

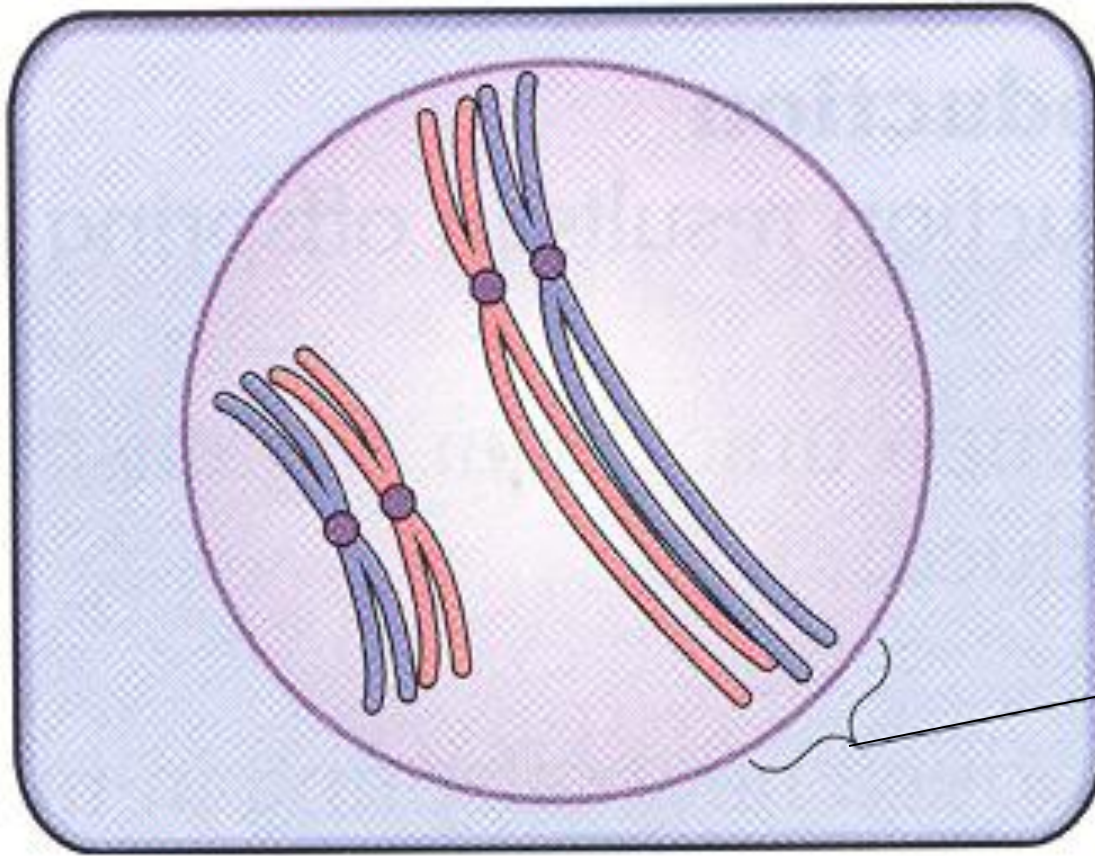
# Meiosis

- This involves 2 divisions of the nucleus -
- The first division is called MEIOSIS 1 and separates the **homologous chromosomes**, halving the number of chromosomes
- The second is called MEIOSIS 2 and separates the sister **chromatids**
- This results in the formation of **four** cells each with half the original chromosome number - **haploid**

- Meiosis is a slower and more complex process than mitosis.
- It is preceded by an interphase stage during which the chromosomes are replicated.
- This doubles the amount of DNA

# Prophase I

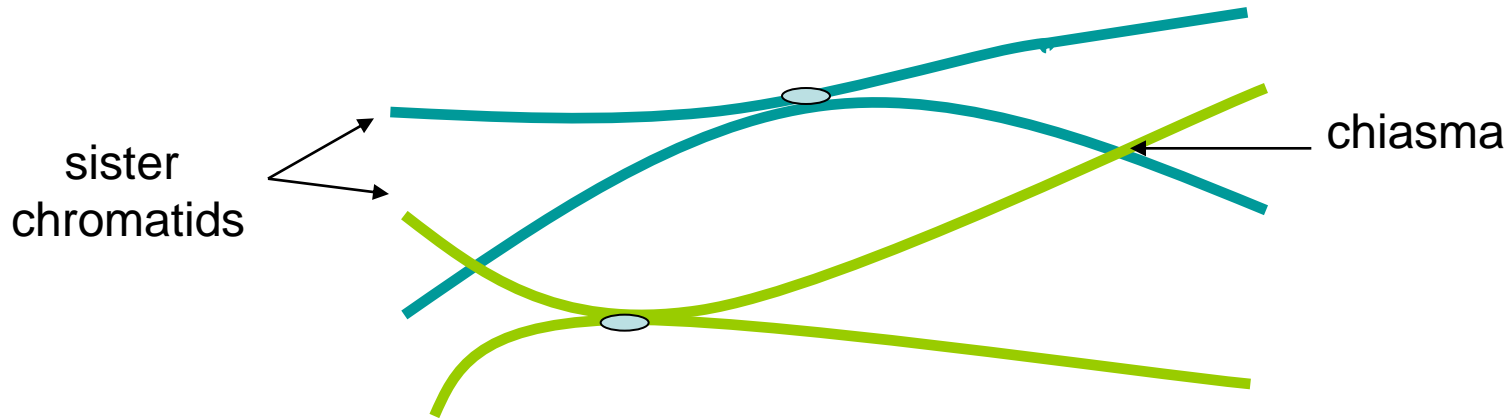
- DNA condenses and chromosomes appear
- As they shorten and open out they reveal their **chromatids**
- Chromatids from one chromosome are referred to as **sister chromatids**
- Homologous chromosomes come together in pairs
- Each chromosome is called a **homologue**
- Together each pair is called a **bivalent** (or tetrad)



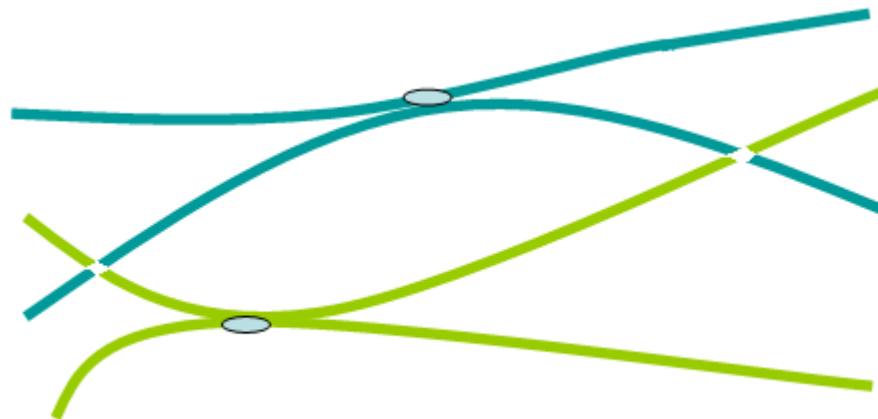
Bivalents:  
each  
chromosome  
composed of  
2 chromatids

- In some places the non-sister chromatids may touch and join.
- The DNA may break at these points and rejoin, **swapping** portions with non-sister chromatids.
- This is called **crossing over** and generates **genetic variation** as the process is **random**.
- The points of exchange are called **chiasmata**.

