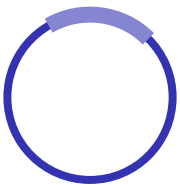
Genetic Technology

A-Level Biology ▪ Topic 19

A-Level Biology



What we will cover

1. The tools
2. Cut & paste DNA
3. The plasmid vector
4. PCR & electrophoresis
5. Recombinant proteins
6. GMOs & ethics

a PCR machine copies DNA

1 Tools

The tools

restriction enzyme 限制性内切酶 – cuts DNA, leaving sticky ends

ligase 连接酶 – joins DNA pieces

plasmid 质粒 – a **cloning vector** 载体 carrying the gene in

reverse transcriptase 逆转录酶 – DNA from mRNA

Recombinant DNA 重组 DNA joins DNA from two sources; the gene is cut out, made from mRNA, or built chemically.

Three ways to get the gene

cut it out

a **restriction enzyme** 限制性内切酶 cuts it from the donor's DNA

build it from mRNA

reverse transcriptase 逆转录酶 makes DNA from the donor's mRNA – no introns

synthesise it

make the DNA to order, base by base, from the known sequence

Microarrays 微阵列 then show which genes are switched *on*, by catching their mRNA, and **databases** 数据库 hold the nucleotide and **amino acid** 氨基酸 sequences so anyone can compare.

What the technology is used for

recombinant proteins	a human gene put into bacteria makes an exact copy of the human protein – insulin, factor VIII
genetic screening 基因筛查	tests DNA for disease alleles before symptoms appear – BRCA1 and BRCA2 raise breast-cancer risk
gene therapy 基因治疗	puts a working copy of a gene into a patient's cells; used for SCID

And in agriculture: **genetically modified organisms** 转基因生物 – crops and farmed animals altered to yield more, resist pests, or survive drought.

Gene editing

Gene editing 基因编辑 is a precise form of genetic engineering.

> It inserts, deletes or replaces DNA at an exact site in the **genome** 基因组.

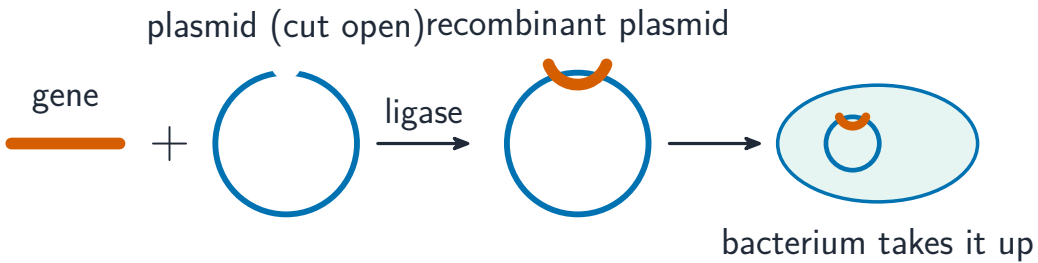
Cut and paste DNA

A **restriction enzyme** 限制酶 cuts DNA at a specific palindromic sequence, often leaving sticky ends. **DNA ligase** DNA 连接酶 joins matching sticky ends – that is how a gene is pasted into a plasmid.

The plasmid vector

The gene is joined into a **plasmid** 质粒, taken up by a bacterium.

- a **promoter** 启动子 switches the gene on
- a **marker gene** 标记基因 (e.g. glowing) shows it worked

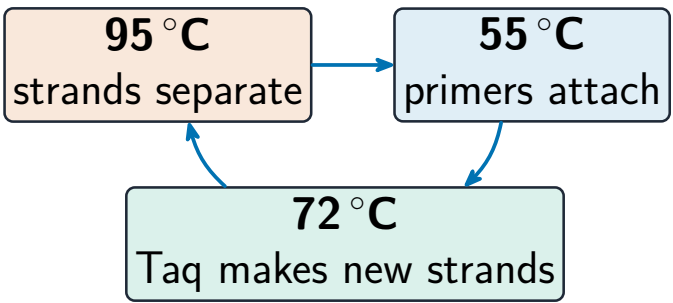


2 Copying and sorting

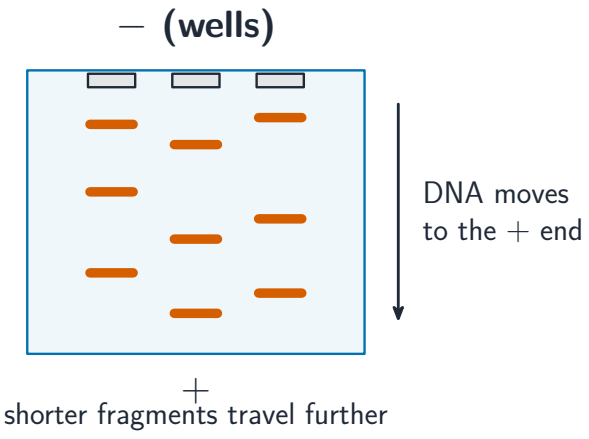
PCR

The **polymerase chain reaction** 聚合酶链式反应 (PCR) **amplifies** 扩增 DNA.

> It repeats heat-and-cool cycles with heat-stable **Taq polymerase** Taq 聚合酶; each cycle doubles the DNA – millions of copies.



Gel electrophoresis

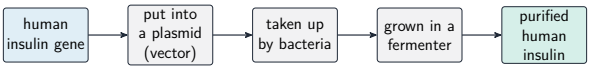


Gel electrophoresis 凝胶电泳 separates DNA **fragments** 片段 by length.

> Fragments move towards the + end; shorter ones travel further, sorting into bands.

