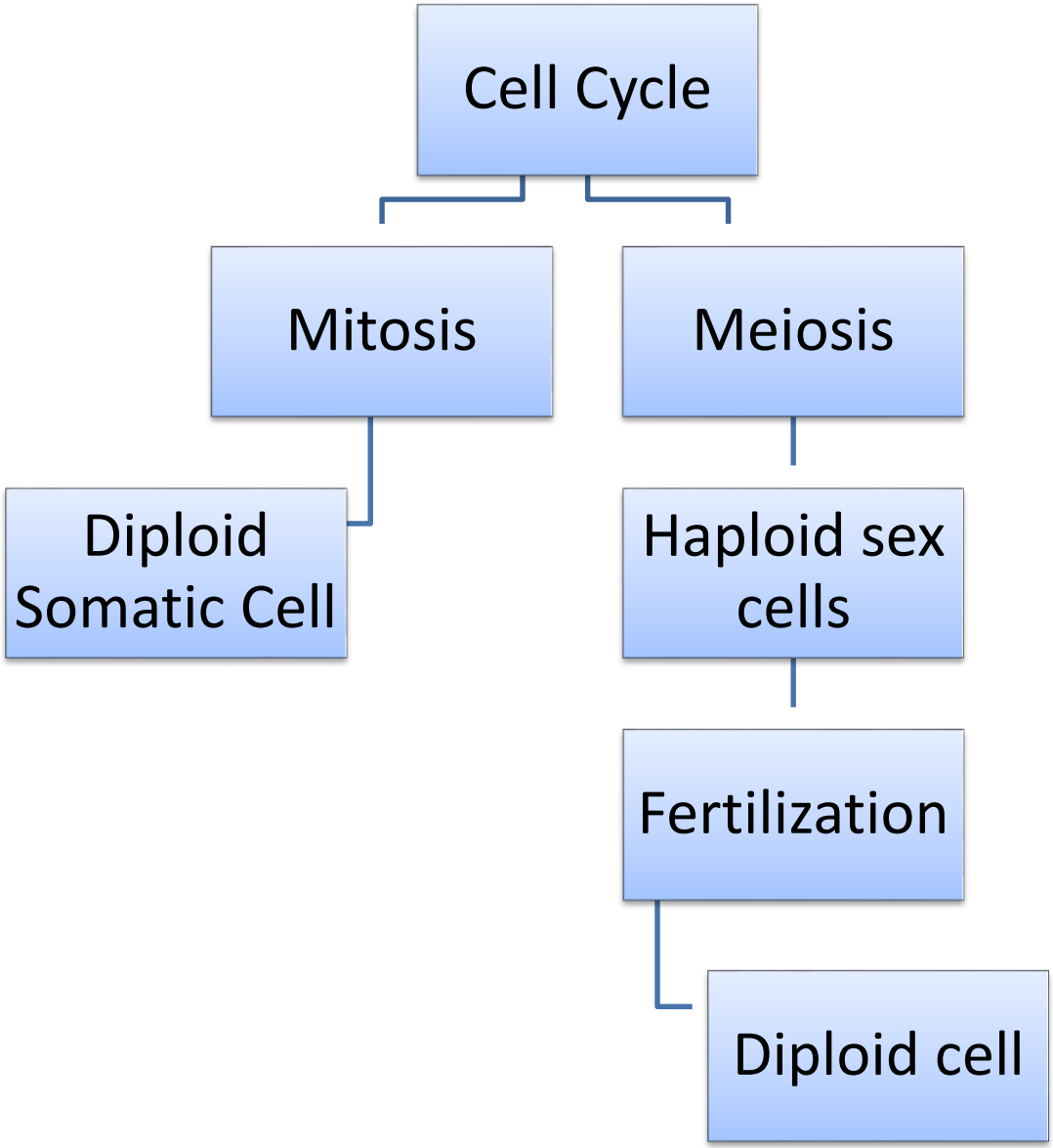
# Unit 2- Reproduction and Development

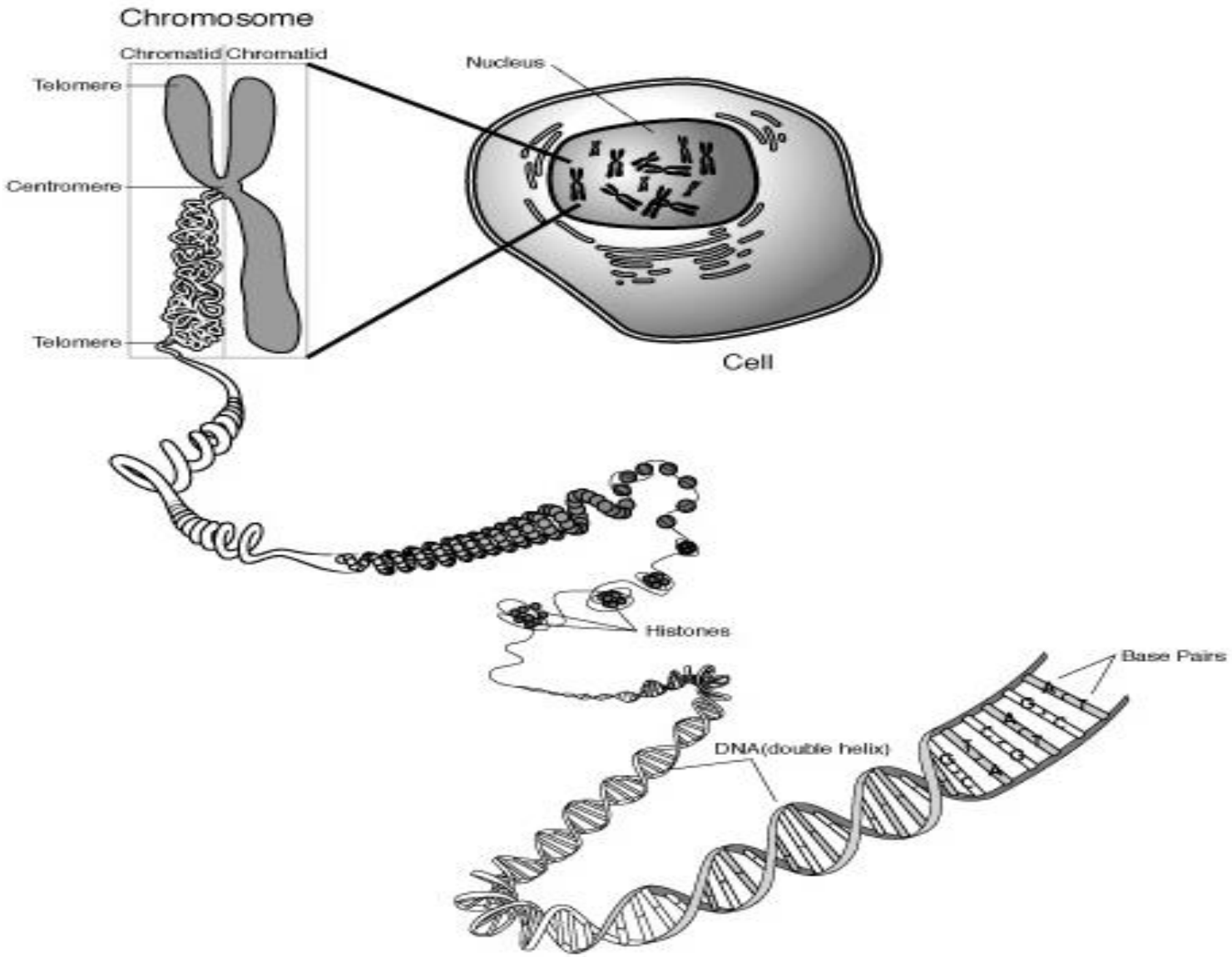
Part 1- Cell Reproduction

# Cell Division

- We all start life as 1 cell. That cell was created from a fusion between sperm and egg that were each carrying 23 chromosomes. So, that original cell would have a total of 46 chromosomes and is considered **DIPLOID.** How did that one cell turn into the 10 trillion that we have today?


Cell Cycle
Mitosis
Meiosis
Diploid Somatic Cell
Haploid sex cells
Fertilization
Diploid cell

# Important Terms



# Important Terms

**Somatic Cell**- Any cell of the body that is not sperm or egg.

**Nucleus**- The central organelle in eukaryotic cells that contains most of the organisms DNA.

**Cell Membrane**- A phospholipid bilayer that surrounds a cell.

**Chromosome**- A thread-like structure inside the cells nucleus that is made up of DNA and proteins called histones.

**Chromatin**- Uncoiled DNA and protein strand that forms the chromosome in the nucleus of the eukaryotic cell.

**Chromatid**- One copy of a newly replicated chromosome, which is typically joined to the other copy by a centromere.

**Histones**- Proteins that join with DNA strands in the nucleus to give structure to chromosomes.

**Kinetochore**- A protein on the surface of the centromere ( on  the chromosome) that attaches to spindle fibers during cell division to guide the movement of chromosomes.

**Centrioles-** two cell structures that migrate to the poles of the cell during division and produce spindle fibers, that aid in chromosome movement.

**Centrosome**- made up of two centrioles. Responsible for organizing the microtubules during cell division.

**Telemere**- like tips of shoe laces, these are the very end sequences of DNA on a chromosome. They keep the ends of the chromosome from deteriorating or fusing with neighboring strands.

# What is the cell cycle?

- The cell cycle explains how cells divide. It is a continuous cycle of growth and division, which is necessary to replace broken or worn out cells.

It is divided into two parts:

1) Growth stage - also called Interphase

2) Division stage – this stage includes Mitosis and Cytokinesis

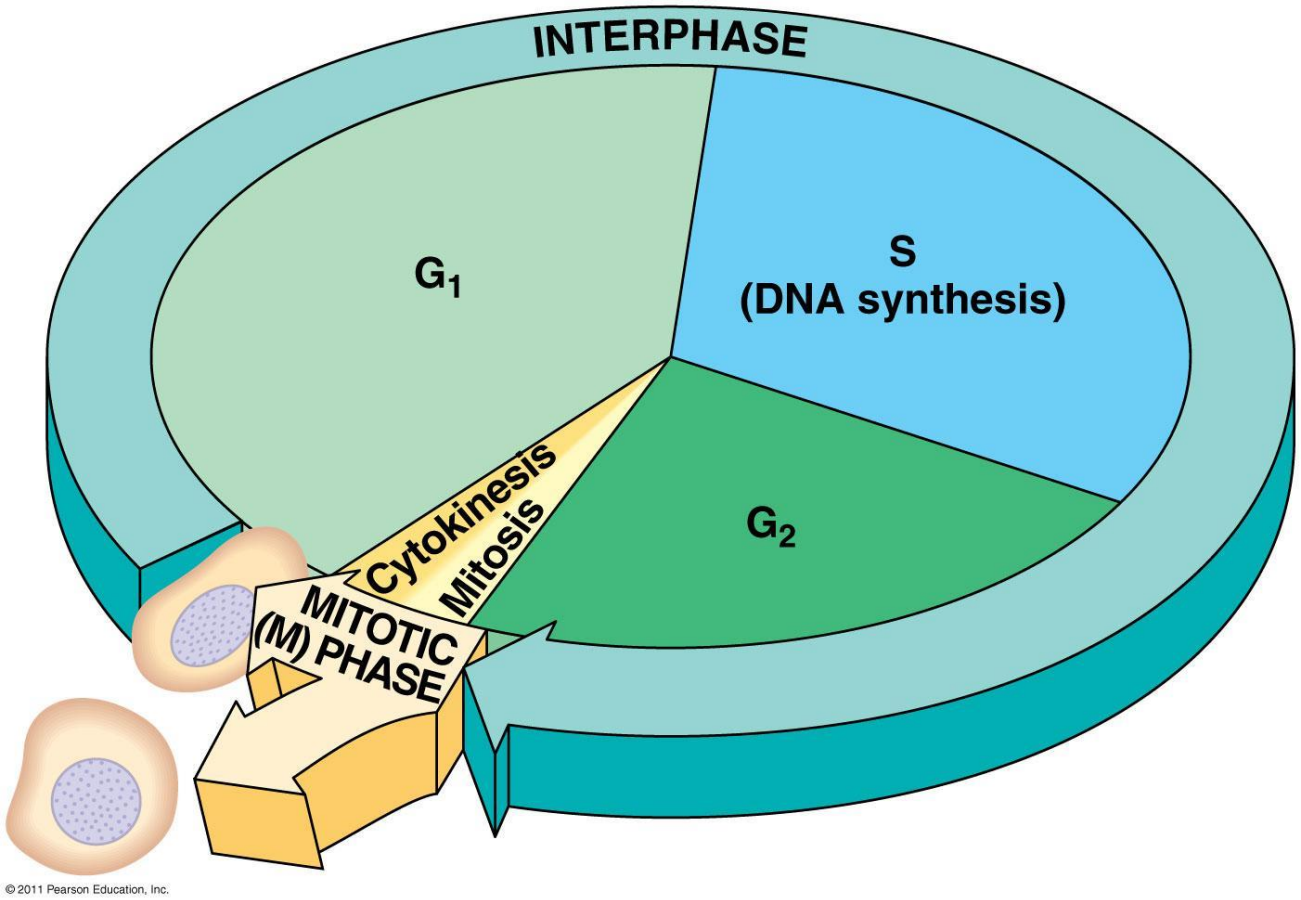
**What happens during the growth phase (interphase)?**

- In this stage, the cell increases its volume and mass. It gets BIGGER!

There are three stages of Interphase:

- **Gap 1 (G1)** – cells carry out metabolic activities to prepare for cell division. Ex: make energy
- **S phase -** DNA synthesis and replication occur
- **Gap 2 (G2)** - the cell prepares to divide

# Cell Cycle Diagram




**G1-** Rapid growth and metabolic activity

**S Phase-** DNA synthesis and replication

**G2 phase-** Centrioles replicate; cell prepares for division.

# Why Do Cells Need to Divide?

1. New cells are needed for growth maintenance and repair
2. Cells must regenerate damaged tissues
3. Cells that do not function properly must be replaced
4. Cells die and need to be replaced  (Ex: blood cells)
5. Chromosome number must be maintained (Ex: humans have 46 chromosomes in somatic cells)

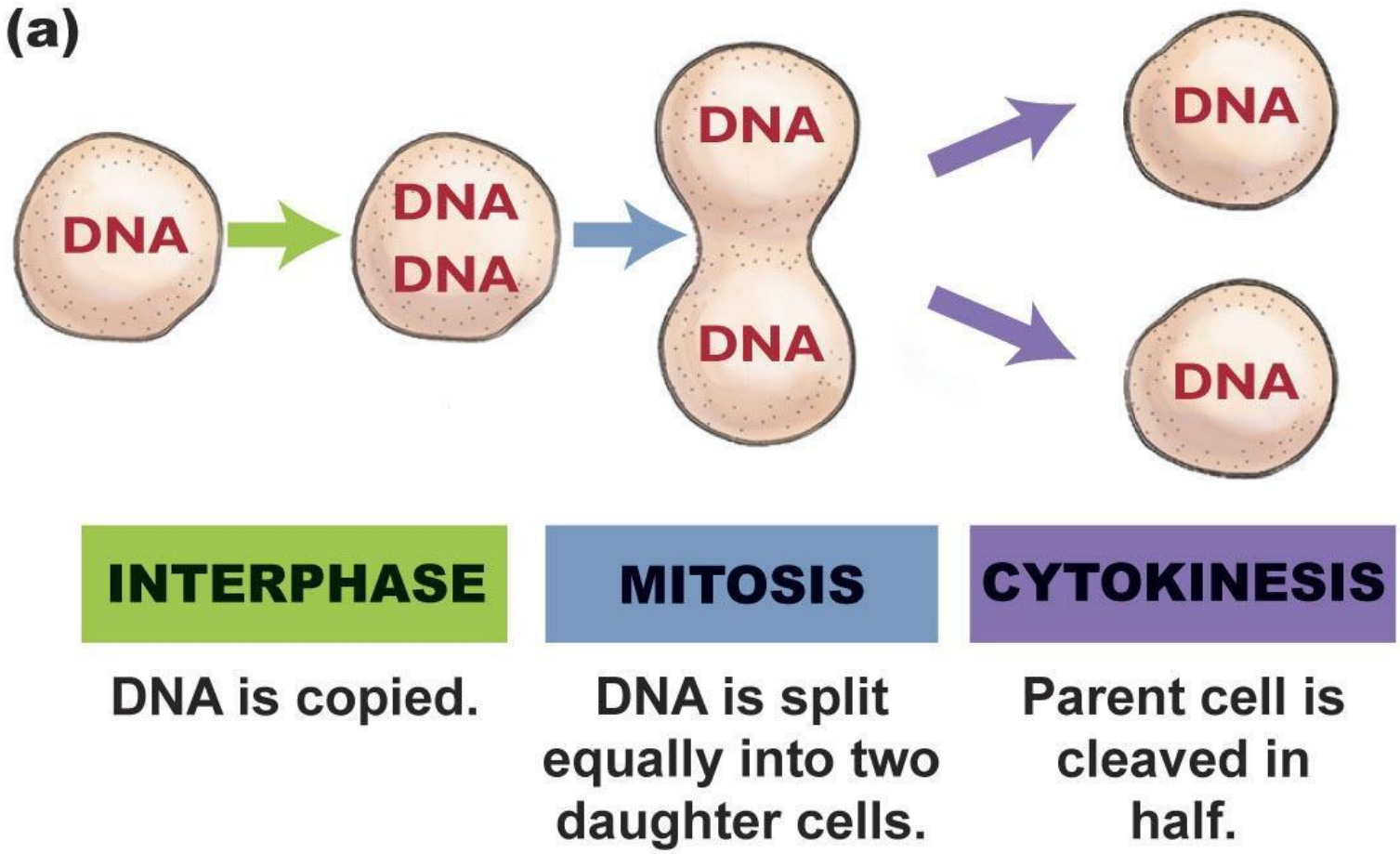
# Reproduction of Somatic Cells (Mitosis)

**What is mitosis? -** When the nucleus of a somatic cell divides

**What is Cytokinesis?** – When the cytoplasm divides

- *Both must occur for the cell cycle to be complete*

# Somatic Cell Division (draw in booklet)



# 4 Phases of Mitosis

**Prophase**

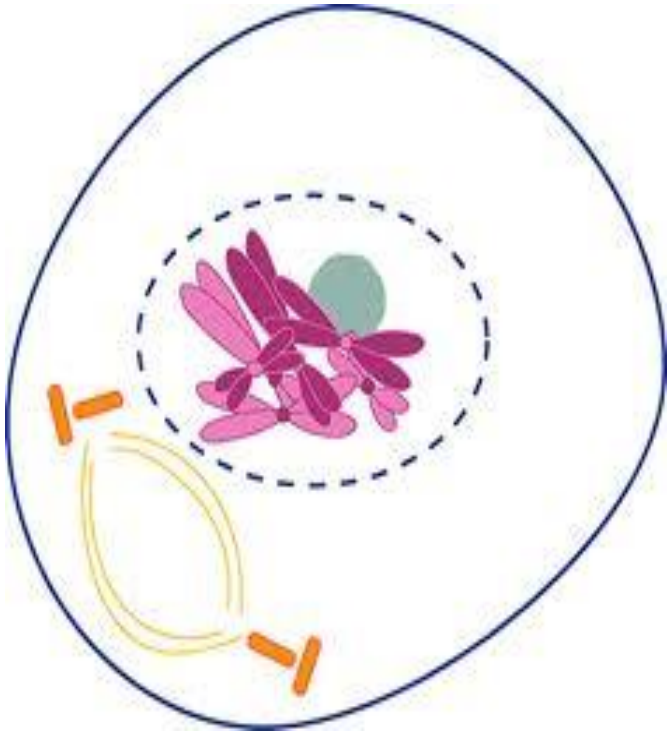
**Metaphase**

**Anaphase**

**Telophase**

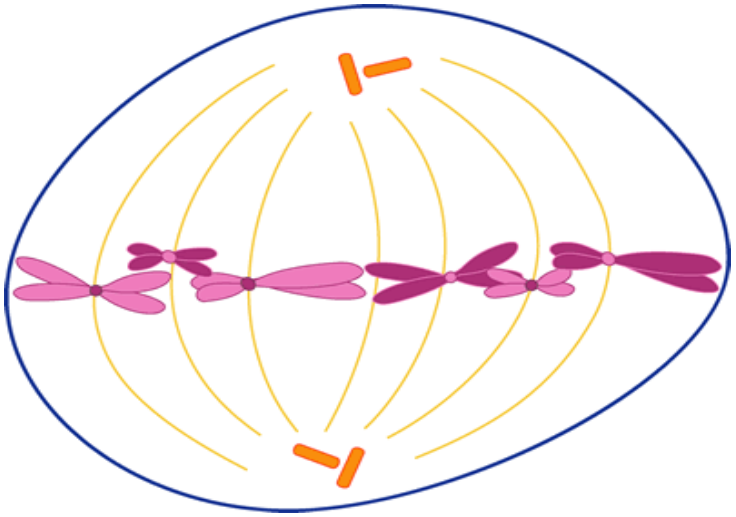
# Prophase

- Chromatin coils and thickens forming **chromosomes**
- The nuclear membrane disappears
- Centrioles migrate to opposite ends of the cell
- Spindle fibers form between the two centrioles



# Metaphase

- Spindle fibers attach to centromere
- Spindle fibers from one pole attach to one chromatid and spindle fibers from the other pole attach to the other chromatid
- Chromatids are guided to the cell's equator, called the metaphase plate