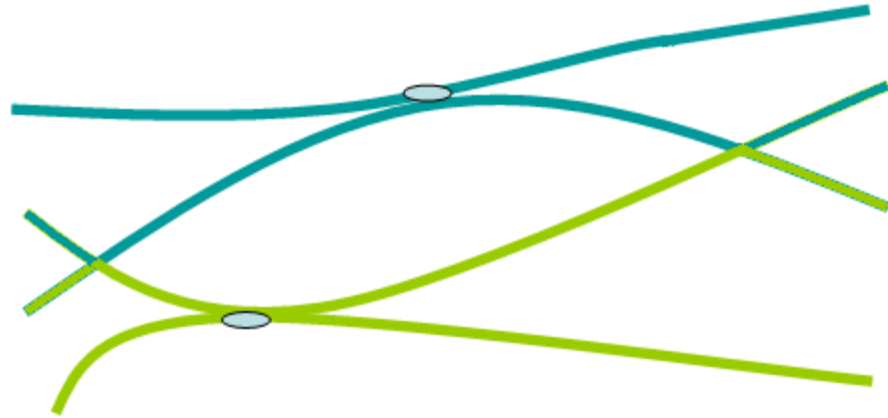
- Non-sister chromatids touch forming chiasma



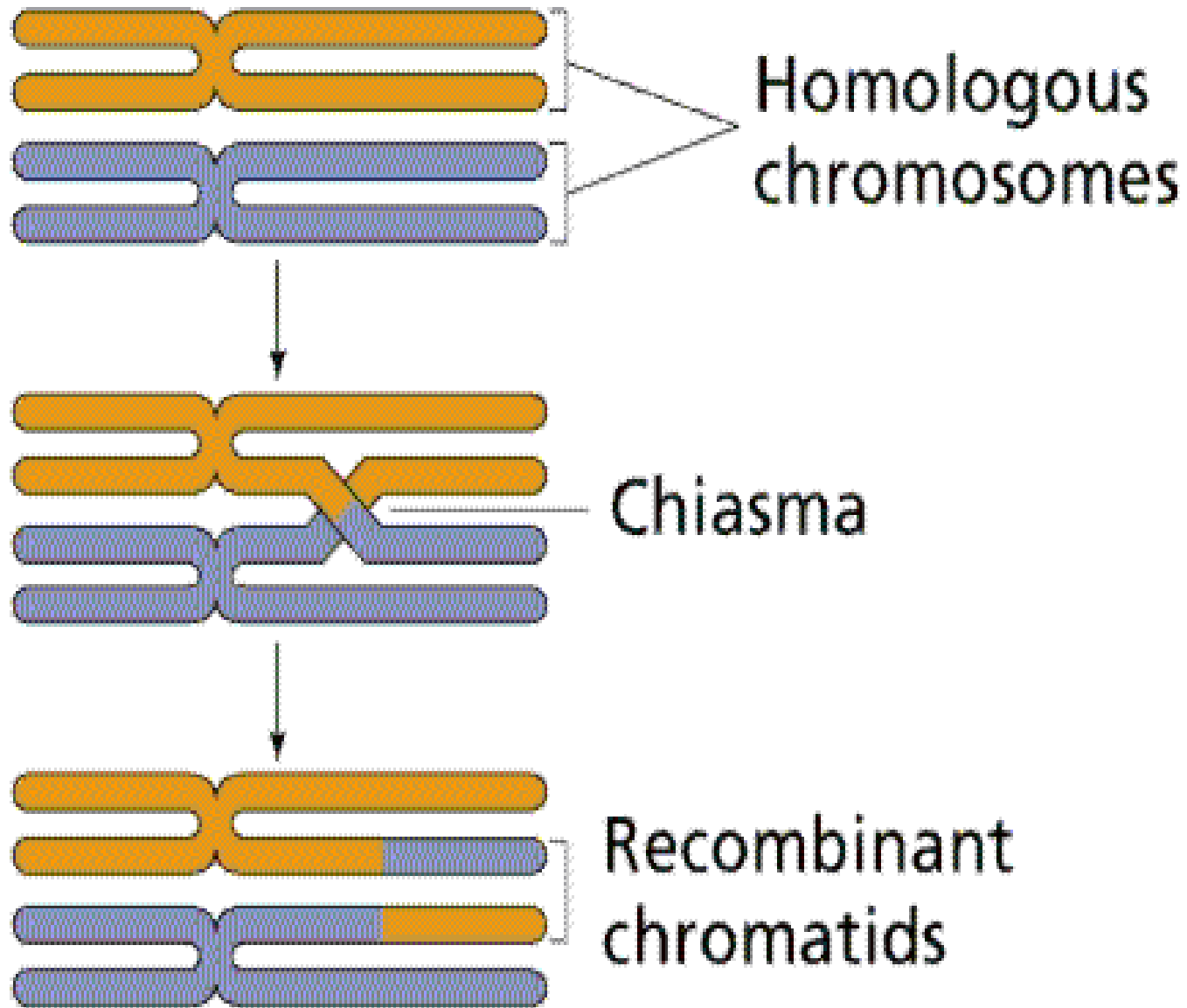
- Non-sister chromatids break at chiasma



- Portions of chromosomes are swapped - **crossing over**
- This gives rise to new combinations of alleles

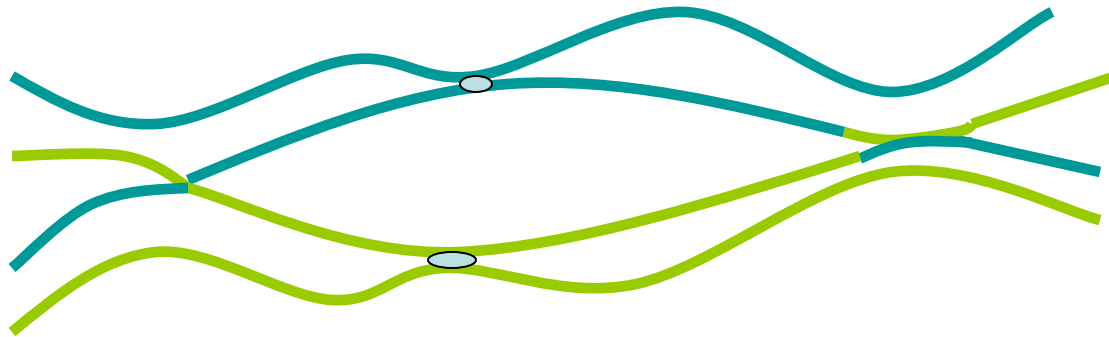


meiosis





- In late prophase 1 the homologues begin to repel each other
- but the chiasmata still hold the chromosomes together and a cross-shaped structure is formed.

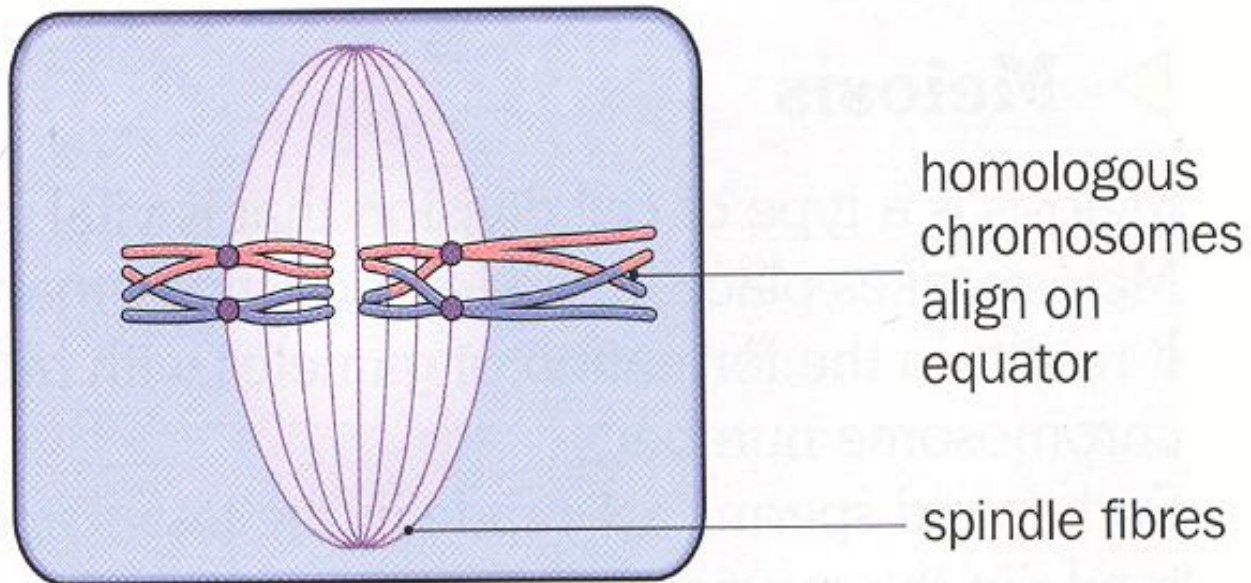


- The disappearance of the nucleoli and the nuclear membrane marks the end of prophase 1

