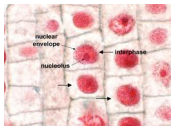
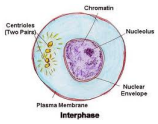
Unit 2: Reproduction

- This unit will examine how cells and organisms reproduce.

- Remember: Although reproduction is an important activity, most of a cell and organism's time is not spent reproducing.



The Cell Cycle p.460-461



- The life of a cell can be divided into two categories:

1. Time spent reproducing (mitosis or meiosis)
2. Time spent not reproducing (**interphase)**

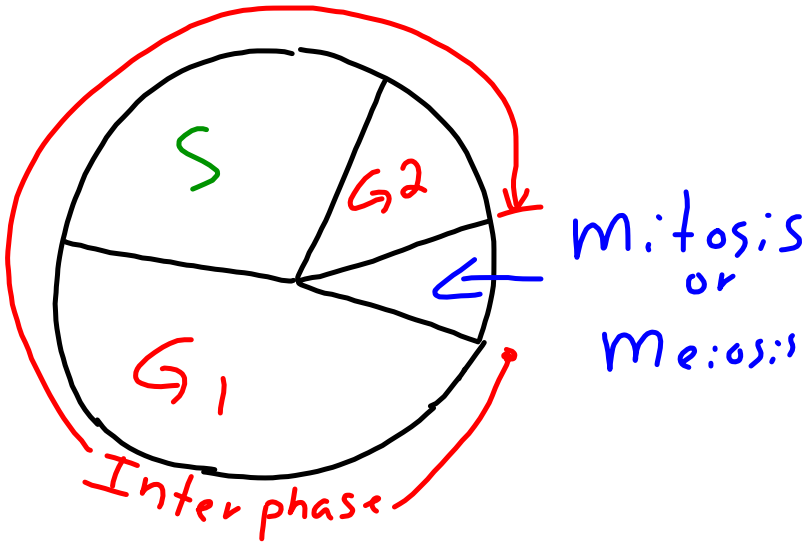
- Interphase can be subdivided further:

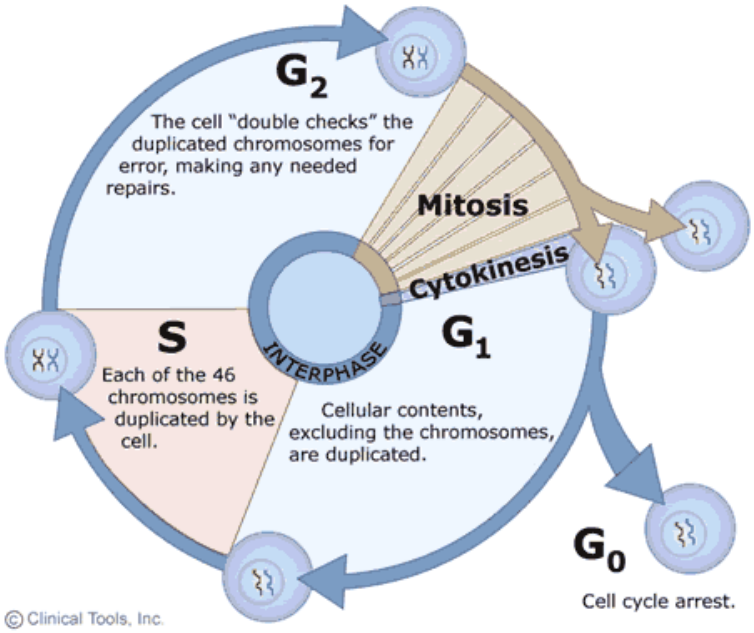
1. **G1 Phase** – Gap 1. Growth and metabolic activity occur.

2. **S Phase** – Synthesis phase. DNA is copied in preparation for cell division.

3. **G2 Phase** – Gap 2. Time between DNA being copied and actual cell division.

The Cell Cycle





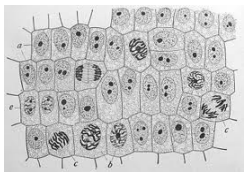
Mitosis p.461-465

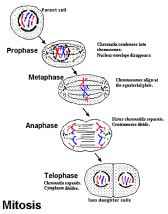
- Mitosis makes exact copies of eukaryotic cells.
- It occurs in almost all the cells of the human body.
- It allows for growth, replacement of aging cells and repairing damage.
- The primary focus of mitosis is the separation of duplicated DNA into two new cells.
- DNA exists in humans in 46 separate strands called **chromosomes.**

Mitosis

- During the early stage of mitosis these chromosomes are wound together tightly into ‘X’ shaped structures.

- These X shaped chromosomes are separated during mitosis so that each new cell gets one ‘leg’ made of identical DNA.



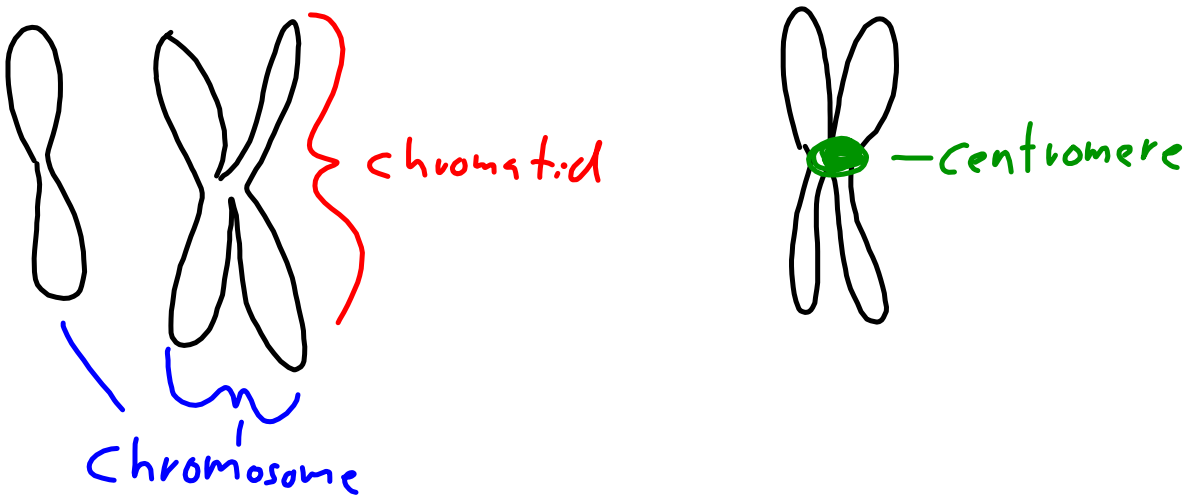


Mitosis

Terminology

- **Chromosome -** Refers to both a single strand of DNA and the duplicated 'X'.

