5.12 GMOs, microarrays and bioinformatics

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS microarray • hybridisation • bioinformatics • gene flow

Objective

Practise statements 8.20-8.21: microarrays to identify active genes, bioinformatics for comparing sequences, and evaluating the risks and benefits of genetically modified organisms.

1 Key knowledge and worked examples

■ Microarrays - a snapshot of transcription

A chip carries thousands of single-stranded DNA probes, one per gene, fixed in a grid. Sample mRNA is copied into fluorescent cDNA and washed over the chip; cDNA hybridises only to the probe of the gene it came from; a fluorescent spot marks a gene that was being transcribed - active - in the sample. Two samples in two colours (red/green) on one chip compare cancerous with healthy tissue gene by gene.

■ Bioinformatics

Computing meets biology: storing, searching and comparing DNA and protein sequences. Applications: measuring how closely species are related (sequence similarity), tracing lineages, identifying disease alleles, designing primers, discovering drug targets.

■ GM: the balance sheet

Benefits: pest-resistant and herbicide-tolerant crops raise yields and cut spraying; Golden Rice addresses vitamin A deficiency; human proteins made cheaply. Risks: gene flow to wild relatives and weeds, effects on non-target organisms (e.g. monarch butterflies and Bt maize debate), farmer dependence on seed companies, and - for animals - welfare and ethical questions. Credit answers that weigh a NAMED benefit against a NAMED risk with evidence.

■ Worked example: reading a microarray

A spot glows red only: gene active in sample A, silent in B. Green only: the reverse. Yellow (both dyes): active in both. Dark: active in neither. "Which gene is a possible drug target?" - the one strongly active in the cancer sample and dark in healthy tissue.

2 Practice

2.1 State what a fluorescent spot on a microarray shows about a gene. [1]

2.2 Name the process by which cDNA binds to its probe on the chip. [1]

2.3 Give one use of bioinformatics other than gene activation. [1]

3 Exam-style questions

3.1 Describe how a microarray identifies which genes are active in a tissue sample, including how the mRNA is prepared and how the result is read. [5]

3.2 Scientists compare the DNA sequences of a gene in three species: A and B differ in 2 bases per thousand, A and C in 14, B and C in 15. Deduce the relationships between the species and explain the reasoning. [4]

3.3 Bt maize carries a bacterial gene for an insect toxin. Discuss the benefits and risks of growing Bt maize, giving one piece of evidence for each side. [6]

Solutions

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

2.1 The gene was being transcribed (active) in the sample - its mRNA hybridised to the probe.

2.2 Hybridisation (complementary base pairing).

2.3 Any one: comparing species relatedness; identifying disease alleles; primer design; drug-target discovery.

3.1 Extract mRNA from the tissue; reverse-transcribe to cDNA with fluorescent nucleotides; wash the chip so cDNA hybridises to complementary probes; scan for fluorescence - a glowing spot marks a gene whose mRNA was present, i.e. active; with two colour dyes, red/green/yellow compares two samples.

3.2 A and B are the closest relatives - fewest base differences (2/1000), so they diverged most recently; C diverged from the common ancestor of A and B earlier, accumulating differences with both.

3.3 Benefits: the toxin kills the European corn borer without spraying, raising yield and reducing insecticide use and its costs. Risks: pollen bearing the toxin can affect non-target insects - the monarch butterfly study - and pest resistance can select toxin-resistant borers; gene flow to wild relatives or contamination of non-GM crops. Judgement: benefits are largest where borer damage is severe and refuges are planted to slow resistance.