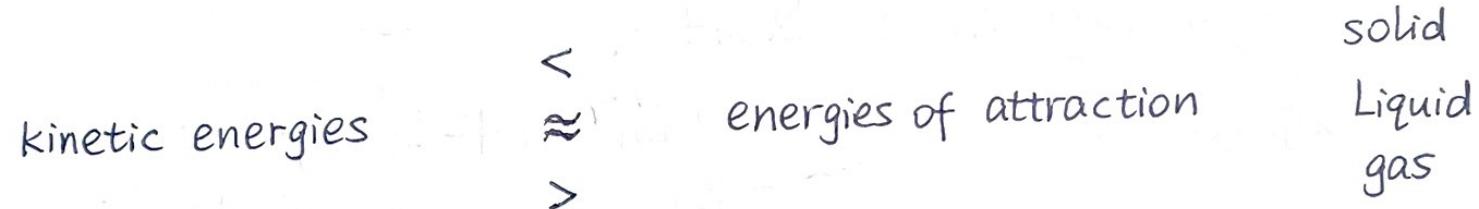
dispersion forces < dipole-dipole forces < ion-dipole forces



result

more easy to polarize,  
easier to polarize, higher boiling point.

### ② State of matter



### ③ viscosity (黏滯性) $\downarrow (T \uparrow)$ :

cohesive forces 内聚力  
adhesive forces 附着力

capillary action (毛细现象)



H<sub>2</sub>O

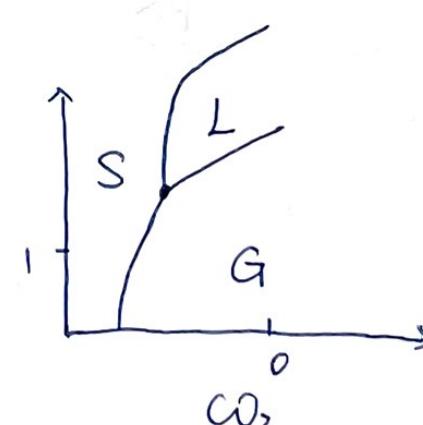
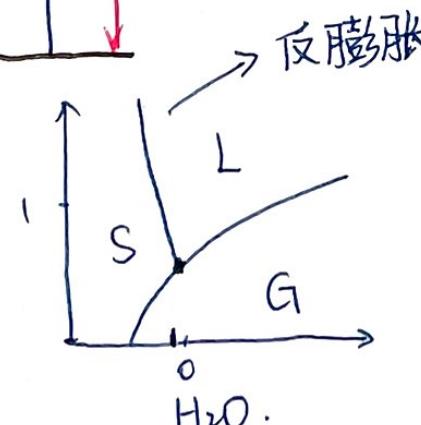
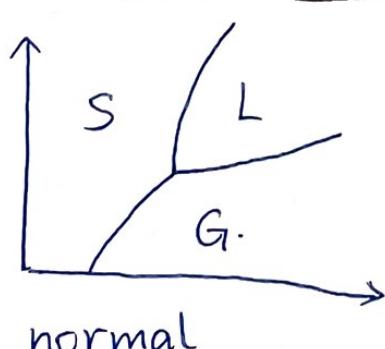
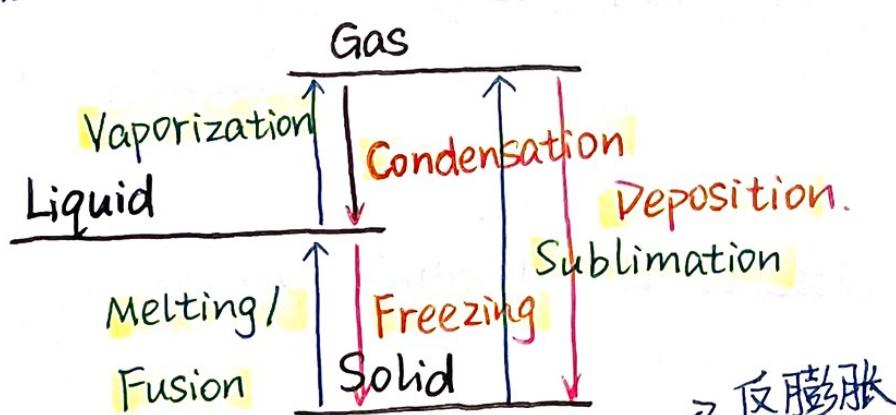


Hg

ad > co  $\rightarrow$  concave surface (凹液面)

ad < co  $\rightarrow$  convex surface (凸液面)

### ④ Phase changes and Phase diagram.

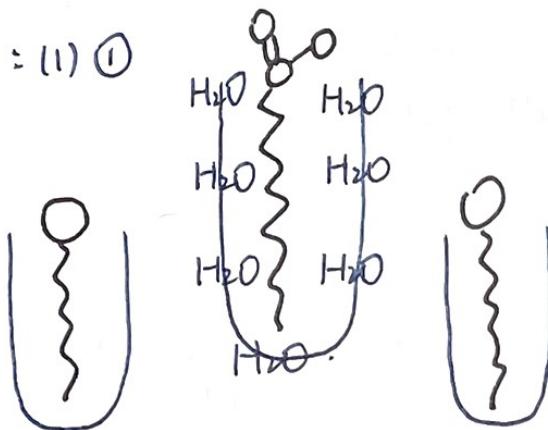


### 3. Water and life

① Amphipathic molecule 两性分子.

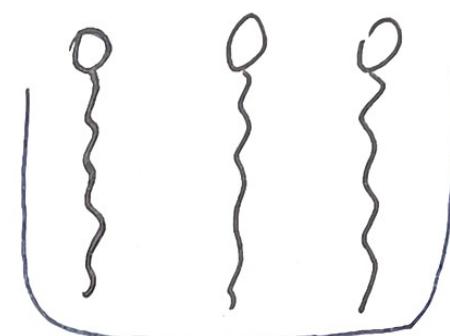
have hydrophobic and hydrophilic groups.

Application: (1) ①



Dispersion of lipid

②



Cluster of lipid

(2) Bilayer vesicle 双层分子膜

② Ionization of water

hydronium ion 水合氢离子.

conjugate acid / base (Bronsted-Lowry Theory) (布朗斯脱-劳里理论)

Henderson-Hasselbalch equation (亨德森-哈塞尔巴尔赫方程)

$$pH = pK_a + \lg \left( \frac{[base]}{[acid]} \right)$$

$$pOH = pK_b + \lg \left( \frac{[acid]}{[base]} \right)$$

① pH influence the structure and function of protein.

③ Acid strength

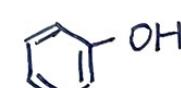
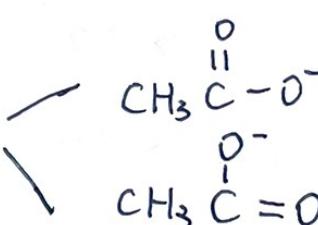
- Electronegativity

- Resonance 共振



- Inductive effects. 诱导效应

The catalytic efficiency of many enzymes critically depends on ionization of groups. ? (基团的电离态?)



④ Buffers.

similar to

The pK value close to the system's pH value. 让阴、阳缓冲离子相等.

## 4. Macromolecules of life sugar

Three categories of macromolecules: ① carbohydrates.

(polymers)

聚合物

② proteins

digestion 消化作用

monomers 单体

③ ~~nucleic~~

nucleic acids (核酸)

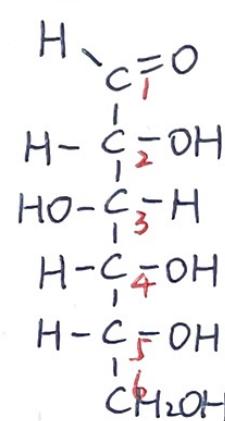
dehydration 脱水

hydrolysis 水解作用

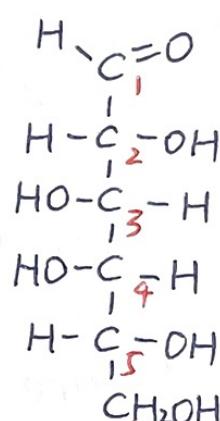
### ① Carbohydrates (碳水化合物)

#### (1) Monosaccharides (单糖)

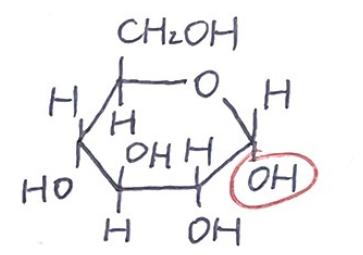
glucose → main fuel for cellular work.  
fructose



$\alpha$ -glucose



$\beta$ -glucose



$\alpha$ -glucose.

