

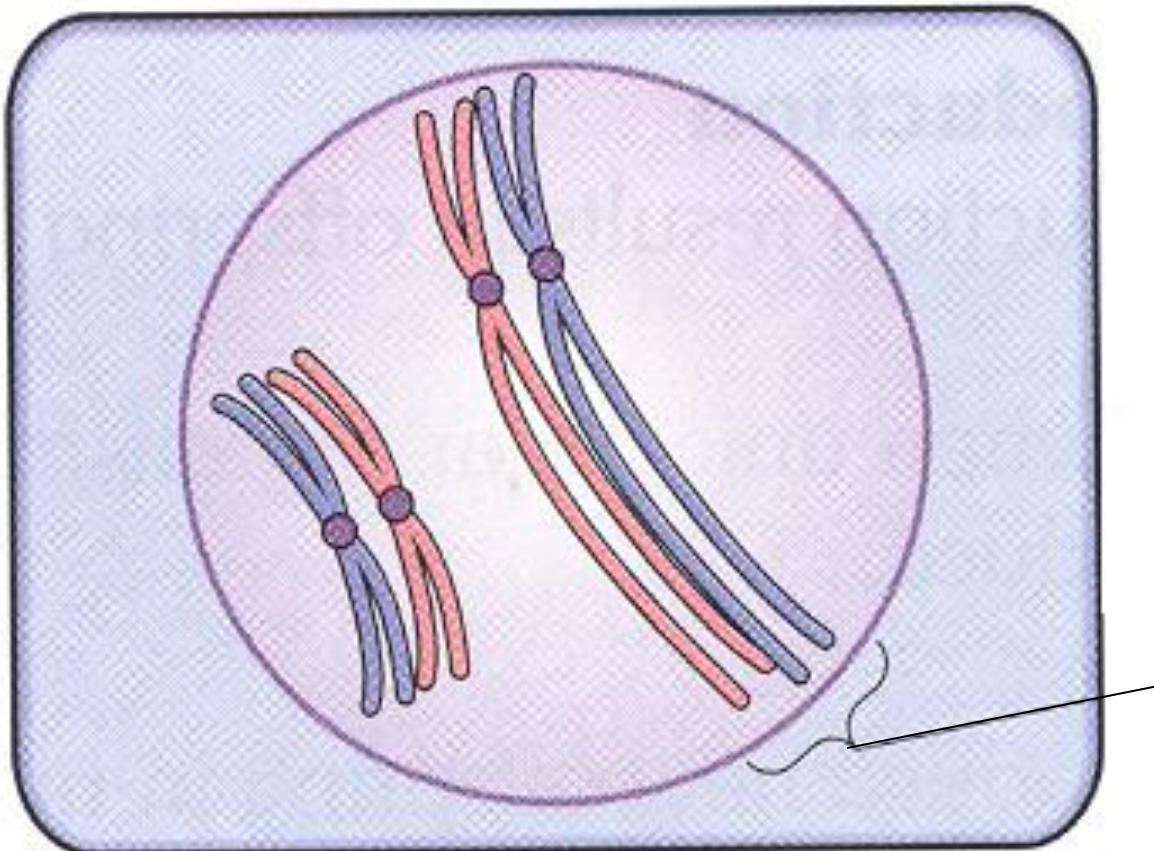
Meiosis

- 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

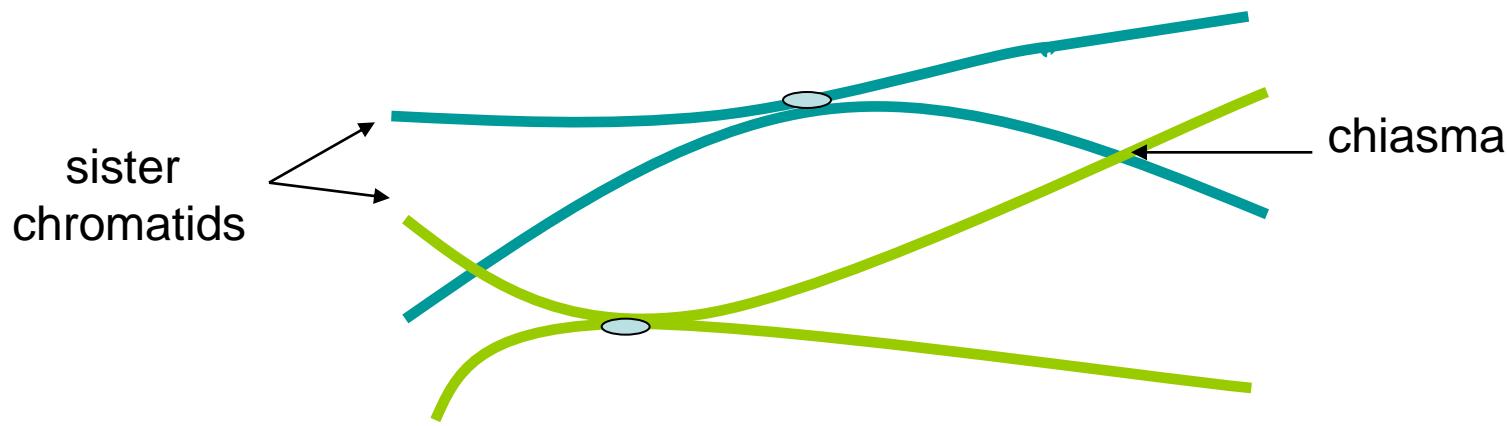
- DNA condenses and chromosomes appear
- As they shorten and open out they reveal their **chromatids**
- Chromatids from one chromosome are referred to as **sister chromatids**
- Homologous chromosomes come together in pairs
- Each chromosome is called a **homologue**
- Together each pair is called a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



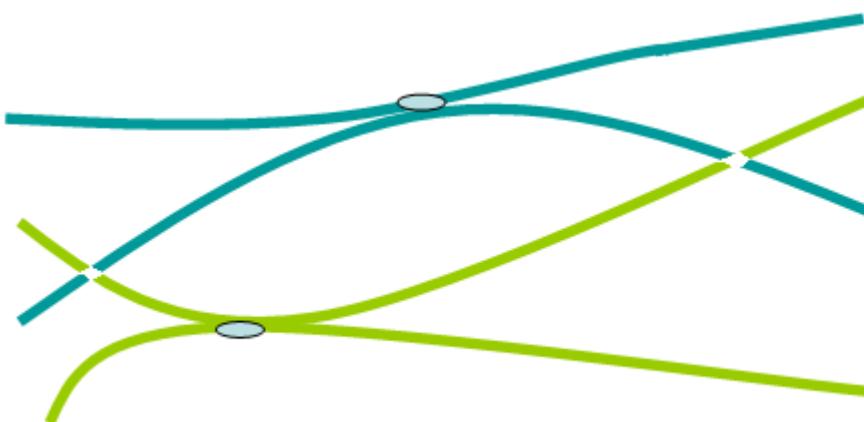
Bivalents:
each
chromosome
composed of
2 chromatids

- 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**.

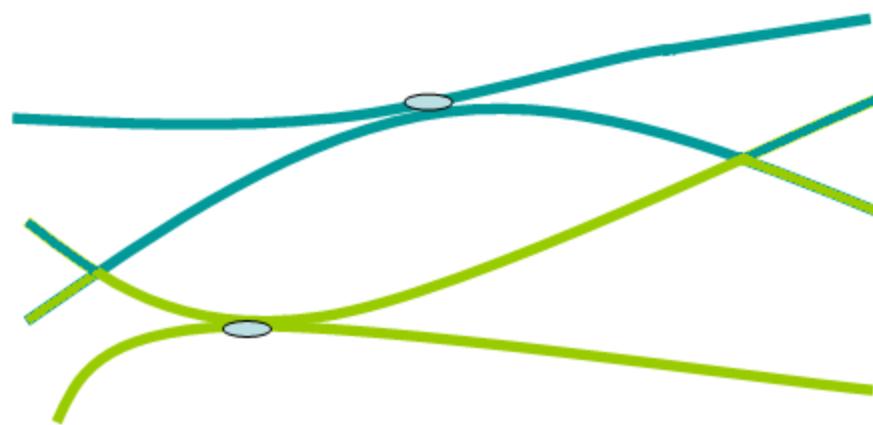
- Non-sister chromatids touch forming chiasma



