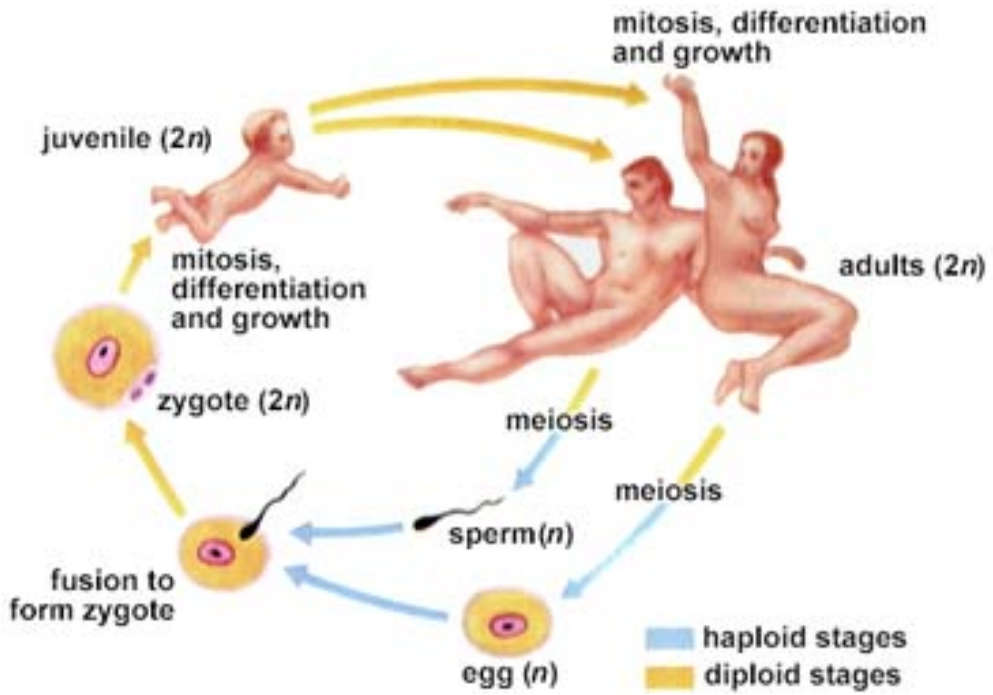
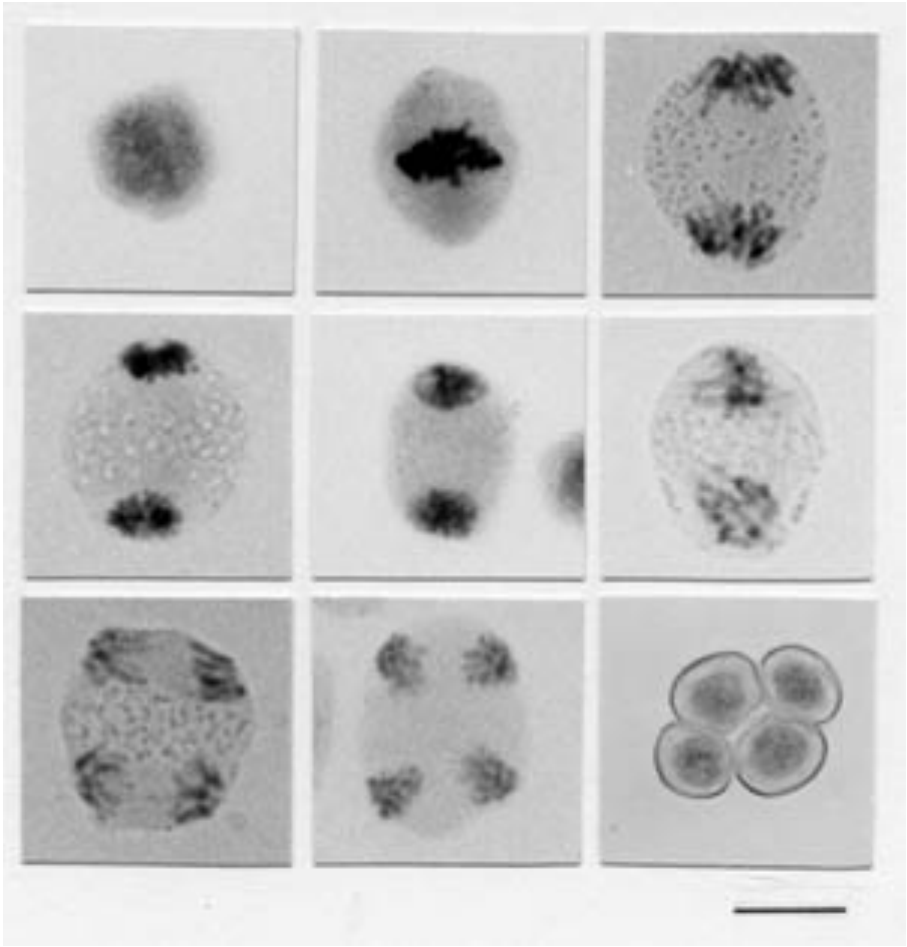
Topic 2 Cell Division – Meiosis





Meiosis Animation

Meiosis

Meiosis Tutorial: The Biology Project!

A second type of cell division designed to make haploid (n) cells called gametes

- Gametes include sperm (from testes) and egg (from ovaries)
- 2n→n

- Meiosis occurs in 2 stages to produce a total of 4 haploid cells

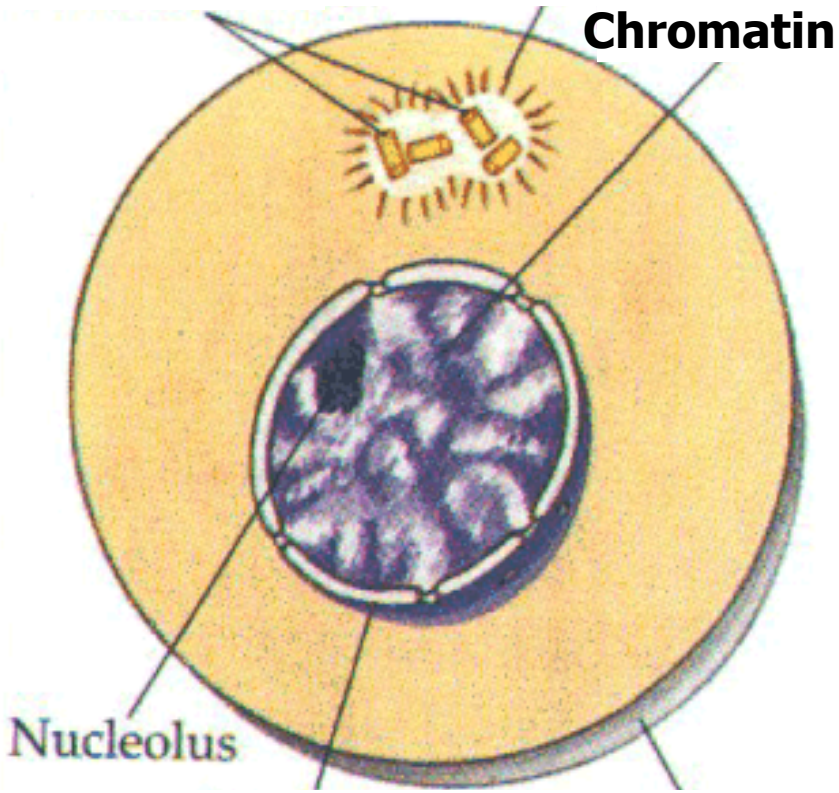
Why are haploid cells necessary?

Interphase: Stage Prior to Meiosis I

- Similar to **mitosis**, germ cells will go through interphase

– During this phase, chromosomes are **replicated (DNA synthesis)**

–The cell prepares for meiosis



Meiosis animation (McGraw-Hill)

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter28/animation__how_meiosis_works.html

Meiosis

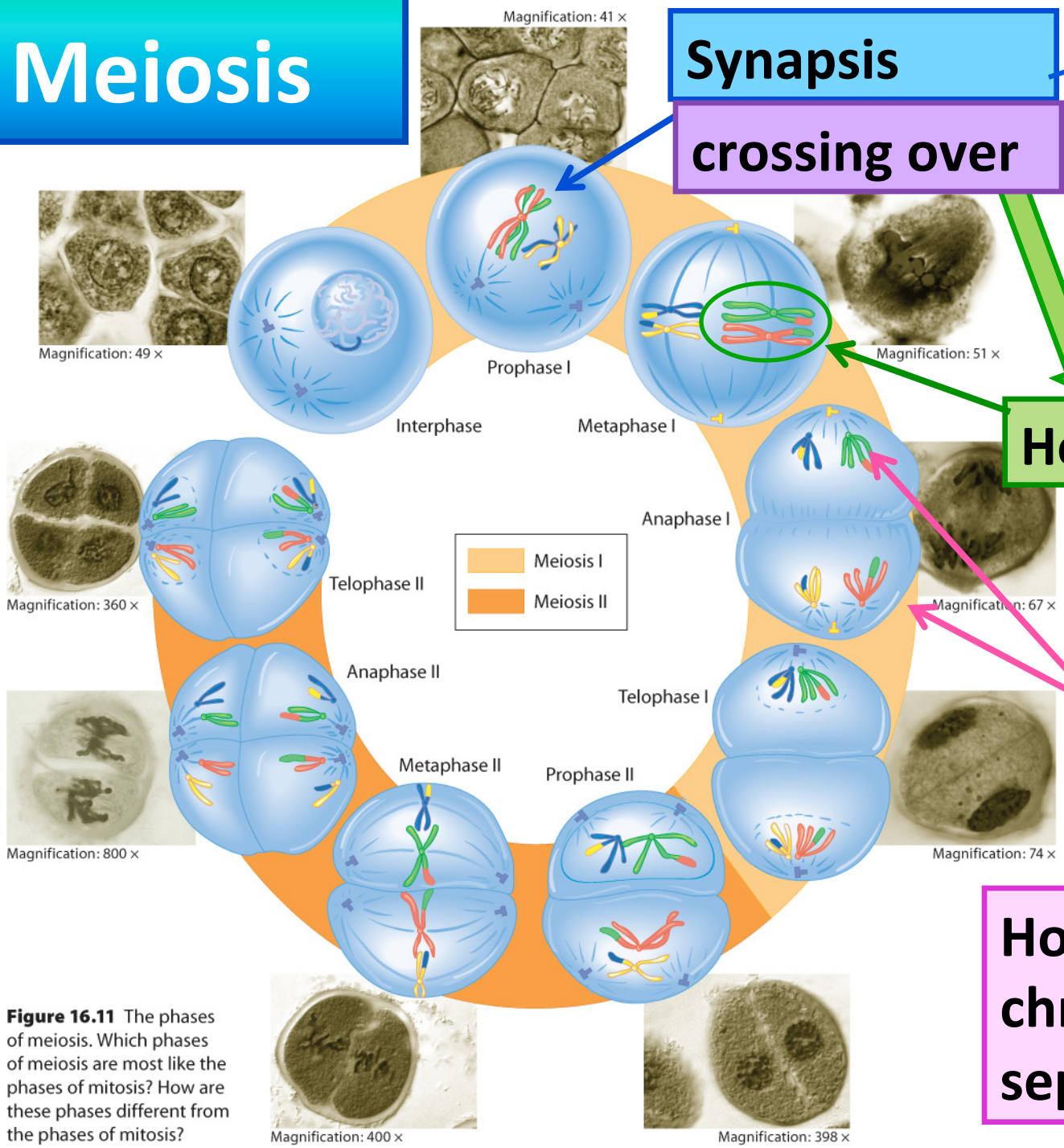


Figure 16.11 The phases of meiosis. Which phases of meiosis are most like the phases of mitosis? How are these phases different from the phases of mitosis?

Synapsis

crossing over

Similar chromosomes pair up and

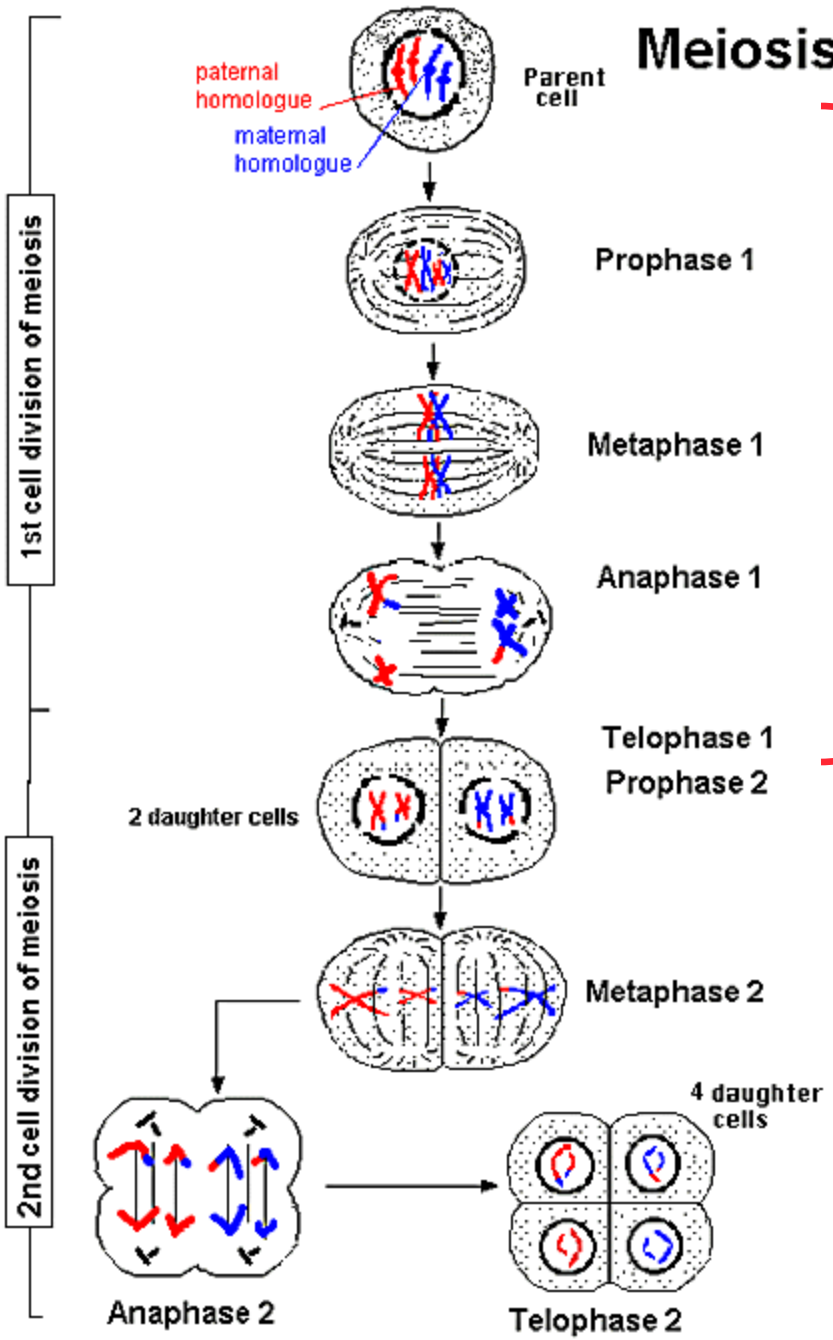
may exchange genetic material

Homologous pair

or tetrad

Segregation

Homologous chromosomes separate



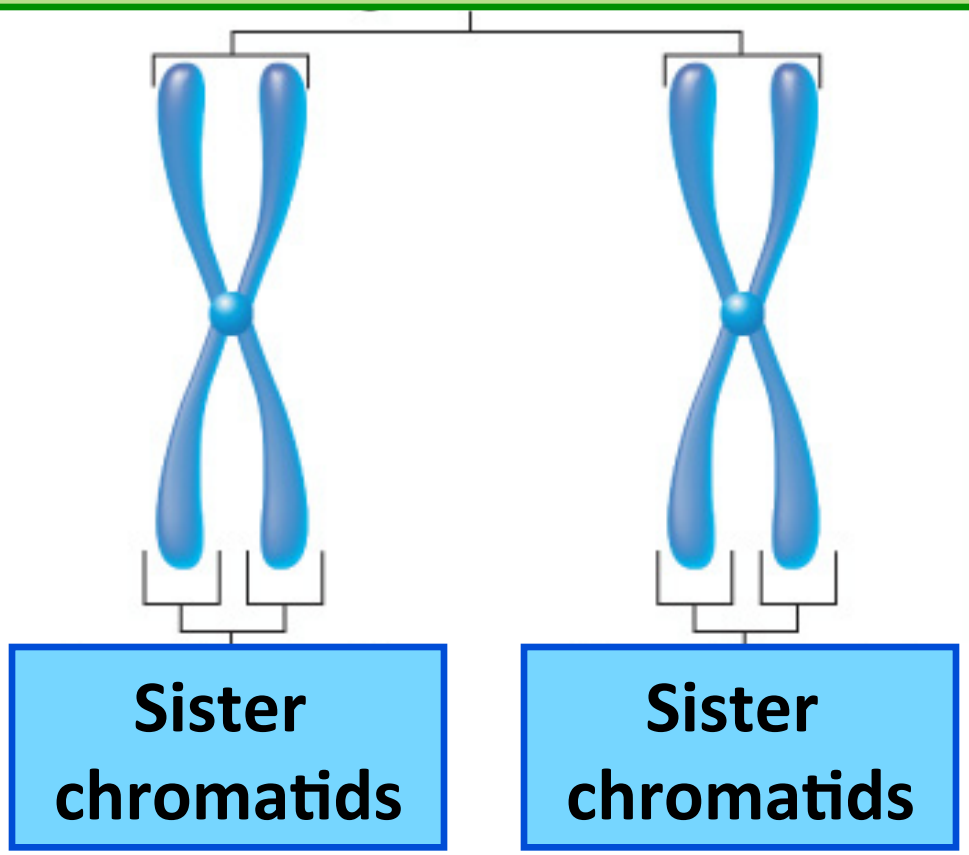
Meiosis I

AKA : Reduction division since chromosome number is reduced (2n→n)