#### (2) Disaccharides (双糖)

lactose (乳糖)

maltose (麦芽糖)

sucrose (蔗糖) → plant sap.

High-fructose corn syrup (HFCS)

#### (3) Polysaccharides.

$\alpha$ -glucose → starch (淀粉)

$\alpha$ -glucose → glycogen (糖原)

$\beta$ -glucose → cellulose (纤维素)

} 1-4 linkage.

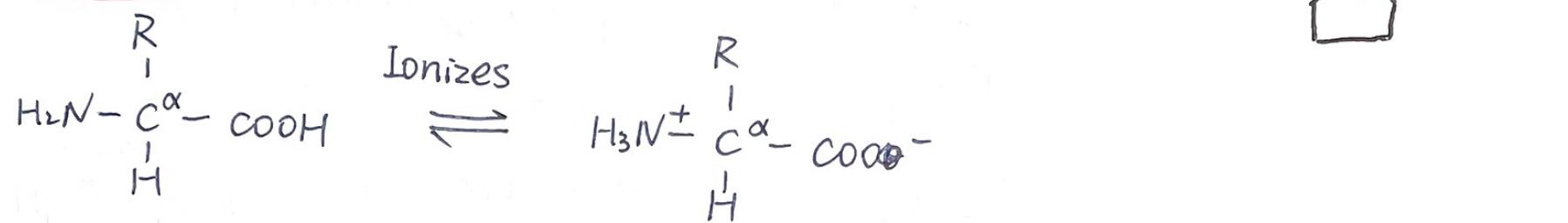
(cannot be broken by any enzyme produced by animals).

## 5. protein

- Content:
1. Amino acids
  2. Peptides
  3. Protein structures
  4. Protein purification and analysis.

### 1. Amino acids

- Properties
- ① All protein can be hydrolyzed (水解) into amino acids.
  - ② Proteins are in fact linear (unbranched) polymers of amino acids.
  - ③ 20 standard amino acids all have primary amino group (X proline)
  - ④ At neutral pH, amino acids exist as an internal salt.



N

- ⑤  $\alpha$ -carbon is usually a chiral center (X glycine).  $\text{H}_2\text{N}-\overset{\text{H}}{\underset{\text{H}}{\underset{|}{\underset{|}{\text{C}}}^{\alpha}}}-\text{COOH}$ .
- ⑥ All natural amino acids are defined as L-amino acids (X glycine) (S configuration).

UV absorption (紫外线吸收).

Beer-Lambert law:  $A = C \cdot I \cdot \epsilon$

Analysis.

$\downarrow$   
The concentration of protein. (浓度).

$\downarrow$   
length.

$\downarrow$   
The molar extinction coefficient.

(摩尔紫外吸收系数).

anion 阴离子

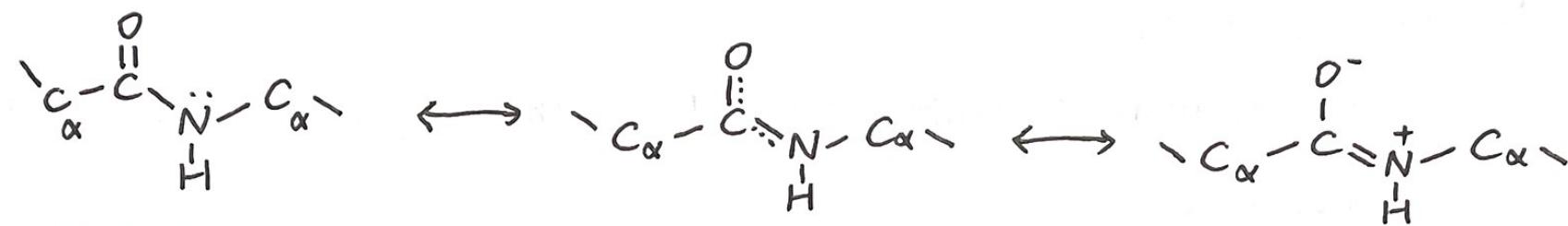
cation 阳离子.

zwitterion 两性离子. have no net charge.

测量 pI 的 6 个步骤.

$$pI = \frac{1}{2}(pK_1 + pK_2)$$

## 2. Peptides (多肽).

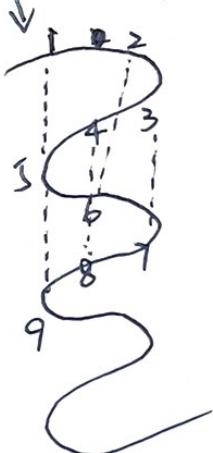


resonance contribution.

Virtually all peptide bonds in proteins occur in trans conformation.  
avoid clash.

## 3. Protein structures.

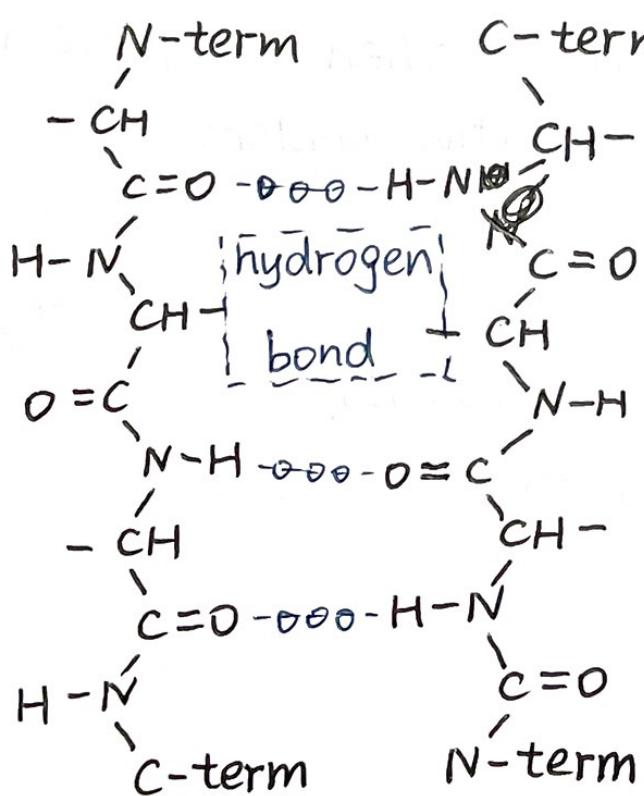
- determines
1. Primary structure. is the sequence of amino acids. linked by peptide bonds (strong covalent bond)
  2. Secondary structure. is a result of non-covalent interactions.
  3. Tertiary structure : folded structures ( $\alpha$ -helix,  $\beta$ -pleated sheet). arrange in 3D.
  4. Quaternary structure. : Packing of several folded polypeptide chains.



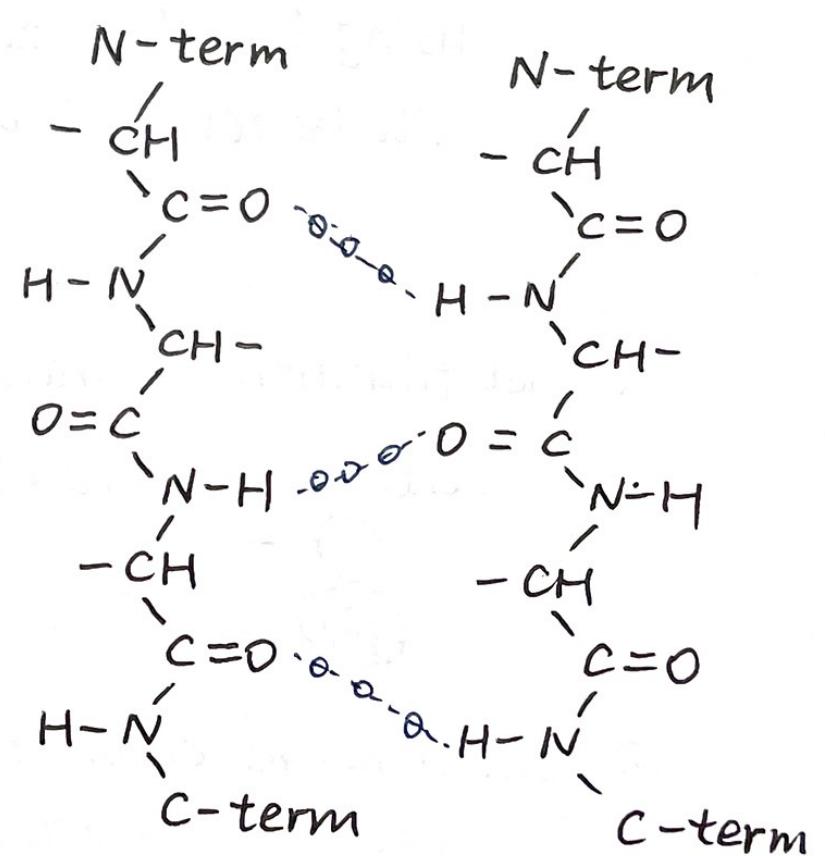
$\alpha$ -helix is rigid, rod-like structure with a right-handed conformation.