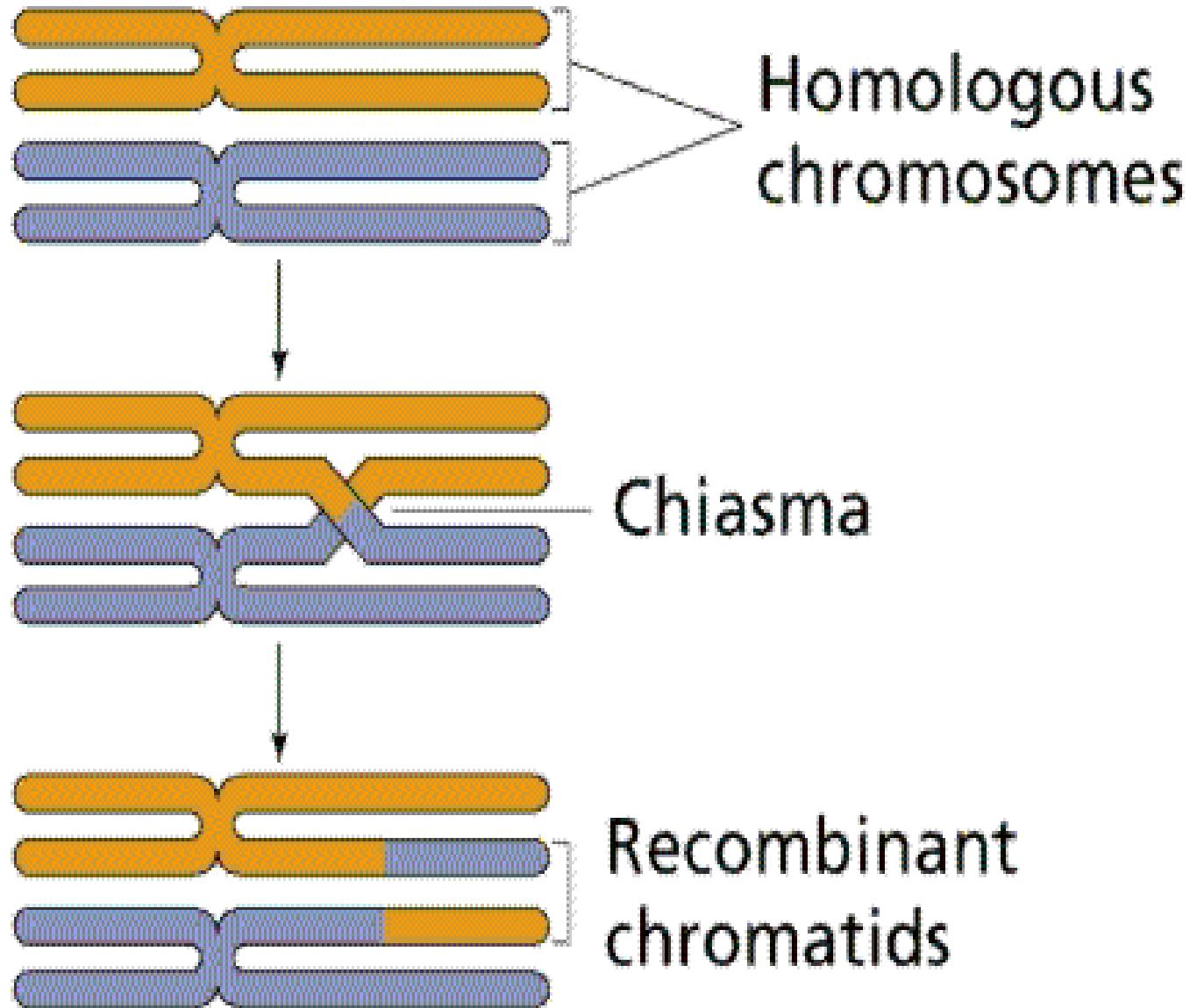
- Non-sister chromatids break at chiasma



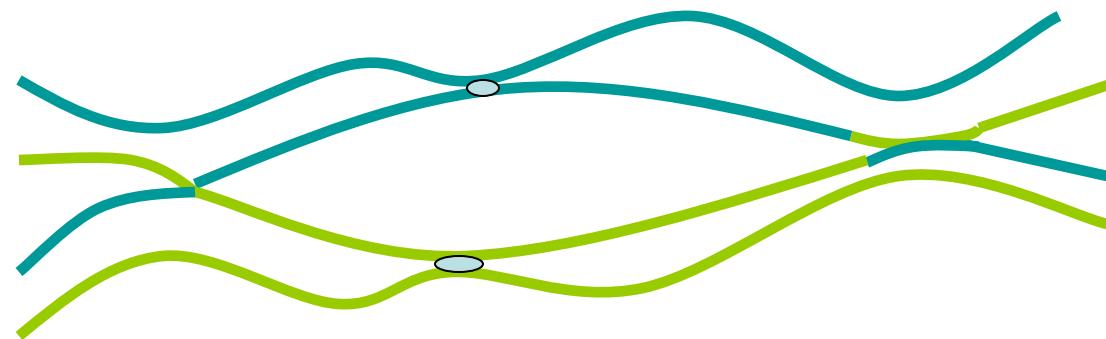
- Portions of chromosomes are swapped - crossing over
- This gives rise to new combinations of alleles



meiosis



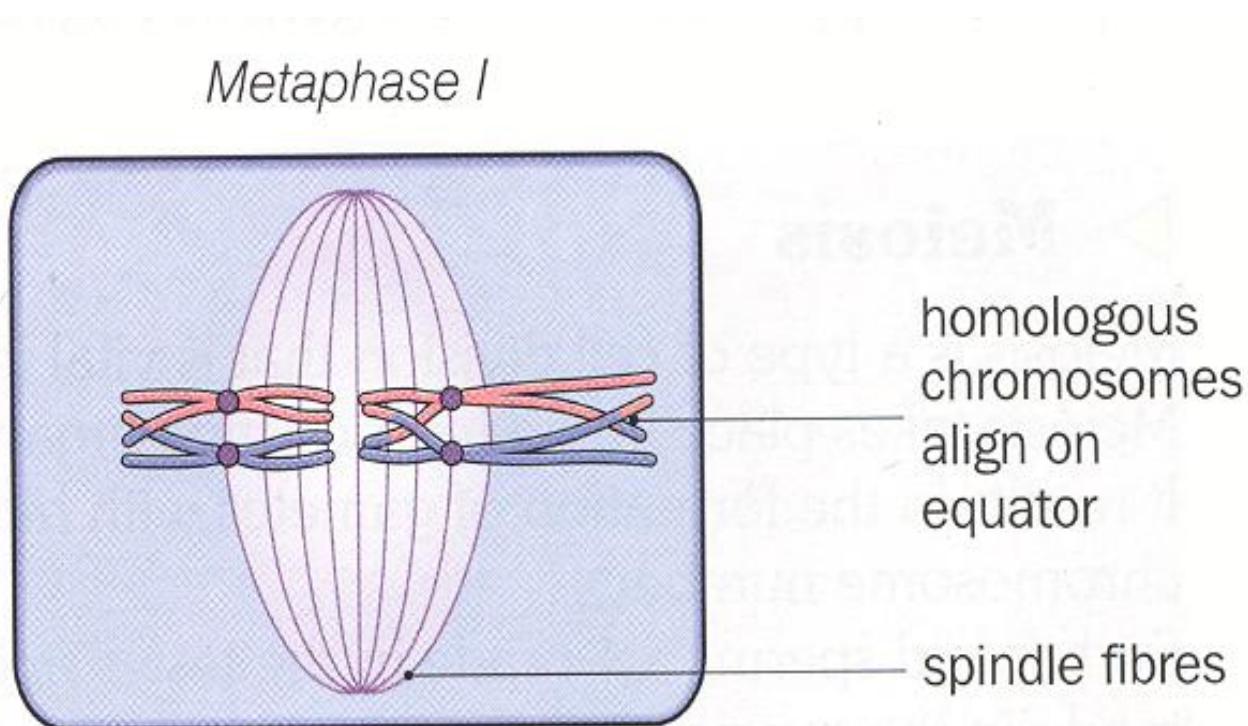
- In late prophase 1 the homologues begin to repel each other
- but the chiasmata still hold the chromosomes together and a cross-shaped structure is formed.



