

Gel Electrophoresis & Biotechnology

Key ideas

Restriction enzymes cut DNA at specific sequences; EcoRI cuts between G and A in G^AAATTC. **PCR** copies a DNA segment, doubling it every cycle.

Gel electrophoresis separates DNA fragments by size. DNA is negative, so it moves from the wells (–) toward the positive end (+). **Small fragments travel farthest.** A DNA ladder of known sizes is run beside the samples.

DNA fingerprinting compares band patterns. **Recombinant DNA** joins a gene into a plasmid so bacteria can make a product such as human insulin.

A Biotechnology vocabulary

3 marks

Write the letter of the matching definition (½ mark each).

- | | |
|-----------------------------|--|
| 1. _____ Restriction enzyme | a. DNA fragments of known sizes run beside samples to measure them |
| 2. _____ DNA ligase | b. Cuts DNA at a specific base sequence |
| 3. _____ Plasmid | c. A small circle of DNA found in bacteria |
| 4. _____ PCR | d. DNA made by joining pieces from two different sources |
| 5. _____ DNA ladder | e. Joins pieces of DNA together |
| 6. _____ Recombinant DNA | f. A method that makes millions of copies of a DNA segment |

B How gel electrophoresis works

4 marks

- | | |
|--|--|
| 7. Why does DNA move toward the positive (+) end of the gel?

_____ | 8. Which DNA fragments travel farthest through the gel, and why?

_____ |
| 9. What is the purpose of the DNA ladder?

_____ | 10. Why must the DNA be stained before it can be seen?

_____ |

C Cutting DNA with EcoRI

4 marks

EcoRI cuts between G and A in the sequence G^AAATTC. One strand of a piece of DNA is shown (5' → 3').

5' CCTAGAATTCGGATCCATTGCAGAATTCTAGTC 3'

- | | |
|--|--|
| 11. How many EcoRI recognition sites are in the sequence?
_____ | 12. How many fragments will EcoRI produce from this piece of DNA?
_____ |
| 13. Give the length of each fragment in base pairs (bp).

_____ | 14. EcoRI leaves "sticky ends." Why are sticky ends useful in genetic engineering?

_____ |

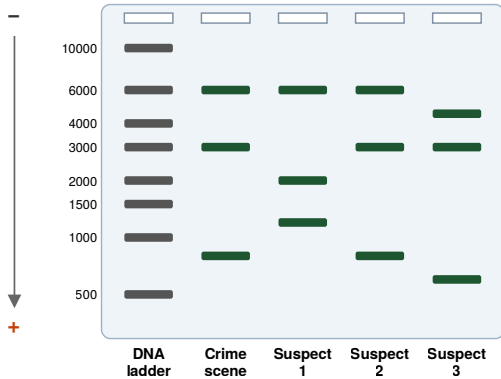
D Biotechnology and society

2 marks

15. Genetically modified (GM) crops can be engineered to resist insects. Give one benefit and one concern about growing GM crops. (2 marks)

E DNA fingerprinting

3 marks



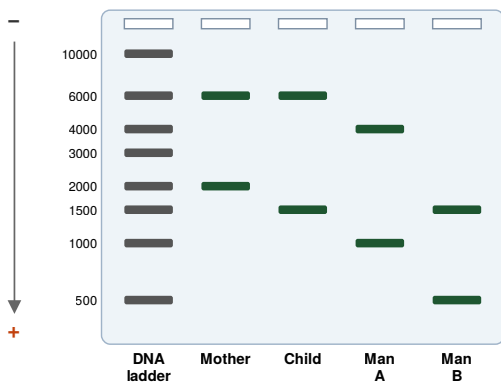
16. Which suspect's DNA matches the crime scene sample?

17. Explain how you know.

18. Use the ladder to estimate the size of the middle crime scene band.

F Paternity testing

2 marks



19. Which man could be the child's biological father?

20. Explain your answer, including why the other man is excluded.

G PCR and recombinant DNA

4 marks

21. PCR doubles the amount of DNA in every cycle. Starting with 10 DNA molecules, how many are there after 5 cycles?

22. Starting with a single DNA molecule, how many copies are there after 30 cycles? Give your answer in scientific notation.

23. Put the steps for making human insulin in bacteria in order. (2 marks)

- P Insert the recombinant plasmid into bacteria
- Q Cut the human insulin gene out with a restriction enzyme
- R Bacteria multiply and produce human insulin
- S Cut a plasmid open with the same restriction enzyme
- T Join the insulin gene into the plasmid with DNA ligase

 →

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H Spot the mistake

2 marks

24. A student writes: "The largest DNA fragments travel the farthest through the gel." Explain the error and correct it.

25. A student writes: "Restriction enzymes cut DNA at random places." Explain the error and correct it.

Gel Electrophoresis & Biotechnology

Name: _____

Date: _____ Score: ____ / 24

ANSWER KEY

Key ideas

Restriction enzymes cut DNA at specific sequences; EcoRI cuts between G and A in G^AAATTC. **PCR** copies a DNA segment, doubling it every cycle.

Gel electrophoresis separates DNA fragments by size. DNA is negative, so it moves from the wells (–) toward the positive end (+). **Small fragments travel farthest.** A DNA ladder of known sizes is run beside the samples.

DNA fingerprinting compares band patterns. **Recombinant DNA** joins a gene into a plasmid so bacteria can make a product such as human insulin.