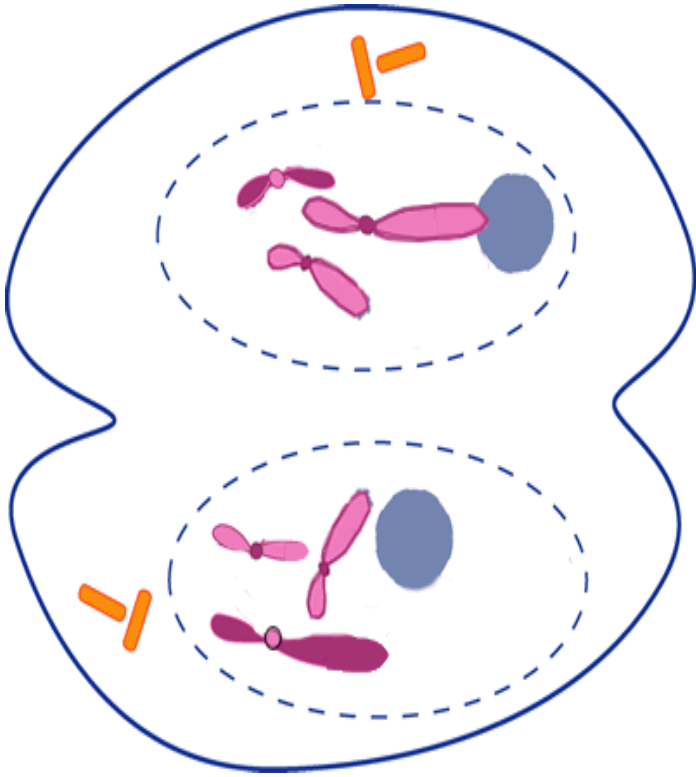


# Anaphase

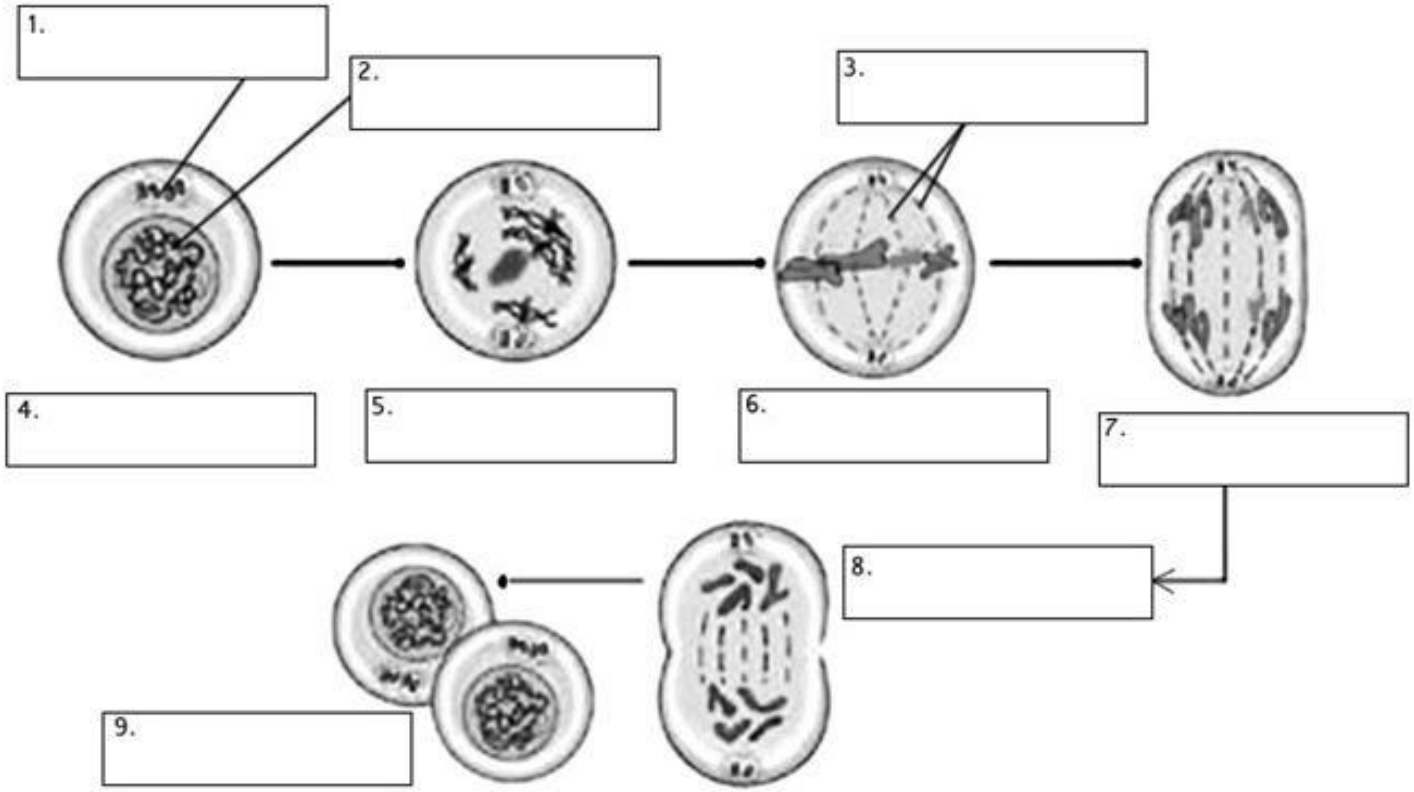
- Centromere splits apart and chromatids are pulled to opposite poles of the cell by spindle fibers.

# Telephase

- Chromatids have reached opposite poles and are now a single, non-replicated chromosome
- Spindle fibers are not needed so they break down and disappear
- Nucleolus reappears and the nuclear membrane forms around each new set of chromosomes.



# Complete workbook questions

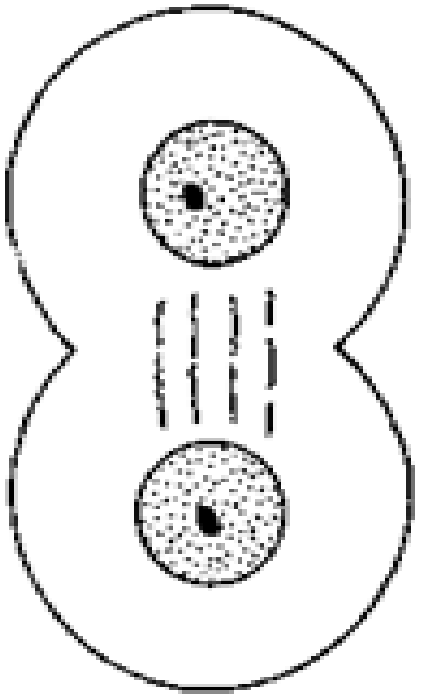


# What is Cytokinesis?

- This is defined as the separation of the cytoplasm and the formation of two new daughter cells.
- In animal cells, the cell membrane becomes indented, pinching off to form two daughter cells. This process is called cleavage.
- In plant cells, a cell plate begins to form, which eventually turns into the cell wall, as the cell divides.

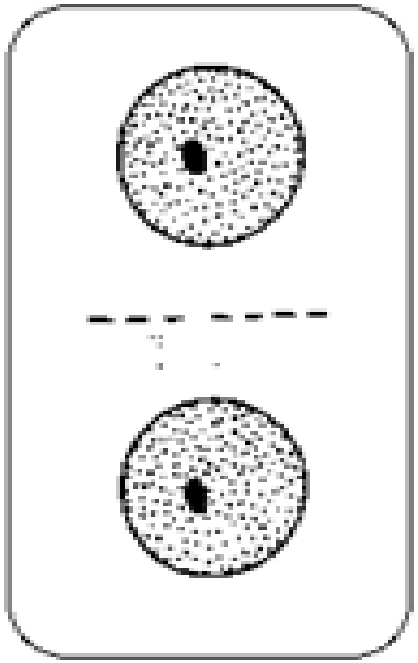
# Cytokinesis

**Animal Cell**



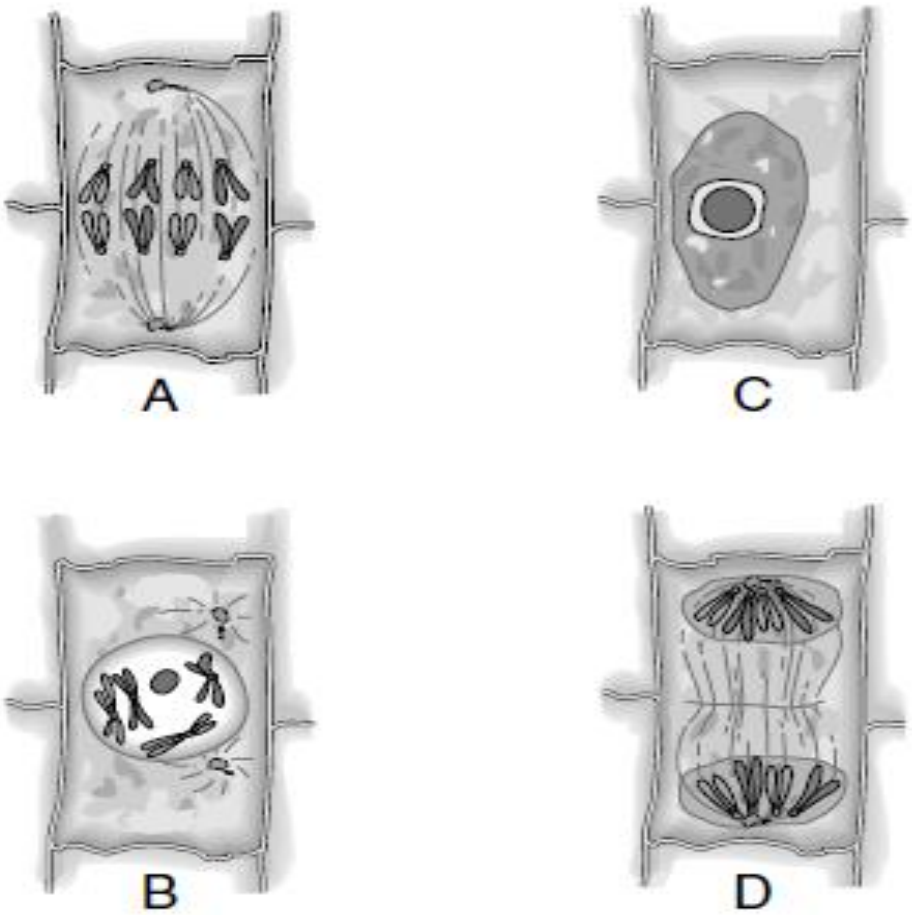
Cleavage formation by Furrow

**Plant Cell**



Cell place formation

# Identify the stages of the cell cycle (wkbk)



# Cancer

Definition:

<u>Uncontrolled division of abnormal cells in a part of the body.</u>

**Why do we use radiation and chemotherapy to treat cancer?**

- Cancer cells divide more rapidly than any other type of body cells. Therefore, anything that interferes with cell division will affect cancer cells more than healthy cells. Radiation and chemotherapy targets rapidly dividing cells.

## What is radiation therapy?

- It directs radiation (x-rays & gamma rays) at the affected part of the body.
- Radiation therapy works by damaging the chromosomes in a cell. As a result, the cell cannot divide.
- Unfortunately, healthy cells also get damaged. Most cells can eventually repair themselves.
- The goal of radiation therapy is to focus the radiation on the diseased part of the body and avoid affecting healthy tissue.

## What is chemotherapy?

- Chemotherapy medication is injected through IV or taken orally, which attacks cells as they divide or prevents them from dividing
- The entire body is affected, including healthy rapidly dividing cells (ex: stomach cells, hair cells)
- May be used along with radiation or on its own.

