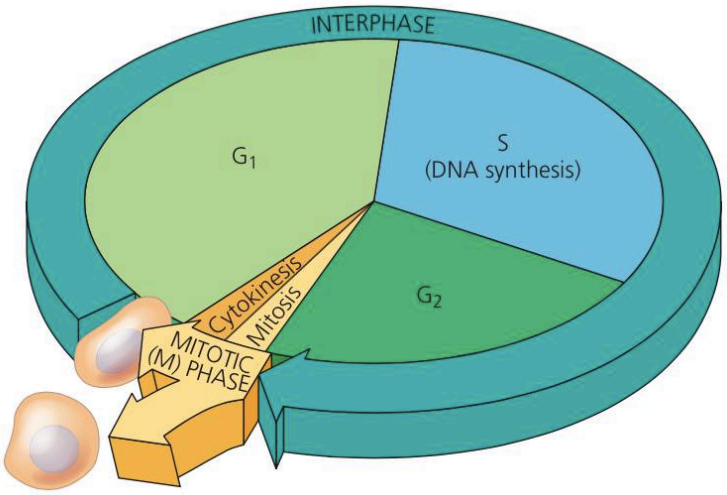
The Mitotic Phase Alternates with Interphase in the Cell Cycle

Phases of the Cell Cycle

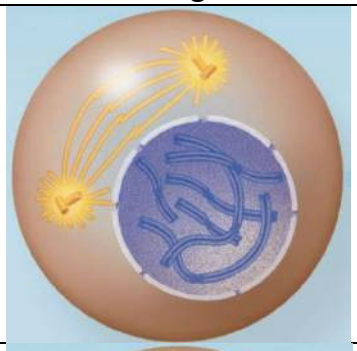
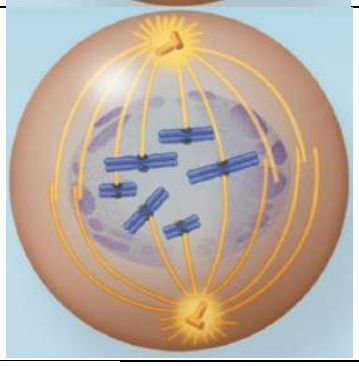
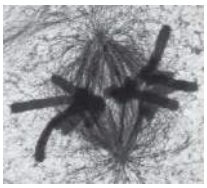
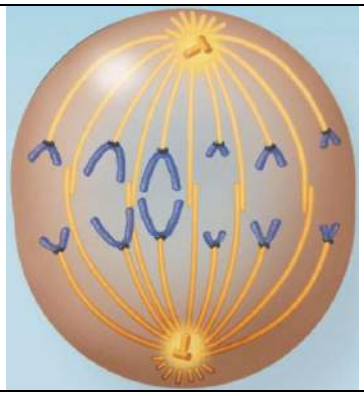
- **Miotic Phase (M)** → incudes both mitosis and cytokinesis
  - Usually the shortest part of the cell cycle
- **Interphase** → has many subphases:
  - G_1 phase: "first gap"
  - S phase: "synthesis"
  - G_2 phase: "second gap"
  - Takes up about 90% of the cell cycle
- In all 3 subphases of interphase, a cell grows by producing proteins and cytoplasmic organelles
  - Duplication of the chromosomes occurs entirely during the S phase
- i.e. the cell cycle goes as follows:
  - G_1 → a cell grows
  - S → cell continues to grow as it copies its chromosomes
  - G_2 → cell grows more as it completes preparations for cell division (duplicates organelles)
  - M → cell divides
- The daughter cells may then repeat the cycle

