Ministry of Higher Education and Scientific Research
University of Baghdad
College of Science
Department of Biology

Practical Cytology
2021-2022

المرحلة الاولى للدراستين الصباحية والمسائية

الفصل الدراسي الاول

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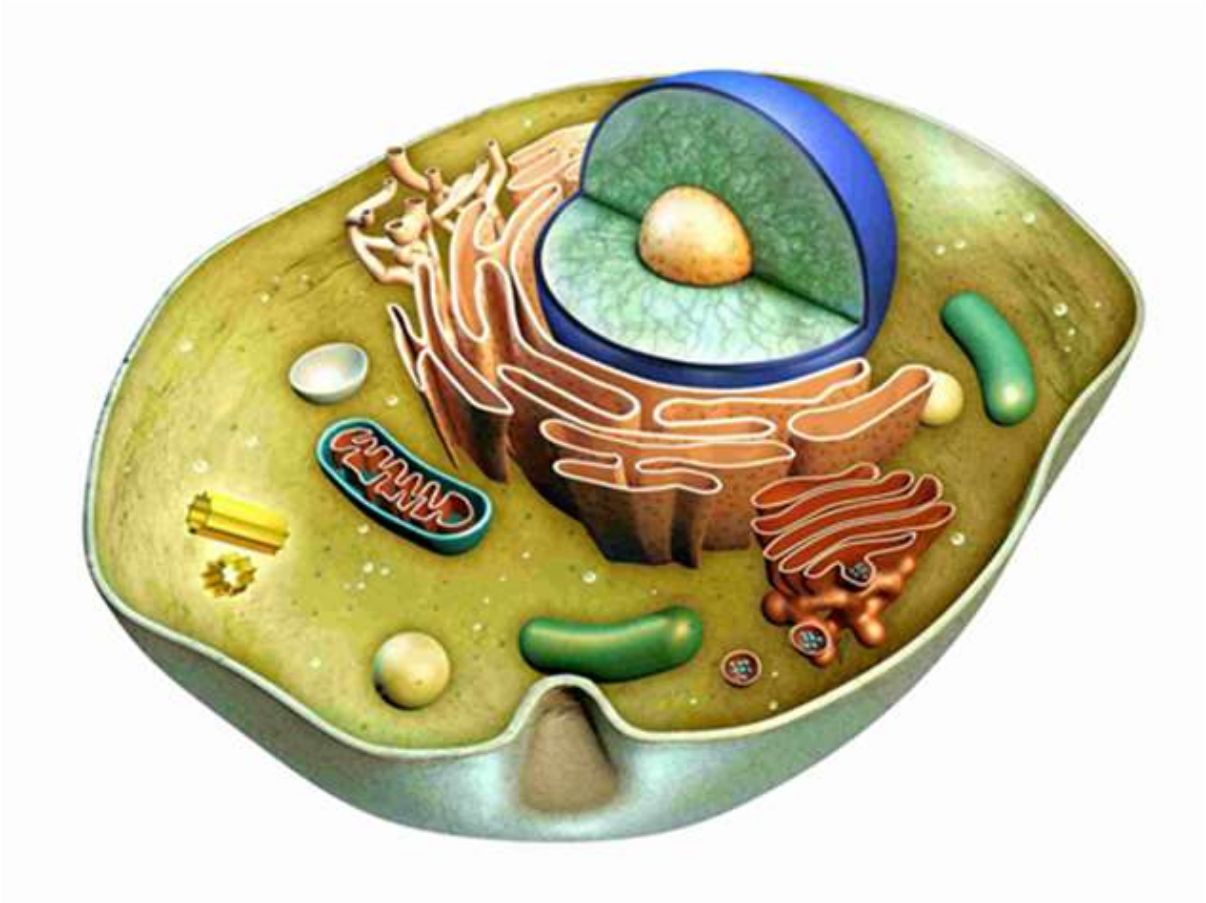


CYTOLOGY LAB

First Year, Department of Biology, College of Science, University of Baghdad

Safety Guidelines

All Materials © Cmassengale

1. Lab coat must be worn at all times in the laboratory.
2. Tie back long hair & secure lose clothing.
3. No horseplay is allowed in the lab.
4. No food or drink is allowed in the laboratory.
5. Practice good "housekeeping" techniques. Return items to proper places in good condition. Avoid cluttering your work area.
6. Never use chemicals from unlabelled containers. Check each label before dispensing a chemical, & do not return a chemical to a bottle without the teacher's permission.
7. Unless told otherwise, treat all chemicals as poisonous or corrosive. Wash hands immediately with plenty of water if chemical gets on them and always wash your hands before leaving lab.
8. No unauthorized lab work may be done, & a teacher must be present to do lab work.
9. Read & study each lab assignment before coming to lab. Pay attention to safety notes in the lab manual and from the instructor. Some common lab concerns:
   * Never pipette by mouth
   * Never use chipped or cracked glassware
   * Do not heat a closed system
   * Do not point heated containers at yourself or another person
   * Use a fume hood for noxious fumes
   * Place heated glass on wire gauze until cool
   * Do not use flammable material near open flame
   * Wear gloves when dispensing irritating chemicals
   * Dilute concentrated acids by adding acid to water
   * Turn off burners and water faucets when not in use & before leaving lab

* Only heat glassware marked Kimex or Pyrex
* Use glycerin and a twisting motion to insert glass tubing into stoppers
* Use tongs, test tube holders, or heat-resistant gloves to handle hot glassware
* Use pins to secure dissecting organisms to the dissecting tray before cutting with a scalpel
* Wash hands before and after dissecting and keep hands away from your face

10. Report all accidents immediately to the teacher.
11. Know the location and proper use of all safety equipment in the lab.
12. Know where all exits are from the lab.

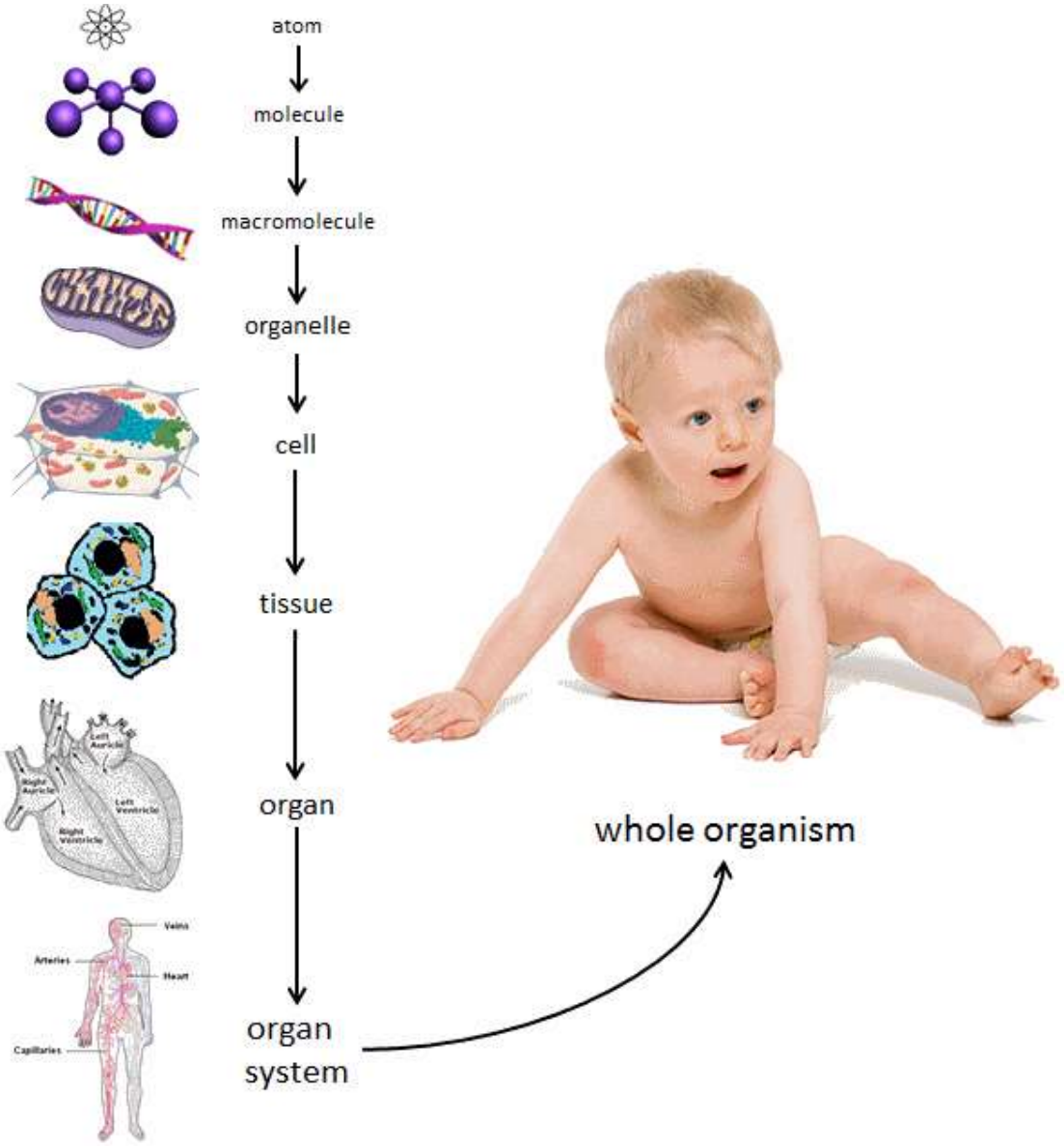
Preface

Why do we study cytology?

Cytology, more commonly known as **cell biology**, studies cell structure, cell composition, and the interaction of cells with other cells and the larger environment in which they exist. The term "**cytology**" can also refer to *cytopathology*, which analyzes cell structure to diagnose disease. Microscopic and molecular studies of cells can focus on either multi-celled or single-celled organisms.

That fact that we as humans are made up of millions of tiny cells, and that other life forms around us are similarly constituted, now barely needs explanation. The concept of the cell is relatively new, however. The scientific community did not accept the idea of the existence of cells until the late 18th century.

Recognizing the similarities and differences of cells is of the utmost importance in cytology. Microscopic examination can help identify different types of cells. Looking at the molecules which form a cell, sometimes called **molecular biology**, helps in further description and identification. All fields of biology depend on the understanding of cellular structure. The field of **genetics** exists because we understand cell structure and components.



From atom to the whole organism, different levels of organization

Lab1: Microscope

1. Microscope Definition

An optical instrument uses a lens or a combination of lenses to produce magnified images of small objects. Micro" refers to tiny, "scope" refers to view or look at.

2. Types of microscope

A. Compound light microscope. Fig. 1.1

B. Electron microscope. Fig.1.2.

C. Dissecting microscope. Fig.1.3.

The compound light microscope is the most common instrument used in education today.

3. Compound light Microscope parts and functions

- **Arm:** supports the tube and connects it to the base.
- **Base:** the bottom of the microscope, used for support.
- **Eyepiece**: where you look to see the image of your specimen.
- **Body tube**: connects the eyepiece to the objective lenses.
- **Revolving Nosepiece**: holds two or more objective lenses and can be rotated to easily change power.
- **Stage**: the flat platform where you place your slides.
- **Fine Adjustment knob**-small, round knob on the side of the microscope used to fine- tune the focus of your specimen.
- **Coarse Adjustment knob**- large, round knob on the side of the microscope used for focusing the specimen.
- **Stage Clips:** hold the slide in place.
- **Iris Diaphragm:** controls the light going through the aperture.
- **Mirror/light source:** to reflect light to the specimen/source of light.
- **Objective lenses** may have:

  A. Scanning objective (4x or 4.5x)

— **B. Low –power objective (10x)**

— **C. High- power objective (40x)**

D. Oil-immersion (100x):which must always be used with a drop of oil to form a liquid bridge between the lens and the surface of the slide being viewed.(This

improves the resolution of your high-power immersion objective by lowering the light refraction.

