Meiosis and Sexual Life Cycles

- In this topic we will examine a second type of cell division used by eukaryotic cells: meiosis.
- In addition, we will see how the 2 types of eukaryotic cell division, mitosis and meiosis, are involved in transmitting genetic information from one generation to the next during eukaryotic life cycles.

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Objective # 1

List, describe, diagram, and identify the stages of meiosis.

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Objective 1

- Only diploid cells can divide by meiosis.
- We will examine the stages of meiosis in a diploid cell where 2N = 6
- Meiosis involves 2 consecutive cell divisions. Since the DNA is duplicated only prior to the first division, the final result is 4 haploid cells:

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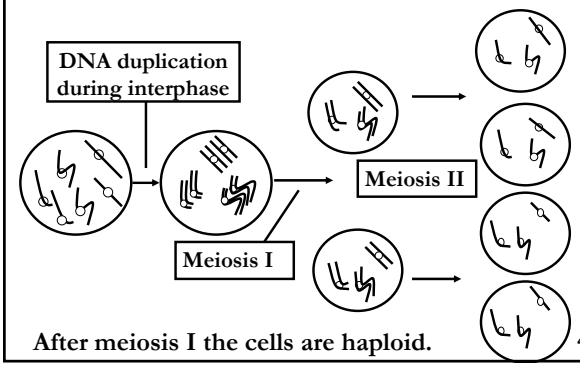
Objective 1

Overview of meiosis in a cell where 2N = 6



After meiosis I the cells are haploid.

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Objective 1, Stages of Meiosis

Prophase I:

- Chromosomes condense. Because of replication during interphase, each chromosome consists of 2 sister chromatids joined by a centromere.
- Synapsis – the 2 members of each homologous pair of chromosomes line up side-by-side to form a tetrad consisting of 4 chromatids:

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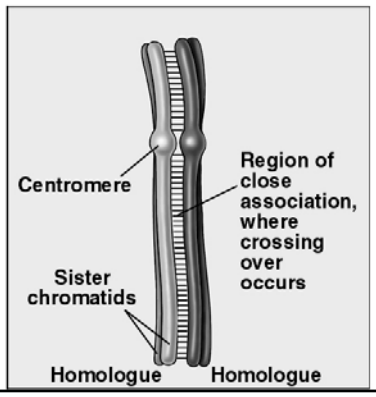
Objective 1, Stages of Meiosis



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Objective 1, Stages of Meiosis

Prophase I:

- During synapsis, sometimes there is an exchange of homologous parts between non-sister chromatids. This exchange is called crossing over.

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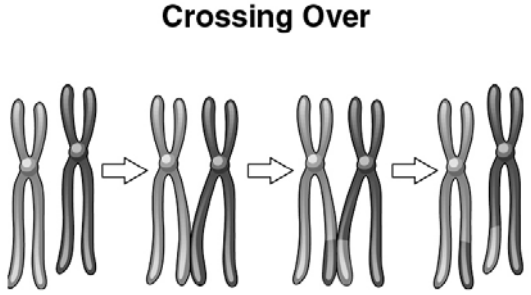
Objective 1, Stages of Meiosis



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Objective 1, Stages of Meiosis

Prophase I:

- the spindle apparatus begins to form.
- the nuclear membrane breaks down:

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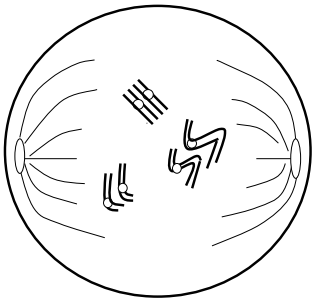
Objective 1, Stages of Meiosis (2N=6)



Prophase I

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Objective 1, Stages of Meiosis

Metaphase I:

- chromosomes line up along the equatorial plate in pairs, i.e. homologous chromosomes remain paired.
- spindle microtubules attach to the kinetochores on each centromere
- orientation of each pair of chromosomes is random and independent of the other pairs (independent assortment):

