Unit 3 · Genetics

HARDER PRACTICE QUESTIONS

Full marks 47

Write your answers on separate paper. Show your working. Arm ratio = long arm (q) ÷ short arm (p).

1 Where are the boundaries? [4]

A chromosome is 15 μm long. By the school's four types, how far from the nearer end must its centromere be for the chromosome to be

i. exactly on the boundary between submetacentric and acrocentric (arm ratio 3)?
ii. exactly on the boundary between metacentric and submetacentric (arm ratio 1.7)?
iii. Write the range of centromere positions, in μm from the nearer end, for each of the four types.

2 Check the claim [5]

Tashi measures five chromosomes of a plant.

Chromosome	A	B	C	D	E
Short arm p (μm)	3.2	2.0	1.0	none	1.5
Long arm q (μm)	3.6	4.6	4.0	3.5	3.0

He writes: "The shorter a chromosome is, the nearer its centromere is to the end. So length decides the type."

i. Copy the table and add rows for the whole length, the arm ratio and the type.
ii. Put the chromosomes in order of length, longest first.
iii. Which two chromosomes show that his claim is wrong? Explain.
iv. What really decides the type?

3 Count them [5]

A made-up animal has 2n = 30 and decides sex by X and Y, as humans do. Copy and complete the table.

Cell	Chromosomes	Chromatids	Centromeres	Autosomes
Male body cell at metaphase of mitosis				
Egg				
Sperm				

How many kinds of sperm can the male make, and what does each carry?

4 Spot the error [3]

Find the mistake in the working and correct it.

Anjila was asked: "A chromosome is 10 μm long, with its centromere 2 μm from one end. Name its type." She wrote:
"Arm ratio = 2 ÷ 8 = 0.25. This is less than 1.7, so the chromosome is **metacentric** and V-shaped at anaphase."

5 DNA in a chromosome [4]

Each base pair adds 0.34 nm to a DNA molecule. Human chromosome 1 has about 248 million base pairs, about 8.4 cm of DNA, coiled at cell division into about a hundredth of a millimeter.

i. How many times shorter is chromosome 1 when coiled?
ii. A made-up chromosome has 50 million base pairs. How long is its DNA in centimeters?
iii. If it were coiled just as tightly as chromosome 1, how long would it look at cell division?
iv. Would you expect it to be seen under a light microscope? Use the limit of about 0.2 µm from Unit 1.

6 Which explanation fits the evidence? [3]

Chimpanzees have 48 chromosomes and people have 46. Rajan says humans lost two chromosomes. Prakriti says two of the apes' smaller chromosomes joined end to end to form our chromosome 2.

i. Which explanation does the DNA in the middle of human chromosome 2 support?
ii. Name the two pieces of evidence, and say what each would look like if Prakriti is right.
iii. What does this tell us about telomere repeats?

7 Predict, then explain [3]

Write your prediction first, then explain it.

A chromosome breaks during an accident in the cell, and its pieces rejoin wrongly. Predict what happens at cell division to (a) a piece with no centromere and (b) a chromosome that now has two centromeres. Then say why a chromosome that lost a telomere would also be in trouble.

8 Follow the eye color [4]

A male fruit fly with Morgan's white-eye allele on his X chromosome mates with a pure red-eyed female. Flies decide sex by X and Y, as humans do; the white allele is recessive.

i. Which sex chromosome does he give each son, and each daughter?
ii. Can any of his sons inherit the white allele from him? Give a reason.
iii. What eye color do his daughters have, and what do they carry?
iv. Explain how the white eyes can come back in a grandson, "through the daughters".

9 Design a fair test [4]

Sudip's farm has two varieties of rice: a tall one and a short one. He wonders whether the difference comes from the genes or from the different fields where he grows them.

i. Plan a test that separates the two causes.
ii. Name three things he must keep the same.
iii. What result would show that the difference is mostly hereditary?
iv. Why might the same variety still differ in height between a rich field and a poor one?

10 Estimate it [3]

Chromosome 1 has about 248 million base pairs and carries about 2,000 genes for proteins. Each base pair adds 0.34 nm.

i. On average, about how many base pairs are there per gene?
ii. How long is that stretch of DNA in micrometers?
iii. Genes for proteins make up less than 2% of our DNA. Is "a chromosome is made of genes" fair?

11 Correct the misconceptions [4]

The paragraph has four mistakes. Write each mistake and correct it.

> Salim wrote: "A human egg has 23 autosomes. The two homologous chromosomes of a pair carry different genes, one set from each parent. TT and Tt plants have different phenotypes because their genotypes differ. A farmer's tanned face will be passed to his children, since it is variation."

12 Think [3]

In humans, it is the father's sperm that decides the sex of a child. In birds, which parent decides it? Explain from the sex chromosomes each parent has. Why can't a rice plant's sex be decided this way?

13 Make your own [2]

Invent four chromosomes, each 20 μm long, one of each of the four types. Give each one's short and long arm, and its arm ratio.