- **Chromatid** – One leg of the 'X'. Note as soon as the legs separate, they are each considered chromosomes.



Centromere – Center of the 'X.'

Centriole – Makes the spindle fibers that attach to the ɛntroments of each chromosome and move them around ɹuring mitosis and meiosis.

'OTE: Plants do not have centrioles.

Disorders of Mitosis p.468-469

- Mitosis creates two daughter cells identical to each other and the mother cell.

- In about 1 in 10,000 divisions a mistake is made in DNA replication.

- **Mutation** – When DNA is changed.

- When DNA is altered three things can happen:
  1. There is NO change in the way a cell behaves and the cell lives.
  2. The difference is severe enough to kill the cell.
  3. Cell behaviour is changed.

- Sometimes the change to a cell allows it to work a bit better.

- Sometimes the cell works a bit worse.

- Sometimes the change causes the cell to rapidly divide.

- **Cancer** - Rapidly dividing cells.

- **Oncogenes** - Genes which cause cancer when they are changed.

- Cancer is often treated with a combination of three procedures:

Cancer treatment

1. **Removal** of the cancerous tissue through surgery.

2. **Radiation** therapy.

- This can be done by directing radiation toward the cancerous areas or implanting radioactive material into the patient.
- Radiation also kills healthy cells, but usually, healthy tissue can repair itself.
- Side effects include fatigue, hair loss, and sterility.

3. **Chemotherapy**.

- This involves taking strong drugs that interfere with cell division.
- Since the drugs are ingested, they can affect many non-cancerous cells throughout the body.
- Side effects include hair loss, nausea and diarrhea.

- What important personal and ethical decisions must be made by someone undergoing cancer treatment?

Meiosis p.470-475

- Mitosis occurs in nearly all cells of the body.

- However, the cells that make **eggs** and **sperm** use meiosis.

- Meiosis also **duplicates** chromosomes and separates them (like mitosis)

- However, in meiosis the chromosomes number is cut in **half**.

- For that reason meiosis is sometimes called "**reduction-division**."

- A cell with two sets of a gene is called **diploid**.
  E.g. most cells of the body, like skin cells.

- A cell with only one set of a gene is called **haploid**.
  E.g. eggs and sperm.

- Does mitosis produce haploid or diploid cells?

Diploid

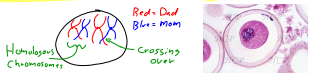
- Does meiosis produce haploid or diploid cells?

Haploid

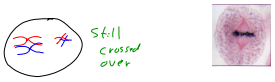
Stages of Meiosis

Meiosis has 2 Stages
Meiosis I

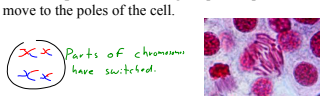
1. **Prophase I** – The DNA has already duplicated. The X shaped chromosomes form and homologous chromosomes pair up. Crossing over occurs.



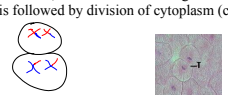
2. **Metaphase I** – Homologous pairs line up along the equator of the cell.



3. **Anaphase I** – Homologous pairs separate and move to the poles of the cell.



4. **Telophase I** – Does not occur in all cells, if not goes straight to meiosis II.
If it does, the chromosomes begin to unwind. This stage is followed by division of cytoplasm (cytokinesis).

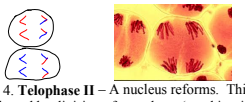


Meiosis II
(occurs in each of the 2 daughter cells formed)
Each phase is exactly the same as in I
Cells are haploid (but have replicated chromosomes - 2 chromatid)

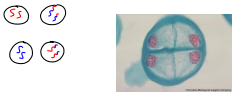
1. **Prophase II** –The X shaped chromosomes have already formed or are reformed.

2. **Metaphase II** – The chromosomes line up along the equator of the cell.

3. **Anaphase II** – The legs of the X shaped chromosomes separate and move to the poles of the cell.



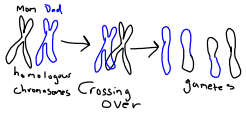
4. **Telophase II** – A nucleus reforms. This stage is followed by division of cytoplasm (cytokinesis). Four cells total have been formed.

