Unit 5 · Applied Biology

HARDER PRACTICE QUESTIONS

Full marks 55

Write your answers on separate paper. Show your working.

1 Spot the error [4]

Find the mistake in the working and correct it.

A crime-scene profile is read at 5 places on different chromosomes, and the repeat number at each place is shared by 1 person in 10. Amisha works out the chance that a person picked at random matches at all 5 places: "1/10 + 1/10 + 1/10 + 1/10 + 1/10 = 1/2, so about half of all people would match."

i. What is her mistake? Give the correct chance.

ii. How many people in a town of 300,000 would be expected to match by chance?

iii. Each place added is again shared by 1 person in 10. How many places in all are needed before fewer than 1 person is expected to match by chance in a country of 30 million?

iv. Why must the places be on different chromosomes for this working to hold?

2 An inheritance puzzle [4]

At one place on a chromosome, the short piece GATA is repeated. A mother has 8 repeats on one chromosome of the pair and 11 on its partner. A father has 9 and 14.

i. List every pair of repeat numbers their child could have.

ii. A child of theirs is said to have 8 and 11. Is this possible? Explain.

iii. Another child has 10 and 14. Give what this suggests, and why a laboratory would not decide from this one place alone.

iv. By how many bases do the mother's piece with 8 repeats and the father's with 14 repeats differ in length? Which goes farther in a gel?

3 Check the claim [4]

A clean, fresh crime-scene sample and three suspects' samples are run on one gel. The bands are measured in cm from the wells.

Lane	Bands (cm from the wells)
Crime scene	1.5, 3.0, 4.5, 6.0
Suspect P	1.5, 3.0, 4.5, 6.0
Suspect Q	1.5, 3.0, 4.5, 5.0, 6.0
Suspect R	1.5, 3.0, 6.0

i. Which band holds the longest pieces of DNA? Give a reason.

ii. Which suspects does this gel clear? Explain, for each.

iii. A police officer says: "P's lane matches, so P committed the crime." Give two reasons why the gel does not show this.

4 What if? [3]

Suppose the Dolly experiment is repeated the other way round, with the nucleus from an udder cell of a **Scottish Blackface** ewe, the empty egg from a **Finn Dorset** ewe, and a Finn Dorset as the surrogate mother.

i. What color will the lamb's face be?
ii. Which sheep's mitochondria will it have?
iii. If the nucleus had instead come from a body cell of a Scottish Blackface **ram**, what would be the lamb's sex? Why?

5 Find the fault [3]

Each trial failed for one reason.

Zeenat's class reads a laboratory's notes on making a bacterium carry a human gene.
Trial 1: the gene was cut with one restriction enzyme and the plasmid with a different one. Gene and plasmid were then mixed with DNA ligase. They did not join.
Trial 2: gene and plasmid were cut with the same enzyme and mixed, without ligase. The ends paired, but the plasmids did not stay in one piece.

i. Explain what went wrong in Trial 1.
ii. Explain what went wrong in Trial 2.
iii. A visitor asks how a bacterium could possibly read a human gene at all. Answer in one sentence.

6 A two-step calculation [3]

A fermenter is started with 1,000 bacteria carrying the insulin gene, and they double every 20 minutes. Take $2^{10} = 1{,}024$.

i. About how long does it take to pass one billion bacteria?
ii. About how long before that moment were there half as many?
iii. If the bacteria doubled every 30 minutes instead, how much longer would it take to pass one billion?

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each one and correct it.

Lochan wrote: "A clone is a perfect copy of its parent. Every piece of its DNA, even in its mitochondria, comes from the animal that gave the nucleus. It starts life at the same age as the parent, with the parent's memories. And because the genes are the same, a cloned cat must have exactly the coat pattern of the cat it was cloned from."

8 Design a fair test [4]

Sagar has a mango tree with sweet, large fruit. He wants to find out which keeps those qualities better: growing new trees from its seeds, or from twigs of it grafted onto sturdy roots. Plan a fair test.

i. What will he compare, and what will he measure?
ii. Name three things he must keep the same.
iii. Why should he use many trees of each kind, not one?
iv. What result do you predict, and why?

9 Read the table, judge the claim [4]

Two banana growers' harvests are shown in tonnes. A new soil fungus reached both farms in Year 3. Farm A grows one variety, all suckers of one plant. Farm B has the same area under five local varieties.

Year	1	2	3	4
Farm A (t)	40	42	6	0
Farm B (t)	30	31	22	25

i. Find each farm's total over the four years, and the percentage by which its harvest fell from Year 2 to Year 3.

ii. Prarthana says: "This proves clones are poor crops." Use Years 1 and 2 to show why that is too simple.

iii. Explain why Farm A's harvest fell so far, and why Farm B's did not.

iv. Advise the owner of Farm A what to do next.

10 Judge each case by the treaties [4]

Say whether each act breaks the treaty named, and why.

i. In 1950, a country party to the Geneva Protocol secretly keeps biological weapons but never uses them.

ii. In 1990, a country party to the Biological Weapons Convention still keeps the same stock.

iii. In 2020, a university in a country party to the Convention studies a germ to make a vaccine.

iv. What does the Sverdlovsk event of 1979 show about keeping such weapons, even unused?

11 A case from a clinic [4]

Nirajan, aged 40, blood group B, has kidney failure and needs a transplant in Nepal. Four people offer a kidney.

Person	Blood group	Crossmatch	Health
His sister	B	positive	healthy
His father	B	negative	diabetes; kidneys damaged
His neighbor	B	negative	healthy
His brother	B	negative	healthy

i. Which person should be chosen? Give the reason for rejecting each of the other three.

ii. Name this kind of graft. Could he stop his medicines once the kidney is working?

iii. If he had an identical twin who could give, how would the graft's name and the need for medicines change? Why?

12 Estimate it [3]

The national transplant center in Bhaktapur opened in 2012 and had done more than 1,500 kidney transplants by 2025. Suppose each patient would otherwise have had hemodialysis three times a week, and that a machine runs three sessions a day, six days a week.

i. Estimate how many transplants the center does in an average year.

ii. How many patients can one machine serve?

iii. Estimate how many machines are freed by one average year's transplants.

13 Which explanation fits the evidence? [3]

The 1954 kidney transplant between the Herrick twins worked, though earlier attempts between unrelated people had all failed within weeks. Two students explain it.

Salim: "Joseph Murray was simply a better surgeon, so his operation succeeded."

Richa: “Identical twins have the same genes and tissue type, so Richard’s body did not reject the kidney.”
Which explanation does the evidence support? Use what allowed later transplants between people who were not twins.

14 Two treatments, one judgment [3]

A disease runs in a family. Doctor 1 proposes to edit the gene in the body cells of a sick adult, Shruti. Doctor 2 proposes to edit the gene in an embryo. Compare the two: who is affected in each case, and who has agreed? Which would you be more cautious about, and why?

15 Think [3]

Therapeutic cloning would make a cloned embryo from a patient’s own body-cell nucleus, only to take stem cells and grow tissue for that patient. Why would this tissue not be rejected? Which of the four kinds of graft does this most resemble, and in what small way would the tissue’s DNA still not be entirely the patient’s?

16 Make your own [3]

On plain paper, draw a gel of your own with four lanes: a mother, a father, their child, and a man who shares some of the child’s bands but can’t be the father. Give the child six bands. Mark the wells, the positive electrode and the smallest piece. Explain how your lanes show that the fourth lane can’t be the father.