# Chapter 13 - Meiosis

## Review

haploid, diploid

homologous chromosomes

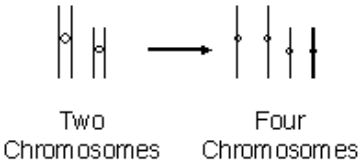
### *Types of Cell Division*

Mitosis produces identical daughter cells.

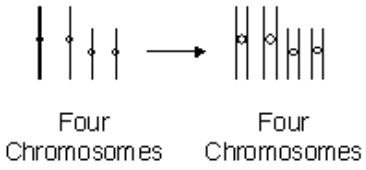
Meiosis produces cells with 1/2 the number of chromosomes as the parent cell.

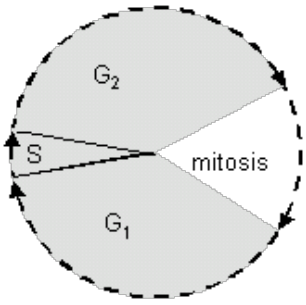
### *Chromosome Doubling/DNA Replication*

Chromosomes double when they split at the end of metaphase.




DNA replicates during the S period of interphase.




### *Summary of Mitosis*

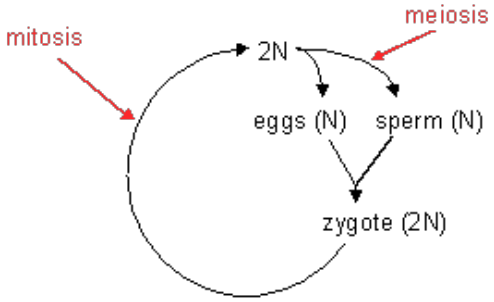
prophase - coil
metaphase - align
anaphase - separate
telophase - uncoil

## Life Cycles

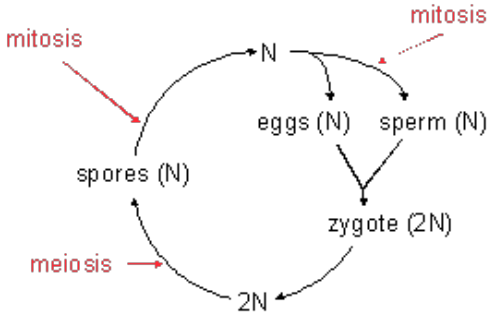
Meiosis functions to reduce the number of chromosomes to one half. Each daughter cell that is produced will have one half as many chromosomes as the parent cell.

Meiosis is part of the sexual process because gametes (sperm, eggs) have one half the chromosomes as diploid (2N) individuals.

In animals, meiosis occurs only when gametes (sperm, eggs) are formed.




In plants, gametes are not produced directly. Instead meiosis produces spores and then mitosis produces gametes. Although plants have an additional step, meiosis eventually results in the production of haploid gametes.




## Phases of Meiosis

There are two divisions in meiosis; the first division is meiosis 1 and the second is meiosis 2. The phases have the same names as those of mitosis. A number indicates the division number (1st or 2nd):

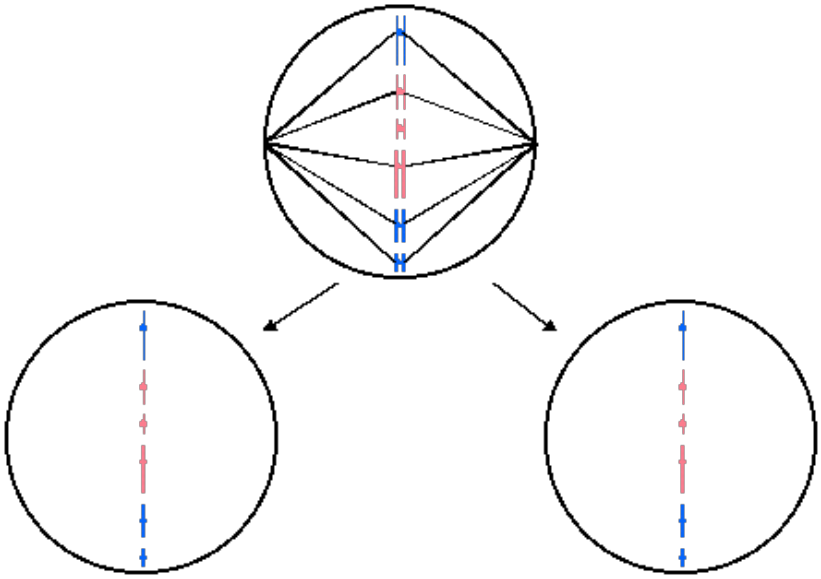
meiosis 1: prophase 1, metaphase 1, anaphase 1, and telophase 1