4. Proper way of focusing the Microscope

- **a.** Keep both eyes open to reduce eyestrain, keep eye slightly above the eyepiece to reduce eyelash interference.
- **b.** To find out the total magnification of the object, multiply the power of eyepiece lens (10x) by the power of the objective.

5. Handling the Microscope

Always use two hands to move the microscope. Place one hand around the arm, lift the scope, and then put your other hand under the base of scope for support.

6. Storing the Microscope

Dust is an enemy to microscope lenses; always keep the microscope covered when not in use.

1.1 Compound Light Microscope

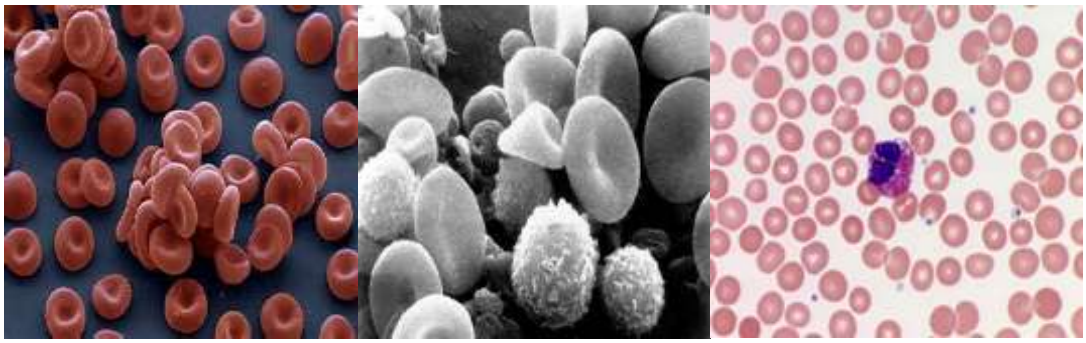
Video BIOLOGY 10 - Basic Microscope Setup and Use

https://www.youtube.com/watch?v=SUo2fHZaZCU

https://www.youtube.com/watch?v=-b3Eejf4rDQ

B. Electron microscope: this microscope provides better magnification than light microscope; magnify objects with a beam of electron. Fig.1.2. A transmission electron microscope can achieve magnifications of up to about 10,000,000x whereas most light microscopes are limited by diffraction to about 200 nm resolution and useful magnifications below 2000x.

(Electron Microscope)Figure 1.2

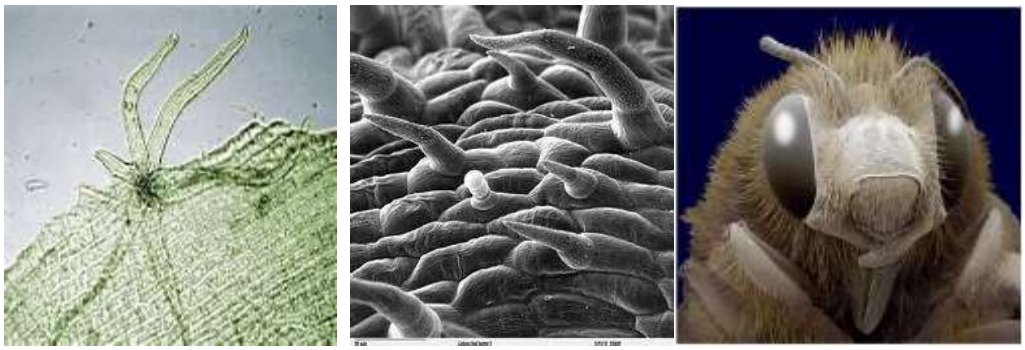


A B C

Figure 1.2.1: RBCs under electron microscope (A and B) while in C the RBCs magnified by the compound light microscope.

B. **Dissecting microscope:**This microscope has relative low magnification; it is used for viewing large objects in three–dimension. Fig. 1.3

Figure 1.3 (Dissecting Microscope)



A B C

Figure 1.3.1: A and B plant trichomes under dissecting and electron microscope, C head of insect under dissecting microscope.

Lab 2: Microscope Calibration

The aim of Calibration

It is often important to know the size of an organism or object you are viewing through the microscope because size may be a diagnostic characteristic.

MICROMETERS

1. **Ocular micrometre**: is a glass disk that fits in a microscope eyepiece that has a ruled scale of either 50 or 100 units, which is used to measure the size of magnified objects. Fig. 2.1.

2. **Stage micrometre**: is a microscopic slide divided into 100 units (divisions) each division of the stage micrometer = 0.01 mm. Fig. 2.2.

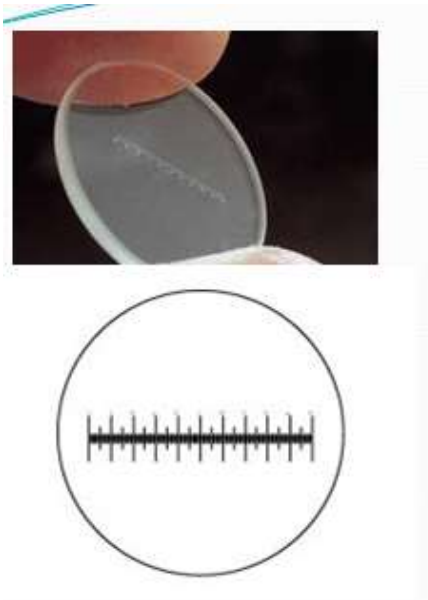


Fig. 2.1

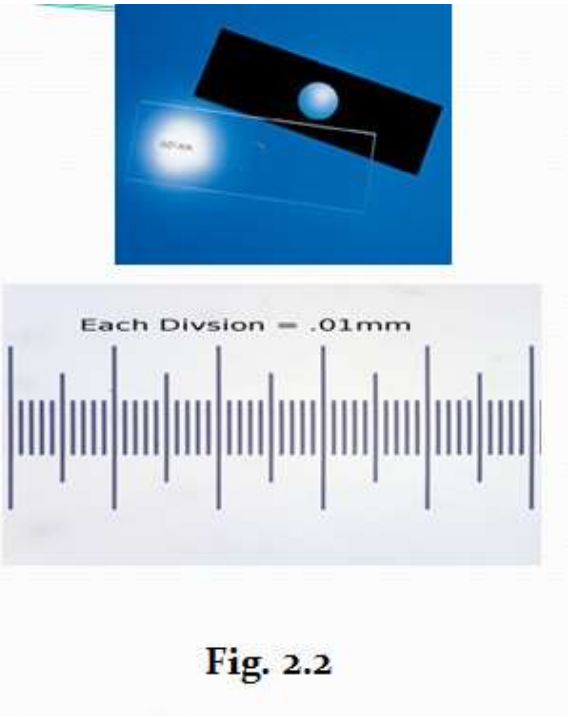
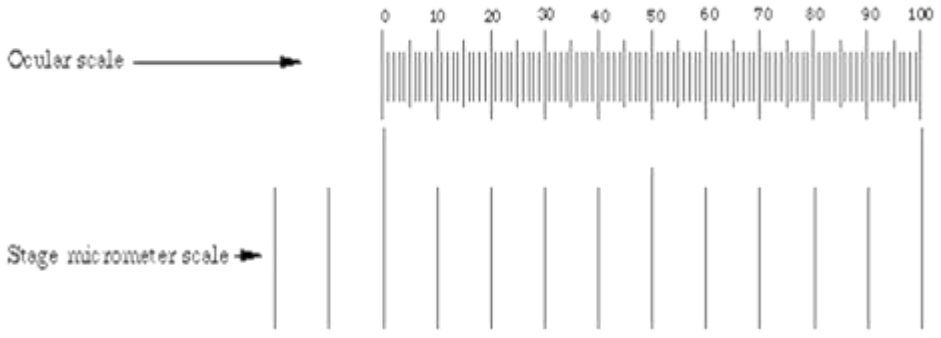


Fig. 2.2



Metric Measurements

1 cm= 10 mm

1 mm= 1000 µm (micrometer)

1 µm= 1000 nm (nanometer)

1 nm= 10 A° (Angstrom)

Procedure

1. **Fit the ocular micrometer into the microscopes ocular. Look through the ocular so you see the scale. Fig. 2.3**
2. **Place the stage micrometer on the microscope stage and focus on the engraved scale with low power objective.**
3. **Rotate the eye piece until the two scales are parallel.**
4. **Move the stage micrometer to bring the 0 line of stage scale in exact alignment with 0 line of the ocular scale. The scales should be slightly superimposed. Fig. 2.4.**
5. **To calibrate the ocular scale for this objectives use the longest portion of the ocular scale that coincides precisely with a line on the stage scale.**

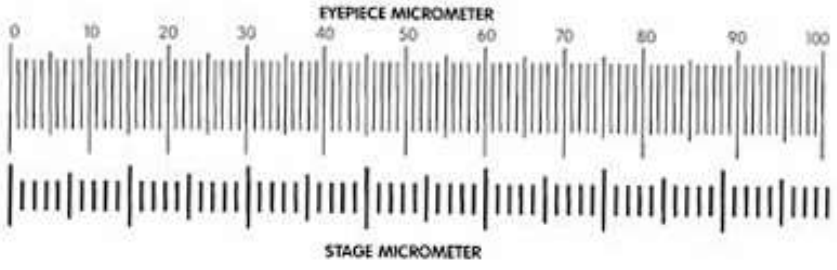


Fig. 2- 3,4

6. Repeat the calibration procedure for scanning lens and high power lens.

7. To measure any object, multiply the number of ocular divisions covered by the specimen with the 1 ocular unit.

***True length= ocular micrometer divisions x 1 ocular unit**

***The power of enlargement picture= length of cell in picture (cm)/ true length of cell (µm) x 10000**

Example 1: Suppose that 10 units on the ocular scale equal 9.9 stage units, what is the 1 ocular unit? Then 10 (OU.)= 9.9 (SU.)

10 SU. = 1 mm= 1000 µm

1 SU. = 100 µm

10 OU.= 990 µm

1 OU= 99 µm

OR

1 Ocular unit= (Stage Units x 0.01 / Ocular units) X 1000

Example 2: If 20 units of stage scales coincides with 60 units of the ocular scale, what is the 1 ocular unit?

Solution: 20x 0.01/60 x 1000= 3.3 µm

Example3: When we examine the Spirogyra cell under microscope the stage micrometer units is 27 and the ocular units is 26. Now:

1-what is the 1 ocular unit?

2- What is the true length if the cell take 14 ocular units

3- what is the enlargement power if the length of cell in picture 4.4 cm?

1 ocular unit = (27x 0.01 / 26)x1000= 10.3 µm

The true length= 14x 10.3= 145.32 µm

Enlargement power= (4.4/ 145.32)x10000= 302.78

Why calibration is necessary?

Small specimens are difficult to measure directly using a ruler.

Lab3: Living component of the cell (Cell organelles)

1-**The cell membrane** is about 10 nm thick and cannot be resolved by the light microscope. The limits of the cell can be visualized with the light microscope when there is a heavy concentration of **glycoproteins** or proteoglycans at the cell surface.

2-**The nucleus** is limited by a **nuclear envelope** that consists of a two membrane bilayers and **nuclear pores** that allow passage of material into and out of the cell. **Chromatin**, complexes of DNA and protein, is the major component of the nucleus and consists of two histological structures. **Heterochromatin** is condensed chromatin scattered throughout the nucleus or accumulated along the inner surface of the nuclear envelope. Heterochromatin is considered transcriptionally inactive. In contrast, euchromatin in abundant in cells engaged in transcription. Euchromatin is dispersed and not easily stained.

3-The nucleus often contains one or more **nucleoli** that are spherical or oval bodies composed chiefly of **ribonucleoproteins** (**RNA**). Nucleoli are usually stained with basic dyes because of their high RNA content and are prominent in cells that are actively participating in protein synthesis.

4-**The endoplasmic reticulum (ER**) is a system of interconnected membranous sacs, channels, or cisternae in the cytoplasm. It has two subtypes**: rough endoplasmic reticulum** (RER) and **smooth endoplasmic reticulum** (SER). The RER is a ribbon-like structure surrounding the nucleus near the base of the cell. Its surface appears rough due to the ribosomes attached to its membrane and it is the first organelle into which membrane-bound or extracellular proteins are inserted. SER lacks ribosomes and participates in lipid synthesis and detoxification.

