مقرر (علم الحيوان Zoo 101– Zoology I لطلاب الفرقة الأولي بكلية العلوم

شعبة البايوتكنولوجي للعام الدراسي 2023/2022 - التيرم الأول

الجزء النظري

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نموذج توزيع المحتوى العلمى لمقرر (General Zoo 101) للعام الدراسى ٢٠٢٢/٢٠٢٣

اولا:- بيانات المقرر

كود المقرر:-	اسم المقرر:- General Zoo 101	الفرقة/الشعبة:- الفرقة الأولي بيوتكنولوجي	الكلية:- كلية العلوم

الفصل الدراسى:-	عدد الساعات اسبوعيا	محاضرة: ٢	القائمين بالتدريس	محاضرة:-أ م د/نادية إبراهيم -د/ سهام علي
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ثانيا:- موضوعات المقرر

اسابيع الدراسة		موضوع المحاضرة/ المعمل	ملاحظات
الاول	محاضرة	1. Introduction: definitions; principles and concepts Introduction Types of microscopes Characteristics of life & ecosystems, structural organization from the atom to the organism	
	معمل	Types of microscopes • مقدمة عامة عن المنهج (الخلية وأنواعها وعضياتها) • الخلية بدائية النواة • الخلية الحيوانية (حقيقية النواة)	
الثاني	محاضرة	2. Introduction to parasitic protozoa Basic steps of the scientific methods and reasoning	
	معمل	Introduction: definitions; principles and concepts • الغشاء البلازمي والميتوكوندريا	
الثالث	محاضرة	3.Sarcodina and Mastigophora Cell structure and function	
	معمل	3.Sarcodina and Mastigophora • الشبكة الاندوبلازمية الخشنة والناعمة	
الرابع	محاضرة	4 .Apicomplexa and Ciliophora Cell Organelles structure and function Part 1	
	معمل	4 .Apicomplexa and Ciliophora • الريبوسومات وجهاز جولجي	

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		Types of animal tissues (Nervous tissue)	
	معمل	12. Parasitic arachnids : Acari ticks & mites	
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	معمل	مراجعـــــــــــة عـــــــــــــامة	

استاذ المقرر　　رئيس مجلس القسم　　وكيل الكلية لشئون التعليم و الطلاب　　عميد الكلية

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INTRODUCTION TO PARASITOLOGY

A **parasite** is a living organism that benefits by deriving nutrients at the expense of the host**.**

Parasitology is a science of studying parasitism and a discipline dealing with the biology of parasites (including its morphology , embryology , physiology, biochemistry , and nutrition, etc.),ecology of parasitism with emphasis on parasite – host and parasite – environment interaction.

ORGANISMAL ASSOCIATIONS

1) Phoresis

- Two organisms simply travel together
- Usually, one is transporting the other

Ex. Barnacles on a whale

2) Commensalism

- One benefits but the other isn't harmed and receives no benefits (usually one feeds off the "wastes" of the other partner).

Ex. Remoras feed on scraps left by shark

3) Parasitism: One organism benefits while the other organism is harmed

Zoonosis: A parasitic disease in which an animal is normally the host, but which also infects man.

Host: The organism which harbors the parasite and provides nourishment and shelter to latter and is relatively larger than the parasite. The parasite may live in, or on the host.

Types of Hosts

Definitive host

The host in which the adult parasite lives and undergoes sexual reproduction.

Intermediate host

In which the larval stage of the parasite lives or asexual reproduction takes place. In some parasites, 2 different intermediate hosts may be required to complete different larval stages.

Definitive host → harbors → adult stage and egg

Intermediate host → harbors → larval stage

Reservoir host

The host harboring a parasite serving as a source of infection for other susceptible hosts show no sign or symptoms.

TYPES OF PARASITES

1. **Location:**

- **Endoparasite:** Lives inside the body of the host may be just under the surface or deep in the body. Ex.: Tapeworms, flukes, protozoans.

- **Ectoparasite:** Stays on outside surface of the host
  Ex.: Mosquitoes, leeches, ticks, fleas, brood parasites

2. **Required or not:**

   a. **Obligate Parasite**
   Requires finding and invading the host to complete its life cycle

   Most of the parasites we will cover are obligate parasites

   b. **Facultative Parasite**
   May become parasitic if it is given the chance but does not require a host.

3. **<u>Amount of time spent:</u>**

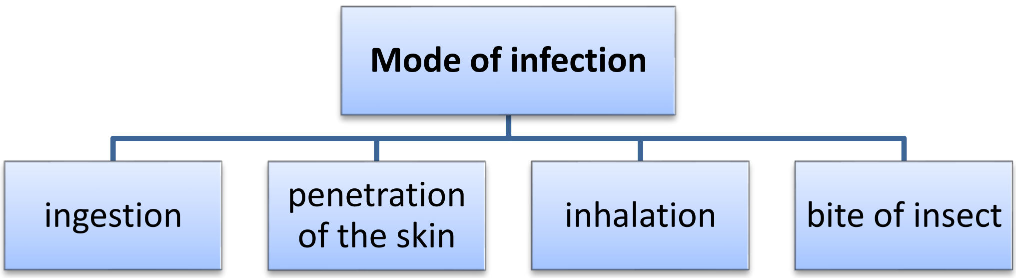
- **Permanent Parasite:** Lives entire adult life stage on or in a host, usually endoparasites.

- **Temporary Parasite:**Spends only a short time on a host**,** usually ectoparasites.

Types of Life cycles

Direct life cycle: when a parasite requires only single host to complete its development.

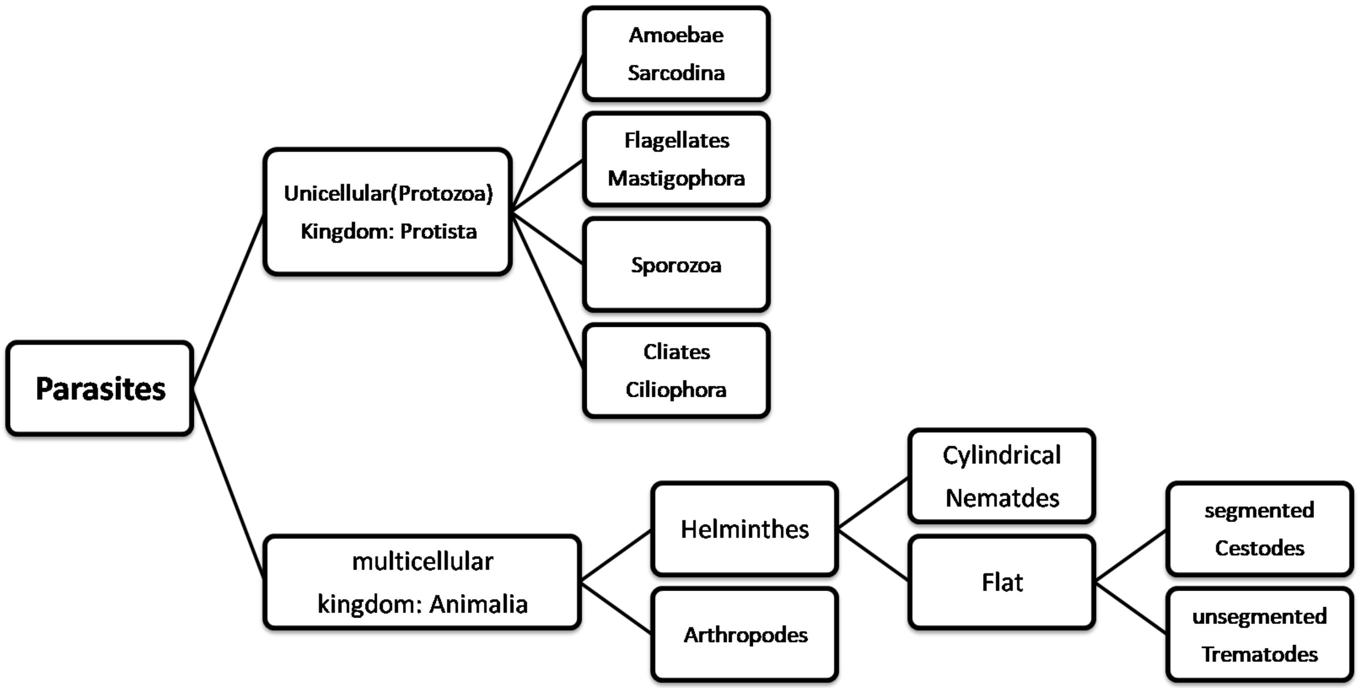
Indirect life cycle: when a parasite requires 2 or more species of host to complete its development