# Side Effects of Treatment

| **Radiation:** | **Chemotherapy:** |
| --- | --- |
| 1. skin inflammation and fatigue<br>2. specific side effects depending on location of treatment (Ex: brain - hair loss; testicular cancer – sterility) | 1. hair loss<br>2. nausea<br>3. Diarrhea |

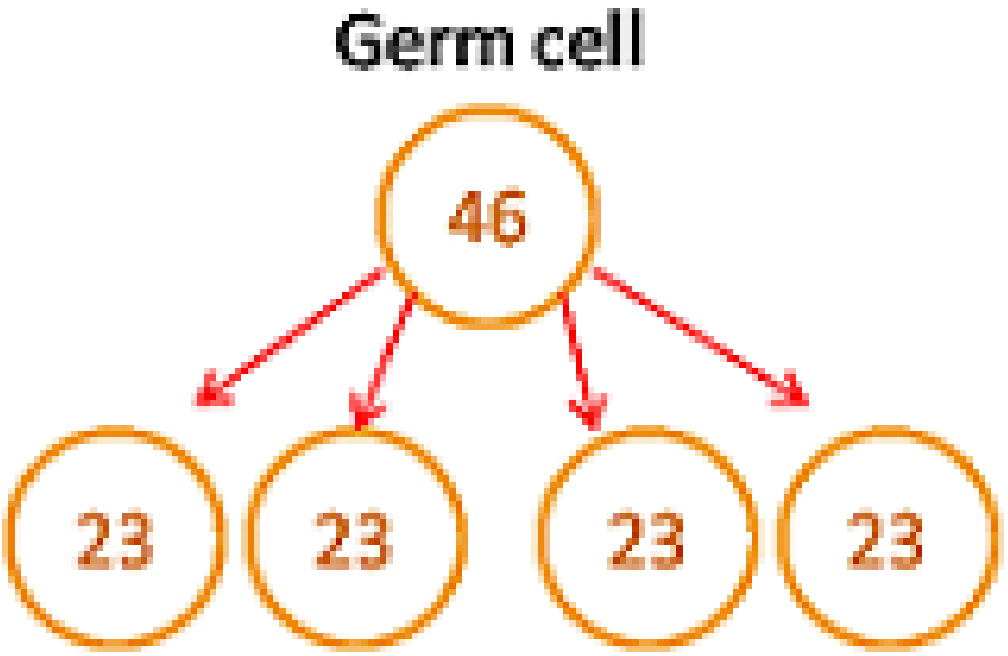
# Side Effects con't

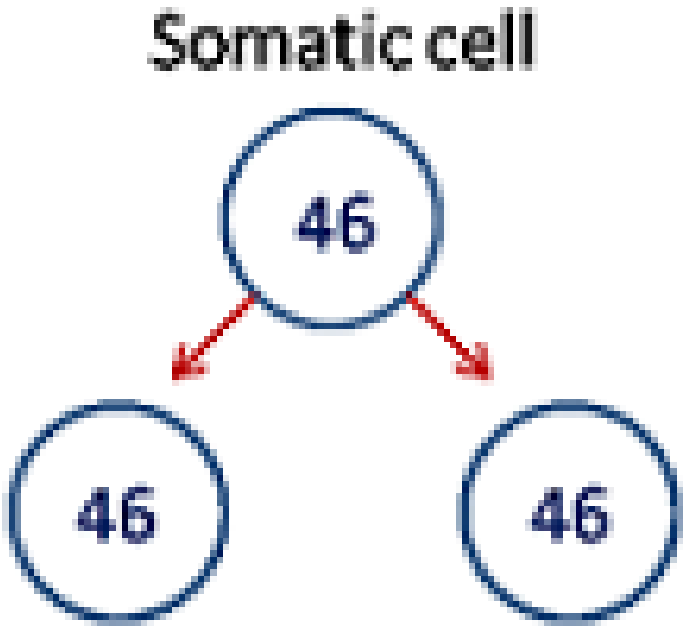
- For both treatments, side effects usually last only for the duration of the treatment. However, sterility can be permanent.
- Radiation and Chemotherapy treatments are particularly harmful to body cells that divide quickly, such as bone marrow cells, skin cells, hair cells, cells in the GI (gastrointestinal) tract and cells of the reproductive system.

# What are the goals of cancer research?

- Prevention
- To find out why cells divide uncontrollably
- To find treatments that affect cancerous cells and leaves healthy cells unharmed

# Overview of Germ VS Somatic Cell Division



# Review Terms:

**Diploid (2n)** means having paired chromosomes

**Haploid (n)** means single chromosomes (NOT paired)

- In human somatic (body) cells there are **46 chromosomes** (23 pairs) therefore we say this is diploid (2n)
- In human sperm or egg cells there are **23 chromosomes** (half the number of chromosomes) therefore we say this is haploid (n)

**Gamete** – a sex cell (ex: sperm or egg)

# Meiosis

**What is Meiosis?**

- Meiosis is a process that makes gametes.

- Gametes are reproductive cells, eggs (ova) and sperm.

# Important terms for meiosis:

**Homologous Chromosomes**- a set of one maternal and one paternal chromosomes that carry the same genes at the same loci.

**Tetrad**- a foursome made up of homologous chromosomes.

**Synapsis-** The pairing of homologous chromosomes that allows crossing over of genetic material.

**Crossing Over**- During synapsis of meiosis 1, homologous chromosomes exchange genetic material, creating variation in daughter cells.

**Reductive Division**-cell division that reduces the chromosome number from diploid to haploid.

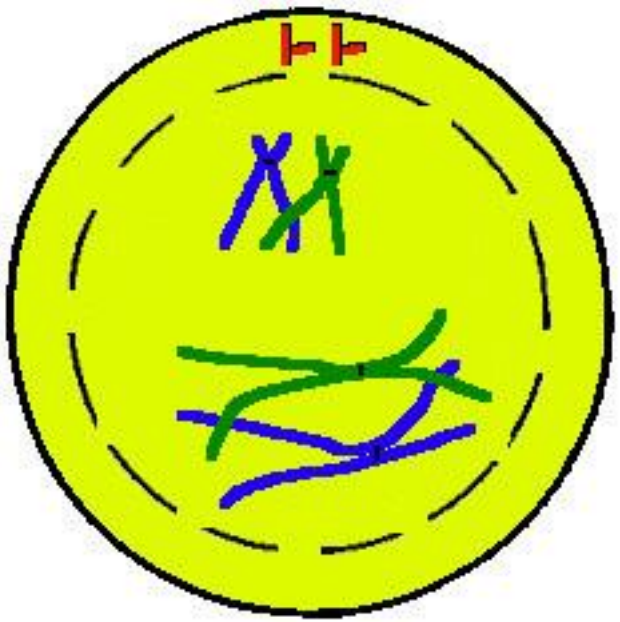
# Phases of Meiosis

**Prophase 1**
**Metaphase 1**
**Anaphase 1**
**Telophase 1**
**(cytokenesis)**
**Prophase 2**
**Metaphase 2**
**Anaphase 2**
**Telophase 2**

**(Cytokinesis)**

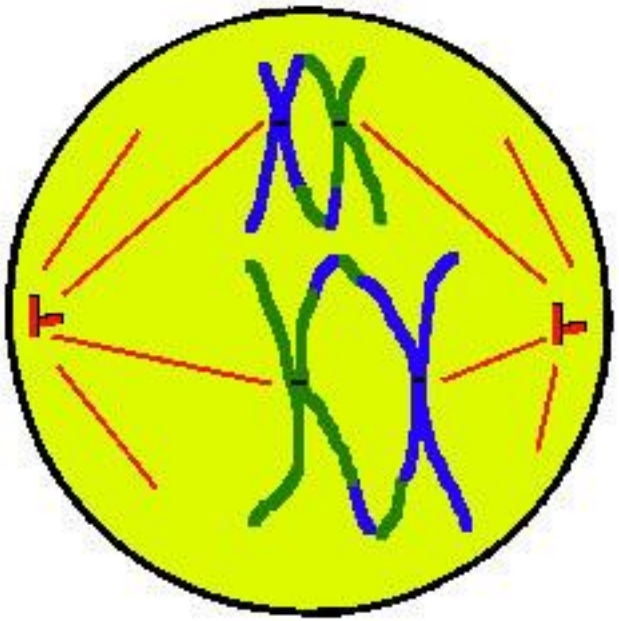
# Prophase 1

- Nuclear membrane and nucleoli begin to disappear
- Centrioles move to opposite poles and spindle fibers are established
- Chromosomes come together in homologous pairs, this structure is called a **tetrad** because it consists of four chromatids
- The pairing of homologous chromosomes is referred to as **synapsis**
- The exchange of genetic material between homologous chromosomes during synapsis is referred to as **crossing-over**



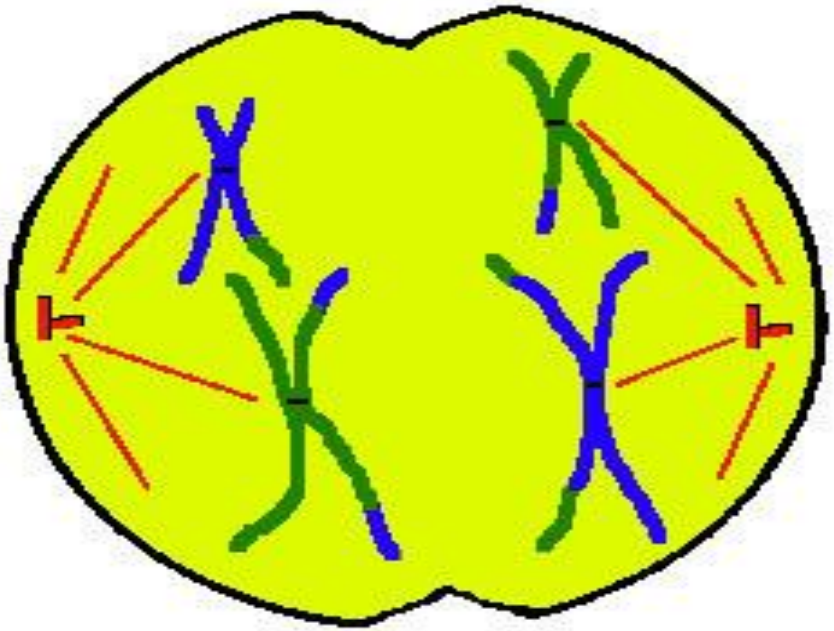
# Metaphase 1

- The tetrads line up along the equator of the cell.
- Spindle fibers from the centrioles attach to the centromeres of the homologous chromosomes.
- There is now a starlike arrangement around the pole of the cell called asters.



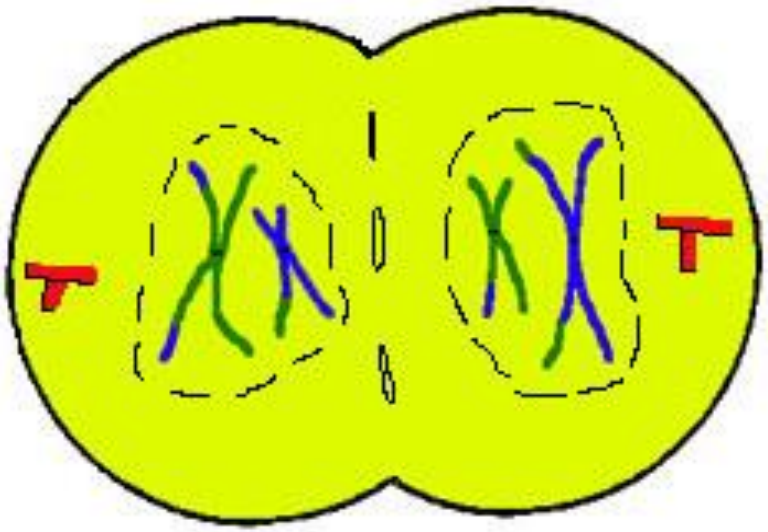
# Anaphase 1

- The homologous chromosomes are pulled apart a process known as segregation.
- Two of the four chromatids move towards each pole.