5-**The Golgi apparatus** is a system of **membranous cisternae** and **vesicles** arranged in stacks near the nucleus. The Golgi processes and modifies sugar side chains on proteins that are being secreted or destined for the plasma membrane or other membrane-bound organelles like the lysosome. Therefore, the Golgi apparatus is particularly prominent in cells synthesizing large amounts of glycoproteins and proteoglycans, such as goblet cells that produce mucous in the gut epithelium. The

Golgi can be stained with **osmium tetra oxide (OsO4)** or **silver nitrate stains** and appears as a network of black-staining tubules or clusters of granules. Golgi complex consists of three main components: a- flat lamella (cisternae), b- vacuoles and c- microvesicles (Figure 3.1).

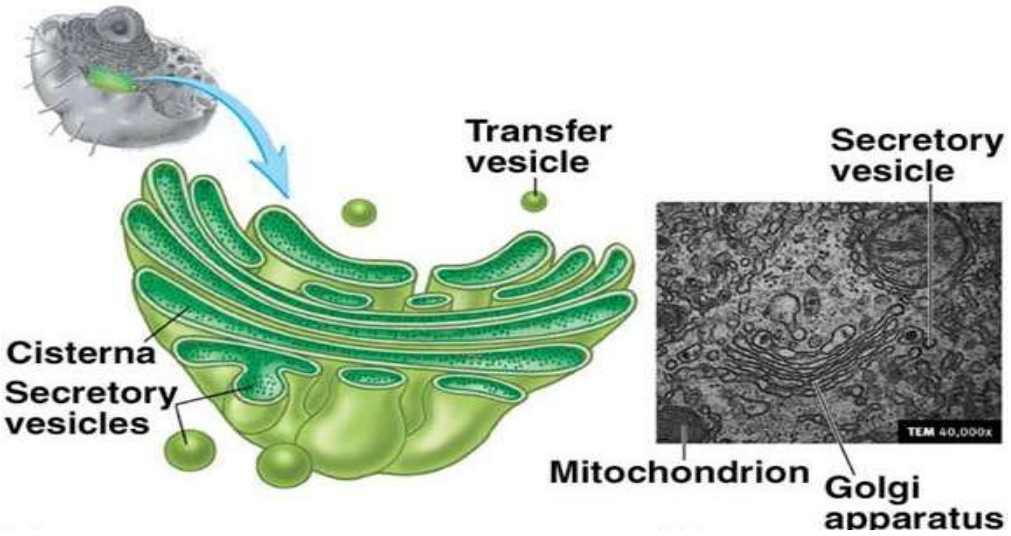


Figure 3.1: Golgi apparatus.

6-**Secretory vesicles** or granules usually contain specific substances synthesized by cells that are exported to the extracellular medium. They include **zymogen granules**, **mucous droplets**, and **mast cell granules**.

7-**Mitochondria** are organell**es** that vary greatly in number, size, and shape between different cells in which the biochemical processes of respiration and energy production occur (that is why they called the power houses). They are **unusual** in that they contain their own mitochondrial DNA (mtDNA) and ribosomes; mitochondrial proteins come from genes in both the nuclear and mitochondrial DNA. These organelles also undergo self-replication. Structurally, two features characterize mitochondria: double bilayer membranes, and cristae, folds that project from the inner membrane into matrix (Figure 3.2).

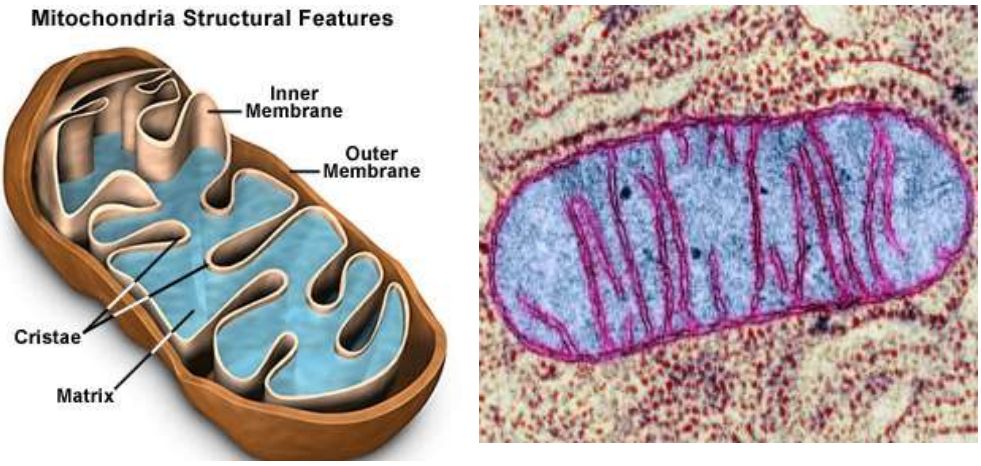


Figure 3.2: Mitochondria structure

Examine mitochondria in onion cells:

Procedure

1- On a clean glass, add 2-3 drops of Janus green stain (**vital stain**). Vital stain is a stain that can be applied on living cells without killing them.

2- Prepare a thin piece of onion epidermis and mount it in the staining solution:

-The preparation should be one-cell thick for the mitochondria to be stained well.

- The onion cells must be healthy and metabolically active.

3- Add the cover slip.

4- Search the periphery of the cells to locate stained mitochondria, they are small blue spheres about 1mm in diameter. The colour will fade in 5-10 min because the reducing of the vital stain by the mitochondria electrons.

5- Repeat the procedure using IKI stain (iodine) and compare the results with Janus green stain.

6- Also examine slides for mitochondria in onion root tips and liver cells, the mitochondria will appear as black points around the nucleus.

8-**Lysosomes** also vary in size and shape, but can be recognized as membrane-bound organelles containing granular material. There are more than 40 lysosomal enzymes that are active at acidic pH.

Lab 4. Plastids are living organelles in plant cells

Plastids are large cytoplasmic organelles. Plastids are major organelles found in the cells of plants and algae. Plastids are the site of manufacture and storage of important chemical compounds used by the cell. Plastids often contain **pigments used in photosynthesis**, and the types of pigments present can change or determine the cell's colour. In plants, plastids may differentiate into several forms, depending upon which function they need to play in the cell (Figure 3.3). The plastids are broadly classified into two main types namely **chromoplasts** and **leucoplasts**.

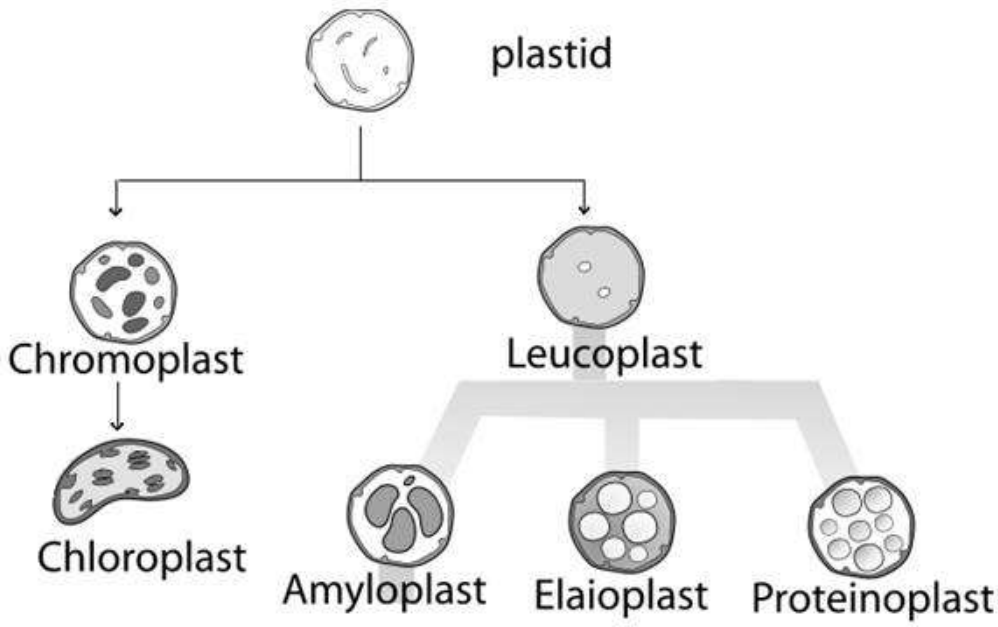


Figure 3-3: The plastids developments

Chromoplast:

These are colored plastids (chromo=color; plast=living). They contain various pigments. They synthesize food materials by photosynthesis. They contain yellow, orange and or red pigments. Chromoplasts are found commonly in flowers and fruits. Chromoplasts also divided into three types based on their colour namely chloroplast, phaeoplast and rhodoplast:

a-Chloroplast: It is in green colour. It contains chlorophyll pigments. It is found in higher plants and green algae.

b- **Phaeoplast**: It is dark brown in colour. It contains fucoxanthin pigments. It is found in brown algae, diatoms and dinoflagelates.

c-Rhodoplast: It is red in colour. It contains phycoerythrin. It is found in red algae.

Leucoplasts:

They **are** non-pigmented plastids (Leuco=white; plast=living). Their main function is to store food materials. They do not involve in synthetic activities. The leucoplasts are subdivided into three types namely **amlyoplast**, **elaioplast** and **proteinoplast**.

1-Amlyloplast: It stores starch and found in tubers, cotyledons and endosperm

2-**Elaioplast**: it stores oil and found in the epidermal cells.

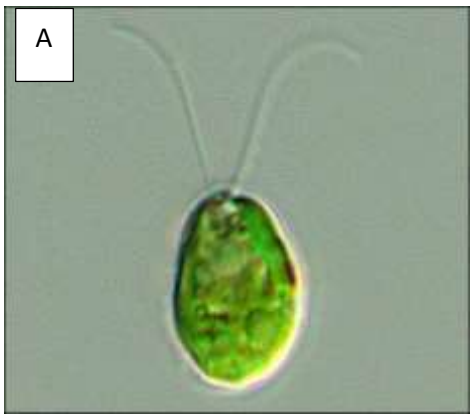
3-**Proteinoplast**: It stores protein and found in seeds and nuts.

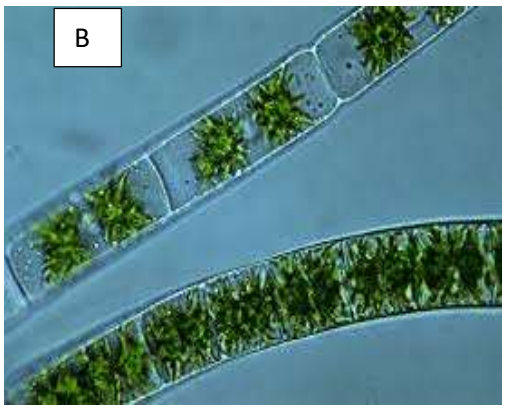
CHLOROPLASTS

Chloroplasts are organelles found in plant cells and other eukaryotic organisms that conduct photosynthesis. The word chloroplast is derived from the Greek words *chloros*, which means green, and *plast*, which means form or entity.

Shape:

Chloroplast varies in shape. They are spheroid or ovoid or discoid in higher plants. They are **cup-shaped** in *chlamydomonas*, **star-shaped** in *Zygnema*, **reticular-shaped** in *Cladophora* and **spirally coiled-shaped** in *spirogyra* (Figure 3.4).