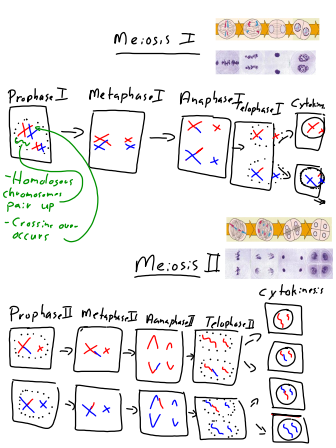


At the end of Meioses cells are:
- Haploid

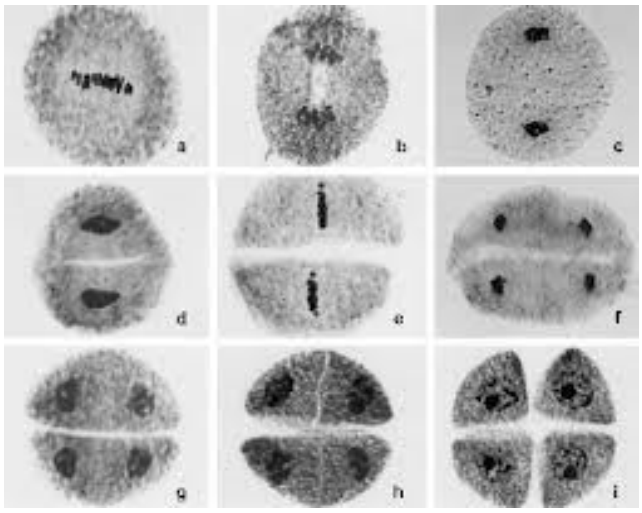
- Have a single, unreplicated chromosome (only 1 chromatid)

-these will develop into gametes





Which phase?



Meiosis

- Meiosis is used in sexual reproduction.

- The primary advantage of sexual reproduction is to create offspring that are **different** from each other and the parent.

- To meet this goal, meiosis has features that **increase the diversity** of the gametes (eggs and sperm):

1. **Homologous pairs separate**

- A significant difference between mitosis and meiosis is the separating of homologous chromosomes in meiosis.

- **Homologous chromosomes** – In humans half of our chromosomes come half from a mother, half from a father.

These chromosomes do not contain different genes only different ***versions*** of the same gene.

I.e. for the gene of ear lobes, mom might give us the "attached ear lobe" version and dad the "unattached" version. (we only show one trait - while we may have 2 in our genes)

2. **Random Assortment**

- When the homologous chromosomes line up during metaphase I, they **randomly** align near one pole or the other.

I.e. you could have all the DNA from the mother on one side and all the DNA from the father on the opposite side.

In reality, there is usually a combination.

3. **Crossing over**

- Crossing over – When homologous chromosomes pair up, they sometimes **exchange** sections of DNA.

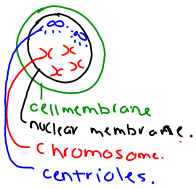
These sections are exchanged when one leg of a X shaped chromosome "crosses over" the leg of its homologous counterpart.

- Both of these differences help increase genetic diversity in the gametes produced by meiosis.

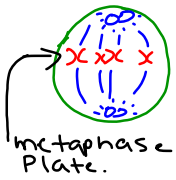
Mitosis

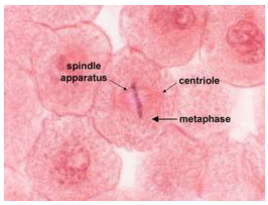
- Mitosis occurs in **4 stages + 1:**

- **1. Prophase** – The chromosomes condense, spindle fibers are made and the nuclear membrane disappears

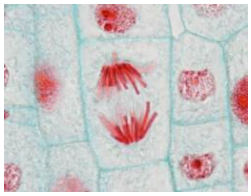


- **2. Metaphase** – Spindle fibers attach to the chromosomes and line up along the equator of the cell.





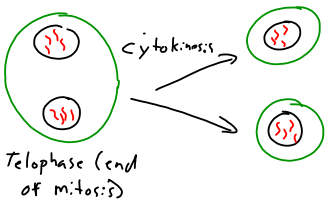
- **3. Anaphase** – The legs of each X shaped chromosome separate. They move to opposite ends of the cell.

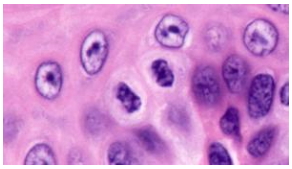


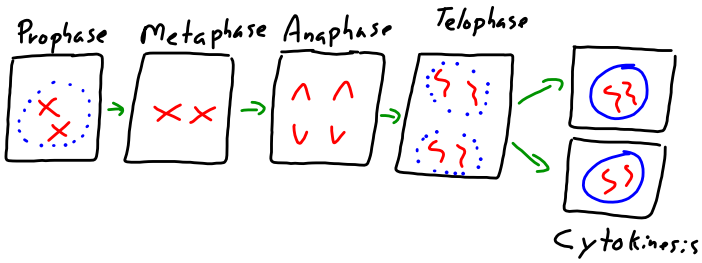
- **4. Telophase** – New nuclei begin to form.

- **Cytokinesis** – The cytoplasm of the "daughter" cells separate. At the end of this stage 2 new cells are formed.

- NOTE: Cytokinesis is not a stage of mitosis.







Gamete Formation

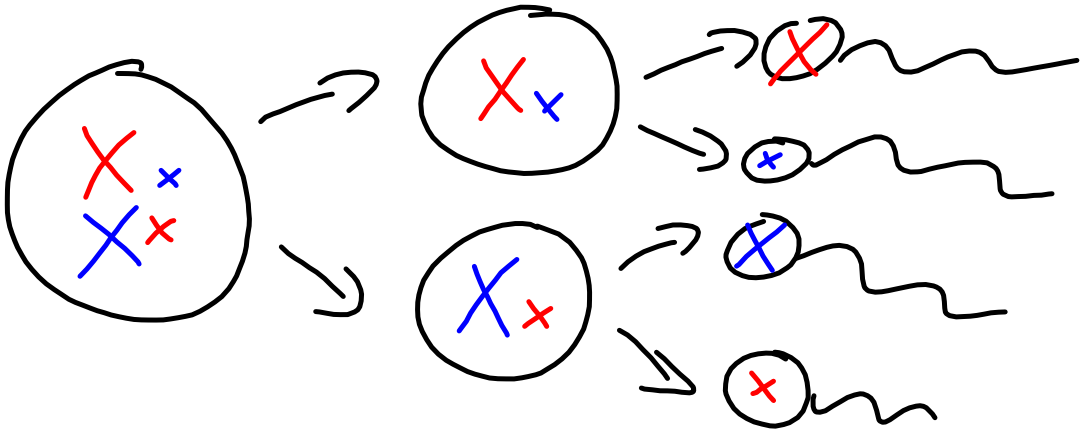
- **Gametogenesis** – gamete formation where daughter cells, or gametes, are produced at the end of meiosis II resulting in sperm and egg.