Habitat of the parasites:

ex. Blood –l intestine — liver – lungs

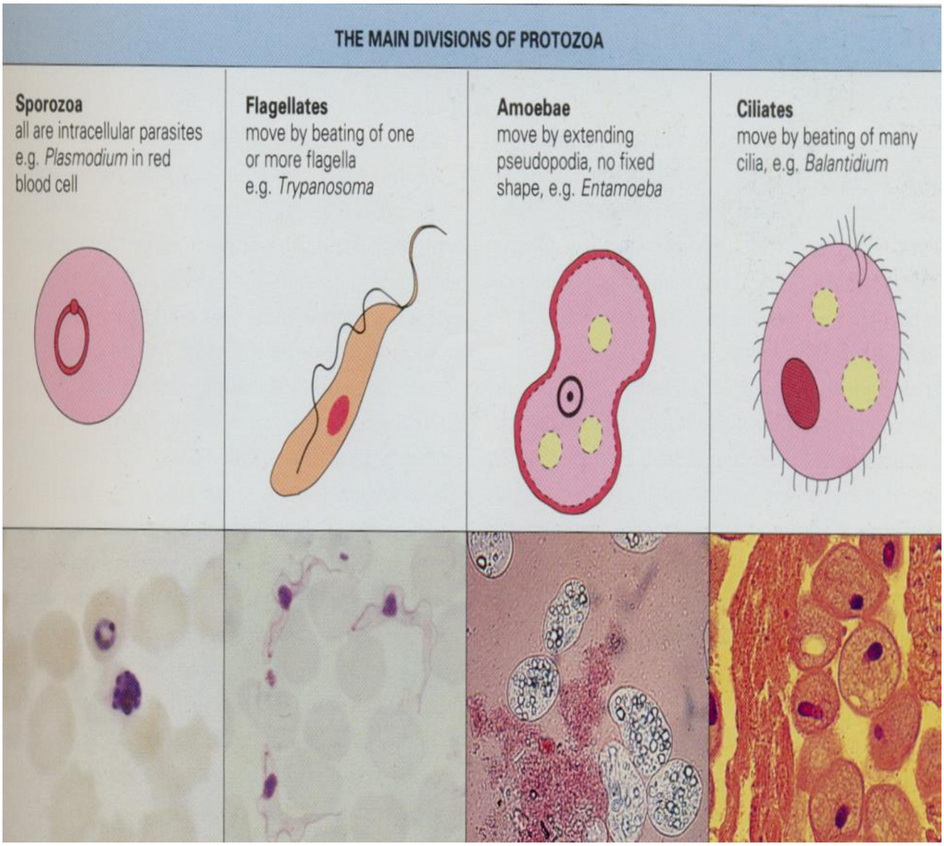
PARASITES ARE EUKARYOTES


Parasites
Unicellular(Protozoa)
Kingdom: Protista
Amoebae
Sarcodina
Flagellates
Mastigophora
Sporozoa
Cliates
Ciliophora
multicellular
kingdom: Animalia
Helminthes
Arthropodes
Cylindrical
Nematdes
Flat
segmented
Cestodes
unsegmented
Trematodes

MEDICAL PROTOZOOLOGY

Medical Classes of Protozoa:

- Sporozoa.
- Flagellata (zoomastigophora)
- Ciliata (Ciliophora)
- Lobosea (sarcodina)



Class (1) : Sporozoa (Coccidia)

<u>Blood species</u> :

Plasmodium falciparium

Plasmodium vivax

Plasmodium ovale

Plasmodium malariae

<u>Tissue species</u>

Toxoplasma gondii

Sarcocystis hominis

<u>Intestinal species :</u>

Isospora belli

Cryptosporidium parvum

Class (2): Flagellata (zoomastigophora)

<u>Intestinal species</u>

Giardia lamblia

Trichomonas hominis

Chilomastix mesnili

Enteromonas hominis

Retortamonas intestinalis

Oral and vaginal species .

Trichomonas tenax

Trichomonas vaginalis

<u>Blood species</u>

Leishmania donovani

Leishmania tropica

Leishmania brazielinses

Trypanosoma cruzi

Trypanosoma gambiense

Trypanosoma rhodesience

Class (3) : Sarcodina :

<u>Intestinal species</u>

Entamoeba histolytica

Entamoeba dispar

Entamoeba hartmanni

Entamoeba coli

Endolimax nana

Iodamoeba butschlii

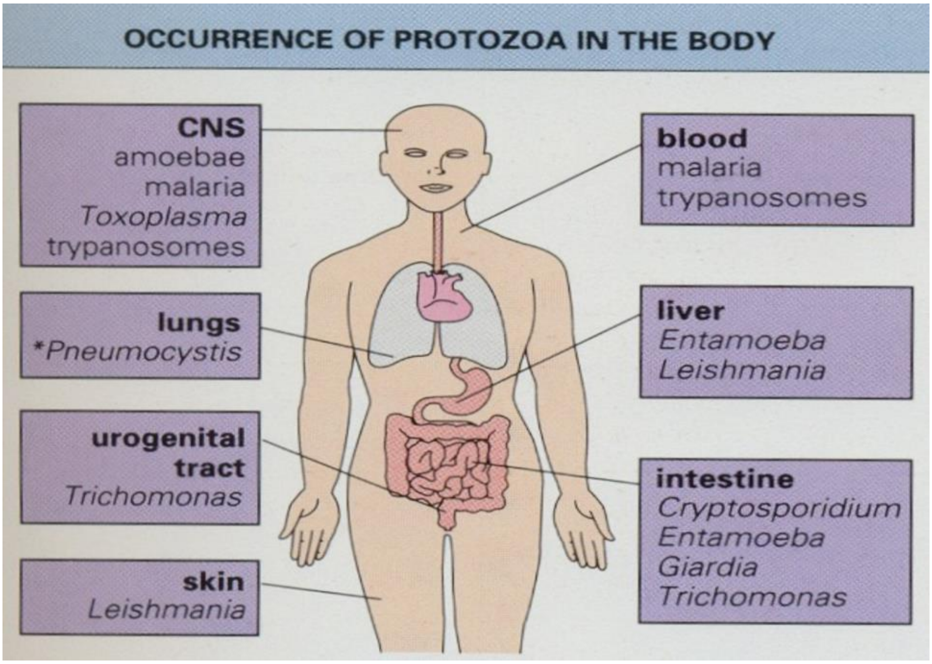
Extra - Intestinal species

Entamoeba gingivalis (mouth)

Naegleria fowleri (brain)

4- Ciliata: Ciliophora

Balantidium coli (intestine)



Sporozoa(Apicomplexa)

Toxoplasma gondii

Toxoplasma is an obligate intracellular parasite.

Toxoplasma gondii has very low host specificity, and it can infect almost any mammal.
It has also been reported from birds.

Geographical distribution: worldwide

Hosts:

Intermediate: cats

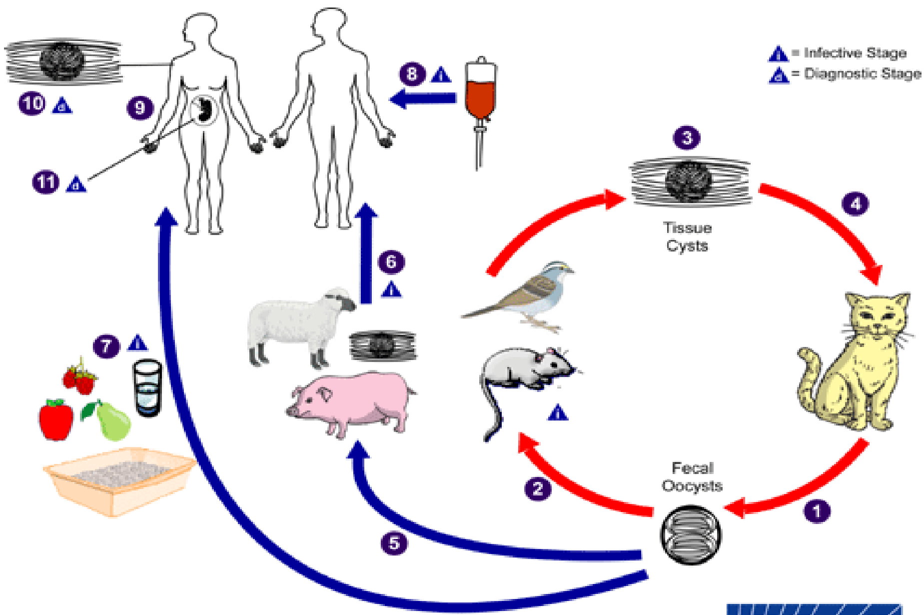
Definitive : humans, mammals and birds

Morphology:

- **Pseudocysts**: in macrophages and reticulo-endothelial cells in the acute stage of infection.
- **Trophozoites**:: obligate intercellular parasites, crescent-shaped with central nucleus multiply by binary fission forming pseudocysts.
- **Cysts**: collection of trophozoites enclosed in a true tissue cyst.
- **Oocysts**: oval contain two sporocysts each contains four sporozoites.and found in stool of infected cats.