# Metaphase I

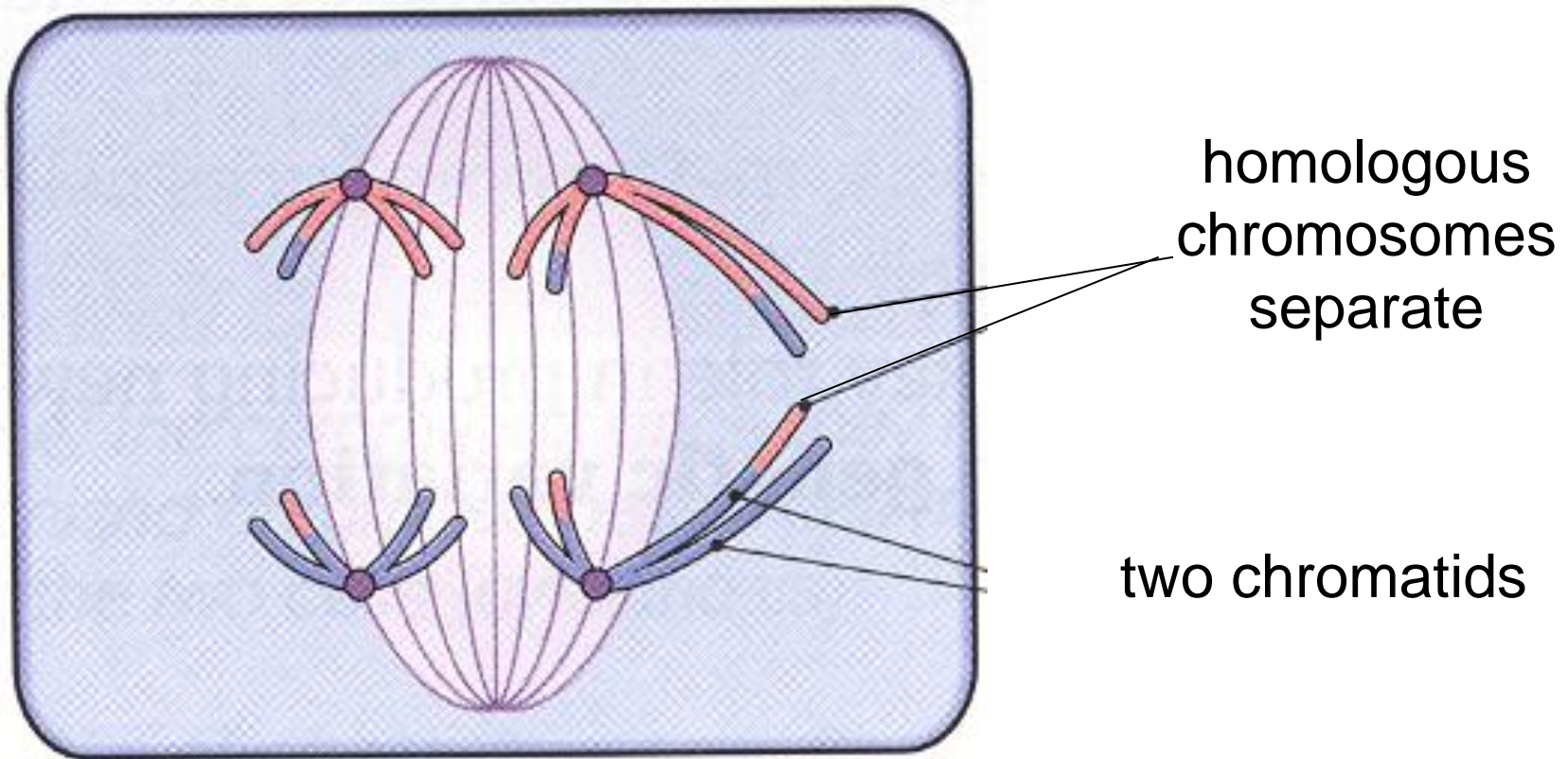
- The spindle forms
- The bivalents attach to the spindle
- The bivalents move towards the equator

*Metaphase I*



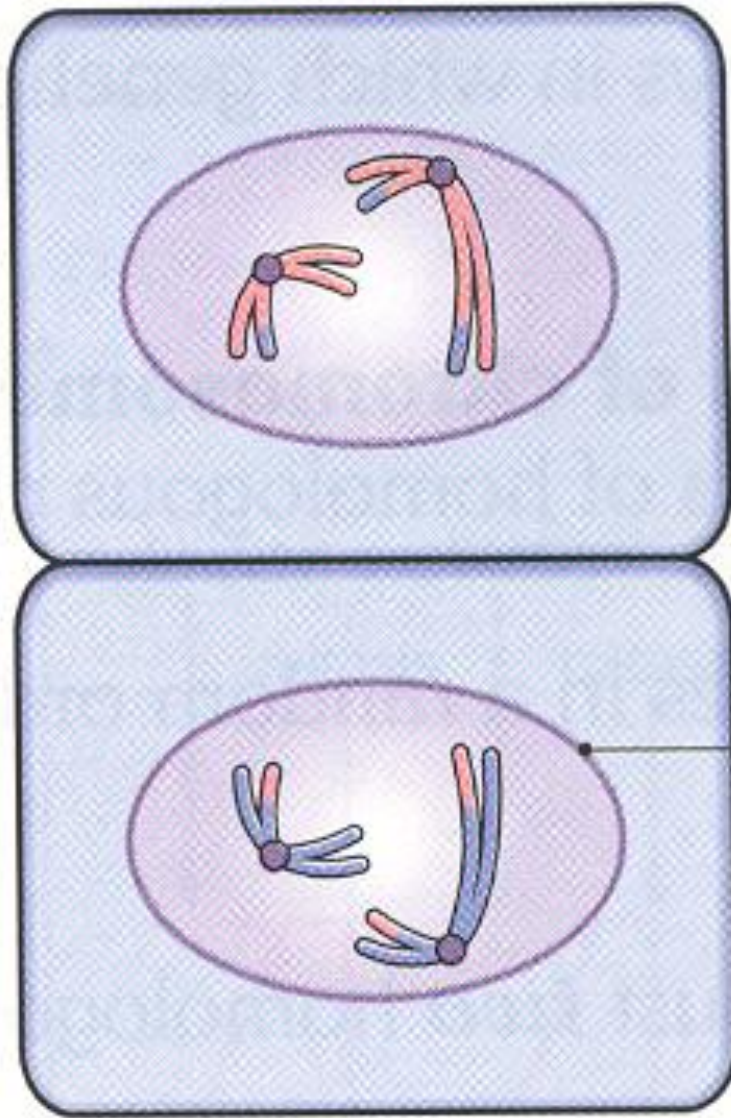
# Anaphase I

➤ Spindle fibres contract and pull the homologous chromosomes apart to opposite poles