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

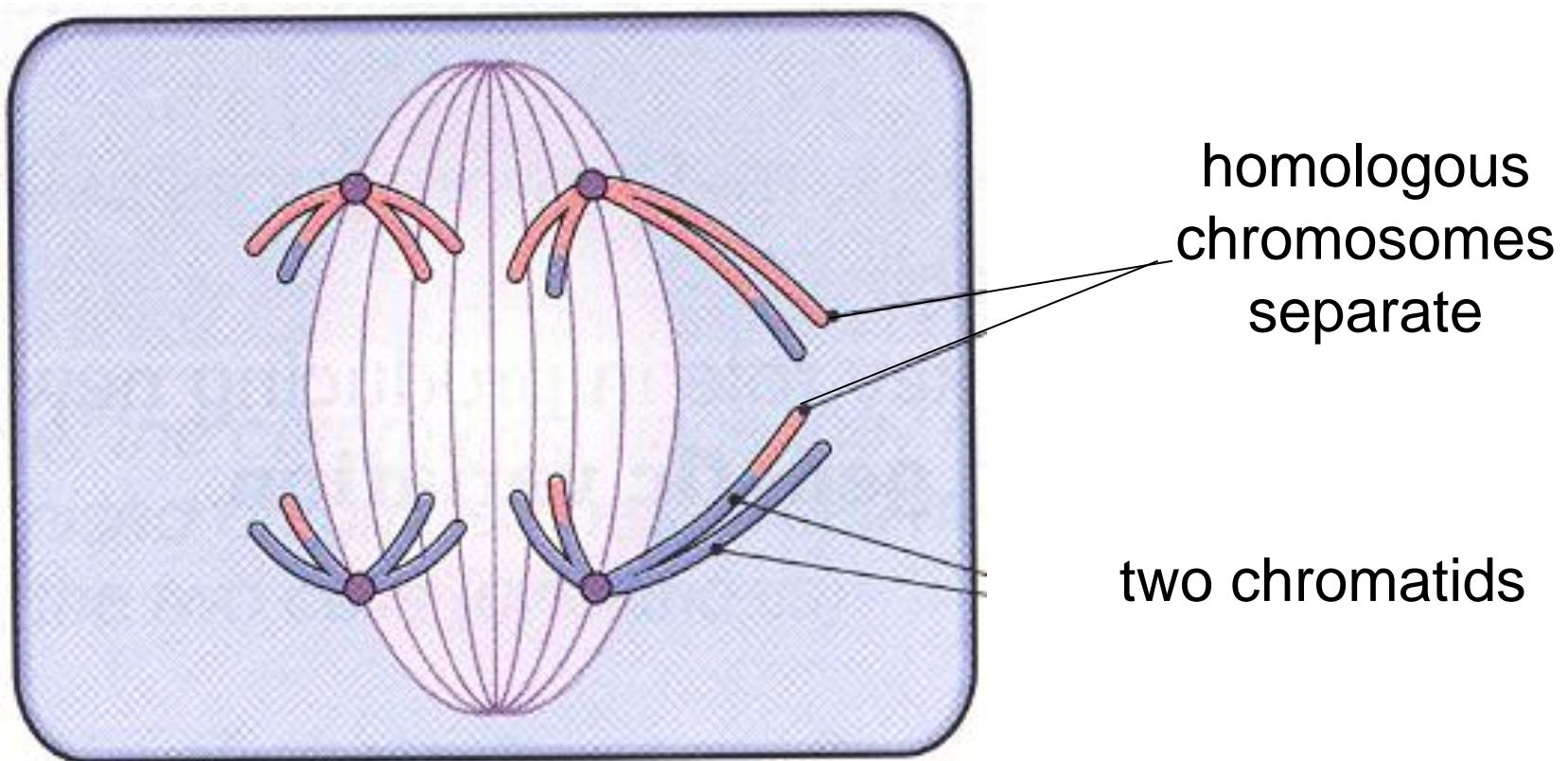
Metaphase I

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



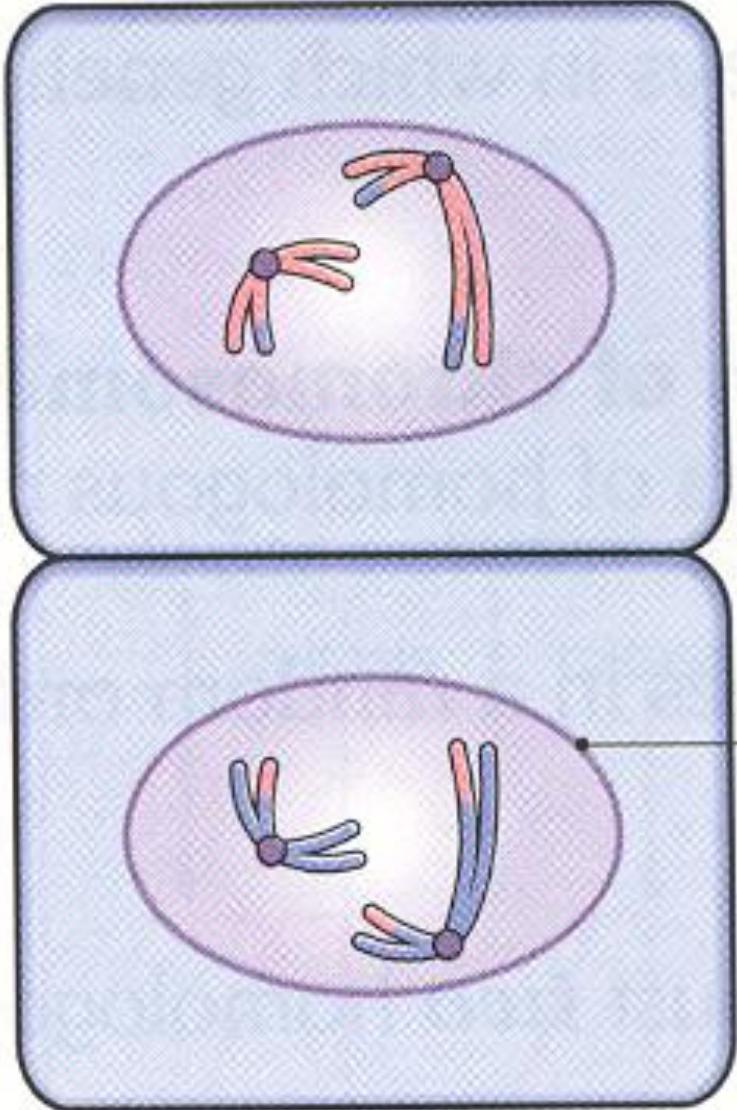
Anaphase I

- 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



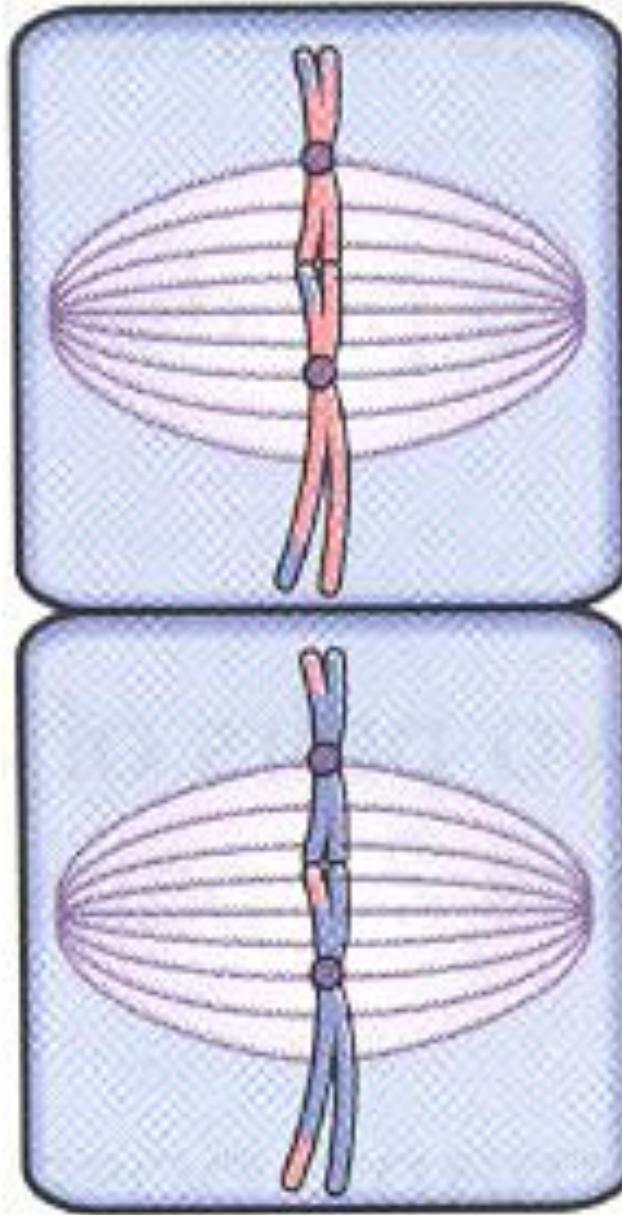
new nuclear
membrane may
form

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

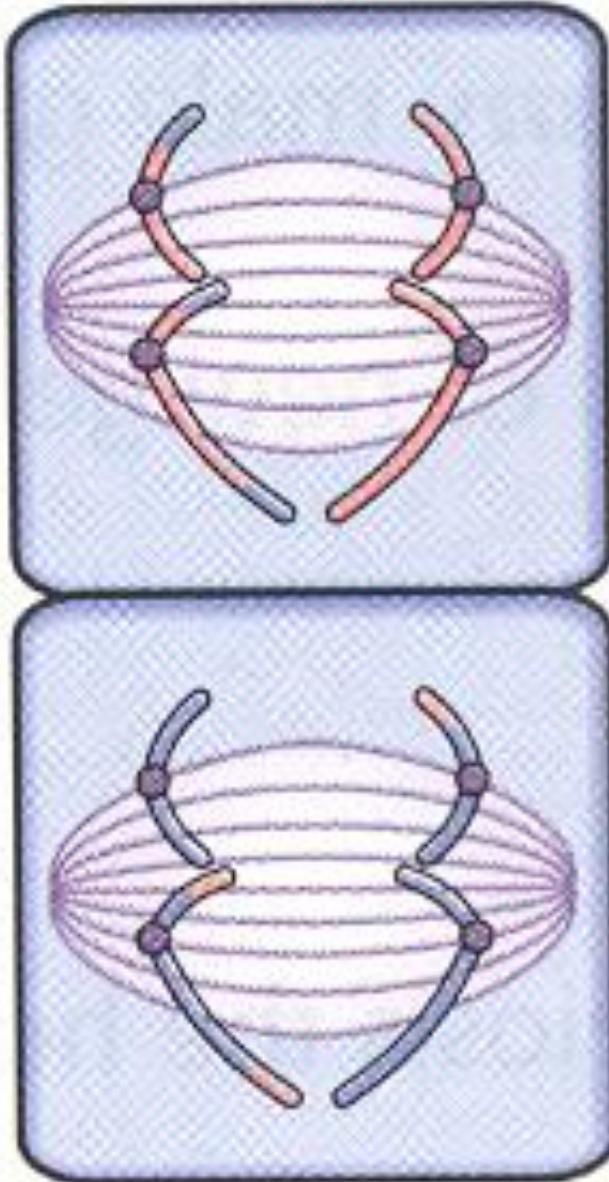