There are 3.6 amino acid residues per turn and the pitch is 0.54nm.

$\beta$ -pleated sheet is held by hydrogen bonding between adjacent sheets of protein.



Antiparallel sheet.



Parallel sheet.

\* supersecondary structure : a combination with  $\alpha$ ,  $\beta$  structure.

#### 4. Quaternary structure

Two or more subunits are held together by non-covalent interactions.

Forces:

- ① Hydrogen bonds
- ② Electrostatic interactions
- ③ metal ion coordination
- ④ Hydrophobic effect.

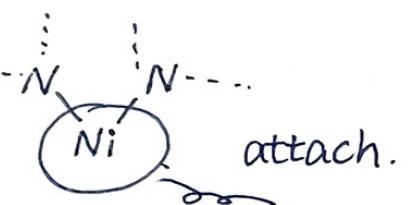
#### 4. Analysis

- X-ray crystallography. (X射线晶体学)
- NMR (nuclear magnetic resonance). (核磁共振)
- CD (circular dichroism) [光]圆二色性.
- Trp fluorescence (Trp 荧光)  
denatured 变性 → coagulate 凝结

#### 5. Purification (提纯)

- ① column chromatography (圆柱色谱法),  
+ UV absorption.

using ligand to attach protein, and then the protein  
will be released by adding competitive binders.



+ 原料 compete Ni

- ② Gel filtration chromatography (size-exclusion).

the largest are eluted first., the smallest last.



- ③ Ion exchange chromatography

using ion to attach the protein and remove it.

- ④ Dialysis (透析).

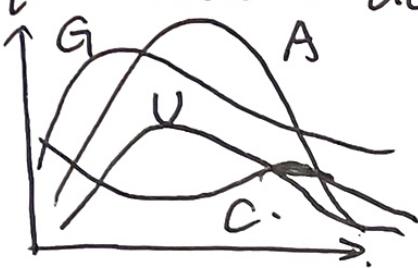
- ⑤ Precipitation at the pI (pI沉淀法).

by adding high concentration of salt (加盐沉淀)

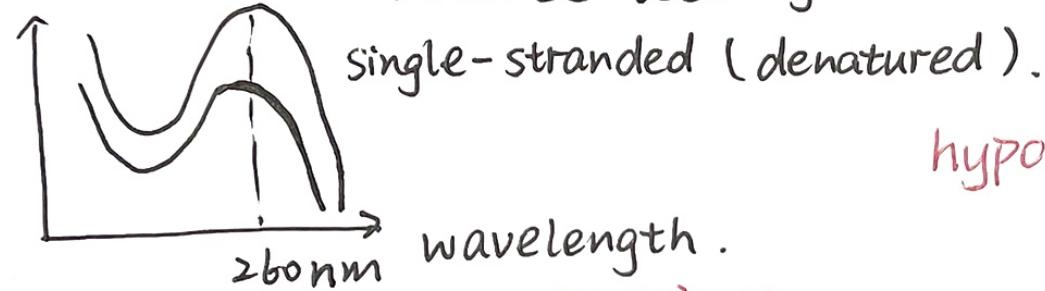
- ⑥ gel electrophoresis (凝胶电泳).

# Ultraviolet absorption spectra (紫外光谱).

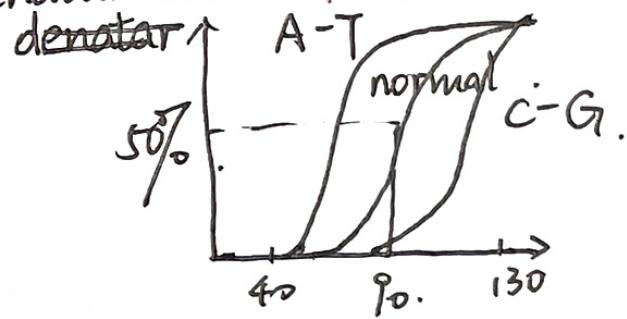
- quantitative determination of nucleic acid.



- native DNA absorbs less light than denatured DNA.

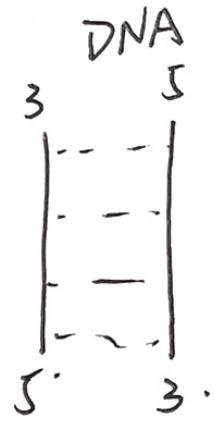


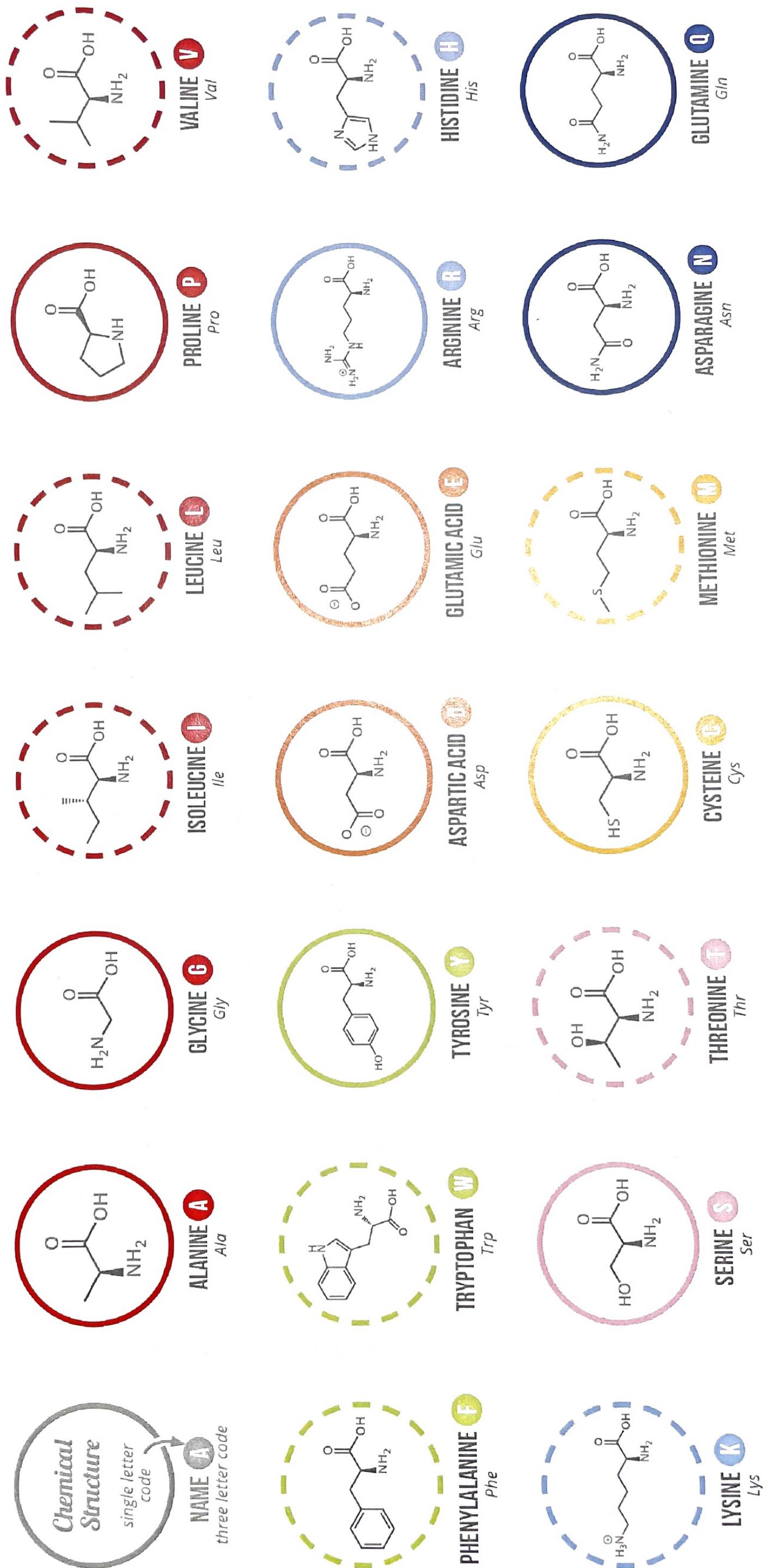
denatured rate 检查高温下DNA是否变性.