# TELOPHASE I

- Chromosomes form 2 groups at either end of the cell and the spindle disappears
- The nuclear membrane reforms.
- Sometimes this phase is indistinct and blends into prophase 2
- At this stage the groups of chromosomes are haploid, but each chromosome is still made up of 2 chromatids



new nuclear  
membrane may  
form

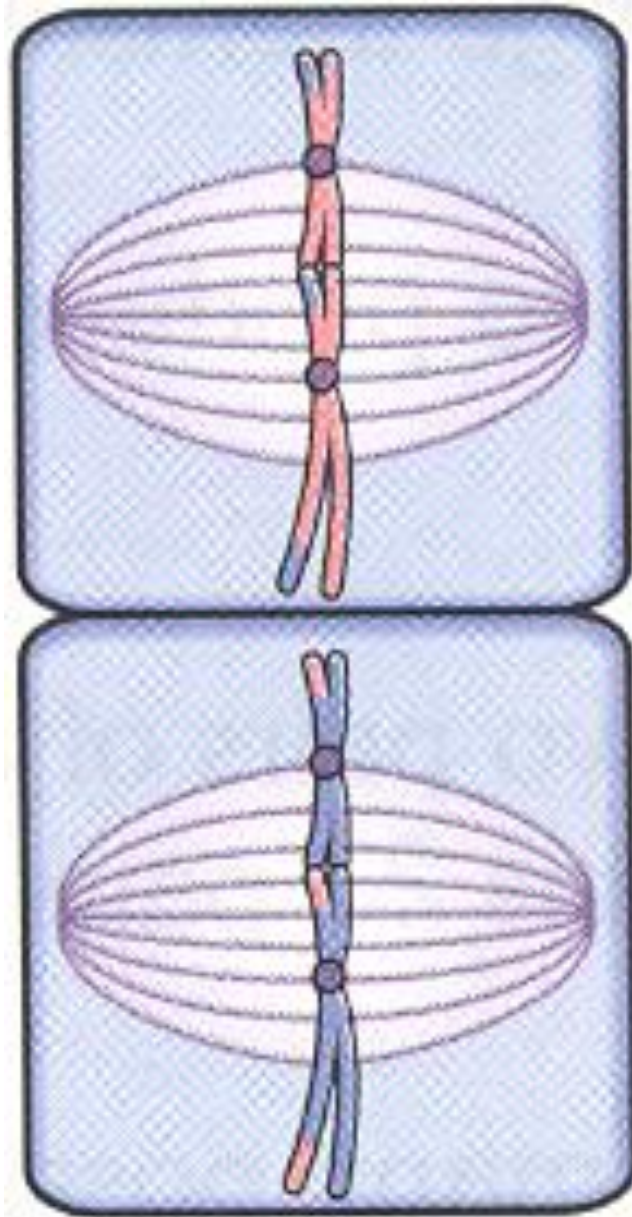
# Prophase II

- New spindle fibres form at right angles to the old spindle
- Nuclear membranes break down
- The chromosomes are no longer in pairs and there is NO crossing over

# Metaphase II

- The chromosomes arrange themselves on the equator of the spindle.
- The chromosomes (composed of two chromatids) attach to the spindle by their centromeres.

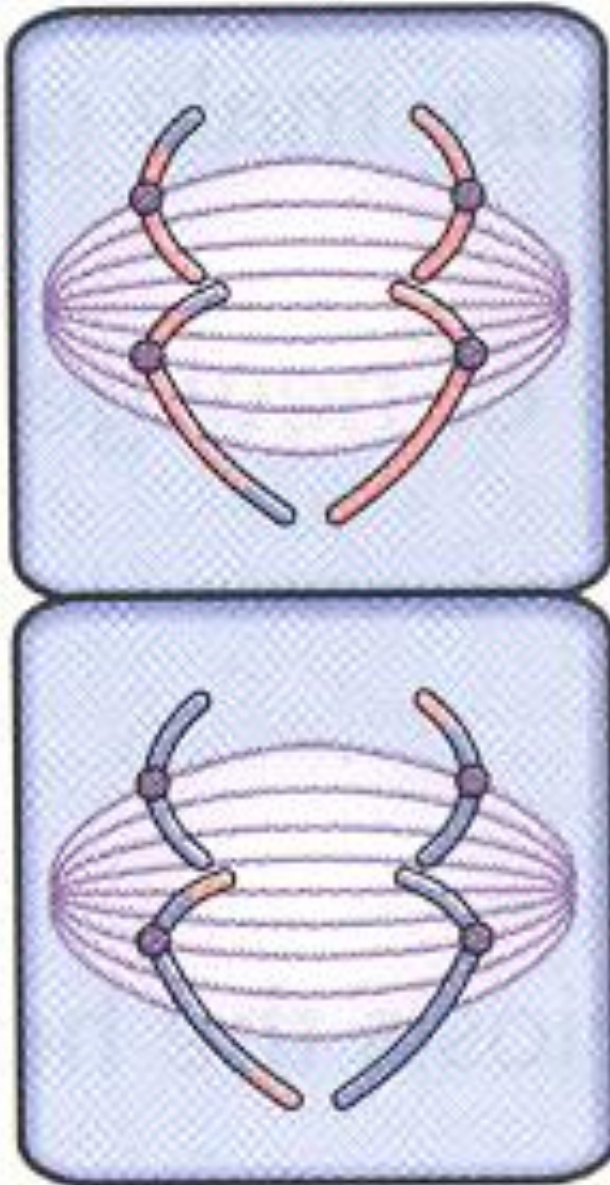




chromosomes align  
on spindle together

# Anaphase II

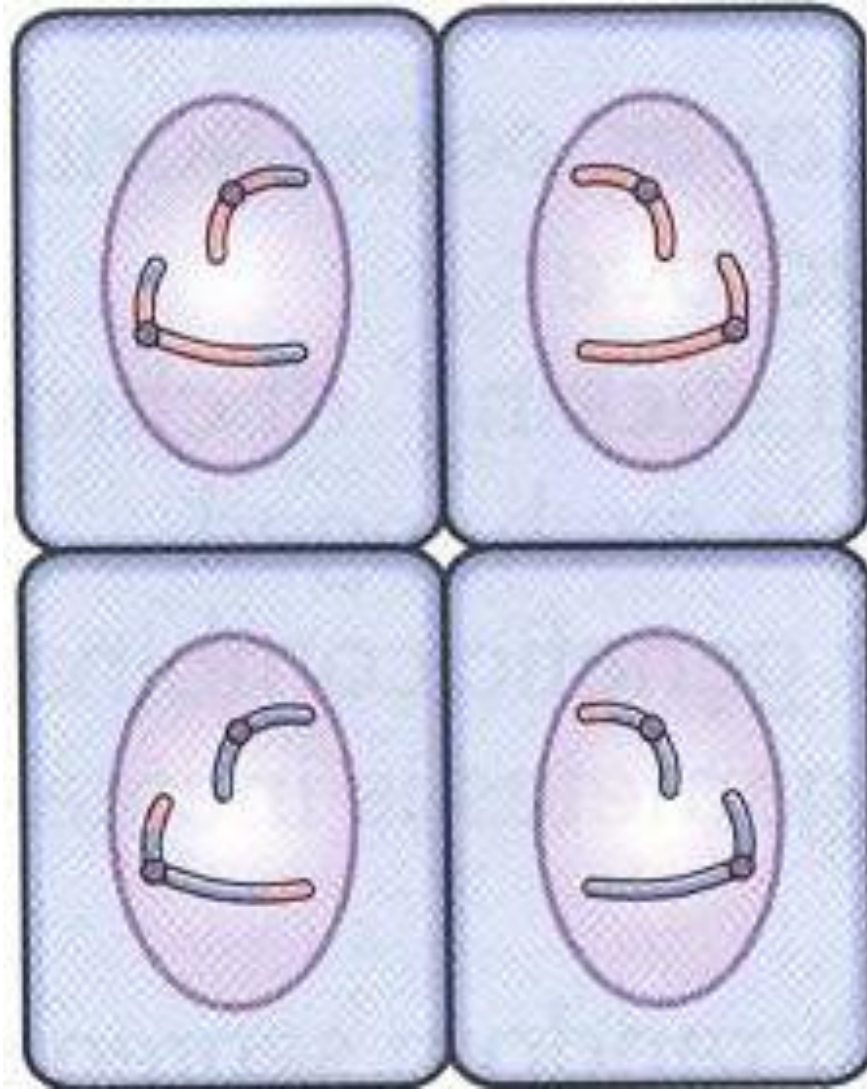
- Centromeres divide and separate
- Sister chromatids get pulled to opposite poles



chromatids separate  
and move to opposite  
poles of the spindle

# TELOPHASE II

- Nuclear membranes form around the 4 groups of chromatids (now chromosomes)
- Chromosomes uncoil and become dispersed **chromatin**
- Nucleoli reappear
- **Cytokinesis** follows
- The 4 new cells are **haploid**.



