PEARSON EDEXCEL · INTERNATIONAL A-LEVEL · BIOLOGY • EXERCISE SHEET

4.10 Decomposition, PCR, profiling and time of death

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS decomposition • polymerase chain reaction • gel electrophoresis • DNA profile DNA • rigor mortis

Objective

Practise statements 6.16-6.20: decomposition and nutrient recycling, the polymerase chain reaction, gel electrophoresis and DNA profiling, and the four clocks of time of death.

1 Key knowledge and worked examples

Decomposition

Saprobiont bacteria and fungi secrete enzymes onto dead material, absorbing the products – carbon dioxide returns to the air, nitrogen compounds return to the soil. The rate of decomposition is a function of temperature, oxygen and moisture, which is why waterlogged peat preserves bodies.

PCR

Cycle: denaturation 95 °C (strands separate) → primer annealing 50-60 °C → extension 72 °C (Taq polymerase). In the ideal doubling model, one starting target copy gives 2^n copies after n cycles. Thirty cycles would give about a billion copies; actual amplification efficiency can be lower.

Electrophoresis and profiling

Negatively charged DNA fragments move toward the anode; short fragments move furthest. A profile of band positions at several loci supports sample comparisons and tests of relatedness. Each child inherits one allele at a locus from each parent; shared allele sizes and overlapping bands mean that exactly half of the visible bands need not come from each parent.

Four clocks of time of death

Body temperature falls about 1 °C per hour (modified by build, clothing, air); **rigor mortis** sets then passes; decomposition stage; insect succession – each coloniser arrives at its own interval.

Worked example: a forensic calculation

A profile needs 13 loci; a suspect matches at all 13 while unrelated people match, on average, at none. In PCR from a 0.5 ng sample of about 1500 genome copies, 10 cycles yield $1500 \times 2^{10} \approx 1.5 \times 10^6$ copies – enough to run.

2 Practice

2.1 Name the enzyme used in PCR and the temperature of the extension step. [2]

2.2 Explain why short DNA fragments travel further than long ones in gel electrophoresis. [2]

2.3 State two factors that affect the rate of decomposition. [2]

3 Exam-style questions

3.1 Describe the three steps of one PCR cycle with their temperatures, explain why the polymerase must survive 95 °C, and calculate the copies produced from one double-stranded template after 12 cycles. [5]

3.2 A DNA profile shows a child sharing 11 of 16 bands with the mother. Explain how the remaining bands identify the father, and why a single shared band alone cannot prove parentage. [4]

3.3 A body found at noon has a core temperature of 31 °C in still air of 12 °C, mild rigor in the jaw only, and blowfly eggs at the eyes and nostrils. Estimate the time of death with reasons, and state one factor that would make the temperature estimate too short. [6]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Taq DNA polymerase; 72 °C.

2.2 The gel's mesh resists movement; shorter fragments thread through the pores more easily, so at the same charge they migrate faster and further in a given time.

2.3 Any two: temperature, oxygen, moisture, presence of scavengers or insects.

3.1 Denaturation at about 95 °C separates the strands; primer annealing at 50-60 °C lets primers bind the template ends; extension at 72 °C, Taq polymerase adding nucleotides 5'→3'. The enzyme must withstand 95 °C each cycle – a mesophilic polymerase would denature itself. $2^{12} = 4096$ copies.

3.2 The child's other bands must have come from the father – every band absent from the mother should be present in him. One shared band could occur by chance in the population; probability falls only as more unmatched bands are excluded, so single-band matches prove nothing.

3.3 Temperature: $(37 - 31) \approx 6$ °C fall at about 1 °C per hour suggests ~6 hours before noon – death near 06:00. Rigor beginning in the jaw (small muscles first) is consistent with 6-12 hours. Blowfly eggs laid within hours of death, not yet hatched to maggots, fit the same window. Heavy clothing or a warm environment slows cooling, which would make 6 hours an underestimate – true interval longer.