- Gamete formation is different depending on wether male or female gametes are formed

Spermatogenesis

- **Spermatogenesis** – the process of male gamete production in animals

- In males, special cells called **spermatogonia** (singular spermatogonium) in the testes produce four functional sperm, each the same size.

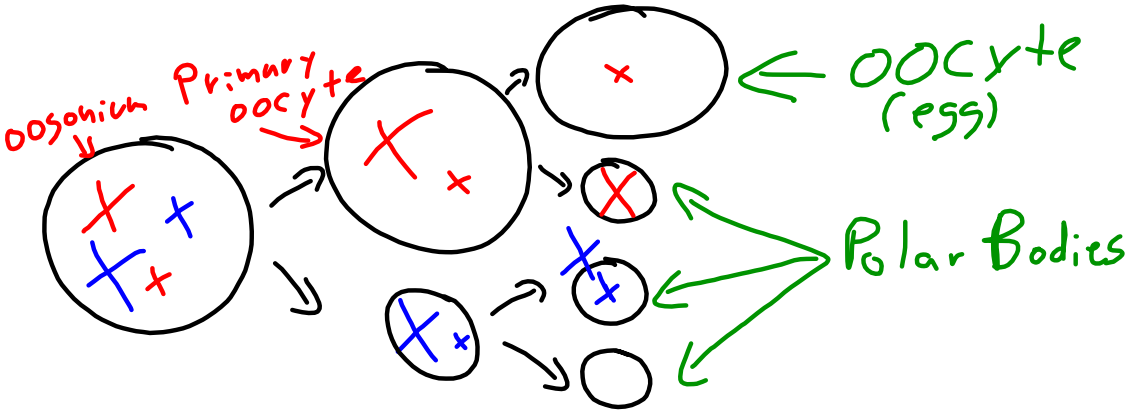


Oogenesis

- **Oogenesis –** the process of female gamete production in animals

- In females, special cells called **oogonia** (singular oogonium) in the ovaries undergo meiosis to produce one **oocyte** (egg) and 3 cells that recieve less cytoplasm and die (polar bodies).

- Cytoplasm is **NOT** equally divided, as in sperm production. Oocyte recieves more.



- The oocyte gets most of the cytoplasm so when the zygote forms it will have enough nutrients.

- In humans meiosis I begins in the ovaries during embryo development and halts until puberty.

- Then once a month, one cell continues meiosis I.

Egg vs. Sperm p.478

- In some organisms, the gametes look very similar. In humans they are quite different.

- Sperm are about 50μm long, eggs about 100μm in diameter.

- Before ejaculation, sperm gets energy from fat, afterward it gets energy from sugar in the seminal fluid.

- Eggs use energy they have stored until they are fertilized. Afterward they obtain nutrients from the wall of the uterus.

- In sperm, 50-100 mitochondria are located in the mid-piece.

Egg vs. Sperm

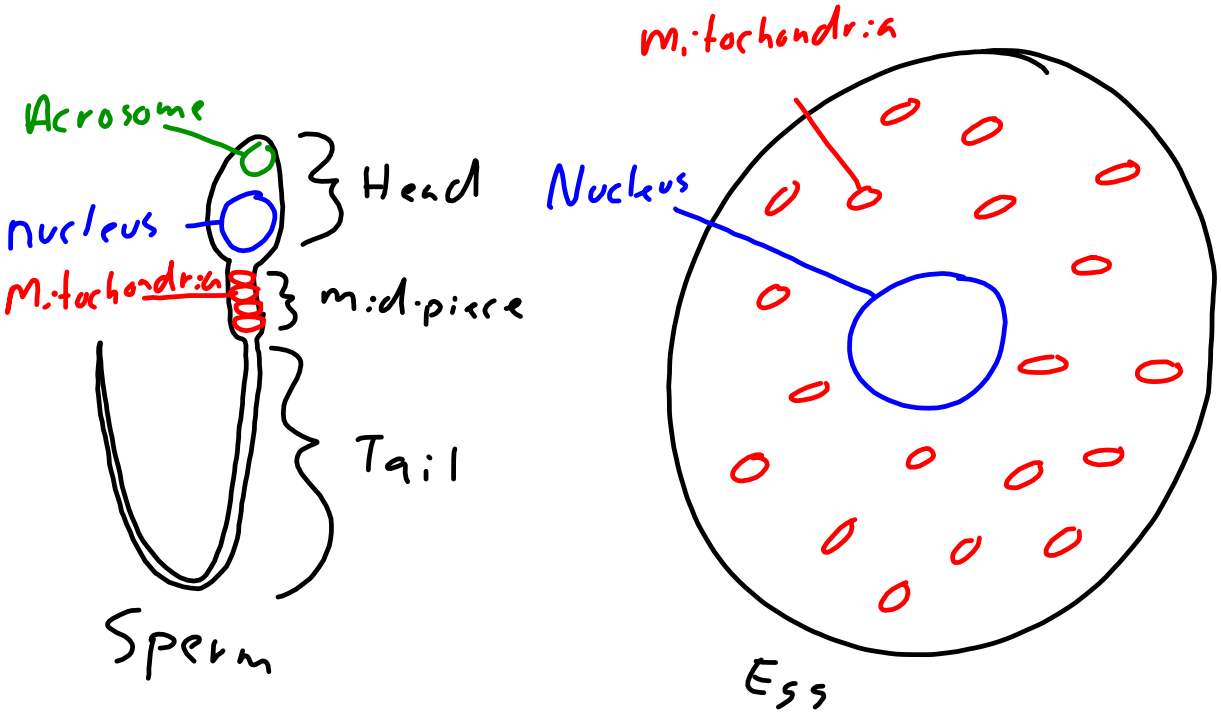
- In eggs, 140,000 mitochondria are located throughout the cytoplasm.

