



Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. mitosis
2. meiosis
3. chromosome
4. gene
5. nucleotides
6. double helix
7. thymine
8. uracil

K • 4

Each carries 0.5 mark.

2 Multiple choice

- i. a. 1 pair

K • 1

One pair (XX or XY); the other 22 pairs are autosomes.

- ii. c. DNA and protein

K • 1

A chromosome is DNA wound round histone proteins.

- iii. d. It helps to repair tissue.

U • 1

Mitosis makes two identical diploid cells, for growth and repair. The other three describe meiosis.

- iv. c. An egg has only an X chromosome, and a sperm has either an X or a Y.

U • 1

Every egg carries an X; half the sperm carry an X and half a Y.

- v. a. DNA

A • 1

High-energy radiation damages DNA (it breaks the strands and changes bases). Cells that divide often, like those making sperm, are the most easily harmed. (The DNA is in the nucleus, but it is the DNA itself that is damaged.)

3 Label the diagram

- | | |
|---------------|----------------------|
| 1. cell | 5. sister chromatids |
| 2. centromere | 6. DNA |
| 3. nucleus | 7. histone proteins |
| 4. chromosome | 8. a gene |

K • 4

Each carries 0.5 mark.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ A segment of DNA in a chromosome that carries the code for a particular character (the unit of heredity).

- b. MARKING SCHEME

K • 1

✓ 23 (22 + X or 22 + Y).

- c. MARKING SCHEME

K • 1

✓ Uracil (U).



5 Short answers

a. MARKING SCHEME

U · 2

- ✓ Any one difference, e.g. mitosis gives 2 daughter cells, meiosis gives 4; or mitosis takes place in body cells, meiosis in the cells that make gametes.
- ✓ Any second difference, e.g. mitosis keeps the chromosome number (diploid, equational), meiosis halves it (haploid, reductional); or meiosis has crossing over and makes cells that differ, mitosis does not.

b. MARKING SCHEME

U · 2

- ✓ All of a woman's eggs carry an X chromosome (22 + X), but a man makes two kinds of sperm, 22 + X and 22 + Y.
- ✓ An X sperm gives a girl (XX) and a Y sperm a boy (XY), so the father's sperm decides the sex.

c. MARKING SCHEME

U · 2

- ✓ In meiosis one diploid cell (2n) produces four haploid cells (n).
- ✓ So the number of chromosomes is reduced to half (46 to 23 in humans).

d. MARKING SCHEME

A · 2

- ✓ No haploid gametes would form, so the organism could not reproduce sexually.
- ✓ If diploid cells fused, the chromosome number would double every generation (46 → 92 → 184), which cells can't survive; and there would be less variation.

6 Long answer

ANSWER

U · 4

A man's cells are 44 + XY and a woman's 44 + XX. By meiosis, a man makes two kinds of sperm in equal numbers (22 + X and 22 + Y), and a woman makes only one kind of egg (22 + X). If an X sperm fertilizes the egg, the zygote is 44 + XX and grows into a girl; if a Y sperm does, it is 44 + XY and grows into a boy. So each child has a 50% chance of being a girl or a boy. Chart: father 44 + XY and mother 44 + XX → gametes 22 + X, 22 + Y and 22 + X → children 44 + XX (daughter) and 44 + XY (son).

MARKING SCHEME

- ✓ A man is 44 + XY and a woman 44 + XX.
- ✓ The man makes two kinds of sperm (22 + X and 22 + Y) in equal numbers; the woman makes one kind of egg (22 + X).
- ✓ X sperm + egg → 44 + XX, a girl; Y sperm + egg → 44 + XY, a boy (50% chance each).
- ✓ A correct chart showing the parents, the gametes and the children.

7 Numerical problem

ANSWER

A · 4

- $2^{10} = 1,024$ cells.
- $\frac{1}{2}$, or 50%: half the sperm carry X.
- $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$ (1 family in 8).
- An egg is 22 + X, so it has 22 autosomes.

MARKING SCHEME

- ✓ i. 1,024 cells.
- ✓ ii. $\frac{1}{2}$ (50%).
- ✓ iii. $\frac{1}{8}$.
- ✓ iv. 22.



8 Think

ANSWER

HA · 2

Each sperm and each egg is made by meiosis, and meiosis shuffles the genes in two ways. **Crossing over** mixes pieces of the grandfather's and grandmother's chromosomes, and each of the 23 pairs lines up **by chance**, so each gamete gets a random mixture. With 23 pairs, the line-up alone can give 2^{23} , more than **8 million** different kinds of egg or sperm, and crossing over adds far more. So every child gets a different combination of their parents' genes (only identical twins, who come from one zygote, share the same genes). Their surroundings and experiences add still more differences.

MARKING SCHEME

- ✓ Each sperm and egg is made by meiosis, in which crossing over and the random sorting of the chromosome pairs give every gamete a different mixture of genes.
- ✓ So every child gets a different combination of the parents' genes; identical twins come from one zygote and share the same genes.

9 Activity: See DNA with your own eyes (at home)

(not marked)

WHAT STUDENTS SHOULD FIND

White, cloudy, stringy threads rise into the spirit within a few minutes: DNA from millions of banana cells, clumped together (DNA does not dissolve in alcohol). One molecule is far too thin to see, but the threads are countless molecules stuck together.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	13	12	7	2	34





Unit 4 • Heredity: genetics and genetic technology

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. allele → **c.** one of the two forms of a gene, such as T or t
2. hybrid → **g.** an organism with two different alleles of a gene, such as Tt
3. recessive → **d.** a character that shows only when both alleles are for it
4. phenotype → **e.** the character you can see, such as tall or dwarf
5. genotype → **f.** the genetic make-up, such as TT, Tt or tt
6. genetics → **b.** the study of genes, heredity and variation

K • 3

Each carries 0.5 mark.