4 haploid cells each with a different genetic make up

# meiosis whf

Cells alive meiosis

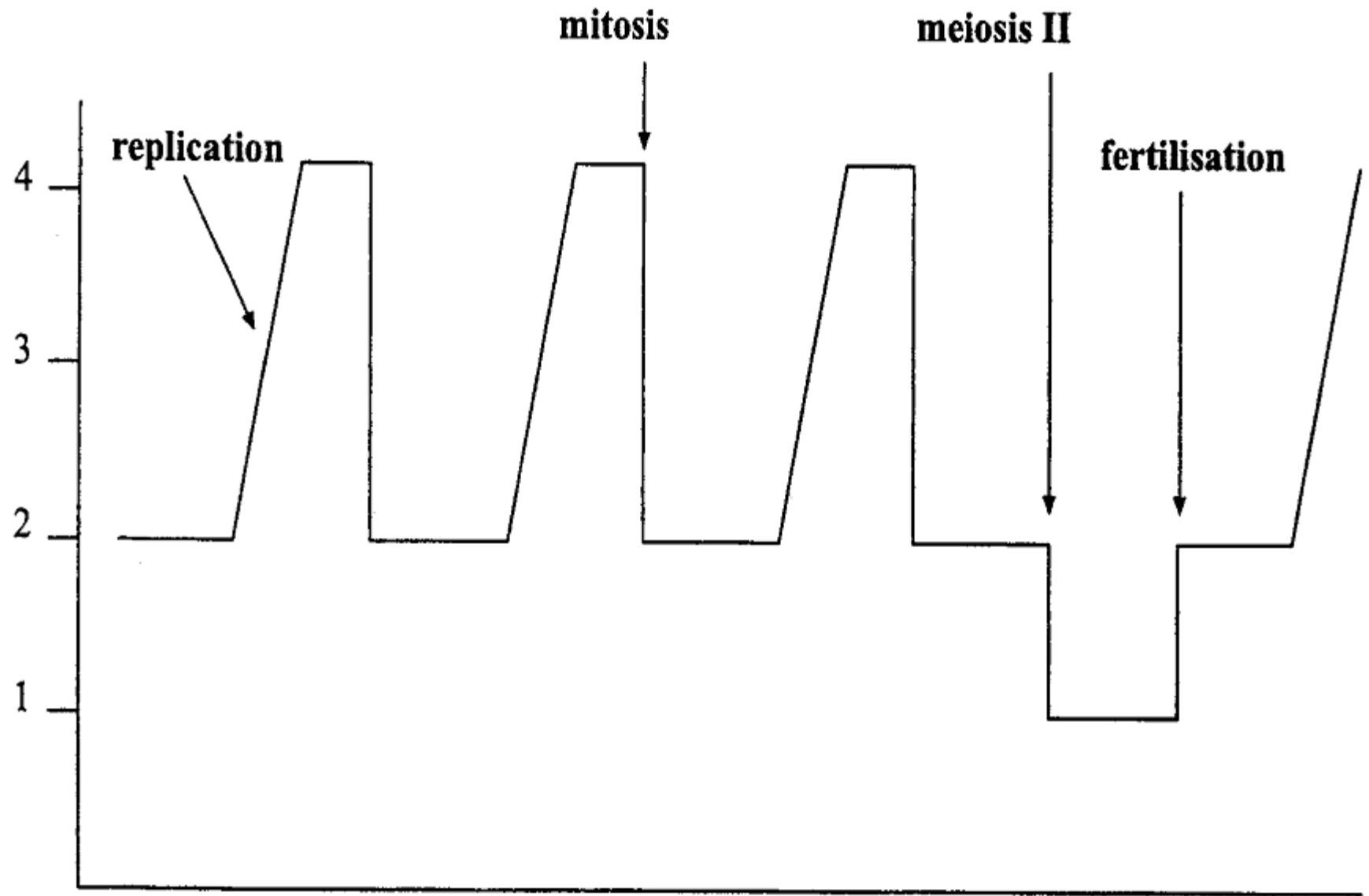
Interactive quiz to id stages of meiosis