Parallel & antiparallel.

antiparallel : DNA double helix.





## 1. Cell

single-celled

{ prokaryotic cell  
prokaryotes (原核生物)  
protists (原生生物) (简单真核)

multicelled

{ plants  
animals  
most fungi (真菌)

{ Archaea 古生菌  
Bacteria 细菌.

- peptidoglycan. 肽聚糖.

\* longest nerve cell: sciatic nerve (坐骨神经)

Cell theory: ① all cells come from earlier cells.

② all living things are composed of cells.

Whether has nut or not

{ prokaryotic cells (原核细胞)  
eukaryotic cells (真核细胞)

double membrane: nucleus, chloroplast (叶绿体), mitochondria. (线粒体).  
(nuclear envelop 核膜)

antibiotic  $\xrightarrow{\text{bind}}$  bacteria ribosome / enzyme.

✓ Gram-positive

✗ Gram-negative.

④ modified drug target

\* 4 ways to fight back. ① inactivating-drug  $\xrightarrow{\text{enzyme}}$  ② pump out ③ modified protein.

membrane { animal  $\rightarrow$  phospholipid bilayer  
plant  $\rightarrow$  cellulose fibers (纤维素纤维).

nucleus { nuclear envelop  
nuclear pore  $\rightarrow$  mRNA exit  
nucleolus.  $\rightarrow$  the components of ribosomes.

ribosome { E.P.A sites.  
some <sup>are</sup> suspended in cytosol.  
some are attached to the outside of nucleus / ER.

endomembrane system (内膜系统)

nuclear envelop.  
endoplasmic reticulum.  
Golgi apparatus.  
lysosomes  
vacuoles.

physically connected  
or linked by vesicles

rough ER → has ribosome attached.

smooth ER → produce lipids (steroids)

phospholipids (cholesterol) 胆固醇 (membrane)

help liver cells detoxify <sup>解毒</sup> circulating drugs.

Golgi apparatus → receive.  
modify the protein by enzyme.  
transport new vesicle.

lysosome → engulf nutrients.  
destroy harmful bacteria.  
sculpt tissues.

\* autophagy 细胞自食.

Vacuoles (液泡) (from ER or Golgi apparatus)

\* certain freshwater protists <sup>have</sup> contractile vacuoles.

store organic nutrients.  
absorb water  
contain pigments (色素)

(伸缩泡)

Energy transformation: Chloroplasts and Mitochondria.

Chloroplast → photosynthesis (光合作用)

contain a single DNA  
can split  
convert the energy from sunlight to sugar / organic molecules  
stroma (基质) (thick fluid)  
grana (基粒)

呼吸作用.

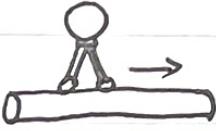
Mitochondria (for cellular respiration)

contain a single DNA  
can split.  
produce ATP.  
matrix (基质) (thick fluid)  
cristae (脊). (many infoldings)  
many enzyme  
皱折.

Pu

cytoskeleton: cell shape and movement.

{ microtubules (微管)      guide .



intermediate filament (中间纤维). strengthen 加固作用.

(肌动蛋白)  
actin filaments (微丝) ?

guide the transport of cargos to a proper location.

assemble or disassemble causes the movement of cell.

Centrioles (中心粒) : only in animals' cell.

Cilia and Flagella: ???

## 2. The working cell.

Energy: Kinetic energy. Potential energy.

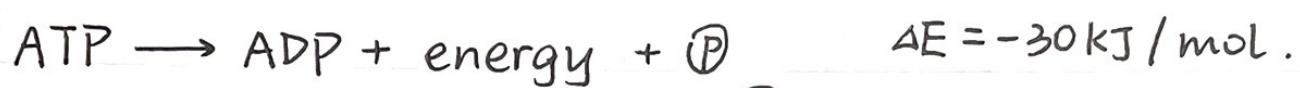
Thermodynamics: ① conservation of energy.

② universal tendency of things to become disordered.

34%. ③ All energy conversions generate heat.

A calorie is the amount of energy that can raise the temperature of 1 gram of water by  $1^{\circ}\text{C}$ . ~~1 Cal = 1000 J~~ 1 kilocalories (Cal) = 1000 cal

### ATP and cellular work.



Conformational change.

$\Delta G$ : Free energy (available)

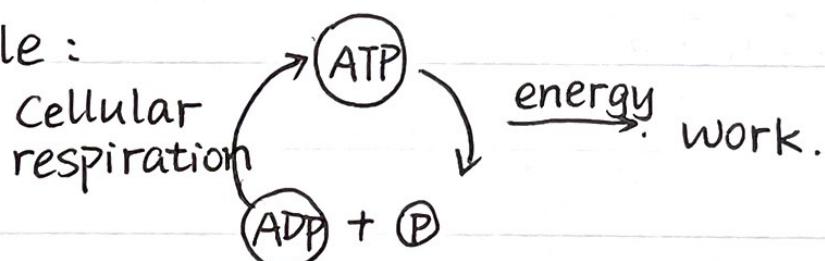
Exergonic reactions: (释放能量) spontaneous 自发的.

Endergonic reactions: (吸能反应).  $\Delta G > 0$ .

Synthesis of amino acids, protein and ...

Coupled reactions: (耦合反应)  $M_1 + M_2 \rightarrow M_1 - M_2 + E$

ATP cycle:



Activation energy (活化能): the energy required to start reaction.

↓ enzyme.

↪ bind substrate → induced fit (诱导配合).  
(基底)

Enzyme inhibitor (酶抑制剂)

① bind the site

② bind another site to change the shape.

the binding of an inhibitor is reversible ⚡.

⚡ feedback inhibition.

Membrane function.

① Passive transport.

a substance diffuses down its concentration gradient.

some need assistance by protein. (facilitated diffusion).

\* osmosis 渗透作用. solute 溶质.

hypotonic 低渗的 hypertonic 高渗的. isotonic 等渗的.

osmoregulation 渗透调节.

\* plant like hypotonic environment.

② Active transport. (need energy)

pumps solute against the concentration gradient.

③ Exocytosis (胞吐作用)

④ Endocytosis (胞吞作用).

### 3. Cellular respiration.

~~autograph~~ autotrophs (自养生物)

a by-product of photosynthesis is  $O_2$ .

heterotrophs (异养生物)

photosynthesis surplus:  
provides material to grow.  
~~is~~ stored as starch.

cellular respiration :  $O_2 \rightarrow ATP \times 32$ .

aerobic 需氧的.