Life cycle

includes two phases called the intestinal (or enteroepithelial) and extraintestinal phases. The intestinal phase occurs in cats only (wild as well as domesticated cats) and produces oocysts. The extraintestinal phase occurs in all infected animals (including cats) and produces tachyzoites and, eventually, bradyzoites or zoitocysts.The disease toxoplasmosis can be transmitted by ingestion of oocysts (in cat feces) or bradyzoites (in raw or undercooked meat)



Human infection takes place by:

- Ingestion of undercooked infected meat.
- Contamination of food or drink with infected cat feces.
- Transplacental(congenital)
- Organ transplantation
- Blood transfusion.
- Laborarory infection.

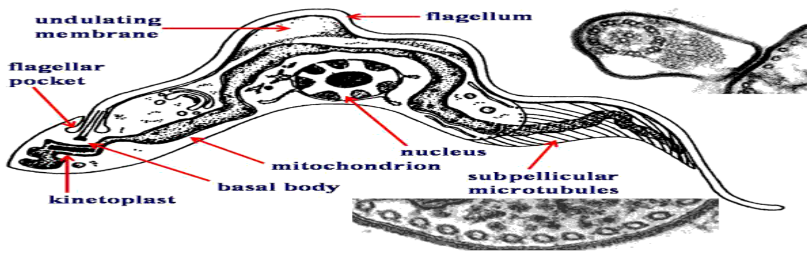
Prevention and control:

- Good cooking of meat.
- Care in handling cats.
- All new married females should be tested for toxopasmosis before pregnancy.

Fagellates

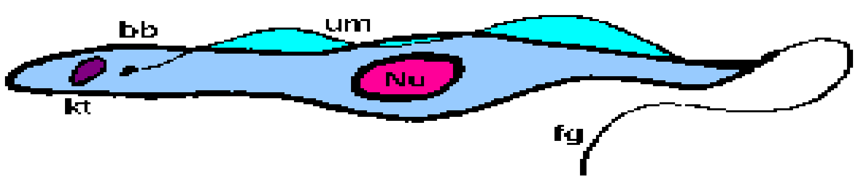
Trypanosoma spp.

Eukaryota (organisms with nucleated cells),Kingdom Protista, Phylum Protozoa. Trypanosomes have a single central nucleus and a single flagellum originating at the kinetoplast and joined to the body by an undulating membrane.

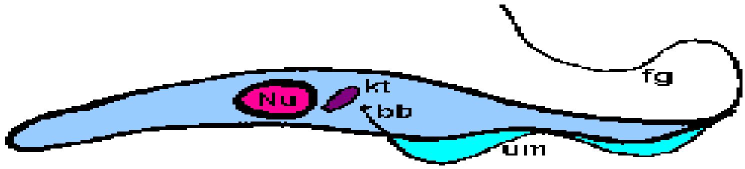


Morphological forms:

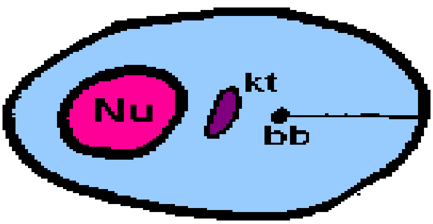
TRYPOMASTIGOTE: The kinetoplast (kt) is located on the posterior end of the parasite. The flagellum emerges from the posterior end and folds back along the parasite's body.



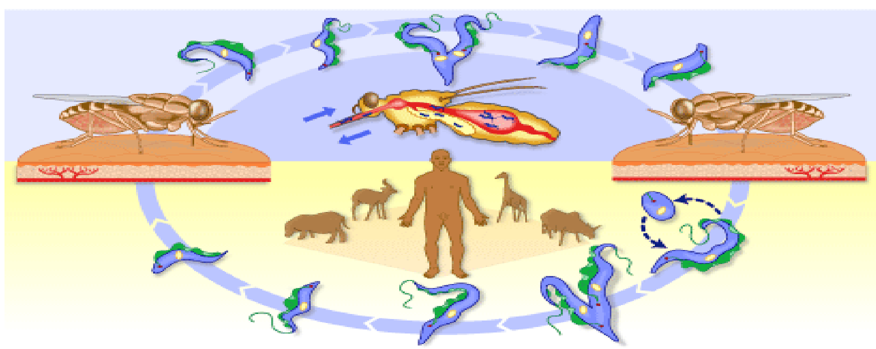
EPIMASTIGOTE: The kinetoplast (kt) is more centrally located, usually just anterior to nucleus (Nu).



AMASTIGOTE: The parasite is more spherical in shape and has no free flagellum. A basal body (bb) and the base of the flagellum is still present.



Life cycle



Trypanosomes cause trypanosomiasis

Trypanosomiasis (Sleeping sickness)

East African trypanosomiasis is caused by the parasite *Trypanosoma brucei rhodesiense*.

West African trypanosomiasis is caused by *Trypanosoma brucei gambiense*. The parasites are spread by tsetse flies, found only in Africa.

Clinical Symptoms

- A tsetse fly bite is often painful and can develop into a red sore, called a chancre.
- fever
- severe headache
- irritability
- extreme tiredness
- swollen lymph glands
- aching muscles and joints.

- Weight loss and a body rash are also common.
- Infection of the central nervous system causes confusion, personality changes, slurred speech, seizures, and difficulty in walking and talking. If left untreated, the illness becomes worse, and death occurs within several weeks to months

Diagnosis:

In the early stages of the disease, the parasites can be demonstrated in lymph nodes and blood; later, they appear in the cerebrospinal fluid

Prevention:

- There is no vaccine or drug to prevent African trypanosomiasis.
- When traveling in areas where the disease occurs, take the precautions against bites from tsetse flies and other insects.

Sarcodina

Entamoeba histolytica

Amoeba: organism that moves and feeds with pseudopodia.

Host: human

Geographic Distribution: Worldwide.

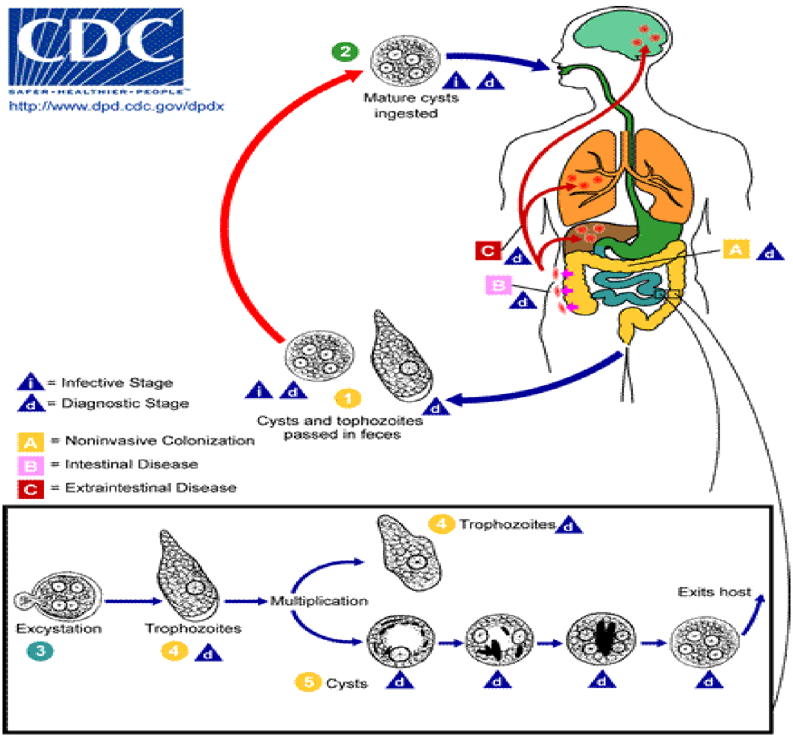
Morphology:

Different form of E. histolytica:

- Trophozoite

- Precyst

■ cyst(1, 2, 4 nuclei)



Amebiasis

(Amebic Dysentery)

Epidemiology:

- Prevalence of amebic infection varies with level of sanitation and generally higher in tropics and subtropics climates.
- ***Entamoeba histolytica*** is the second leading cause of mortality due to parasitic disease in humans. (The first being malaria). Amebiasis is the cause of an estimated 50,000-100,000 deaths each year.