Meiosis II

Synapsis

homologous replicated chromosomes = tetrad



Prophase 1

- Nuclear membrane disintegrates and spindle fibers form
- Chromatin coils up into chromosomes
- Two homologous (similar) chromosomes come together to form a tetrad
- This process is called **synapsis**
- A tetrad consists of 2 replicated homologous chromosomes or 4 chromatids
- During this time, chromosomes are so close together, **crossing over** can occur

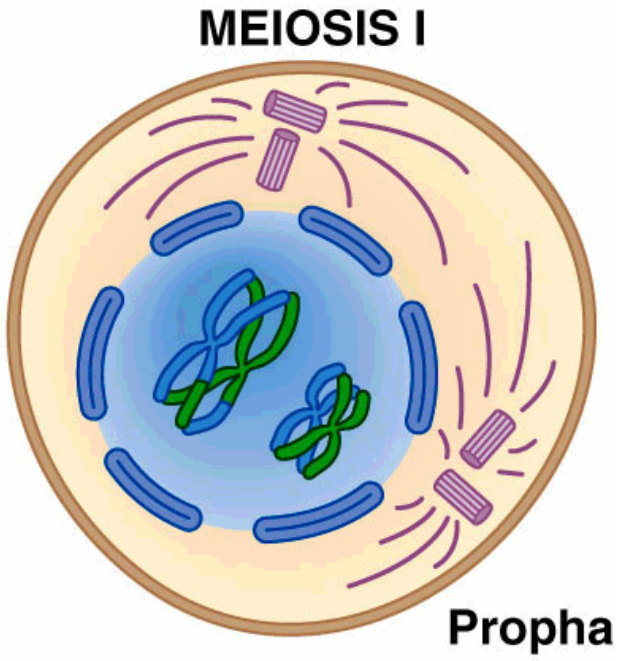
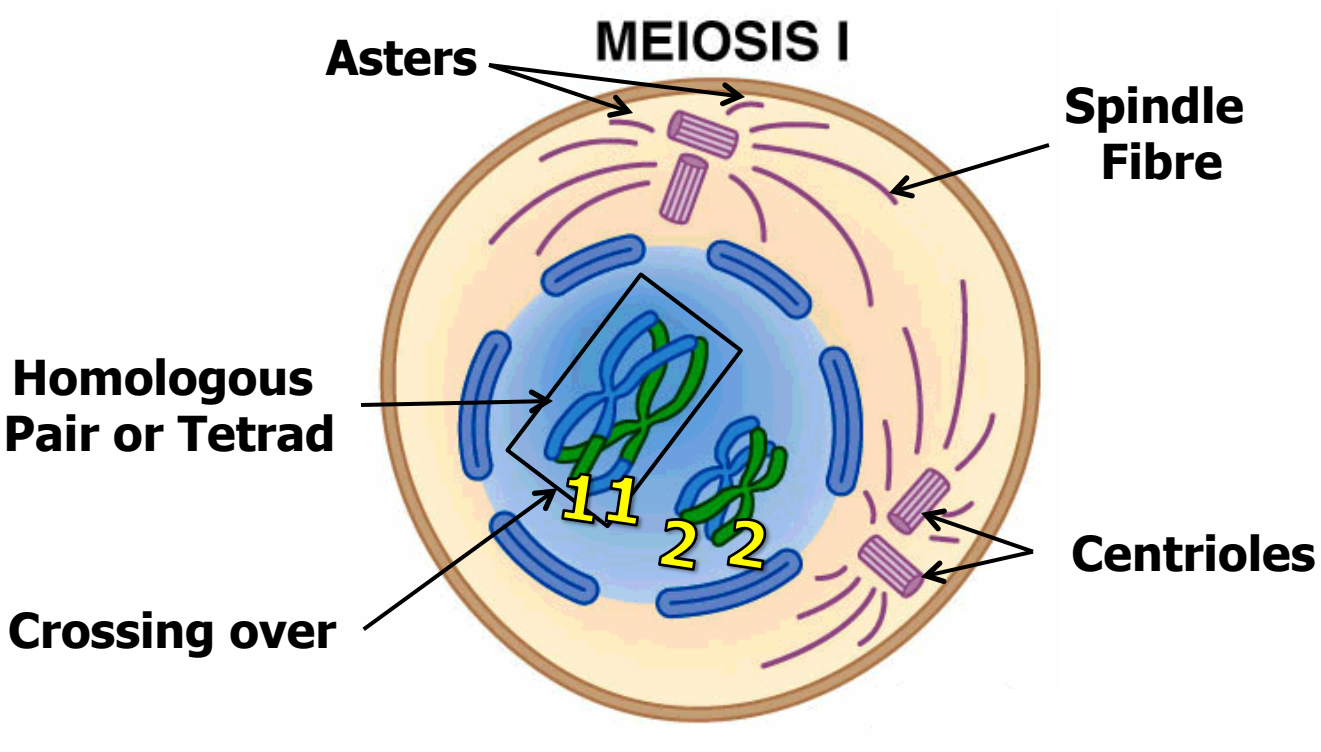


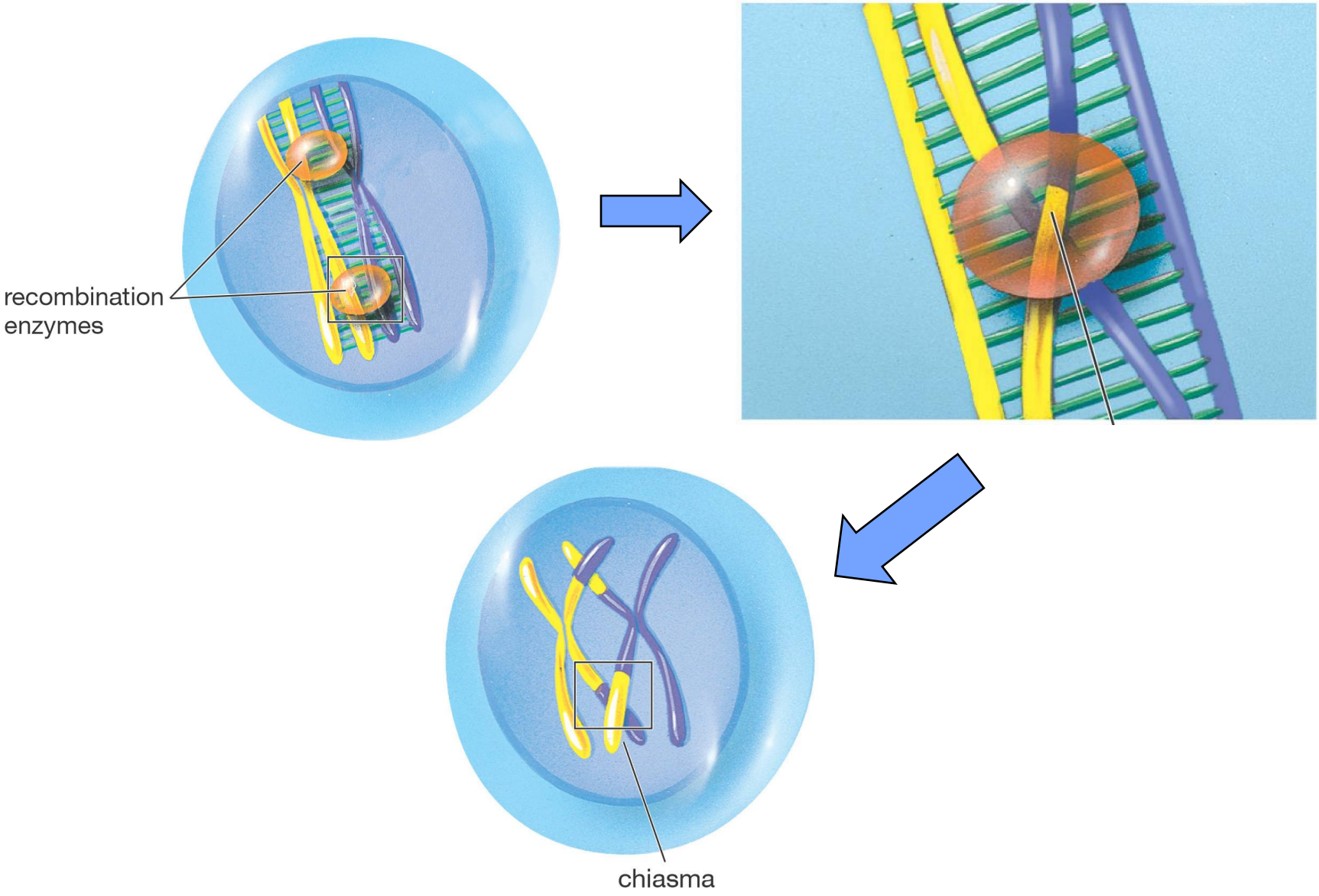
**Diagram on next page!

The result is entirely new genetic combinations not seen in the parents

Prophase 1


MEIOSIS I
Asters
Spindle Fibre
Homologous Pair or Tetrad
Crossing over
Centrioles
1
1
2
2

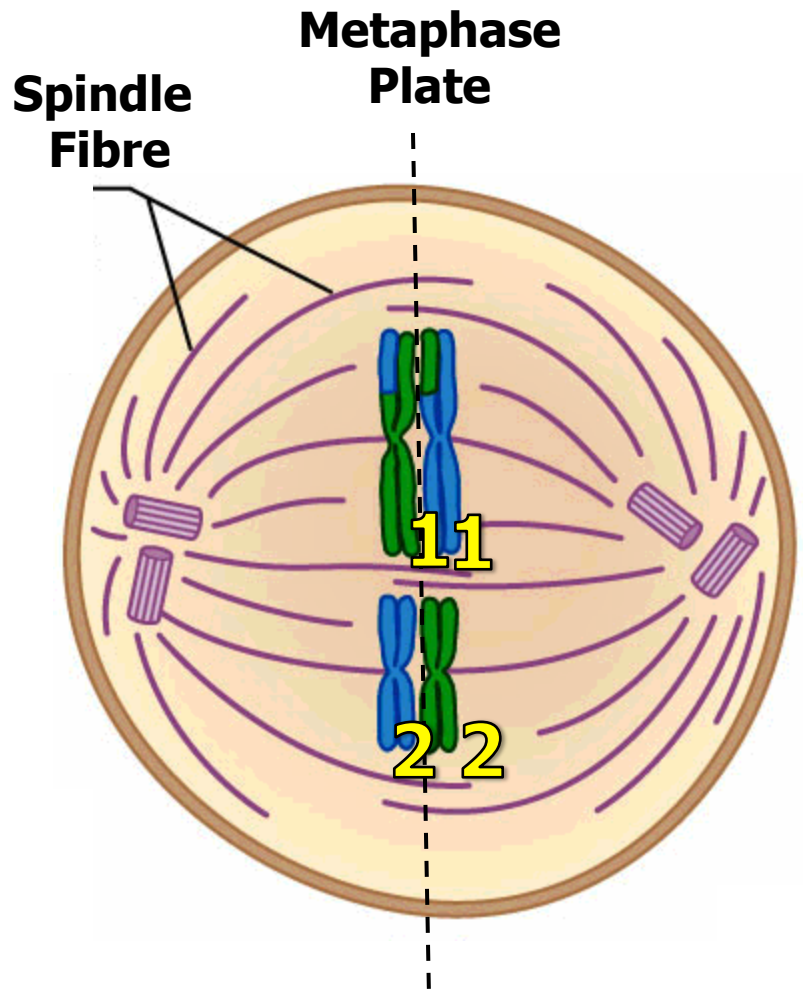
Crossing Over



Metaphase I

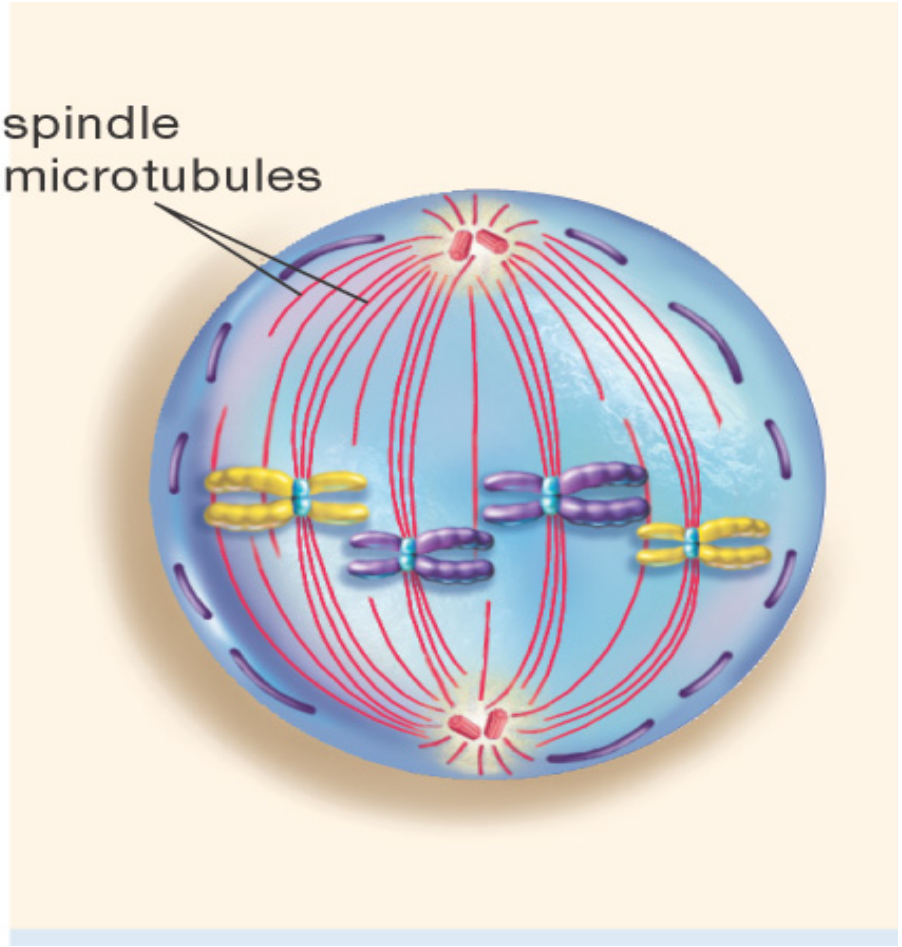
- **Homologous replicated chromosomes line up at the equator on the metaphase plate on the same spindle fiber**

- Recall in metaphase of mitosis, all chromosomes lined up at the middle

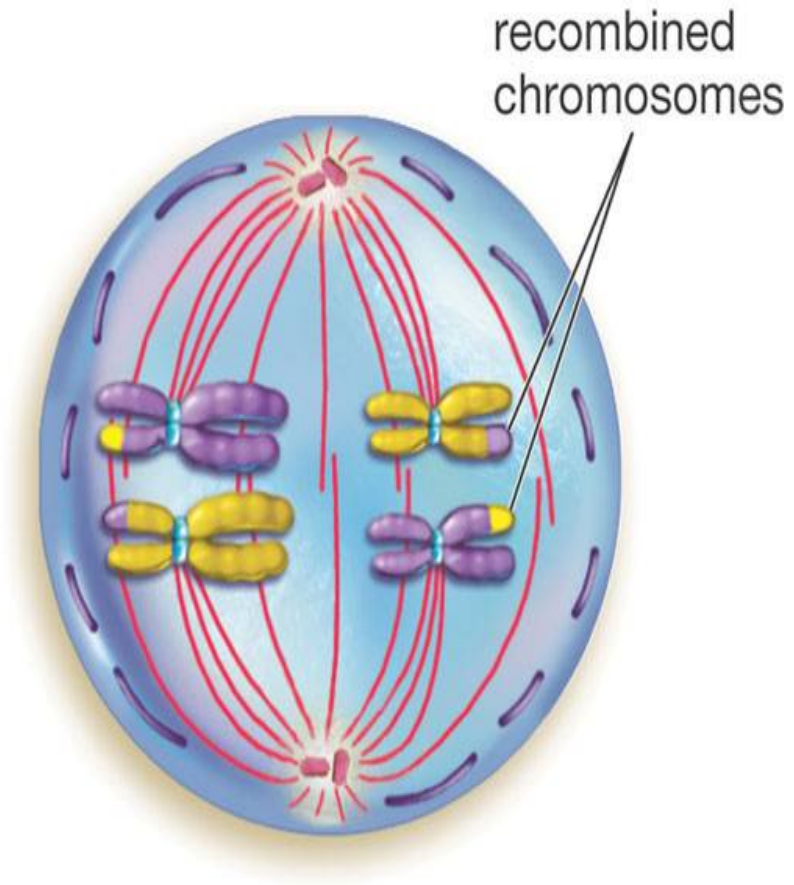


Metaphase – what's different?

