

Meiosis & Nondisjunction

Name: _____

Date: _____ Score: ____ / 30

Key ideas

Meiosis: one diploid (2n) cell divides twice to make four haploid (n) gametes. **Meiosis I** separates homologous chromosomes; **meiosis II** separates sister chromatids.

Sources of variation: crossing over (prophase I), independent assortment (metaphase I), random fertilization.

Nondisjunction: chromosomes fail to separate, giving gametes with $n + 1$ or $n - 1$ chromosomes → trisomy ($2n + 1$) or monosomy ($2n - 1$) after fertilization.

A Key terms3 marks

Write the letter of the matching definition (½ mark each).

1. _____ Diploid (2n)

2. _____ Haploid (n)

3. _____ Homologous chromosomes

4. _____ Sister chromatids

5. _____ Tetrad

6. _____ Crossing over
- a. Exchange of DNA segments between non-sister chromatids of homologous chromosomes

b. A cell with one set of chromosomes, such as a gamete

c. Two identical copies of a chromosome joined at a centromere

d. A cell with two sets of chromosomes, one set from each parent

e. A homologous pair of duplicated chromosomes (four chromatids) joined in prophase I

f. A pair of chromosomes carrying the same genes, one from each parent

B Chromosome numbers4 marks

	Organism	Body cell (diploid, 2n)	Gamete (haploid, n)
7.	Human	46	
8.	Dog	78	
9.	Fruit fly		4
10.	Corn		10

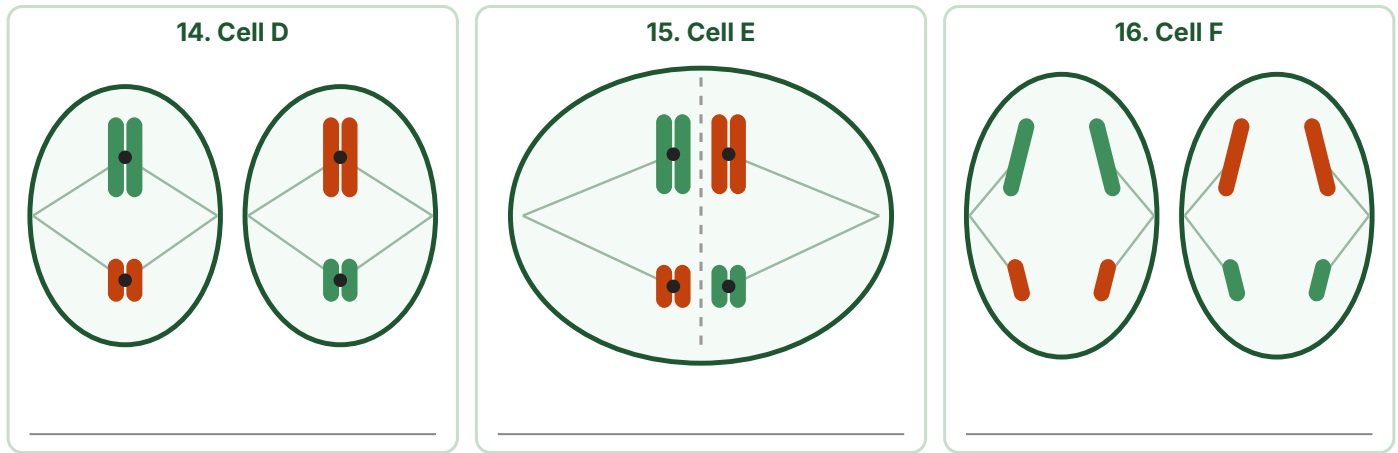
C Identify the stage of meiosis6 marks

Each cell has $2n = 4$. ■ from mother ■ from father

11. Cell A

12. Cell B

13. Cell C



Bonus: put the cells in order: _____ → _____ → _____ → _____ → _____ → _____

D Mitosis vs meiosis

5 marks

1 mark per row.

	Feature	Mitosis	Meiosis
17.	Number of divisions		
18.	Number of daughter cells		
19.	Chromosome number in daughter cells		
20.	Genetically identical to parent?		
21.	Purpose		

E Sources of genetic variation

4 marks

22. Describe crossing over: when it happens, which chromosomes are involved, and why it matters. (2 marks)

23. Independent assortment can produce 2^n chromosome combinations, where n is the haploid number. How many combinations are possible for a fruit fly ($2n = 8$)?

24. How many combinations are possible for a human ($2n = 46$)? Ignore crossing over.

F Nondisjunction

6 marks

25. Nondisjunction of chromosome 21 happens in **meiosis I** of a human cell. How many chromosomes does each of the four gametes have?

26. Nondisjunction instead happens in **meiosis II**, in one of the two cells only. How many chromosomes does each gamete have?

Identify each disorder from its karyotype and give the total chromosome number (1 mark per row).

	Karyotype	Disorder	Total chromosomes
27.	47,XX,+21		
28.	45,X		
29.	47,XXY		
30.	47,XY,+18		

G

Spot the mistake

2 marks

31. A student writes: "Meiosis produces two genetically identical diploid cells." Explain the error and correct it.

32. A student writes: "Crossing over happens between sister chromatids during prophase II." Explain the error and correct it.

Meiosis & Nondisjunction

ANSWER KEY**Key ideas**

Meiosis: one diploid ($2n$) cell divides twice to make four haploid (n) gametes. **Meiosis I** separates homologous chromosomes; **meiosis II** separates sister chromatids.