meiosis 2: prophase 2, metaphase 2, anaphase 2, and telophase 2

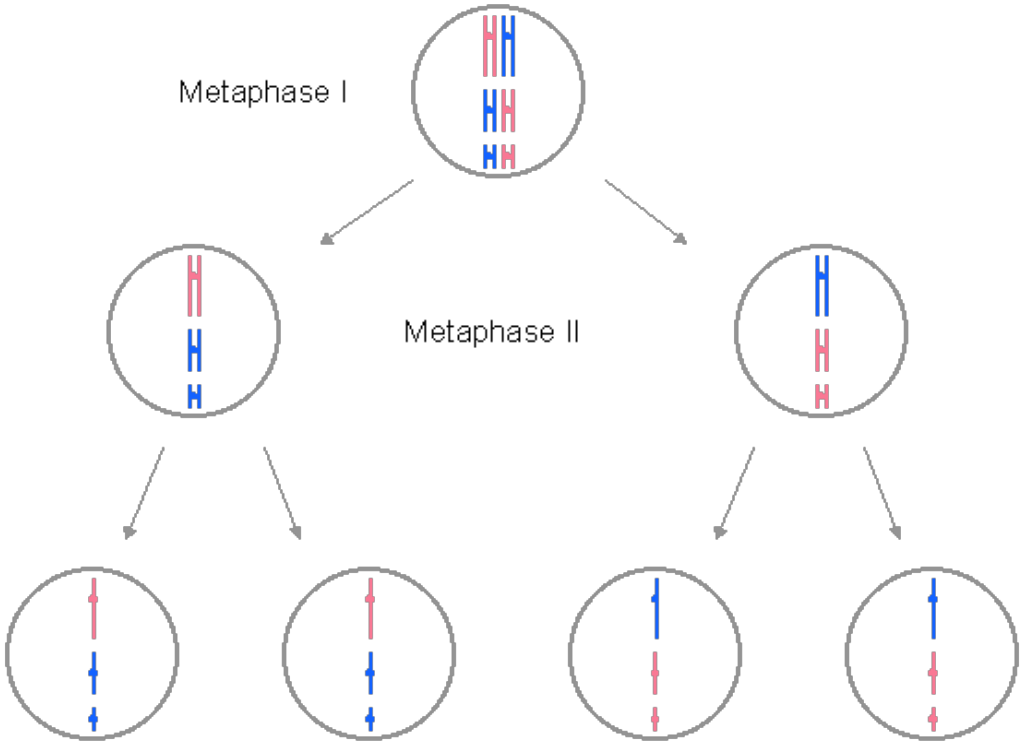
In the first meiotic division, the number of cells is doubled but the number of chromosomes is not. This results in 1/2 as many chromosomes per cell.

The second meiotic division is like mitosis; the number of chromosomes does not get reduced.

The diagram below shows that the chromosome alignment pattern during metaphase of ***mitosis*** results in the chromosomes splitting (doubling). Prophase, anaphase and telophase are not shown.



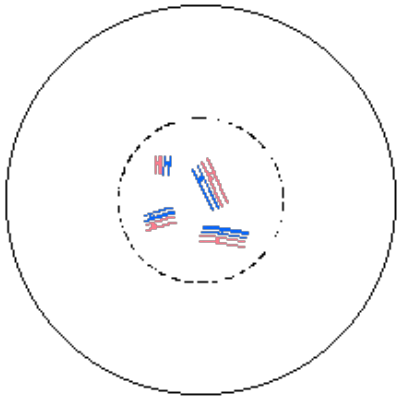
Below: The alignment pattern during metaphase I of ***meiosis*** results in pairs separating; there is no doubling.