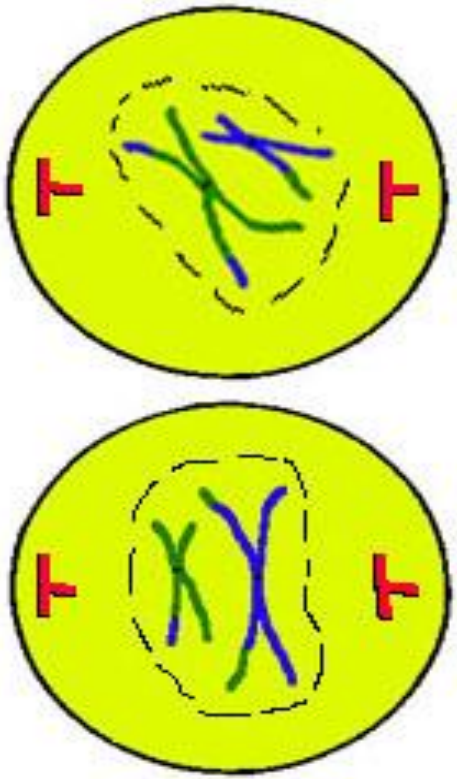
# Telophase 1

- The nuclear membrane reforms around each daughter nucleus.
- The cytoplasm divides (cytokinesis) forming two cells.
- Nucleoli returns and spindles disappear.



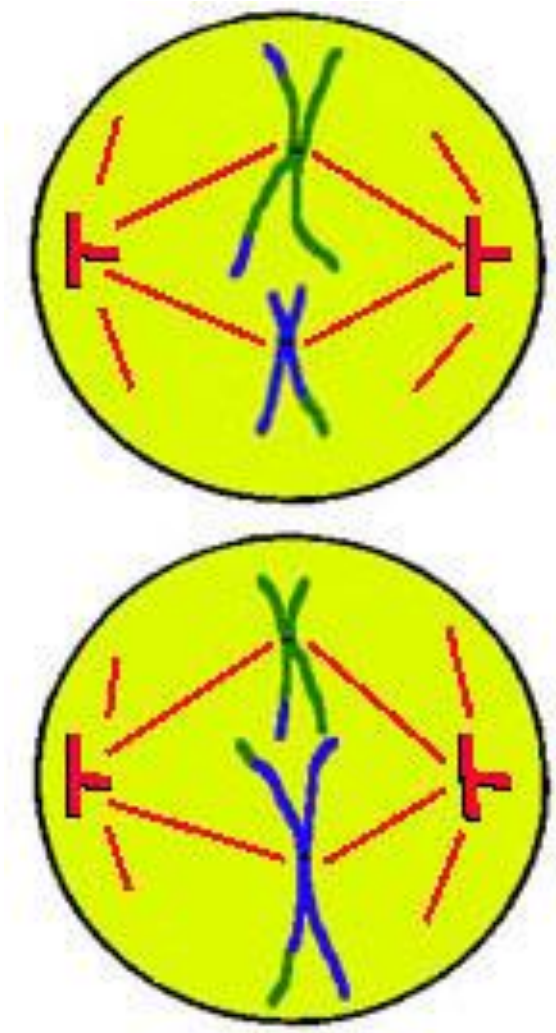
# Prophase 2

- We now have two cells each are haploid with two chromosomes.
- Spindle fibers start to form at the poles.



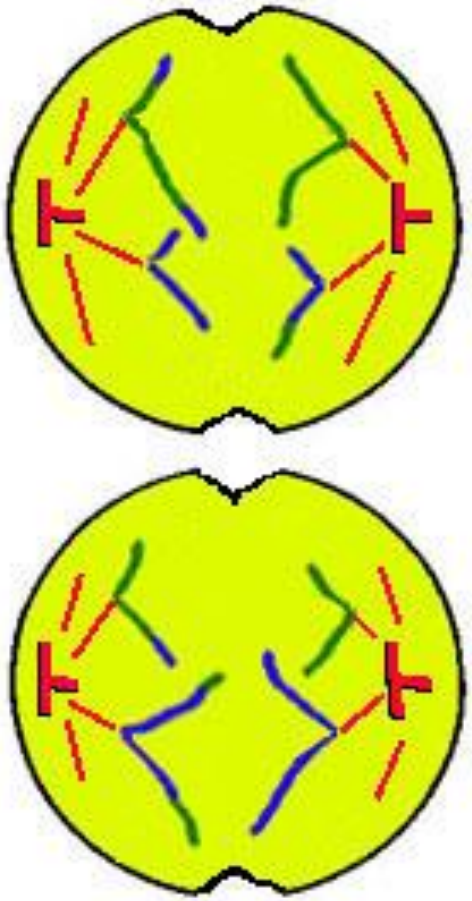
# Metaphase 2

- Metaphase II is similar to mitosis, with spindles moving chromosomes into equatorial area and attaching to the opposite sides of the centromeres in the kinetochore region.



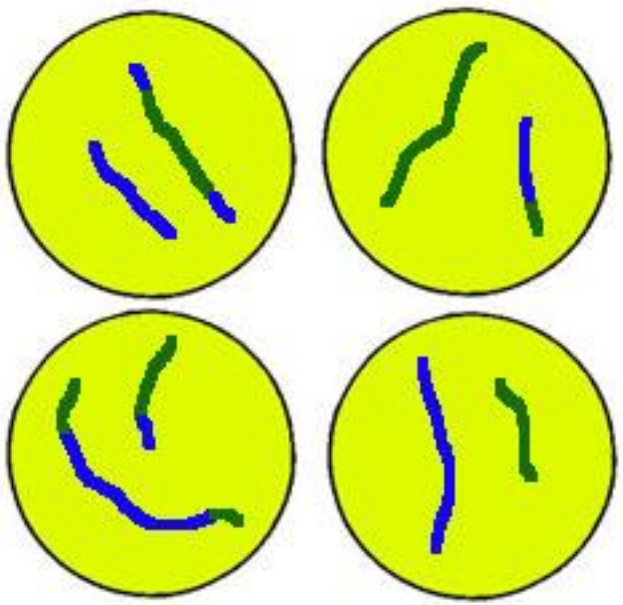
# Anaphase 2

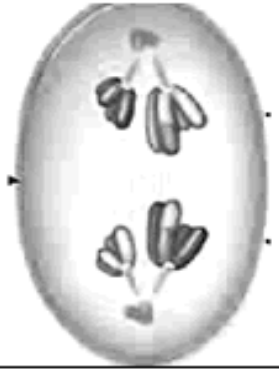
- During Anaphase II, the centromeres split and the former chromatids (now chromosomes) are segregated into opposite sides of the cell.



# Telophase 2

- Telophase II is identical to Telophase of mitosis.
- Cytokinesis separates the cells.





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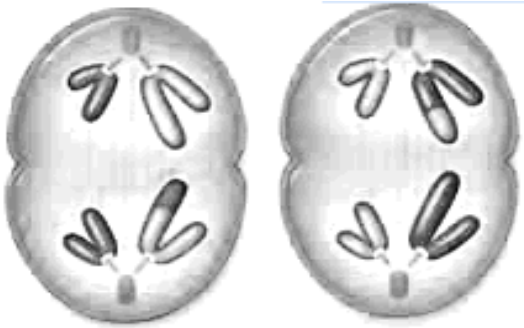

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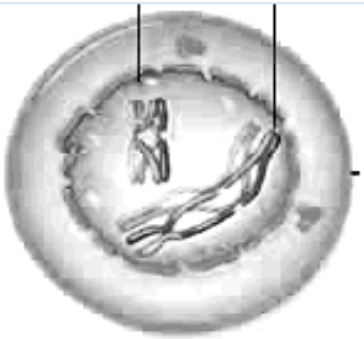

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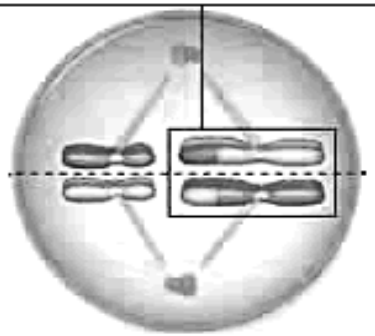

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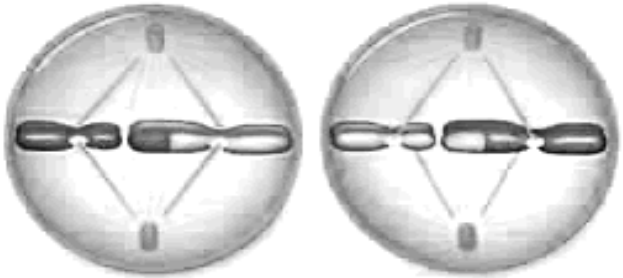

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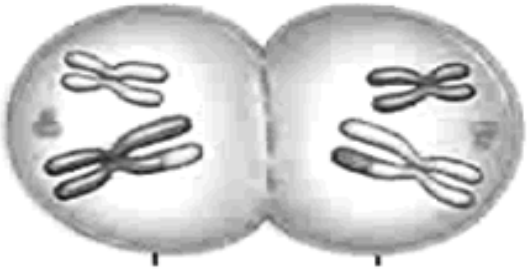

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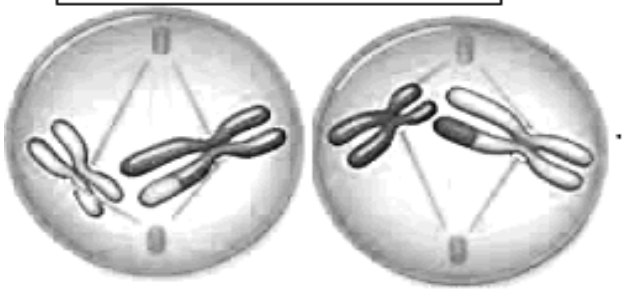

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## What makes Meiosis different than Mitosis?

