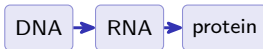


Gene Expression and Regulation

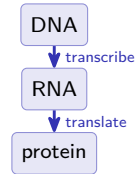
AP Biology ■ Unit 6

AP Biology



What we will cover

- 1 DNA and RNA structure
- 2 Replication
- 3 Transcription
- 4 Translation
- 5 Regulation
- 6 Mutations and biotechnology

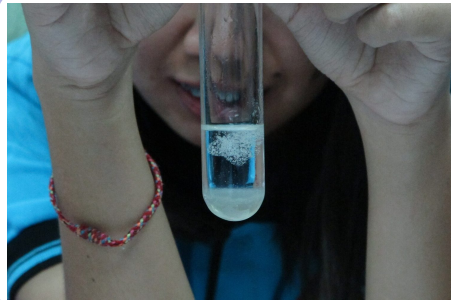


DNA and RNA structure

DNA 脱氧核糖核酸 is a **double helix** 双螺旋 of **nucleotides** 核苷酸 (sugar + phosphate + base).

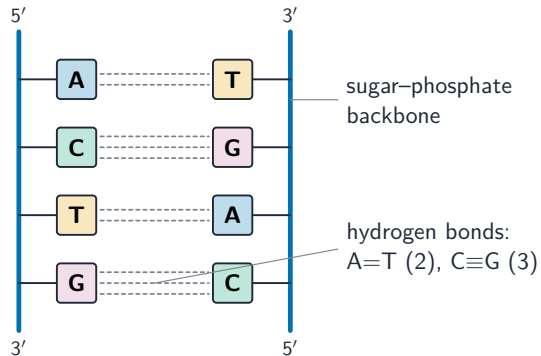
- strands are **antiparallel** 反平行的
- **complementary pairing** 互补碱基配对: A-T, C-G
- RNA: ribose, single strand, U for T

One strand's **sequence** 序列 fully determines the other – the key to faithful copying.



DNA's sequence is the heritable code

DNA and RNA structure



the two strands run in opposite directions (antiparallel)

DNA replication

Replication 复制 is **semiconservative** 半保留的: each new molecule keeps one old strand, one new.

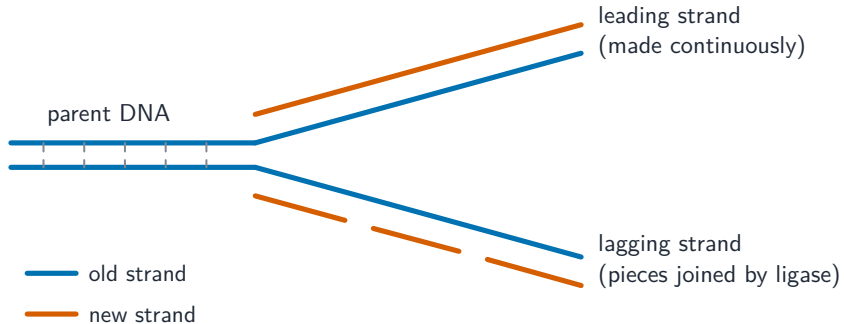
- **helicase** 解旋酶 unzips the helix
- **DNA polymerase** DNA 聚合酶 builds $5' \rightarrow 3'$
- **ligase** 连接酶 joins the pieces

Continuous **leading strand** 前导链;
piecewise **lagging strand** 后随链.



thermal cyclor

DNA replication



each new molecule = one old strand + one new strand (semi-conservative)