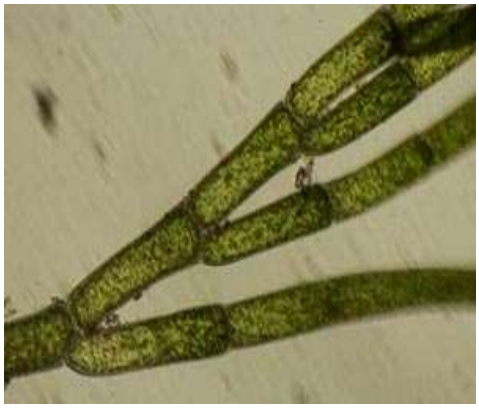


Figure 4.4 Chloroplasts shapes: A) cup-shaped in *Chlamydomonus* ; B) Star-shaped in *Zygnema* ; C) Reticular-shape in *Cladophora* and D) **spirally coiled-shaped** in *spirogyra*

Size

The size of the plastids varies from species to species. But the size remains constant for a given cell type. In higher plants, it is 4-5microns in length and 1-3microns in thickness. Generally chroloplasts of plants growing in shady places are larger in size.

Number:

The number of chloroplasts varies from plant to plant, but it remains constant for a given plant. In higher plants there are 20 to 40 chloroplasts per cell or upto 1000 chloroplasts.

Structure

Chloroplast is bounded by a double membrane called the **chloroplast envelope**. In addition to the **inner** and **outer** membranes of the envelope, chloroplasts have **a third** internal membrane system, called the **thylakoid membrane**. The thylakoid membrane forms a network of flattened discs called thylakoids, which are

frequently arranged in stacks called **grana**. Grana are interconnected by branching membraneous tubules called frets (stromal lamellae). . Photosynthesis takes place on the thylakoid membrane. The stroma lies inside the envelope but outside the thylakoid membrane (Figure 4.5).

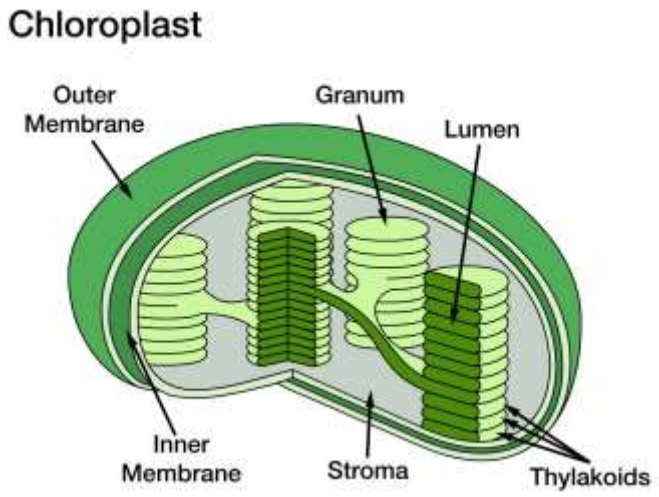


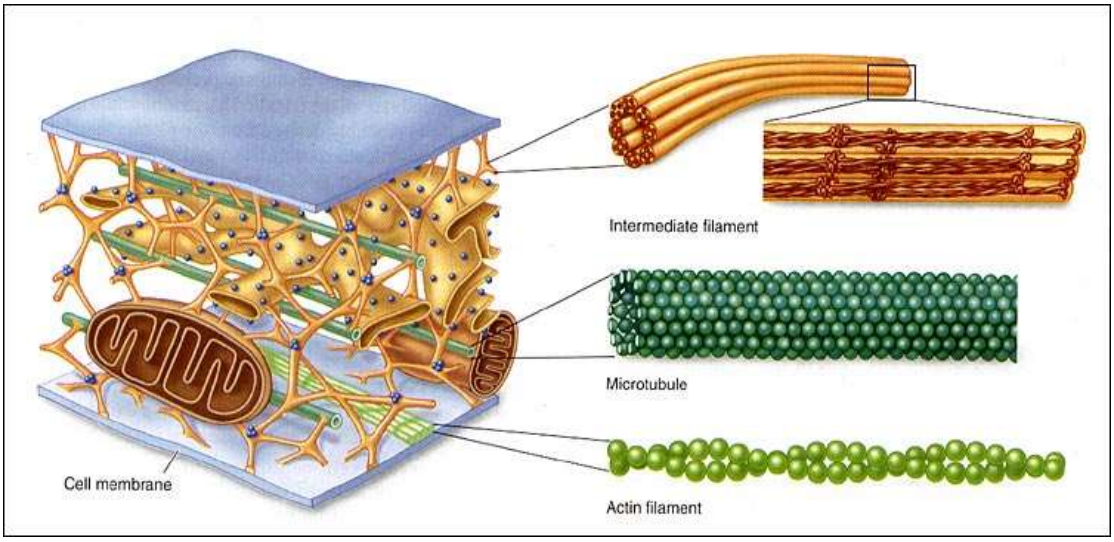
Figure 4.5: The structure of chloroplast

Lab5 Non-living cellular components (cytoplasmic inclusions)

The non-living cell inclusions include **ergastic substances** and **cytoskeleton elements:**

1. **Ergastic substances**: These are non-living cell inclusions of cytoplasm like reserve food materials (**starch**, protein, and oils), secretory products (nectar, **pigments**, and enzymes), excretory products (alkaloids, resins, latex, and tannins) and **mineral crystals** (prismatic, cystoliths, raphides, druses).

2. **Cytoskeleton**: It is a complex network of interconnected **microfilaments** and **microtubules** of protein fibres present in cytoplasm. The microfilaments are composed of **actin** and microtubules are composed of **tubulins**. It helps **in mechanical support**, **cell motility**, **cell division** and **maintenance of the shape of the cell**.



Starch grain

Starch grains are small granules found in the leaves, roots, stems, fruits and seeds of plants. These grains serve as energy reserves for plants. People may consume starch grains for energy, as starch grains are carbohydrates. Common foods containing starch grains or starch grain compounds include wheat, barley, rice, oats, millet, corn, lentils, green peas, corn, **potatoes** and chick peas.

1-Cut through a potato and **wipe** the exposed surface across the centre of a slide.

2-Quickly add a small droplet of water to the smeared potato, and place a coverslip over it.

3- Examine your preparation under a 10X and a 40X objective and observe the starch grains. Draw the outline of a few starch grains as seen under HP (at least 5cm in diameter). Experiment with different diaphragm apertures, as well as with different levels of focus and change the condenser lens setting (if your microscope can do this). Try to make the **concentric lamellae**, as well as the small, central dot, or **hilum** visible. Add these features to your drawing and complete it by labelling fully, and include a **scale of magnification.** These starch grains have been contrasted using a very dilute concentration of **Toluidine blue stain (Figure 4.1)**.

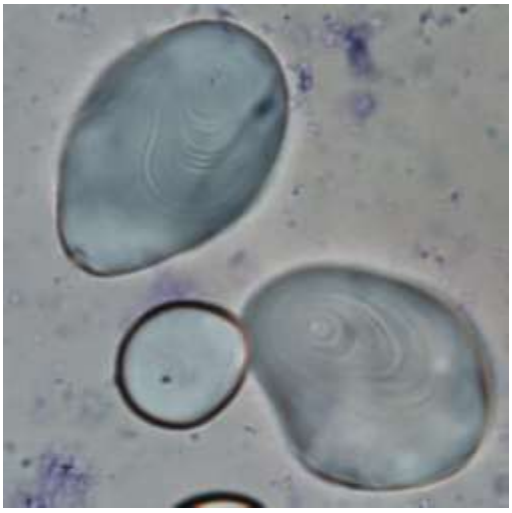
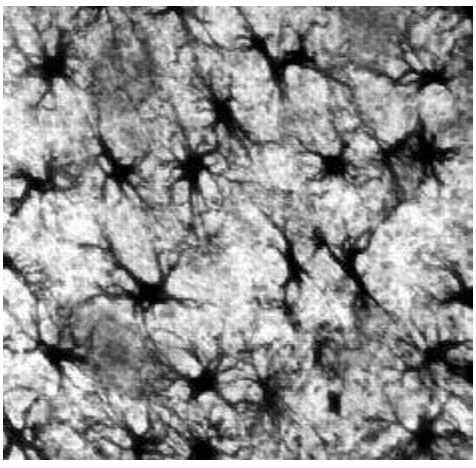


Figure 4.1: Starch grain in potato tissue.

Pigments granules

Membrane bound granules that contain pigments such as melanin which is dark brown to black pigments called melanosomes which are synthesized by melanocytes. It is located in basal layer of skin and it contributes to the color of skin. Melanin pigment granules are also found in retina, iris, and certain cells of brain. Melanin **functions** for protection from the Ultraviolet rays.

Depending on the colour inside them, pigment granules can be termed as erytherophores (red), xanthophores (yellow), mealanophores (black) and leucophores (white). Examine mealanophroes in frog skin.



Crystals

Calcium oxalate is a common biomineral in plants, occurring as crystals of various shapes. It can be found in any tissue or organ in plants and is often formed in the vacuoles of specialized cells called crystal idioblasts. Recent work indicates that calcium oxalate formation is generally a mechanism for **regulating bulk-free calcium levels in tissues and organs**. However, various other functions might have evolved secondarily. A function in physical protection **against grazing animals** is implicated by the size, shape and placement of crystals in some tissues and organs.

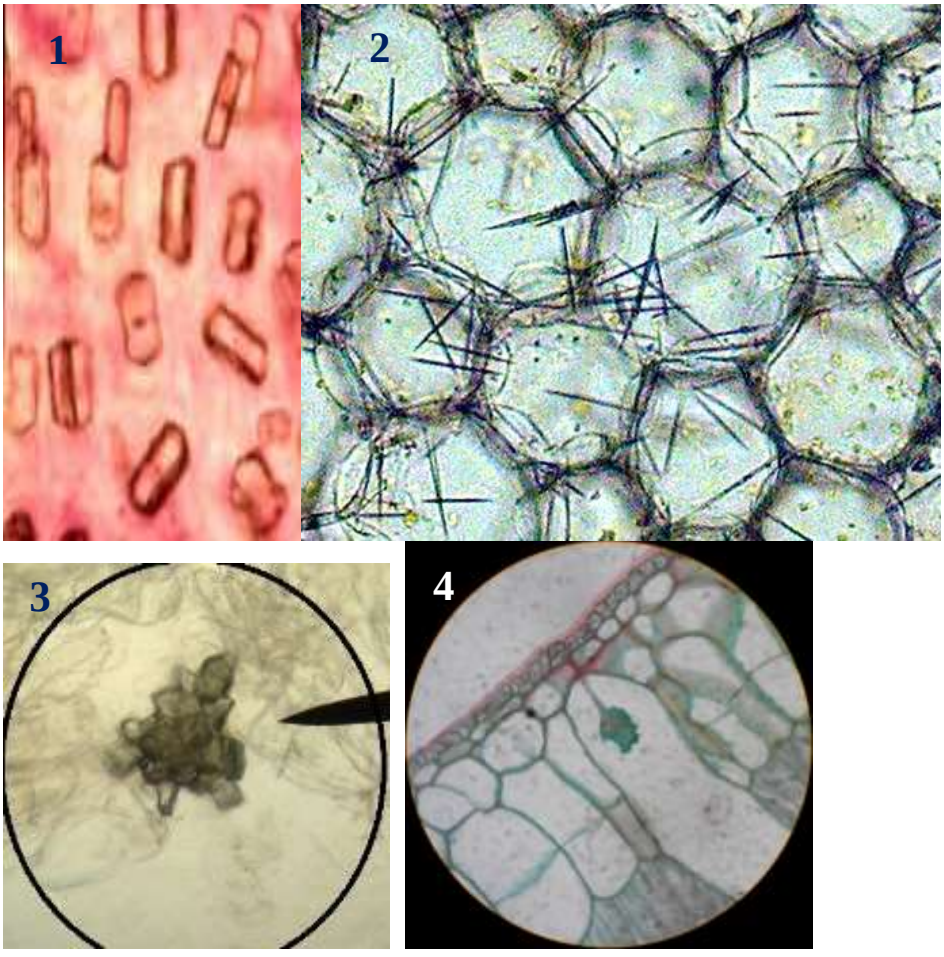
Different types of crystals can be found in plant cells, for exmaples:

1- Prismatic crystal (rod-like or cubic crystals) in onion scales

2- Raphides crystals (needle-like) in *Mirabilis* stem C.S.