Transmission:

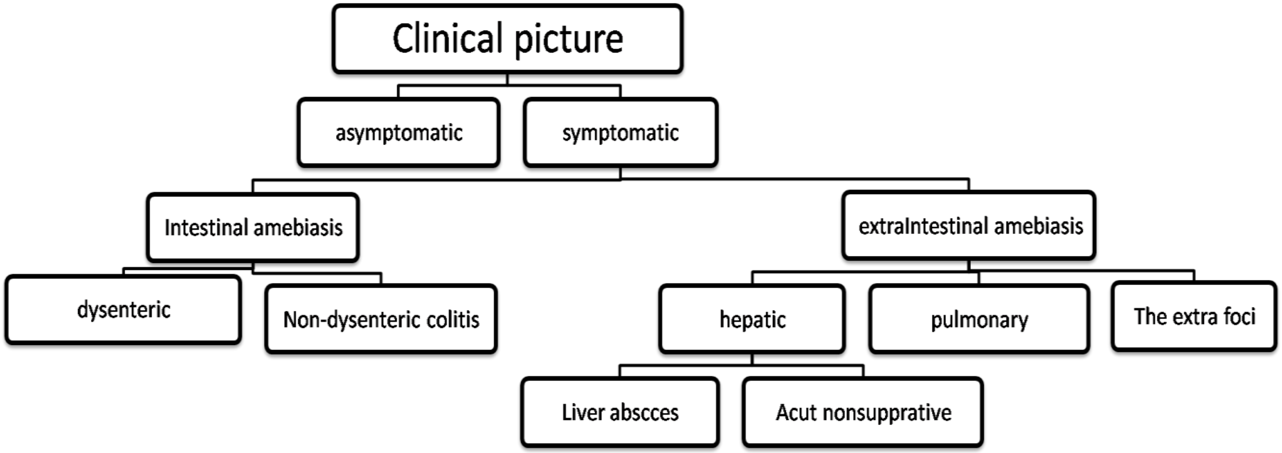
1-driect contact of person to person(fecal-oral)

2- Veneral transmission among homosexual males(oral-anal

3- Food or drink contaminated with feces containing the E.his. cyst

4- Use of human feces (night soil) for soil fertilizer

5- contamination of foodstuffs by flies, and possibly cockroaches


Clinical picture
asymptomatic
symptomatic
Intestinal amebiasis
extraIntestinal amebiasis
dysenteric
Non-dysenteric colitis
hepatic
pulmonary
The extra foci
Liver abscces
Acut nonsupprative

Pathogenesis

Tissue: large intestine (colon, cecum)

Amoebic dysentery, erosion of mucosa and coating of the epithelium in the intestine, invasion of tissue causing flask-shaped ulcer

→ can reach the bloodstream

→can finally result in peritonitis (bacteria reach abdominal cavity)

Diagnosis: Microscopic examination of stool

Control:

- Treatment of patients.
- Examination and treatment of food handlers.
- Environmental sanitation.
- Personal prophylaxis.
- Human faeces should not be used as fertilizers.

Ciliates(Ciliophora)

Balantidium coli

The largest protozoan parasite of humans

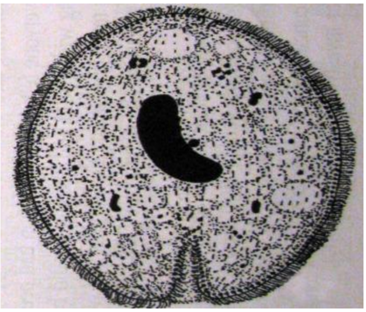
Disease: Balantidiosis and balantidial dysentery

Host : Humans

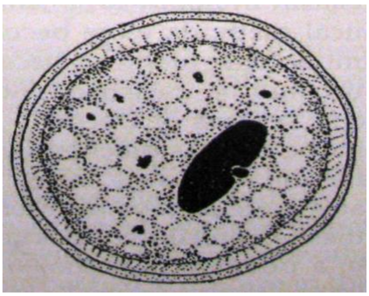
Geographic Distribution : Cosmopolitan

Morphology:

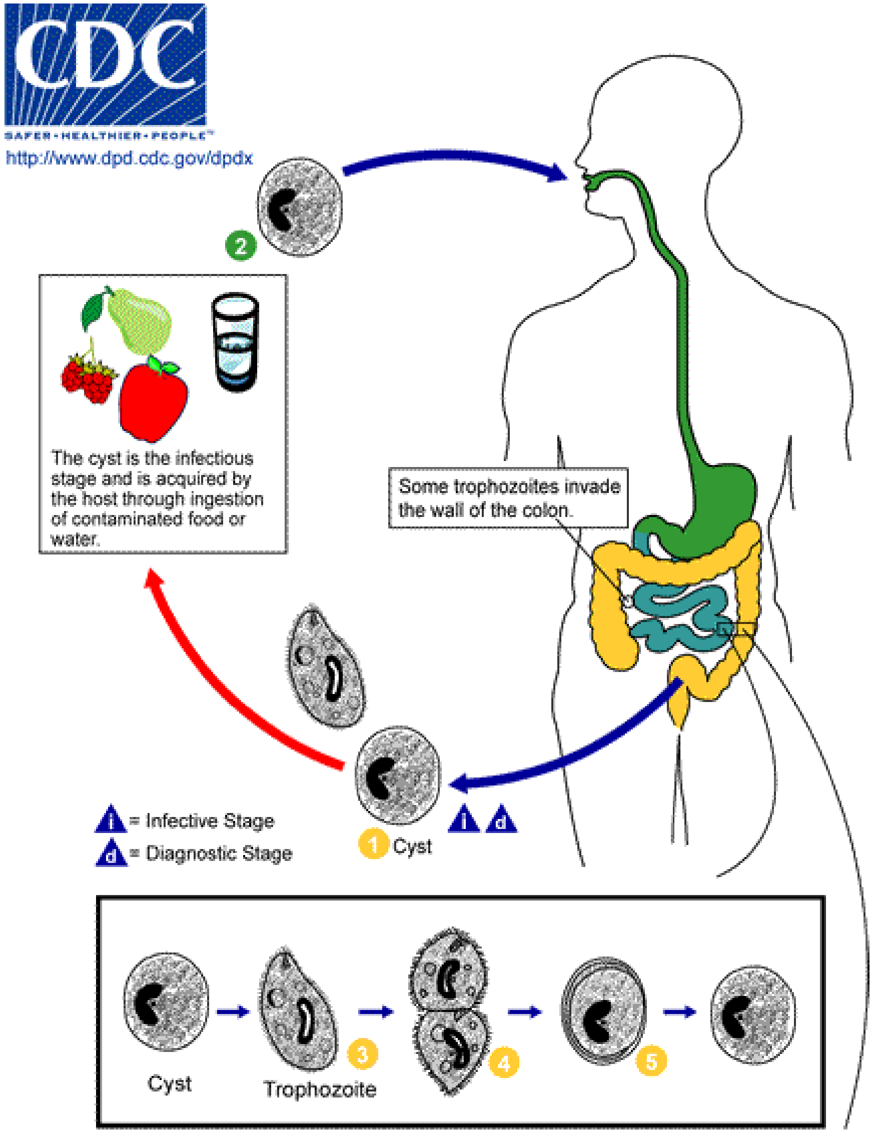
- Trophozoite: with a prominent kidney shaped macronucleus and a smaller micronucleus.



- **cyst**: cysts are round with a rounder and thicker macronucleus.



Life cycle



CDC
SAFER·HEALTHIER·PEOPLE™
http://www.dpd.cdc.gov/dpdx
2
The cyst is the infectious stage and is acquired by the host through ingestion of contaminated food or water.
Some trophozoites invade the wall of the colon.
i = Infective Stage
d = Diagnostic Stage
1 Cyst
Cyst
Trophozoite
3
4
5

Pathogenesis

- ♦ In acute disease, explosive diarrhea.
- ♦ Perforation of the colon may also occur in acute infections which can lead to life-threatening situations.

Diagnosis

Microscopic examination of stool

Prevention and control:

- ➢ Good hygiene practices:
- Washing hands after using the toilet
- Washing vegetables and fruits.

Helminthes

Classification of Helminthes According to transmission methods:

1- Soil transmitted Helminthes : Ascaris, Hook worms

2- Snail t. H. : Trematoda (*Schistosoma,….)*

3- Arthropods t. H. *: Fillaria, Dracanculus medinensis*

4- Food and Meat t. H*. : Taenia saginata, Taenia solium*

5- Direct t. H. (contagious H.): *Enterobius vermicularis,…*

Platyhelminthes (Flat worms)

Cestodes (Tapeworms)

Taenia spp.

General characters of Cestoda:

- **Cestode body :**

1) an attachment organ(scolex);- sucker(bothria, bothridia) - rostellum
2) neck region
3) a chain of segments(strobila): Immature proglottids - Mature p. - Gravid p.

- **Digestive system;** tegument play role of absorption tract

- **Reproduction system** : all tapeworms of human are hermaphrodites (male and female organs are found in mature proglottids).