- The chromosomes arrange themselves on the equator of the spindle.
- The chromosomes (composed of two chromatids) attach to the spindle by their centromeres.



chromosomes align
on spindle together

Anaphase II

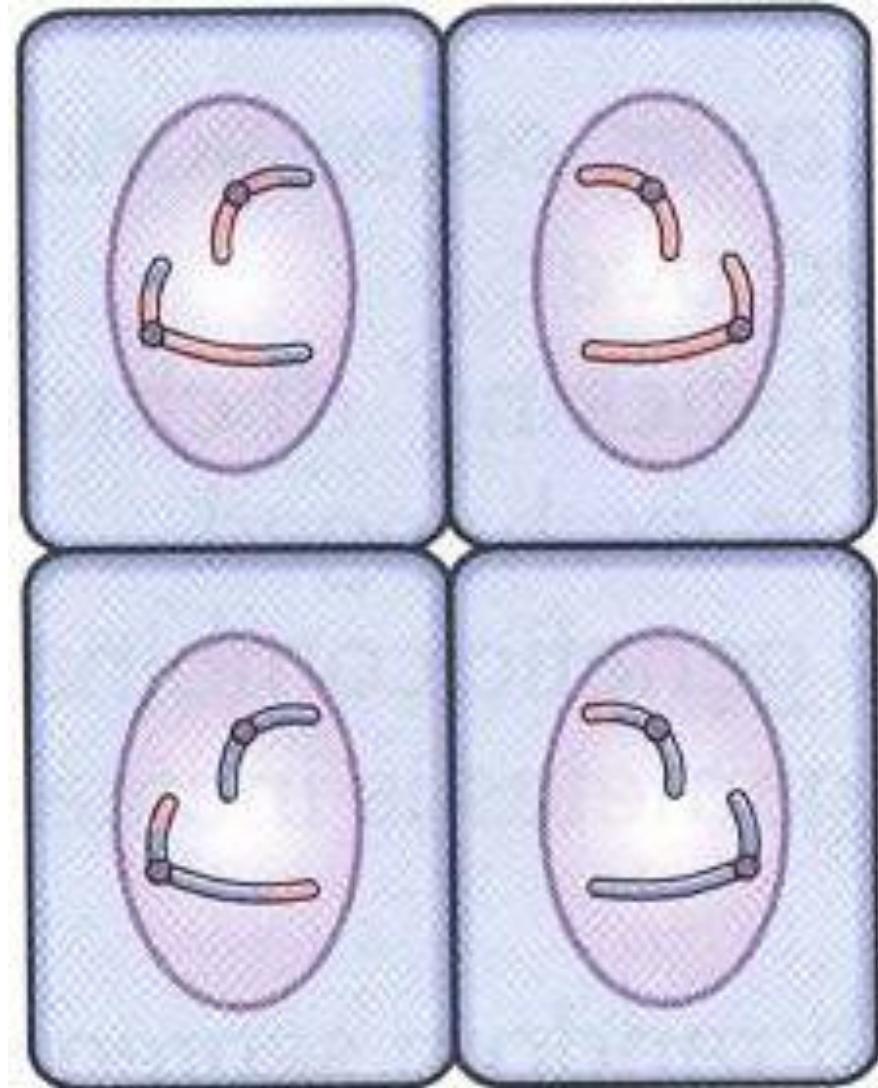
- Centromeres divide and separate
- Sister chromatids get pulled to opposite poles



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

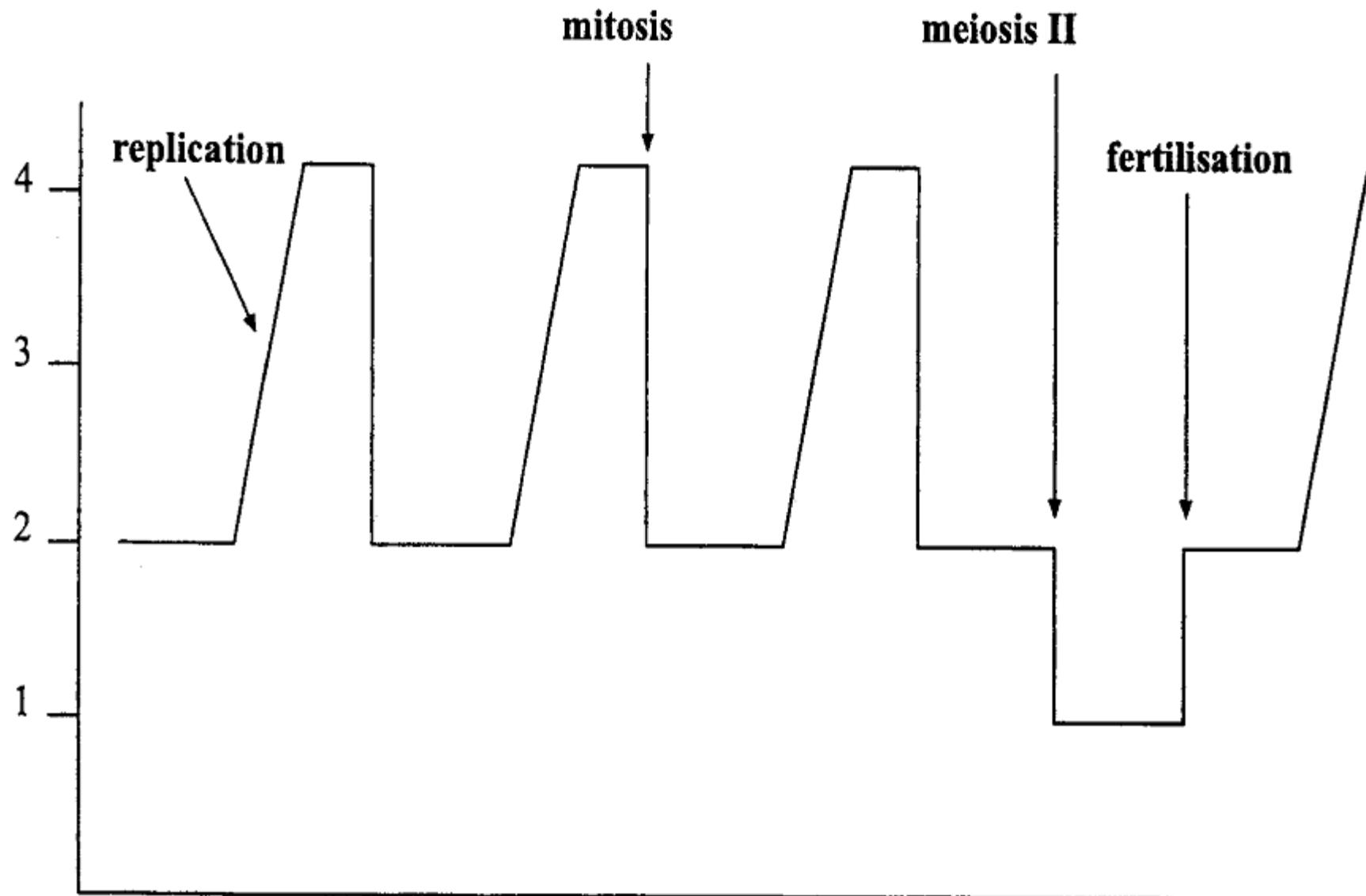
Interactive quiz to id stages of meiosis

