Topic2

membranes,proteins, dna and gene expression

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01

知识梳理：细胞膜，物质运输，气体交换，酶

02

DNA/RNA，基因编码，遗传学

03

做题咯~

01

细胞膜构造，物质运输，气体交换，酶

Cell membranes

1. Fluid mosaic model:

fluid ：individual phospholipid and protein molecules move around within their monolayer.

mosaic ：describes the pattern produced by scattered protein molecules when the surface of the membrane is viewed from above.

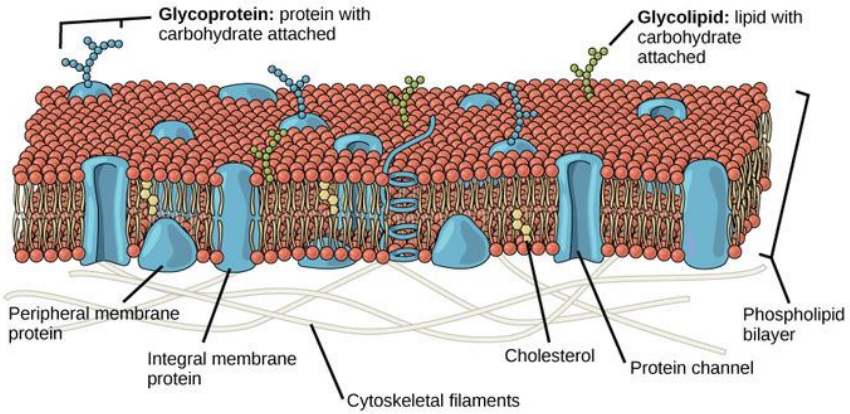
2. phospholipid: →hydrophobic tails : 2 fatty acid chains

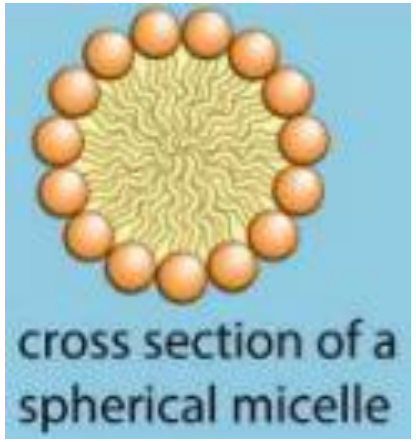
→hydrophilic heads: phosphate group and glycerol

3. phospholipid bilayer: basic structure of membrane

特点：partially permeable, 有极性的分子无法通过（可溶于水的物质也不行）

4. micelle





Fluidity的影响因素：

1.more unsturated, more fluid（越不饱和，流动性越强）because unsaturated tails are bent ，fit together more loosely(不饱和的脂肪酸链被弯曲，结合越松散，流动性增强）

2.longer the tails, less fluid(tails越长，越容易缠在一起，流动性降低）

3.cholesterol 会降低 fluidity： 会和磷脂分子结合，阻碍热运动，降低通透性）

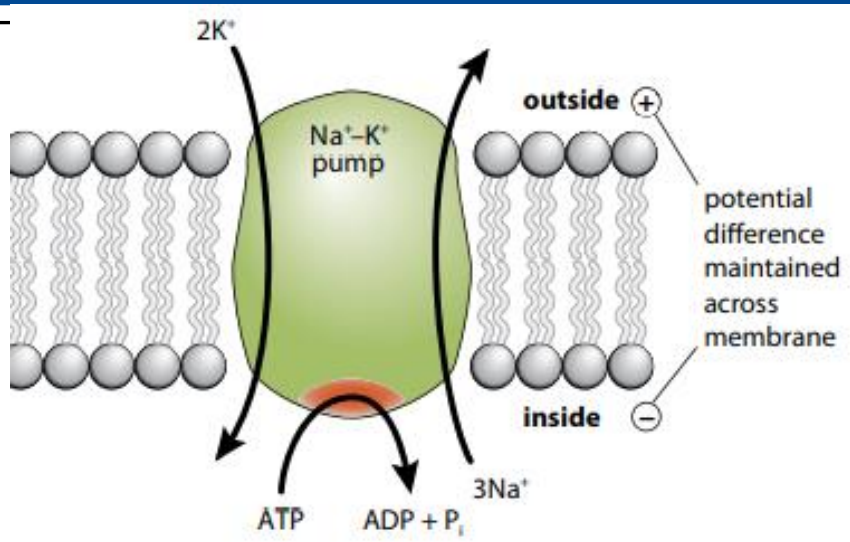
4.temperature：温度越高，得到动能，分子运动速率越快，流动性越强

transport

1. passive transport 包含：diffusion和facilitate diffusion

- Diff usion特点: from a region of high concentration to a region of low concentration, down the concentration gradient
- Facilitated diff usion: 1. down the concentration gradient
  2. Molecules go through
  channel proteins or carrier proteins

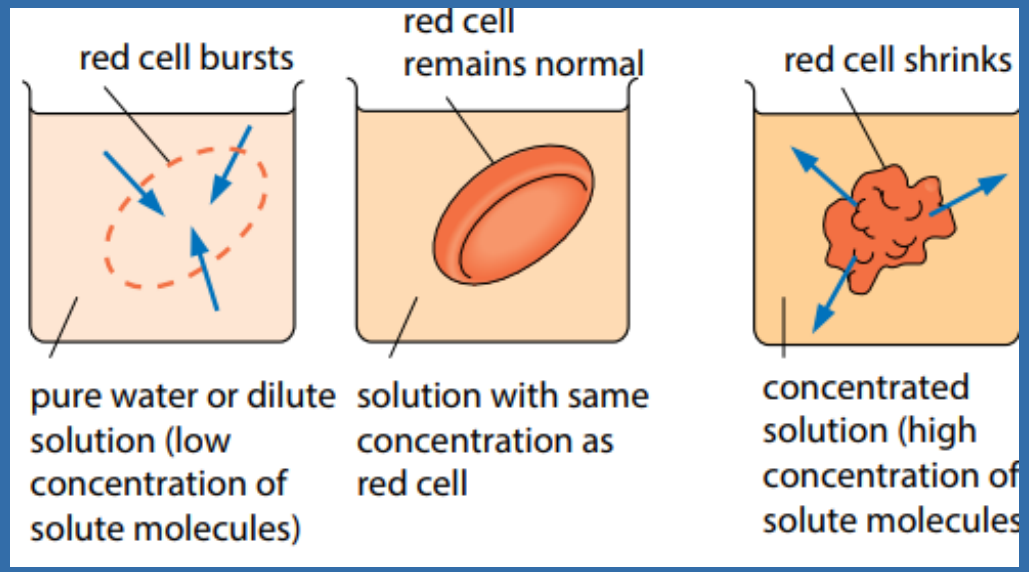
This allows for the passage of
large polar ions and molecules e.g.
glucose, amino acids, Na+
*no ATP energy required for any passive transport



2.active transport: channel proteins(carrier proteins), against concentration gradient, use ATP energy

3.cytosis: * exocytosis：物质运输从内到外，借助vesicles
* endocytosis：物质运输从外到内，借助vesicles

4.osmosis（special case of diffusion ,针对水分子）
运输from high water potential to low water potential