Mitosis – Metaphase

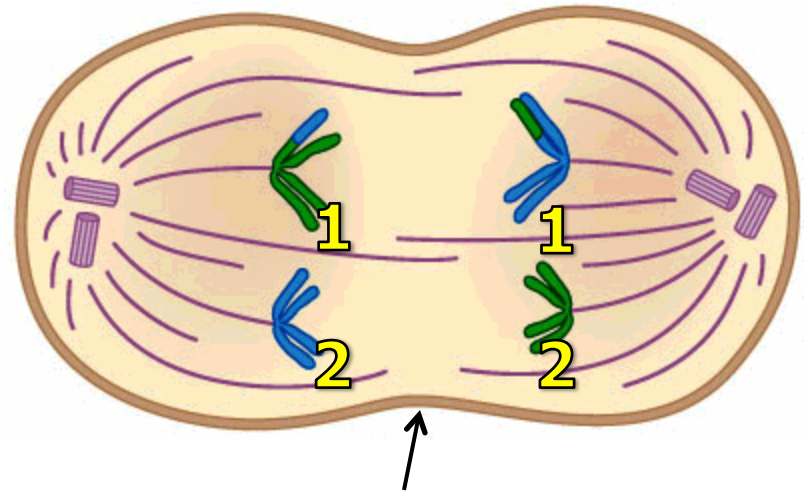


Meiosis – Metaphase I



Anaphase I

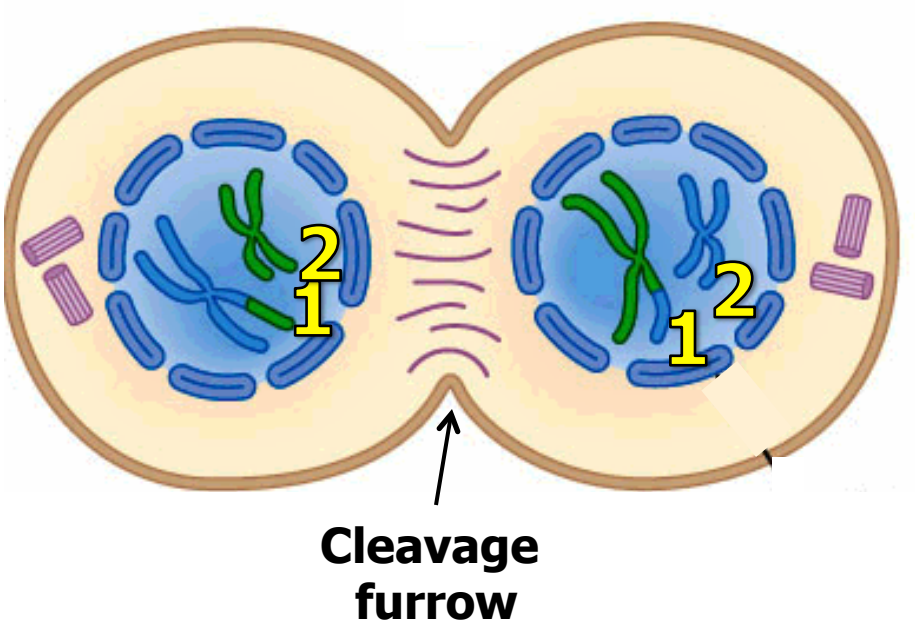
- **Apart!**
- **Homologous chromosomes separate to opposite poles**
- **This is known as segregation 2n→n**
- **Individual chromatids in the replicated chromosomes do not separate yet**



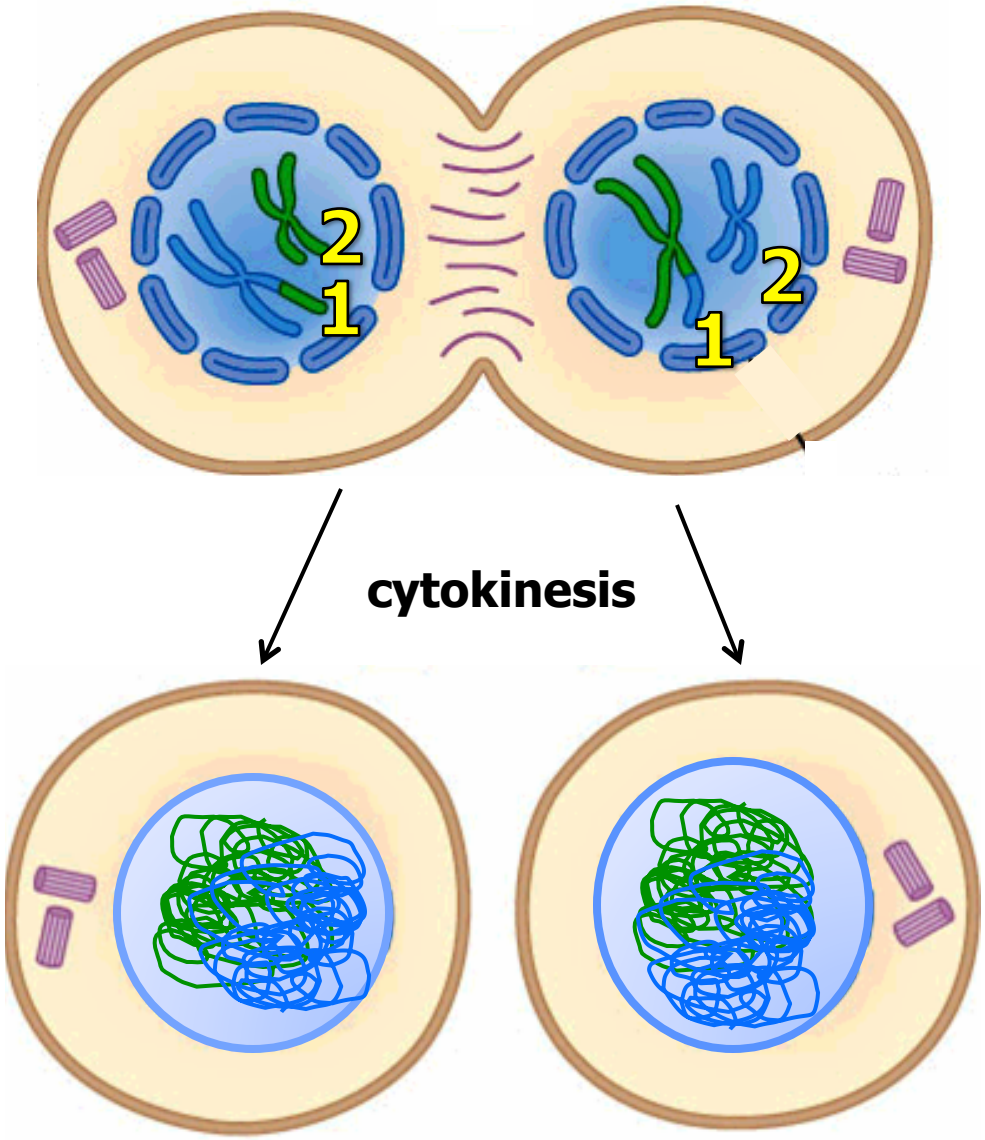
No indent until telophase!

Telophase 1

- Chromosomes arrive at opposite poles
- Cytokinesis occurs in animal cells
- 2 haploid cells form
- Chromosomes may become chromatin and enter an interphase 2 in some cells
- Haploid cells now go into Meiosis II (similar to Mitosis)

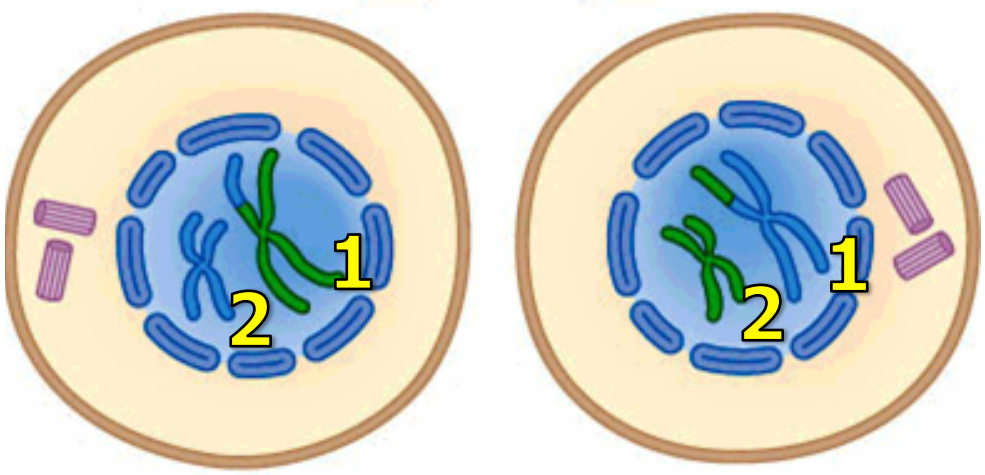


Telophase 1



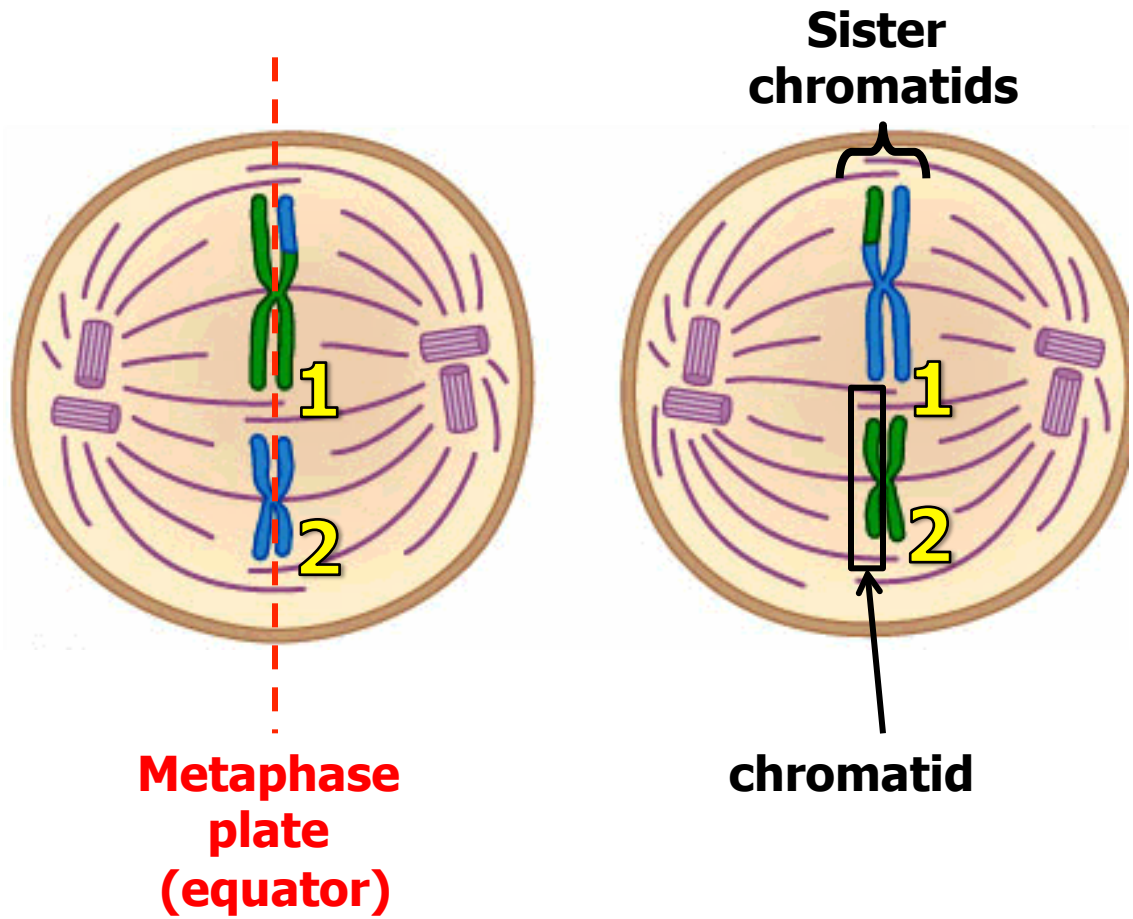
Prophase II

- New spindle fibers form
- Nuclear membrane dissolves
- Chromatin becomes visible chromosomes



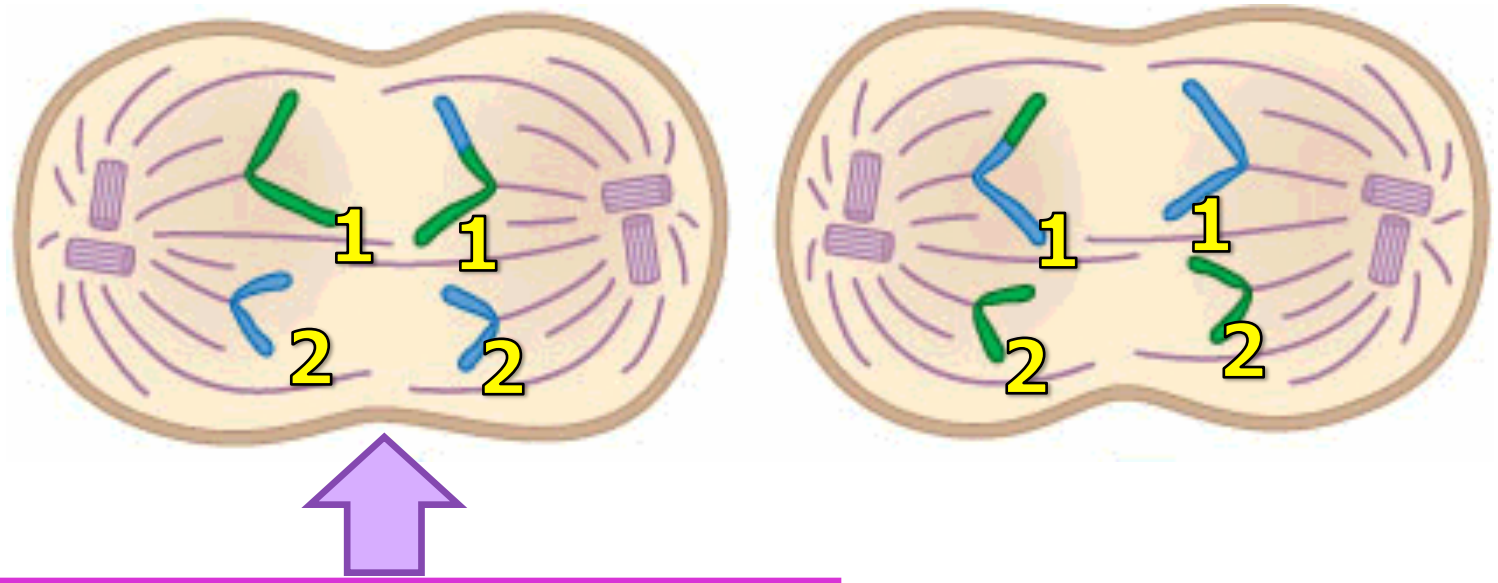
Metaphase II

- Chromosome line up at the metaphase plate
- Chromosomes here are made up of 2 chromatids