- Meiosis involves two separate cell divisions (Meiosis I and Meiosis II)
- The resulting daughter cells have **half** the number of chromosomes as the parent cell. Therefore daughter cells are NOT identical to parent cell.
- In meiosis, a diploid cell (2n) produces four haploid (n) daughter cells
  - **Meiosis I** - reduces the number of chromosomes from diploid to haploid. This is referred to as **reduction division.**
  - **Meiosis II –** is the same as mitosis

**What is the result of Meiosis I?**

- At the end of **Meiosis I**, each of the two cells has HALF the original number of chromosomes,
- One chromosome from each original homologous pair.
- Since the chromosome number is halved, Meiosis I is referred to as **reduction division.**
- **The two haploid daughter cells are NOT identical**

## What is the result of Meiosis II?

- 4 cells are formed, each having half the number of chromosomes as the original cell
  - In males these cell will turn into 4 sperm
  - In females these cell will turn into 1 egg and 3 polar bodies

# What makes Meiosis different from Mitosis?

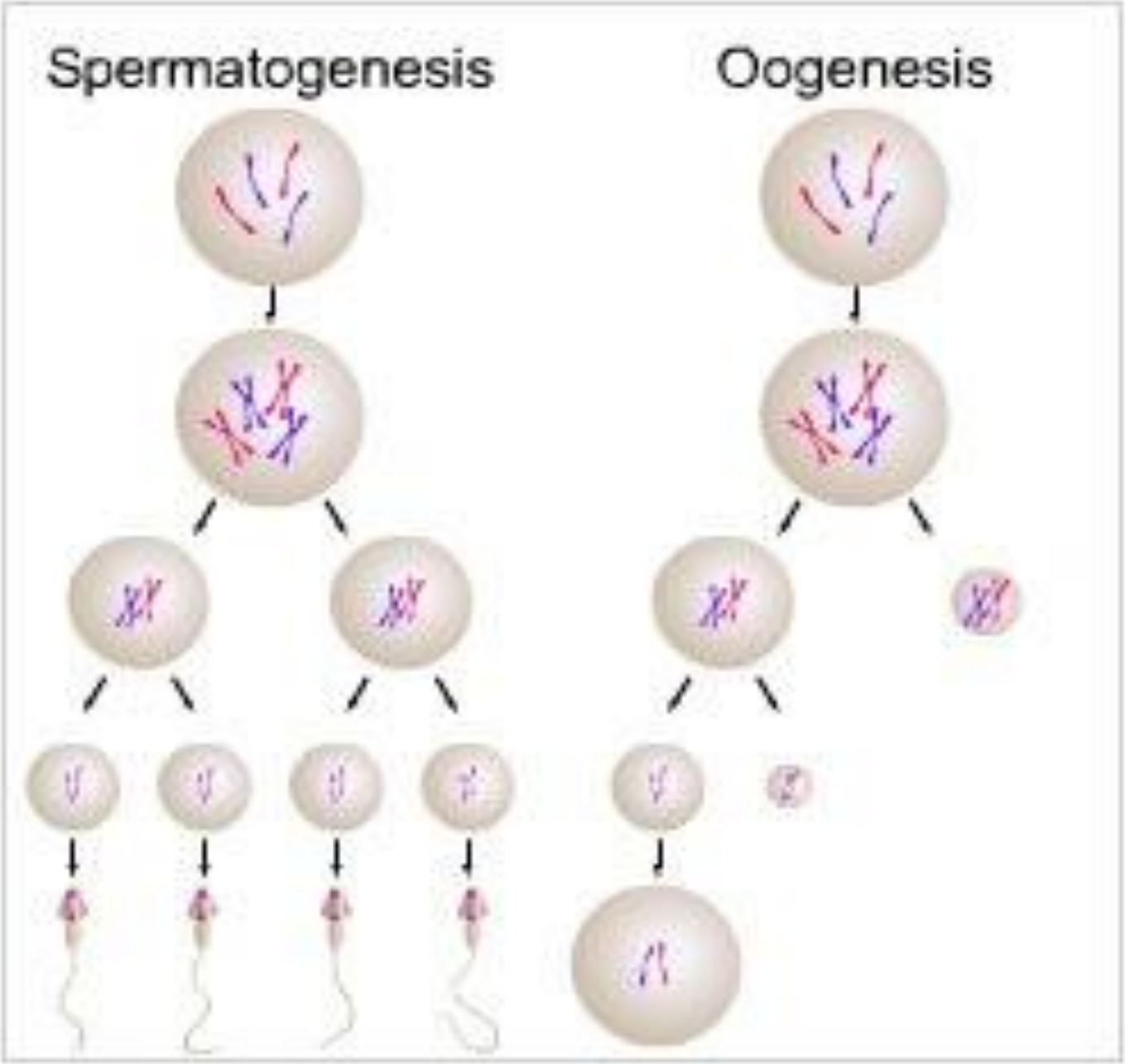
1. Synapsis
2. Crossing over (homologous pairs)
3. Reduction division

| | Mitosis | Meiosis |
|---|---|---|
| # Chromosomes at start | 46 | 46 |
| # stages | 4 | 8 |
| Name the stages | Prophase<br>Metaphase<br>Anaphase<br>Telophase | Prophase<br>Metaphase<br>Anaphase<br>Telophase<br>Prophase II<br>Metaphse II<br>Anaphase II<br>Telophase II |
| What happens in metaphase and anaphase? | Chromosomes line up at equator of cell<br>Sister chromatids are pulled apart | Tetrads line up and equator of cell (metaphase 1)<br>Singular chomosomes line up at equator during mataphase II.<br>Tetrads are pulled apart, homologous chromosomes separate (anaphase 1)<br>Chromosomes are separated into chromatids during anaphase II |
| # chromosomes at end | 46 | 23 |
| # cells made | 2 | 4 |
| What do these cells | Somatic | Gametes |

# Spermatogenesis and Oogenesis

What is it?

The production of sperm and ova following Meiosis.


Spermatogenesis
Oogenesis

| | Spermatogenesis | Oogenesis |
|---|---|---|
| What is it? | The production of sperm | The production of eggs |
| Where does it happen? | Testes | Ovary |
| The process starts with a diploid cell called? | Spermatogonium | Oogonium |
| How many cells are formed? | 4 | 1 |
| What is the final product? | Sperm | Ovum |
| How many chromosomes are in each cell? | 23 | 23 |

**What are some unique things about spermatogenesis?**

- Flagella to swim
- Acrosome to help the sperm break through the egg
- Sperm production is continuous throughout the lifetime

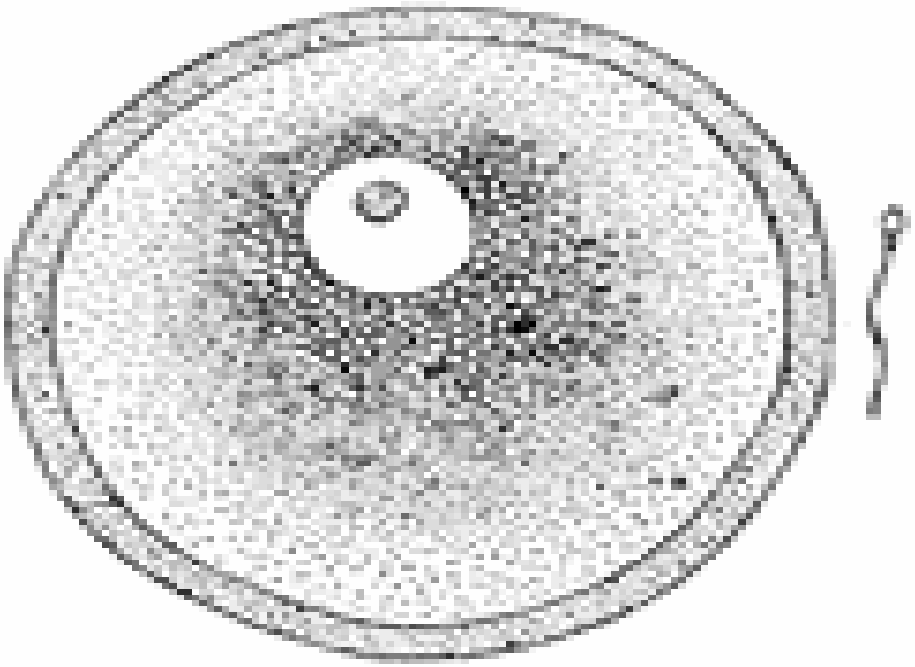
## What are some unique things about oogenesis?

- The cytoplasm is not equally divided between the daughter cells
- **Only ONE cell is produced**, instead of four
  - 1 Ovum (egg)
  - 3 polar bodies – not actually cells
- Meiosis I begins in ovarian tissue before birth and does not continue past prophase I until ovulation begins during puberty (1 egg/month)
- Meiosis II takes place **ONLY after fertilization** by a sperm cell
- Oogenesis continues from puberty until menopause (40-50 years old)

**Why there is only one functional egg produced during oogenesis?**

- The unequal cell division provides the ovum (egg) with enough nutrients to support the developing zygote in the first few days after fertilization

# Compare: Egg VS Sperm (wkbk)



| | **Sperm** | **Egg** |
|---|---|---|
| Size | | |
| Mitochondria | *Found in the middle piece, provide energy for swimming*<br>*About 50-100 mitochondria in one sperm* | *Found throughout the cell*<br>*About 140 000 mitochondria in one egg* |
| Number Produced | | |
| Motility | | |
| Outer Structures | | |

# STSE- Stem Cell Research

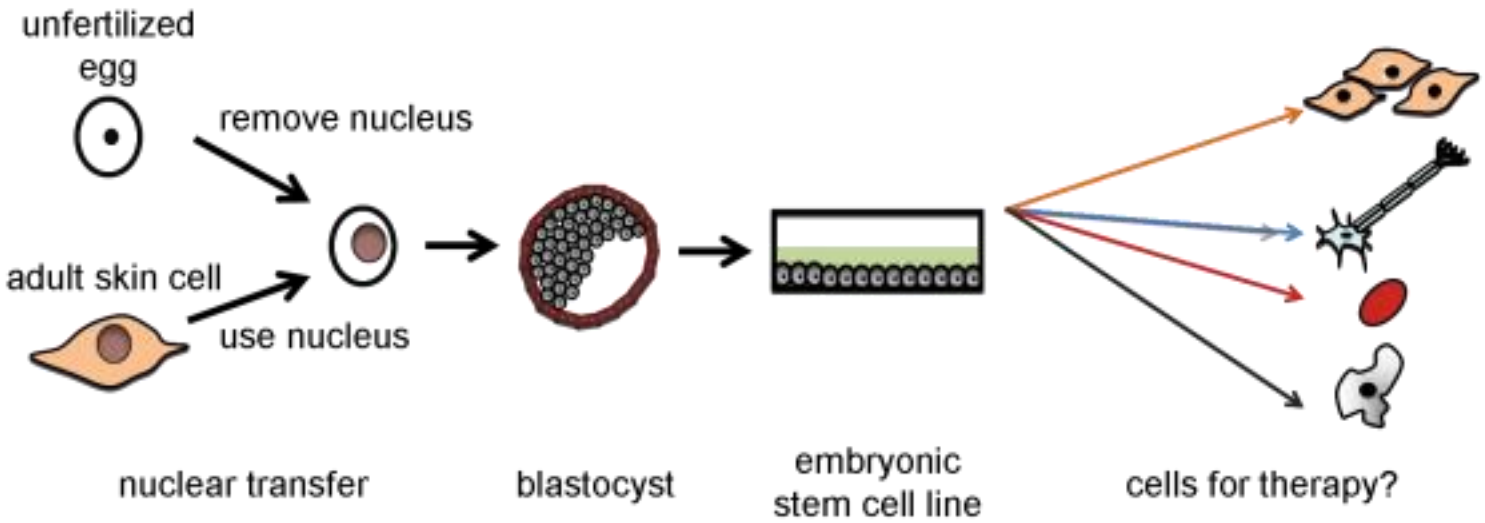
# Technology related to Cell Division

1. **<u>Stem Cell Research</u>**- Furthering of our understanding about how specialized cells can arise from undifferentiated stem cells (embryonic or adult).