A Biotechnology vocabulary

3 marks

Write the letter of the matching definition (½ mark each).

- | | |
|------------------------------------|--|
| 1. <u> b </u> Restriction enzyme | a. DNA fragments of known sizes run beside samples to measure them |
| 2. <u> e </u> DNA ligase | b. Cuts DNA at a specific base sequence |
| 3. <u> c </u> Plasmid | c. A small circle of DNA found in bacteria |
| 4. <u> f </u> PCR | d. DNA made by joining pieces from two different sources |
| 5. <u> a </u> DNA ladder | e. Joins pieces of DNA together |
| 6. <u> d </u> Recombinant DNA | f. A method that makes millions of copies of a DNA segment |

B How gel electrophoresis works

4 marks

- | | |
|--|--|
| 7. Why does DNA move toward the positive (+) end of the gel?
DNA is negatively charged (phosphate groups), so it is attracted to the positive electrode. | 8. Which DNA fragments travel farthest through the gel, and why?
The smallest fragments; they slip through the pores of the gel more easily. |
| 9. What is the purpose of the DNA ladder?
It contains fragments of known size, so the sizes of sample bands can be estimated. | 10. Why must the DNA be stained before it can be seen?
DNA is colourless; the stain binds to it so the bands show up. |

C Cutting DNA with EcoRI

4 marks

EcoRI cuts between G and A in the sequence G^AAATTC. One strand of a piece of DNA is shown (5' → 3').

5' CCTAGAATTTCGGATCCATTGCAGAATTCTAGTC 3'

- | | |
|---|---|
| 11. How many EcoRI recognition sites are in the sequence?
2 | 12. How many fragments will EcoRI produce from this piece of DNA?
3 fragments |
| 13. Give the length of each fragment in base pairs (bp).
5, 18, 10 bp (total 33 bp) | 14. EcoRI leaves "sticky ends." Why are sticky ends useful in genetic engineering?
The short single-stranded overhangs can pair with matching ends cut by the same enzyme, so DNA from two sources can be joined. |

D Biotechnology and society

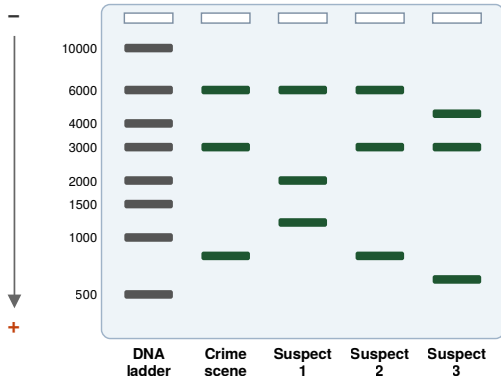
2 marks

15. Genetically modified (GM) crops can be engineered to resist insects. Give one benefit and one concern about growing GM crops. (2 marks)

Benefit: e.g. higher yields, less pesticide spraying, better nutrition. Concern: e.g. genes spreading to wild plants, pests evolving resistance, effects on non-target insects, corporate control of seeds.

E DNA fingerprinting

3 marks



16. Which suspect's DNA matches the crime scene sample?

Suspect 2

17. Explain how you know.

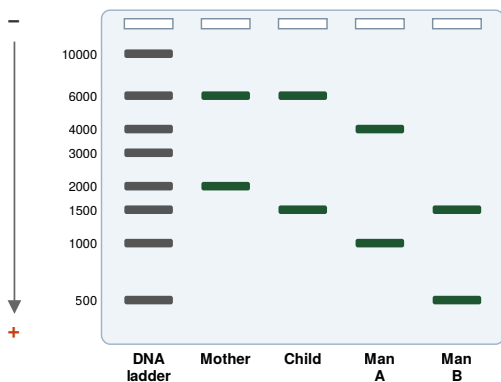
Every band lines up with the crime scene bands: same number and same positions.

18. Use the ladder to estimate the size of the middle crime scene band.

About 3000 bp

F Paternity testing

2 marks



19. Which man could be the child's biological father?

Man B

20. Explain your answer, including why the other man is excluded.

The child's 6000 bp band matches the mother, so the 1500 bp band must come from the father. Man B has it; Man A does not, so he is excluded.

G PCR and recombinant DNA

4 marks

21. PCR doubles the amount of DNA in every cycle. Starting with 10 DNA molecules, how many are there after 5 cycles?

$$10 \times 2^5 = 320 \text{ molecules}$$

22. Starting with a single DNA molecule, how many copies are there after 30 cycles? Give your answer in scientific notation.

$$2^{30} = 1\,073\,741\,824 \approx 1.07 \times 10^9 \text{ copies}$$

23. Put the steps for making human insulin in bacteria in order. (2 marks)

- P Insert the recombinant plasmid into bacteria
- Q Cut the human insulin gene out with a restriction enzyme
- R Bacteria multiply and produce human insulin
- S Cut a plasmid open with the same restriction enzyme
- T Join the insulin gene into the plasmid with DNA ligase

Q → S → T → P → R

H Spot the mistake

2 marks

24. A student writes: "The largest DNA fragments travel the farthest through the gel." Explain the error and correct it.

The smallest fragments travel farthest; large fragments are slowed down by the gel and stay near the wells.

25. A student writes: "Restriction enzymes cut DNA at random places." Explain the error and correct it.

Each restriction enzyme cuts only at its own specific recognition sequence (EcoRI cuts G^AAATTC).