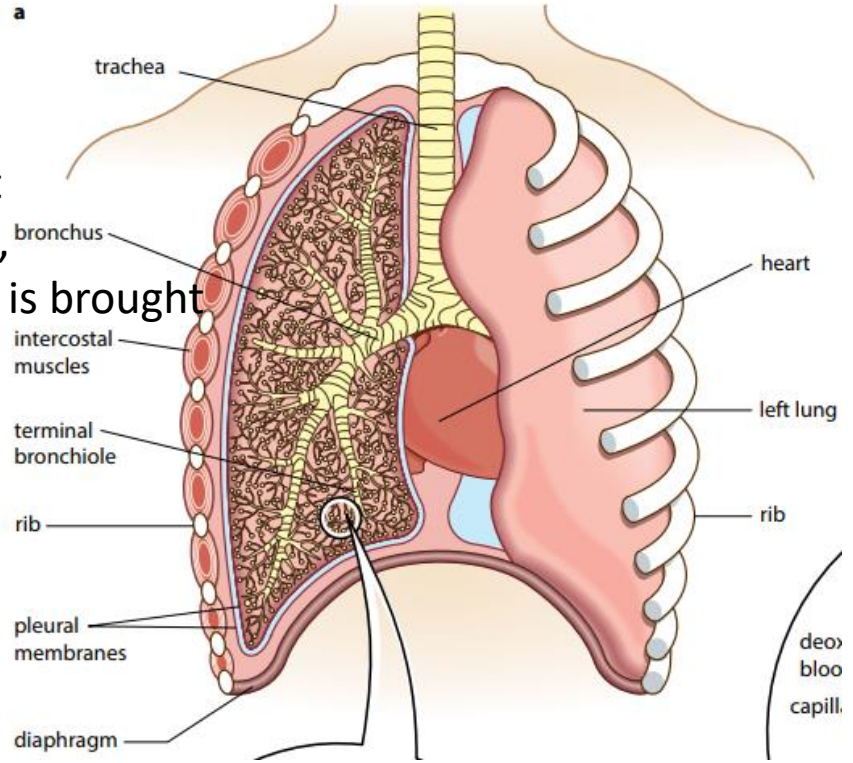


Gas exchange system

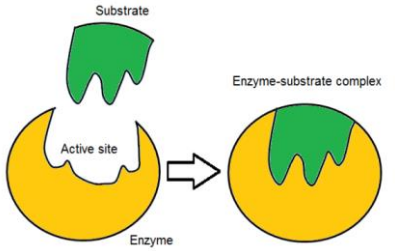
顺序：trachea，bronchi，bronchioles，alveoli
efficient gas exchange:1.large surface area： A large number of alveoli is present to increase the surface area 2. thin surface： to decrease the diffusion distance, 毛细血管的walls也thin 3.steep concentration gradient ： Deoxygenated blood is brought to the alveoli 4.ventilation 通气量： maintain diffusion gradient

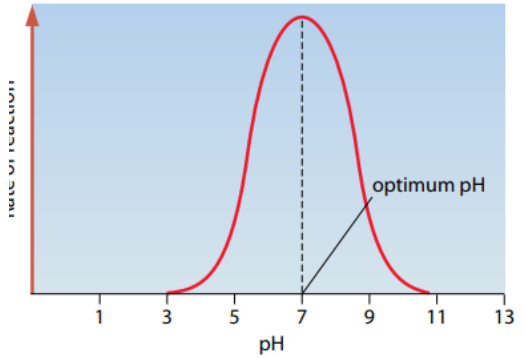
Eepithelium：杯状细胞分泌粘液（mucus）catch pathogen 和微粒
纤毛细胞将粘液带出气道，通向喉
cartilage（c形骨）：打开通气道（airways），减少空气阻力，prevents from collapsing and bursting（防止trachea 和bronchi 坍塌和爆裂， 当air pressure changes）

bronchiole：有smooth muscle，去relax 和 contract，
调整通气道的直径，舒张让更多空气通向肺泡。



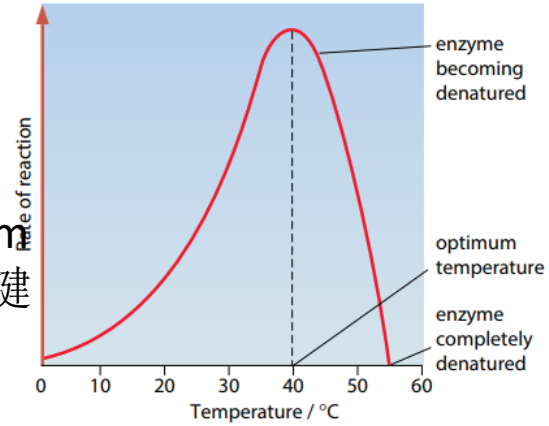
Enzyme(本质上是蛋白质）





1.biological catalyst： accelerate metabolic reactions.
2.globular proteins： spherical shape and water-soluble
3.active sites: specific that are complementary to the shape of substrate
active site 和 substrate 之间由氢键和离子键连接，形成enzyme-substrate complex
4.enzymes lower the activation energy
5.induced fit theory： enzymes are flexible and can slightly change shape as substrate enters active site

蛋白质活性的影响因素：1.temperature：温度越高，动能和酶活性增加，酶和底物之间的碰撞更加频繁，底物和酶的结合更加快和多，rate增加。但是当温度大过于optimum temperature，rate会decrease，因为动能过多导致酶（蛋白质）的二级，三级结构的化学键断裂，酶和活性位点的形状发生改变，底物不能和酶进行结合了，蛋白质失活。



2. PH
3.enzyme cocentration: 一开始，浓度越高，enzyme数量越多，有更多的活性位点可以和底物相结合，更多产物，rate增加。时间久了后，有限数量的底物已经都和enzyme结合了，酶的数量增加已经对速率没有影响了，此时限制因素是底物的浓度
4.substrate concentration：浓度越高，更高的几率和酶碰撞形成enzyme-substrate complex。时间久后，有限数量的酶都和底物进行了结合，此时底物浓度的增加已经对速率没有影响了，限制因素转为enzyme concentration。

02

DNA&RNA
基因编码，遗传

DNA&RNA

1.NUCLEIC ACIDS： double-strand,deoxyribose, bases: Adenine, thymine, guanine, and cytosine

其中，A和T之间有2个氢键，C和G 之间有3个氢键

2，backbone 之间的化学键是phosphodiesterbond / bases之间的化学键是hydrogen bond

3.DNA： double helix,double strands, deoxyribose, AGCT

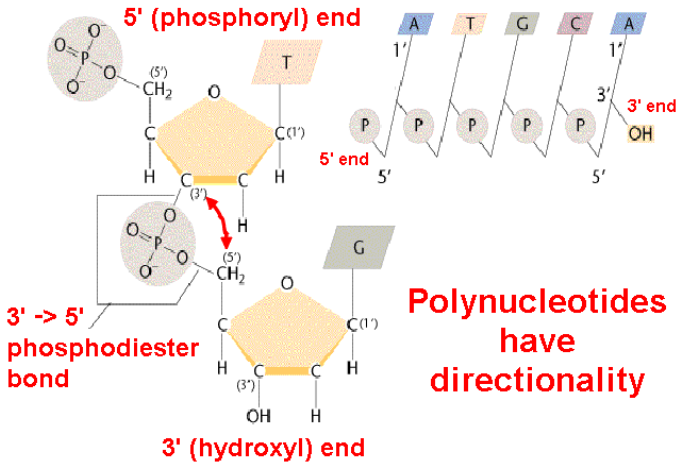
RNA:single strand ,oxyribose,AUCG

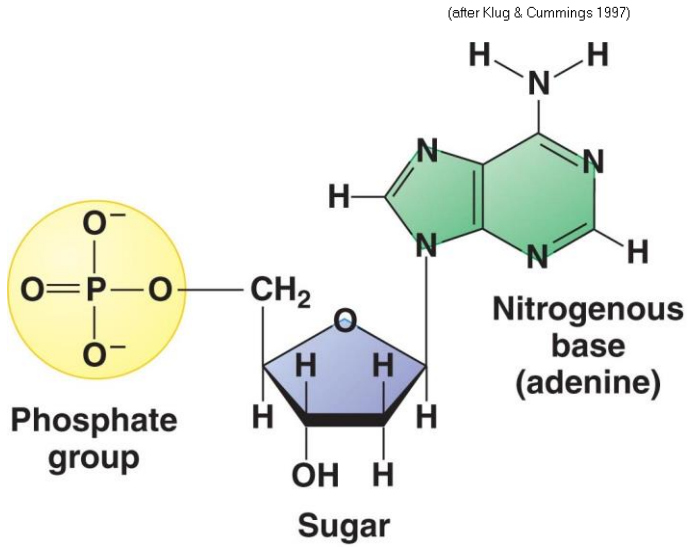
4.semi-conservative replication： The DNA separates into two strands, and each strand acts as a template.

Each new DNA molecule consists of one old strand and a complementary new strand.