Below: Metaphase 1 and metaphase 2 of meiosis

## Phases of Meiosis

### Prophase I



The events that occur during prophase of mitosis also occur during prophase I of meiosis. The chromosomes coil up, the nuclear membrane begins to disintegrate, and the centrosomes begin moving apart.

***Synapsis*** (joining) of homologous chromosomes produces ***tetrads*** (also called bivalents).

The two chromosomes may exchange fragments by a process called ***crossing over***.

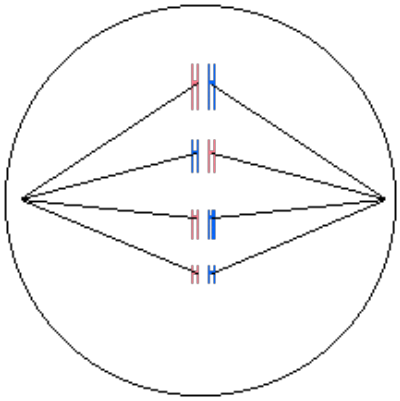
When the chromosomes partially separate in late prophase, the areas where crossing over occurred remain attached and are referred to as ***Chiasmata*** (sing. chiasma). They hold the chromosomes together until they separate during anaphase.

Crossing over between homologous chromosomes is likely to occur at several different points, resulting in chromosomes that are mixtures of the original two chromosomes.

One kinetochore forms on each chromosome instead of on each chromatid as in mitosis.

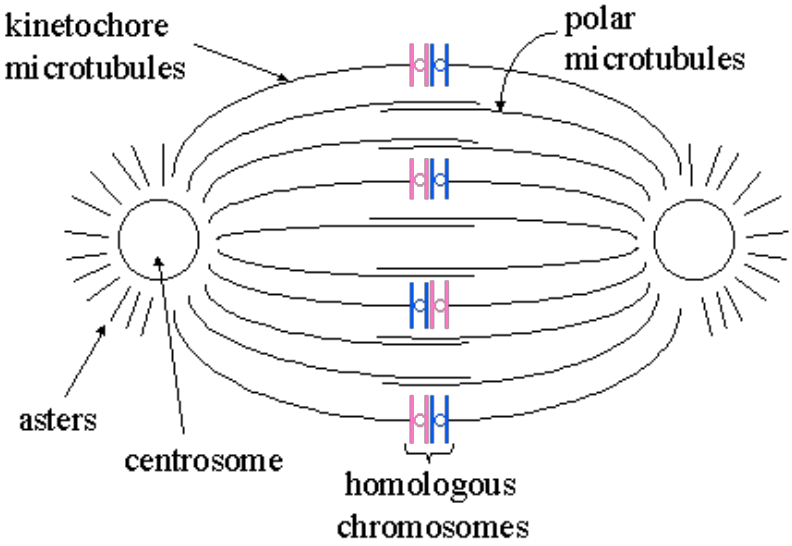
The spindle fibers attach to the chromosomes and begin to move them to the center of the cell as they do in mitosis.

## Metaphase I

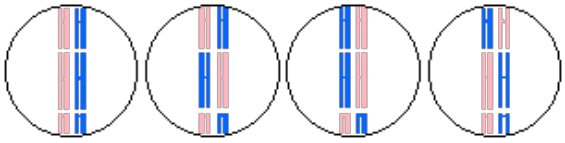


Bivalents (tetrads) become aligned in the center of the cell and are attached to spindle fibers.

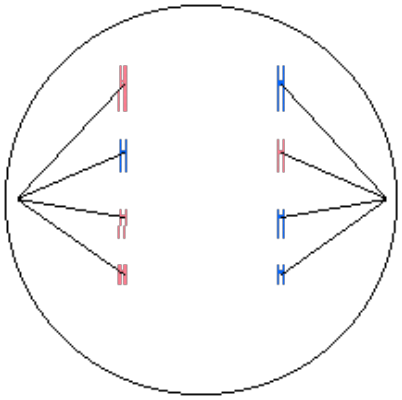
The chromosome alignment illustrated below is from a cell with a diploid chromosome number of 8.