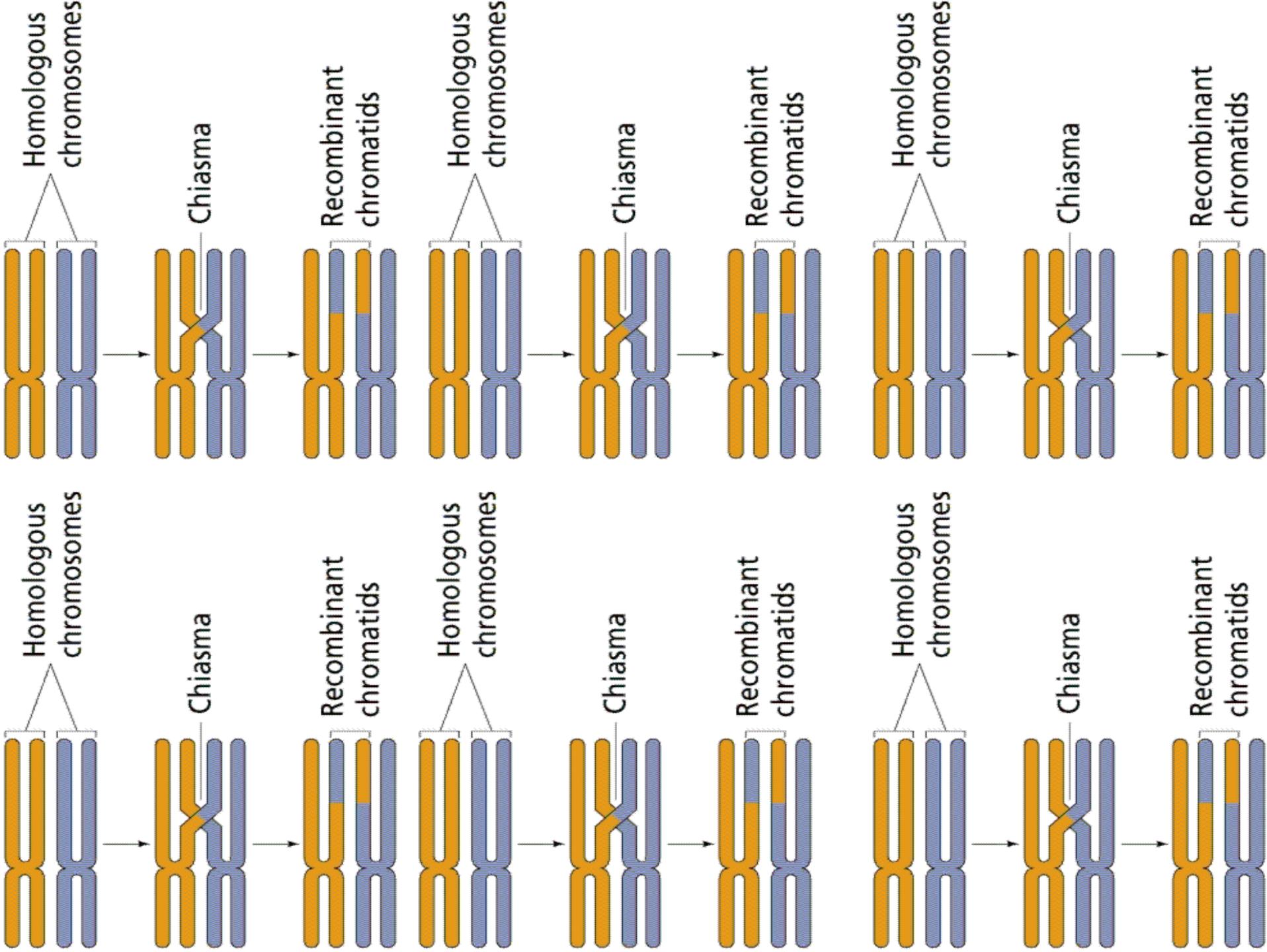
<http://bcs.whfreeman.com/thelifewire/content/chp09/0903004.html>

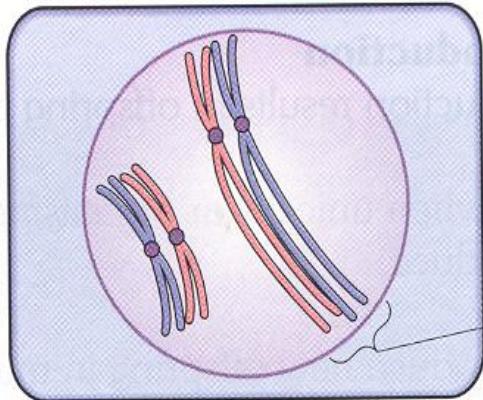
Differences between Mitosis & Meiosis

Mitosis	Meiosis
• one division/two daughter cells	two divisions/four daughter cells
• may occur in diploid or haploid cell	occurs only in diploid cells
• no change in chromosome number	chromosome number reduced from diploid to haploid
• chromosomes do not associate in pairs	homologous chromosomes pair
• alleles remain in sequence	alleles may be exchanged between homologous chromosomes
• nuclear clones result	nuclei not identical

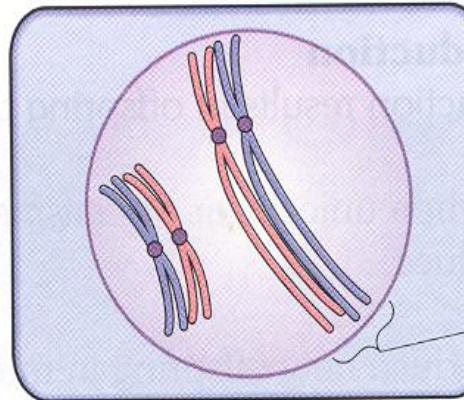
DNA content of cell/arbitrary units



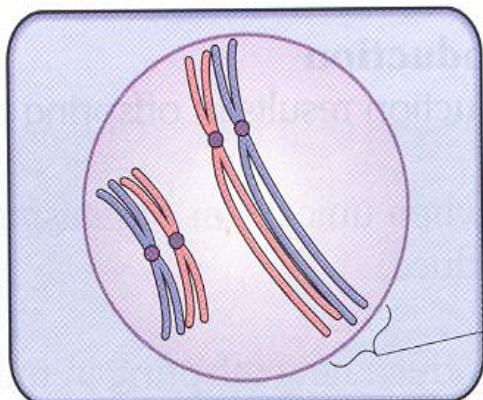




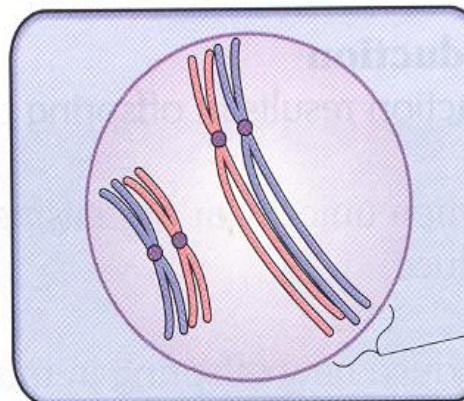
bivalent – two chromosomes split into two chromatids