(要熟悉证明半保留复制的实验，用氮15同位素和氮14同位素培养后代），正确描述实验步骤和实验现象

5。





DNA 复制

1.The DNA double helix unwinds and ‘unzips’ as the hydrogen bonds between the bases break by DNA helicase

2.the free nucleotides that pair up by complementary base pairing on each of the old DNA

3.DNA polymerase links adjacent nucleotides to each other by catalysing phosphodiester bonds.

4.DNA ligase links the okazaki fragments together

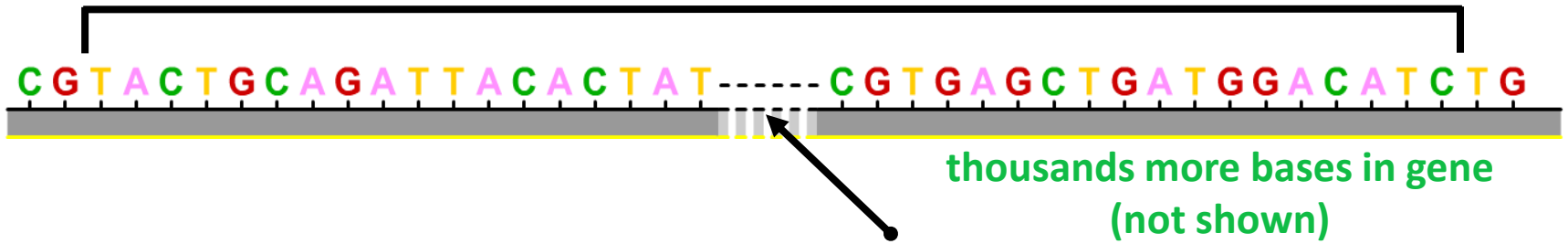
5.Hydrogen bonds form within the structure, allowing it to coil up into a double helix

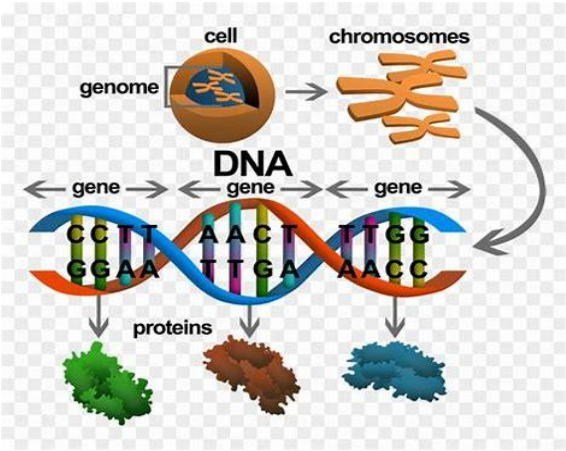
genetic code

一个染色体上只有一个gene，其中gene里面是有用的dna，可以形成有用的protein，一条dna上有很多基因

Gene: a length of DNA that codes for a particular polypeptide or protein

Codon密码子（1 codon=3bases）: A sequence of 3 bases in DNA or mRNA（还有anticodon）.





It is a three-letter code, known as a triplet code：three bases make the code for one amino acid.

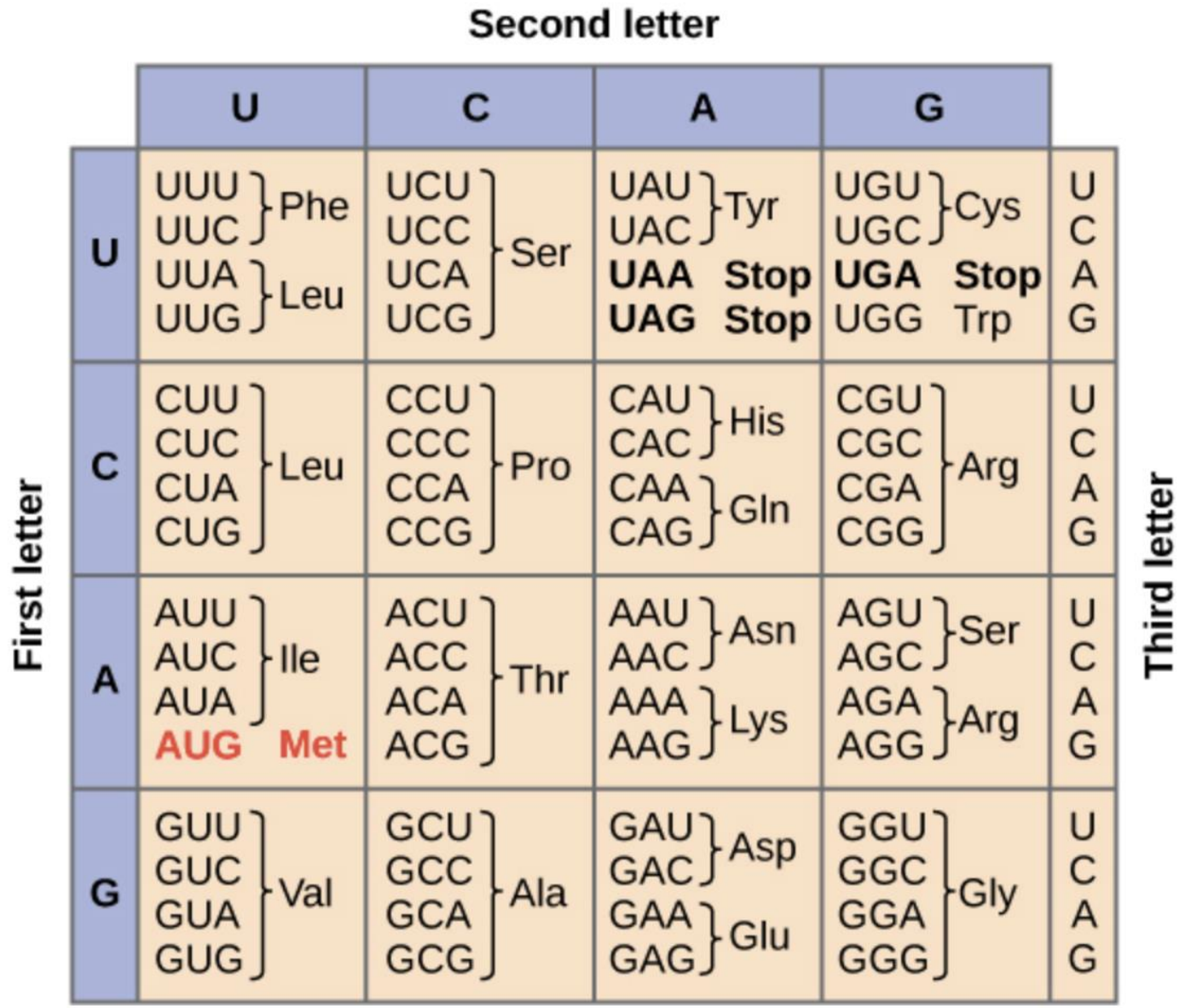
- The code is universal通用性:in all living things.
- The code has punctuations.

stop triplets（终止密码）: UAG,UAA,UGA. start codon： AUG起始密码子

- The code is degenerate简并性（多个droplet）or degeneracy.

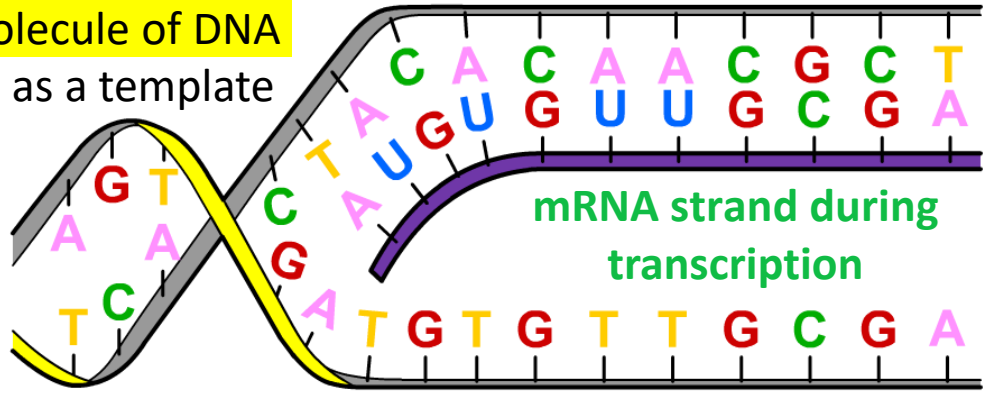
some amino acids are coded for by more than one triplet:cysteine is coded for by ACA and ACG.