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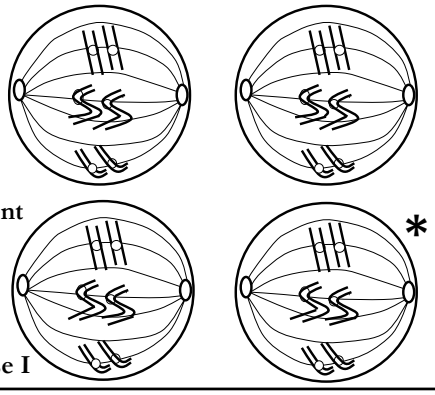
Objective 1, 4 Possible Metaphase I Arrangements:



***We will follow this arrangement**

*

Metaphase I

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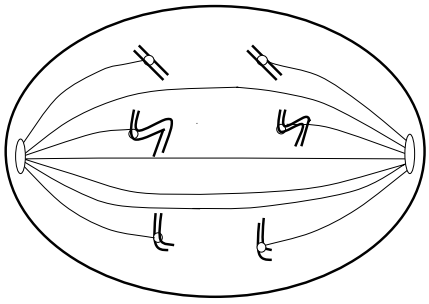
Objective 1, Stages of Meiosis

Anaphase I:

- spindle microtubules contract, pulling the 2 members of each homologous pair to opposite poles of the cell.
- when the spindle fibers have fully contracted, each pole has one complete set of duplicated chromosomes:

Objective 1, Stages of Meiosis (2N=6)



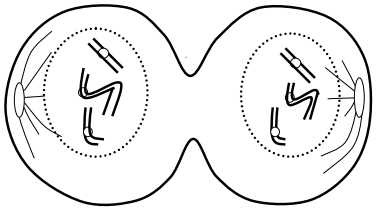
Anaphase I

Objective 1, Stages of Meiosis

Telophase I:

- a nuclear membrane reforms around each set of duplicated chromosomes
- cytokinesis divides the original cell into 2 haploid, non-identical, daughter cells:

Objective 1, Stages of Meiosis (2N=6)



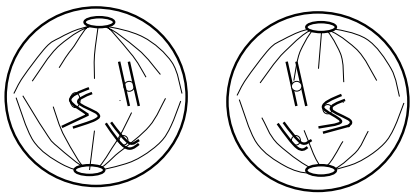
Telophase I

Objective 1, Stages of Meiosis

Prophase II:

- in each daughter cell, the nuclear membrane breaks down,
- and a new spindle forms:

Objective 1, Stages of Meiosis (2N=6)



Prophase II

Objective 1, Stages of Meiosis

Metaphase II:

- chromosomes line up along the equatorial plate
- spindle microtubules attach to the kinetochores on each centromere:

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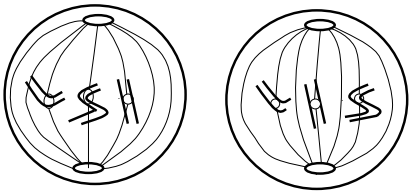
Objective 1, Stages of Meiosis (2N=6)



Metaphase II

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Objective 1 Stages of Meiosis

Anaphase II:

- centromeres split and each former chromosome becomes 2 separate chromosomes
- spindle microtubules contract pulling the 2 members of each pair of chromosomes (that were formerly sister chromatids) to opposite poles of the cell:

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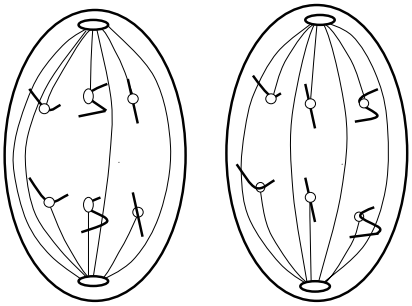
Objective 1, Stages of Meiosis (2N=6)



Anaphase II

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Objective 1, Stages of Meiosis

Telophase II:

- nuclear envelope reforms around the 4 sets of daughter chromosomes
- chromosomes uncoil
- cytokinesis divides the 2 daughter cells into 4, genetically unique, haploid cells:

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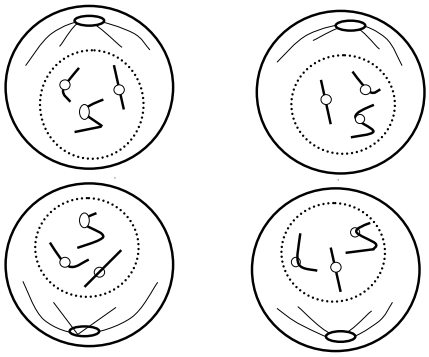
Objective 1, Stages of Meiosis (2N=6)



Telophase II

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Objective # 2

Describe the processes of independent assortment and crossing over and explain their biological significance.

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Objective 2

- Independent assortment and crossing over increase genetic variability among the daughter cells produced during meiosis.
- If there are n pairs of chromosomes in the original cell, independent assortment produces 2^n possible chromosome combinations in the daughter cells:

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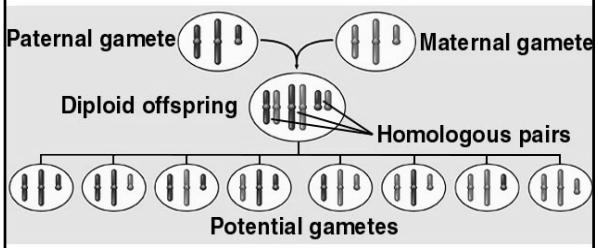
Objective 2

Independent assortment produces 2^n possible chromosome combinations :



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Objective 2

- In addition, because of crossing over, each chromosome involved in meiosis winds up with a different combination of genes.
- Therefore, an almost limitless number of gene combinations are possible in the daughter cells produced during meiosis:

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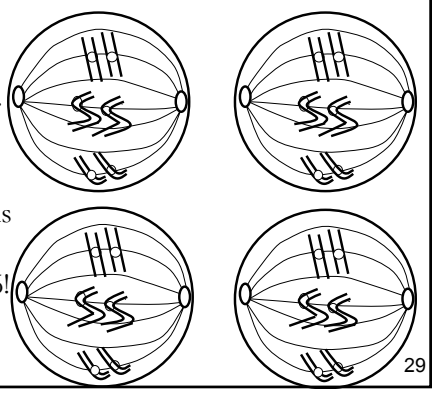
Objective 2

With just 1 crossover, the number of possible gene combinations increases from 8 to 16!



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Objective # 3

Compare mitosis with meiosis and explain the importance of each.

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Objective 3

Mitosis	Meiosis
Homologous chromosomes do not pair up	Synapsis
No genetic exchange between homologous chromosomes	Crossing over
DNA duplication followed by 1 cell division	DNA duplication followed by 2 cell divisions

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Objective 3

Mitosis	Meiosis
One diploid cell produces 2 diploid cells OR one haploid cell produces 2 haploid cells	One diploid cell produces 4 haploid cells
New cells are genetically identical to original cell (except for mutation)	Each new cell has a unique combination of genes

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Objective 3

Importance:

- Mitosis allows a cell to produce more identical copies of itself. This is the basis for asexual reproduction.
- Meiosis reduces the number of chromosomes from 2 sets to 1 set. This is the basis for life cycles where each parent contributes half the genes needed to produce a new individual.

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Objective # 4

Explain the role of mitosis, meiosis, and fertilization in the life cycle of animals and plants.

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Objective 4

- Unlike prokaryotes, which are always haploid (each cell has one set of genetic instructions), most eukaryotes have a life cycle that alternates between haploid and diploid stages:

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Objective 4

- In eukaryotic life cycles:
  - Mitosis keeps the number of chromosomes in each cell the same.
  - Meiosis reduces the number of chromosomes from 2 sets to 1 set.
  - Fertilization doubles the number of chromosomes from 1 set to 2 sets.

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