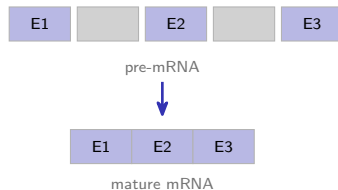
Transcription and RNA processing

Transcription 转录: RNA

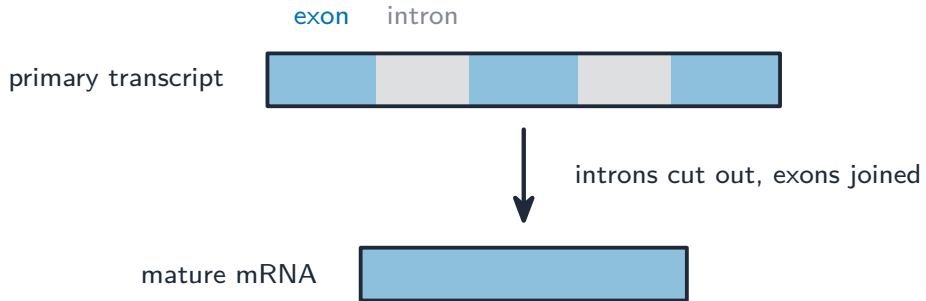
polymerase RNA 聚合酶 copies one DNA strand into **mRNA** 信使 RNA (U replaces T).

- add a **cap** 帽子结构 and **poly-A tail** 多聚腺苷酸尾
- **splicing** 剪接 removes **introns** 内含子, joins **exons** 外显子

Alternative splicing 可变剪接 lets one gene make several proteins.



Transcription and RNA processing

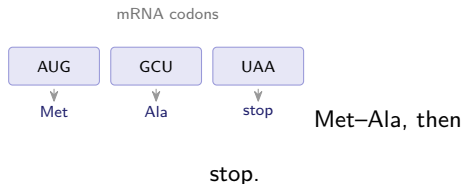


Translation

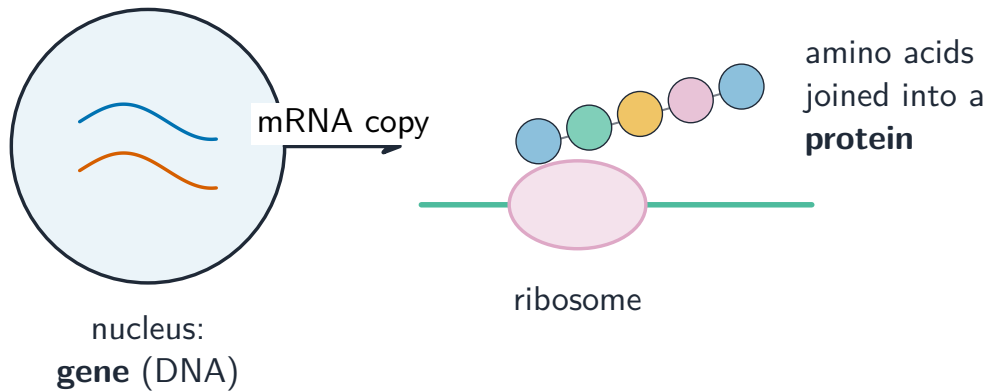
A **ribosome** 核糖体 reads mRNA three bases at a time. Each **codon** 密码子 names one amino acid.

- AUG = **start** 起始密码子 (Met);
UAA/UAG/UGA = **stop** 终止密码子
- **tRNA** 转运 RNA **anticodon** 反密码子 delivers the amino acid

The **genetic code** 遗传密码 is nearly universal – evidence of a **common ancestor** 共同祖先.



Translation



Regulation of gene expression

Every cell shares one genome – **differential gene expression** 差异基因表达 makes them differ:

Promoter + factors

transcription factors 转录因子

switch a gene on/off

Operon

bacteria control related genes as a group

Epigenetics – DNA methy-

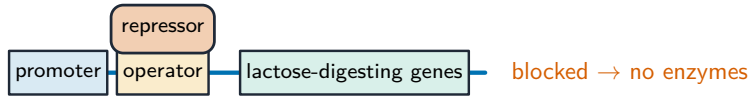
lation DNA 甲基化

silences a gene without changing the sequence

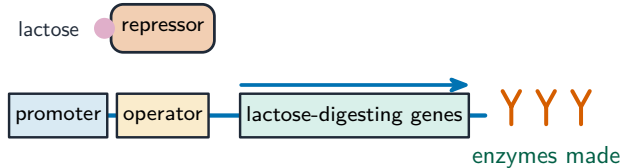
Hox genes 同源异形基因 are master switches that lay out the body plan.