① glycolysis 糖酵解 ② citric acid cycle ③ electron transpo. <sup>rt</sup>

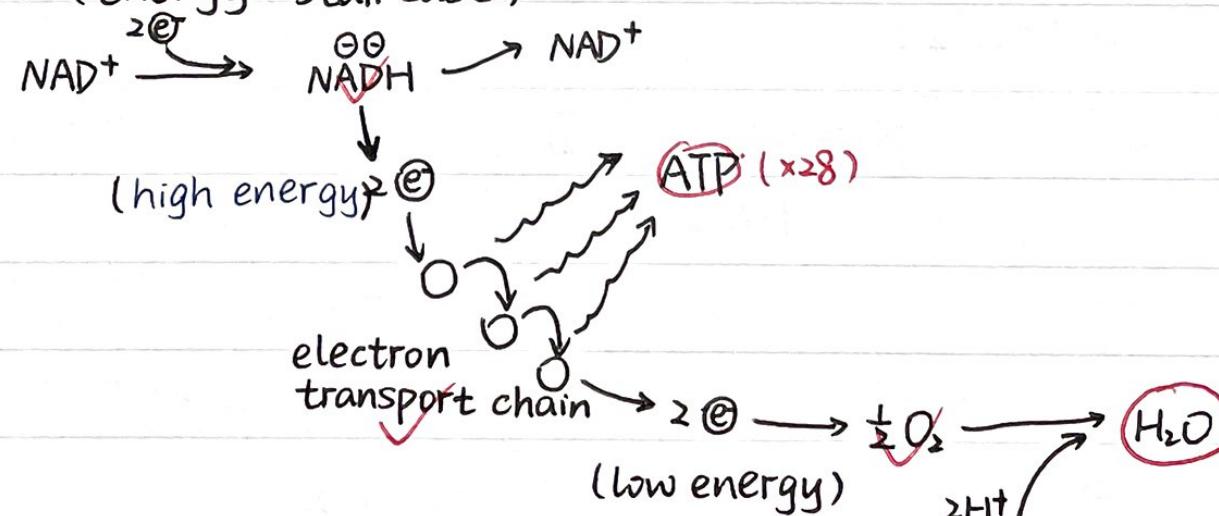
Glycolysis: ~~in cytoplasm~~ glucose  $\xrightarrow{-2ATP}$  (2x) pyruvic  $\xrightarrow{NAD^+}$  G3P  $\xrightarrow{\text{enzyme}}$  G3 acid (x2) obtain:  $4-2=2$  ATPs.

Citric acid cycle: ① G3 acid  $\xrightarrow{\text{lose } CO_2 \text{ (waste)}}$  CH<sub>3</sub>COOH  $\xrightarrow{NAD^+}$  Acetyl-CoA.

② Acetic acid  $\xrightarrow[\text{help to exit.}]{\text{CoA}}$  Citric acid  $\xrightarrow{2CO_2}$  ATP (5C)  $\xrightarrow{FADH_2 \times 2, 3NAD^+ \rightarrow NADH \times 2}$  Oxaloacetate (Acceptor molecule)

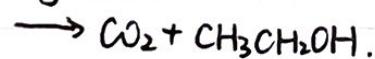
obtain: ATP (x2) = 2ATPs.

Electron transport: (energy staircase)



Fermentation (发酵): anaerobic harvest of food energy. 2ATP.

yeast.



glycolysis  $\longrightarrow$  (waste product) Lactic acid, 乳酸 + 2ATPs.

cause muscle fatigue.??

4. Photosynthesis: autotrophs (自养生物)

photo-autographs 光合自养生物.

chlorophyll 叶绿素. (pigment)

stomata 气孔  $\xleftarrow{CO_2}$   $\xrightarrow{O_2}$ .

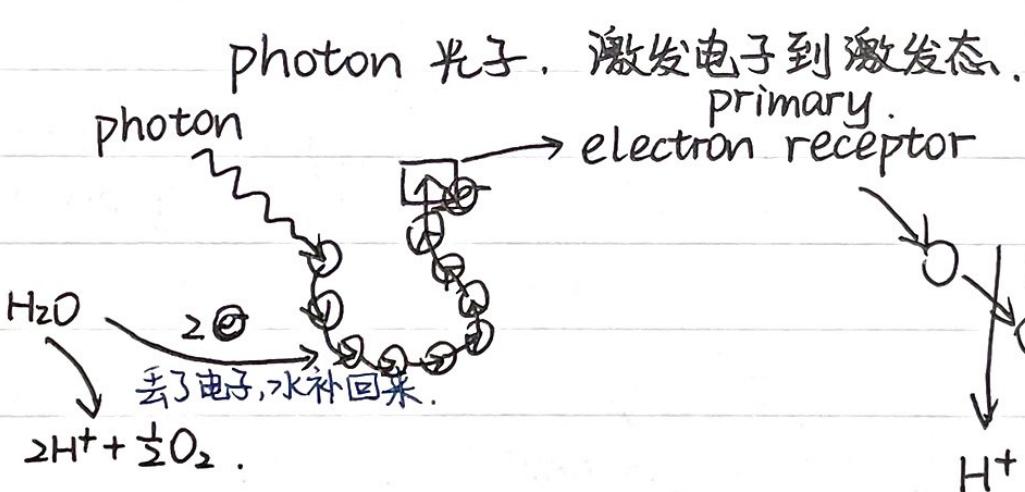
thylakoids 类囊体. —— grannum 基粒.

Light reactions: chlorophyll absorbs solar energy  $\rightarrow$  ATP + NADPH  
 $\downarrow H_2O \rightarrow O_2$  (by-product)

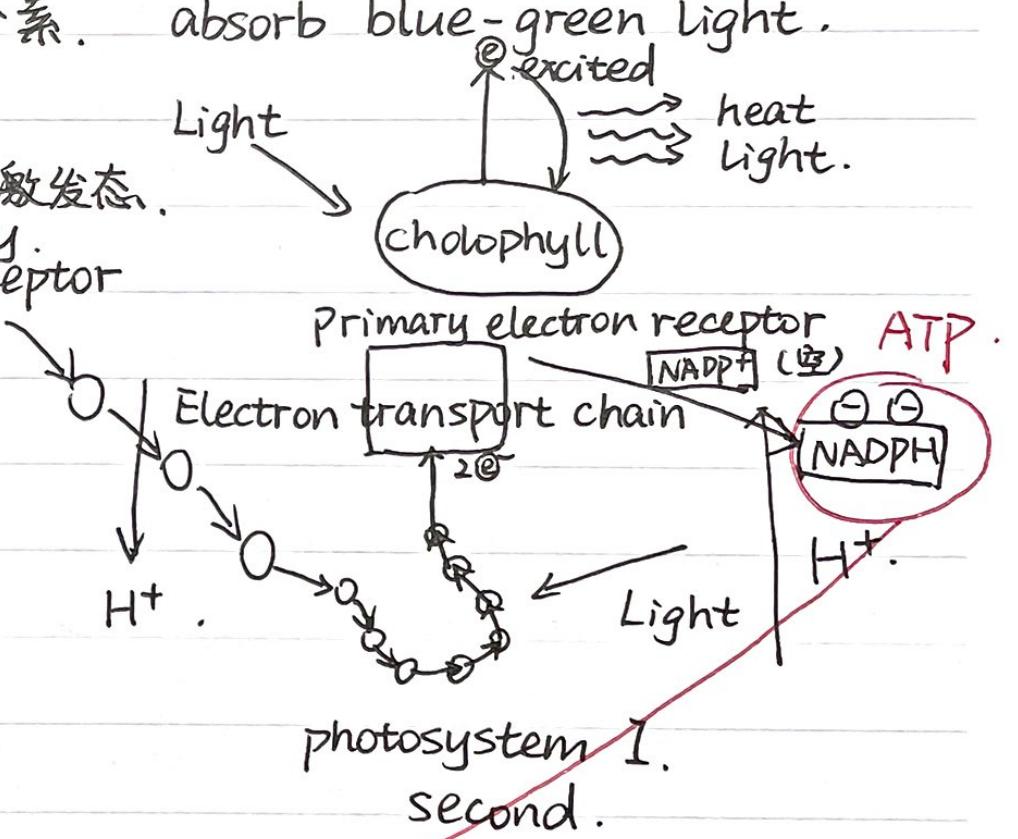
\* (main) chlorophyll a. (participate directly in the light reaction)  
 absorb blue and red light.

chlorophyll b. absorb blue and orange light.  
 energy.

