

Exercise walk-through

19.1

Principles of genetic technology

A-Level Biology

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

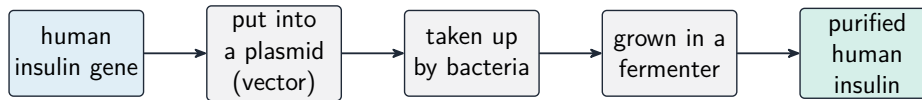
gene therapy

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

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

– crops and farmed

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.

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.

Exercises 2.1-2.2

2.1 Name the enzyme that (a) cuts DNA at a specific sequence and (b) joins DNA fragments. [2]

2.2 State why a marker gene is transferred along with the desired gene. [1]

Exercises 2.1-2.2

2.1 Name the enzyme that (a) cuts DNA at a specific sequence and (b) joins DNA fragments. [2]

2.1

(a)

- restriction endonuclease

(b)

- DNA ligase

2.2 State why a marker gene is transferred along with the desired gene. [1]

2.2

- to check (confirm) that the gene has been taken up and is expressed

Exercises 2.3-2.4

2.3 Name the enzyme that cuts DNA at a specific sequence, and the enzyme that joins two fragments. [2]

2.4 Explain why the gene and the plasmid must be cut with the same restriction enzyme. [2]

Exercises 2.3-2.4

2.3 Name the enzyme that cuts DNA at a specific sequence, and the enzyme that joins two fragments. [2]

2.3

- Restriction endonuclease; DNA ligase

2.4 Explain why the gene and the plasmid must be cut with the same restriction enzyme. [2]

2.4

- Each restriction enzyme cuts at one specific sequence and leaves a particular sticky end; using the same enzyme on both means their overhangs are complementary, so the gene and the plasmid pair together specifically

Exercises 2.5-3.1

2.5 State the purpose of a marker gene.

[2]

3.1 What is the role of a plasmid in genetic engineering?

[1]

☐

A to cut the DNA

B to act as a vector that carries the gene into a cell

C to copy the DNA millions of times

D to separate DNA fragments by length

Exercises 2.5-3.1

2.5 State the purpose of a marker gene.

[2]

2.5

- It allows the cells that have taken up the plasmid to be identified; for example an antibiotic-resistance gene lets only transformed cells grow on a medium containing that antibiotic

3.1 What is the role of a plasmid in genetic engineering?

[1]

☐

A to cut the DNA

B to act as a vector that carries the gene into a cell

C to copy the DNA millions of times

D to separate DNA fragments by length

3.1 B

- A plasmid is a vector carrying the gene into the cell

Exercise 3.2

3.2 In gel electrophoresis, the DNA fragments that travel **furthest** are the: [1]

☐

A longest

B shortest

C most positively charged

D circular ones

Exercise 3.2

3.2 In gel electrophoresis, the DNA fragments that travel **furthest** are the: [1]

☐

A longest

B shortest

C most positively charged

D circular ones

3.2 B

- Shorter fragments move further through the gel

Exercise 3.3

3.3 (a) Explain why a promoter must often be transferred along with a gene. [2]

(b) Describe how the polymerase chain reaction (PCR) makes many copies of a DNA sample. [3]

Exercise 3.3

3.3 (a) Explain why a promoter must often be transferred along with a gene. [2]

(b) Describe how the polymerase chain reaction (PCR) makes many copies of a DNA sample. [3]

3.3

(a)

- the promoter is the switch that starts transcription; without it the transferred gene would not be transcribed / stay silent

(b)

- heat to ~95 °C to separate the strands; cool to ~55 °C so primers attach; 72 °C lets Taq polymerase build new strands – repeating the cycle doubles the DNA each time

Exercise 3.4

3.4 Explain why restriction enzymes and DNA ligase are both needed to make recombinant DNA. [2]

Exercise 3.4

3.4 Explain why restriction enzymes and DNA ligase are both needed to make recombinant DNA. [2]

3.4

- the restriction enzyme cuts the gene and the plasmid, leaving matching sticky ends; DNA ligase joins the gene into the plasmid to make recombinant DNA

Exercise 3.5 (a)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(a) Describe how the gene can be obtained from a human cell that expresses it, naming the enzyme used. [3]

Exercise 3.5 (a)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(a) Describe how the gene can be obtained from a human cell that expresses it, naming the enzyme used. [3]

(a)

- Extract the mRNA for the protein from a cell that expresses it; use reverse transcriptase to make complementary DNA from that mRNA template; this cDNA is the gene, and it has no introns. (Cutting the gene from the genome with a restriction endonuclease is also accepted.)

Exercise 3.5 (b)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(b) Explain the role of sticky ends in inserting the gene into a plasmid. [3]

Exercise 3.5 (b)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(b) Explain the role of sticky ends in inserting the gene into a plasmid. [3]

(b)

- Sticky ends are short single-stranded overhangs left when the restriction enzyme cuts; the gene and the plasmid are cut with the same enzyme, so their overhangs are complementary; the bases pair by hydrogen bonding, holding the gene in place in the plasmid

Exercise 3.5 (c)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(c) Name the enzyme that seals the gene into the plasmid, and state what the product is called.

[2]

Exercise 3.5 (c)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(c) Name the enzyme that seals the gene into the plasmid, and state what the product is called. [2]

(c)

- DNA ligase; the product is recombinant DNA

Exercise 3.5 (d)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(d) Describe how the bacteria that have taken up the plasmid can be identified. [3]

Exercise 3.5 (d)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(d) Describe how the bacteria that have taken up the plasmid can be identified. [3]

(d)

- The plasmid also carries a marker gene, for example antibiotic resistance; the bacteria are grown on a medium containing that antibiotic; only the cells that took up the plasmid survive and form colonies, so those are the transformed cells. (A fluorescent marker viewed under UV is equally acceptable.)

Exercise 3.5 (e)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(e) Suggest two advantages of producing this protein in bacteria rather than extracting it from animals. [2]

Exercise 3.5 (e)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(e) Suggest two advantages of producing this protein in bacteria rather than extracting it from animals. [2]

(e)

- Any two of: the protein is identical to the human one, so it is less likely to cause an immune response; it can be produced in unlimited quantity by culturing bacteria; production does not depend on a supply of animal tissue; it avoids religious or ethical objections to an animal product

Exercise 3.5 (f)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(f) Explain how gel electrophoresis could be used to check that a fragment of the expected length has been inserted. [3]

Exercise 3.5 (f)

3.5 A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(f) Explain how gel electrophoresis could be used to check that a fragment of the expected length has been inserted. [3]

(f)

- Cut the plasmid with the same restriction enzyme to release the insert; run the fragments through a gel under an electric field, where smaller fragments travel further; compare the distance travelled with a set of fragments of known length, and a band at the expected position shows the insert is the right size