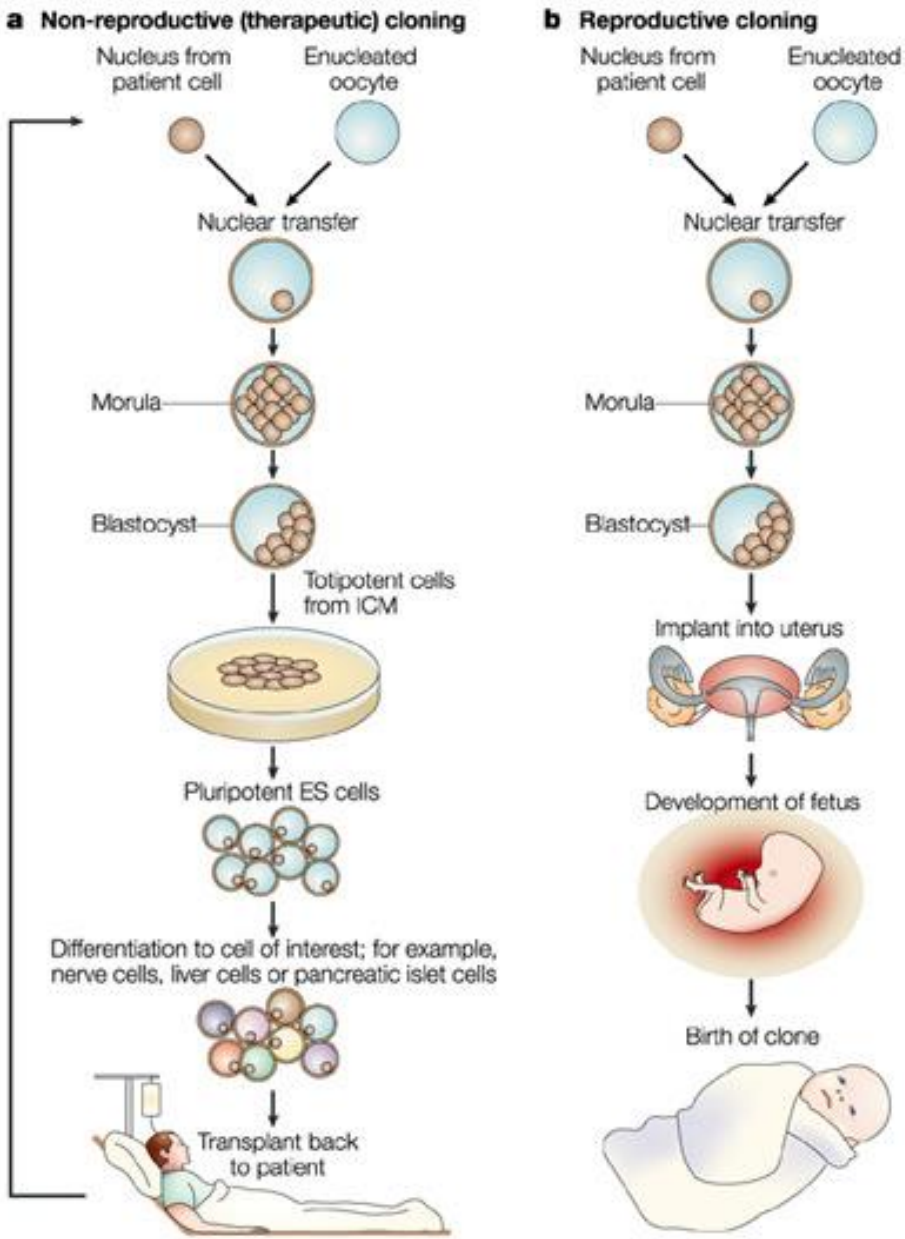
2. **<u>Cell Transplant</u>**- Involves how best to replace damage or diseased cells with an infusion of healthy stem cells.

3. **<u>Spinal Cord injury therapy</u>**- Replacement of damaged nerve tissue by use of stem cells. Could result in loss of paralysis.

**<u>4. Therapeutic Cloning</u>**- The growth of *pleuripotent* embryonic stem cells from a patient that needs a stem cell transplant.



**5. Reproductive Cloning**- the production of a genetic duplicate of an existing organism. It is achieved in the same manner as therapeutic cloning, except the newly formed embryo is inserted into a surrogate mother and brought to full term, rather than just used to harvest stem cells and discarded.


a Non-reproductive (therapeutic) cloning
Nucleus from patient cell
Enucleated oocyte
Nuclear transfer
Morula
Blastocyst
Totipotent cells from ICM
Pluripotent ES cells
Differentiation to cell of interest; for example, nerve cells, liver cells or pancreatic islet cells
Transplant back to patient
b Reproductive cloning
Nucleus from patient cell
Enucleated oocyte
Nuclear transfer
Morula
Blastocyst
Implant into uterus
Development of fetus
Birth of clone

# Asexual Reproductive Strategies

Budding

Binary Fission

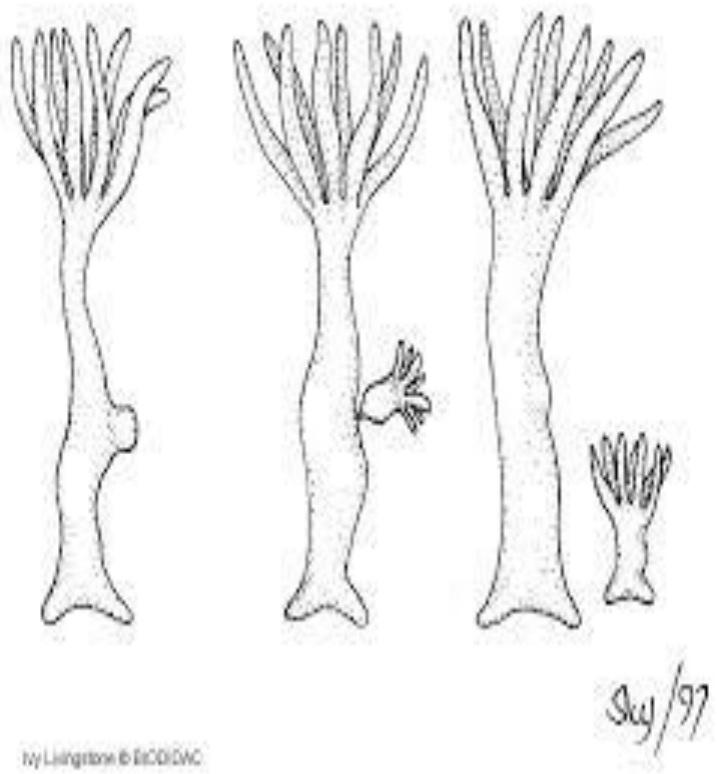
Spore Production

Fragmentation

Parthenogenesis

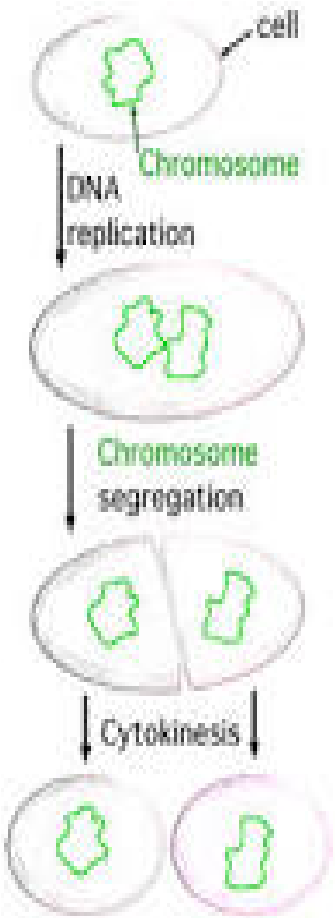
# Budding in Hydra

A new organism develops from an outgrowth or bud due to cell division at one particular site.



# Binary Fission

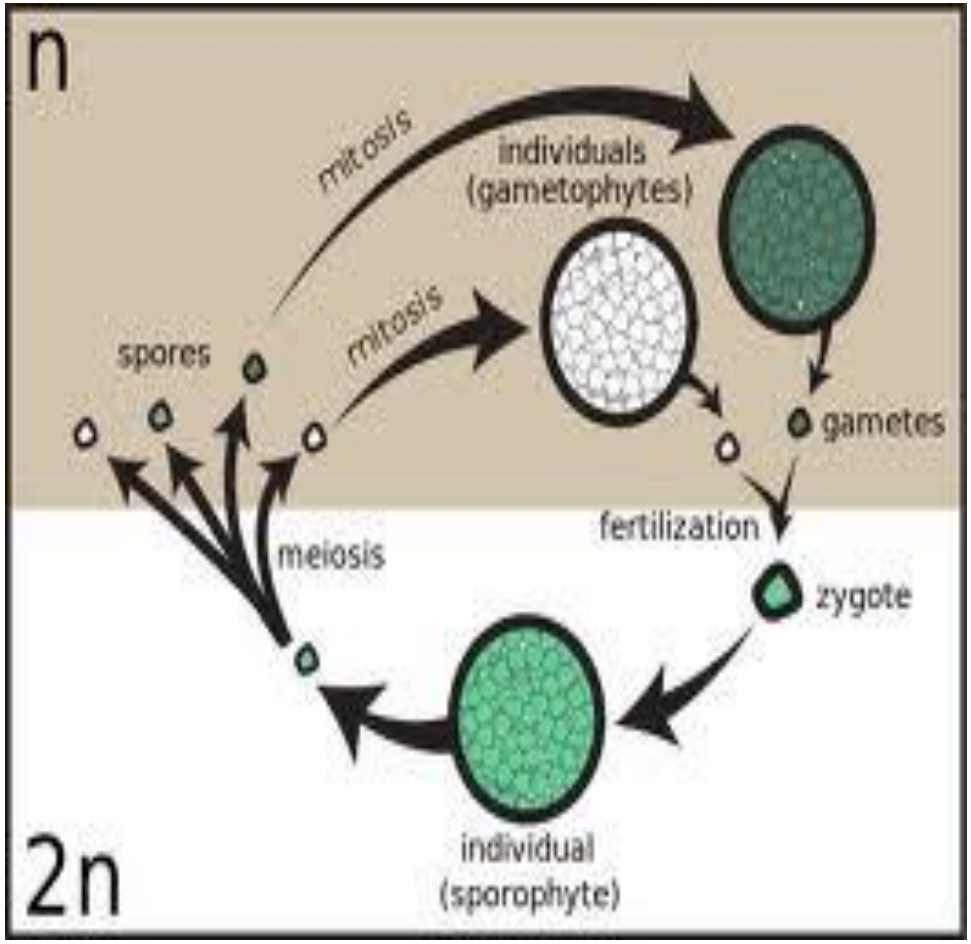
Occurs in prokaryotic Bacterial cells.
Replication of the circular DNA molecule inside the cell.
Replicated DNA move to either poles of the cell.
The cell lengthens.
The equatorial plate of the cell constricts and separates the plasma membrane so each new cell has exactly the same genetic material.



# Spore production

A**sexual spore formation**, involves mitosis giving rise to reproductive cells called mitospores that develop into a new organism after dispersal.

Occurs in all plants, some fungi and algae.



# Fragmentation

Occurs when th eorganism splits into fragments. Each of these fragments develop into mature, fully grown individuals that are clones of the original organism.