Regulation of gene expression

no lactose



lactose present

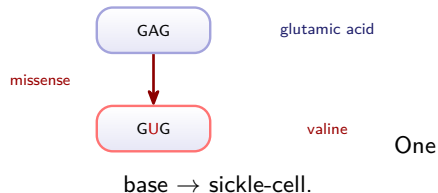


Mutations

A **mutation** 突变 is any change in DNA sequence – the ultimate source of new **variation** 遗传变异.

- **silent** 沉默: same amino acid
- **missense** 错义: one amino acid changes
- **nonsense** 无义: early stop
- **frameshift** 移码: insert/delete shifts every codon

Germ cell 生殖细胞 mutations are inherited; **somatic** 体细胞的 ones are not.



Mutations

original

A	T	G
---	---	---

C	A	T
---	---	---

T	A	C
---	---	---

substitution

A	A	G
---	---	---

C	A	T
---	---	---

T	A	C
---	---	---

deletion

A	T	G
---	---	---

A	T	T
---	---	---

A	C
---	---

insertion

A	T	G
---	---	---

G	C	A
---	---	---

T	T	A
---	---	---

C

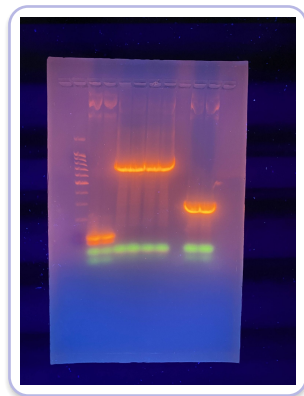
red = changed base; shaded = shifted by a frameshift (deletion or insertion)

Biotechnology

Tools to study, copy, and move genes:

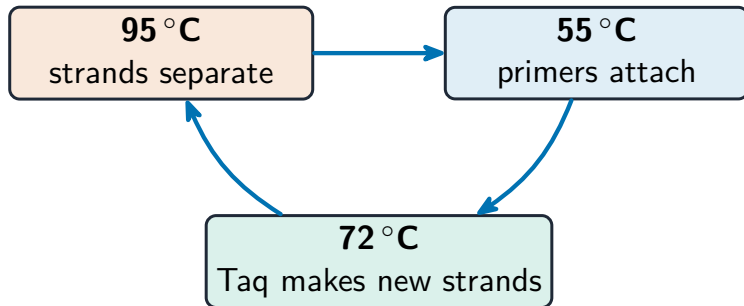
- **gel electrophoresis** 凝胶电泳 sorts DNA by size
- **PCR** 聚合酶链式反应 **amplifies** 扩增 a target
- **genetic engineering** 基因工程 makes a **GMO** 转基因生物

Insert the human insulin gene into bacteria $\Rightarrow$ real human insulin, grown in tanks.



*Gels sort DNA;
PCR amplifies a target*

Biotechnology



each cycle **doubles** the DNA → millions of copies

Unit 6 – key takeaways

1

Central dogma

DNA $\rightarrow$ RNA $\rightarrow$ protein; A–T,
C–G pairing

2

Copy & read

semiconservative replication;
codons on a ribosome

3

Regulation

transcription factors, operons,
epigenetic methylation

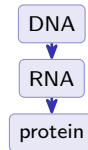
4

Change & tools

point/frameshift mutations; PCR,
gels, GMOs

Check yourself

- 1 What base pairs with adenine in DNA? in RNA?
- 2 Why is replication called semiconservative?
- 3 How many bases make one codon?
- 4 Which mutation shifts every later codon?



Answers 1. T (DNA), U (RNA) 2. each new molecule keeps one old strand 3. three
4. frameshift