***Independent assortment*** refers to the random arrangement of pairs of chromosomes. The diagram below shows four possible arrangements of chromosomes during metaphase 1 from an individual that has 6 total chromosomes. Suppose that the pink chromosomes are those that the individual inherited from its mother and the blue colored ones were inherited from its father. For each chromosome pair, the chromosome that is on the left (maternal or paternal) is determined randomly. As can be seen, there are several alignment possibilities.

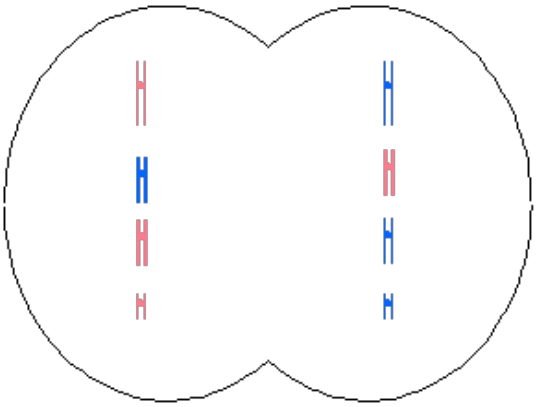


## Anaphase I



Anaphase I begins when homologous chromosomes separate.

### Telophase I



The nuclear envelope reforms and nucleoli reappear.

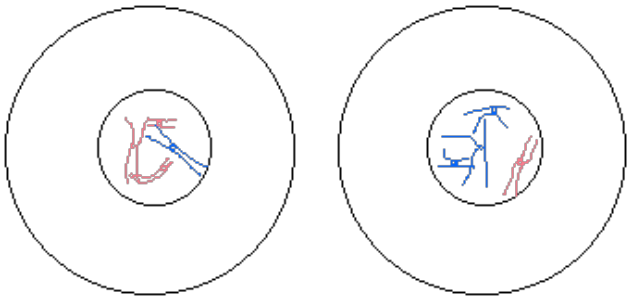
This stage is absent in some species.

### Interkinesis

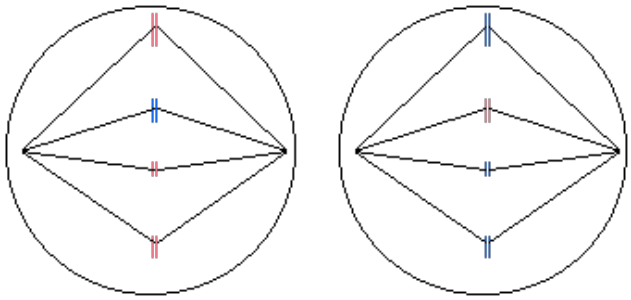
Interkinesis is similar to interphase except DNA synthesis does not occur.

The events that occur during meiosis II are similar to mitosis.