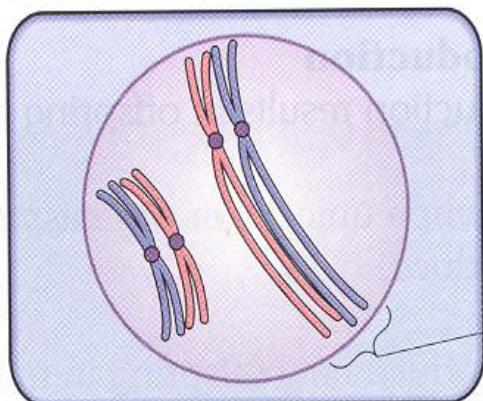
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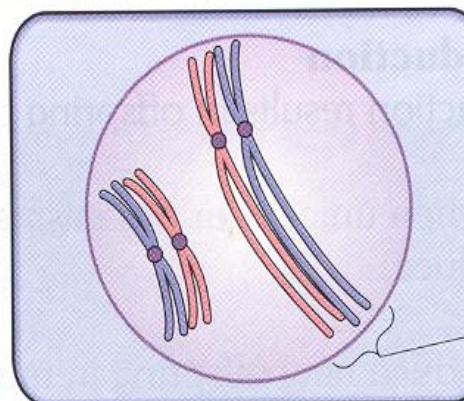
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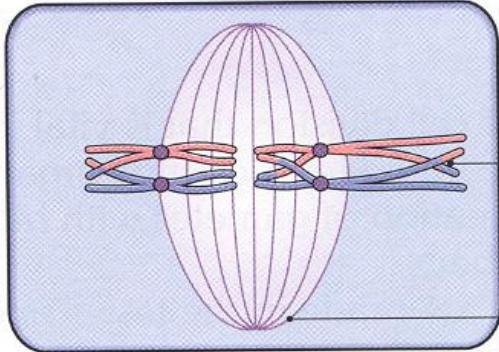