<http://bcs.whfreeman.com/thelifewire/content/chp09/0903004.html>

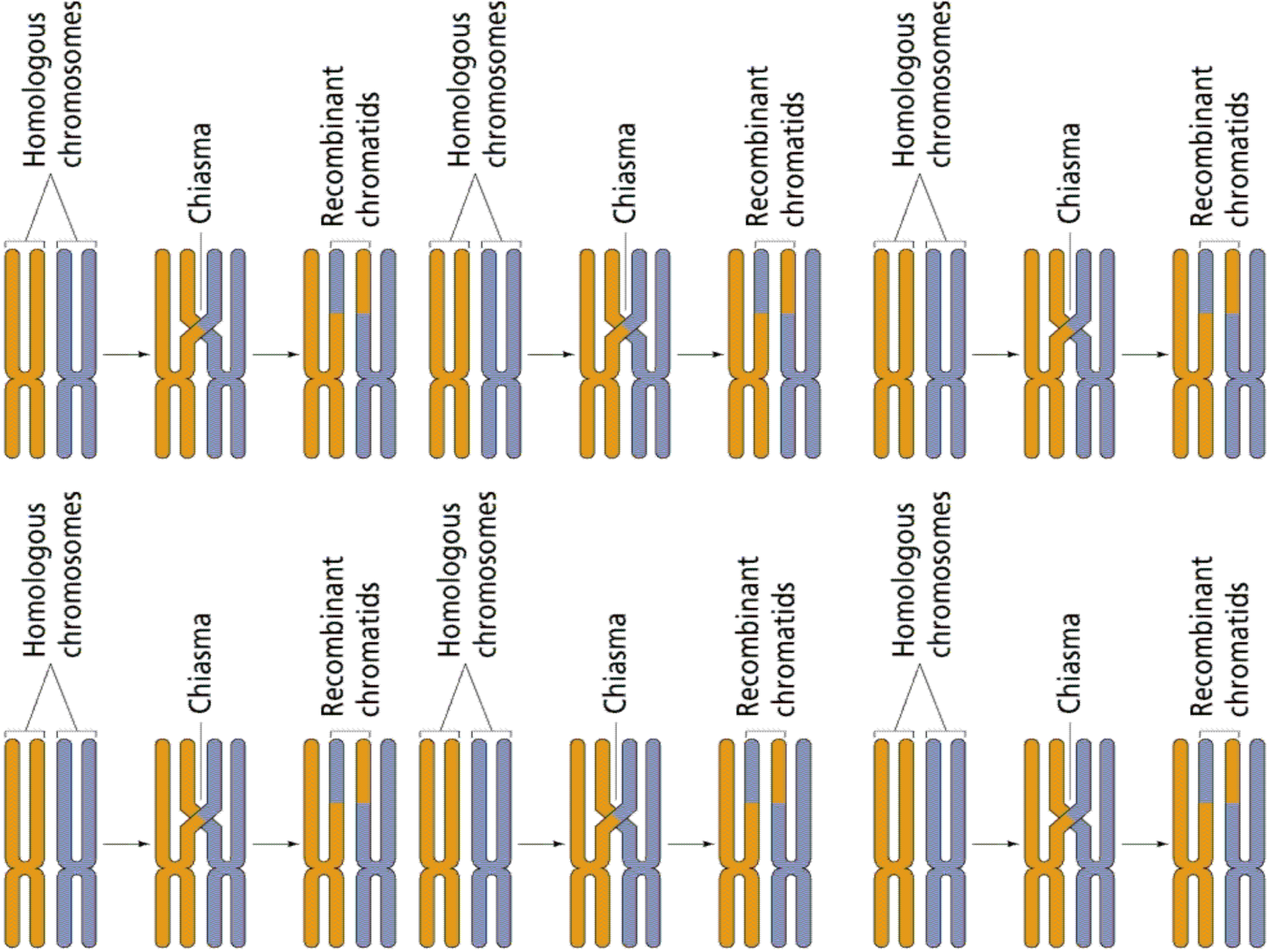
# Differences between Mitosis & Meiosis

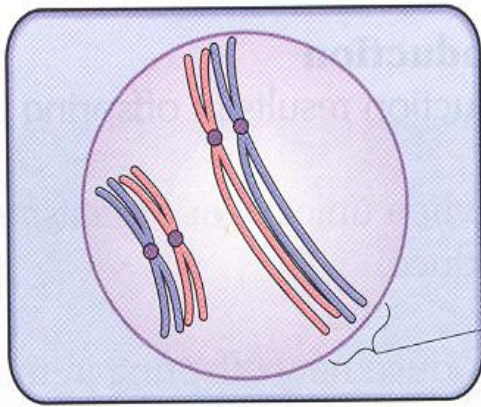
| <b>Mitosis</b>  | <b>Meiosis</b>  |
|---|---|
| <ul style="list-style-type: none"><li>• one division/two daughter cells</li></ul>       | two divisions/four daughter cells                       |
| <ul style="list-style-type: none"><li>• may occur in diploid or haploid cell</li></ul>  | occurs only in diploid cells                            |
| <ul style="list-style-type: none"><li>• no change in chromosome number</li></ul>        | chromosome number reduced from diploid to haploid       |
| <ul style="list-style-type: none"><li>• chromosomes do not associate in pairs</li></ul> | homologous chromosomes pair                             |
| <ul style="list-style-type: none"><li>• alleles remain in sequence</li></ul>            | alleles may be exchanged between homologous chromosomes |
| <ul style="list-style-type: none"><li>• nuclear clones result</li></ul>                 | nuclei not identical                                    |

DNA content of cell/arbitrary units

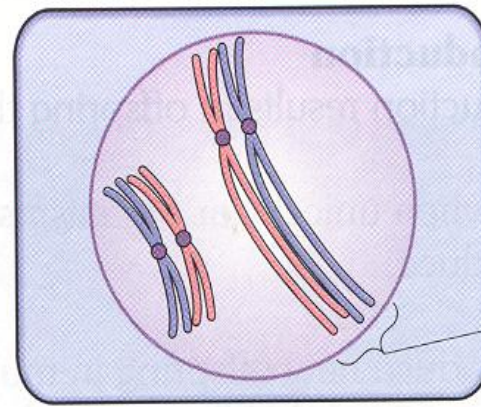




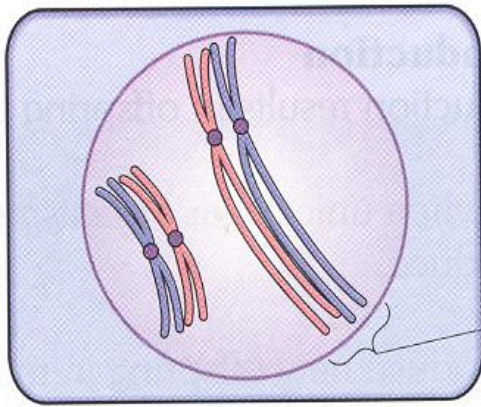




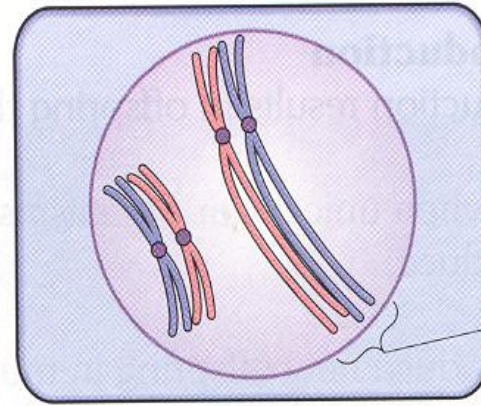
bivalent – two chromosomes split into two chromatids



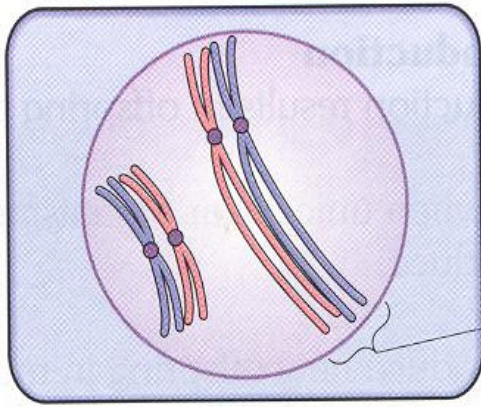
bivalent – two chromosomes split into two chromatids



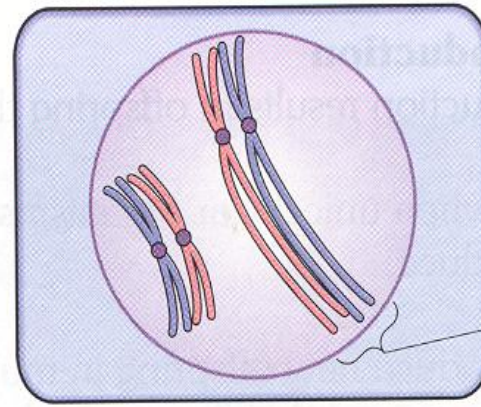
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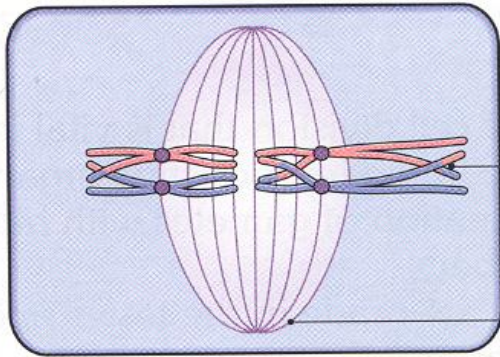


bivalent – two chromosomes split into two chromatids



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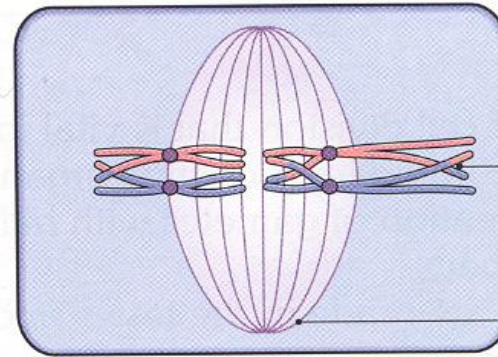
*Metaphase I*



homologous chromosomes align on equator

spindle fibres

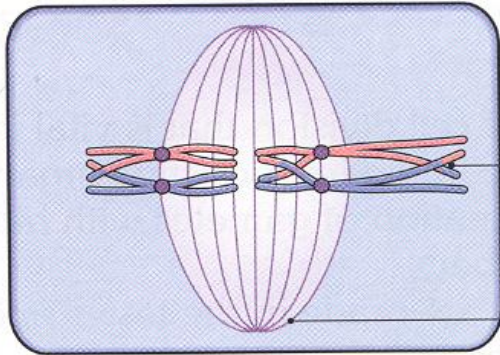
*Metaphase I*



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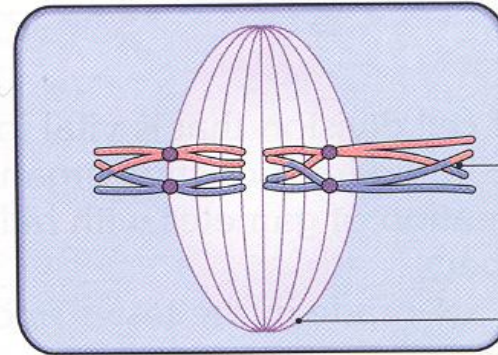
*Metaphase I*