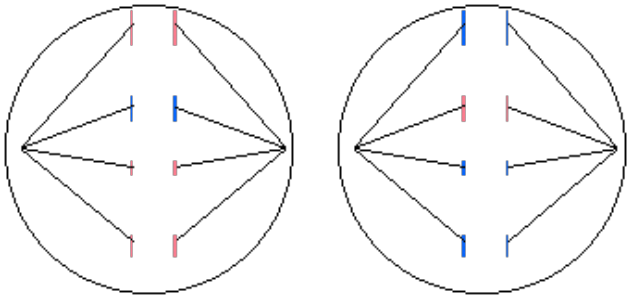
### Prophase II



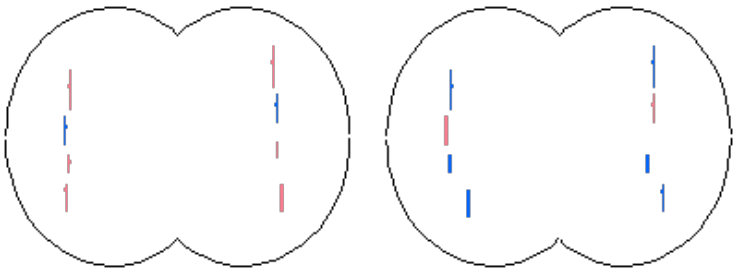
### Metaphase II



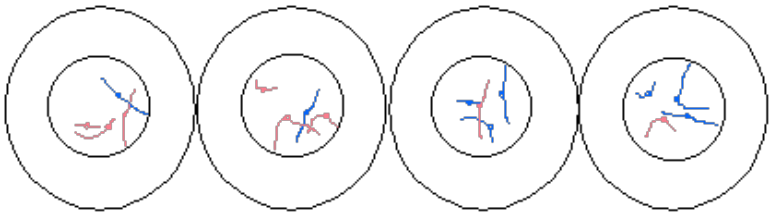
### Anaphase II



### Telophase II



### Daughter Cells



## Review

Use the diagram below to answer the following questions. The questions pertain only to the chromosomes.

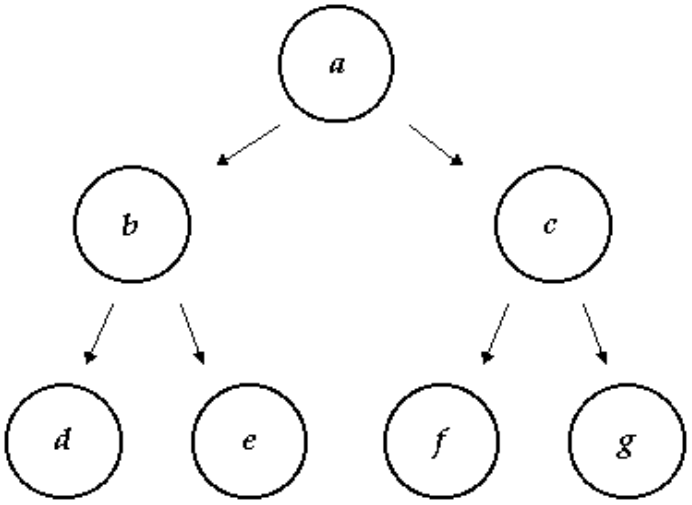
How does cell "a" differ from "b" in the diagram below?

How does "b" differ from "c"?

How does "b" differ from "d"?

How does "d" differ from "e"?

How does "e" differ from "f"?




## Variation

Sexual reproduction promotes variation because each gamete (sperm or egg) contains a mixture of genes from two different parents.

***Crossing-over*** and ***Independent assortment*** promote variation. During prophase of meiosis, crossing-over results in chromosomes that have some genes from one parent and some genes from the other parent.

Individuals contain two sets of each chromosome but gametes contain only one set. For each homologous pair of chromosomes, one chromosome will be randomly selected for each gamete formed (***independent assortment***).

Variation is necessary for natural selection. Recall that natural selection favors individuals with characteristics that are best adapted to their environments. Variation is therefore necessary for species to become adapted to their environment and it enables them to change when the environment changes.