- About 300 – 500 million sperm are present in a male at any time and they are continuously produced.

- There are initially 300,000 to 400,000 oogonia at the start of puberty in each ovary. Usually only one matures each month.

- Sperm move with their long flagellum, eggs can not move.

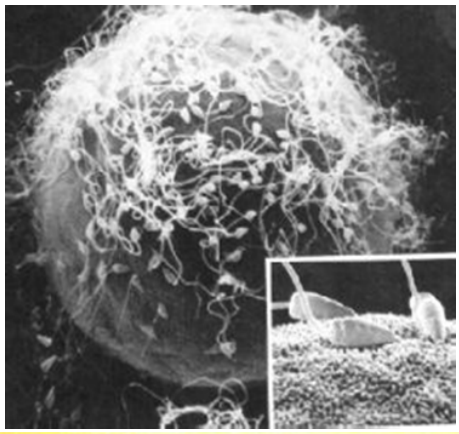
- Sperm have a cap at the tip of their head called an **acrosome**, which contains enzymes that help it enter the egg.



Egg vs. Sperm

- The outside of an egg has a special coating that allows only sperm of the same species to enter.

- Once one sperm enters the egg, this coating changes, and doesn't allow any other sperm to enter.



Overview: Sperm Vs. Egg

	Sperm	Egg
Size	- Small	- Large
motility	- mobile	- not mobile
outer structure	- have a cap called an acrosome which contains enzymes used to enter the egg cell	- covered by a thick outer coating. After one sperm penetrates the egg, no more can enter
numbers	- millions produced continuously (300 million-500 million)	- one egg matures per month from puberty to menopause
mitochondria	- 50-100 mitochondria per cell	- about 140, 000 mitochondia per cell
energy	- before ejaculation: uses fat for energy- after ejaculation: uses sugar (fructose) for energy	- can only live for about a day or so with its food supply

Asexual Reproduction

- This strategy involves only one parent and mitosis.

- There are several advantages to asexual reproduction:

- Don't need a mate.
- Faster. *
- Can make more. *
- Less waste.
- Less energy needed.

- There are many cost associated with sexual reproduction (opposite of the advantages of asexual reproduction).

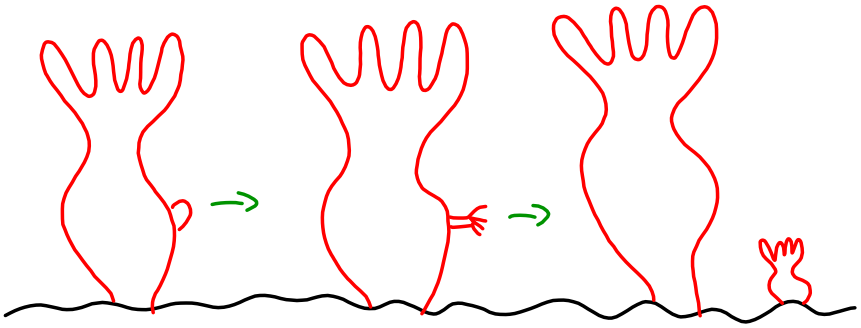
- The main advantage of sexual reproduction is the variety of offspring produced.

- This is particularly important so a population can adapt if the environment changes.

Asexual Reproduction

- Types of asexual reproduction include:

1. **Budding** – An entire new organism grows off the parent, starting as a "bud" of cells.
E.g. Hydra, strawberries.



Modes of Reproduction

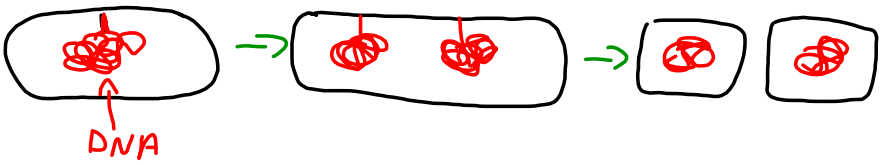
	Types	Description	Representative Example
Asexual	Budding		
	Binary Fission		
	Spore Production		
	Fragmentation		
	Parthenogenesis		

Sexual	

Asexual Reproduction

2. **Binary fission** – This is done by bacteria.

- One bacteria makes two identical daughter cells.
- It is a similar process to mitosis in eukaryotic cells.
- However it is different due to the method used to replicate DNA, and the division of the cytoplasm.



