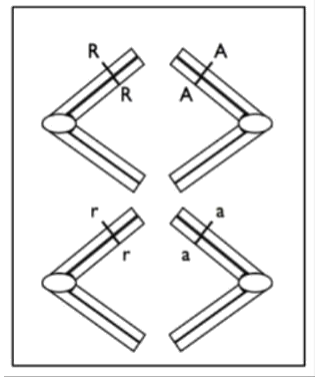
Meiosis (and mitosis) - Sally Scenario – **Answer Key**

1. The four diagrams below show chromosomes of a heterozygous diploid organism at anaphase. The organism is $2n = 4$ and has the genotype *A/a*; *R/r*. The two genes (gene *A* and gene *R*) are on different chromosomes (i.e., different homologous pairs). Each image represents one cell undergoing anaphase. Assume that no mutations have taken place during replication.

In the spaces provided below, indicate which of the following processes might possibly be taking place: **mitosis**, **meiosis I**, **meiosis II** … *or* an **impossible** situation. Please briefly justify each of your answers. (**4 marks**)

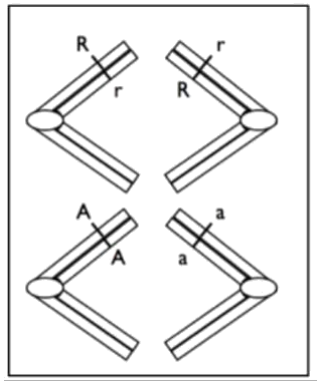
a.



Impossible situation (0.5 mark)

Example explanation (0.5 mark):
Non-homologous chromosomes are pulling away from each other (as indicated by the presence of different genes on the chromosomes that are across from one another); this means it can't be meiosis I. Also, the chromosomes still have two sister chromatids (which means it can't be mitosis or meiosis II).

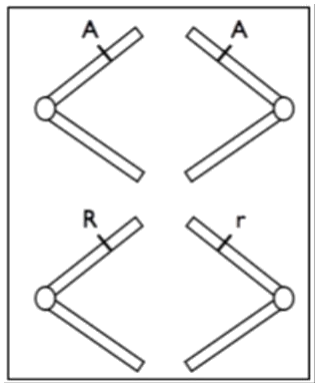
b.



Meiosis I (0.5 mark)

Example explanation (0.5 mark):
Chromosomes have two sister chromatids each and the cell is diploid, which are both characteristics of meiosis I.
Although the two homologous chromosomes containing gene *R* have different alleles from one another, this is possible if crossing over in prophase I of meiosis resulted in recombination of those alleles/that section of the chromosome.

c.



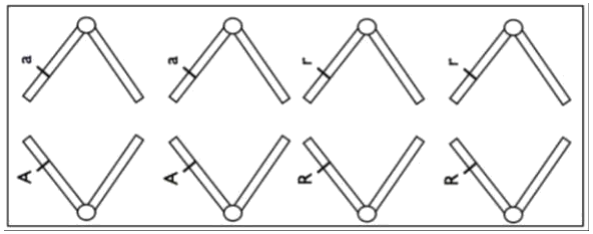
Meiosis II (0.5 mark)

Example explanation (0.5 mark):

Chromosomes have one sister chromatid each and the cell is haploid, which are both characteristics of meiosis II.

Although the two sister chromatids containing gene *R* have different alleles from one another, this is possible if crossing over in prophase I of meiosis resulted in recombination at that locus (= that location on the chromosome).

d.



Impossible situation (0.5 mark)

Example explanation (0.5 mark):

This can't be meiosis I because the sister chromatids have separated.

It can't be mitosis, because the sister chromatids that are pulling away from one another are not identical – the alleles are different. Crossing-over/recombination between homologous chromosomes does not occur during mitosis (because the homologous chromosomes don't pair up), and we have been told to assume that no mutations have occurred.

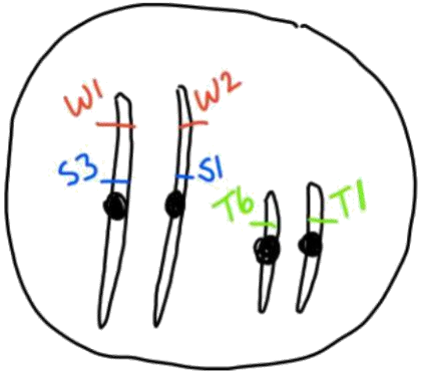
It can't be meiosis II because homologous chromosomes are present (i.e., there are two chromosomes with alleles for gene *A*, and two chromosomes with alleles for gene *R*). (0.5 marks)

2. Sally has the genotype ***W1/W2; S1/S3; T1/T6***. Sally's mother had the genotype *W1*/*W1*; *S3*/*S3*; *T6*/*T6*. Sally's father had the genotype *W1*/*W2*; *S1*/*S3*; *T1*/*T6*. The "W" and "S" genes are located on chromosome #1 and the "T" gene is located on chromosome #2. On chromosome #1, the "W" and "S" genes are on the same side of the centromere, but the "S" gene is very close to the centromere and the "W" gene is further away.