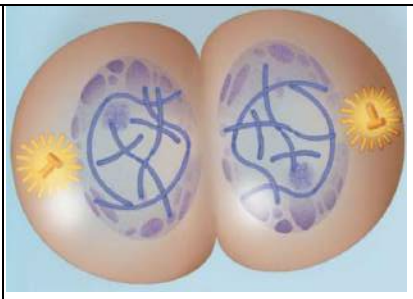
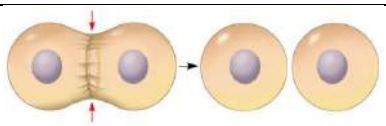
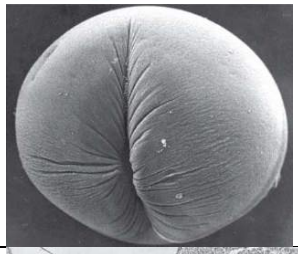
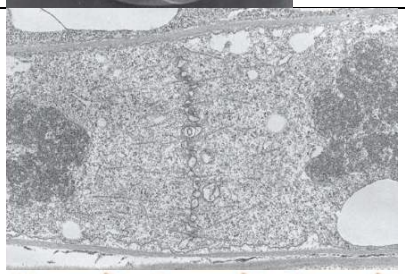
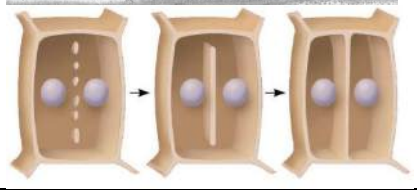


- If a human cell took 24 hours to complete cell division, it would be broken up into:
  - 1 hour = M phase
  - 10-12 hours = S phase
  - 4-6 hours = G_2 phase
  - 5-6 hours = G_1 phase
    - G_1 phase is most variable in time in different types of cells

PART 1: MITOSIS: making copies of existing cells

- **Somatic Cell Division: Mitosis Steps**
  - Prophase
  - Prometaphase
  - Metaphase
  - Anaphase
  - Telophase
- **Cytokinesis**

Step	What Happens?	Diagram
Prophase	- Condensation of chromosomes - Dissolution of nucleoli - Mitotic spindle begins to form and microtubules lengthen	
Prometaphase (Late Prophase)	- Nuclear envelope disintegrates - Further chromosomal condensation occurs - The mitotic spindle comes in contact with the chromosomes - Some microtubules connect to parts of the centromere - Other microtubules interact with those from the opposite pole	
Metaphase	The chromosomes are aligned along the equator	  Centrome: 
Anaphase	The adhesive proteins holding the sister chromatids are cleaved The microtubules attached to the sister chromatids shorten In animal cells as the other microtubules increase in length: the cell lengthens	

<table>
<tr><td>Telophase</td><td>In each half of the cell a nuclear envelope reassembles around the complete set of daughter chromosomes
The mitotic spindle disassembles
The chromosomes become less condensed
(In an animal cell, while telophase occurs, so does cytokinesis)</td><td>  </td></tr>
<tr><td rowspan="3">Cytokinesis</td><td colspan="2">Cytokinesis is the division of the cytoplasm.</td></tr>
<tr><td><u>Animal:</u>
Occurs by a process known as cleavage.
1st sign of cleavage is the cleavage furrow
→ a shallow grove in the cell surface.
This is caused by a contractile ring of microfilaments, which act like a drawstring.
The parent cell is pinched into 2 daughter cells.</td><td> 
  </td></tr>
<tr><td><u>Plant:</u>
There is no cleavage furrow.
During telophase, vesicles from the Golgi apparatus move microtubules to the middle of the cell (equator).
Here, they coalesce and form the cell plate.
The cell plate enlarges until its surrounding membrane fuses with the plasma membrane along the perimeter of the cell.
This gives rise to a cell wall that will divide to 2 daughter cells</td><td> 
  </td></tr>
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Binary Fission in Bacteria