3- Druses crystals (like a glistening diamond) in *Tilia* stem C.S.

4- Cystolith crystals (consist of stalk and body) in *Ficus* leaf C.S.



A vacuole is a membrane-enclosed fluid filled sac found in the cells of plants including fungi. Vacuoles can be large organelles occupying between 30% and 90% of a cell by volume.

Vacuoles appear to have three main functions, they:

1. Contribute to the rigidity of the plant using water to develop hydrostatic pressure.
2. Store nutrient and non-nutrient chemicals.
3. Break-down complex molecules including material may be harmful for the cell.
4. Play a major role in autophagy, endocytosis and exocytosis.

Examine vacuoles in:

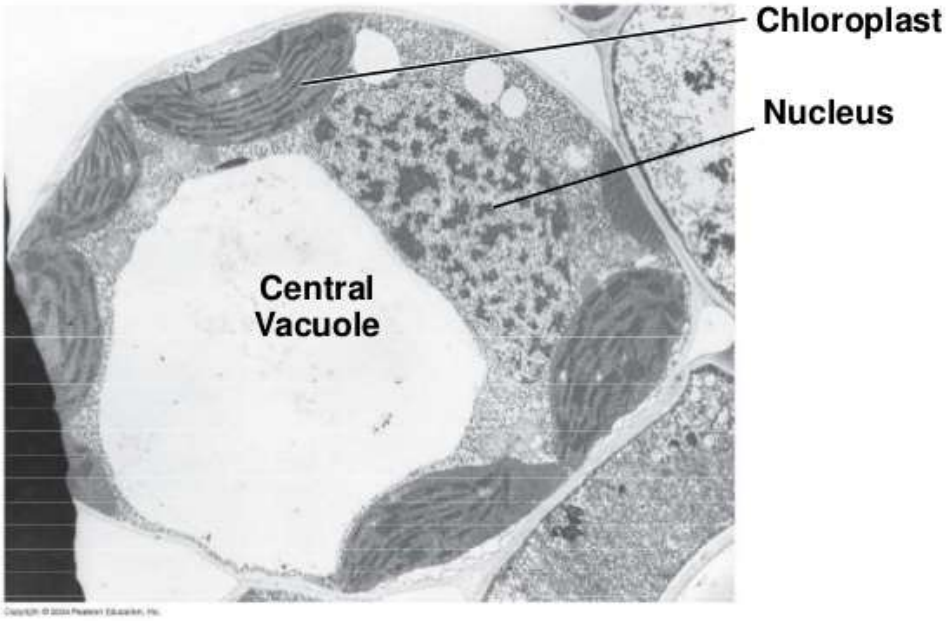
A-Onion leaf:

1. Cut a red onion and remove a fleshy leaf.
2. Snap the leaf backward and remove the thin piece of the inner epidermis that will be formed at the break point. This tissue will be as thin and flexible as plastic wrap.
3. When you obtain your piece of onion, prepare a wet-mound slide by adding a drop of water on the middle of a clean slide. The add cover slide and examine the tissue. The preparation should be one cell thick.
4. Stain the onion tissue by placing one drop of **neutral red** at the edge of the cover slip for 5-15 min.
5. Carefully focus to distinguish the vacuoles surrounded by the stained cytoplasm.

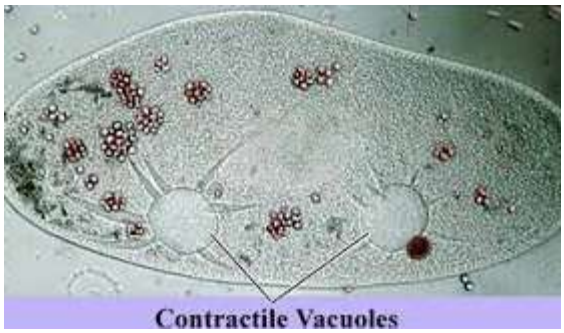
B- Rose leaf:

1. Snap a thin tissue from **the toothed margin** of a red leaf of **rose plant** using sharp lancet**.**
2. Mount it on a slide and add cover slip.

3. Carefully focus to distinguish the colourless vacuoles near the margion. If you search far from the toothed margin, you can see red colour vacuoles because they contain anthocyanin in their cell sap.



Central vacuole in a plant cell



Lab 6: Cells shapes

Cells are the building blocks of life – all living organisms ar made up of them. Textbooks often show a single **'typical'** example o a plant cell or an animal cell, but in reality, the shapes of cells can var widely. Animal cells in particular come in all kinds of shapes an sizes. Plant cell shapes tend to be quite similar to each other **becaus of their rigid cell wall**.

We can learn a lot about what a cell does by looking at its shape an size, and **microscopes** are the ideal tool for this.

Shaped for the task (function)

Cells have different shapes because they do different things Each cell type has its own role to play in helping our bodies to wor properly, and their shapes help them carry out these roles effectively The following cell types all have unusual shapes that are important fo their function (**Figure 6.1, 6.2 and 6.3)**

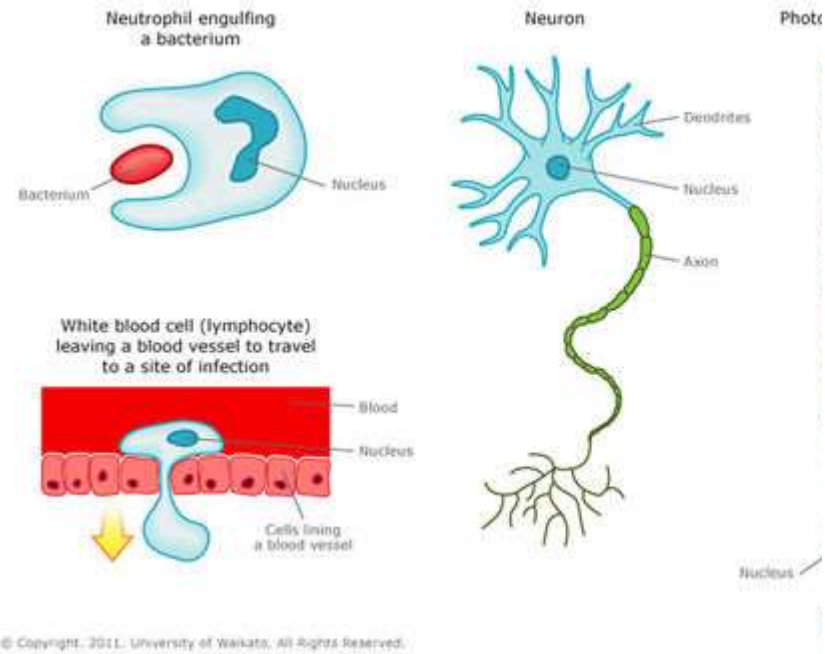


Figure 5.1: Cells with distinctive shapes

1-Satellite shape: Neurons are cells in the brain and nervous system. Their job is to carry electrical messages all the way from the brain to the rest of the body and back (almost like electrical wires), so they are very long, thin cells. They also need to connect with other neurons to form communication networks, so they have many long branches (Figure 5.1). This satellite cell shape also can be found in *Canna indica* plant leaves (Figure 5.3-D).

2- **Spheroid shape**: such as lymphocytes (Figure 5.3) and tomato cells

3- **Columnar shape**: in columnar epithelial tissue (Figure 5.3) and palisade layer in *Ficuselastica*(Figure .4-C)

4- **Cubic shape**: in cuboidal epithelial tissue (Figure 6.3) and meristematic region in *Allium cepa* root tip (Figure 6.4-A)

5- **Filiform shape**: in striated muscles and also in Olea leaf fibers(Figure 6.4-B) .

6- **Spindle shape**: in smooth muscle (Figure 6.3) and*Vitis*fiber).

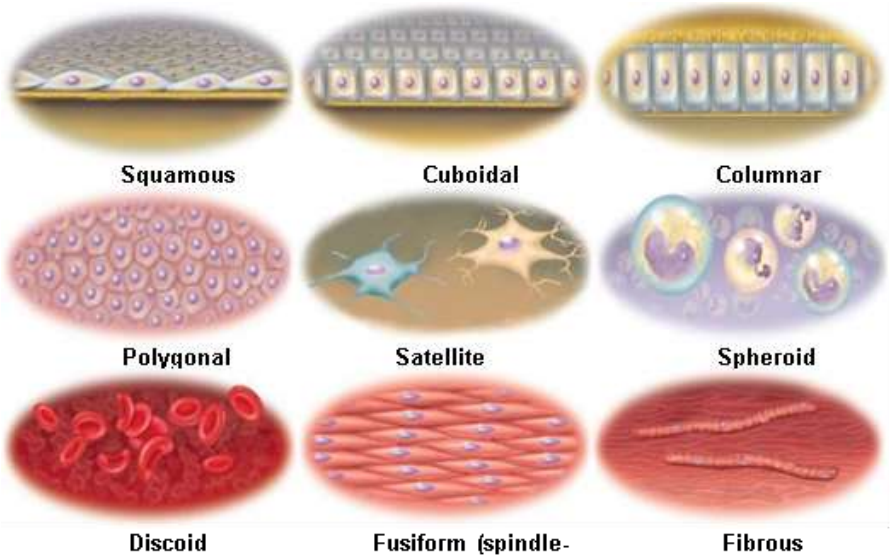


Figure 6.2: Different shapes of animal cells that suite the function of different tissues.

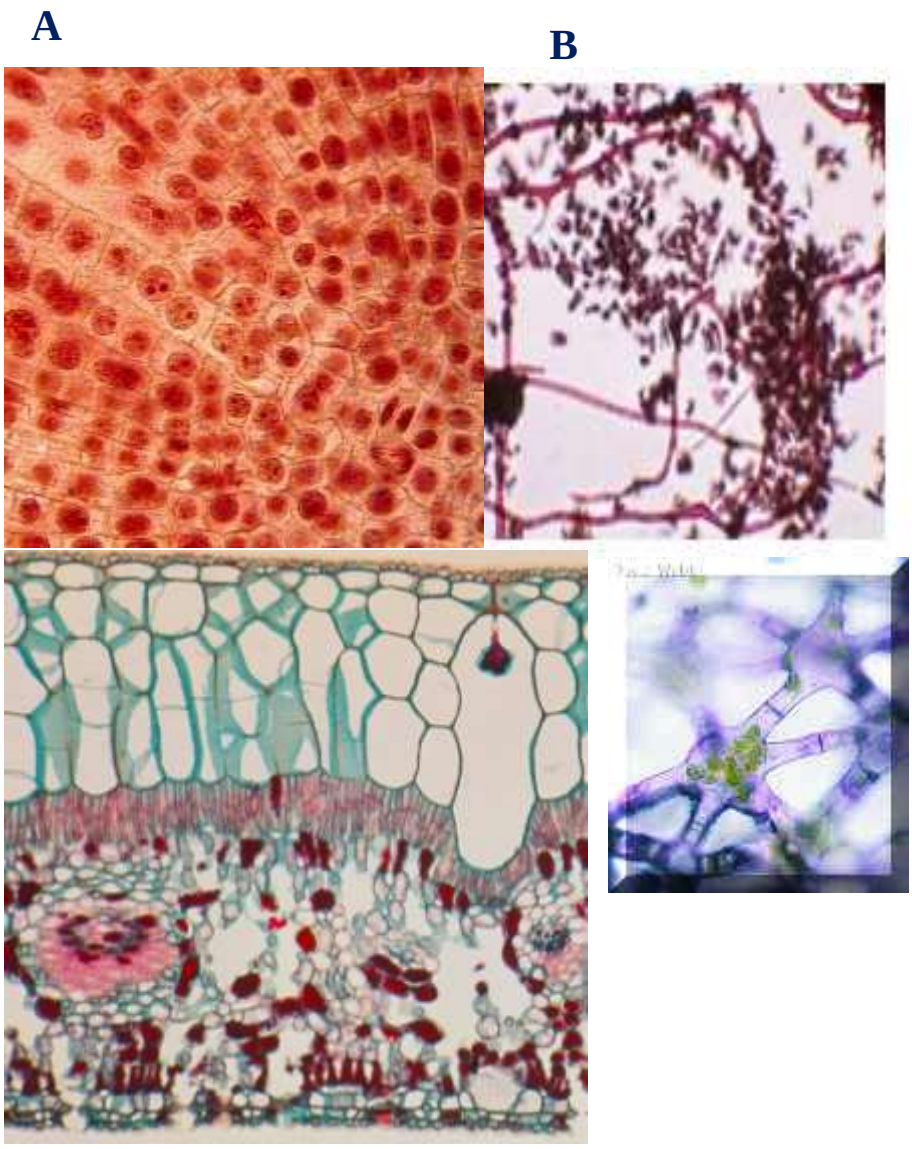


Figure 5.3: Different plant cells shapes: A) Cubic in meristematic tissues in *Allium cepa*; B) Filiform shape in Olea leaf; C) Columnar shape in palisade layer in *Ficuselastica* and D) Satellite shape in *Canna indica* plant leaves