homologous chromosomes align on equator

spindle fibres

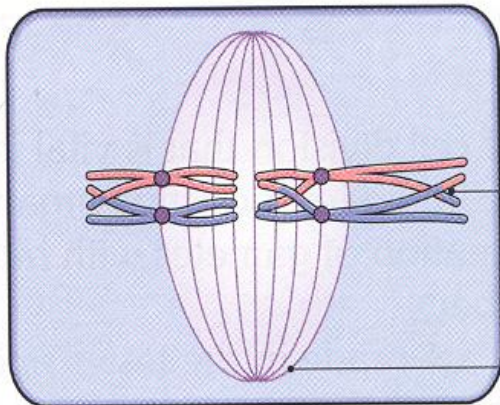
*Metaphase I*



homologous chromosomes align on equator

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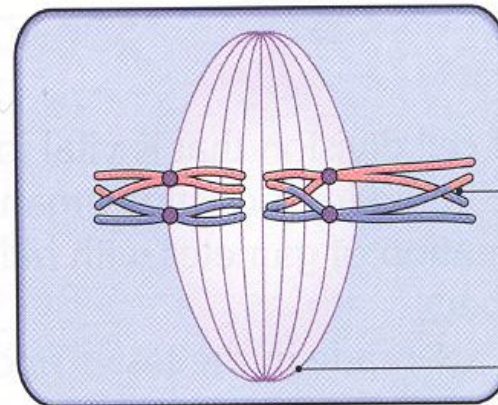
*Metaphase I*



homologous chromosomes align on equator

spindle fibres

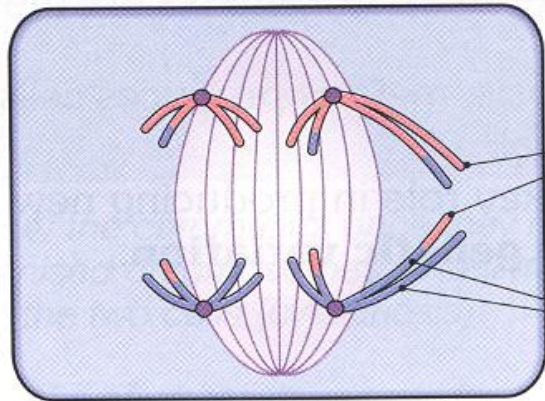
*Metaphase I*



homologous chromosomes align on equator

spindle fibres

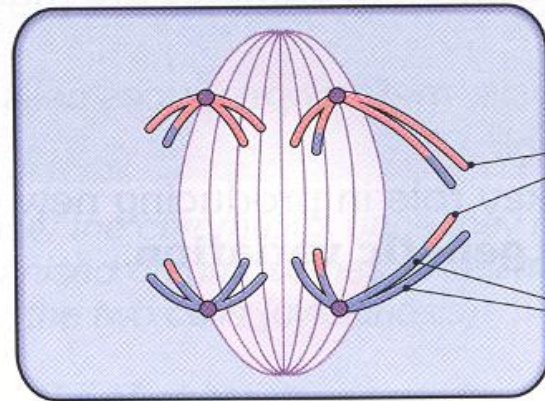
*Anaphase I*



homologous chromosomes separate

two chromatids

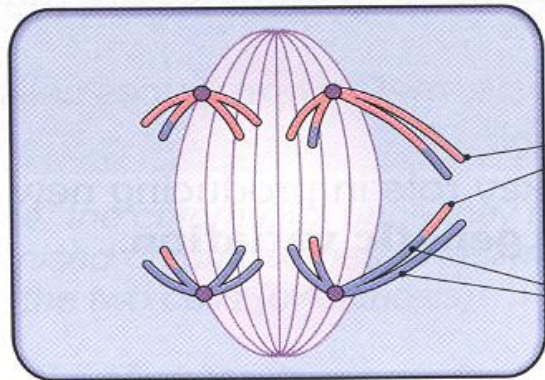
*Anaphase I*



homologous chromosomes separate

two chromatids

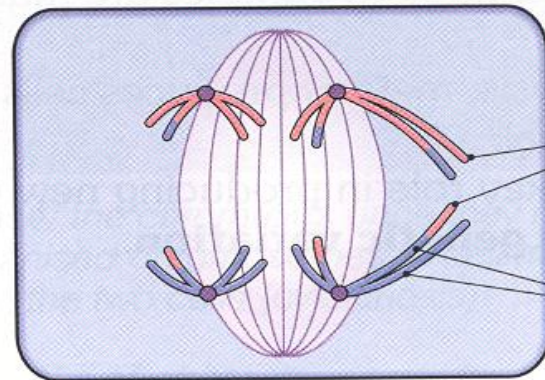
*Anaphase I*



homologous chromosomes separate

two chromatids

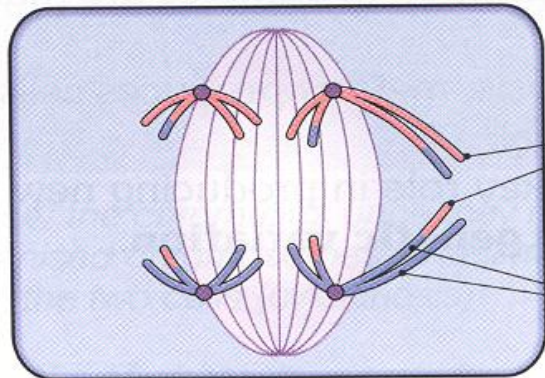
*Anaphase I*



homologous chromosomes separate

two chromatids

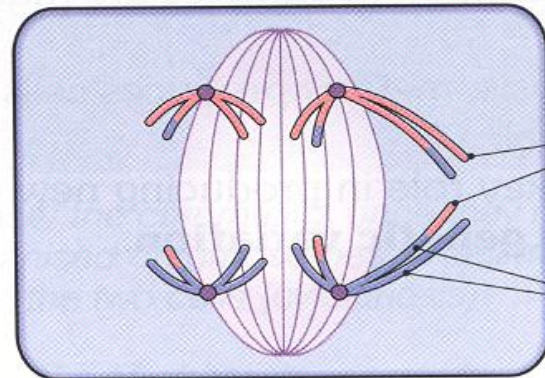
*Anaphase I*



homologous chromosomes separate

two chromatids

*Anaphase I*

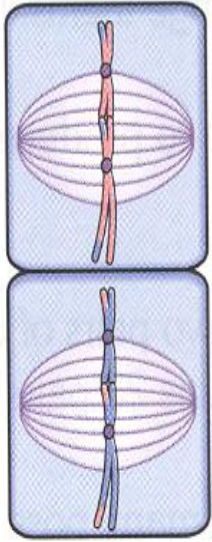


homologous chromosomes separate

two chromatids

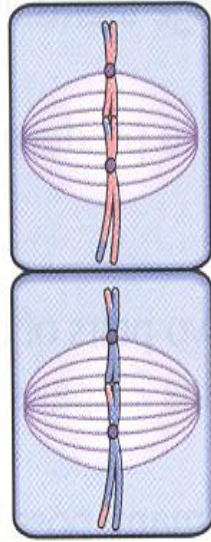


*Metaphase II*



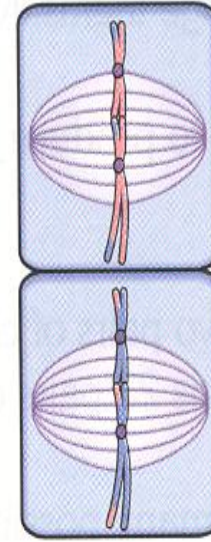
chromosomes align  
on spindle together

*Metaphase II*



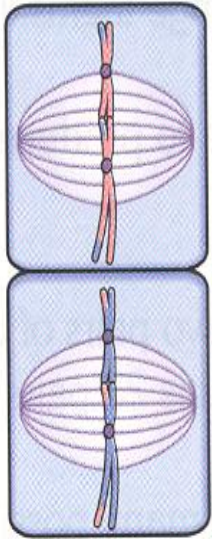
chromosomes align  
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*Metaphase II*



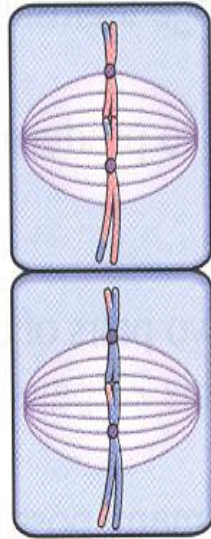
chromosomes align  
on spindle together

*Metaphase II*



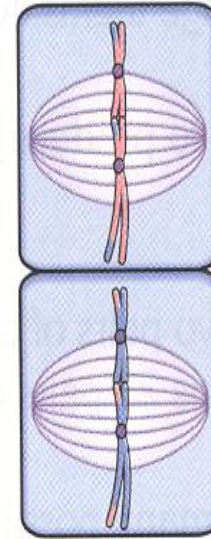
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on spindle together