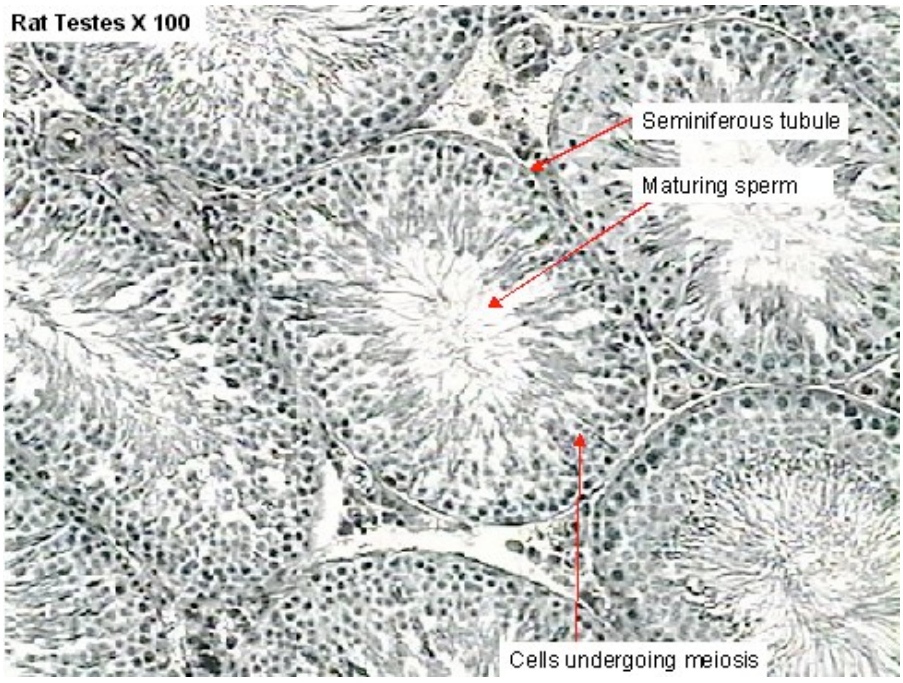
## Gametogenesis

Gametogenesis is the formation of gametes. The formation of eggs is ***oogenesis*** and the formation of sperm is ***spermatogenesis***.

In animals, gametes are formed by meiosis.

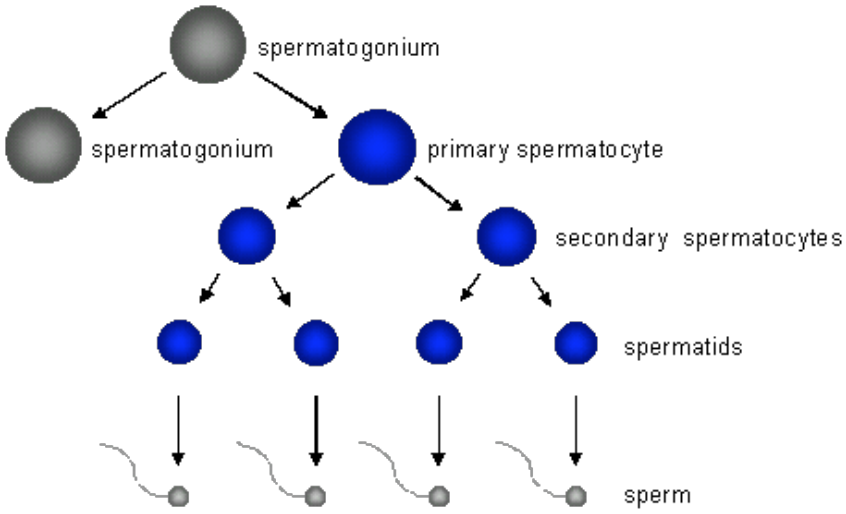
### Spermatogenesis

Spermatogenesis occurs in ***seminiferous tubules*** in testes.




The cell that undergoes meiosis is a ***primary spermatocyte***. The first meiotic division produces two ***secondary spermatocytes*** and the second division produces ***spermatids***, which mature to form sperm.

Meiosis I, Meiosis II, and the maturation process each take approximately 16 days (48 days total).




Males do not run out of sperm because mitosis precedes each meiosis. The diagram above shows that a spermatogonium divides by mitosis to produce a primary spermatocytes and a spermatogonium.

Human males produce approximately1000 sperm per second (30 billion/year).

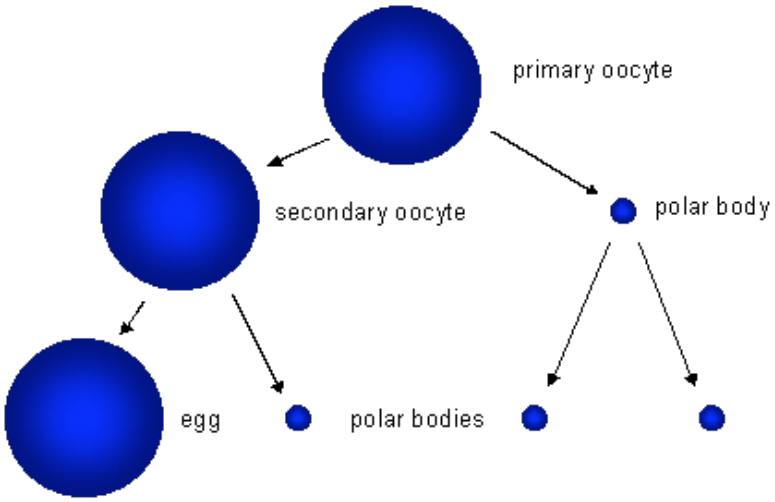
Each ejaculation should contain 200 - 300 million sperm.