bivalent – two chromosomes split into two chromatids

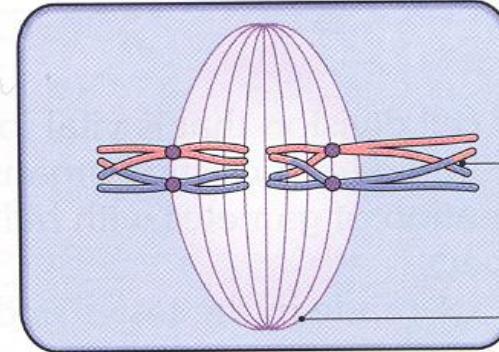


bivalent – two chromosomes split into two chromatids

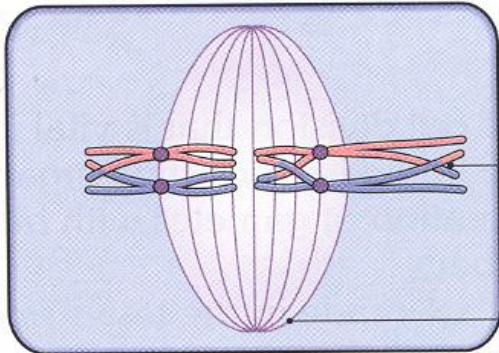
Metaphase I



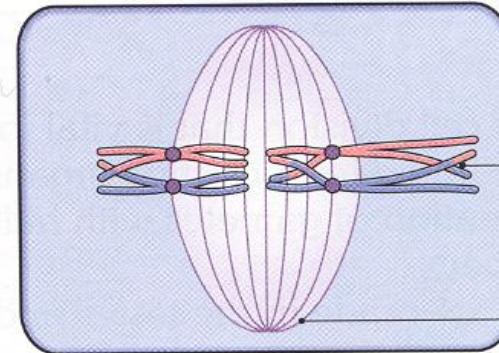
Metaphase I



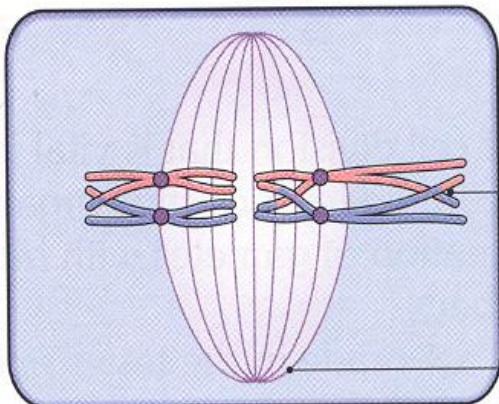
Metaphase I



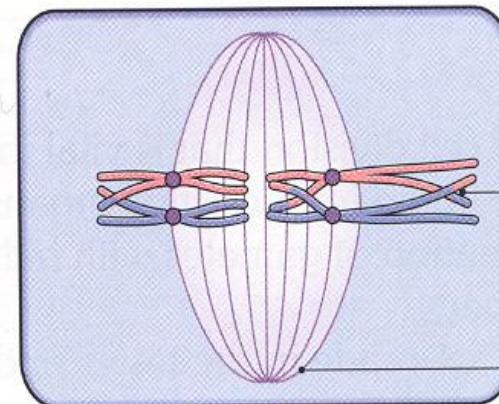
Metaphase I



Metaphase I



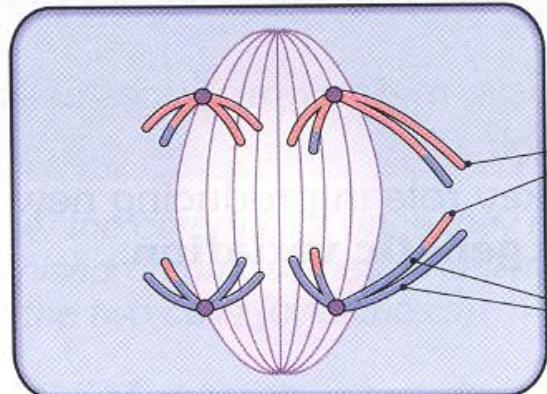
Metaphase I



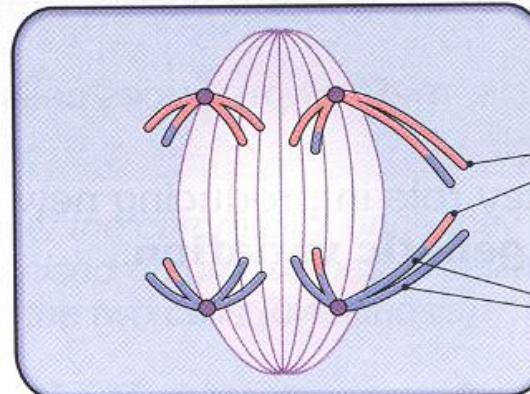
homologous chromosomes align on equator

spindle fibres

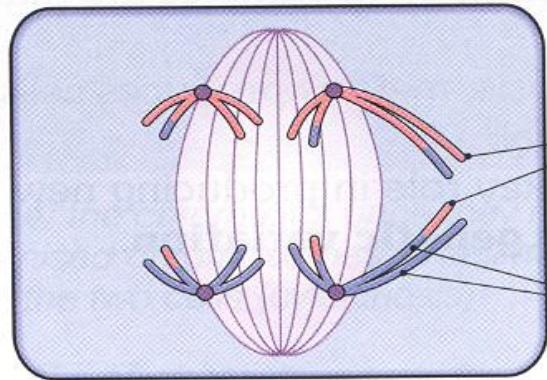
Anaphase I



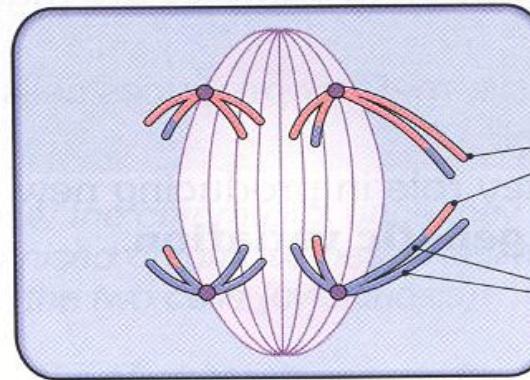
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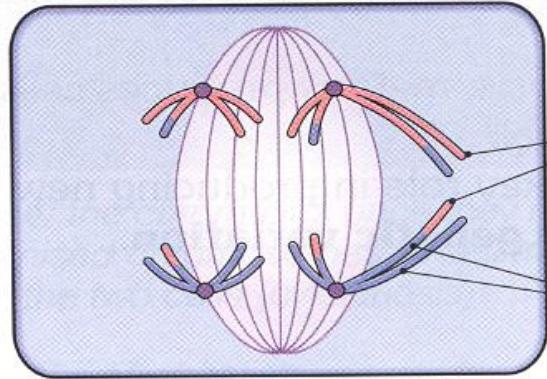
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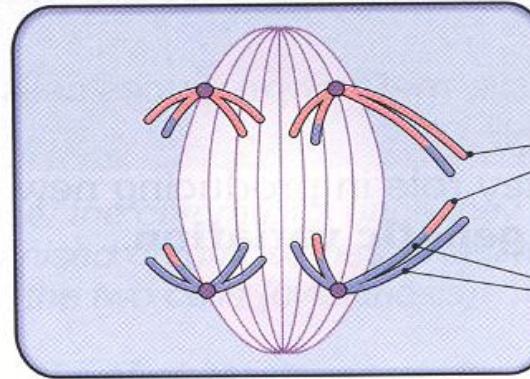
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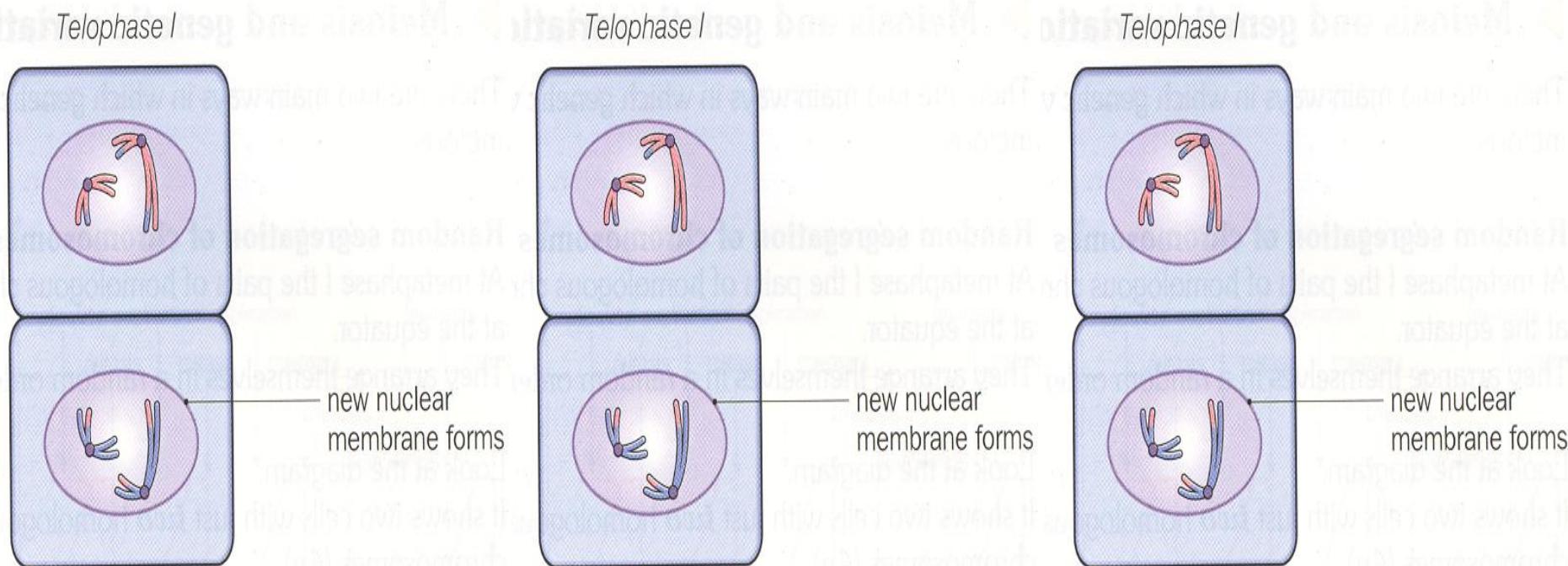
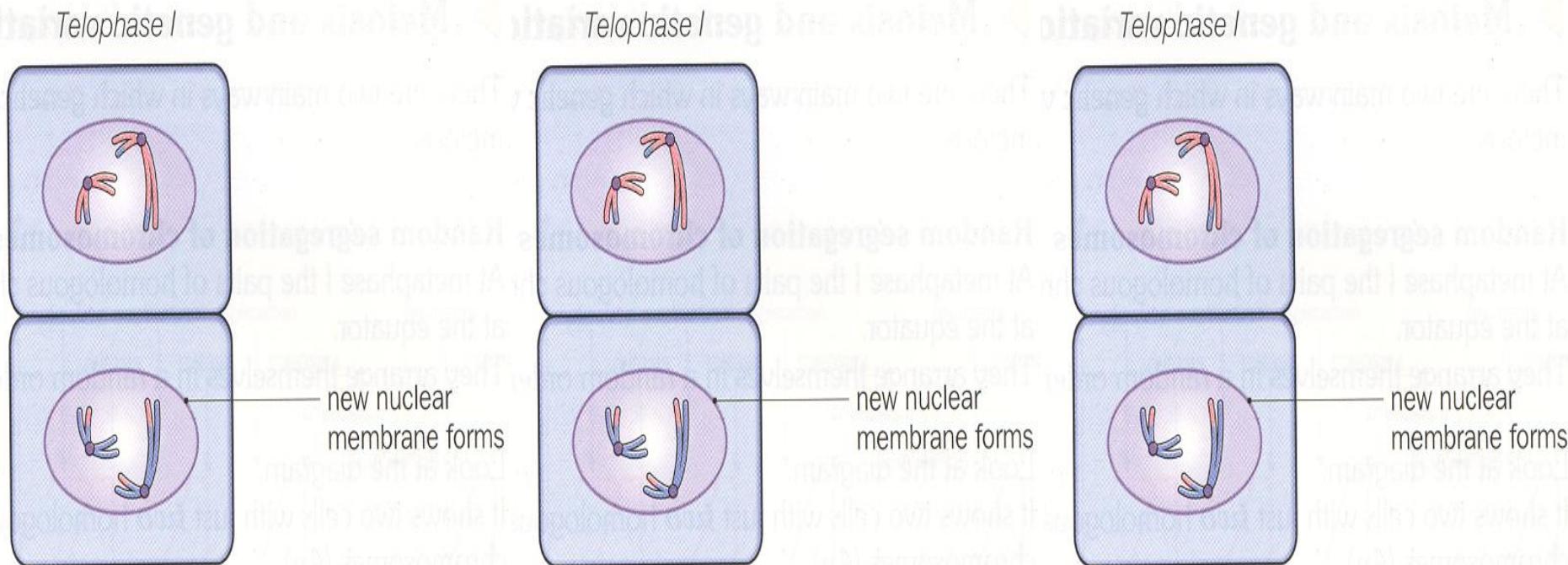


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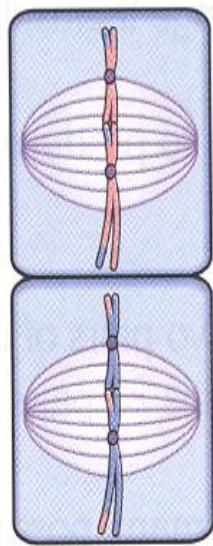