Modes of Reproduction

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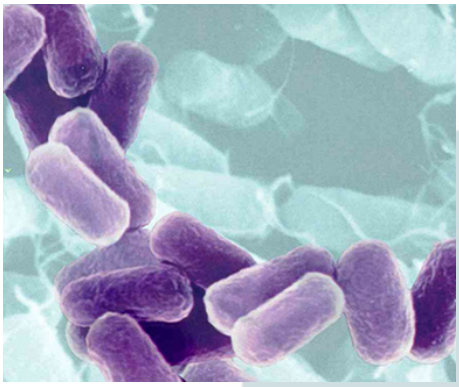
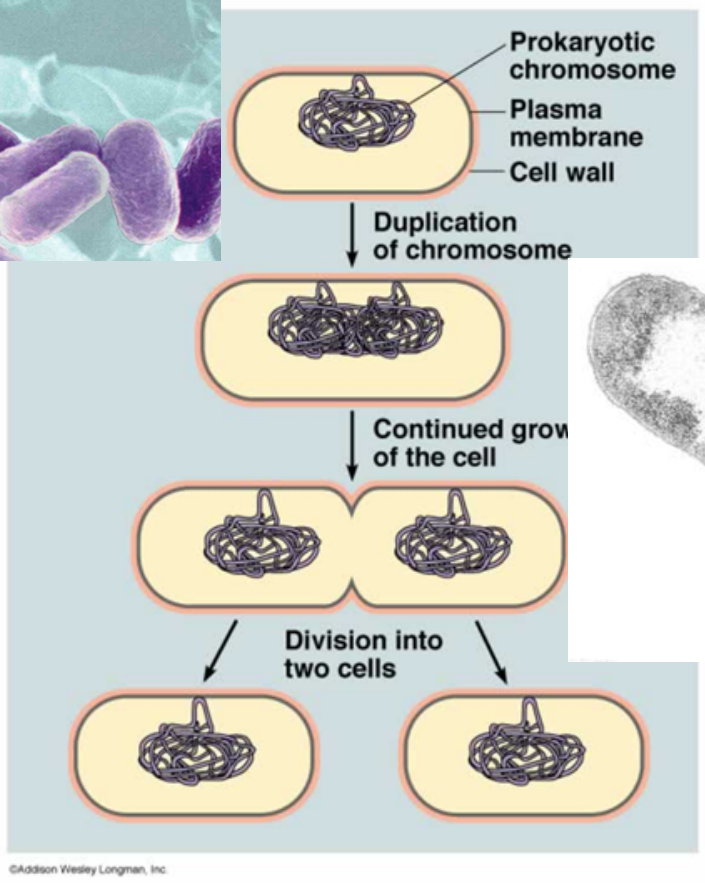
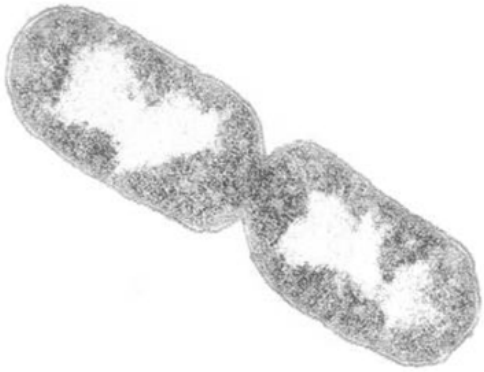
Sexual	



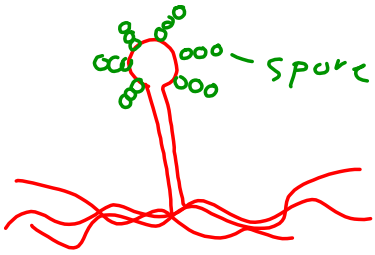

Prokaryotic chromosome
Plasma membrane
Cell wall
Duplication of chromosome
Continued grow of the cell
Division into two cells
©Addison Wesley Longman, Inc.



Asexual Reproduction

3. **Spore production** – Spores are used to disperse organisms over large areas.

- They can be produced sexually or asexually.
- Some fungi use asexual spores as their primary means of dispersal.
- These fungi are haploid and **use mitosis to produce haploid spores.**



Modes of Reproduction

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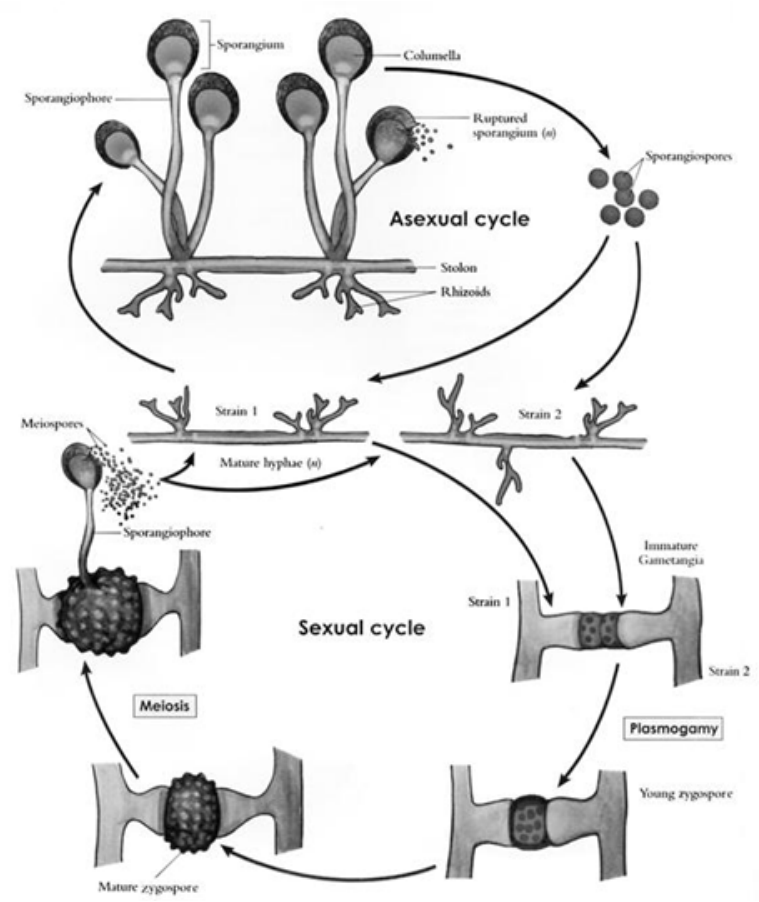
Asexual	Budding		
	Binary Fission		
	Spore Production		
	Fragmentation		
	Parthenogenesis		

Draw

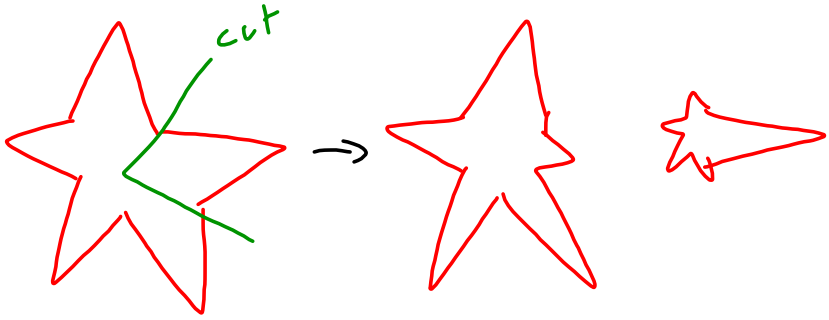
Sexual	


Sporangium
Columella
Sporangiophore
Ruptured sporangium (n)
Sporangiospores
Asexual cycle
Stolon
Rhizoids
Strain 1
Strain 2
Meiospores
Mature hyphae (n)
Sporangiophore
Immature Gametangia
Strain 1
Sexual cycle
Strain 2
Meiosis
Plasmogamy
Young zygospore
Mature zygospore

Asexual Reproduction

4. **Fragmentation** – Some organisms can produce a new individual when a section of one is removed.