- Commaless连续性：after one amino acid is coded, the second amino acid will be automatically, coded by the next three letters
- The genetic code is non-overlapping不重叠: each base is only part of one triplet/codon, and each


Second letter
U
C
A
G
First letter
Third letter
U
UUU Phe
UUC
UUA Leu
UUG
UCU
UCC
UCA
UCG Ser
UAU Tyr
UAC
UAA Stop
UAG Stop
UGU Cys
UGC
UGA Stop
UGG Trp
C
CUU
CUC
CUA
CUG Leu
CCU
CCC
CCA
CCG Pro
CAU His
CAC
CAA Gln
CAG
CGU
CGC
CGA
CGG Arg
A
AUU
AUC
AUA Ile
AUG Met
ACU
ACC
ACA
ACG Thr
AAU Asn
AAC
AAA Lys
AAG
AGU Ser
AGC
AGA Arg
AGG
G
GUU
GUC
GUA
GUG Val
GCU
GCC
GCA
GCG Ala
GAU Asp
GAC
GAA Glu
GAG
GGU
GGC
GGA
GGG Gly

mRNA

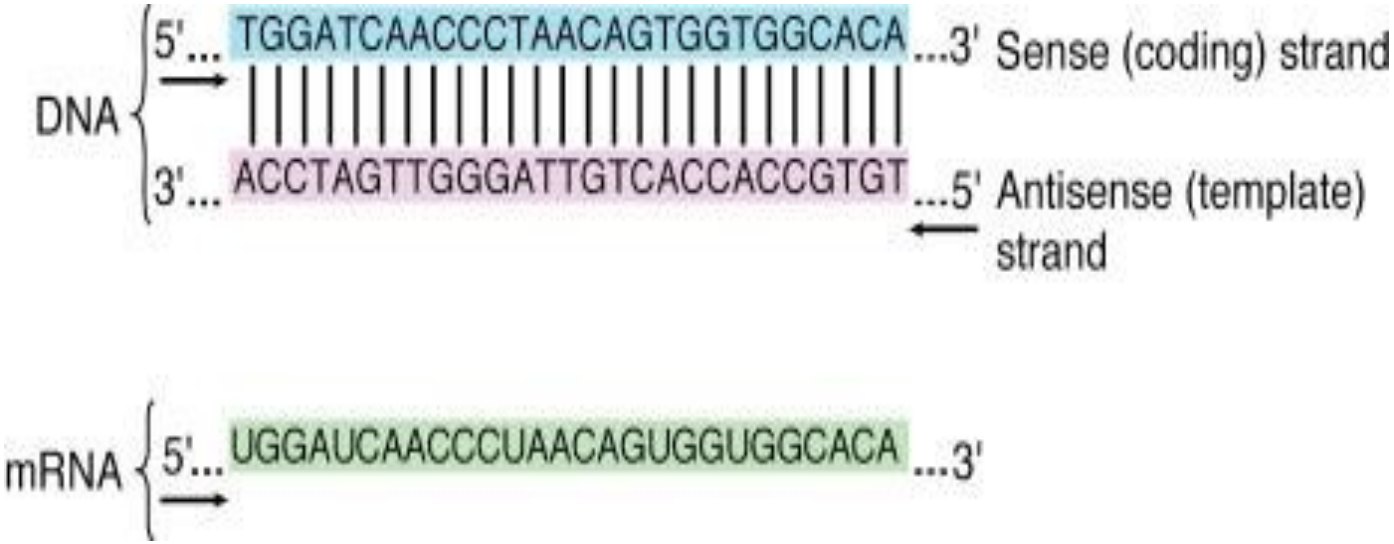
Transcription（发生在细胞核）: copying the genetic information in a molecule of DNA into a complementary strand of mRNA; a single strand of the DNA is used as a template（一条链可以作为模版进行互补）



after transcription ,mRNA will leave the nucleus into the cytoplasm

Like DNA, mRNA is a nucleic acid, but it differs in that:

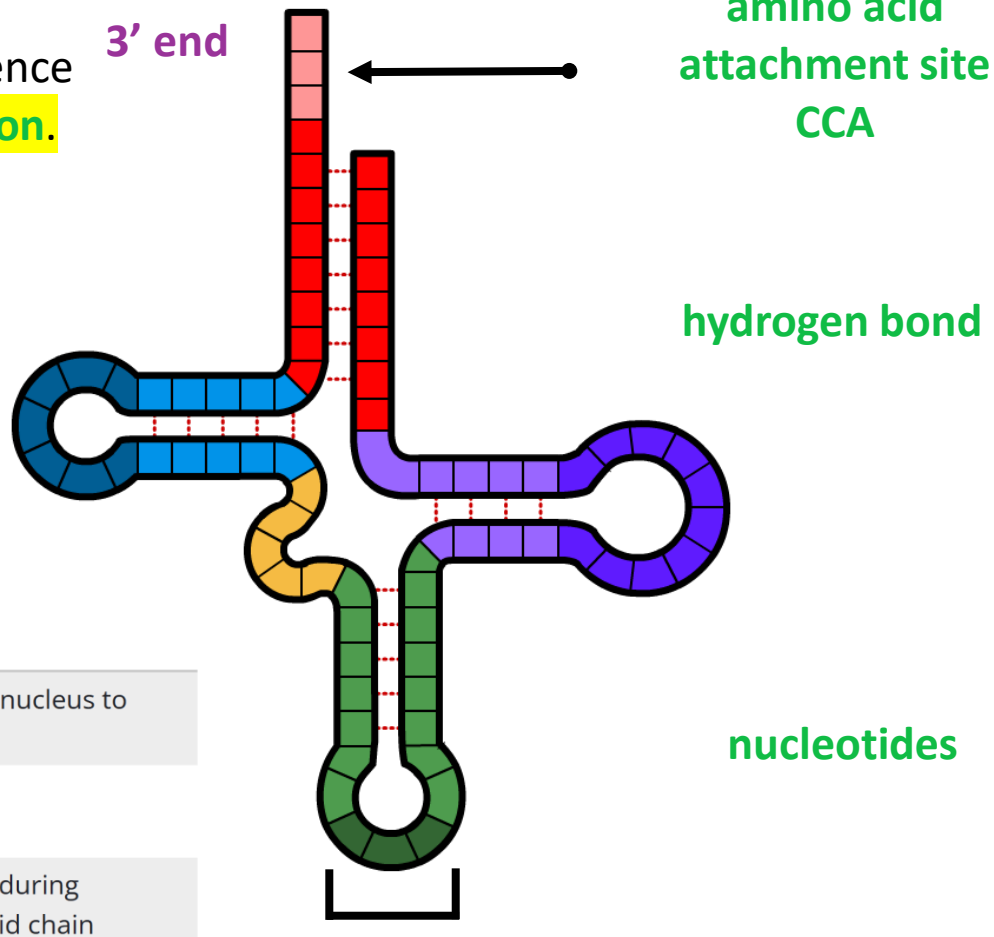
- it is single stranded
- it contains ribose instead of deoxyribose
- it contains uracil instead of thymine.



tRNA

In the cytoplasm, amino acids attach to **transfer RNA** (**tRNA**) molecules. Each tRNA is specific for one amino acid.

