Unit 10 · Mutation and Polyploidy

ANSWER KEY · FOR TEACHERS

Full marks 32

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. mutagens
2. transition
3. frameshift
4. nonsense
5. inversion
6. non-disjunction
7. aneuploidy
8. euploidy

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. radish 2n = 18
2. gamete n = 9 (R)
3. hybrid 2n = 18 (RC) sterile: no partners
4. Raphanobrassica 2n = 4x = 36 (RRCC) fertile: every one paired
5. gamete n = 9 (C)
6. chromosomes double

K · 3

Each carries 0.5 mark.

3 Multiple choice

i. **c.** one in a cell of the testes or ovaries that goes on to make gametes — K · 1

Only a change in the **germ line**, the cells that make eggs or sperm, reaches a child. Mutations in body cells, however they are caused, stay in that person (though they can lead to cancer).

ii. **c.** a silent substitution, a transition — U · 1

A replaced by G is purine for purine, a **transition**, and since TTG also codes for leucine the protein doesn't change: it is **silent**. The code has more than one codon for most amino acids, so many substitutions in a codon's third base are silent.

iii. **b.** trisomy, an aneuploidy — U · 1

One chromosome is present three times: **trisomy** (2n + 1), a change in a single chromosome, so an **aneuploidy** (here Edwards syndrome). Triploidy would mean three copies of every chromosome, 69 in all.

iv. **b.** the deletion of one base near the start of the gene — A · 1

Deleting one base near the start shifts the reading frame for **almost the whole gene**: nearly every amino acid after it is wrong. A three-base deletion removes only one amino acid; a substitution changes one codon at most.

v. **b.** after doubling, every chromosome has an identical partner to pair with in meiosis — A · 1

The hybrid's chromosomes from the two species aren't homologous, so they can't pair in meiosis, and its gametes get uneven sets. After doubling (AB → AABB) each chromosome has an **exact copy** to pair with, meiosis is normal, and the gametes work. The plant is a new species, not either parent.

4 Short answers

a. MARKING SCHEME — K · 2

- ✓ Autopolyploidy: more sets of one species, with an example (e.g. banana).
- ✓ Allopolyploidy: a hybrid's sets doubled, with an example (e.g. bread wheat).

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b. MARKING SCHEME U · 2

✓ A transversion (substitution, purine to pyrimidine).

✓ Missense: glutamic acid replaced by valine in the β chain of hemoglobin.

c. MARKING SCHEME A · 2

✓ ATG ACA TGT ATG A… (codons read again from the start).

✓ Frameshift: every amino acid after it changes and the stop is lost.

d. MARKING SCHEME U · 3

✓ Deletion and duplication.

✓ Inversion.

✓ Translocation, to a non-homologous chromosome.

5 Numerical problem

ANSWER A · 4

n = 7.

- Monosomic 2n − 1 = **13**; trisomic 2n + 1 = **15**; nullisomic 2n − 2 = **12**.
- Triploid 3n = **21**; tetraploid 4n = **28**.
- Hybrid: gametes of 7 + 9 = **16**; allotetraploid (doubled) = **32**.

MARKING SCHEME

✓ 13, 15 and 12 for the aneuploids.

✓ 21 and 28 for the euploids.

✓ Hybrid 16.

✓ Allotetraploid 32.

6 Long answer

ANSWER U · 4

Aneuploidy is the loss or addition of one or more particular chromosomes from the diploid set, usually from **non-disjunction** in meiosis.

Hypoploidy (loss):

- **Nullisomy** (2n − 2): both chromosomes of a pair missing; lethal in animals.
- **Monosomy** (2n − 1): **Turner syndrome**, 44 + XO (45 chromosomes).

Hyperploidy (gain):

- **Trisomy** (2n + 1): **Down syndrome** (trisomy 21), **Klinefelter syndrome** (44 + XXY).
- **Tetrasomy** (2n + 2): tetrasomy X (48,XXXX); pentasomy (2n + 3) and hexasomy (2n + 4) are very rare.

MARKING SCHEME

✓ Definition: loss or gain of single chromosomes (non-disjunction).

✓ Nullisomy and monosomy (Turner 44 + XO).

✓ Trisomy (Down or Klinefelter).

✓ Tetrasomy or higher.

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7 Think

HA · 3

ANSWER

With **three sets** (3n), the chromosomes can't pair and be shared out evenly in **meiosis**: each gamete gets an uneven mix, so almost no gametes work and the fruit develops with **little or no seed**.
Bananas are grown from **suckers** (vegetatively), so the triploid is copied unchanged.
Seedless watermelon seed is made fresh each year by crossing a **tetraploid** (4n, made with colchicine) with a **diploid** (2n): the seeds of the cross are **triploid**.

MARKING SCHEME

- ✓ Three sets can't pair evenly in meiosis, so gametes fail and no seeds form.
- ✓ Bananas are propagated from suckers.
- ✓ Seedless watermelon seed comes from a 4n × 2n cross each year.

8 Activity: A sentence read in threes

(not marked)

WHAT STUDENTS SHOULD FIND

The substitution spoils **one word**. One letter added or lost shifts the frame and turns **every word after it** into nonsense (THE BIG XRE DDO GAT ETH EHO TBU N). Three letters lost remove **one word** and leave the rest readable. A cell reads a gene the same way, so a **frameshift** near the start does the most harm.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	10	11	8	3	**32**

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