Taenia saginata
(beef tapeworm)

Geographical distribution: cosmopolitan

Location in host: small intestine

Morphology:

- Scolex is pear-shaped with 4 prominent round sucker without rostellum

- Size of worm is very long(usually about 5 meters, sometimes exceeding 20 meters)

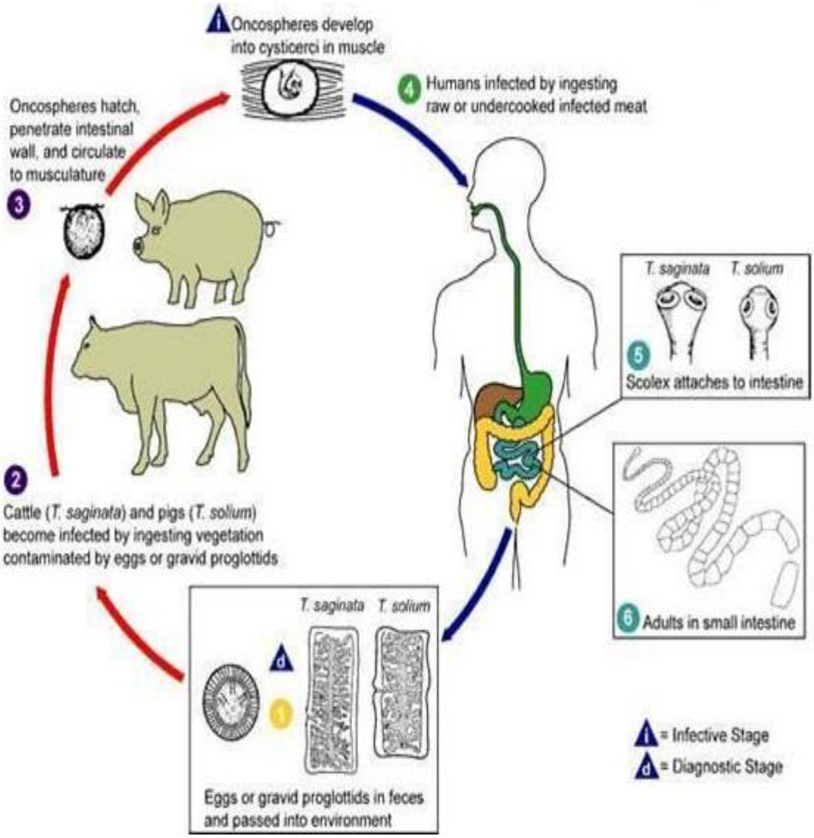
Taenia solium
(Pork tapeworm)

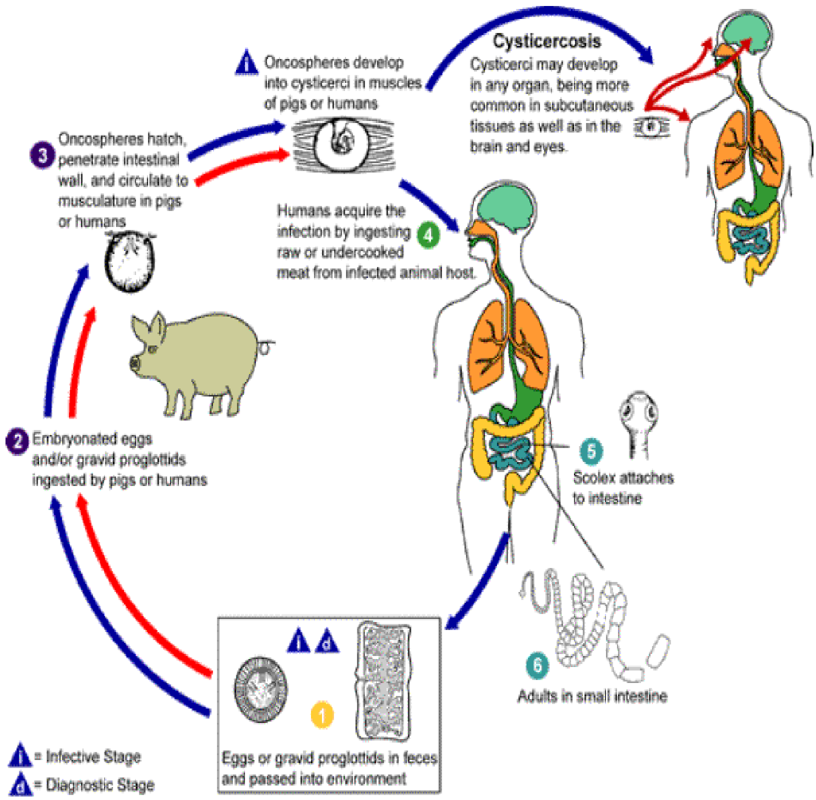
Geographical distribution: cosmopolitan in countries where pork is eaten raw or undercooked.

Location in host: small intestine.

Morphology:

- Scolex has 4 large suckers and a rostellum with 2 rows of hooks.
- Size of worm is long(2-10 meters in length).





Life cycle of T. solium

Clinical Manifestation

Due to adult worm:

Often the first and only sign of infection:

- Presence of active proglottids in the feces, feeling of them crawling out through the anus.
- There may be umbilical pain, nausea, weakness, loss of weight, alteration of appetite and

headache (possibly caused by toxic products or are allergic reaction) .

- ➢ Allergic manifestations, such as urticaria

Pathogenesis

- Physical action of the scolex on the mucosa
- Inflammation of the mucosa in the ileum sometimes occurs.
- Intestinal obstruction, perforation or appendicitis have been reported.

Diagnosios

Detect of eggs and proglottids in feces is diagnostic for taeniasis,(*but is not possible during the first 3 months following infection, prior to development of adult tapeworms*).

Prevention and control

- ✓ Meat inspection (include the heart, shoulder muscle, tongue, …)
- ✓ Freezing meat at -15ºC for 3 days 0r by good heating.
- ✓ Treatment of patients.

Platyhelminthes (Flat worms)

Fasciola hepatica

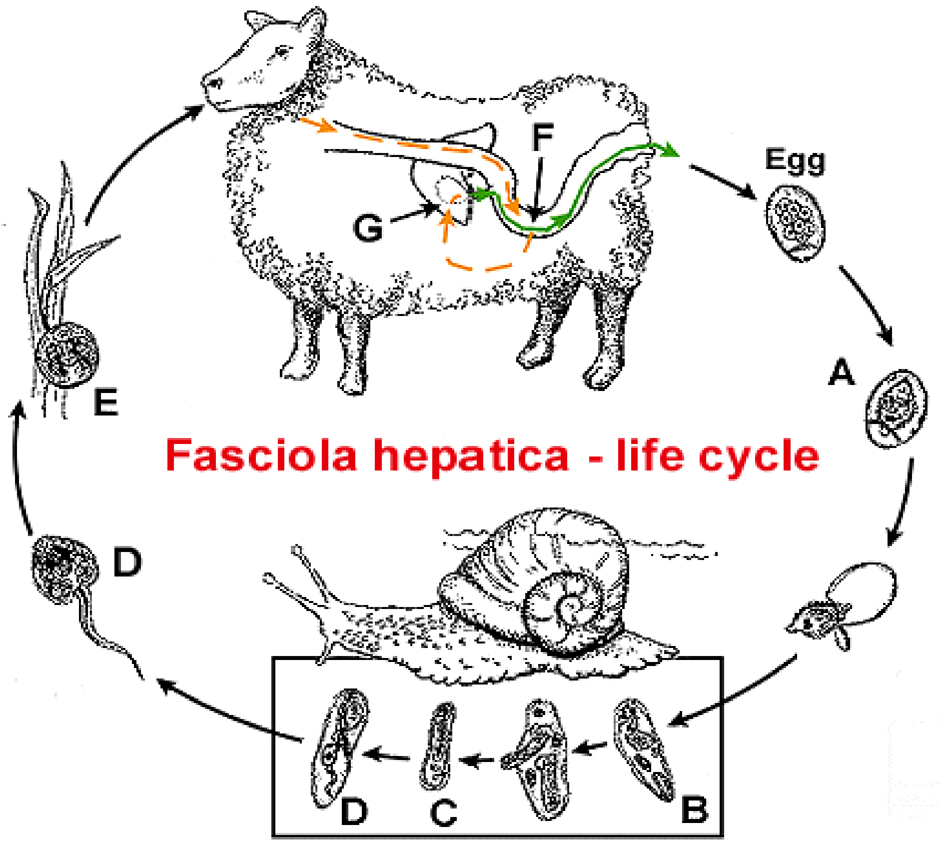
- Commonly known as liver fluke

Geographical Distribution

- Found in Rural areas of temperate and tropical regions
- Especially located in regions with cattle and sheep herding.