E.g. Starfish, planarian



Modes of Reproduction

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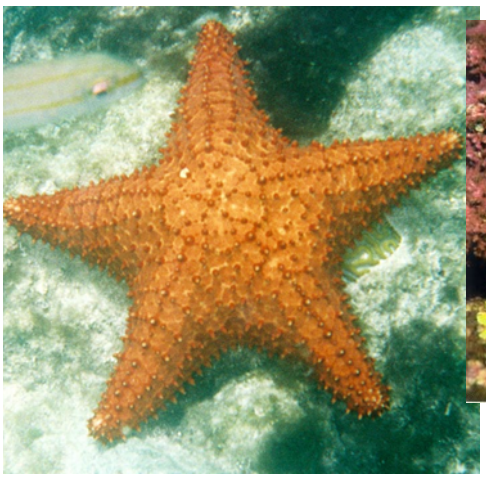
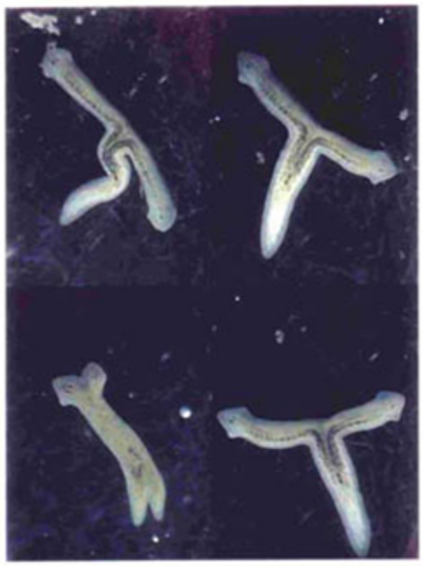
Asexual	Budding		
	Binary Fission		
	Spore Production		
	Fragmentation Draw		
	Parthenogenesis		

Sexual	

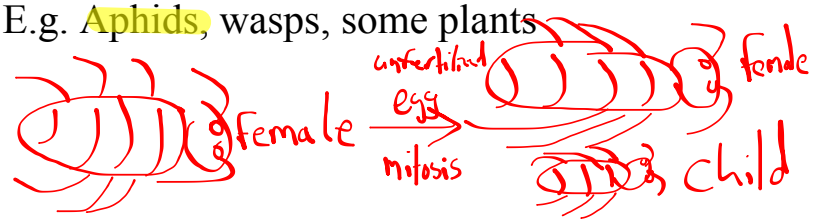




Asexual Reproduction

5. **Parthenogenesis** – When a female produces an embryo and it develops without fertilization.

E.g. Aphids, wasps, some plants



Modes of Reproduction

	Types	Description	Representative Example
Asexual	Budding		
	Binary Fission		
	Spore Production		
	Fragmentation		
	Parthenogenesis Draw		

Sexual	

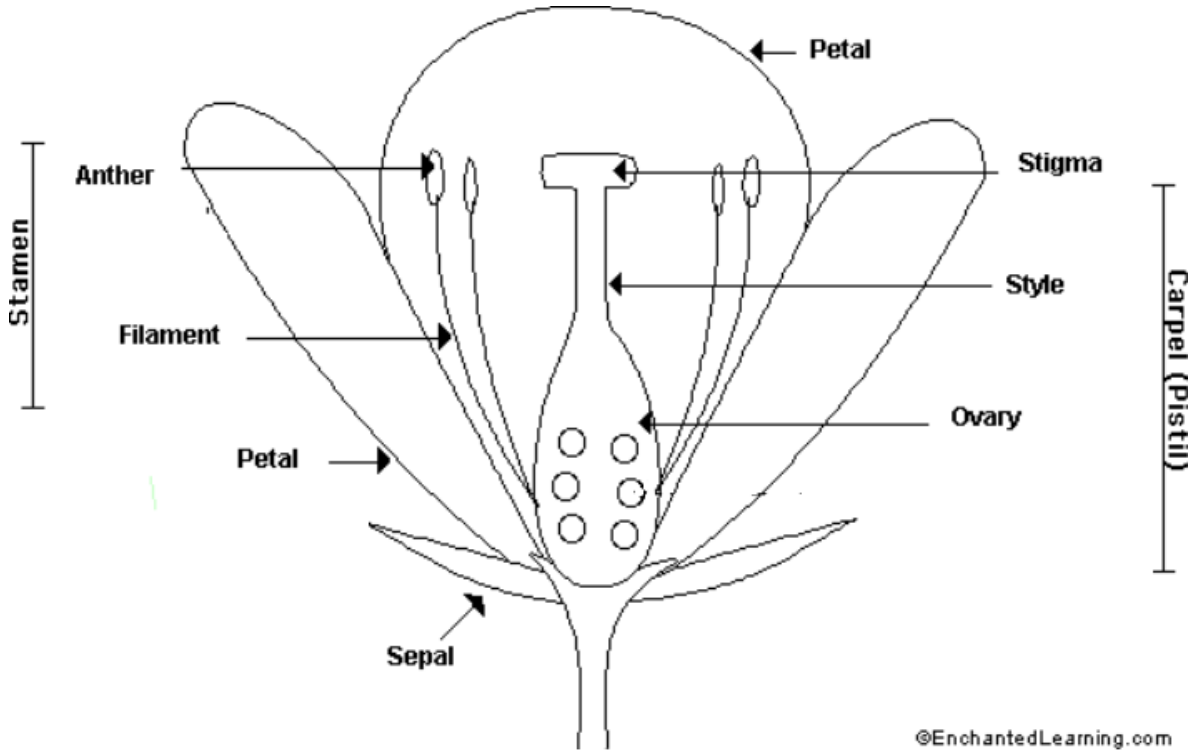
Reproduction in Angiosperms

- **Angiosperms**– The Division of plants that contains all flowers.