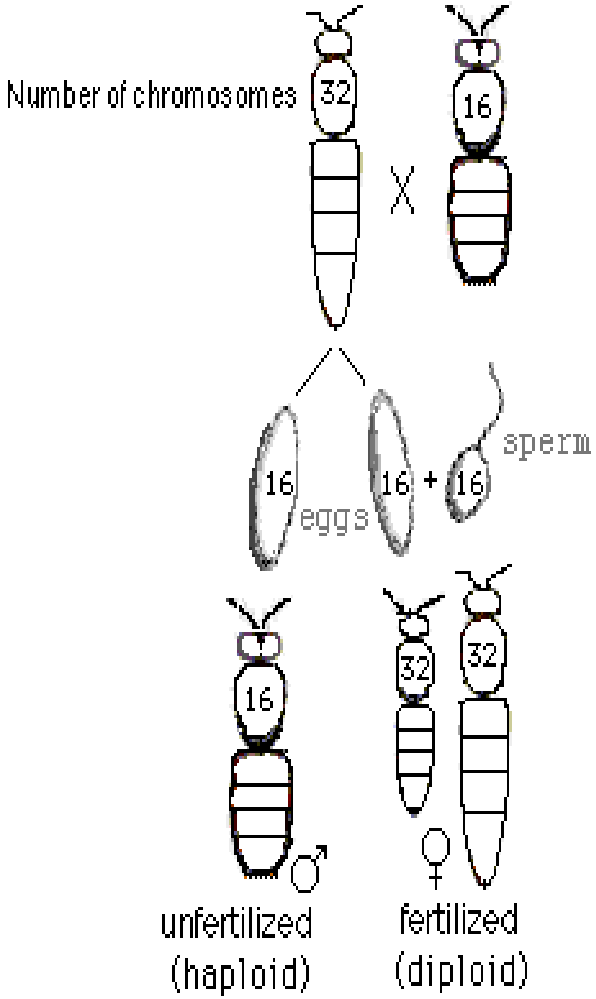
# Parthenogenesis

- is a type of asexual reproduction in which the offspring develops from unfertilized eggs.

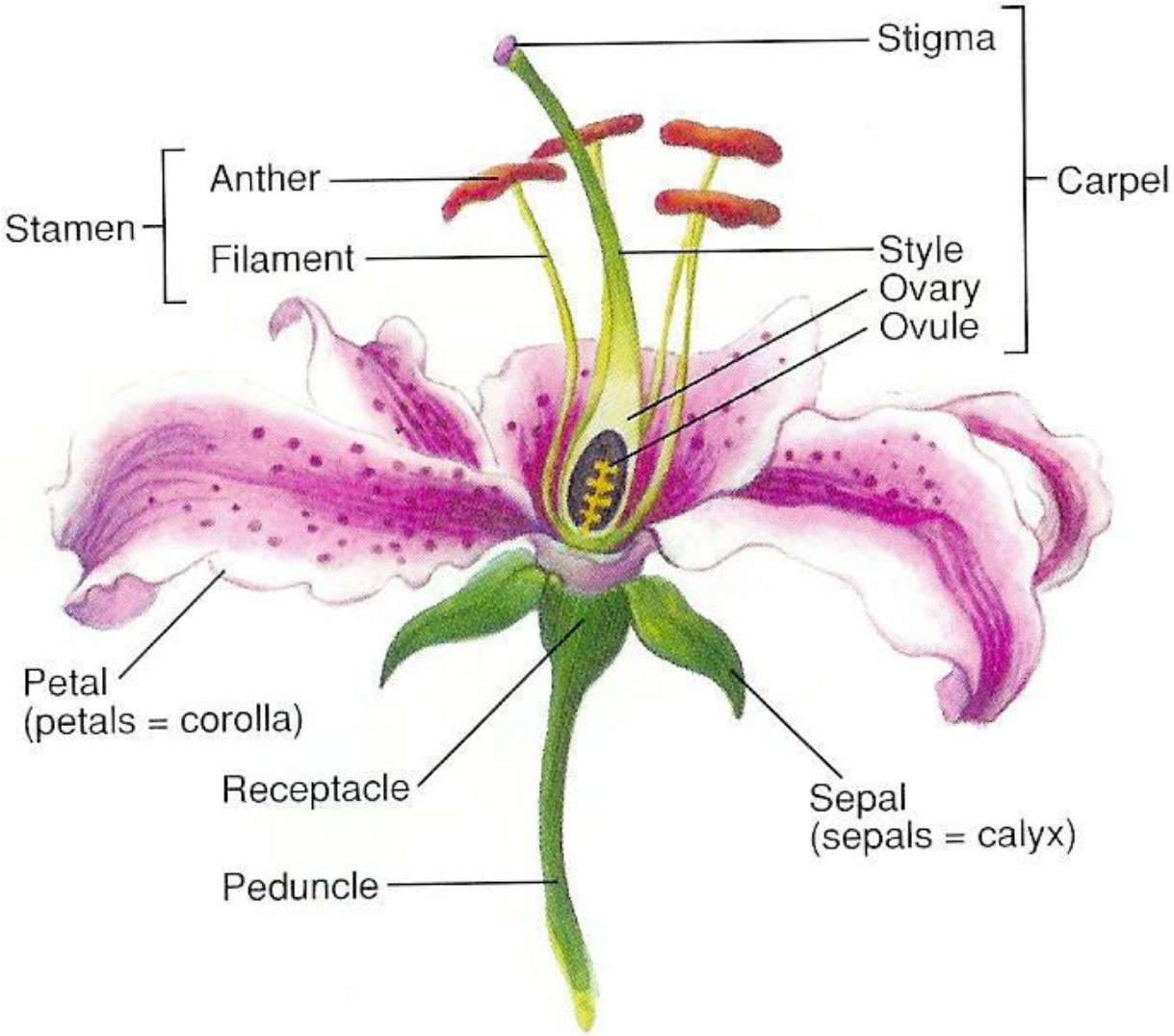
# Parthenogenesis

The asexual, all-female whiptail species *Cnemidophorus neomexicanus* (center), which reproduces via parthenogenesis, is shown flanked by two sexual species

# Parthenogenesis in Bees



# Sexual Reproduction in Angiosperms



## What are the steps of Sexual Reproduction in Angiosperms (Flowers)?

### 1.Pollination

- Pollen is transferred from the anther to the stigma

### 2. Fertilization

- Pollen tube grows down through the style to deliver sperm nuclei to the egg
- Egg and sperm nuclei unite to form a zygote

## 3. Seed Development

- The zygote grows and develops into an embryo plant
- Ovule wall thickens to become a seed coat
- The seed will contain stored food for the developing embryo

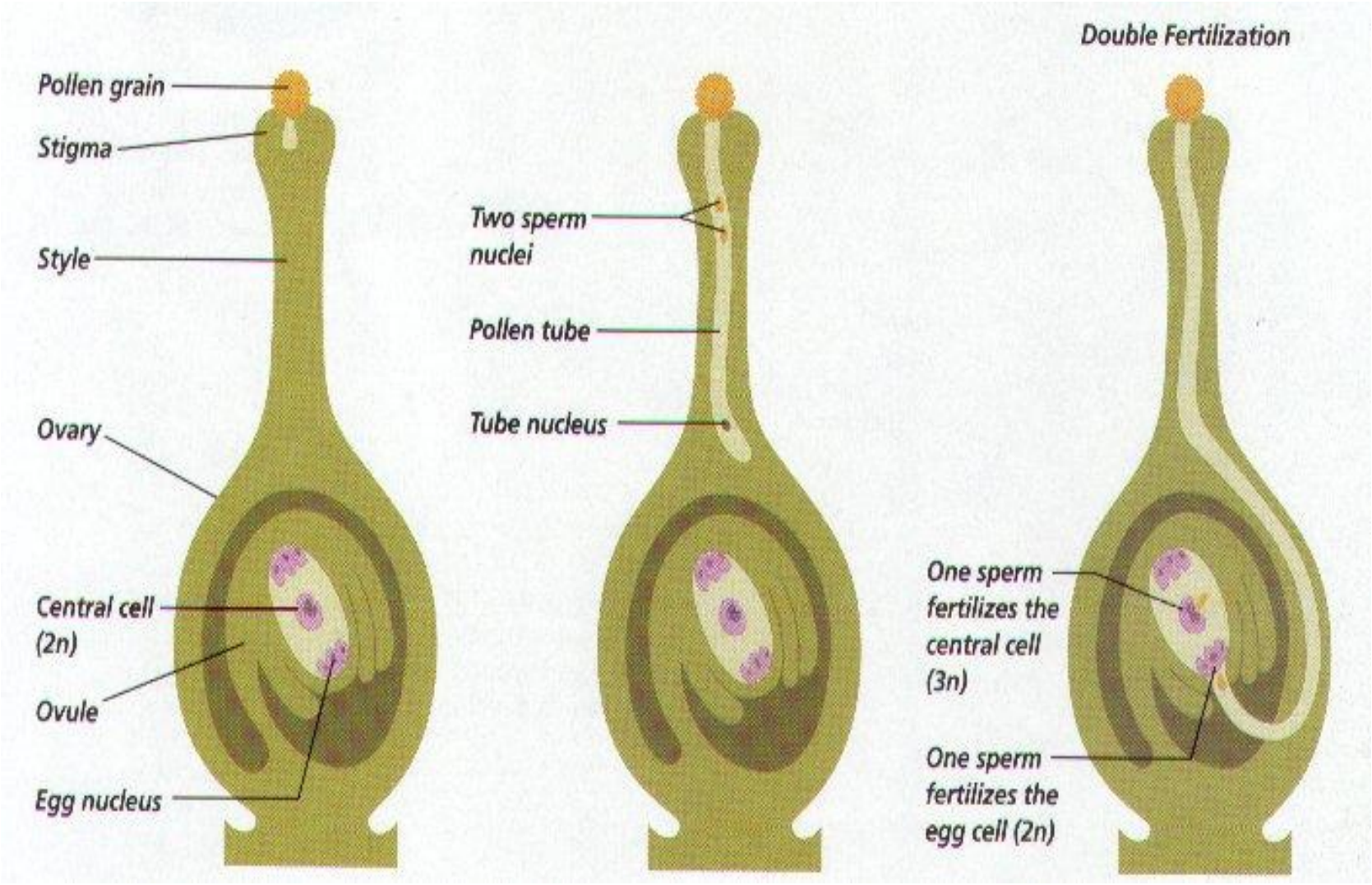
## 4. Fruit Development

- The ovary tissue develops to enclose the seeds
- This is called the fruit (ex: apple, tomato, green pepper)
- It helps with seed dispersal

| What is Found in a pollen grain? (Pollen = sperm) | What is found in an ovule? (Ovule = egg) |
| --- | --- |
| 1. A generative nuclei, which divides to produce two sperm nuclei<br><br>2. A tube nuclei, which causes the pollen tube to grow | 1. One Egg<br><br>2. Two polar bodies |

# What is double fertilization?

- When the pollen tube enters an ovule:
  - One sperm nuclei fuses with an egg to form the zygote (2n)
  - The other sperm nuclei combines with two polar nuclei to form the endosperm (3n) - a food reserve


Double Fertilization
Pollen grain
Stigma
Style
Ovary
Central cell (2n)
Ovule
Egg nucleus
Two sperm nuclei
Pollen tube
Tube nucleus
One sperm fertilizes the central cell (3n)
One sperm fertilizes the egg cell (2n)