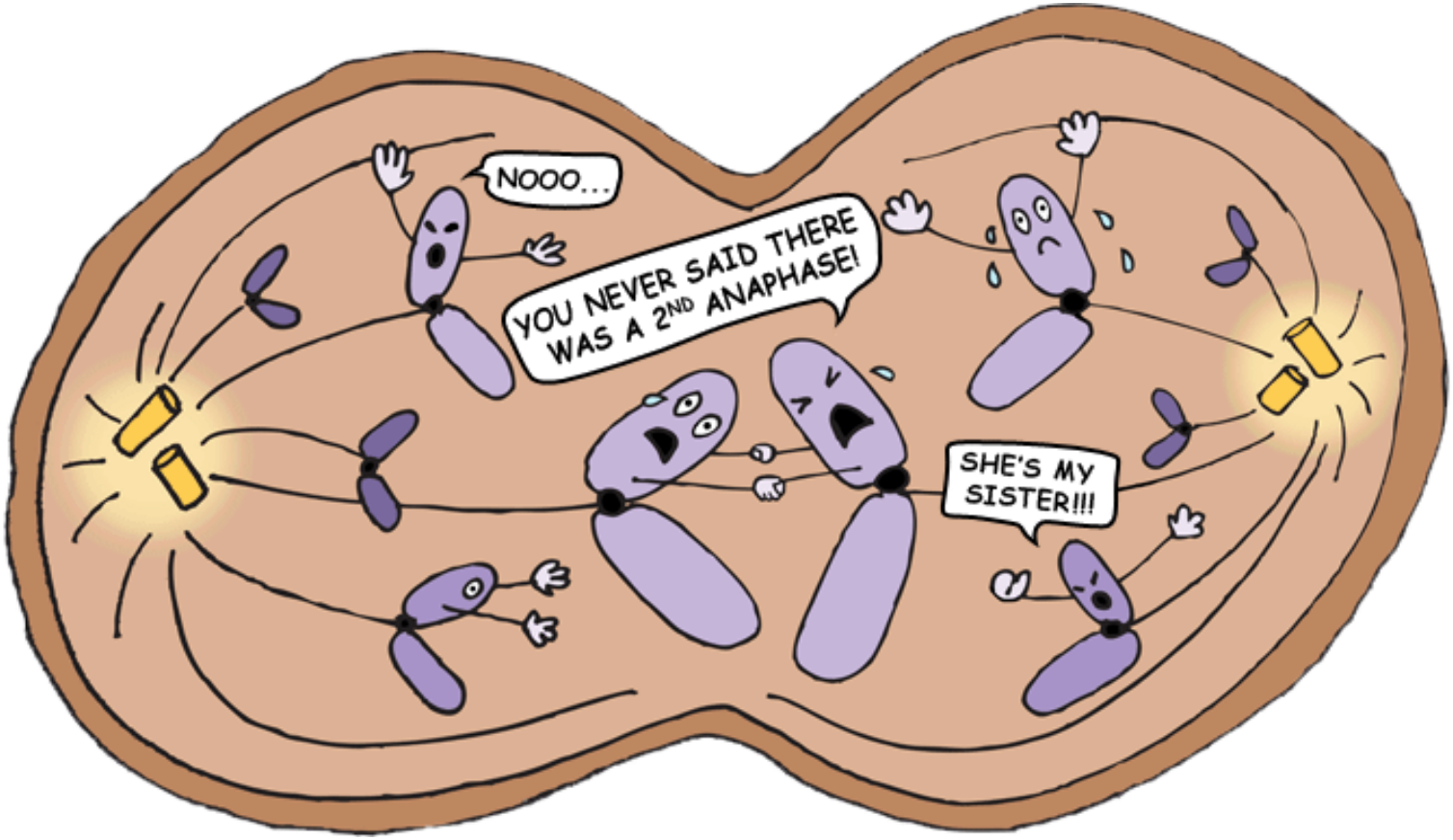
Anaphase II

- Centromeres split
- **Chromosomes** move to the poles



No cleavage furrow yet!
(Indent should not be there!)

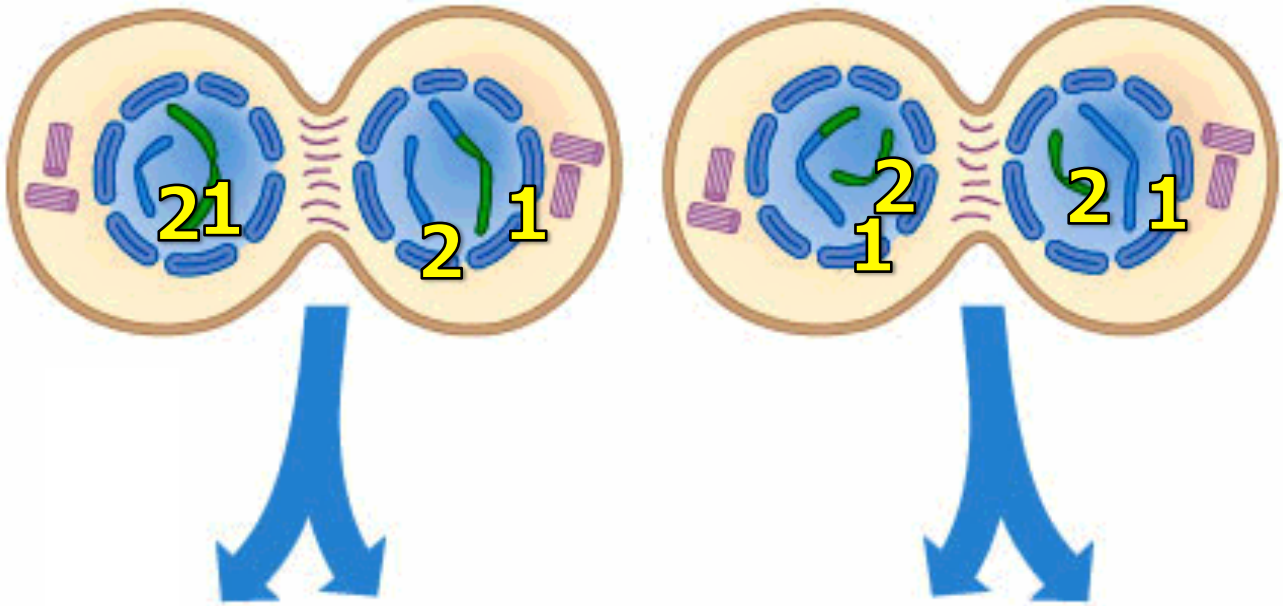
Anaphase II



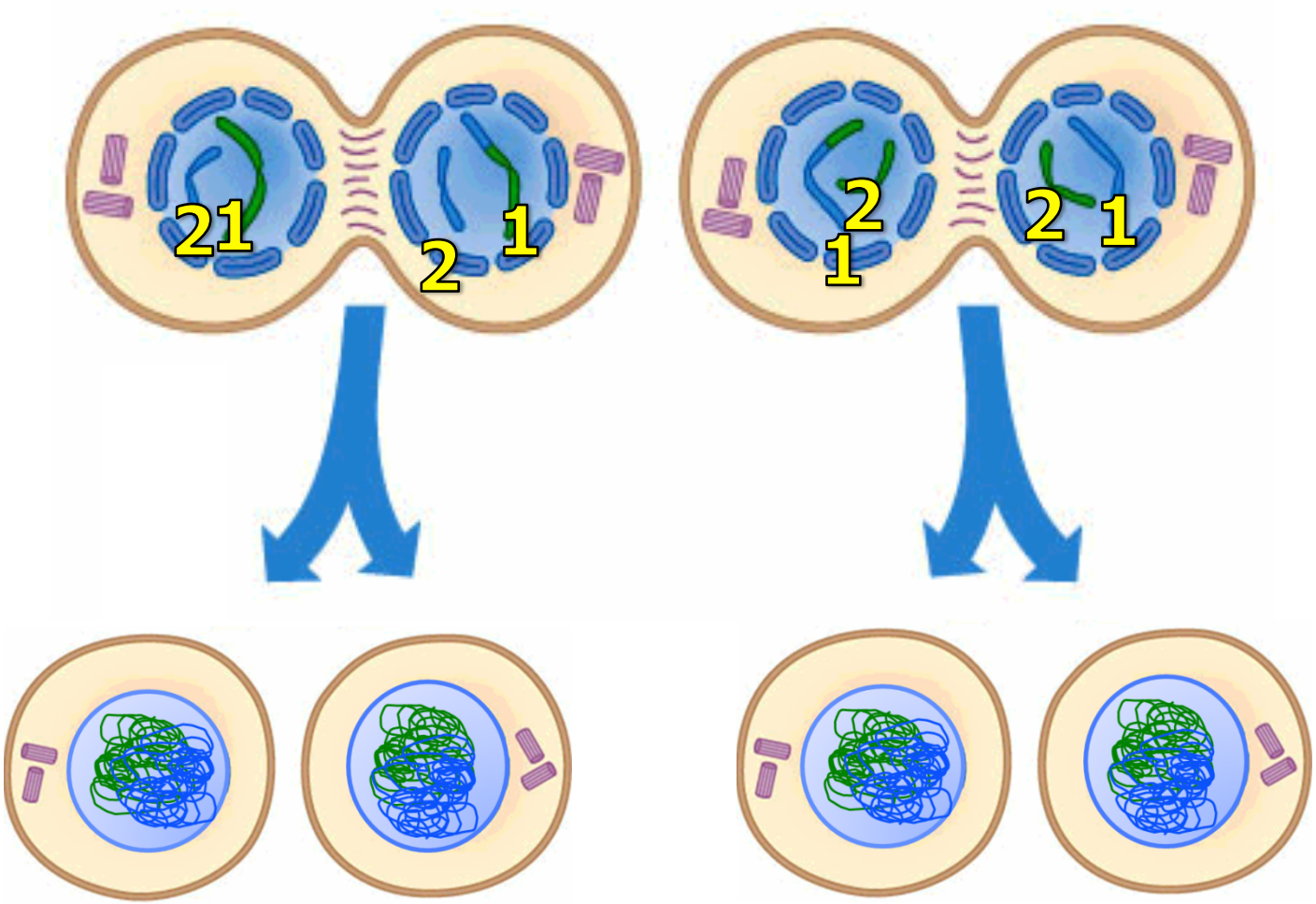
Telophase II

- Chromosomes arrive at poles
- Cytoplasm starts to pinch in
- Cytokinesis occurs
- End result is 4 haploid cells

Excellent Narrated Movie of Meiosis



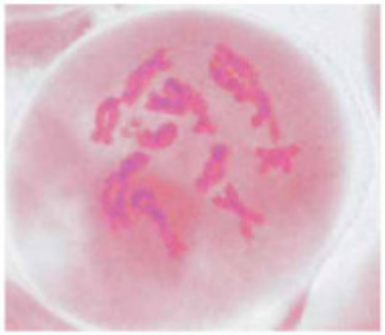
Cytokinesis

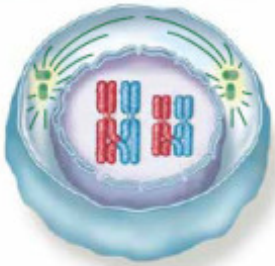


Meiosis Square Dance http://www.youtube.com/watch?v=iCL6d0OwKt8

Meiosis I

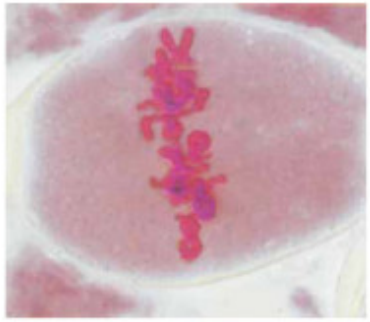
Late prophase I–prometaphase

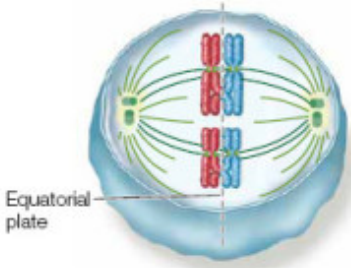




3 The chromosomes continue to coil and shorten. Crossing over results in an exchange of genetic material. In prometaphase the nuclear envelope breaks down.

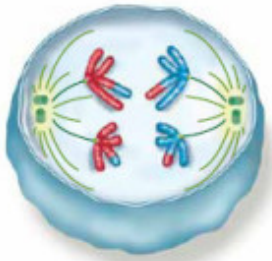
Metaphase I





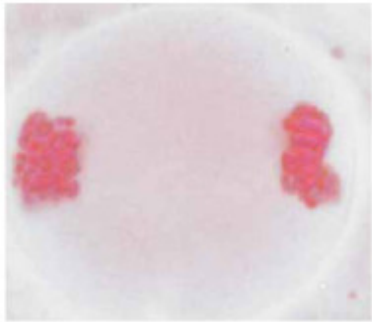
4 The homologous pairs line up on the equatorial (metaphase) plate.