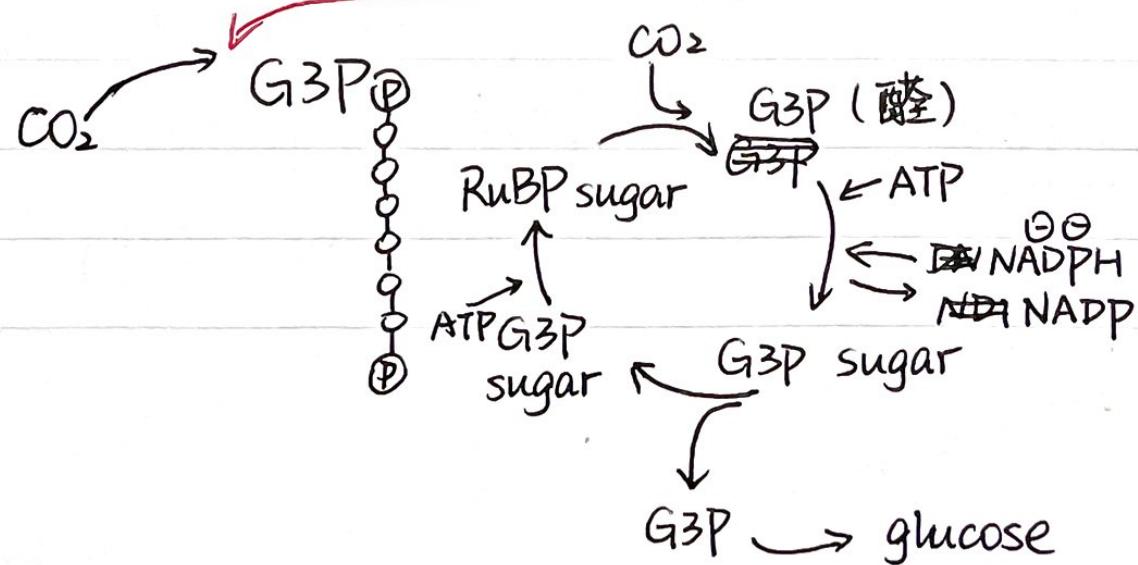
carotenoids 类胡萝卜素. absorb blue-green light.  
 (longer lasting)



photosystem II  
 first

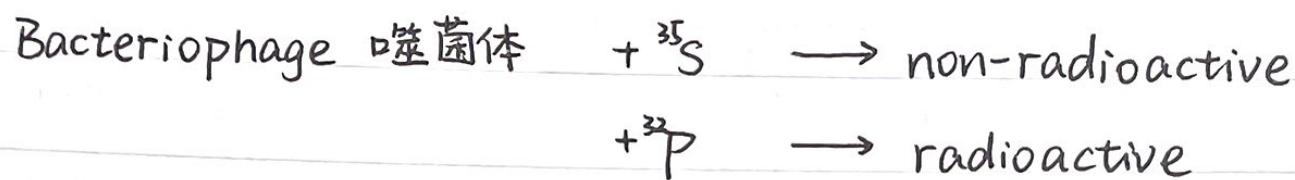


The calvin cycle: sugar factory.



## 5. DNA.

Hershey-Chase experiment:



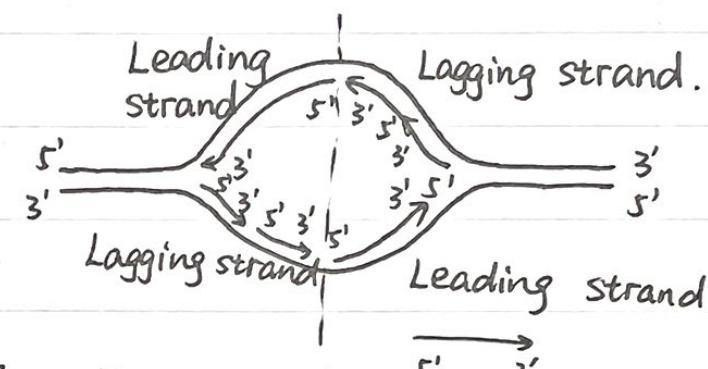
3 steps. ① infection ② Blending ③ centrifugation. (离心)

Watson and Crick's discovery.

DNA is double helix.

DNA replication:

DNA polymerases (聚合酶)



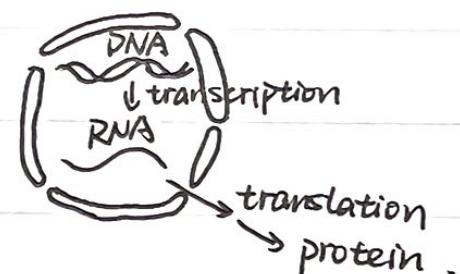
How an Organism's Genotype Determines Its Phenotype?

By transcription and translation.

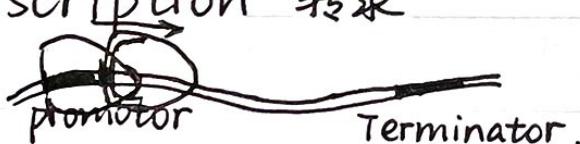
eukaryotic cell

codons (密码子) - a triplet code ( $64 = 61 + 3$ )

genetic code - codons  $\rightarrow$  protein.



Transcription 转录



① initiation ② elongation ③ termination.

RNA processing (eukaryotic)  
splicing  
cap, tail, introns (内含子), exons (外显子).  
↓  
G → @@@@A...  
98%

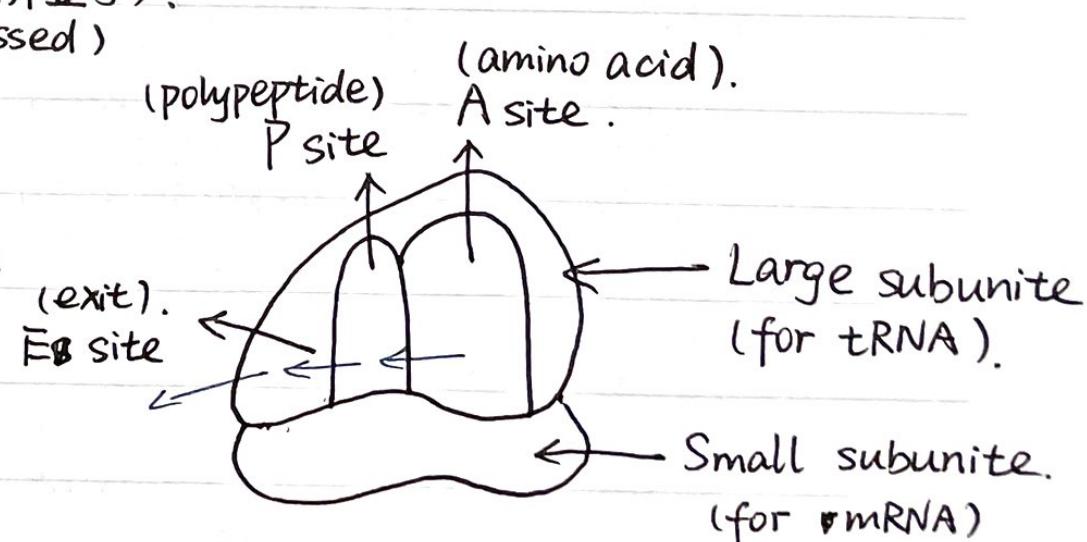
2%  
(expressed)

(polypeptide)  
P site  
(amino acid).  
A site.

mRNA translation.