Lab7: Cell Division

Cell Division:

- All cells are derived from pre-existing cells (**Cell Theory**)
- Cell division is the process by which cells produce new cells
- Cell division **differs** in **prokaryotes** (bacteria) from **eukaryotes** (protests, fungi, plants, & animals)
- Some tissues must be repaired often such as the lining of gut, white blood cells, and skin cells with a short lifespan.
- Other cells **do not divide** at all after birth such as muscle & nerve

Reasons for Cell Division:

- Cell growth
- Repair & replacement of damaged tissue parts
- Reproduction of the species

Cell Cycle:

- Cells go through phases or a cell cycle during their life before they divide to form new cells
- The cell cycle (Figure 6.6)includes 2 main parts --- **interphase**, and **cell division**

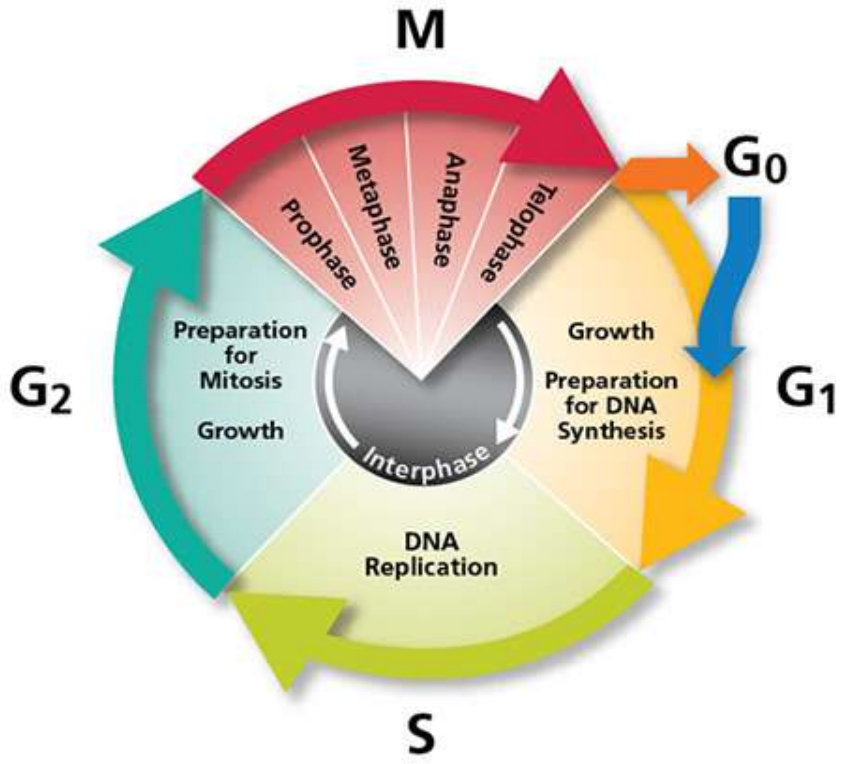


Figure 6.6: The cell cycle

- Cell division includes **mitosis** (nuclear division) and **cytokinesis** (division of the cytoplasm)
- **Interphase** is the **longest part** of a cell's life cycle and is called the "resting stage" because the cell isn't dividing
- Cells grow, develop, & carry on all their normal metabolic functions during interphase
- Interphase consists of 3 parts --- **G_1**, **S**, &**G_2**phases

Interphase:

- G_1 or **1st growth phase** occurs after a cell has undergone cell division
- Cells mature & increase in size by making more cytoplasm & organelles while carrying normal metabolic activities in G_1
- S or **synthesis phase** follows G_1 and the genetic material of the cell (DNA) is copied or replicated
- G_2 or **2nd growth phase** occurs after S phase and the cell makes all the structures needed to divide

Stages of Mitosis:

- Division of the nucleus or mitosis **occurs first**
- Mitosis is an **a**sexual method of reproduction
- Mitosis consists of **4** stages ---**1)** Prophase, **2)** Metaphase, **3)** anaphase, &**4)**Telophase (Figure 6.7)

- **Prophase:**
  - Chromosomes **become visible** when they **condense** into sister chromatids
  - **Sister chromatids** attach to each other by the **centromere**
  - **Centrioles** in animal cells move to opposite ends of cell
  - Spindle forms from centriole (animals) or microtubules (plants)
  - **Kinetochore fibers** of spindle attach to centromere
  - **Polar fibers** of spindle extend across cell from pole to pole
  - Nuclear membrane dissolves
  - Nucleolus disintegrates
- **Metaphase:**
  - Chromosomes **line up in center** or equator of the cell attached to kinetochore fibers of the spindle
- **Anaphase:**
  - Kinetochore fibers attached to the centromere **pull the sister chromatids apart**
  - Chromosomes move toward opposite ends of cell
- **Telophase:**
  - Nuclear membrane forms at each end of the cell around the chromosomes
  - Nucleolus reform
  - Chromosomes become less tightly coiled & appear as chromatin again

- Cytokinesis begins

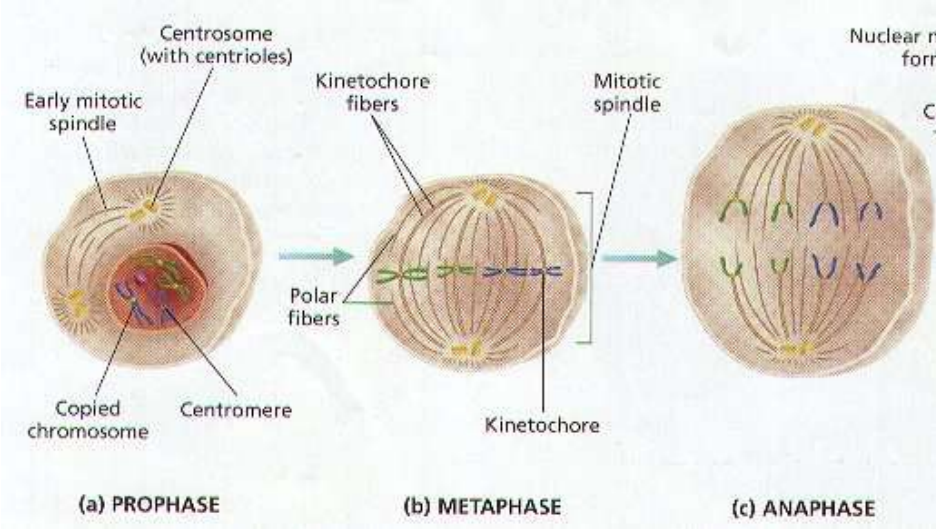


Figure 6.7: Mitosis division phases

Lab work:

Examine *Allium cepa*root tips (L.C.) to identify the different mitosis phases, draw them and label the main features of each phase.

Cytokinesis:

- Cytoplasm of the cell and its organelles separate into 2 new daughter cells
- In animals, a groove called the cleavage furrow forms pinching the parent cell in two (Figure .6.7).

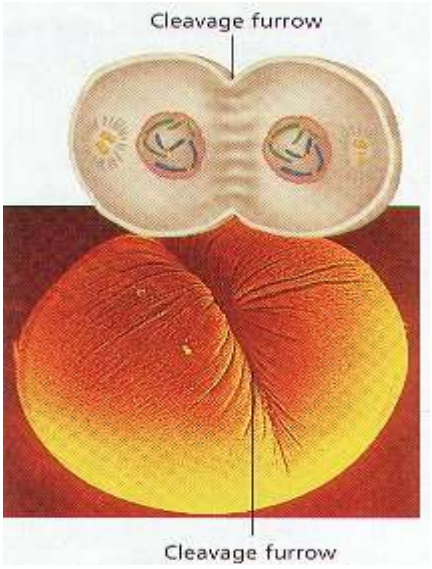


Figure 6.7: Cytokinesis (cytoplasmic division) showing the formation of cleavage furrow.

- In plants, a cell plate forms down the middle of the cell where the new cell wall will be (Figure 6.8).

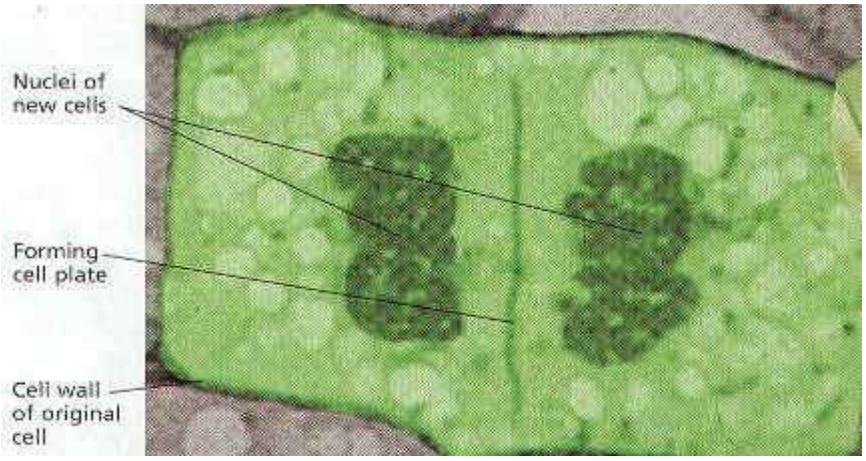
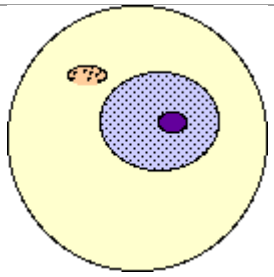


Figure 6.8: Cytokinesis of plant cell showing the formation of cell plate.

Cancer is uncontrolled mitosis:

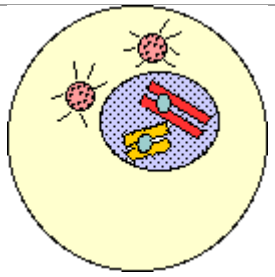
- Mitosis must be controlled, otherwise growth will occur without limit (cancer)
- Control is by special proteins produced by oncogenes (proto-oncogenes) and tumour suppressor genes.Mutations in control proteins can cause cancer

Summary of Mitosis:



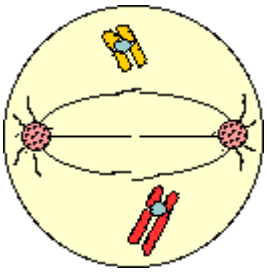
Interphase

1. Cell matures & carries on normal activities
2. DNA copied & appears as chromatin
3. Nucleolus visible



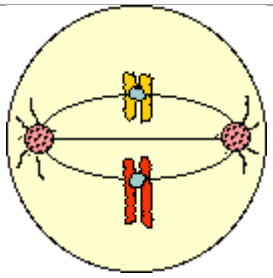
Early Prophase

1. Chromosomes condense & become visible
2. Centrioles separate & spindle starts forming



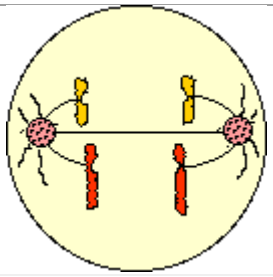
Late Prophase

1. Spindle forms with aster at each pole
2. Nuclear membrane & nucleolus disintegrate
3. Centromere of chromosomes attaches to spindle fibers



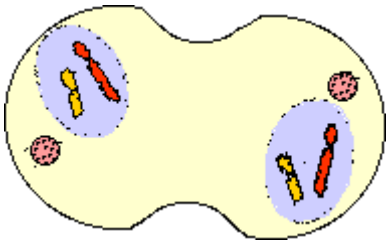
Metaphase

1. Chromosomes line up at the equator of the cell attached to kinetochore fibers of spindle



Anaphase

1. Centromeres split apart
2. Homologs move to opposite poles of the cell



Telophase/Cytokinesis

1. Nuclear membrane & nucleolus reform
2. Cell pinches into 2 cells in animals
3. In plants, a cell plate separates the 2 new cells

Lab 8: DNA Replication :

- Since the **instructions for making cell parts** are encoded in the DNA, each new cell must get a **complete set of the DNA molecules**
- This requires that the DNA be copied (replicated, duplicated) before cell division (Figure 6.1 DNA replication).