Anaphase I



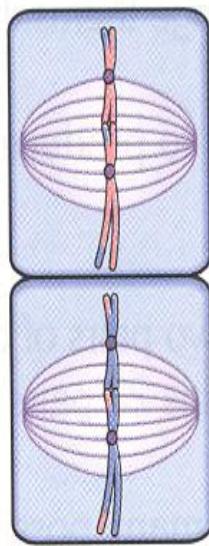


Metaphase II



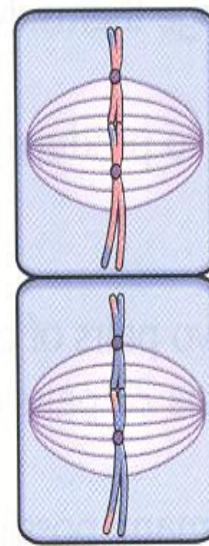
chromosomes align
on spindle together

Metaphase II



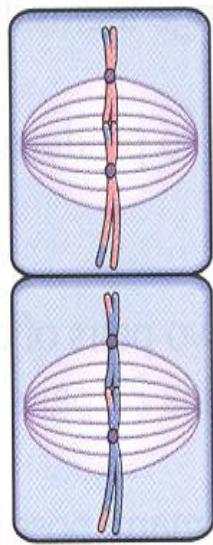
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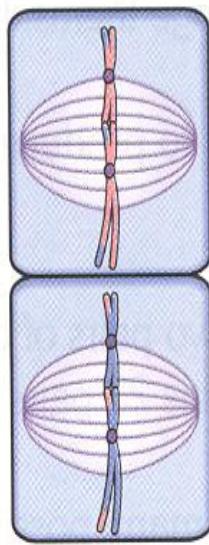
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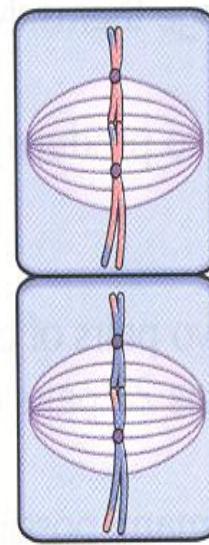
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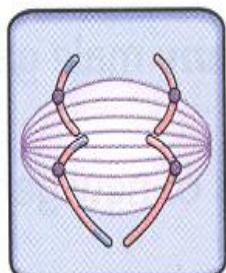
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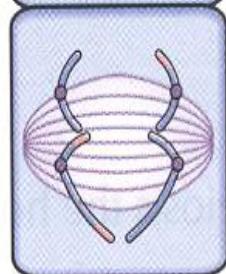


chromosomes align
on spindle together

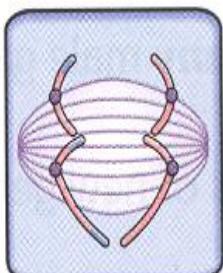
Anaphase II



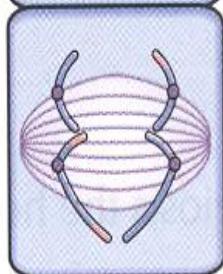
chromatids separate
and move to opposite
poles of spindle



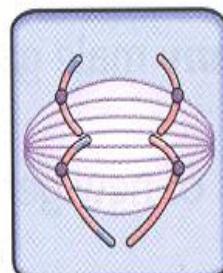
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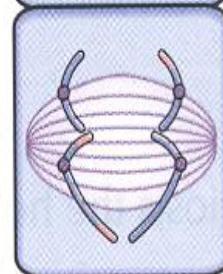
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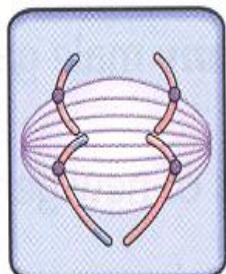
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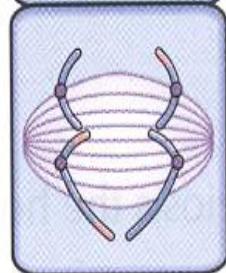
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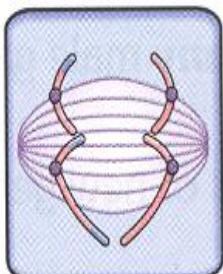
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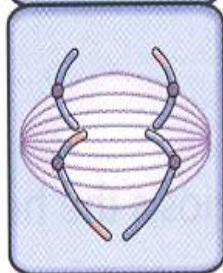
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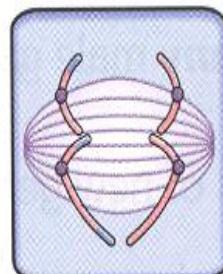
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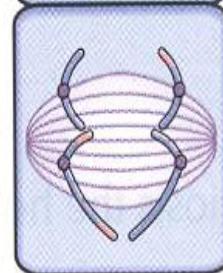
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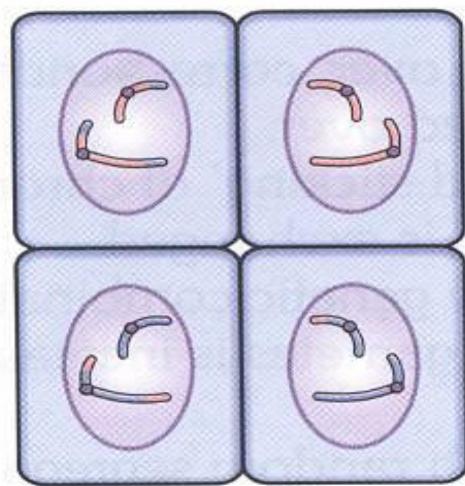
Anaphase II



chromatids separate
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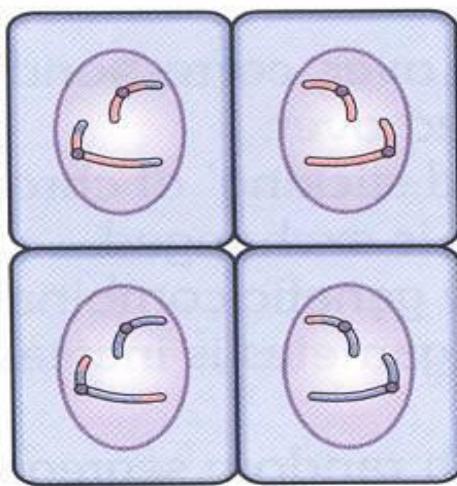


Telophase II



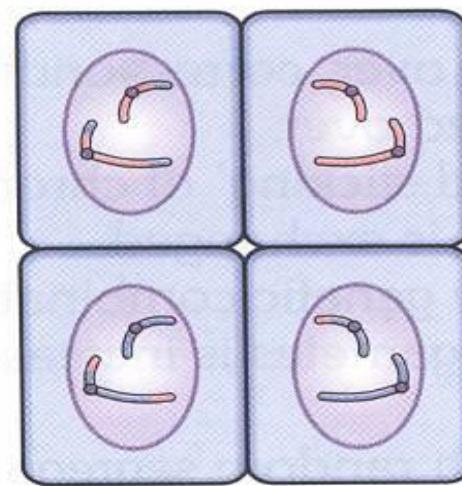
4 haploid cells each with a different genetic make up

Telophase II



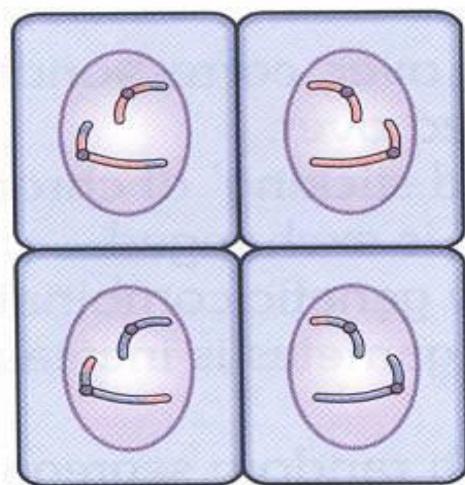
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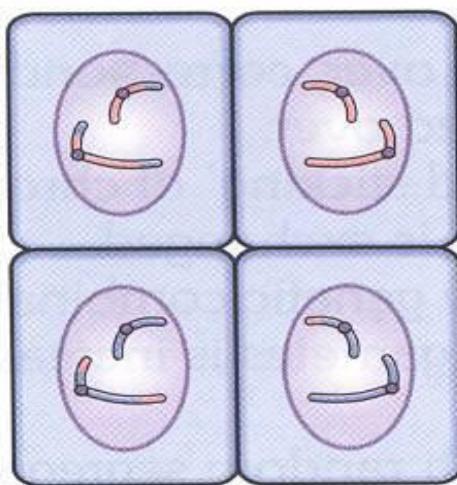
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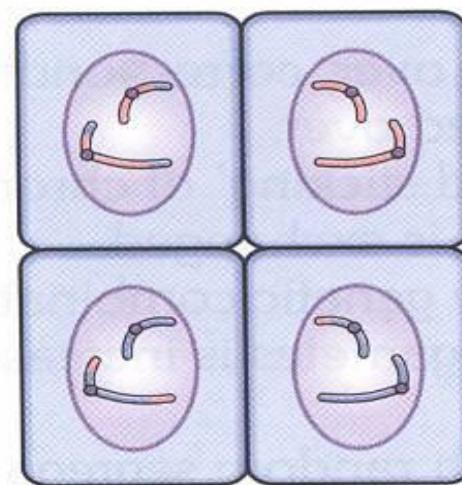
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Telophase II



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Telophase II



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