Hosts: cattle, sheep sometimes humans

Life cycle:



Four Symptomatic Patterns

- Acute Phase
- Cronic Phase
- Halzoun
- Ectopic Infection

Diagnosis:

- Presence of F. hepatica eggs either in a stool sample, duodenal aspirate or biliary aspirate
- Flukes do not begin to produce eggs until about 4 months after infection, so you cannot test the stool
- Prior to 4 months: serological tests can be used
    - FAST-ELISA (most popular)
- Ultrasound can be used to visualize adult flukes in the bile ducts
- CT scan can reveal burrow tracts made by the worms

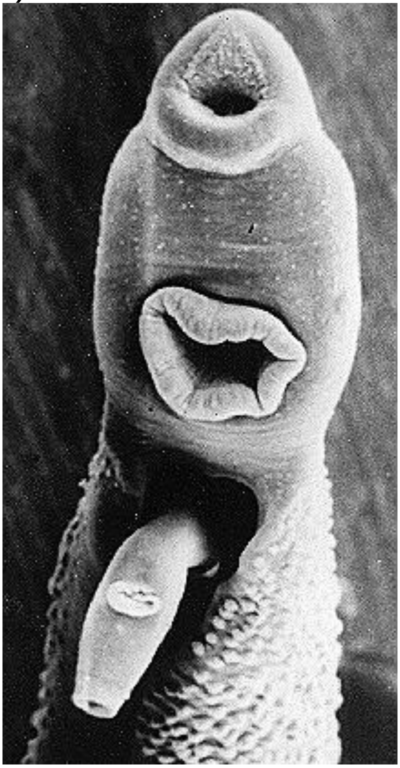
Control:

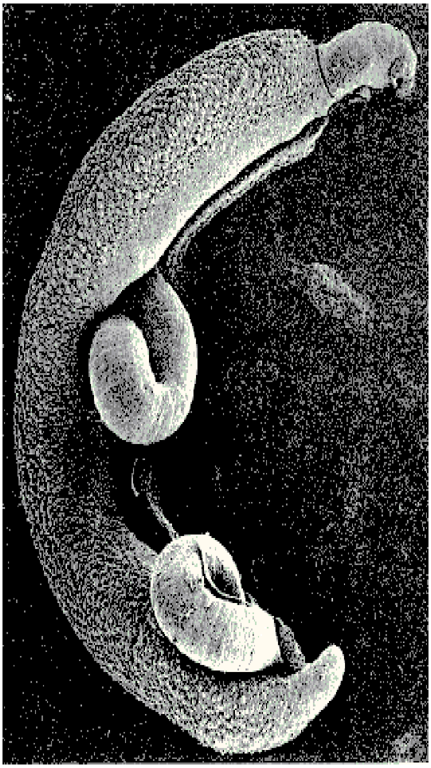
- Education
- Molluscicides: application of malluscicides to decrease the population of Lymnaea snails
- Chemotherapy

Schistosoma spp.

The three main species infecting humans are:

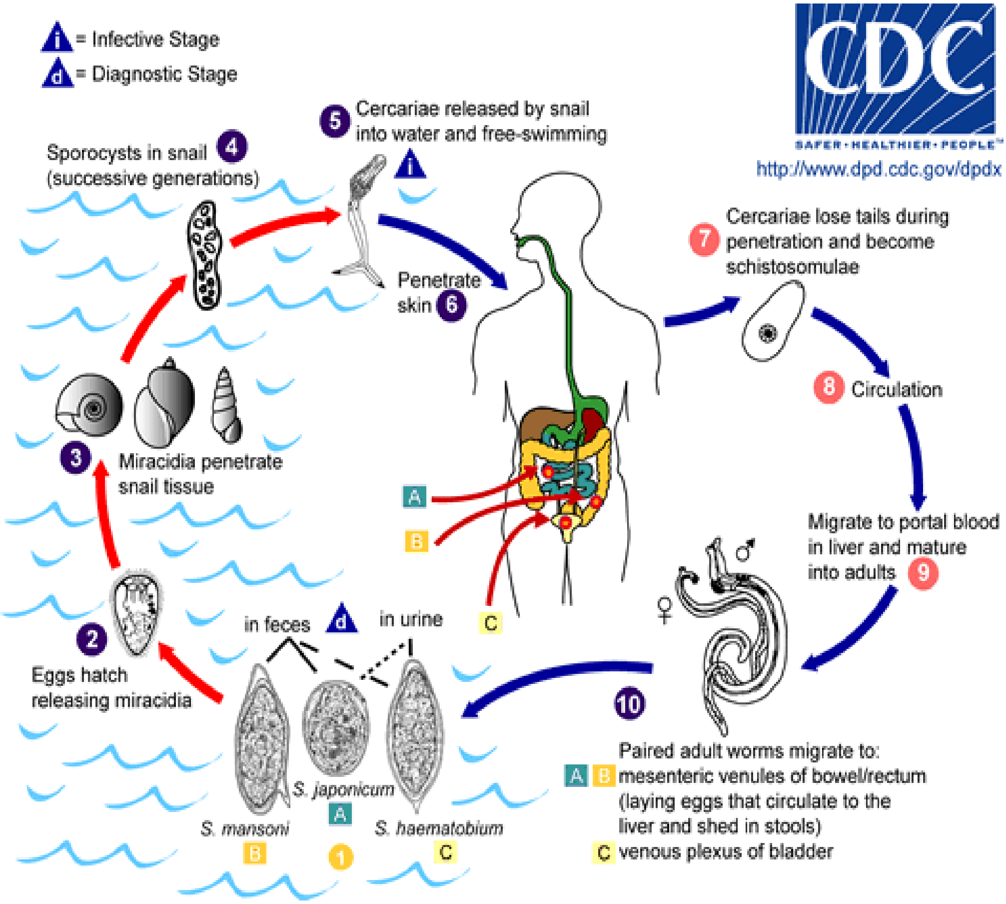
1) *Schistosoma haematobium*
2) *S. japonicum*
3) *S. mansoni*





Geographic Distribution

Schistosoma mansoni is found in parts of South America and the Caribbean, Africa, and the Middle East ;*S. haematobium* in Africa and the Middle East; and *S. japonicum* in the Far East .



Clinical picture

- Many infections are asymptomatic.
- Swimmer's itch (Cercarial Dermatitis)
- Acute schistosomiasis (Katayama's fever) may occur weeks after the initial infection, especially by *S. mansoni* and *S. japonicum.*
- .Manifestations include fever, cough, abdominal pain, diarrhea, hepatospenomegaly, and eosinophilia.
- Occasionally central nervous system lesions occur.

Diagnosis:

- Microscopic identification of eggs in stool or urine is the most practical method for diagnosis.
- Stool examination should be performed when infection with *S. mansoni* or *S. japonicum* is suspected, and urine examination should be performed if *S. haematobium* is suspected.

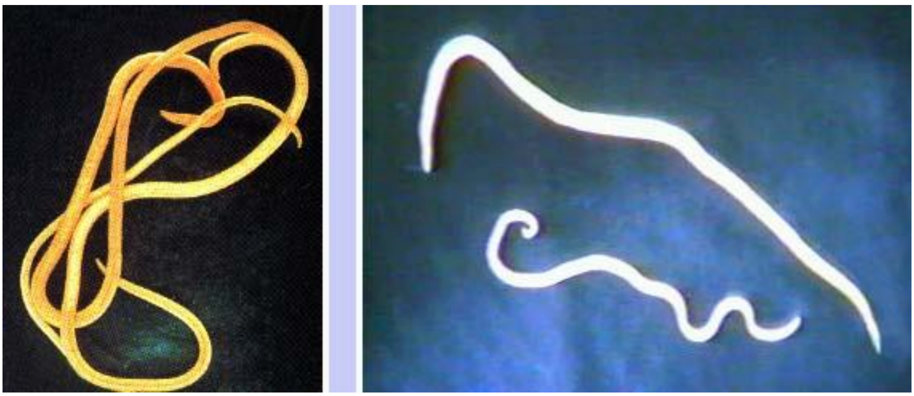
Nemadodes(round worms)

Ascaris Lumbricoides

Ascaris lumbricoides is the largest of the intestinal nematodes parasitizing humans.

Geographic distribution:. It is worldwide, and more prevalent in the countryside than in the city.

Adult: cylindrical in shape, creamy-white or pinkish in color. The female averages 20-35cm in length, the largest 49cm. The male is smaller, averaging 15-31cm in length and more slender than the femalewith typical curled tail with a pair sickle like copulatory spines. On the tip of the head there are three lips They have a complete digestive tract. Reproductive organs are tubular. Male has a single reproductive tubule. The female has two reproductive tubules.



Adult worm of *A. lumbricoides*

Egg: There are three kinds of the eggs. They are fertilized eggs, unfertilized eggs and decorticated eggs.