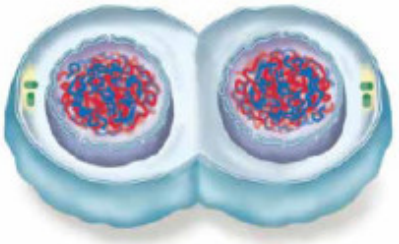
Anaphase I



5 The homologous chromosomes (each with two chromatids) move to opposite poles of the cell.

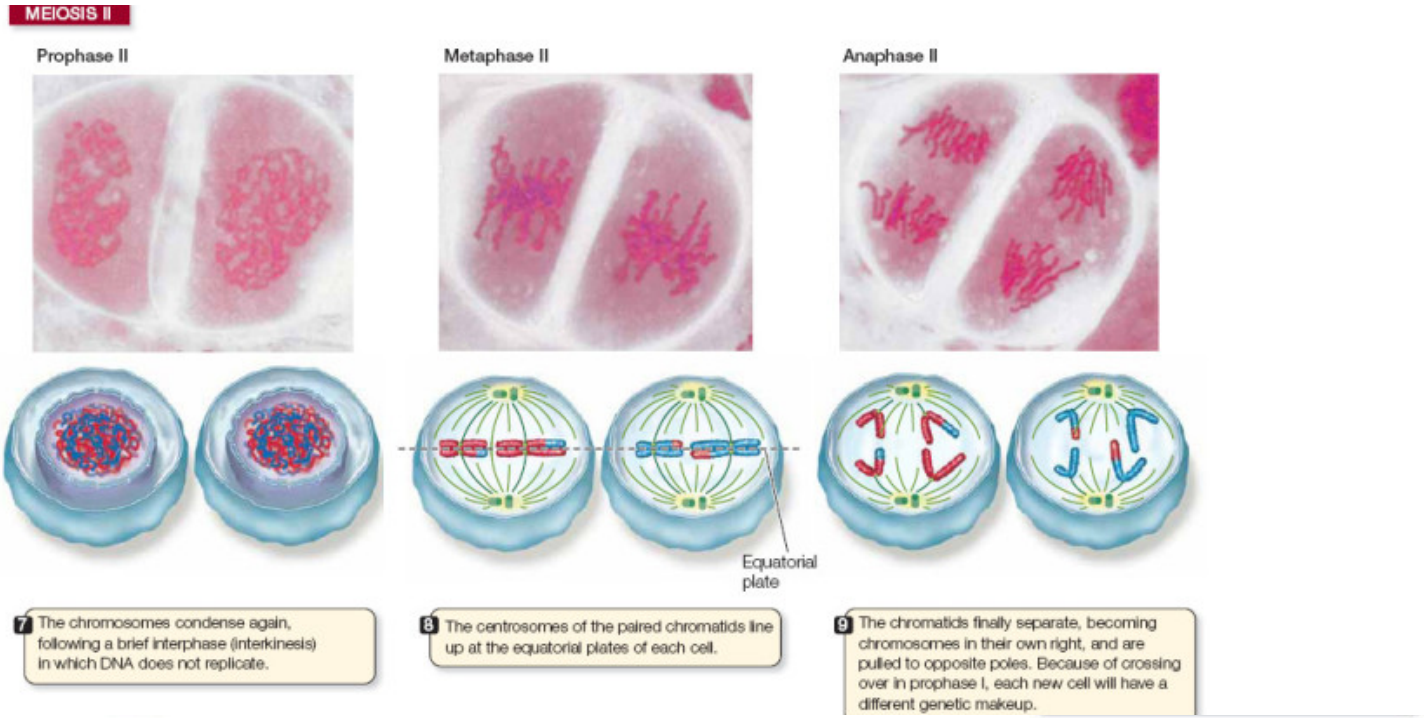
Telophase I

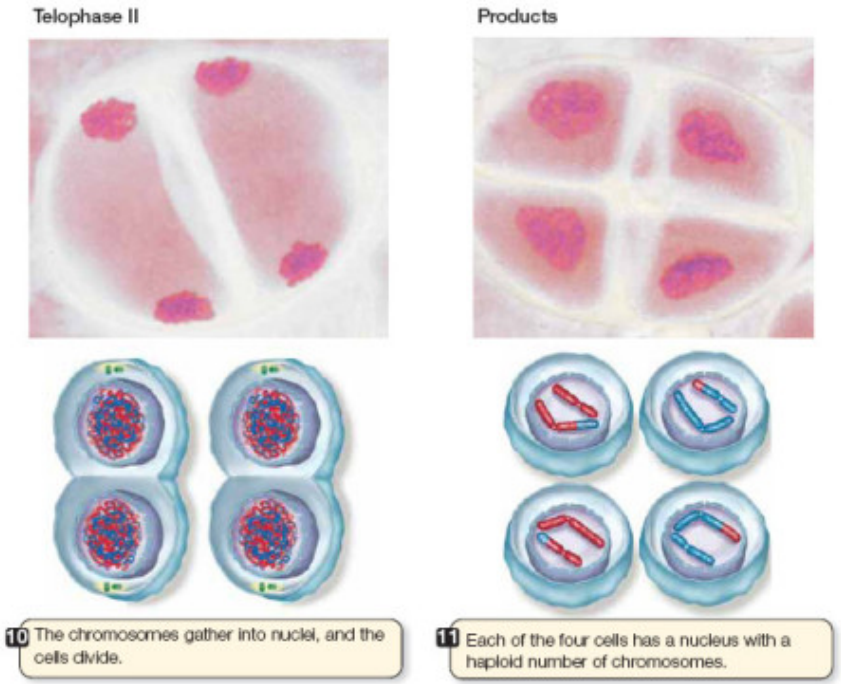




6 The chromosomes gather into nuclei, and the original cell divides.

Meiosis II

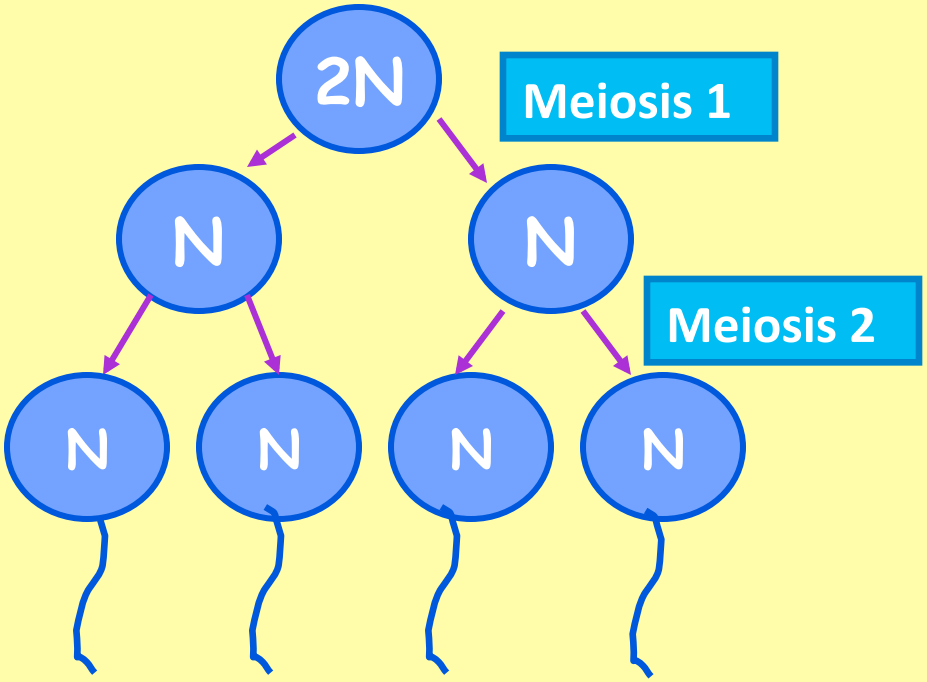

MEIOSIS II
Prophase II
Metaphase II
Anaphase II
Equatorial plate
7 The chromosomes condense again, following a brief interphase (interkinesis) in which DNA does not replicate.
8 The centrosomes of the paired chromatids line up at the equatorial plates of each cell.
9 The chromatids finally separate, becoming chromosomes in their own right, and are pulled to opposite poles. Because of crossing over in prophase I, each new cell will have a different genetic makeup.


Telophase II
Products
10 The chromosomes gather into nuclei, and the cells divide.
11 Each of the four cells has a nucleus with a haploid number of chromosomes.

Meiosis in Males and Females

Males - Spermatogenesis

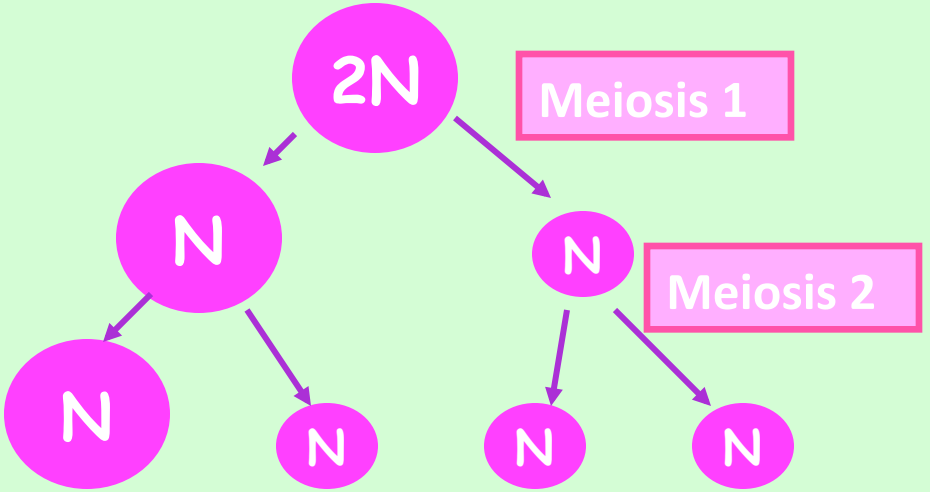
Location : **testes**



4 equal sperm

Females - Oogenesis

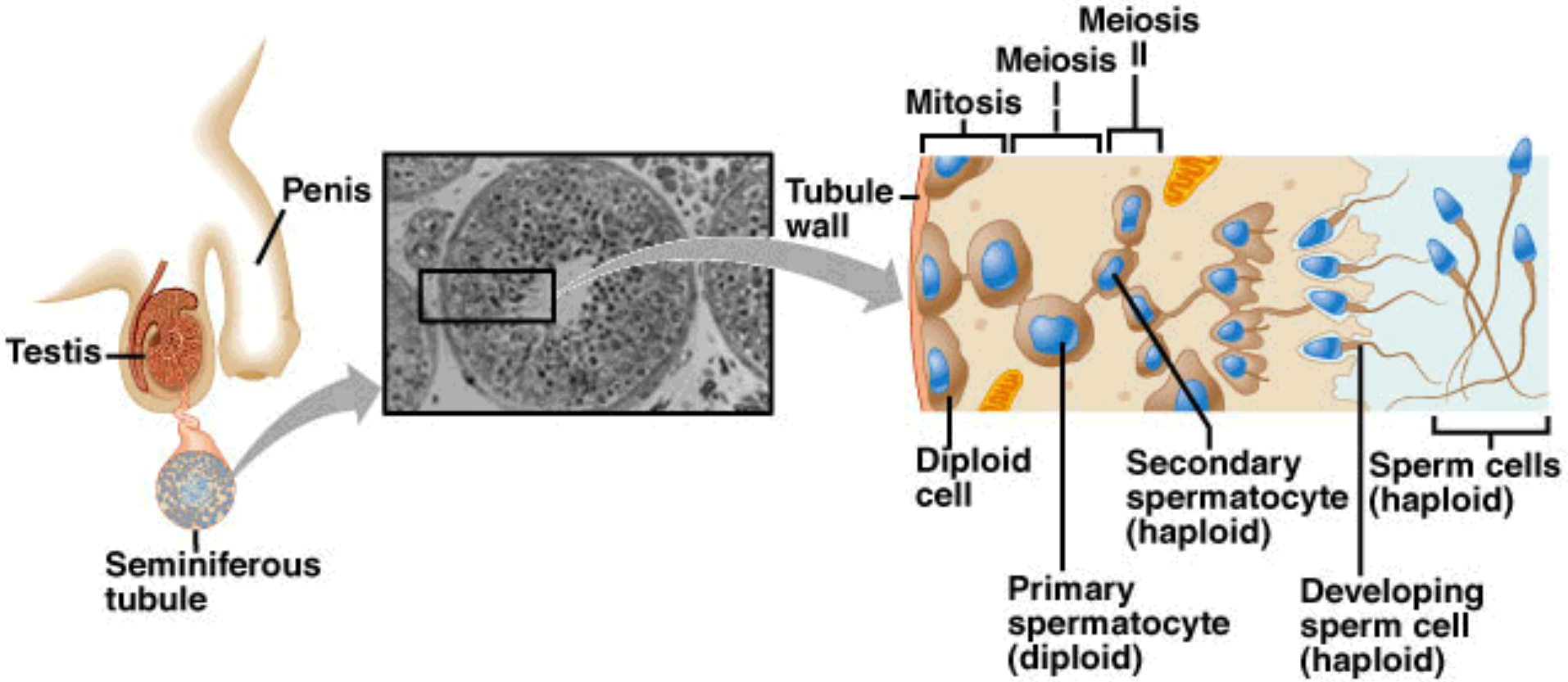
Location: **ovaries**



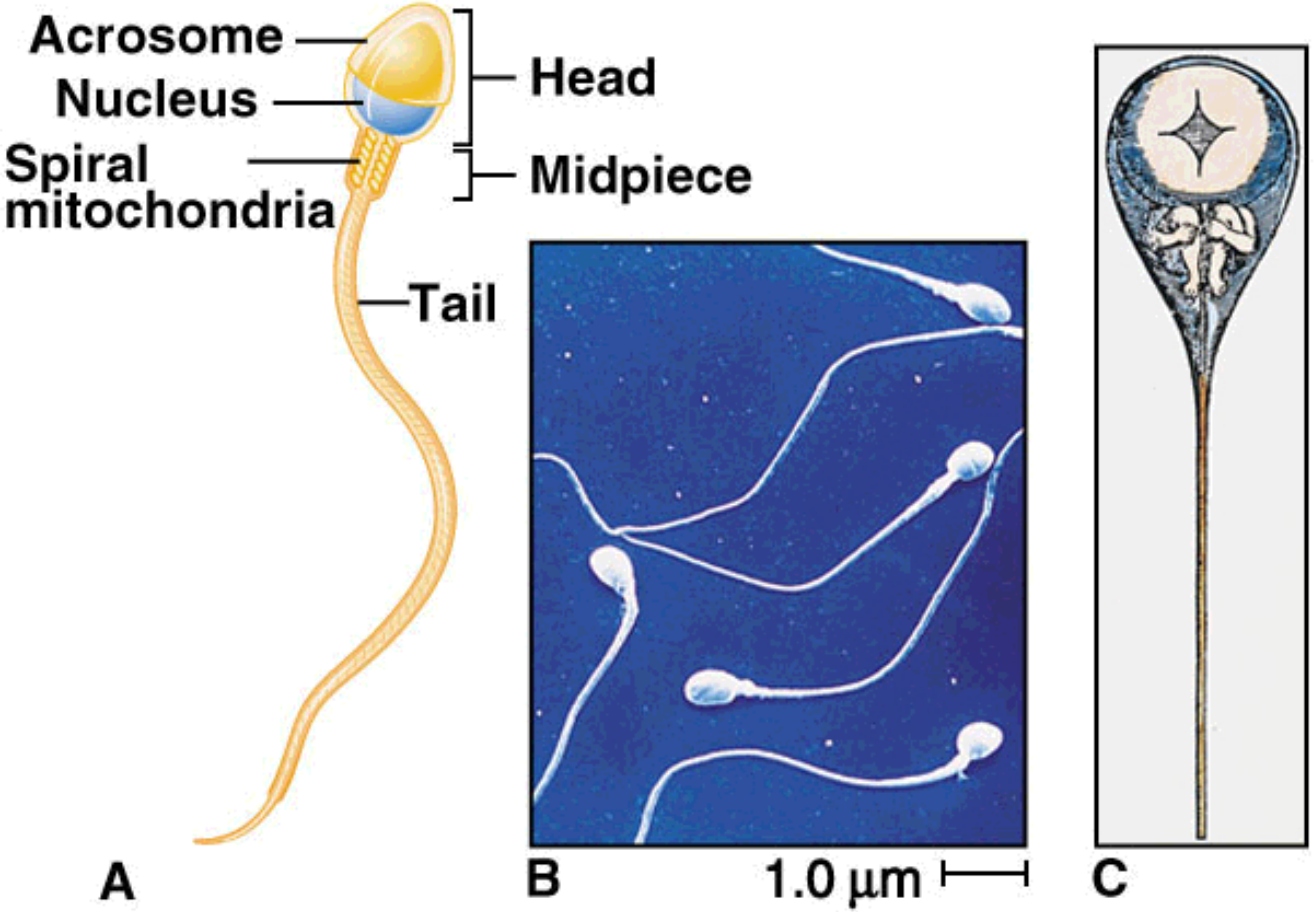
1 egg and 3 polar bodies

Egg (ootid) gets most of the cytoplasm. Polar bodies die and are absorbed by body.

Meiosis Produces Sperm Cells



Structure of Human Sperm



Meiosis

Spermatogenesis

Oogenesis

Sperm (n)

Egg (Ovum) (n)

Fertilization

Zygote(2n)