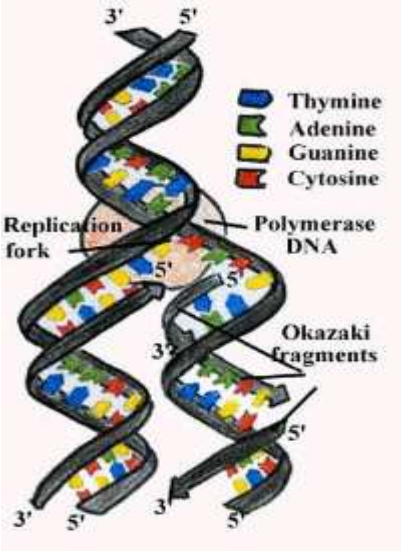


Figure 8.1: DNA replication through the activity of DNA polymerase

Chromosomes & Their Structure:

- The plans for making cells are coded in DNA
- DNA, deoxyribose nucleic acid, is a long thin molecule that stores genetic information
- DNA in a human cell is estimated to consist of six billion pairs of nucleotides
- DNA is organized into giant molecules called chromosomes
- Chromosomes are made of protein & a long, single, tightly-coiled DNA molecule visible only when the cell divides

- When a cell is not dividing the DNA is less visible & is called chromatin
- DNA in eukaryotic cells wraps tightly around proteins called histones to help pack the DNA during cell division
- Non-histone proteins help control the activity (expression) of specific DNA genes

- Kinetochore proteins bind to centromere and attach chromosome to the spindle in mitosis
- Centromeres hold duplicated chromosomes together before they are separated in mitosis
- Telomeres are the ends of chromosomes which are important in cell aging
- When DNA makes copies of itself before cell division, each half of the chromosome is called a sister chromatid (Figure 8.2)

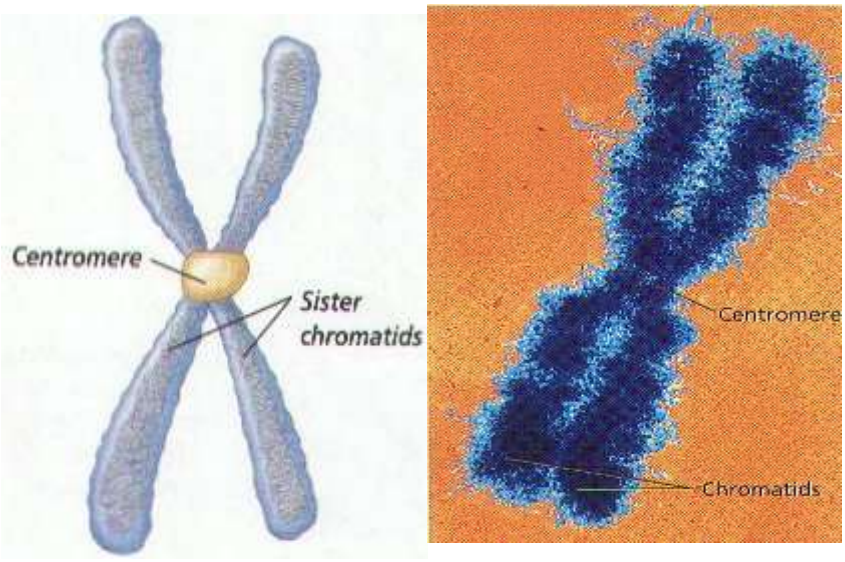


Figure 8.2: A chromosome structure showing sister chromatids and the centromere

- DNA of prokaryotes (bacteria) is one, circular chromosome attached to the inside of the cell membrane (Figure 6.3)

Figure 8.3: Bacterial chromosome

Chromosome Numbers:

- Humans somatic or body cells have 23 pairs of chromosomes or 46 chromosomes (diploid or 2n number)
- The 2 chromatids of a chromosome pair are called homologues (have genes for the same trait at the same location) (Figure 8.4)

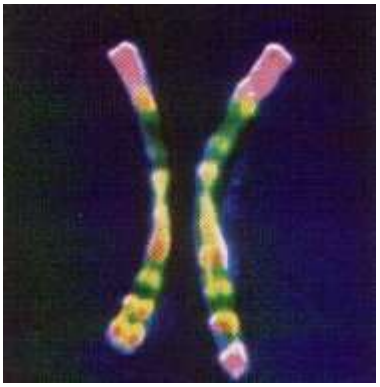


Figure 6.4: homologues chromatids

- Human reproductive cells or gametes (sperms & eggs) have one set or 23 chromosomes (haploid or n number)
- Every organism has a specific chromosome number

- Fertilization, joining of the egg & sperm, restores the diploid chromosome number in the zygote (fertilized egg cell)
- Sex chromosomes, either X or Y, determine the gender of the organism
- Two X chromosomes, XX, will be female and XY will be male
- All other chromosomes, except X & Y, are called autosomes
- Chromosomes from a cell may be arranged in pairs by size starting with the longest pair and ending with the sex chromosomes to make a karyotype
- A human karyotype has 22 pairs of autosomes and 1 pair of sex chromosomes (23 total) (Figure 8.5)

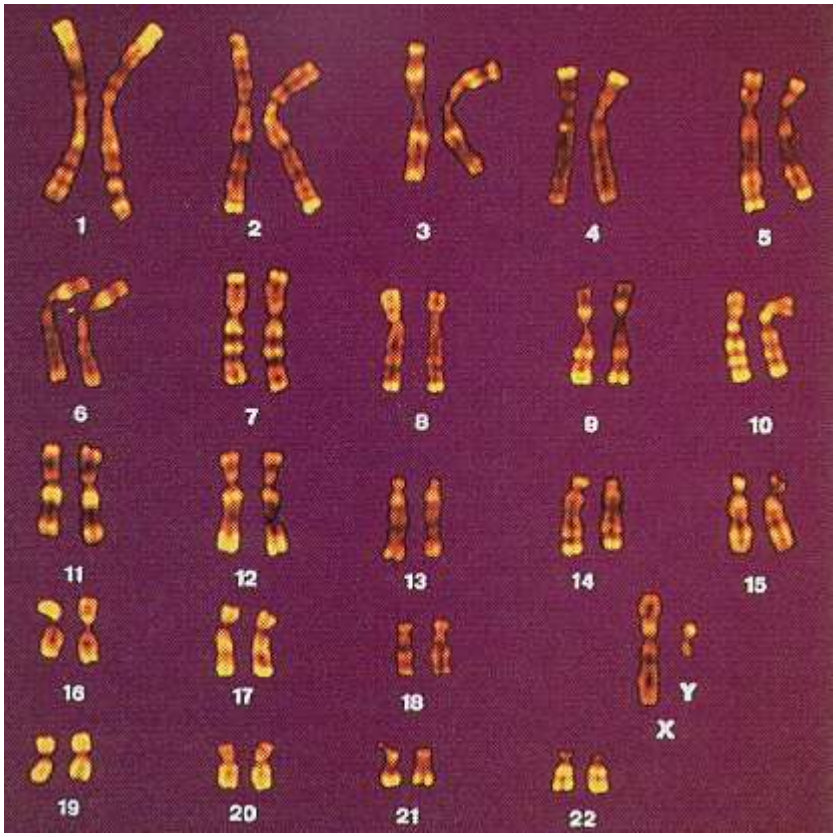


Figure 8.5: Human Male Karyotype

Genes:

- A section of DNA which codes for a protein is called a gene
- Each gene codes for one protein
- Humans have approximately 50,000 genes or 2000 per chromosome
- About 95% of the DNA in chromosome is "**junk**" that does not code for any proteins

Lab9: Meiosis

- Reduces the number of chromosomes in new cells to half the number in the original cell
- New cells have a single copy of chromosomes (23 total) but are **not identical to each other or the original parent cell.**
- Used for making gametes (sperm and eggs) with the haploid or n number
- In meiosis, cells divide twice after a single DNA duplication
- Meiosis I separates **homologs** & the Meiosis II separates **sister chromatids**
- Meiosis I stages are Prophase I, Metaphase I, Anaphase I, & Telophase I
- Meiosis II stages are Prophase II, Metaphase II, Anaphase II, & Telophase II
- Produces 4 haploid cells or gametes
- When a sperm fertilizes an egg to form a zygote, the diploid number of chromosomes is restored (23 + 23 = 46)
- Egg cells or ova (ovum, singular) are larger , non-motile cells
- Gametogenesis is meiosis producing eggs & occurs in the female's ovaries (Figure 9.1 Oogenesis)

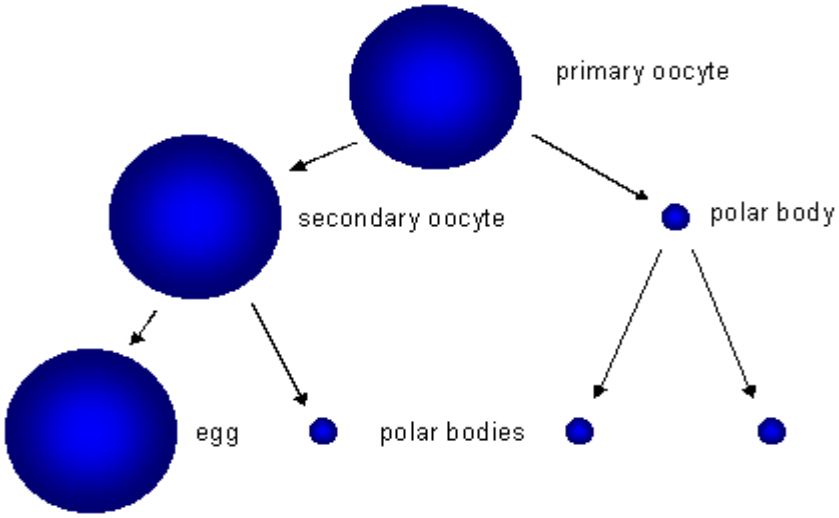


Figure 7.1: Oogenesis, producing eggs cell through meiosis

- Sperms contain less cytoplasm so they're smaller & have a flagellum to swim to the egg
- Spermatogenesis is meiosis producing sperm cells & occurs in the testes (Figure 9.2)