## Oogenesis

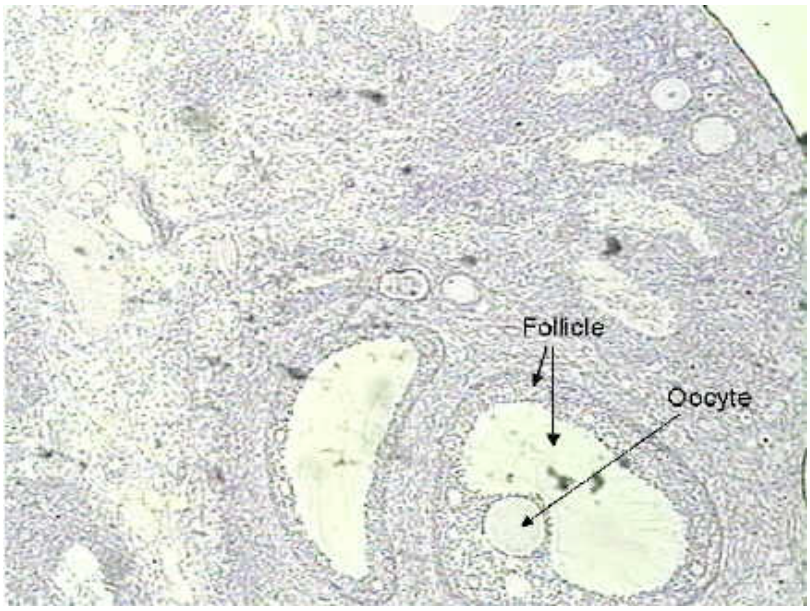
Oogenesis occurs in the ovary.

Each of the divisions in humans is unequal. During the first meiotic division, a large secondary oocyte and a small polar body are produced. The secondary oocyte will divide to produce an egg and a polar body. The first polar body may divide to produce two more polar bodies.

Although the polar bodies are very small and nonfunctional, they contain a full set of chromosomes.




The photograph below shows a cross section of a rabbit ovary X 40. The primary oocyte is contained within a structure called a follicle. As the follicle enlarges, it produces hormones. During ovulation, the follicle
ruptures and, in humans, releases the secondary oocyte.



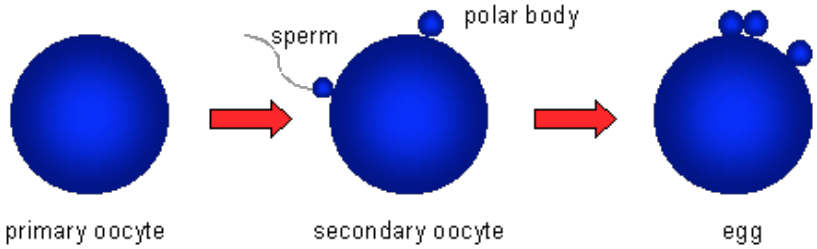

Meiosis in human females begins before person is born but stops in prophase I and does not resume until after puberty.

Each month, approximately 1000 primary oocytes will to mature but most will die.

Ovulation occurs approximately once every 28 days. Females ovulate approximately 400 times during their lifetime.

Secondary oocytes are released at ovulation. The second meiotic division resumes after penetration by sperm.

In humans, secondary oocytes are fertilized. Eggs are produced only after fertilization of a secondary oocyte.