In the spaces below, draw a diagram showing chromosomes #1 and #2 within one of Sally's cells at each of the specified stages. Make sure you clearly label the location of the genes and alleles as described above. (**16 marks**)

a. Cell in G1 Phase:

(Although technically the chromosomes aren't condensed at this stage, please show them as discrete entities with visible centromeres for the purposes of labelling the genes and alleles)

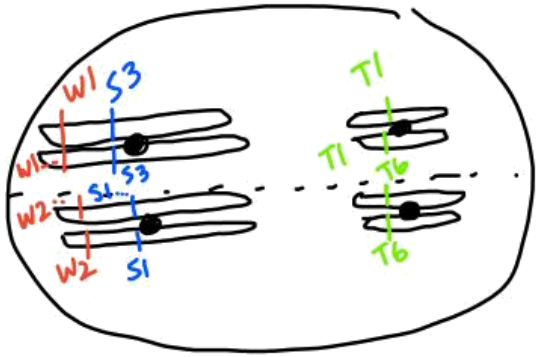


Characteristics to look for:

- The cell should be diploid (it should have obvious pairs of chromosomes of the same size, with centromeres and genes located in the same places); the chromosomes should be unreplicated (single DNA molecules).
- Chromosome pair #1 should carry the "W" and "S" alleles. The "S" and "W" alleles should be on the same "arm" of the chromosome, but the "W" allele should be further away from the centromere.
- One of the chromosome #1 homologues should carry alleles *W1* and *S3* (inherited from Sally's mother), the other homologue of chromosome #1 should carry

b. Cell in metaphase I of meiosis, that will eventually produce daughter cells with the following genotypes (2 of each):

- **(*W1*; *S3*; *T1*), (*W2*; *S1*; *T6*)**



Characteristics to look for:

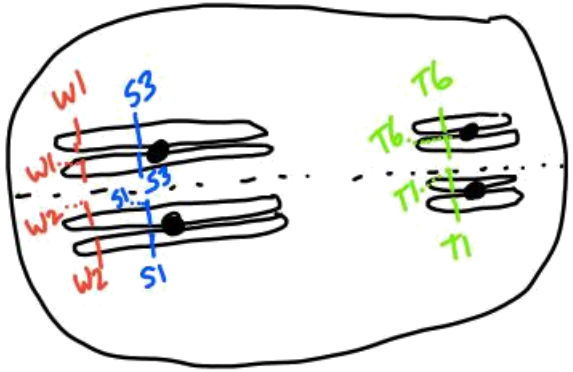
- The cell should be diploid; the chromosomes should be replicated (with two sister chromatids).
- Homologous pairs should be lined up across from one another (i.e., on either side of the metaphase plate)
- The chromosome #1 homologue carrying *W1* and *S3* should be on the same side of the metaphase plate as the chromosome #2 homologue carrying *T1*; the chromosome carrying *W2* and *S1* should be on the same of the metaphase plate as the chromosome carrying *T6*.
- All sister chromatids should carry the same allele as one another (e.g., *W1* and *W1*, *S3* and *S3*).

alleles *W2* and *S1* (inherited from Sally's father).

- Chromosome pair #2 should carry the "T" alleles. One homologue should carry allele *T6*, the other homologue should carry allele *T1*.

c. Cell in metaphase I of meiosis, that will eventually produce daughter cells with the following genotypes (2 of each):

- **(*W1*; *S3*; *T6*), (*W2*; *S1*; *T1*)**

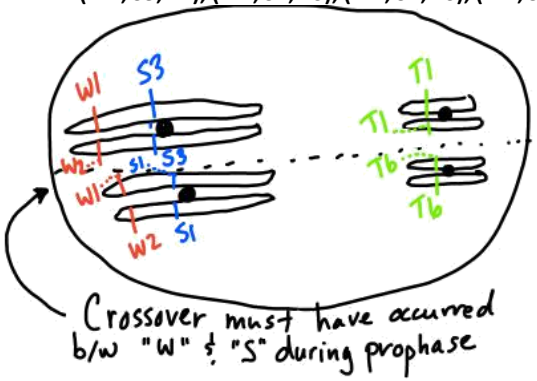


Characteristics to look for:

- The cell should be diploid; the chromosomes should be replicated (with two sister chromatids).
- Homologous pairs should be lined up across from one another (i.e., on either side of the metaphase plate)
- **The chromosome #1 homologue carrying *W1* and *S3* should be on the same side of the metaphase plate as the chromosome #2 homologue carrying *T6*; the chromosome carrying *W2* and *S1* should be on the same of the metaphase plate as the chromosome carrying *T1*.**
- All sister chromatids should carry the same allele as one another (e.g., *W1* and *W1*, *S3* and *S3*).

d. Cell in metaphase I of meiosis, that will eventually produce daughter cells with the following genotypes (one of each):

- **(*W1*; *S3*; *T1*), (*W2*; *S1*; *T6*), (*W1*; *S1*; *T6*), (*W2*; *S3*; *T1*)**



Characteristics to look for:

- The cell should be diploid; the chromosomes should be replicated (with two sister chromatids).
- Homologous pairs should be lined up across from one another (i.e., on either side of the metaphase plate)
- **The chromosomes and their chromatids must be lined up in such a way that all four gamete genotypes are possible (i.e., W1, W2, S3, S3, T1, T1 on one side of the metaphase plate; W1, W2, S1, S1, T6, T6 on the other)**
- **The location of one or more crossover events that could have resulted in the allele arrangement described above must be clearly and explicitly indicated**