Unit 3 · Cell Division

ANSWER KEY · FOR TEACHERS

Full marks 39

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. karyokinesis
2. G_0
3. kinetochores
4. synapsis
5. synaptonemal complex
6. pachytene
7. chiasmata
8. interkinesis

Each carries 0.5 mark. **K · 4**

2 Label the diagram

1. astral rays
2. centrosome
3. chromosomal fiber
4. daughter chromosome
5. continuous fiber
6. interzonal region

Each carries 0.5 mark. **K · 3**

3 Multiple choice

i. **b.** S **K · 1**

S is the synthesis phase, when the DNA is copied: each chromosome becomes two identical chromatids joined at the centromere. In G_1 the cell grows before copying; in G_2 it prepares to divide; G_0 is outside the cycle.

ii. **b.** non-sister chromatids of homologous chromosomes **K · 1**

Crossing over swaps matching pieces between a chromatid of the mother's chromosome and a chromatid of the father's, which are non-sister chromatids of a homologous pair. Swapping between sister chromatids would change nothing, since they are identical.

iii. **c.** J **U · 1**

An acrocentric chromosome has its centromere close to one end, so it has one very short arm and one long arm: pulled by the centromere, it bends into a J. Metacentric gives a V, submetacentric an L, and telocentric (centromere at the very end) an I.

iv. **b.** 46 chromosomes, 92 chromatids **U · 1**

Chromosomes are counted by their **centromeres**: still 46, each of two sister chromatids, so **92 chromatids**. Only at anaphase, when the centromeres split, are there 92 chromosomes for a few minutes.

v. **c.** before anaphase, unable to separate its chromatids **A · 1**

Without spindle fibers the chromosomes can't be pulled apart, so the cell is stuck **before anaphase** and dies. Cancer cells, dividing far more often than most body cells, are hit hardest.

4 Very short answers

a. **MARKING SCHEME** **K · 1**

✓ Amitosis, mitosis and meiosis.

b. **MARKING SCHEME** **K · 1**

✓ Center to wall, becoming the middle lamella.

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c. MARKING SCHEME U · 1

✓ The chromosome number stays n: only sister chromatids separate.

5 Short answers

a. MARKING SCHEME U · 2

✓ It only looks inactive: the chromosomes are uncoiled.

✓ It is the most active stage: growth, DNA copied in S, preparation in G_2.

b. MARKING SCHEME U · 2

✓ Animal: a furrow by a ring of actin and myosin, from outside in.

✓ Plant: a cell plate from Golgi vesicles, from the center out.

c. MARKING SCHEME A · 2

✓ No spindle: chromosomes are not shared out exactly.

✓ Used only where that matters little (macronucleus of Paramecium, cartilage).

d. MARKING SCHEME U · 3

✓ Centromeres split in mitosis, not in anaphase I.

✓ Sister chromatids separate in mitosis; homologs in anaphase I.

✓ 2n to each pole in mitosis; n, a mixture of maternal and paternal, in anaphase I.

6 Numerical problems

ANSWER A · 4

i. Dividing cells: 64 + 24 + 12 + 20 = 120. Mitotic index = 120 ÷ 800 × 100 % = **15 %**.

ii. 20 h = 1200 min. Prophase: 64 ÷ 800 × 1200 = **96 min**; anaphase: 12 ÷ 800 × 1200 = **18 min**.

iii. 680 ÷ 800 × 20 h = **17 h**.

iv. **Anaphase**: it has the fewest cells (12), because it is the **shortest** stage, so few cells are caught in it.

MARKING SCHEME

✓ Mitotic index 15 %.

✓ Prophase 96 min and anaphase 18 min.

✓ Interphase 17 h.

✓ Anaphase, the shortest stage, so the fewest cells.

7 Long answers

a. ANSWER U · 4

Leptotene: the chromosomes condense into long, thin threads with bead-like **chromomeres**; in many cells their ends gather in a **bouquet**; envelope and nucleolus remain.
Zygotene: homologous chromosomes pair side by side (**synapsis**), held by the **synaptonemal complex**, forming **bivalents** (23 in a human cell).
Pachytene: the bivalents thicken and four chromatids are seen (**tetrad**); non-sister chromatids break and swap pieces: **crossing over**.
Diplotene: the synaptonemal complex comes apart and the homologs separate except at **chiasmata**; human oocytes pause here.
Diakinesis: chromosomes most condensed, chiasmata slide to the ends (**terminalization**), the nucleolus and nuclear envelope disappear and the spindle forms.

MARKING SCHEME

✓ Leptotene: thin threads with chromomeres.

✓ Zygotene: synapsis into bivalents by the synaptonemal complex.

✓ Pachytene: tetrads, crossing over between non-sister chromatids.

✓ Diplotene and diakinesis: chiasmata, terminalization, envelope and nucleolus gone.

b. ANSWER

Any four:

- It makes the **haploid gametes** and spores that sexual reproduction needs.
- It keeps the **chromosome number constant**: n in gametes, restored to 2n at fertilization.

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- **Crossing over** makes new combinations of genes on each chromosome. A · 4
- **Independent assortment** at metaphase I mixes whole chromosomes: one person can make 2^{23}, about 8.4 million, kinds of gamete.
- It **segregates genes**, which is why Mendel's laws work.
- The variation it gives is what **evolution** and **breeders** select from; failed separation can give **polyploids** such as wheat.

MARKING SCHEME

✓ A first importance explained.
✓ A second importance explained.
✓ A third importance explained.
✓ A fourth importance explained.

8 Think

ANSWER HA · 3

G_1: **2C**. After S: **4C**. After meiosis I (homologs separated): **2C** in each of two cells. After meiosis II (sister chromatids separated): **1C** in each of four cells, half the G_1 amount, as a gamete needs.
If the DNA were copied again in interkinesis, each gamete would end with **2C** (a full diploid set); fertilization would then give **4C**, and the amount of DNA would **double every generation**, which is what meiosis exists to prevent.

MARKING SCHEME

✓ 2C, then 4C after S.
✓ 2C after meiosis I, 1C in each of four cells after meiosis II.
✓ A second copying would leave diploid gametes, doubling the DNA each generation.

9 Activity: Explore mitosis in an onion root tip

(not marked)

WHAT STUDENTS SHOULD FIND

Small, box-shaped cells, most in **interphase** (a round, evenly stained nucleus with a darker nucleolus); threads in prophase, a line across the middle at metaphase, two groups of V-shaped chromosomes moving apart at anaphase, two groups at the ends with a cell plate between them at telophase. Anaphase is the hardest to find, being shortest. No centrioles or asters: onion cells have none.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	14	11	3	**39**

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