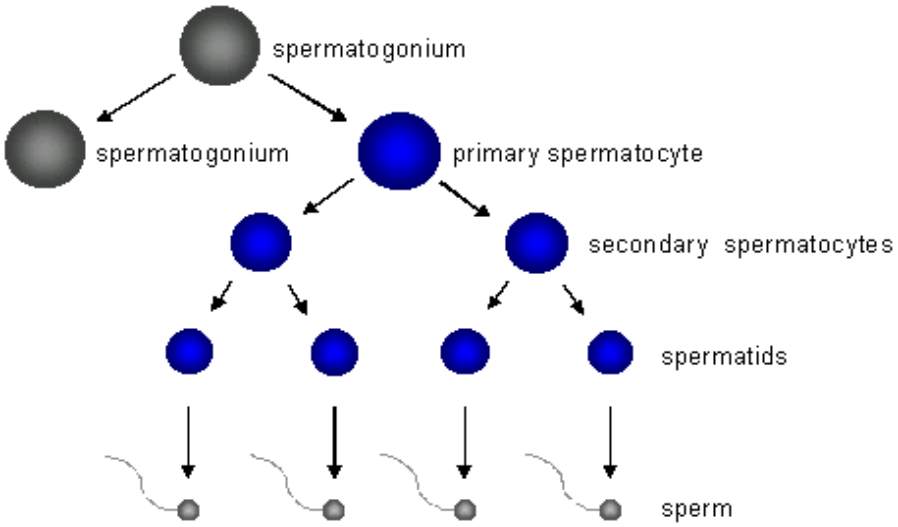


Figure 9.2: Spermatogenesis

Meiosis I:

- The cell that undergoes meiosis I is a primary spermatocyte or oocyte .
- **Prophase I:**
  - Chromosomes coil tightly & are visible
  - Nuclear membrane & nucleolus disintegrate
  - Spindle forms
  - Synapsis (joining) of homologous chromosomes occurs making tetrads
  - Kinetochore fiber forms on each chromosome
  - Chromosomes in tetrad exchange fragments by a process called **crossing over** **(Figure 9.3).**

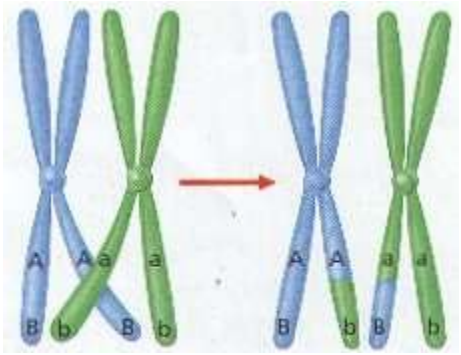


Figure 9.3: Crossing over

- **Metaphase I:**
    - Tetrads become aligned in the center of the cell attached to spindle fibers.
- **Anaphase I:**
    - Homologous chromosomes separate
- **Telophase I:**
    - May not occur in all species
    - Cytokinesis occurs producing 2 cells
    - In females, 2nd cell in females is called the 1st Polar Body
    - 1st Polar Body dies due to **uneven** splitting of the cytoplasm. See figure 9.4 for all meiosis I phases.

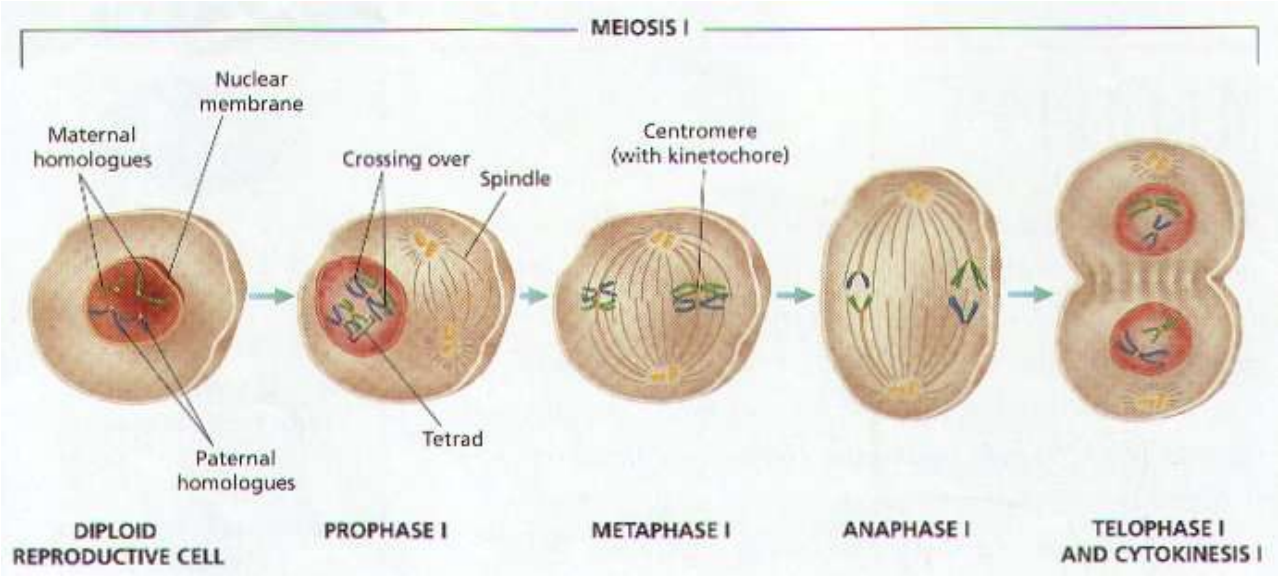


Figure 7.4: Meiosis I

Meiosis II (see figure 7.5)

- **Prophase II:**
    - Cells called Secondary Spermatocytes or oocytes
    - DNA is not copied before cell divides

- Chromatids attach to spindle fiber

- **Metaphase II:**
  - Chromosomes become aligned in the center of the cell attached to spindle fibers
- **Anaphase II:**
  - Sister chromatids separate randomly
  - Called independent assortment
- **Telophase II:**
  - Cytokinesis occurs producing 4 cells in males called spermatids
  - Spermatids mature & form flagellum to become sperm
  - Cytokinesis in females produces a 2nd Polar Body that dies and an ootid.
  - Ootids mature to become ovum or egg.

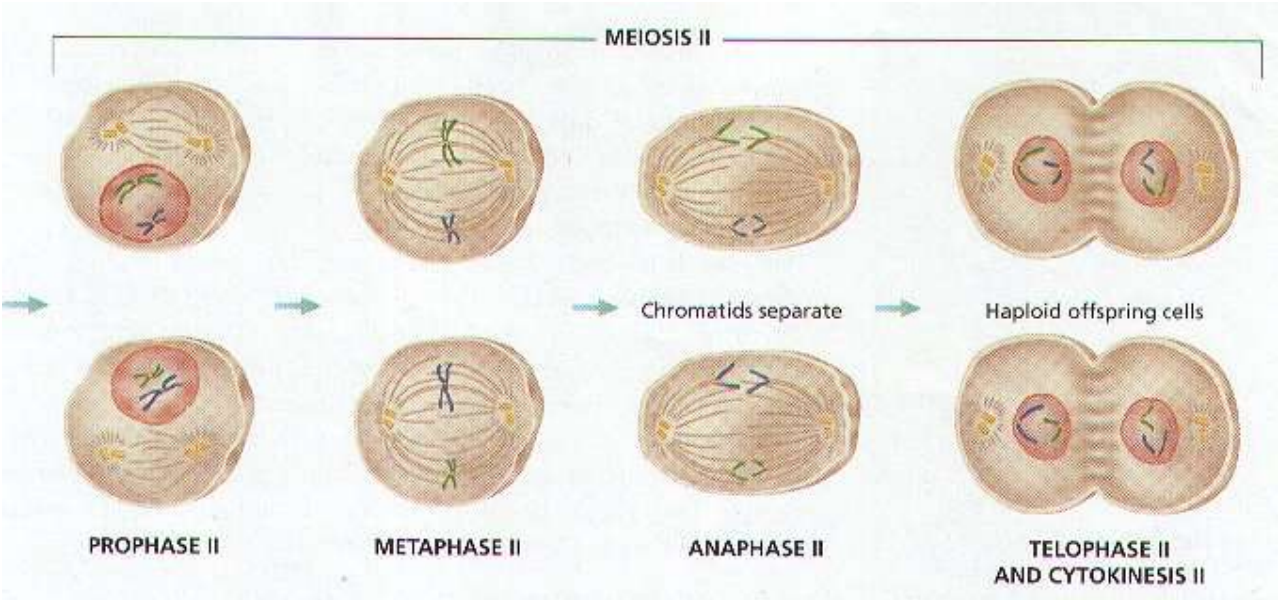


Figure 9.5: Meiosis II phases

Lab work: Examine the different meiosis phases in sections of rose plant ovaries

Lab. 10 Scientific Names and Classification

Our species has always needed to name plants and animals that were harvested for food or avoided for survival. Problems arose when different cultures tried to talk about organisms that bore different names originating in very different languages. Karl von Linné—a Swedish botanist better known as Carolus Linnaeus—solved the problem. In 1758, Linnaeus proposed a system for classifying organisms. He published it in his book, Systema Naturae.

In this system, each species is assigned a two-part name; for this reason, the system is known as **binomial nomenclature**. The names are based in the universal language: Latin. The first part of the scientific name is the **genus**, and it is always capitalized. (The plural is "genera"). The second part is the **species** epithet. The entire name is written in italics. Our own species, for example, was given ***Homo sapiens*** (it means "man who is wise").

Linnaeus' system gives each species a unique identity. The system also fulfilled a second need of humans: the need to classify things.

Living things were first classified as plants or animals. These kingdoms were subdivided into smaller categories called classes, and these into still smaller divisions: genera.

Originally, an organism was placed into a subgroup with other organisms on the basis of shared physical traits. After Charles Darwin awoke the world in 1859 with his book, On the Origin of Species, the evolutionary history of organisms became an important part of their classification. Today, sophisticated techniques such as DNA sequencing are essential tools used by taxonomists (scientists who classify living things).

Each genus contains species that share common ancestry. For example, because the wild dogs—wolves (***Canis lupus*****)** and coyotes (***Canis latrans***)—arose from a recent common ancestor, they are placed in the same genus: *Canis*. Red foxes (***Vulpes vulpes***) are wild dogs but they are not as closely related to wolves or coyotes and so they are placed in a different genus: *Vulpes*.

A current and popular classification system consists of eight main categories:

- **domain**
- **kingdom**
- **phylum**
- **class**
- **order**
- **family**
- **genus**
- **species.**

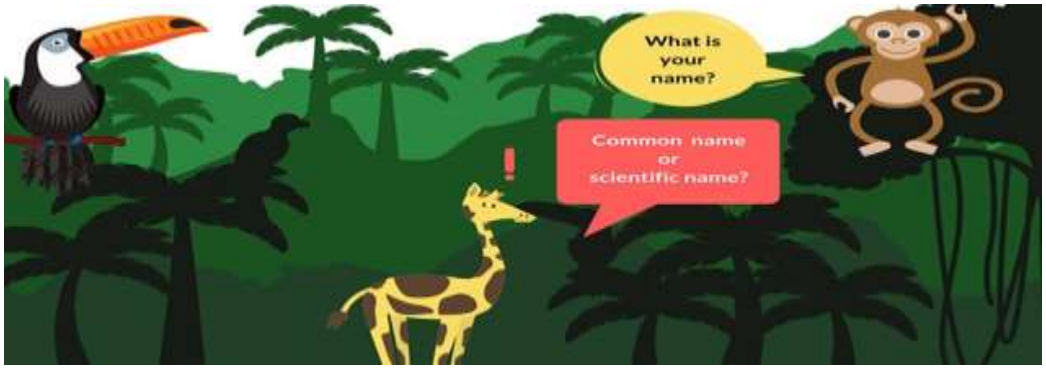
Common name: These are used locally and may vary by region or country.

Scientific name: These are unique names used by the scientific community to accurately and universally identify species.

Examples:

Gray wolf (*Canis lupus*)

Royal grevillea (*Grevillea victoriae*)



Onion

Scientific classification	
Kingdom:	**Plantae**
Division:	**Magnoliophyta**
Class:	**Liliopsida**
Order:	**Asparagales**
Family:	**Alliaceae**
Genus:	***Allium***
Species:	***A. cepa***

Drosophila melanogaster	
Scientific classification	
Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Diptera
Family:	Drosophilidae
Genus:	*Drosophila*
Subgenus:	*Sophophora*
Species group:	*melanogaster*
Species subgroup:	*melanogaster*
Species complex:	*melanogaster*
Species:	***D. melanogaster***
Binomial name