Each tRNA molecule has a sequence of three bases called an **anticodon**. These are complementary to codons on the mRNA molecule,



Types of RNA

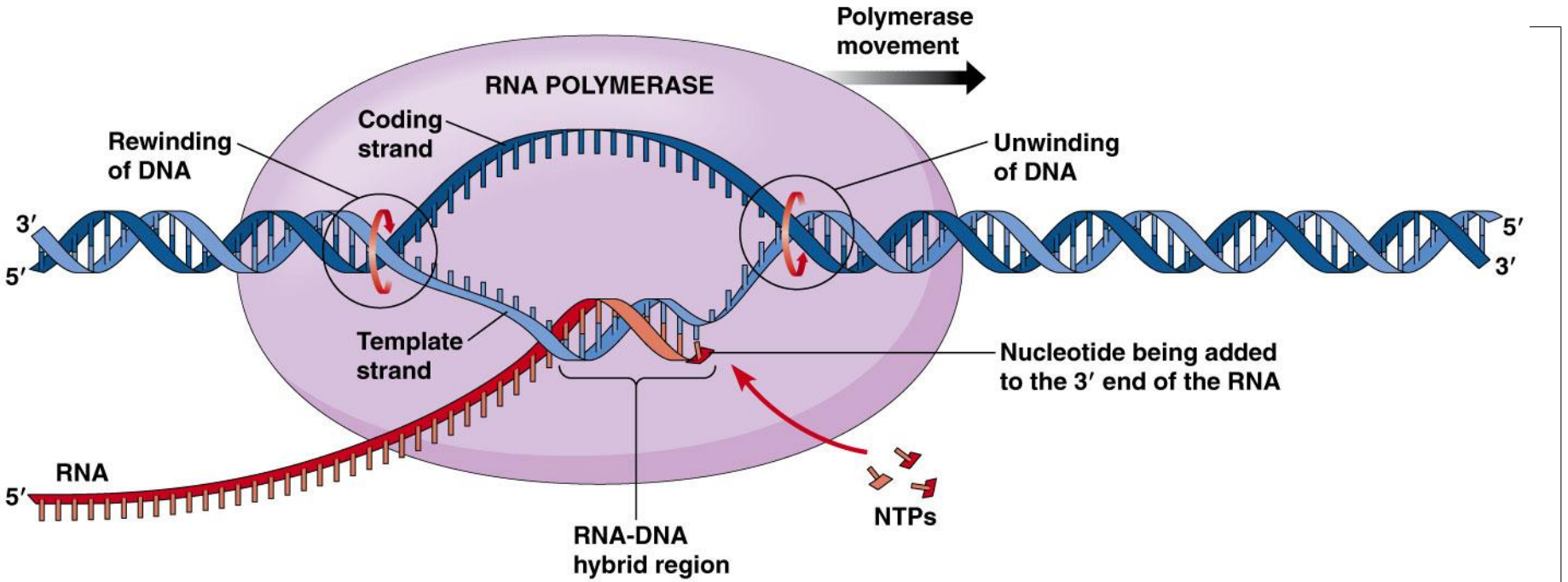
Type	Role
Messenger RNA (mRNA)	Carries information from DNA in the nucleus to ribosomes in the cytoplasm
Ribosomal RNA (rRNA)	Structural component of ribosomes
Transfer RNA (tRNA)	Carries amino acids to the ribosome during translation to help build an amino acid chain

Transcription

- Process by which enzymes use the antisense strand of DNA as a template to produce a messenger RNA (mRNA) molecule.

1) RNA polymerase（先断开氢键，再继续复制） binds to a region of gene to be copied

- this signals DNA to unwind so bases can be read
- the strand that' s read is the template/antisense strand



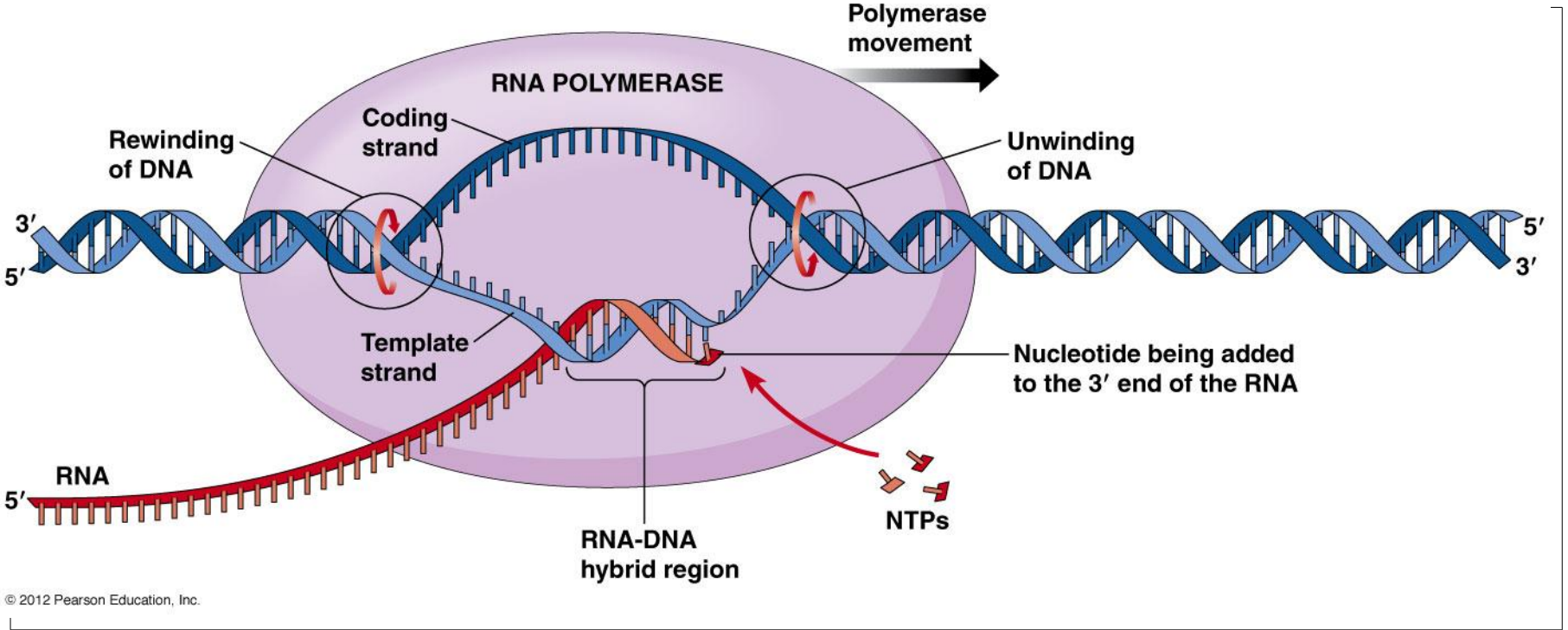
2) RNA polymerase reads antisense strand and generates mRNA from 5′ to 3′ , phosphodiester bonds， hydrogen bonds

3) when RNA polymerase has reached the terminator sequence at the end of the gene, transcription stops ， mRNA is released

- enzyme detaches from gene and DNA returns to original structure

4) STOP Code： in DNA the stop codons are UAA, UGA, UAG

5） Once a molecule of mRNA has been transcribed, it moves out of the nucleus via a nuclear pore



Translation:1,发生场所：cytoplasm

Process by which the genetic code in mRNA is read to make a protein.

1) every 3 bases (a codon) on mRNA codes for a specific anticodon which is carried by a transfer RNA (tRNA) molecule