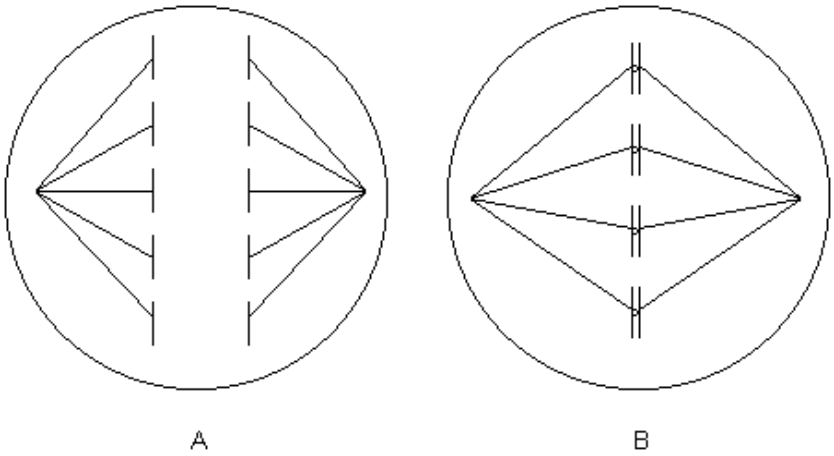

In the diagram above, the first polar body produced after the first meiotic division did not divide again.

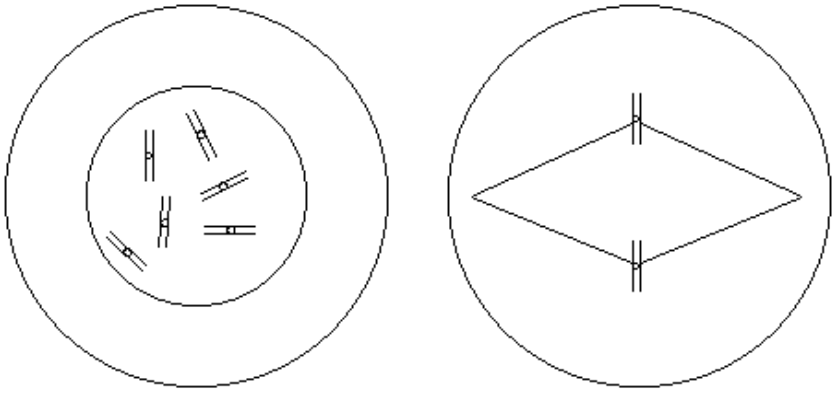
Women are born with all of the primary oocytes that they will ever have (2 million). At puberty, there are approximately 400,000 left.

Some chromosomal abnormalities associated with maternal age may be due to the long time they remain paired during prophase I.

## Review questions

The four questions below refer to the following diagrams.





C D

Click here to see the answers to these questions.

1. Diagram A represents a cell from an organism with a diploid chromosome number of 10. Therefore, the diagram represents which one of the following stages?

A. interphase of mitosis
B. anaphase of mitosis
C. metaphase I of meiosis
D. prophase II of meiosis
E. anaphase II of meiosis

2. Diagram B represents a cell from an organism with a diploid chromosome number of 8. Therefore, the diagram represents which one of the following stages?

A. prophase of mitosis
B. metaphase of mitosis
C. metaphase I of meiosis
D. telophase I of meiosis
E. metaphase II of meiosis

3. Diagram B represents a cell from an organism with a diploid chromosome number of 4. Therefore, the diagram represents which one of the following stages?

A. prophase of mitosis
B. metaphase of mitosis
C. metaphase I of meiosis
D. telophase I of meiosis
E. metaphase II of meiosis

4. Diagram B represents a cell from an organism with a diploid chromosome number of 6. Therefore, the diagram represents which one of the following stages?

A. Prophase of mitosis
B. Metaphase of mitosis
C. Metaphase I of meiosis
D. Telophase I of meiosis
E. Metaphase II of meiosis
F. None of the above

5. Diagram C represents a cell from an organism with a diploid chromosome number of 6. Therefore, the diagram represents which one of the following stages?

A. prophase of mitosis
B. metaphase of mitosis
C. metaphase I of meiosis
D. prophase II of meiosis
E. metaphase II of meiosis

6. Diagram D represents a cell from an organism with a diploid chromosome number of 2. Therefore, the diagram represents which one of the following stages?

A. prophase of mitosis
B. prophase I of meiosis
C. prophase II of meiosis
D. metaphase of mitosis
E. metaphase I of meiosis
F. metaphase II of meiosis

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