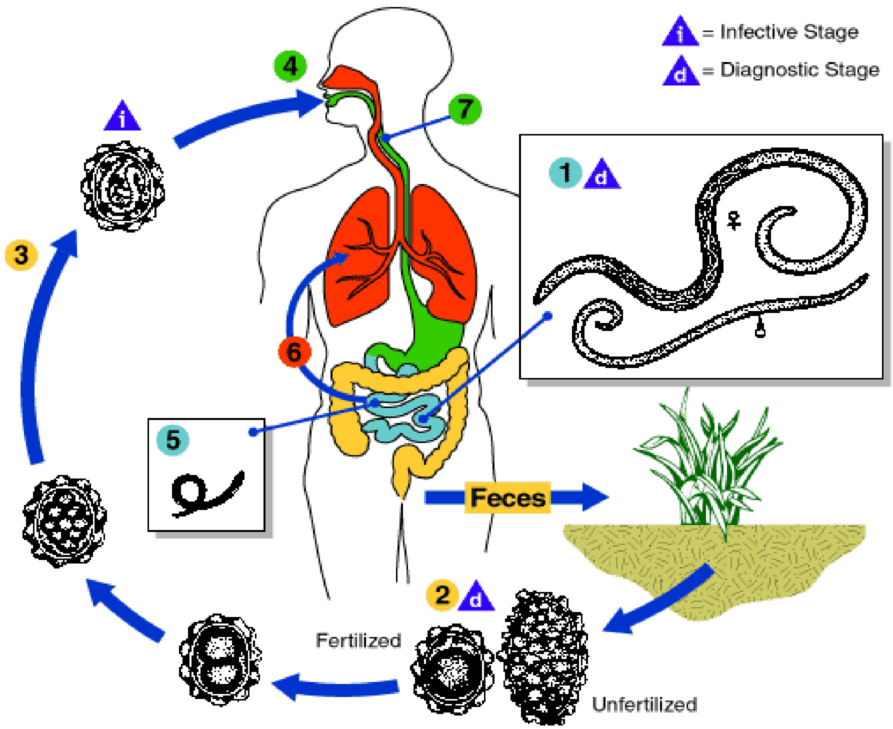
Site of inhabitation: small intestine

Infective stage: embryonated eggs

Route of infection: by mouth

Host: human , no intermediate host

Life span of the adult: about 1 year



Pathogenesis

There are two phases in ascariasis:

1. The blood-lung migration phase of the larvae: During the migration through the lungs, the larvae may cause a pneumonia. The symptoms of the pneumonia are low fever, cough, blood-tinged sputum, asthma. Large numbers of worms may give rise to allergic symptoms. Eosionophilia is generally present.

2. The intestinal phase of the adults. The presence of a few adult worms in the lumen of the small intestine usually produces no symptoms, but may give rise to vague abdominal pains. A heavy worm burden can result in malnutrition. Wandering adults may block the appendical lumen or the common bile duct and even perforate the intestinal wall. Thus complications of ascariasis, such as intestinal obstruction, appendicitis, biliary ascariasis, perforation of the intestine, etc

Diagnosis: Depends on the identification of the worm or its egg.

1. Examination of sputum for Ascaris larvae

2. Feces are examined for the ascaris eggs.

3 Recovery of adult worms

Epidemiology:

Factors favoring the spread of the transmission:

1. Simple life cycle.
2. Enormous egg production.
3. These eggs are highly resistant.
4. Social customs and living habits.
5. Disposal of feces is unsuitable.

Prevention

- Sanitary disposal of feces.
- Hygienic habits such as cleaning of hands before meals.
- .Health education.

Nematodes /Hook worms

Ancylostoma duodenale

- Common name: Old world hookworm
- Habitat: Small intestine
- Definitive host: Human

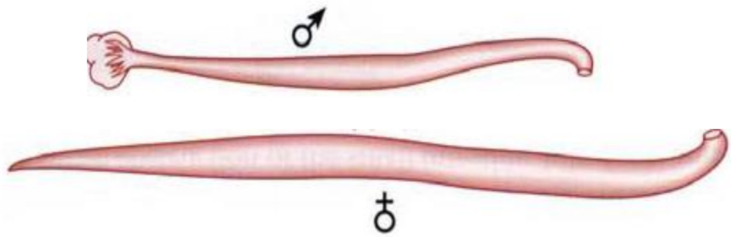
- Route of infection: Filariform larvae penetrate the skin of human
- Infective stage: Third stage larvae (filariform)
- Diagnostic stage: Eggs in Stool
- Disease: Hookworm infection, Ancylostomiasis
- Geographic Distribution: Southern Europe, North parts of Africa, China, India, and Japan.

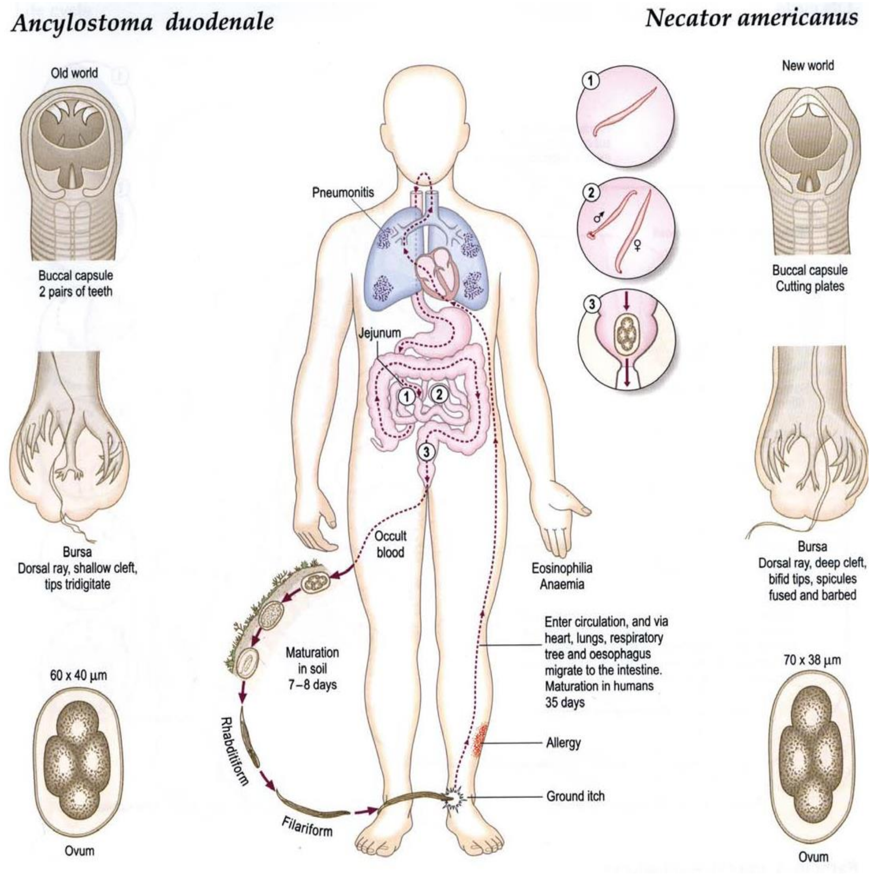
Morphology:

1- Adult female is about 9-13 mm, and the male is smaller than 5-11mm.

2- The anterior end have buccal capsule with two ventral pairs of teeth.

3- The posterior end of the male has copulatory bursa, females have simple tail.





Clinical manifestations:

1-Invasion stage: Lesions, at the site of entry of filariform larva

2-Migration stage: passage of the larvae in the lung leads to haemorrhages and pneumonia, cough, fever, eosinophylia.

3-Intestinal stage:

- sucking of blood by the worm (iron-dificiency anaemia).
- Bleeding at the site of attachment and after movement to a new sites.
- Toxic substances .
- intestinal ulcers: flatulence, nausea, vomiting ,diarrhea.

Diagnosis:

1- Hookworm eggs in a recently collected stool sample.

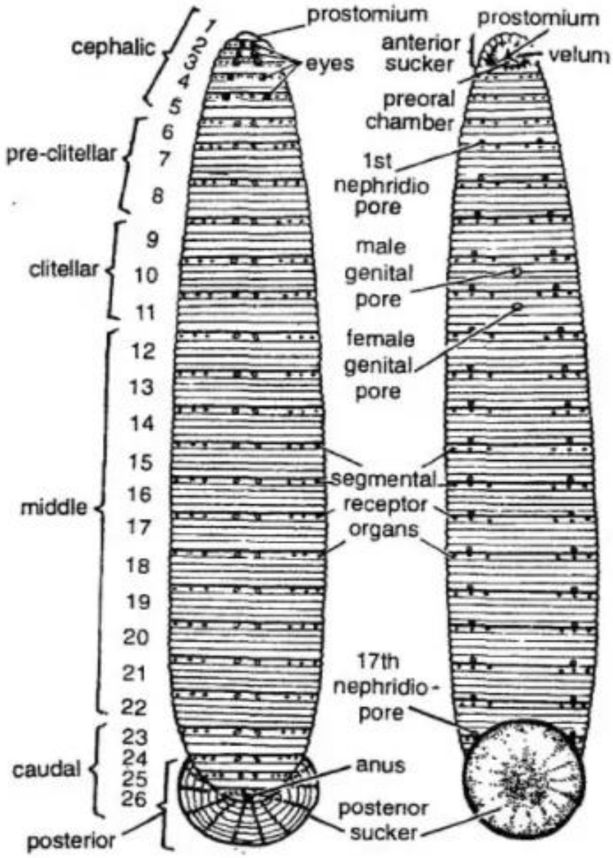
2-Blood tests for anemia and nutritional deficiencies, particularly iron, can help to confirm the diagnosis.

Prevention and Control

- Sanitary disposal of human faeces
- Wearing of footwear
- Health education
- Treatment of infected individuals

Annelida

Hirudo medicinalis



They are hermaphrodites and may lay eggs in cocoons.