*Metaphase II*



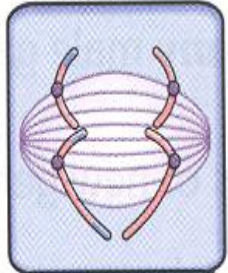
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*Metaphase II*

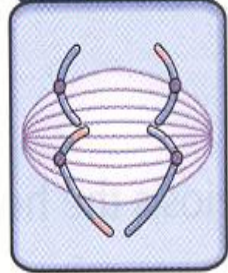


chromosomes align  
on spindle together

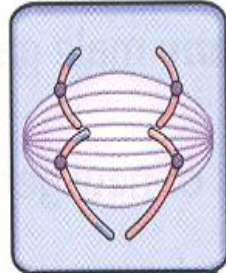
*Anaphase II*



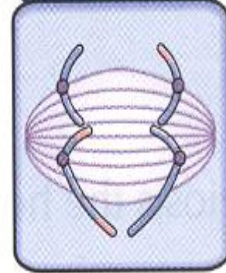
chromatids separate  
and move to opposite  
poles of spindle



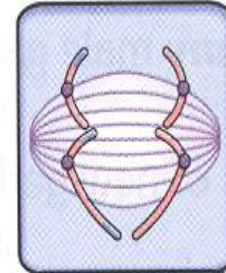
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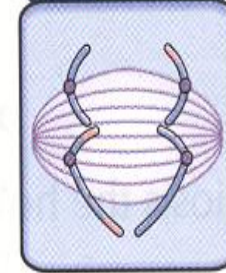
chromatids separate  
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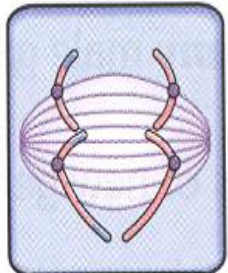
*Anaphase II*



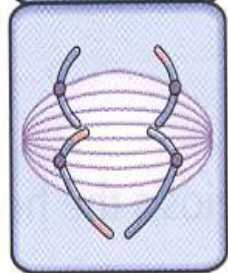
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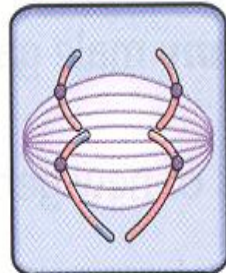
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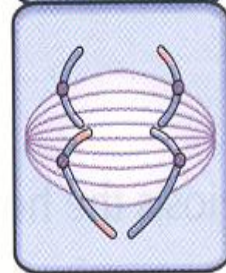
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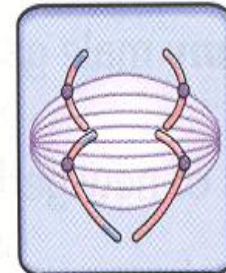
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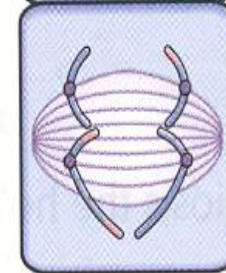
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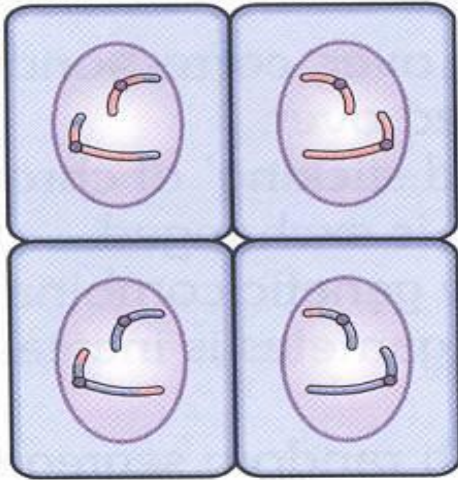
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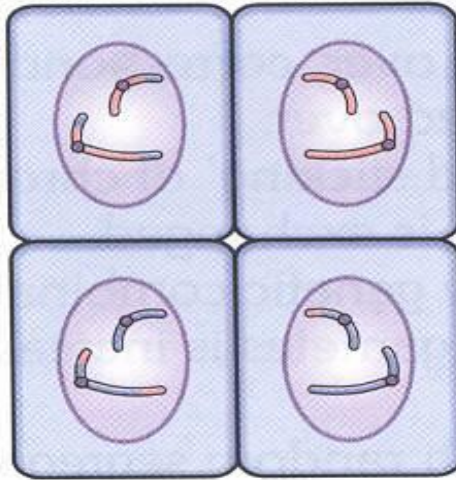
chromatids separate  
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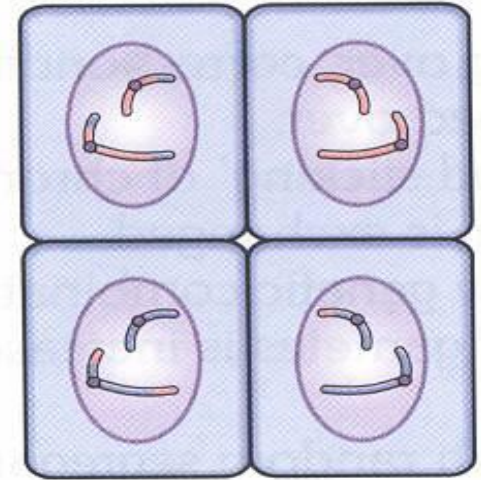
*Telophase II*



*Telophase II*



*Telophase II*

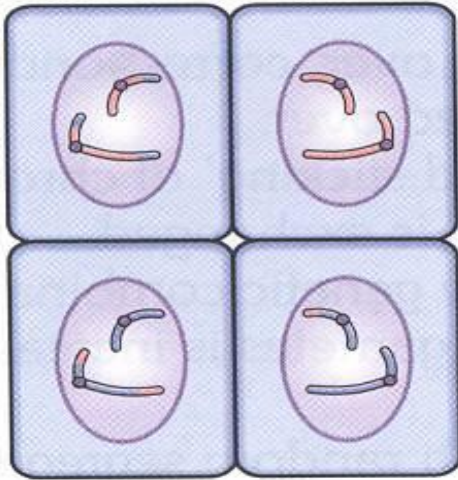


4 haploid cells each with a different genetic make up

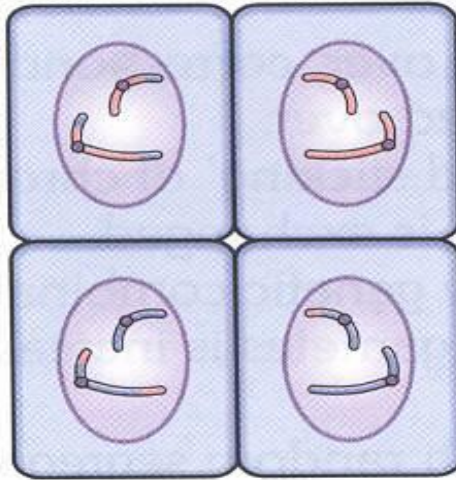
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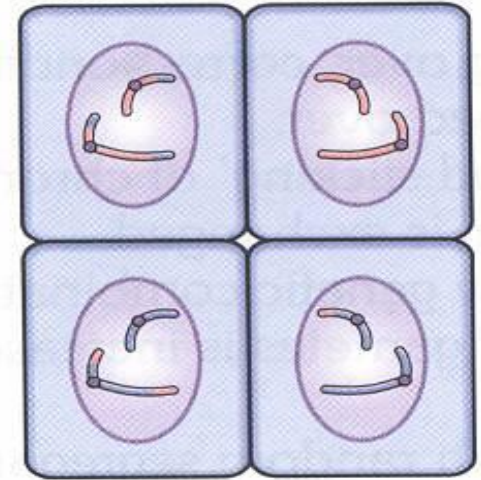
*Telophase II*



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*Telophase II*



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