2 Label the diagram

- | | |
|-------------|----------------|
| 1. purple | 5. inflated |
| 2. round | 6. constricted |
| 3. white | 7. tall |
| 4. wrinkled | 8. dwarf |

K • 4

Each carries 0.5 mark.

3 Multiple choice

- i. **a. pea** K • 1
The garden pea, *Pisum sativum*.
- ii. **c. 1 : 2 : 1** K • 1
TT : Tt : tt = 1 : 2 : 1. (3 : 1 is the phenotypic ratio, and 9 : 3 : 3 : 1 the dihybrid phenotypic ratio.)
- iii. **a. The parents were hybrid.** U • 1
For a recessive character to show, the child needs a recessive allele from **each** parent, so both dark parents must have carried it hidden: they were hybrids (Bb × Bb gives 1 in 4 bb). Real human skin color, though, is decided by **many genes**, so children of the same parents can have many different shades.
- iv. **c. a hybrid plant** U • 1
The offspring of a cross between two different kinds is a hybrid.
- v. **c. Mules can't produce offspring naturally.** A • 1
Mules are sterile, so a new mule has to come from crossing a donkey with a horse again. Her family must buy a mule, or breed a male donkey with a mare.

4 Very short answers

- a. **MARKING SCHEME** K • 1
✓ A cross between two pure organisms that differ in one pair of contrasting characters.
- b. **MARKING SCHEME** K • 1
✓ 9 : 3 : 3 : 1.
- c. **MARKING SCHEME** K • 1
✓ Artificial insemination (AI).



5 Short answers

a. MARKING SCHEME

U · 2

- ✓ Phenotype is the character that can be seen (tall, dwarf); genotype is the genetic make-up (TT, Tt, tt).
- ✓ Any second difference, e.g. two plants with the same phenotype (tall) can have different genotypes (TT or Tt); or the F_2 phenotypic ratio is 3 : 1 but the genotypic ratio is 1 : 2 : 1.

b. MARKING SCHEME

U · 2

- ✓ The tall parent (TT) gives T and the dwarf parent (tt) gives t, so every F_1 plant is Tt.
- ✓ Tall (T) is dominant and hides dwarf (t), so all the F_1 plants are tall (law of dominance).

c. MARKING SCHEME

U · 2

- ✓ Every person's DNA is unique (except identical twins), the same in every cell and unchanged through life.
- ✓ Even a trace of blood, hair, skin or saliva at a crime scene can be matched with a suspect's DNA, and a chance match between unrelated people is extremely unlikely.

d. MARKING SCHEME

A · 2

- ✓ The hybrid gets one set of chromosomes from each parent, and the two sets don't match (horse 64, donkey 62, mule 63).
- ✓ In meiosis the chromosomes can't pair properly, so normal gametes can't form and the hybrid is sterile.

6 Long answer

ANSWER

A · 4

A monohybrid cross is a cross between two pure organisms that differ in one pair of contrasting characters.

Let R = red (dominant) and r = white (recessive). (Mendel's peas actually had purple flowers; the method is the same.)

Parents: pure red RR × pure white rr

Gametes: R and r

F_1 : all Rr, red (hybrid)

F_1 self-pollinated: Rr × Rr; gametes R, r from each parent

	R	r
R	RR (red)	Rr (red)
r	Rr (red)	rr (white)

F_2 : phenotypic ratio red : white = 3 : 1; genotypic ratio RR : Rr : rr = 1 : 2 : 1.

MARKING SCHEME

- ✓ A monohybrid cross is a cross between two pure organisms that differ in one pair of contrasting characters.
- ✓ Parents RR × rr give gametes R and r, so F_1 is all Rr, red.
- ✓ F_1 self-pollinated: Rr × Rr, with a correct chart (Punnett square) giving RR, Rr, Rr, rr.
- ✓ F_2 : phenotypic ratio red : white = 3 : 1; genotypic ratio RR : Rr : rr = 1 : 2 : 1.



7 Problem

ANSWER

A - 4

- Round : wrinkled = 3 : 1.
- RR : Rr : rr = 1 : 2 : 1.
- Wrinkled (rr) is 1 in 4: $\frac{1}{4} \times 400 = 100$ seeds.
- The RR plants: both their alleles are for round seeds, so they make only R gametes and breed true.

MARKING SCHEME

- ✓ i. 3 : 1.
- ✓ ii. 1 : 2 : 1.
- ✓ iii. 100 seeds.
- ✓ iv. RR, because both alleles are for round (they make only R gametes).

8 Think

ANSWER

HA - 2

The black parent was pure (BB) and the white one was bb. All the gametes of the black parent carried B and all those of the white parent carried b, so every offspring was Bb. Black (B) is dominant, so it hid the white allele (b) and all the F_1 were black. White can show only in a bb animal, which this cross can't produce. (If the black parent had been Bb, about half the young would have been white.)

MARKING SCHEME

- ✓ The black parent was pure (BB) and the white bb, so every offspring got B from one parent and b from the other: all Bb.
- ✓ Black is dominant and hides white; white shows only in bb, which this cross can't produce.

9 Activity: Hybrids you know (Activity 4.7)

(not marked)

WHAT STUDENTS SHOULD FIND

Crossbred Jersey and Holstein cows (more milk); Murrah buffalo crosses; Boer and Jamunapari goat crosses (more meat); broiler chickens; hybrid maize, rice and cucumber seed (bigger harvests); seedless grapes and watermelon; the mule (horse $\times$ donkey, strong carrier, sterile); the chauri (yak $\times$ cattle).

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	12	8	11	2	33