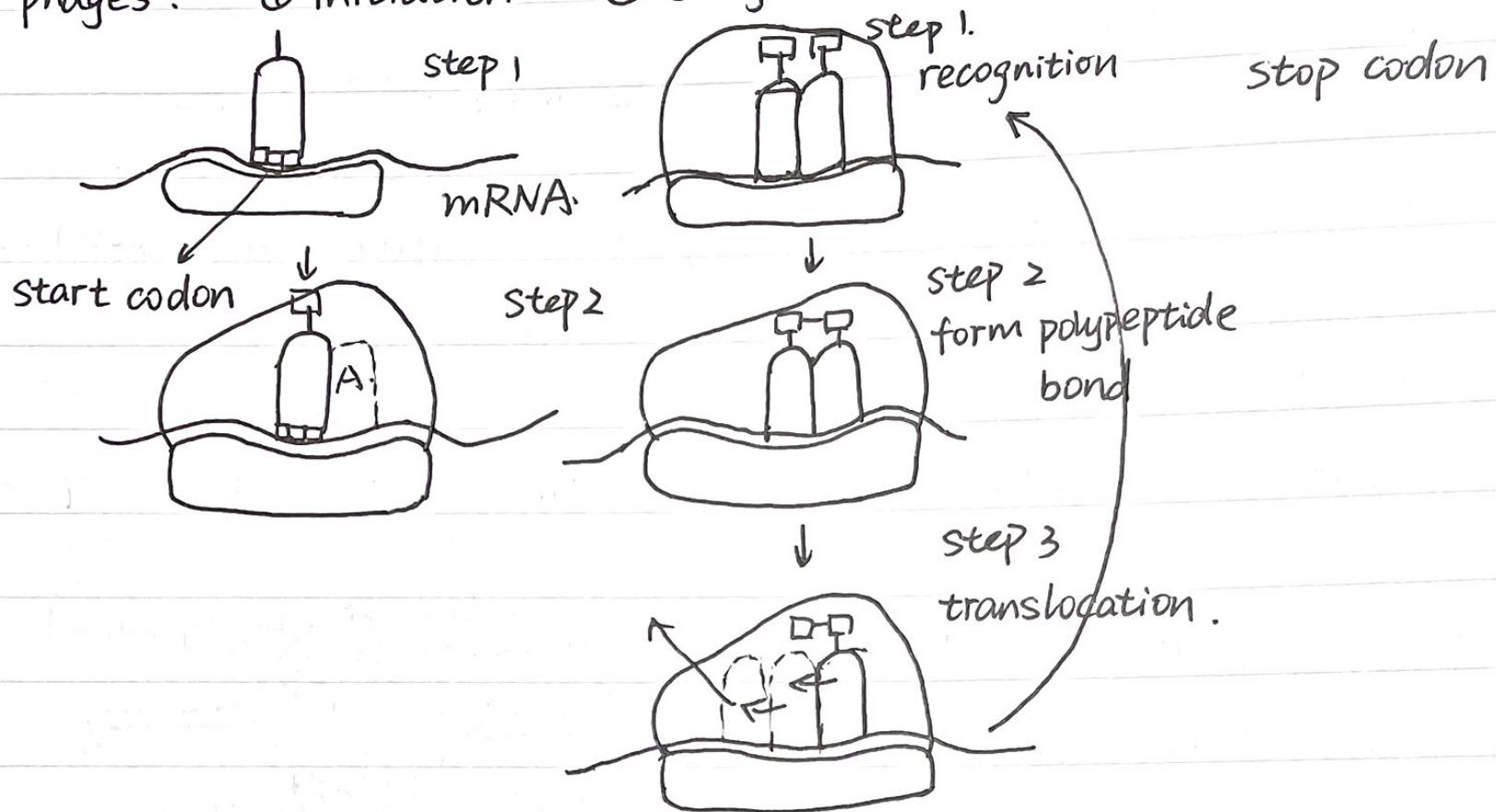
tRNA + ribosome + ATP.

↓  
Anticodons + attachment site.



## Translation

3 phases: ① initiation ② elongation ③ termination.



## Mutation

- ≥ mainly types:
  1. nucleotide substitution
  2. nucleotide deletions or insertions.

Missense mutations 错义突变

Nonsense mutation 无义突变

frameshift mutations 移码转移. (X)

common cancer mutation.

grow rapidly  
stop division  
repair damaged genes.  
tell a cell to die.

## Virus. (bacteriophage)

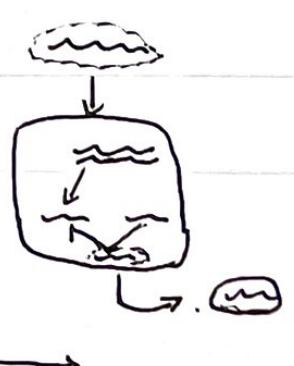
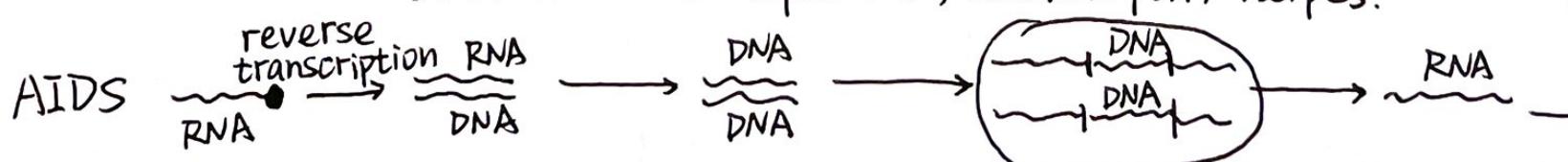
when infect a bacterium, most phages enter a reproductive cycle. the lytic cycle.  
some viruses reproduce an alternative route - the lysogenic cycle.

共生关系.

Plant virus (tobacco mosaic virus) <sup>TMV</sup> → retrovirus.

Animal virus: RNA viruses: flu, AIDS, common cold, polio.

DNA viruses: hepatitis, chicken pox, herpes.



## b. Gene regulation.

Gene regulation: same genetic info develop into different type.

Gene expression: genetic flow from genes to protein.

glycolysis enzyme (always "on")

Prokaryotic organisms

DNA find in cytoplasm

RNA trans and protein form simultaneously

Gene expression at transcriptional level

Eukaryotic organisms

nucleus

RNA trans than protein form.

many level

★ One control sequence has promotor ↓ initiation operator operon, (termination)

? whether a protein is bound there determines gene express or not.

the protein called repressor (抑制子)  
(silencers) protein

in ~~eukaryotic~~ eukaryotic cells, the speed can up and down (precise control) 水管.

The regulation of DNA packing.

常染色质 euchromatin ✓

异染色质 Heterochromatin (condensed) X

↳ Barr body (long-term inactivation)

Tortoiseshell cats. (三色猫)

Transcription 转录

transcription factors 转录因子. bind to DNA sequence (enhancers) 增强子.

↳ activator protein  
+ other protein

and promotor

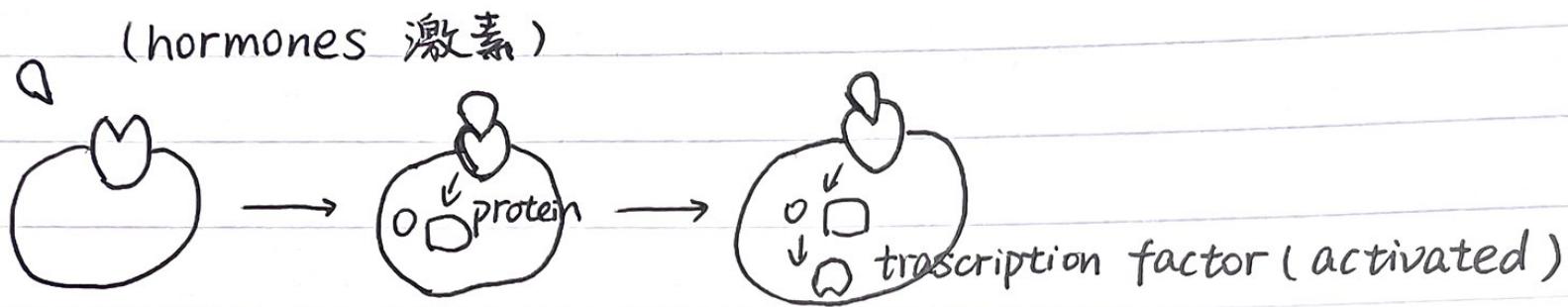
注射 控制表达

microRNA trigger breakdown of RNA. (many many...)

protein activation (selective) (cutting, chemical modification)