2） each different tRNA is linked to a particular amino acid

process：

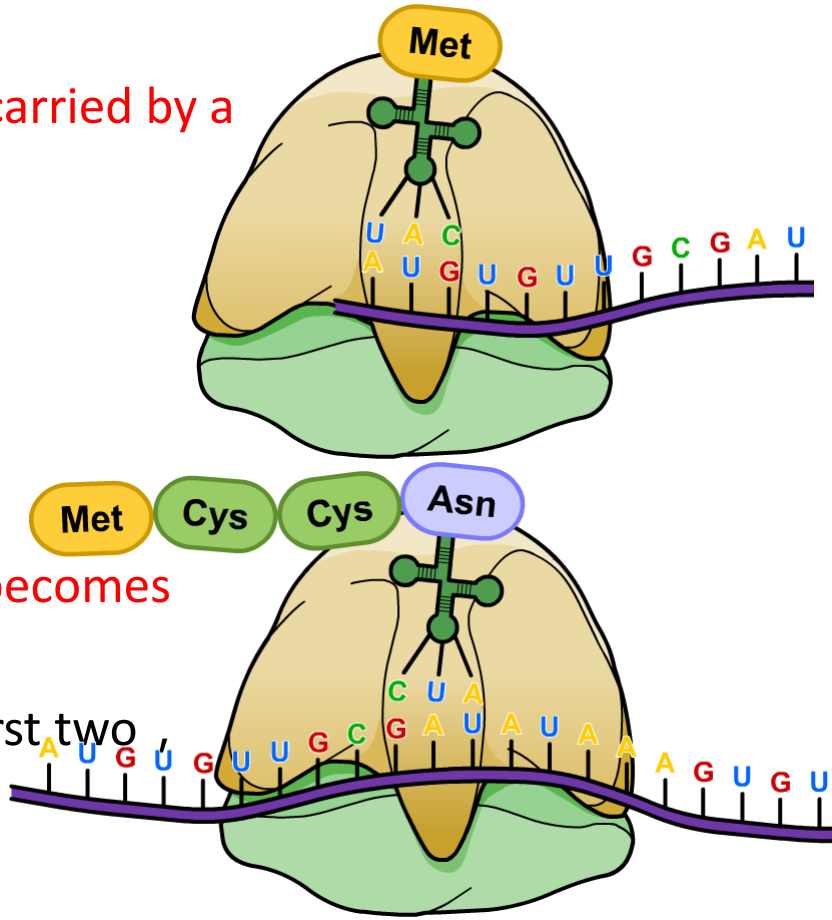
1）mRNA leaves the nucleus and binds to the ribosome

2) an initiator tRNA carriers amino acid to adheres to a START codon：AUG

3) the next tRNA enters the ribosome carrying an amino acid with it which becomes covalently bound to methionine from the initiator tRNA

4）moving of ribosome， a new amino acid carried by new tRNA links the first two， first tRNA detaches

5） this polypeptide chain continues to grow till a STOP codon is reached



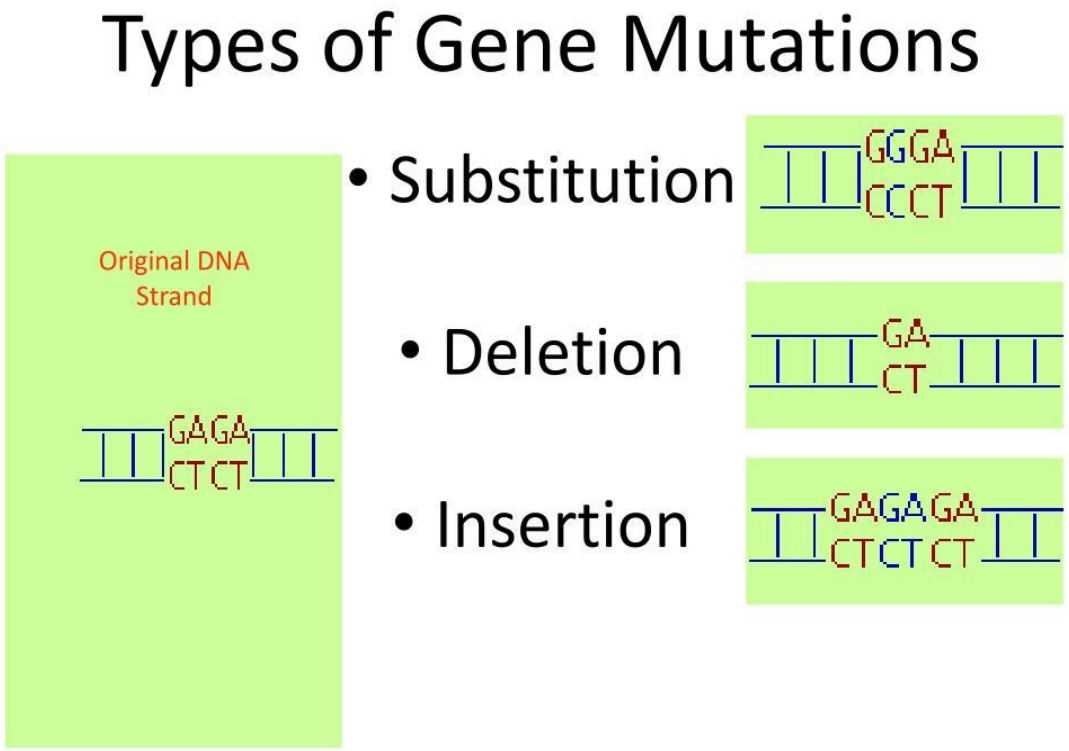
Genetic mutations

A **mutation** is a change in the amount or structure of DNA. There are two types of mutation:

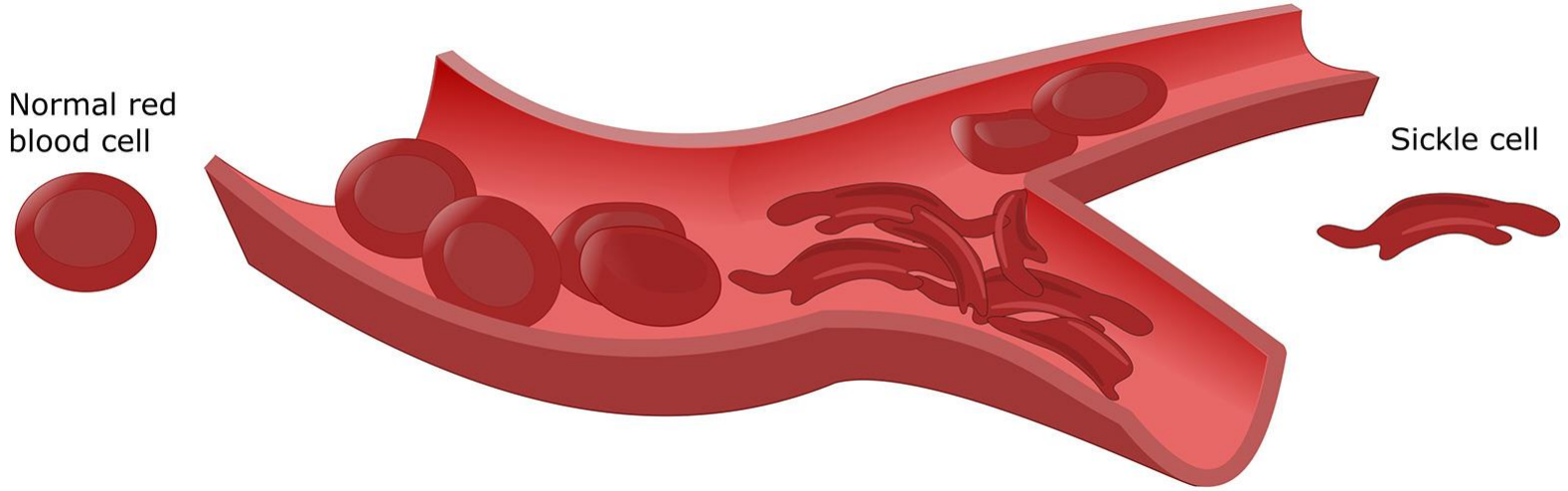
- A **gene** or **point mutation** – a change in the base sequence of a gene, which can cause a change in the polypeptide chain. It is caused by errors that occur during **DNA replication**.

- A **chromosome mutation** – a change in the number or structure of the chromosomes. It is caused by errors that occur during **cell division**.