Mitosis

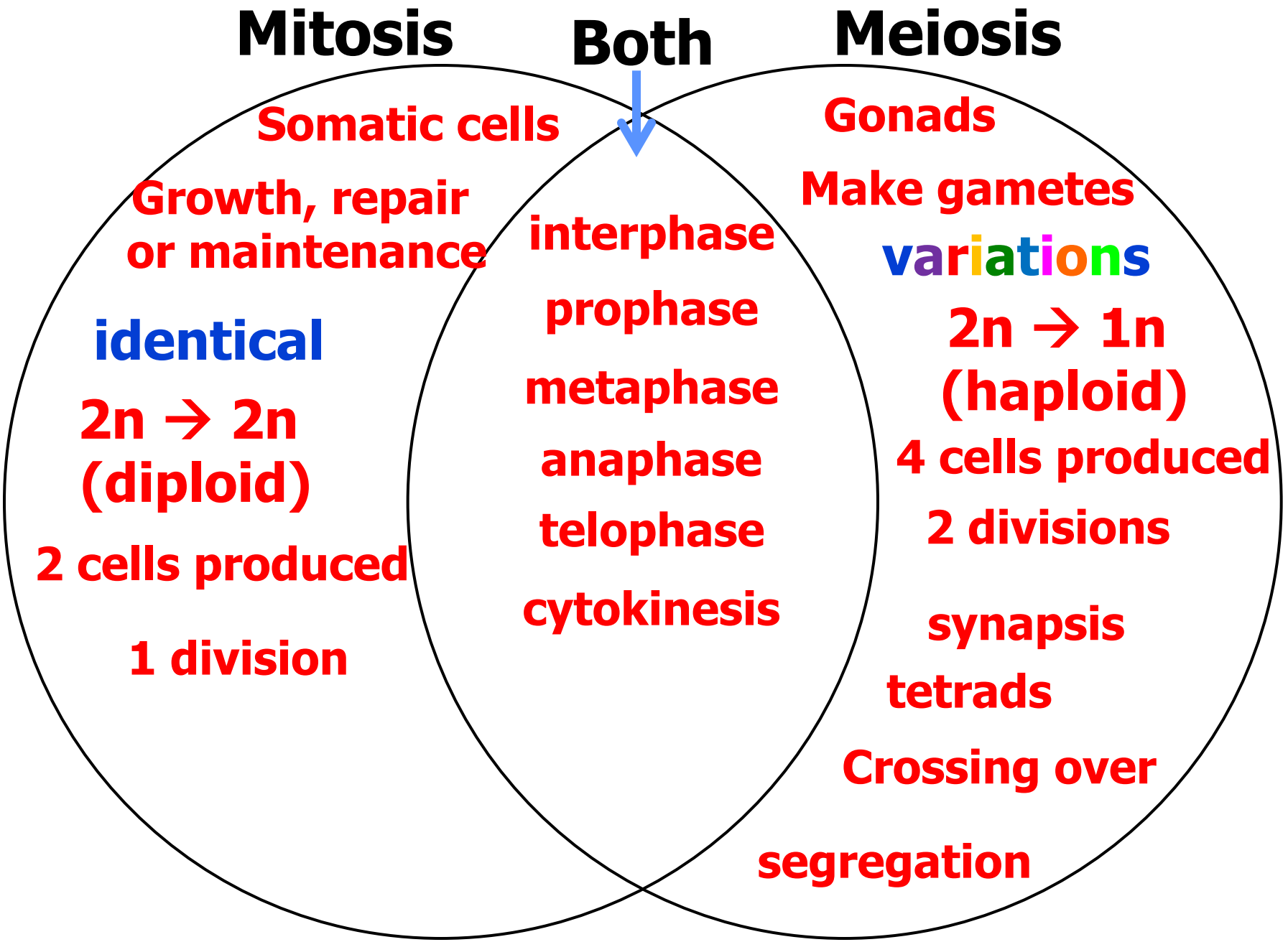
Embryo

(2n) Fetus

Child

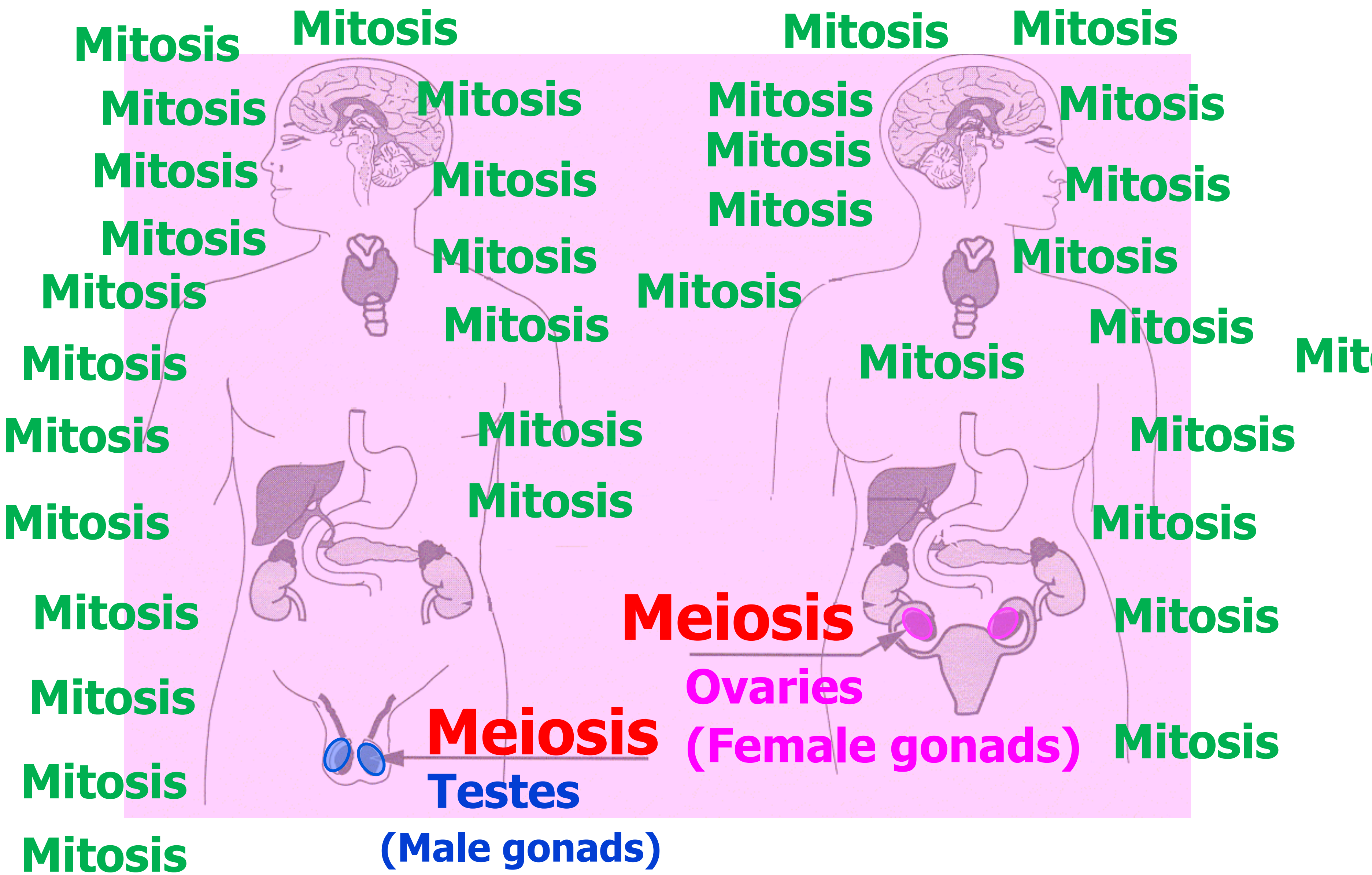
FYI: males make approx 10^9 sperm cells every day

FYI: females are born with approx 400 000 egg cells. 1000 mature every month, but only one leaves ovary.



Mitosis vs. Meiosis animation & quiz

http://highered.mcgraw-hill.com/sites/9834092339/student_view0/chapter11/comparison_of_meiosis_and_mitosis.html



Mitosis
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Mitosis
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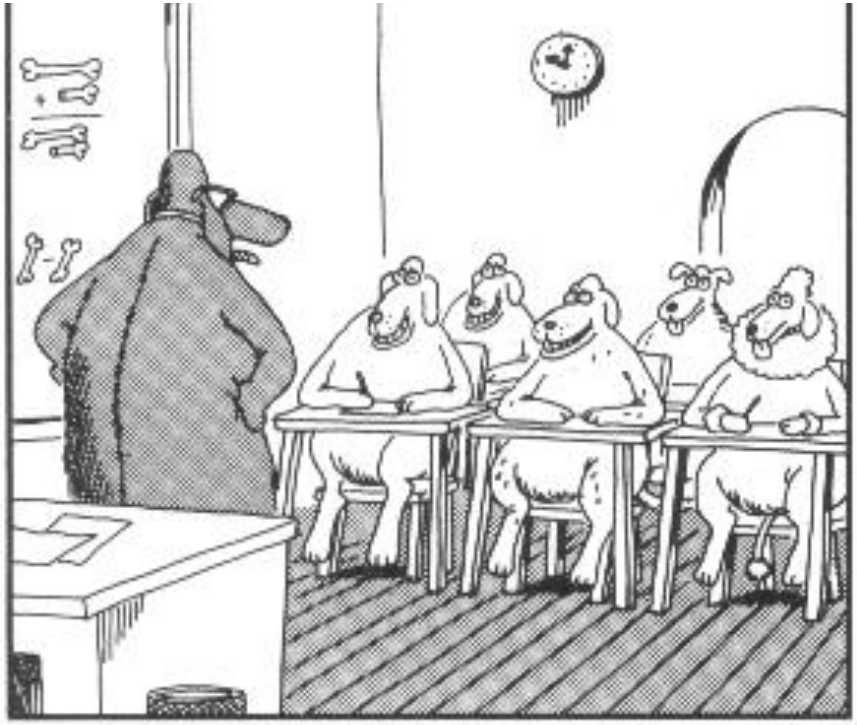
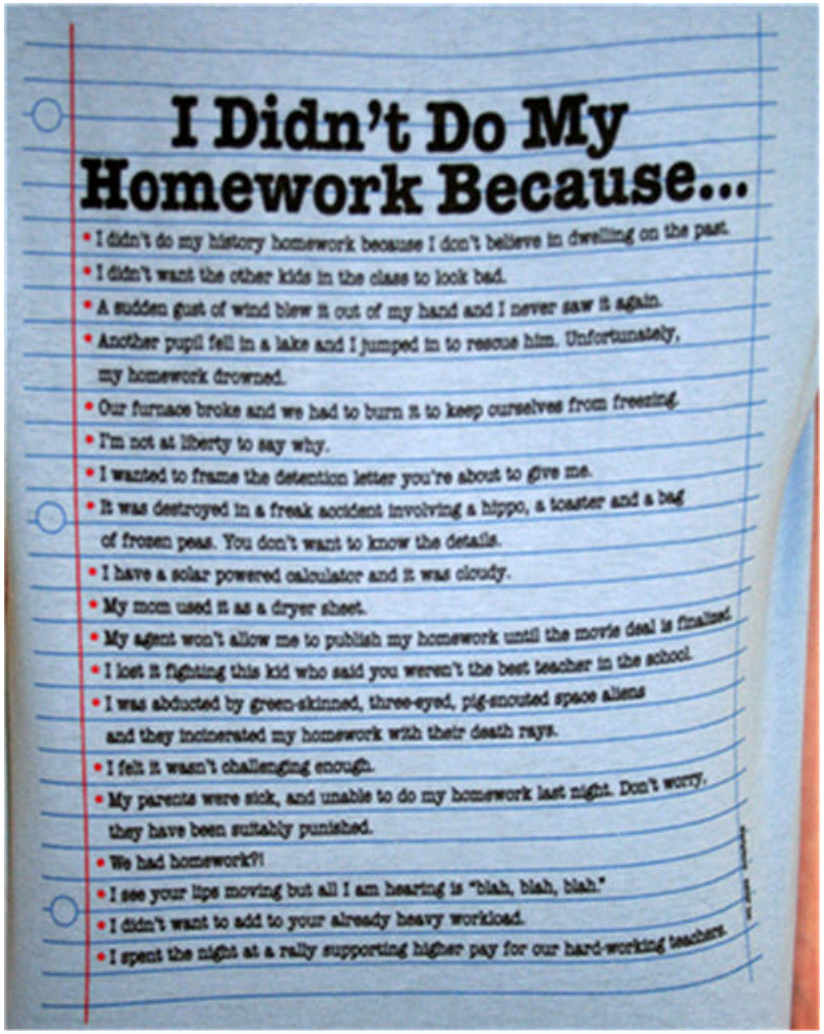
Mitosis
Mitosis
Mit
Meiosis
Ovaries
(Female gonads)
Meiosis
Testes
(Male gonads)

Do the questions in your workbook



"Well, here we go again. ... Did anyone here *not* eat his or her homework on the way to school?"

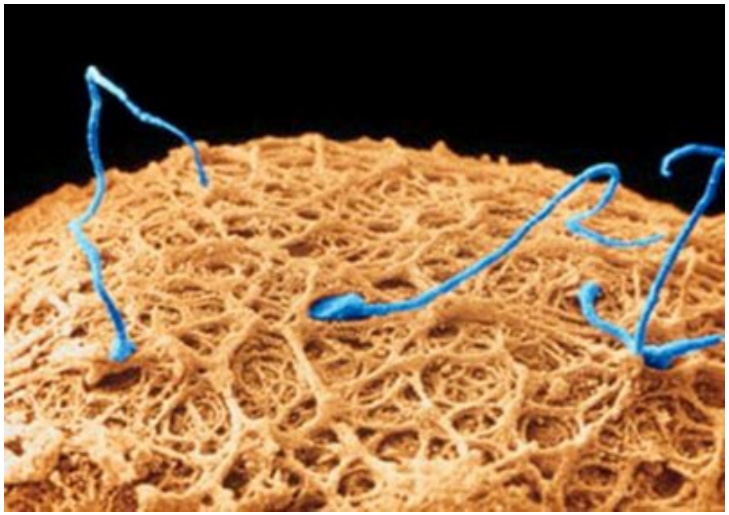


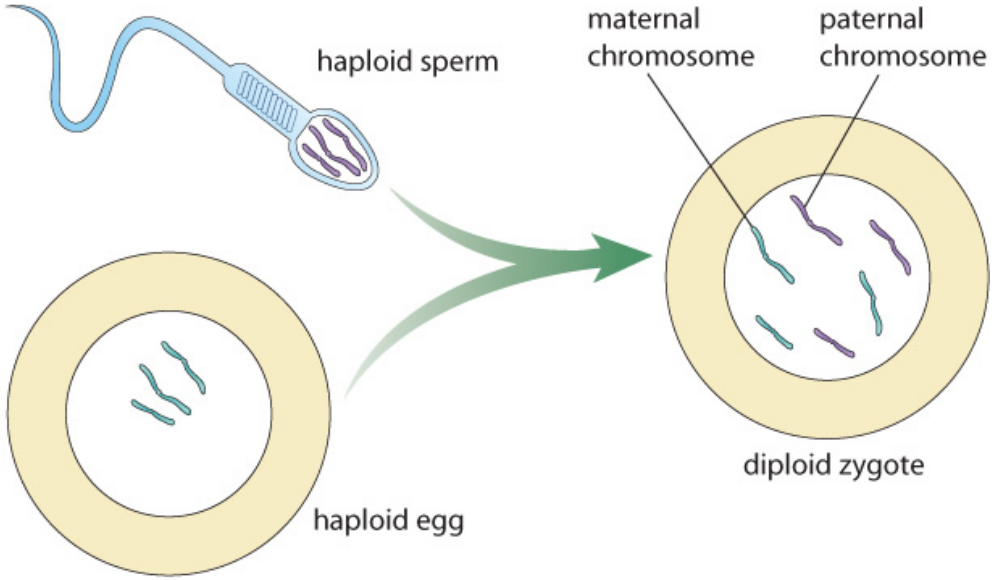
Meiosis - Sources of Variation

Mitosis produces daughter cells that are genetically IDENTICAL

- Meiosis produces daughter cells with different **combinations** of genes.
- This variation is accomplished by:

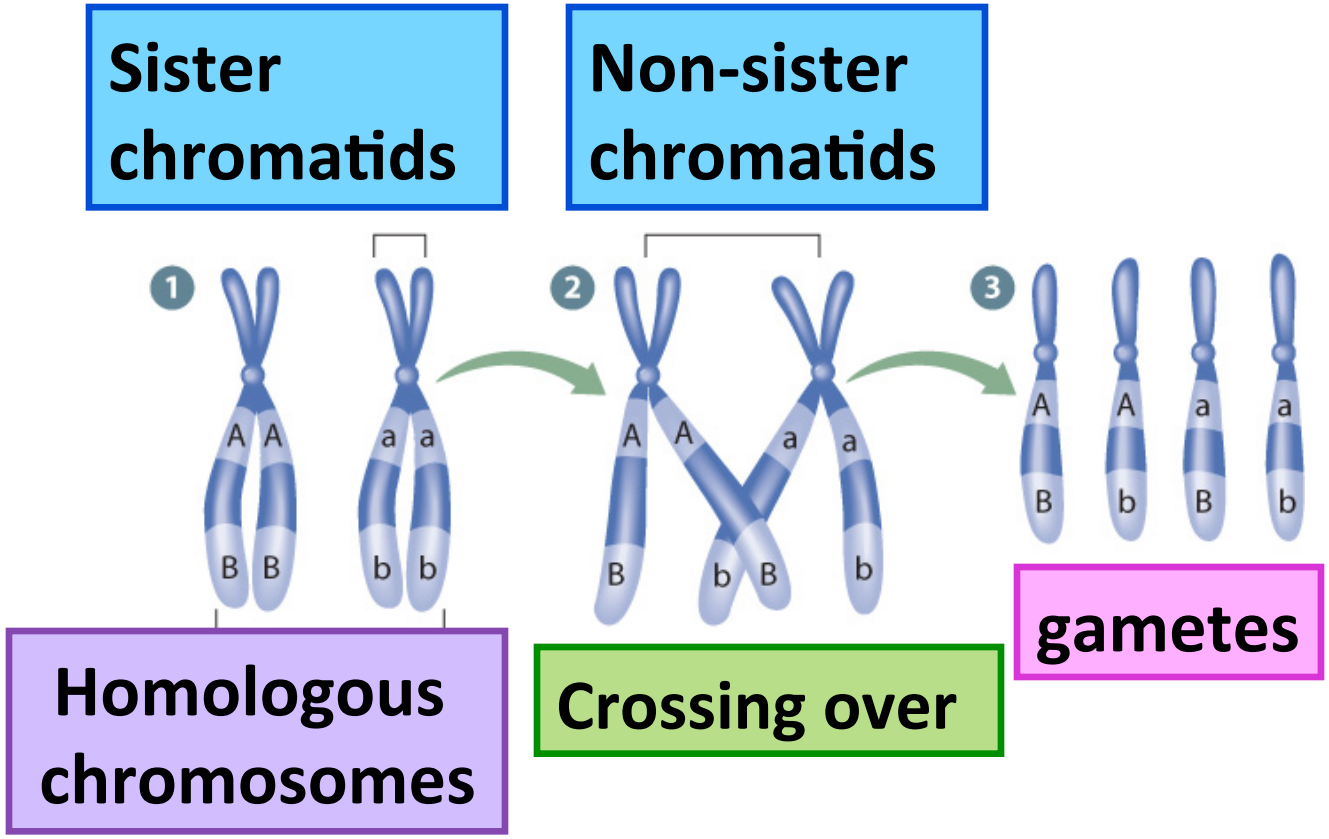
  1. **Gamete success - only one sperm can fertilize the egg.**





Crossing Over

2. **Crossing Over - depends on distance between genes and length of chromosome**



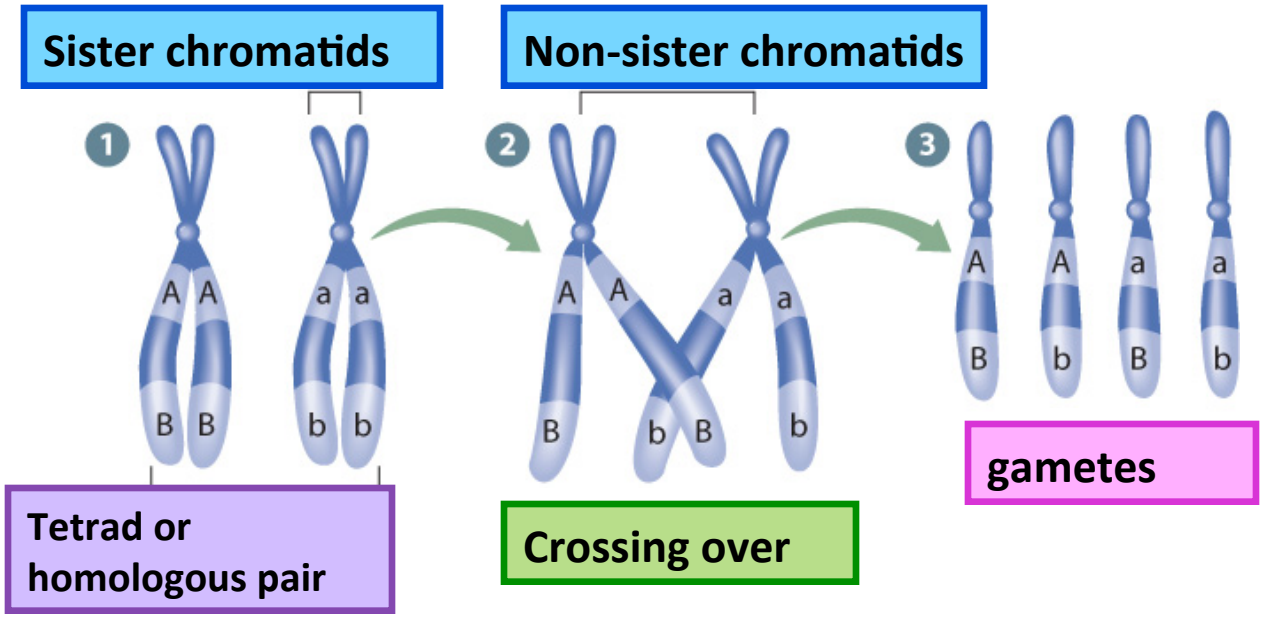
Crossing Over

Crossing over occurs at random between pairs of **homologous chromosomes.**

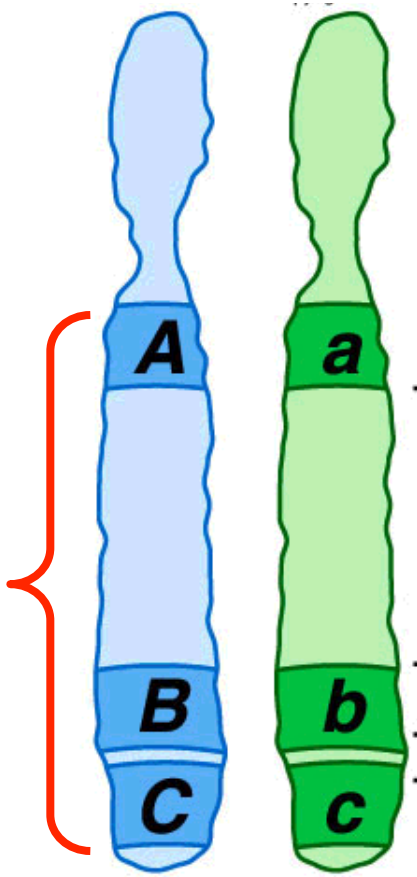
(1) During **prophase I**, homologous chromosomes form pairs.