3 Medicine and GMOs

Recombinant proteins in medicine



A human gene in bacteria makes a **recombinant** 重组 human protein – e.g. **insulin** 胰岛素 for **diabetes** 糖尿病. **Genetic screening** 基因筛查 tests for disease alleles; **gene therapy** 基因治疗 adds a working gene.

Social and ethical questions

Genetic screening and gene therapy raise concerns: who should see your genetic results, whether insurers or employers could misuse them, whether changes are safe and permanent.

> These **ethical** 伦理 and social questions must be weighed against the benefits.

GMOs and ethics

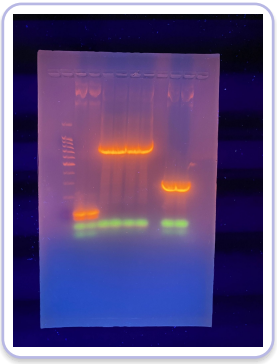
GM salmon
grow faster

GM soybean
herbicide 除草剂-resistant

GM cotton
pest 害虫-resistant

GMOs 转基因生物 raise **ethical** 伦理 questions: are they safe to eat, could the genes spread, and who controls the food supply?

Copying and sorting DNA



A real gel under

Copying and sorting DNA

Microarrays and genetic screening

a microarray 微阵列	thousands of DNA probes fixed in a grid on a slide
what it does	labelled sample DNA or cDNA binds where it matches, and the pattern of fluorescence is read
its two uses	studying whole **genomes** 基因组, and detecting which genes are switched on in a given tissue or condition
genetic screening 基因筛查	tests a person's DNA for disease alleles before symptoms appear
the examples	newborn screening, carrier testing before having children, and predictive testing for late-onset conditions
the ethical weight	a result may be actionable, or it may only tell someone what is coming

Screening produces information a person cannot un-know, and which insurers and employers may want. The consent question is part of the biology answer here.

What genetic screening looks for

BRCA1 and BRCA2	Alleles that raise the risk of **breast cancer** 乳腺癌 – a risk, not a certainty, which is exactly what makes the counselling hard.
Huntington's disease	**Huntington's disease** 亨廷顿病: dominant and late-onset, so a person may be tested long before any symptom.
Cystic fibrosis	**Cystic fibrosis** 囊性纤维化: recessive, so screening also identifies healthy carriers.
Why PCR first	**PCR** 聚合酶链反应 is used to **clone** 克隆 and **amplify** 扩增 the DNA – millions of copies – because a screen needs more than one sample's worth.

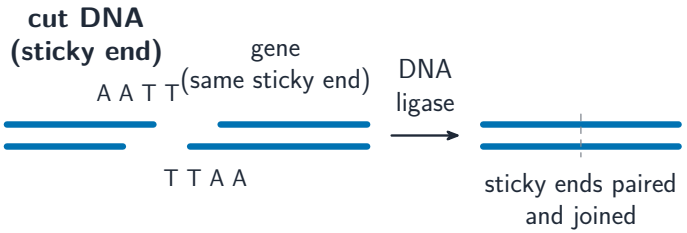
Each of these three raises a different ethical question: risk without certainty, knowledge without treatment, and information about relatives who did not consent.

Genetically modified organisms in agriculture

Both plants faced the same insects. The insect-resistant GM cotton on the left is barely touched; the ordinary cotton on the right has been stripped – because the GM plant makes a protein that kills the pests as they feed

Genetically modified organisms in agriculture

Sticky ends, cut and joined



A restriction endonuclease leaves matching sticky ends, and ligase joins the gene to the cut DNA. A **promoter** 启动子 must travel WITH the gene – it is the switch that lets the gene be transcribed in its new host, and without it nothing is made. A **marker gene** 标记基因 beside it, often for a **fluorescent** 荧光 protein, shows the transfer worked.

Exam tips

- Outline the toolkit: **restriction enzymes** (cut at specific sequences, sticky ends), **ligase** (join), **plasmid vectors**, and **PCR** (amplify).
- Explain **gel electrophoresis**: DNA separates by size, smaller fragments travel further – used in genetic fingerprinting.
- Give a balanced **benefit vs concern** for GMOs and gene therapy.

Principles of genetic technology

Recombinant 重组 DNA is DNA that has been made by joining together DNA from two different sources.

- cut out of the DNA of a **donor** 供体 organism,
- made from the donor's mRNA, using the enzyme **reverse transcriptase** 逆转录酶,
- built chemically from **nucleotides** 核苷酸.

4 Recap

Worked example – reading a gel

DNA is cut with a restriction enzyme and run on a gel. Explain how the bands separate.

- DNA is negatively charged (phosphate groups), so it moves towards the anode (+).
- The gel is a mesh: small fragments travel furthest, large ones are held back.
- So distance moved depends on fragment length.
- Compare with a ladder of known sizes to read each band ⇒ a DNA profile.

Load at the negative end – DNA runs towards +. Bands are made visible by a stain or a labelled probe, since DNA itself is colourless.

Topic 19 – key takeaways

1 Tools

restriction enzyme, ligase, plasmid vector

2 Insertion

sticky ends; promoter & marker gene

3 Copying

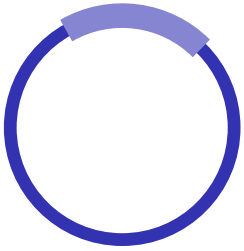
PCR amplifies; electrophoresis sorts by length

4 Uses

recombinant insulin; gene therapy; GMOs

Check yourself

1. Which enzyme leaves sticky ends?
2. What carries the gene into a bacterium?
3. What does each PCR cycle do to the DNA?
4. In a gel, which fragments travel furthest?



Answers **1.** a restriction endonuclease **2.** a plasmid (vector) **3.** doubles it **4.** the shortest