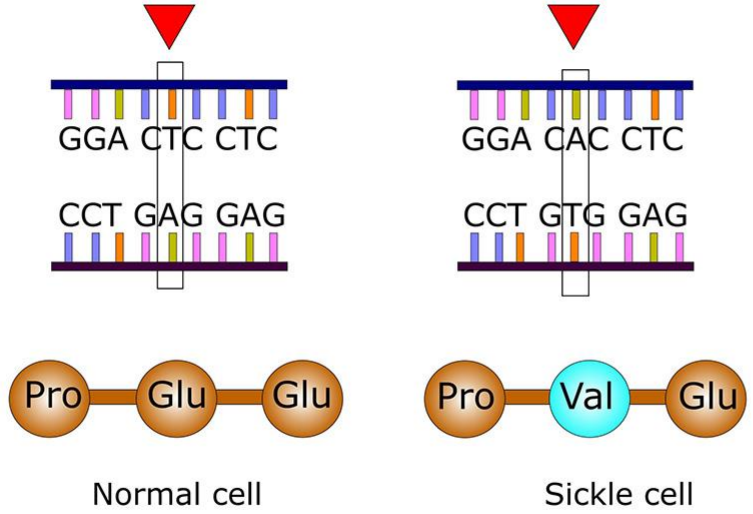
substitution： one base in a gene is substituted for another
deletion： a base is completely lost
insertion： an extra base is added into a gene, which may be a repeat or a different base

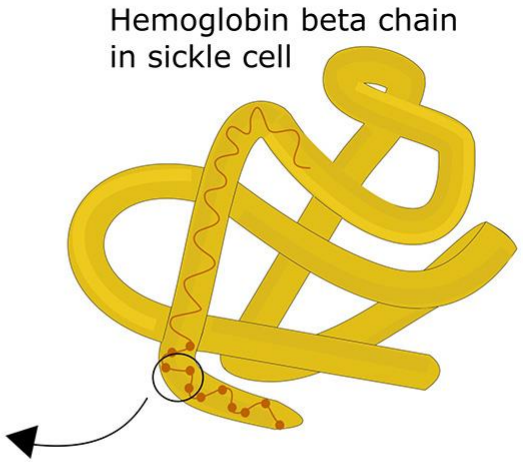


- sickle cell anemia镰刀形贫血症（隐性疾病）



mutation is called substitution





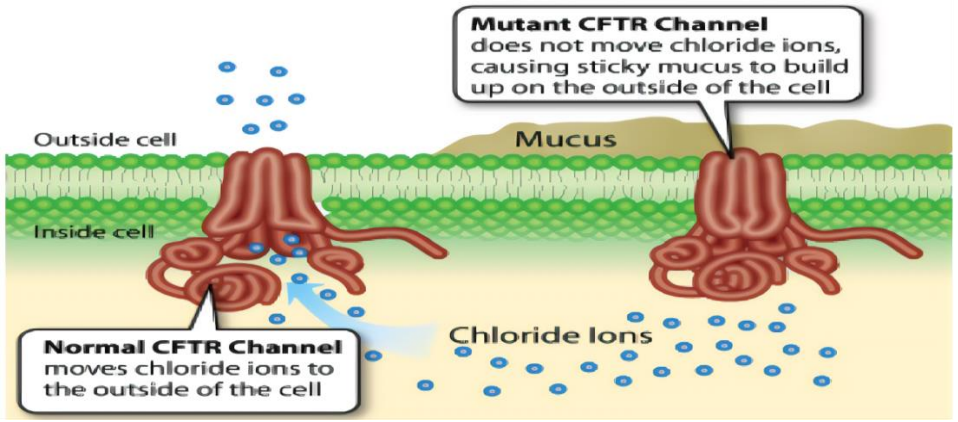
疟疾

表面积减少，氧含量减少，感到疲惫

Cystic fibrosis囊性纤维化

Cystic fibrosis (CF) is a recessive inherited disease隐性遗传病.
It is caused by a number of different point mutations
in the **CFTR** （氯离子通道）gene, which codes for a
transmembrane protein that acts as an Cl- pump.

normally， In the lung,the CFTR ion channel moves chloride ions
from inside the cell to outside the cell.
With CFTR mutations, excessive Cl- accumulate inside the cell,
causing more water to return from the outside and mucus to be
more thick and sticky



Effects on respiratory system

unable to move as the mucus is so thick and sticky

- frequent infections
- block airways which limits gas exchange粘液粘在气道壁上，narrow airways
- The surface area for gas exchange is reduced which can cause breathing difficulties
- lack in energy
- reduced immunity

Effects on the digestive system

Thick mucus in the digestive system

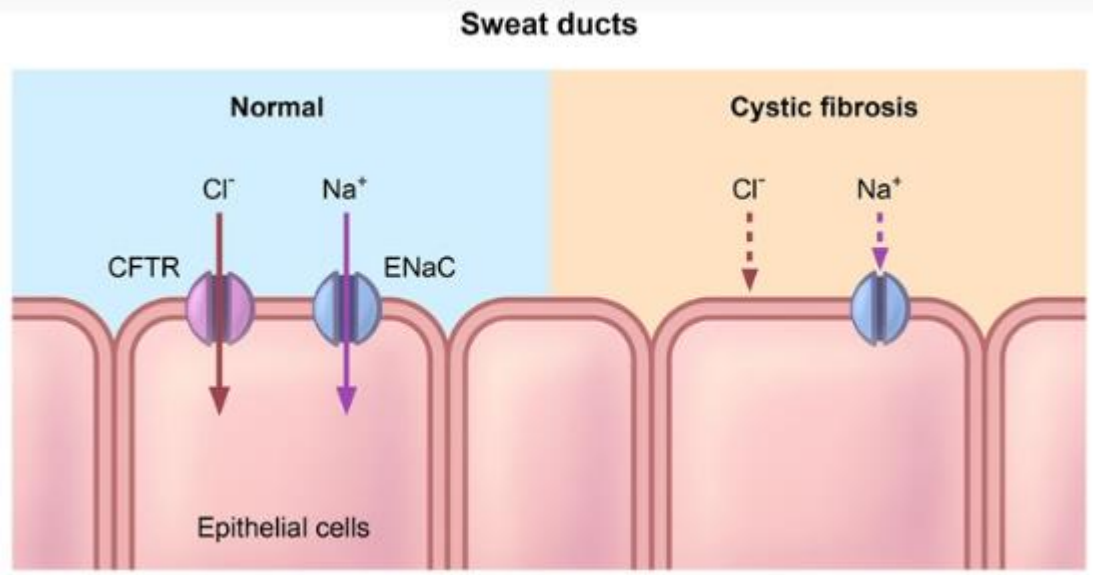
- Blockage of the pancreatic duct reduces digestion of nutrients
- The villi of the small intestine are covered to reduce absorption
- malnutrition
- Islets胰岛 may be destroyed by enzymes, leading to disease-diabetes
- 产生脂肪酶，淀粉酶，消化酶，蛋白酶，胰岛素分泌，
- 通过胰腺管输出到小肠，被粘液堵住了，所以通不过去

Effects on the reproductive system

- in men， seminiferous duct输精管 is blocked, preventing sperm from reaching the penis
- In women thickened cervical宫颈 mucus can prevent sperm reaching the oviduct to fertilise an egg过于粘稠而堵住不让精子进入。

Effects on the sweat glands

In sweat glands, CFTR functions to reabsorb Na+，Cl-
Sweat is mainly composed of salt and water
Reabsorption of salt prevents the body from losing too much salt
Mutations in CFTR cause sodium and chloride ions remain in sweat
Saltier sweat更咸，氯离子堆积，汗水更咸



Prenatal testing

The DNA can be obtained by chorionic villus samplingCVS or amniocentesis in the uterus

1. Amniocentesis羊水穿刺 involves removing about 20cm3 of the amniotic fuid which surrounds the fetus using a needle and syringe.
2. This is done at about the 16th week of pregnancy.
3. Fetal epithelial cells and blood cells can be recovered from the fuid after spinning it in a centrifuge离心.
4. The cells are cultured培养 for 2---3 weeks and then a number of genetic defects and the sex can be determined .

Amniocentesis has the following disadvantages.

- It can only be carried out relatively late in the pregnancy making it very difficult for the parents if termination of the pregnancy is necessary.
- The results are not available until 2-3 weeks after the test.
- It carries a 0.5- -1% risk of spontaneous abortion after the procedure, regardless of the genetic status of the fetus

In chorionic villus sampling, a small sample of embryonic tissue is taken from the developing placenta at 8-10th week.

1. Insert an instrument called a speculum窥镜 into your vagina
2. Using ultrasound guidance, a thin tube will be guided through the cervix to the chorionic villi.
3. Ultrasound will be used to help guide a long, thin, hollow needle through your abdomen and into the uterus and placenta.
4. Cells will be gently suctioned through the tube into a syringe.
5. The tube/needle will then be removed.

benefits of CVS：

1. This makes a much bigger sample更多样本 of fetal tissue available for examination. 不用培养
2. The cells can be tested for a wide range of genetic abnormalities.
3. This diagnostic technique can be carried out much earlier in the pregnancy, so that if a termination is necessary it is physically less traumatic for the mother
4. The results are also available more rapidly than for amniocentesis.

