DNA fingerprinting and PCR

Biology · Class 12 Biology: Biotechnology (PCR, gel electrophoresis), Molecular Basis of Inheritance

The trap

✗ Most students think

~~A DNA fragment's charge depends on its size, and the big pieces run farthest in the gel.~~

✓ Actually

Every DNA fragment is **negative** (phosphate backbone), so all of them move to the **anode**. The gel is a sieve: **small pieces travel farther**.

The concept in 5 lines

1. About **99.9%** of any two people's DNA is identical; DNA fingerprinting reads the **0.1%** that differs.
2. The differences used are **repeat counts** in repetitive DNA: **VNTRs** (shorter **STRs** in modern forensics).
3. **PCR** copies one chosen region: denature (≈ 95 °C) → anneal primers (≈ 55 °C) → extend (72 °C) with **Taq polymerase**, which survives 95 °C.
4. Each cycle doubles the DNA, so **30 cycles** from one copy give about **10^9** copies.
5. In **gel electrophoresis** the negative DNA moves to the anode; smaller fragments go farther, giving a barcode of bands.

Remember

$$copies = N_0 \times 2^n$$

Why it matters

Molecular Basis of Inheritance averages about **7 NEET questions a year**, and Biotechnology: Principles and Processes (PCR, gels) **4 to 6**.

Previous-year question, solved

NEET 2017

DNA fragments are

(A) Positively charged
(B) Either positively or negatively charged depending on their size
(C) Neutral
(D) Negatively charged

Answer: (D) Negatively charged

1. Every nucleotide carries a **phosphate group**; in the DNA backbone these phosphates are ionised (PO_4^-).
2. So every fragment is negative **whatever its length**. Size decides only how far it moves in the gel, not the sign of its charge.
3. That is why DNA is loaded at the cathode end and runs towards the **anode**.

Option letters differ between paper versions; match the answer by its wording.

Practice: try each one before you check the answers

Q1 Class 12 Why can't a sample of only mature red blood cells be used for DNA fingerprinting?

Q2 NEET Why is Taq polymerase used in PCR instead of an ordinary DNA polymerase?

Q3 NEET / JEE A sample starts with 5 copies of a DNA region. Assuming perfect doubling, how many copies are there after 10 PCR cycles?

Q4 NEET / JEE What is the minimum number of cycles needed to get at least one million copies from a single DNA molecule?

Q5 NEET DNA fingerprinting is based on differences in: (a) genes for enzymes (b) repetitive DNA such as VNTRs (c) ribosomal RNA (d) the number of chromosomes

Answers

1. Mature human RBCs have **no nucleus**, so they carry no nuclear DNA. White blood cells are used instead.
2. It comes from the heat-loving bacterium *Thermus aquaticus* and is **thermostable**: it survives the 95 °C denaturation step in every cycle, so it doesn't need to be added again.
3. $5 \times 2^{10} = 5 \times 1{,}024 =$ **5,120 copies**.
4. $2^{19} = 524{,}288$ (not enough) and $2^{20} = 1{,}048{,}576$. So **20 cycles**.
5. **(b)** The number of repeats in repetitive DNA (VNTRs/STRs) differs between individuals.

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