Unit 3 · Genetics

HARDER PRACTICE QUESTIONS

Full marks 53

Write your answers on separate paper. Show your working.

1 Spot the error [3]

One strand of a piece of DNA has 30% A, 10% T, 25% G and 35% C. Anuska wrote: "By Chargaff's rules, A = T and G = C, so **this strand can't exist**, because 30 isn't 10 and 25 isn't 35."
Find her mistake, and find the percentage of each base in the whole double-stranded piece.

2 Three characters [4]

Peas also differ in height, tall (T) over dwarf (t), and in this question all three genes assort independently. A plant RrYyTt is self-pollinated and gives 640 seeds.

i. How many kinds of gamete does it make?
ii. What fraction of the seeds grow into round, yellow, tall plants? How many is that?
iii. How many seeds are expected to be wrinkled, green and dwarf?
iv. How many different genotypes are possible?

3 Work back to the parents [4]

Two pea plants were crossed, and their seeds were counted (made-up figures).

Round yellow	Round green	Wrinkled yellow	Wrinkled green
302	98	295	105

i. Find the ratio for shape alone and for color alone.
ii. Write the genotypes of the parents.
iii. How many of each kind would you expect if your answer is right?

4 Check the claim [4]

Pasang crossed two pure lines of a plant, then selfed the F_1, and followed two characters, A/a and B/b. Of 600 F_2 plants (made-up figures), he counted:

A– B–	A– bb	aa B–	aa bb
430	20	25	125

He wrote: "Since all four kinds appear, **these genes assort independently**."

i. Work out what 9 : 3 : 3 : 1 would predict.
ii. Is his claim right? Which two kinds are short?
iii. What is the most likely explanation?

5 Two steps [4]

A double-stranded DNA molecule has 1,200 base pairs, and 30% of its bases are adenine.

i. Find the number of each base.
ii. How many hydrogen bonds hold its strands together?
iii. Find its length, and its number of turns.

6 From gene to protein [5]

This strand of a gene is copied into mRNA: 3′-TAC CGA ACC ATT-5′.

i. Write the mRNA, with its ends.
ii. How many amino acids does it code for? Explain.
iii. Write the anticodon of the tRNA that reads its third codon.
iv. A mutation changes the middle C of ACC to T. Write the new third codon and say what happens to the protein.

7 Which explanation fits the evidence? [4]

Meselson and Stahl moved heavy (^{15}N) *E. coli* onto light (^{14}N) food. Lalita compares two ideas: **semi-conservative** (each molecule keeps one old strand) and **whole-copy** (the old molecule stays whole beside an all-new one).

i. What would each idea predict for the DNA after **one** generation?
ii. Which idea did their result support?
iii. Under semi-conservative copying, what fraction of molecules would be half-heavy after **three** generations, and what fraction light?

8 A family's chances [4]

Sunil and Anusha both have normal blood clotting, and their son has hemophilia. Their daughter Nisha has a normal husband.

i. Write Anusha's and Sunil's genotypes.
ii. What is the chance that Nisha is a carrier?
iii. Before Nisha has any children, what is the chance that her first child is a son with hemophilia?
iv. Her first child is a son with hemophilia. What now is the chance that her next son has it?

9 Rule it out [3]

For a rare character in each family, say whether it can be **X-linked recessive**, **Y-linked**, both or neither. Give a reason.

Family A: an affected man has 3 affected sons and 2 unaffected daughters.
Family B: an affected man has only unaffected children; his daughter's son is affected.
Family C: an affected daughter has an unaffected father.

10 Estimate it [3]

Hemophilia A affects about 1 in 5,000 boys born. Treat this as the share of X chromosomes that carry the allele.

i. About how many women in 25 million would have hemophilia A?
ii. About what share of women are carriers?
iii. What does this say about the claim in older books that a hemophilic woman is impossible?

11 Change the model [4]

In Practical 7, drawing from two separate cups models independent assortment. Rachana wants a model of two **linked** genes that never cross over.

i. How should she change the cups?
ii. Which kinds of gamete would she now get from an F_1 plant?
iii. Which F_2 phenotypes would she get, in what ratio?
iv. Why does she need many offspring, not five or six?

12 What if? [3]

Cells must code for 20 amino acids and a stop signal. Could a two-base codon work with the four bases we have? What is the smallest number of kinds of base that would let a two-base codon work? Why does our three-base code have many codons to spare?

13 Predict, then explain [3]

Write your prediction first, then explain it.

Two DNA samples are heated. In sample P, 18% of the bases are adenine; in sample Q, 32% are. Which strands separate at the higher temperature? Compare the hydrogen bonds per 100 base pairs.

14 Correct the misconceptions [3]

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

Prashant wrote: “A and T are joined by a double bond and G and C by a triple bond. A color-blind father passes his allele to his sons, who are then color-blind. Sixteen kinds of gamete are made by an RrYy plant, one for each box of the checkerboard.”

15 Make your own [2]

Make up a family puzzle about color blindness, with at least three people, that can be solved from what the unit teaches. Write its answer, using X^c, X and Y.