结合催化蛋白  
→ 蛋白体酶  
→ 分解

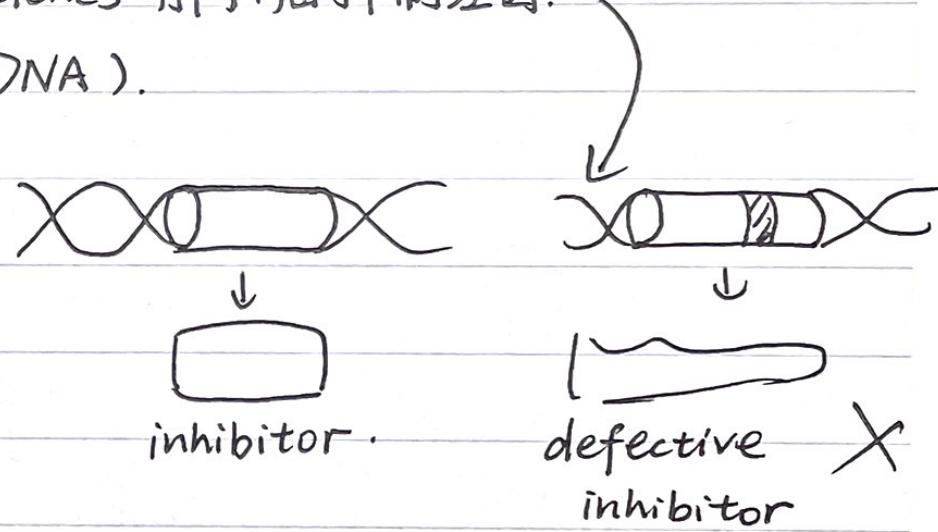
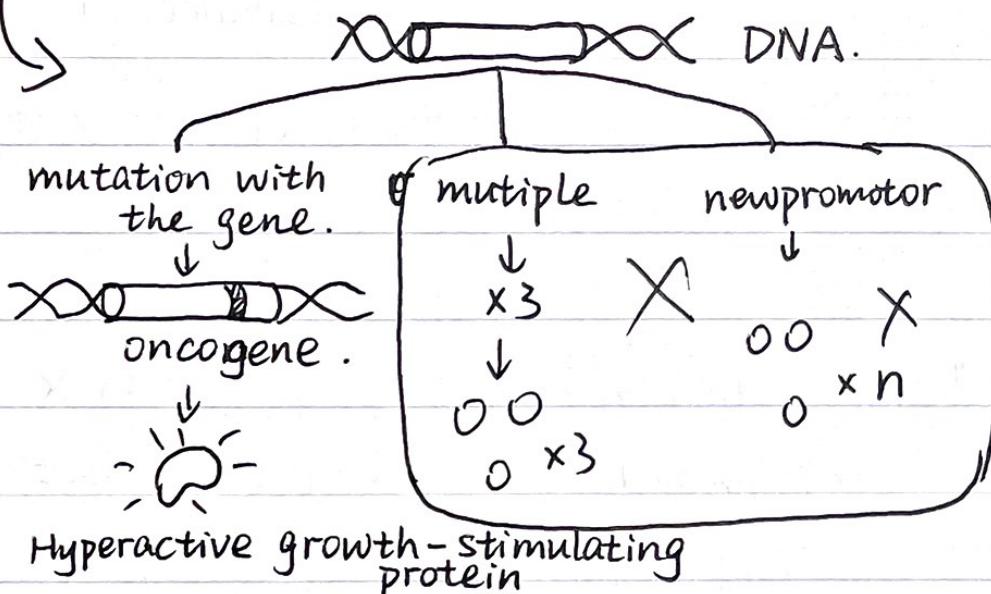
Information flow: Cell signaling.



Homeotic Genes: encode for transcription factors.  
(master control genes)

DNA microarrays: ① mRNA isolate ② Reverse transcriptase. form ~~cRNA~~. cDNA. ③ add cDNA mixture.  
④ cDNA rinse (漂洗).

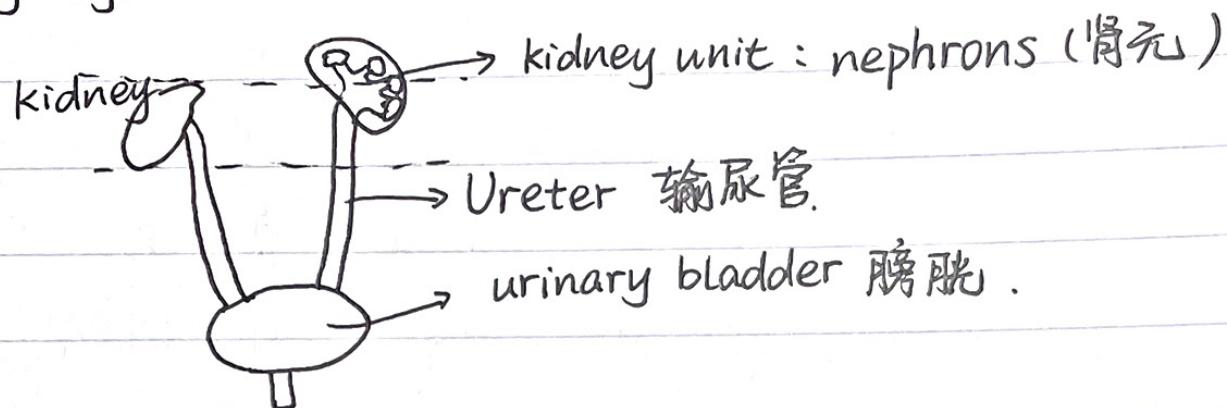
{ Oncogene 致癌基因. Tumor-Suppressor 原癌基因. (mutation on DNA).  
proto-oncogene 肿瘤抑制基因.



(感觉的)

Nerve tissue: sensory information  
basic unit: neuron.

## Urinary system



过滤 filtration 重吸收 reabsorption 形成尿 secretion 排泄 excretion

blood → filtrate 滤液 filtrate → blood.

## 8. Digestive system.

Ingestion (take in)      Digestion      Absorption      Elimination.

Mechanical digestion      \* Chemical digestion.



protein pepsin 胃蛋白酶.

~~amylase~~ <sup>Hydro</sup> Carbohydrate amylase 淀粉酶

Fat lipase 脂肪酶.

trachea 气管.

Saliva 唾液 Esophagus 食道      Pharynx 咽      Colon 结肠      Rectum 直肠.

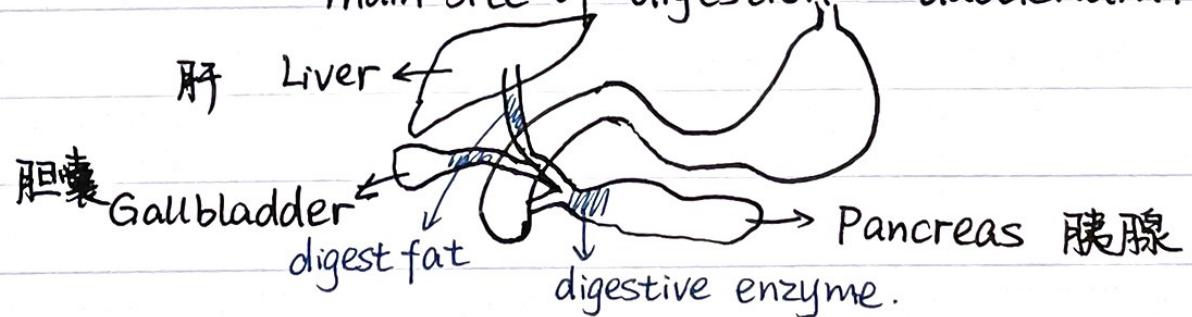
teeth: Incisors 门牙      Canine 犬牙      Premolars 前磨牙      molars 磨牙  
cutting food      tearing      grinding

breath. epiglottis. (会厌) ↑      swallowing epiglottis ↓.

spincter sphincter 括约肌. 出现在 stomach 两端 + 食道顶端.

The small intestine (小肠): the longest part (6~7m).  
absorption.

main site of digestion: duodenum.



The large intestine (大肠): absorbs water and produces feces (排泄物)

## 9. Circulation System.

Two ways to exchange materials: ① diffusion. ② circulation system.

cardiovascular system 心血管系统.

heart: atrium 心房 ventricle 心室.

blood vessel: ① ~~arteries~~ arteries <sup>thick</sup> 动脉 arterioles 小动脉.

② capillaries 毛细血管. (only 5%-10% have a steady flow of blood)

③ venules (small veins) 静脉

double circulation: pulmonary circuit (肺循环) right chamber pumps blood  
systemic circuit (体循环) left chamber receives blood  
right to lungs  
left from lungs.

Cardiac cycle: diastole 心舒期. Systole 心缩期.

heart murmur ← heart valves.

SA node and AV node (control the tempo)

## 10. Immune system.

2 level defenses : Innate Defenses.

① external barriers

skin

② internal defenses.

phagocytic cells.

吞噬细胞

defensive proteins. { interferon 干扰素

complement proteins 补体.

Inflammatory response 炎症反应.

immediate don't change

highly specific  
acquired with exposure

③ Adaptive Defenses.

Lymphocytes B.T.

Antibodies