Sources of variation: crossing over (prophase I), independent assortment (metaphase I), random fertilization.

Nondisjunction: chromosomes fail to separate, giving gametes with $n + 1$ or $n - 1$ chromosomes → trisomy ($2n + 1$) or monosomy ($2n - 1$) after fertilization.

A Key terms**3 marks**

Write the letter of the matching definition (½ mark each).

- | | |
|------------------------------------|---|
| 1. <u>d</u> Diploid ($2n$) | a. Exchange of DNA segments between non-sister chromatids of homologous chromosomes |
| 2. <u>b</u> Haploid (n) | b. A cell with one set of chromosomes, such as a gamete |
| 3. <u>f</u> Homologous chromosomes | c. Two identical copies of a chromosome joined at a centromere |
| 4. <u>c</u> Sister chromatids | d. A cell with two sets of chromosomes, one set from each parent |
| 5. <u>e</u> Tetrad | e. A homologous pair of duplicated chromosomes (four chromatids) joined in prophase I |
| 6. <u>a</u> Crossing over | f. A pair of chromosomes carrying the same genes, one from each parent |

B Chromosome numbers**4 marks**

	Organism	Body cell (diploid, $2n$)	Gamete (haploid, n)
7.	Human	46	23
8.	Dog	78	39
9.	Fruit fly	8	4
10.	Corn	20	10

C Identify the stage of meiosis**6 marks**

Each cell has $2n = 4$. ■ from mother ■ from father

11. Cell A

Anaphase I

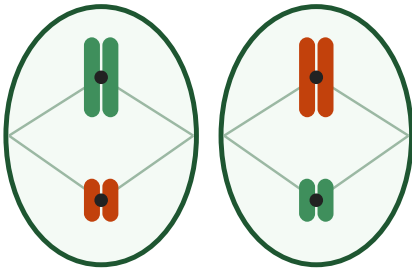
12. Cell B

Telophase II (four haploid cells)

13. Cell C

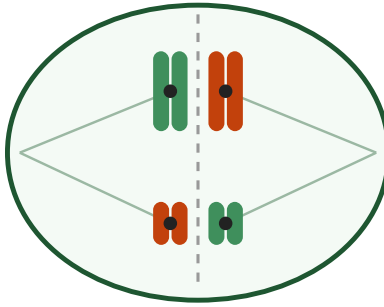
Prophase I (crossing over)

14. Cell D



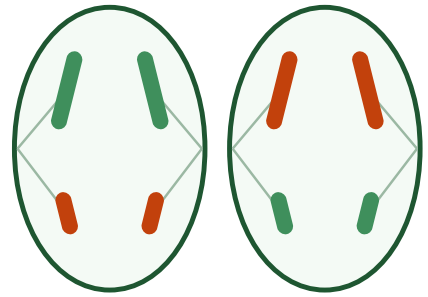
Metaphase II

15. Cell E



Metaphase I

16. Cell F



Anaphase II

Correct order: C → E → A → D → F → B (not marked)

D Mitosis vs meiosis

5 marks

1 mark per row.

	Feature	Mitosis	Meiosis
17.	Number of divisions	1	2
18.	Number of daughter cells	2	4
19.	Chromosome number in daughter cells	Diploid (2n), same as the parent	Haploid (n), half of the parent
20.	Genetically identical to parent?	Yes	No, each cell is unique
21.	Purpose	Growth, repair, asexual reproduction	Making gametes (eggs and sperm)

E Sources of genetic variation

4 marks

22. Describe crossing over: when it happens, which chromosomes are involved, and why it matters. (2 marks)
In prophase I, non-sister chromatids of homologous chromosomes exchange segments. This makes new combinations of alleles on each chromosome, so every gamete is genetically different.

23. Independent assortment can produce 2^n chromosome combinations, where n is the haploid number. How many combinations are possible for a fruit fly ($2n = 8$)?
 $n = 4$, so $2^4 = 16$ combinations

24. How many combinations are possible for a human ($2n = 46$)? Ignore crossing over.
 $n = 23$, so $2^{23} = 8,388,608$ combinations

F Nondisjunction

6 marks

25. Nondisjunction of chromosome 21 happens in **meiosis I** of a human cell. How many chromosomes does each of the four gametes have?

Homologues fail to separate: 24, 24, 22, 22 (two gametes $n + 1$, two gametes $n - 1$)

26. Nondisjunction instead happens in **meiosis II**, in one of the two cells only. How many chromosomes does each gamete have?

Sister chromatids fail to separate in one cell: 24, 22, 23, 23 (two gametes are normal)

Identify each disorder from its karyotype and give the total chromosome number (1 mark per row).

	Karyotype	Disorder	Total chromosomes
27.	47,XX,+21	Down syndrome (trisomy 21)	47
28.	45,X	Turner syndrome (monosomy X)	45
29.	47,XXY	Klinefelter syndrome	47
30.	47,XY,+18	Edwards syndrome (trisomy 18)	47

G Spot the mistake

2 marks

31. A student writes: "Meiosis produces two genetically identical diploid cells." Explain the error and correct it.
That describes mitosis. Meiosis produces four genetically different haploid cells.

32. A student writes: "Crossing over happens between sister chromatids during prophase II." Explain the error and correct it.
Crossing over happens between non-sister chromatids of homologous chromosomes during prophase I.