- Angiosperms have the most complex reproductive structures of any plant.

- **Flower** – Reproductive organ of the Angiosperms. (complex)

Parts of a flower



1. **Stamen** - The entire male part of the flower.

2. **Anther** - Makes the pollen grains.

3. **Filament** - Holds the anther up.

4. **Pollen grain** - The male gametophyte. It contains two nuclei. One generative and one tube.

5. **Carpel or Pistil -** The entire female part of the flower.

6. **Stigma** - Top part where pollen lands

7. **Style** - Long part that pollen tube travels down

8. **Ovary** - Contains the eggs (ovules). This will become the fruit and the ovules will become the seeds.

Reproduction in Angiosperms

- **Pollen** is produced in the **anther** at the tip of the **stamen**.

- Pollen grains contain two nuclei: **generative** and **tube**.

- When pollen reaches the top of the **pistil** (the **stigma**) the tube nucleus produces the **pollen tube**.

- When the pollen tube reaches the **ovary**, the generative nucleus travels down it.

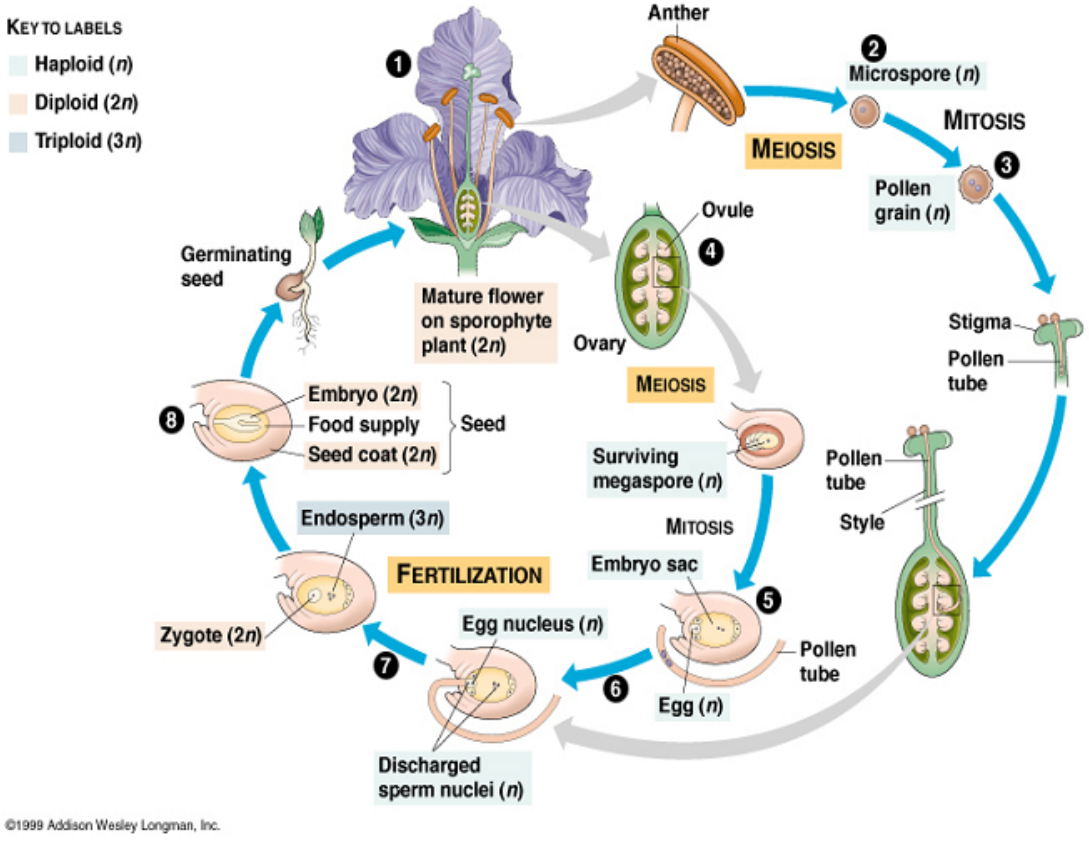
Reproduction in Angiosperms

- Before leaving the pollen tube the generative nucleus divides, creating two **sperm nuclei**.

- One of the sperm nuclei fertilizes the **ovum** (egg) creating a diploid zygote ("baby plant").

- The other sperm joins two nuclei outside the zygote to become the **triploid endosperm**. (3n)

- Endosperm will be food for the developing embryotic plant.


KEY TO LABELS
Haploid (n)
Diploid (2n)
Triploid (3n)
1
Anther
2
Microspore (n)
MEIOSIS
MITOSIS
3
Pollen grain (n)
Stigma
Pollen tube
Style
Pollen tube
Germinating seed
Mature flower on sporophyte plant (2n)
Ovule
4
Ovary
MEIOSIS
Surviving megaspore (n)
MITOSIS
Embryo sac
5
Pollen tube
Egg (n)
6
Egg nucleus (n)
7
Discharged sperm nuclei (n)
FERTILIZATION
Zygote (2n)
Endosperm (3n)
8
Embryo (2n)
Food supply
Seed coat (2n)
Seed
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