(2) Non-sister chromatids cross over each other and exchange segments of chromosomes.

(3) Chromosomes in the gametes contain **new combinations** of genetic material



Linked Genes



Crossing over occurs more often between genes that are further apart.

Genes *A* and *B* far apart; crossing over more likely

Genes *B* and *C* close together; crossing over less likely

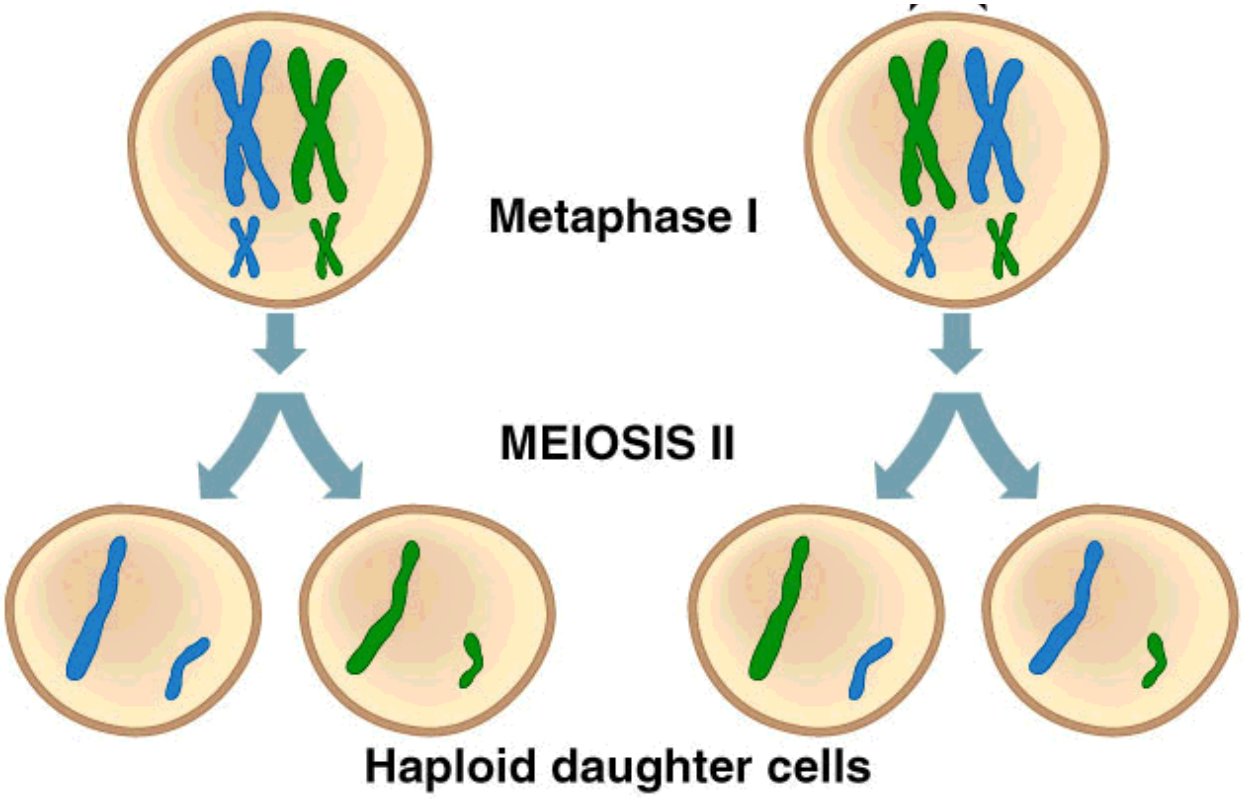
A, B and C are linked. So are a, b and c.

They are on the same chromosome.

The only way they would not be transferred together is if they were crossed over during Prophase I.

Independent Assortment

3. **Independent assortment** - the way one homologous pair lines up has nothing to do with the way another homologous pair lines up! It is **random**.



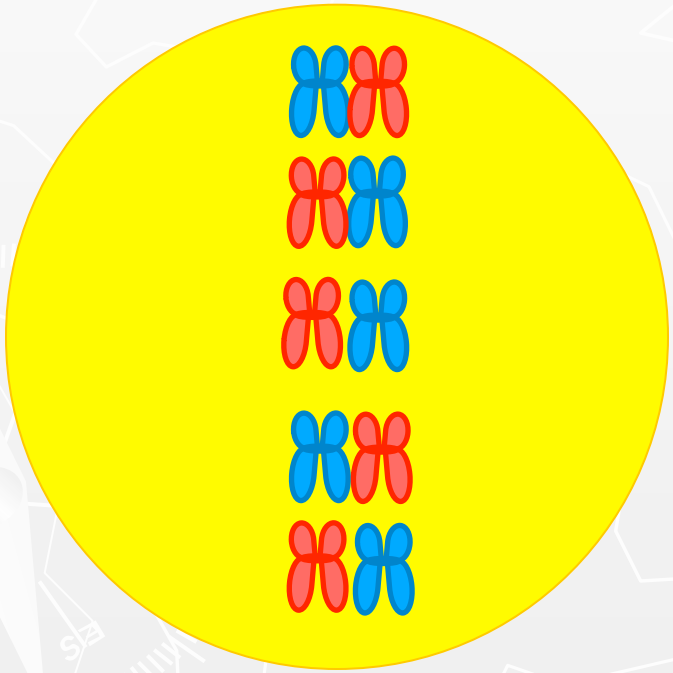
Meiosis Video: (9:35)

http://www.youtube.com/watch?v=rB_8dTuh73c&safety_mode=true&safe=active

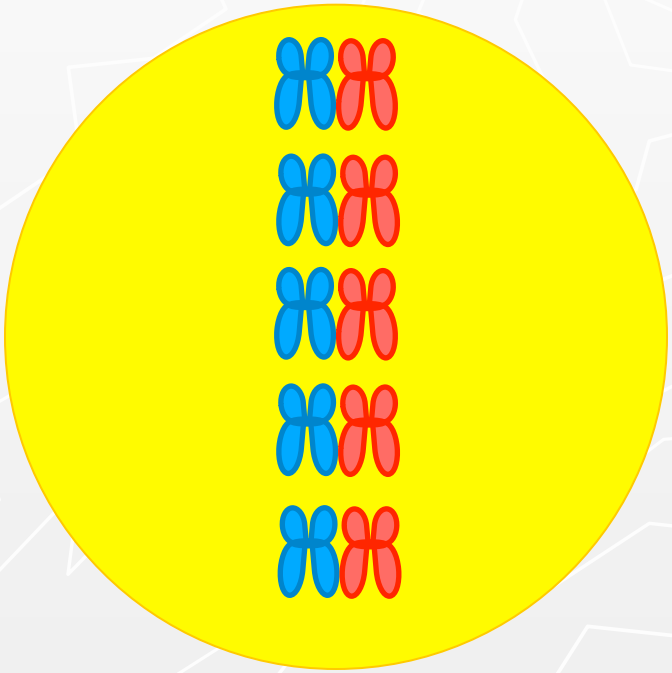
Law of Independent Assortment

- **Different pairs of alleles line up independently of each other (completely random!)**

Independent Assortment



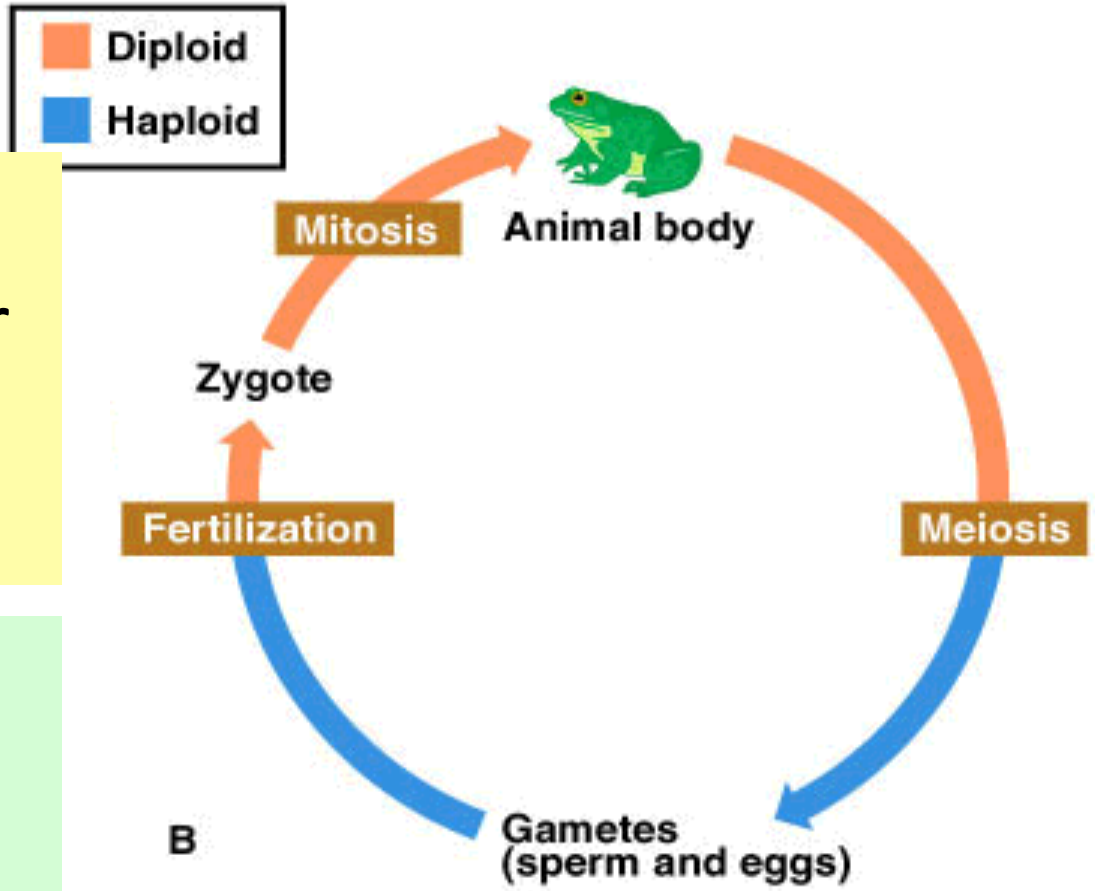
Very unlikely according to Independent Assortment



