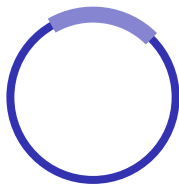


Genetic Technology

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



The tools

restriction enzyme – cuts DNA, leaving sticky ends

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

ligase – joins DNA pieces

reverse transcriptase – DNA from mRNA

Recombinant DNA 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** cuts it from the donor's DNA

build it from mRNA

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

synthesise it

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

Microarrays then show which genes are switched *on*, by catching their mRNA, and **databases** hold the nucleotide and **amino acid** 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

tests DNA for disease alleles **before** symptoms appear – BRCA1 and BRCA2 raise breast-cancer risk

gene therapy

puts a working copy of a gene into a patient's cells; used for SCID

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

Gene editing

Gene editing is a precise form of genetic engineering.

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

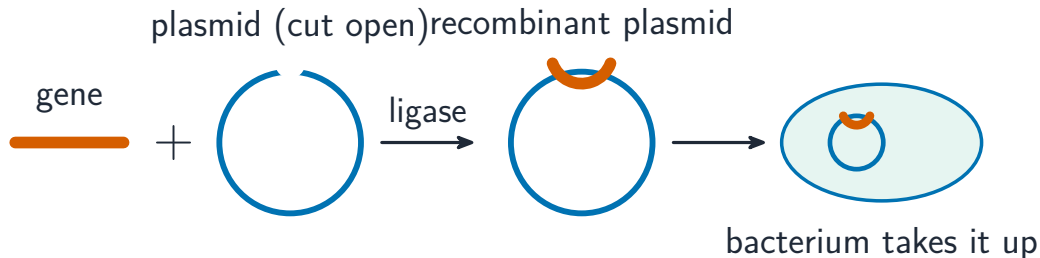
Cut and paste DNA

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

The plasmid vector

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

- a **promoter** switches the gene on
- a **marker gene** (e.g. glowing) shows it worked

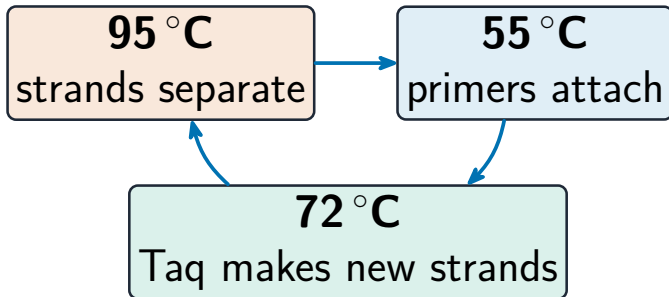




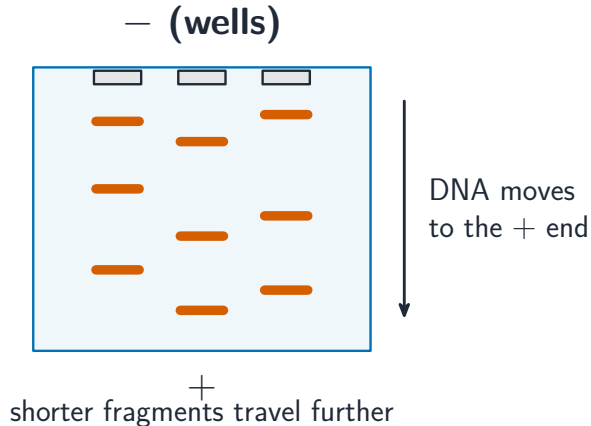
PCR

The **polymerase chain reaction** (PCR) **amplifies** DNA.

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



Gel electrophoresis

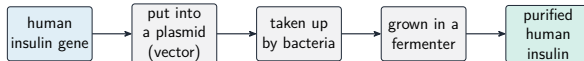


Gel electrophoresis separates DNA **fragments** by length.

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



Recombinant proteins in medicine



A human gene in bacteria makes a **recombinant** human protein – e.g. **insulin** for **diabetes** .

Genetic screening tests for disease alleles; **gene therapy** 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** and social questions must be weighed against the benefits.

GMOs and ethics

GM salmon

grow faster

GM soybean

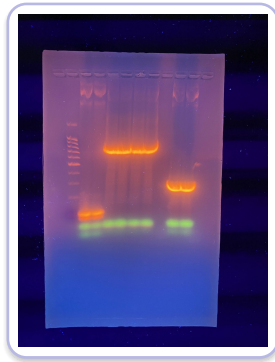
herbicide -resistant

GM cotton

pest -resistant

GMOs raise **ethical** 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	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 , and detecting which genes are switched on in a given tissue or condition
genetic screening	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** – a risk, not a certainty, which is exactly what makes the counselling hard.

Huntington's disease

Huntington's disease : dominant and late-onset, so a person may be tested long before any symptom.

Cystic fibrosis

Cystic fibrosis : recessive, so screening also identifies healthy carriers.

Why PCR first

PCR is used to **clone** and **amplify** 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.

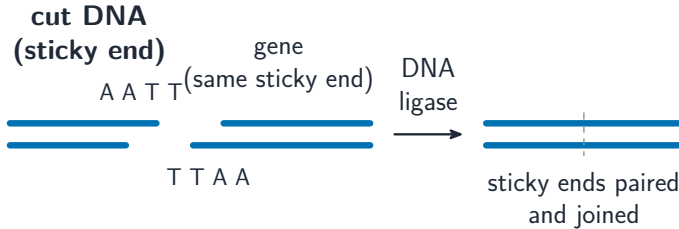
Genetically modified organisms in agriculture



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** 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** beside it, often for a **fluorescent** 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 DNA is DNA that has been made by joining together DNA from two different sources.

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



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 $\Rightarrow$ **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

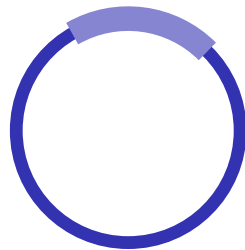
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Uses

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