There are two disadvantages to chorionic villus sampling.

- There is a 0.5- -1% risk that the embryo may spontaneously abort after the tissue sample is taken
- All paternal X chromosomes are inactivated in fetal placental cells so any problems in the genes on that chromosome cannot be detected by this technique.

Ethical &Social Issuesof Genetic Screening

1. Belief that God is in control may mean that a pregnancy will be continued no matter what genetic screening might show
2. belief that embryos are potential human beings would mean that the abortion of a foetus would be considered impossible

3. Processes that involve screening embryos on the basis of factors, e.g. sex or intelligence; the potential future of ' designer babies'
4. Positive screening results for non life-threatening conditions, e.g. Down syndrome,can lead to the abortion of foetuses
5. some believe the embryo or unborn baby that they are deserving of full human rights while others do not

03

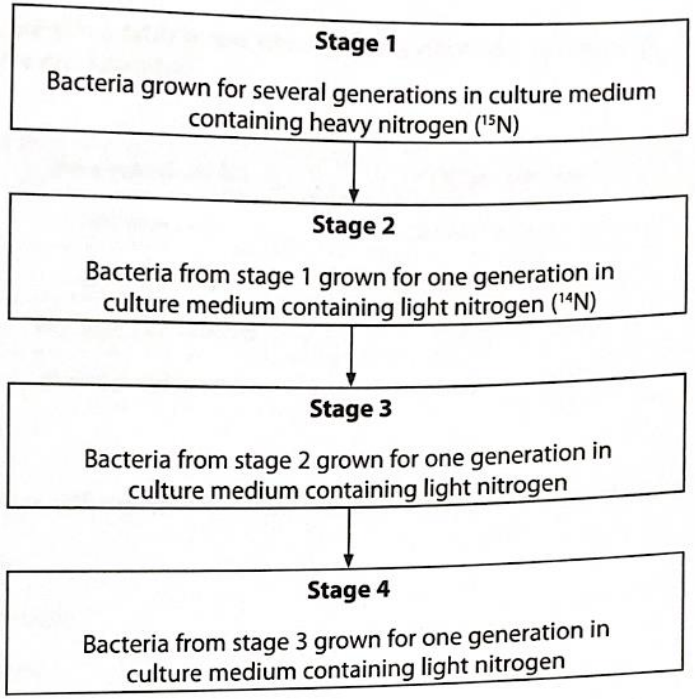
做题

(6)

Question number	Answer	Additional guidance	Mark
1	A description that includes the following points: DNA only • deoxyribose • thymine DNA and mRNA accept two from • phosphate (group) • cytosine • guanine • adenine mRNA only • ribose • uracil	Items should not be written in "both" space as well as "mRNA" or "DNA" space Names of bases should be written in full (not just letter abbreviations) and broadly correct IGNORE nitrogenous base, pentose sugar, purine, pyrimidine	**(6)**

(Total for Question 1 = 6 marks)

(b) The flow chart summarises part of one experiment performed by Meselson and Stahl.



Complete the table to show the percentage of the total number of DNA molecules containing heavy nitrogen only, light nitrogen only or both heavy and light nitrogen, at the end of each stage. (3)

End of stage	Percentage of DNA molecules containing		
	heavy nitrogen only	light nitrogen only	both heavy and light nitrogen
1	100	0	0
2	0	0	100
3	0	50	50

(Total for Question 4 = 8 marks)

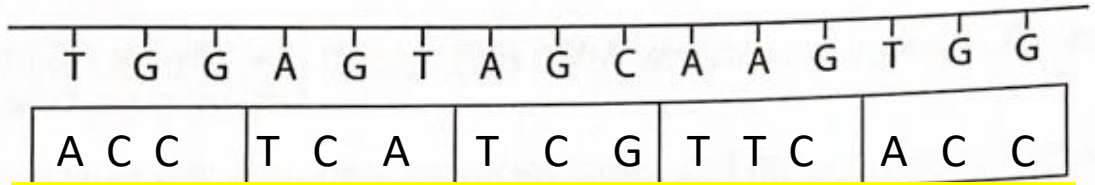
半保留复制

3 The sequence of bases in DNA determines the sequence of amino acids in a polypeptide.

The table shows four amino acids and their genetic codes.

Amino acid	Genetic code
alanine (Ala)	GCT or GCC or GCA or GCG
lysine (Lys)	AAA or AAG
serine (Ser)	AGT or AGC or TCT or TCC or TCA or TCG
tryptophan (Trp)	TGG

(a) The diagram shows a DNA base sequence.



tryptophan serine serine lysine tryptophan

(i) Complete the diagram to show the sequence of amino acids coded by this DNA base sequence. (1)

(ii) Explain why only five amino acids are coded by this sequence of bases. (2)

there are 3 triplet code,there is no stop codon

(b) The respiratory system of an elephant is different from that of other mammals.

The lungs are attached to the chest cavity wall and diaphragm by collagen fibres.

Describe how the lungs of an elephant are adapted for gas exchange.

(3)

alveoli provides large surface area, greater diffusion rate
large capillary network
thin walls: short diffusion distance ,great diffusion rate

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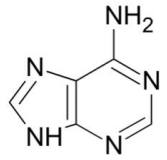
(c) Compare and contrast the structure of messenger RNA (mRNA) with the structure of transfer RNA (tRNA).

(4)

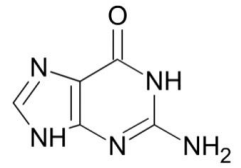
相同点：both trna and mrna are single stranded(1’)
both cantain ribose（1’）
不同点：mrna is a straight chain while trna is folded(1’)
mrna has codons while trna has anticodon(1’)

R is adenine because it can form 2 hydrogen bonds.
R is adenine is double- ringed base.

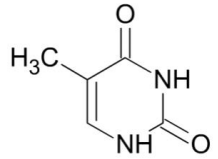
ine



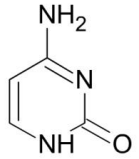
A



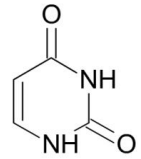
G



T



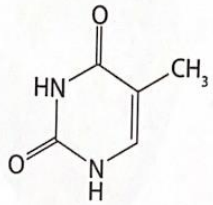
C



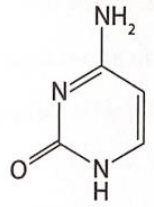
U

(ii) The diagram shows

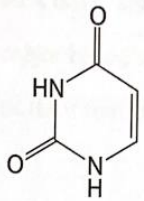
Bases **P** and **S** can form three hydrogen bonds each and bases **Q** and **R** can form two hydrogen bonds each.



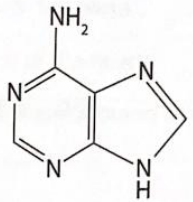
thymine



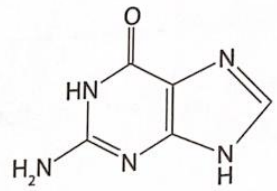
base **P**



base **Q**



base **R**



base **S**

Explain which of the four bases **P**, **Q**, **R** or **S** is adenine.

(2)

Aa (brown)

brown Aa → phenotypes: parents'

Aa Aa genotypes:

(A) or (a) (A) or (a) gametes

	(A)	(a)
(A)	AA	Aa brown
(a)	Aa	aa

brown

n pairs → 284 offspring

one pair: AA → $\frac{1}{4}$ $284 \times \frac{1}{4} =$

Aa → $\frac{1}{2}$ $284 \times \frac{1}{2} =$

aa → $\frac{1}{4}$ $284 \times \frac{1}{4} =$

ding phenotypes
bred together.

(3)

f heterozygous pairs of rabbits were bred together and produced
bbits.

e expected number of homozygous brown rabbits, heterozygous
its and white rabbits produced.

(3)

Number of homozygous brown rabbits .....

Number of heterozygous brown rabbits .....

Number of white rabbits .....

(Total for Question 2 – 6 ...