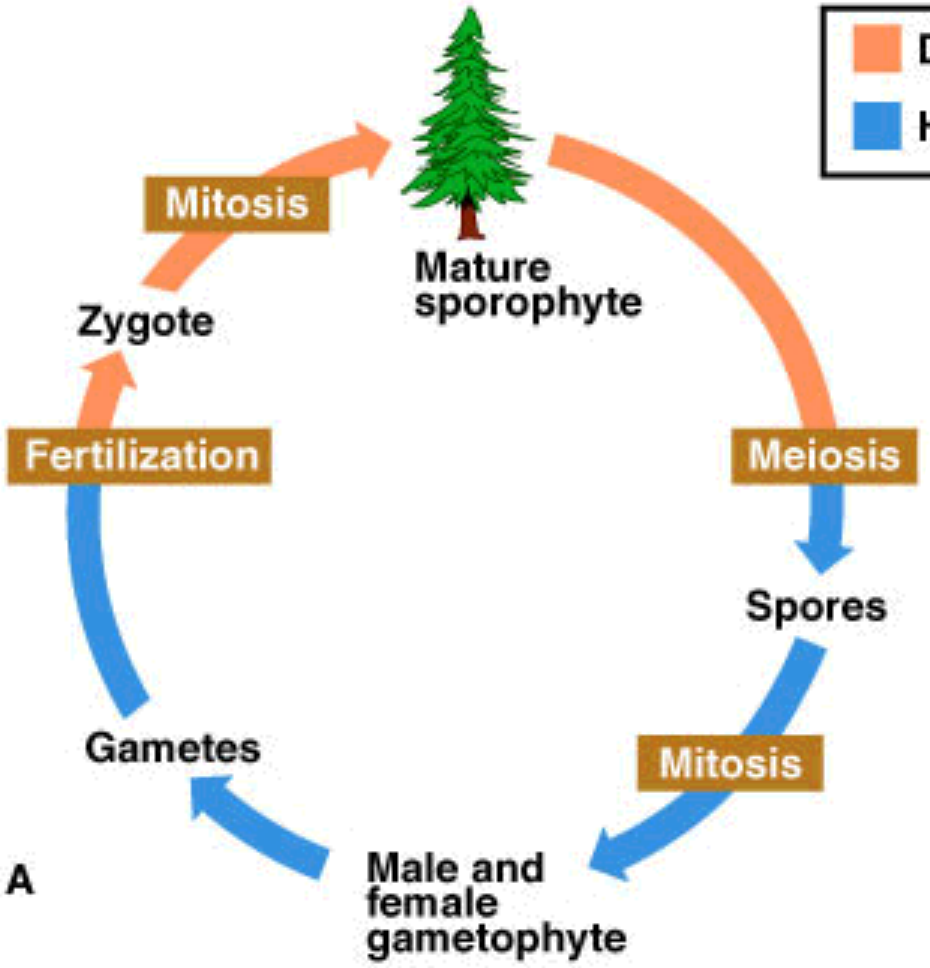
Animal Life Cycle

The animal life cycle is based on a regular pattern of mitosis and meiosis

Humans reproduce sexually and live in the diploid stage

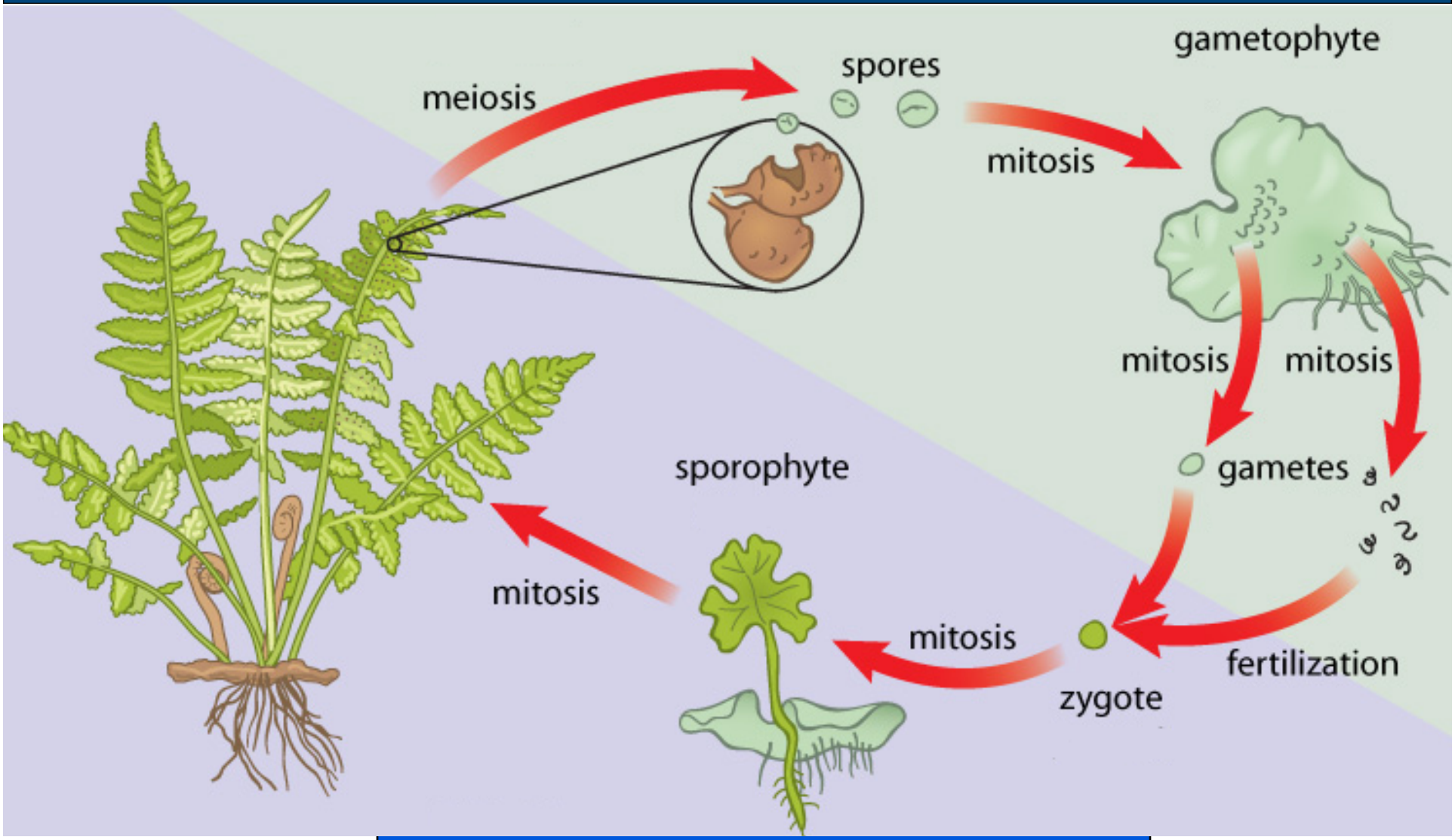


Plant Life Cycle



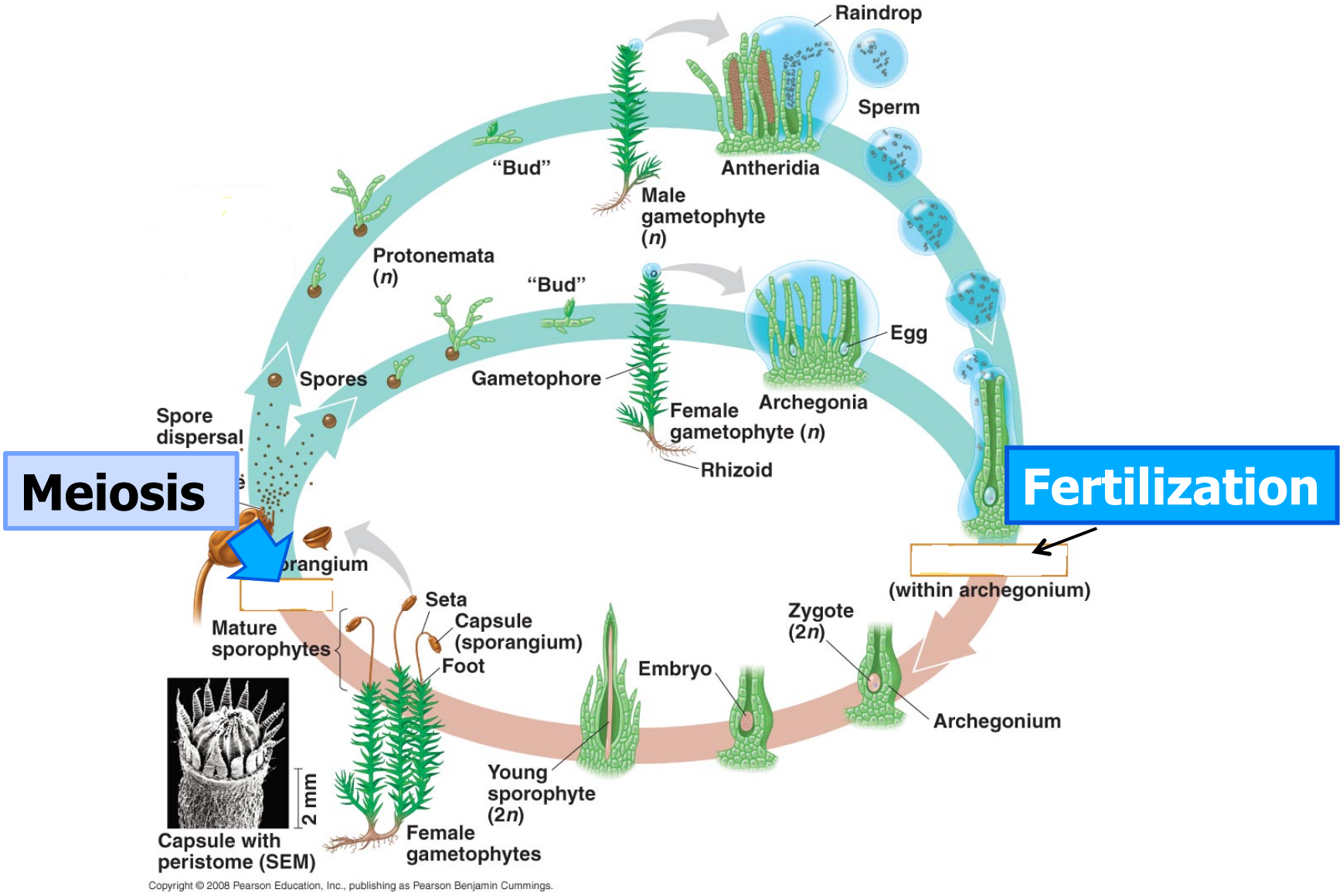
Plants can exist in haploid And Diploid stages known as Alternation of Generations

Fern Life Cycle

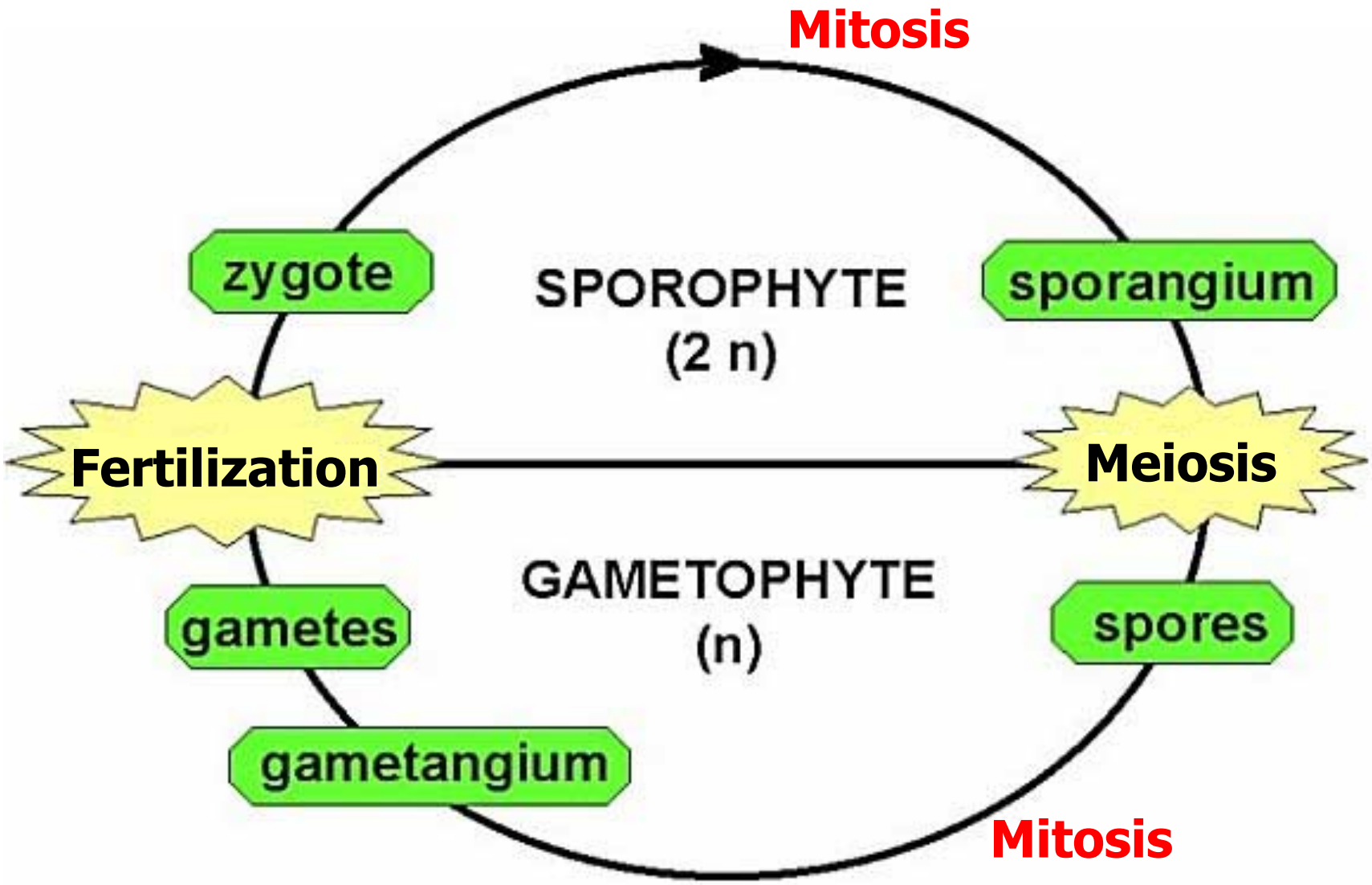


Alternation of generations

Plant Life Cycle



Plant Life Cycle



Meiosis

Test yourself! 10 interactive questions:

http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/01q.html

Use the following information to answer the next four questions.

Interleukin-4 is a polypeptide that causes the body's immune system to destroy cancer cells. Researchers have genetically engineered neural stem cells of rats to produce interleukin-4. Previous studies have shown that when neural stem cells are injected into the brain, they migrate throughout it. The researchers hypothesized that the genetically engineered stem cells would carry the interleukin-4 to a brain tumour. When the genetically engineered neural stem cells were injected into rats with malignant brain tumours, the rats survived longer than untreated rats and their tumours became smaller.

Malignant brain tumours form as a result of

A. abnormal mitosis
B. abnormal meiosis
C. a long interphase stage of the cell cycle
D. a long cytokinesis stage of the cell cycle

The process that occurs to form an eight-cell embryo from a zygote is

A. mitosis of diploid cells
B. mitosis of haploid cells
C. meiosis of diploid cells
D. meiosis of haploid cells

In the embryos of most animals, cytokinesis immediately follows mitosis and, therefore, the embryo grows as a ball of cells. However, *Drosophila* (fruit fly) embryos develop in an unusual manner. In *Drosophila*, separating membranes do not appear until after several thousand nuclei have been produced. This development trait has led researchers to use fruit fly embryos to study development.

In most animals, cytokinesis occurs at the end of the mitotic phase known as

A. anaphase
B. prophase
C. telophase
D. metaphase

Use the following information to answer the next question.

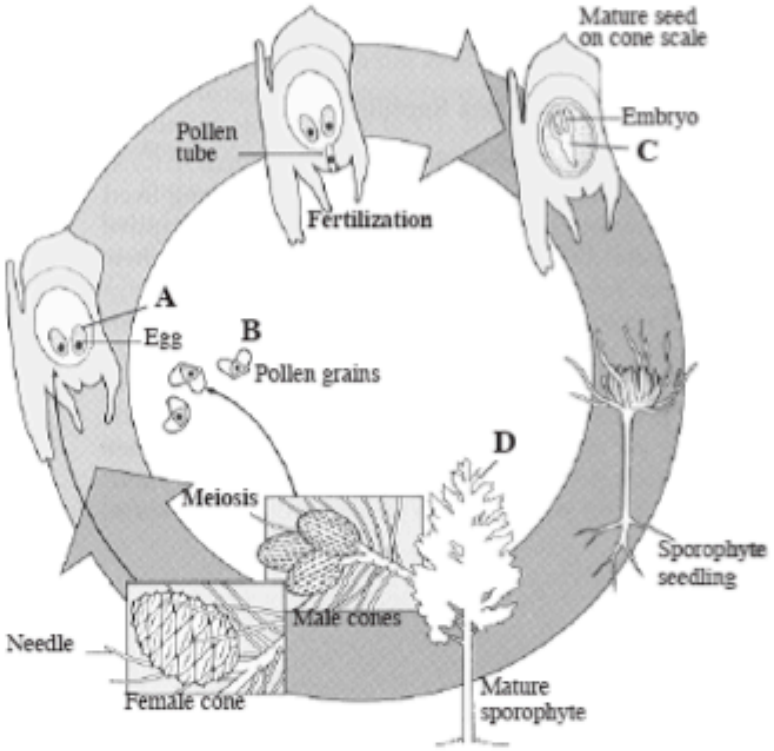
Some Events That Occur in Various Stages of Oogenesis

1 DNA replication takes place.
2 Centromeres split; sister chromatids pull apart.
3 Homologous chromosomes align at the equator of the cell.
4 Homologous chromosomes separate; members of each chromosome pair move to opposite poles.

Match each of the events that occur in oogenesis numbered above with the stage at which it occurs, as given below.

Event:	1	3	4	2
Stage:	**Interphase**	**Metaphase I**	**Anaphase I**	**Anaphase II**

Conifer Life Cycle



Major Stages in the Conifer Life Cycle

1 Haploid stage
2 Diploid stage

—from *Levine and Miller, 1991*

erical Response

Identify the stages in the conifer life cycle, as numbered above, that correspond with the letters that represent these stages on the diagram.

Stages:	1	1	2	2
Diagram:	**A**	**B**	**C**	**D**

Use the following information to answer the next three questions.

> Researchers have found a gene known as p53. It codes for a protein that binds to specific areas of DNA and activates them. This causes the production of a set of proteins that halts cell division or, in some cells, activates the cell's suicide program (apoptosis). The p53 gene is activated when a cell is damaged and/or undergoes a DNA mutation.
>
> —from *Seachrist, 1996*

The normal function of the p53 gene is likely to

A. encourage a cell to undergo mitosis
B. encourage a cell to undergo meiosis
C. prevent an abnormal cell from reproducing
D. prevent the transcription of a cell suicide gene

Use the following additional information to answer the next two questions.

Research on the p53 gene was initially done with cancer cells obtained from a laboratory animal. These cells were grown in a petri dish. A cell with two normal *p53* alleles was found to have normal cell division. Cells with one normal and one mutated *p53* allele were also found to have normal cell division. Cells that had mutations in both *p53* alleles were unable to control cell division and were associated with cancer.

The initial research findings described above

A. demonstrate that the activated p53 gene causes cancer in lab animals

B. demonstrate that the p53 protein causes the formation of cancer cells

C. indicate that the normal p53 gene is responsible for preventing cancer in all mammals

D. indicate that the normal p53 gene is responsible for preventing cancer under laboratory conditions

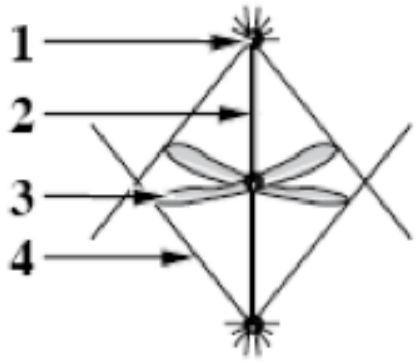
Gene therapy that might stop uncontrolled cell division due to the mutant *p53* allele would require

A. one functional *p53* allele to be successfully inserted into cancer cells
B. two functional *p53* alleles to be successfully inserted into cancer cells
C. one functional *p53* allele to be successfully removed from cancer cells
D. two functional *p53* alleles to be successfully removed from cancer cells

Use the following information to answer the next three questions.

Investigators were interested in determining the role chromosomes play in the formation of the mitotic spindle. Using extracts of eggs from the African frog *Xenopus laevis*, they monitored spindle assembly in a test tube. The researchers replaced the chromosomes with beads coated with random sequences of DNA. The beads served as substitute genetic material, but centrosomes (centrioles) were absent. As well, a part of the centromere was missing.

Simplified Diagram of Normal Mitotic Cell



—from *Travis, 1996*

Which of the structures numbered above was replaced by the beads in the experimental setup?

A. 1
B. 2
C. 3
D. 4

Use the following additional information to answer the next question.

> Other studies showed that the phase that involves pulling chromosomes to the two poles of mitotic cells can be delayed for up to 4.5 h by pulling a chromosome out of line from the centre of the cell.
>
> —from *Travis, 1996*

The phase that is delayed and the phase where the chromosomes line up at the equator are, respectively,

A. telophase and anaphase
B. metaphase and prophase
C. interphase and telophase
D. anaphase and metaphase