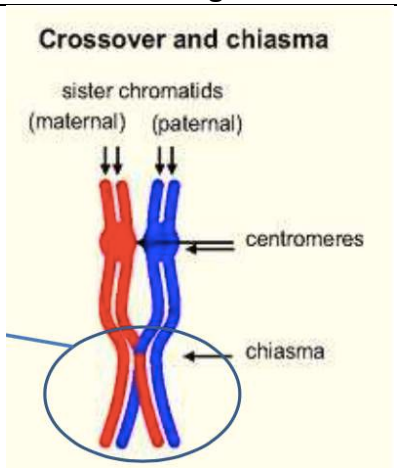
- Refers to prokaryotic reproduction (where the cell doubles in size and divides to form 2 cells) and to the asexual reproduction of single-celled eukaryotes
    - "Division in half"
- Most genes are carried on a single bacterial chromosome that consists of a circular DNA molecule and associated proteins
    - This chromosome can be very long, and highly folded and coiled
- Process of E.coli:
    - DNA begins to replicate at a specific place on the chromosome called the origin of replication, producing 2 origins
    - 1 origin moves rapidly toward the opposite end of the cell
    - While the chromosome is replicating, the cell elongates
    - When replication is complete and the bacterium is 2x its size, its plasma membrane pinches inward, dividing cell into 2 daughter cells
    - ∴ Each cell inherits a complete genome

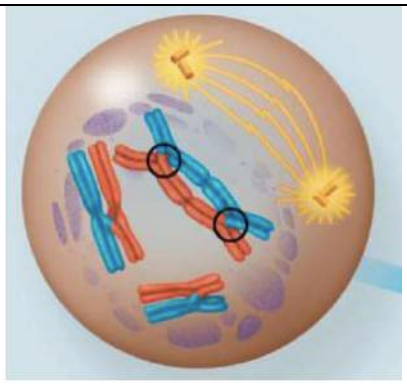
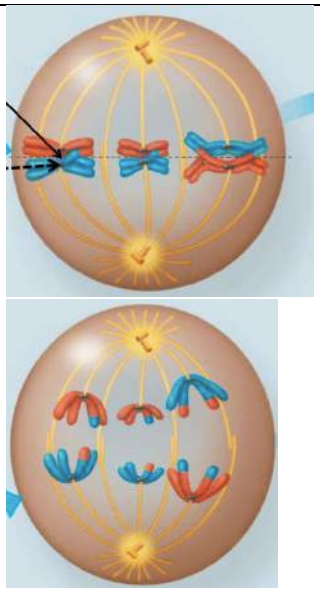
PART 2: MEIOSIS: Making Gametes for Sexual Reproduction

- Many species rely on sexual reproduction to create new combinations derived from individual genomes
- In this case the first cell the zygote is the fusion of 2 gametes
- A haploid cell has only one member from every homologous pair of chromosomes
- Meiosis is a reductive division where a diploid parent gives rise to haploid gametes
- 2 nuclear divisions occur and up to four daughter cells are formed
- The daughter cells are not genetically identical to parent

THE STAGES OF MEIOSIS

Meiosis 1	Meiosis 2
o Prophase 1 o Metaphase 1 o Anaphase 1 o Telophase 1	o Prophase 2 o Metaphase 2 o Anaphase 2 o Telophase 2

Step	What Happens?	Diagram
Prophase 1	- Interphase is like that of mitosis so the chromosomes exist as sister chromatids held together - BUT ALSO: synapsis occurs where homologous chromosomes pair up like alongside each other held together by a synaptonemal complex - This forms a tetrad - In this state the same genes can swap between adjacent chromatids: this is called crossing over - Towards the end of prophase the homologous chromosomes have partially pulled apart except at the chiasmata (singular = chiasma) where there has been crossing over	

Metaphase 1	- Spindle formation and nuclear envelope breakdown occur (as with prophase and prometaphase of mitosis) - The spindle fibres will attach to the tetrad made up of the homologous pair of chromosomes - The tetrads of each homologous pair of chromosomes line up along the equator - As to which member of the pair is on which side of the equator is a totally random event - Microtubules from one pole are attached to one member of the pair - Microtubules of the other pole are attached to the other member of pair	 In the diagram chiasmata are circled
Anaphase 1	- Points of attachment between the members of the pair break down - However, the adhesion between sister chromatids stays intact - The members of the homologous pair are pulled apart while sister chromatids of the same chromosome stay together	
Telophase 1	- The nuclear envelope may reform and the in animal cells cytokinesis may occur at the same time - E.g. this occurs with sperm - For ova the steps going from telophase to the final gametes include some unique steps which may be separated by a substantial amount of time