Leeches are subdivided based on physique, which include:

1. Pharyngobdellida have no jaws or teeth hence swallow the prey {small invertebrates} whole.
2. Arhychobdellida have three muscular jaws which have rows of teeth for cutting, and produce a non-enzymatic secretion called hirudin which prevents blood clotting.
3. Rhychobdellida have muscular proboscis that allow them to feed on blood drawn form tissues beneath an organism's skin. Secrets enzyme hemetin which dissolves clots once formed.Due to these characterizes, *Hirudo medicinalis* from their enzyme hirudin, are used in medical therapy –Hirudotherapy.

   Their saliva also contain an anesthetic so their victims do not feel them break their skin

   Hirudo medicinalis can consume between 5 – 15 ml of blood which is almost 4 – 6 times their body weight in a single feeding, this is due to large branched gastric caecci or pouches that allow them to expand during feeding.

they are used in microsurgery, they provide an effective means to reduce blood coagulation

Side effects and benefits

- They rarely lead to serious complications. The normal pain of treatment and short term itching are regular side effects.
- The benefits of leech therapy are not only the amount of blood that the leech removes, It is the anti-blood clotting enzymes in their saliva that allow blood flow.
- They normally carry parasites ,viruses and bacteria from their pervious blood source which can survive for months in them. This could probably be transmitted to humans.
- After leeches drop off, the edges of the wound swell for 12 – 48 hours accompanied by tension , heat and reddening .Small blood spots develop below the skin and around the leech bites

MEDICAL ENTOMOLOGY

Entomology: The science that study insects (Entomon = Insecta) and other species belonging to Phylum Arthropoda, in relation to health, and its control.

Medical entomology: Study of vector, vector borne diseases and abnormalities caused by insects.

Vector: Vector are mostly insects which carry and transmit disease agents from patient to healthy person; or from disease sources to uninfected food or drinks.

Arthropodes are divided into 5 classes

I. **Class Insecta** --- Medically important insect :

* Order Diptera
* Order Anoplura
* Order Hemiptera
* Order Siphonaptera

II. **Class Arachnida**

III. **Class Crustacea**

IV. **Class Chilopoda**

V. **Class Diplopoda**

Characteristics of Arthropodes:

- Multicellular animal (metazoa)
- Symmetric, bilateral
- Segmented body
- Possess an exoskeleton
- Appendages : antennae, palpa etc**.**

ROLE OF ARTHROPODA

Insects may act as

- Vector/transmitter of disease agents
- As direct cause/etiology of disease or injury

Mode of transmission

Two modes of transmission

- As mechanical vector
- As biological vector

<u>Role as mechanical vector</u>

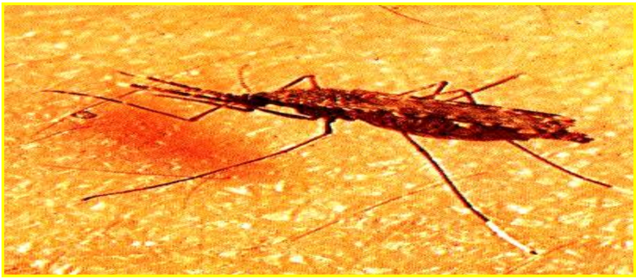
disease agents do not develop or multiply inside the vector,ex. gastroenteritis agents in.

- Transmission occurs through the proboscis, legs, body, wings

ROLE AS BIOLOGICAL VECTOR

- ☒ Disease agents develop or multiply inside the vector.
- ☒ Transmission occurs through the proboscis

Example :*Plasmodium sp.* at *Anopheles sp.*



Anopheles , vector of malaria

Role as the cause of disease

<u>Disease or injury may be caused by insects through various means</u> :

- Mechanical injury
- Injection of poisonous substances
- Allergies
- Psychosis

<u>Mechanical injury</u>

- ☒ Bites - sting - piercing and bloodsucking - larval movement

<u>Injection of Toxic substance</u>

Poison enters through :

- Direct contact (caterpillars), bites (spider), sting (scorpion), piercing (mosquito)

Common symptoms :

- Itching, swelling, urticaria (mosquito, caterpillars)
- Hemolysis (scorpion)
- bleeding (bees)
- Nerve damage (scorpion**)**

Allergies

- **Dyspnea /asthma : caterpillar.**

Psychosis

- Entomophobia

A. Mosquitoes

Example :

Main vectors of malaria: *Anopheles*

B. **Flies**:

Examples :

- sand fly: As vector of leishmaniasis
- Tse tse fly: As vector of Arfiican sleeping disease
- *Musca domestica:*
  - Adult flies may act as mechanical vector of many disease agents : protozoa, worm eggs, bacteria, virus.
  - Larva stage may invade human tissue causing a disease called myiasis

C. Mites:

Example : Scabies Mites

Parasites and Environment

- Parasites are often occupying the 3rd great environment (aquatic-terrestrial-parasitic)
- Traditionally, only considered to be protists, worms, and arthropods.
- Now known to encompass everything from prokaryotes up to the diversity of metazoans.
- One of the most common lifestyles in existence, with an estimate 1/3 of life being parasitic,
- In fact, of the animal phyla, only echinoderms, chordates, and a few minor phyla do not have representative parasitic members.

There are a variety of ways that environmental changes affect parasites, suggesting that information on parasites can indicate anthropogenic impacts. Parasitism may increase if the impact reduces host resistance or increases the density of intermediate or definitive hosts. Parasitism may decrease if definitive or intermediate host density declines or parasites suffer higher mortality directly (eg. from toxic effects on parasites) or indirectly (infected hosts suffer differentially high mortality). Although these scenarios are opposing, they can provide a rich set of predictions once we understand the true associations between each parasite and impact. Some studies discuss how parasite ecologists have used and can use parasites to assess environmental quality.

مقرر (علم الحيوان Zoo 101– Zoology I "جزء الخلية والأنسجة") لطلاب الفرقة

الأولي بكلية العلوم شعبة البايوتكنولوجي للعام الدراسي 2022/2023 - التيرم الأول

د/ سهام علي مبارك- المدرس بقسم علم الحيوان

- **رؤية جامعة جنوب الوادي 2018 -2023**

التميز في التعليم العالي لبناء تنمية مستدامة في صعيد مصر

- **رسالة جامعة جنوب الوادي 2018 -2023**

تسعي جامعة جنوب الوادي الى إعداد الخريجين لممارسة مهنية وبحثية منافسة إقليميا وعالمياً من خلال قدرة مؤسسية وفاعلية تعليمية جاذبة وداعمة تمكن الطلاب من اكتساب مهارات متطورة، وباحثين قادرين على تطوير تخصصاتهم بتقديم بحوث إبداعية وتطبيقية، وتقديم خدمات مجتمعية وبيئية متميزة تسهم في التنمية المستدامة من خلال بناء شراكات استراتيجية فاعلة وتعزيز القيم الوطنية والهوية الثقافية، والتطوير المستمر لبرامج وكليات الجامعة وإداراتها وتأهيلها للاعتماد، ورفع جاهزية وتنافسية الجامعة واستقلال فرعيها والتوظيف الأمثل للموارد.

- **رؤية كلية العلوم 2018 -2023**

التميز في تعليم العلوم الأساسية والبحث العلمي للمساهمة في التنمية المستدامة

- **رسالة كلية العلوم 2018 -2023**

تقديم تعليم مميز في مجالات العلوم الأساسية وإنتاج بحوث علمية تطبيقية للمساهمة في التنمية المستدامة من خلال إعداد خريجين متميزين طبقا للمعايير الأكاديمية القومية، وتطوير مهارات وقدرات الموارد البشرية، وتوفير خدمات مجتمعية وبيئية تلبي طموحات مجتمع جنوب الوادي، وبناء الشراكات المجتمعية الفاعلة.

﴿ الغايات والأهداف الإستراتيجية ﴾

الغاية الأولي: إمداد المجتمع بخريج متميز ذو قدرة تنافسية في السوق.

- تحسين البيئة التحتية التعليمية للكلية بما يتوافق مع المعايير القياسية القومية
- التطوير المستمر للبرامج التعليمية
- تنمية مهارات الطلاب بما يفي مع متطلبات سوق العمل
- تنمية كفايات هيئة التدريس بما يحقق مواصفات الخريج
- تعزيز مهارات الجهاز الإداري

الغاية الثانية: تطوير برامج الدراسات العليا والبحث العلمي.

- التقويم المستمر لبرامج الدراسات العليا
- تحسين البيئة التحتية البحثية
- تسويق البحوث العلمية وبرامج الدراسات العليا
- تطوير الخطة البحثية سنويا

الغاية الثالثة: المشاركة في التنمية المستدامة لخدمة البيئة وتنمية المجتمع.

- تنمية الوعي البيئي للمجتمع المحيط
- تطوير أداء الوحدات ذات الطابع الخاص
- بناء شراكات مجتمعية فعالة لتحقيق التنمية المستدامة
- تنمية الوعي الوطني

Contents

Microscopes

Types of microscopes

1 Light microscope.

2 Phase contrast microscope.

3 Polarizing microscope.

4 Fluorescence microscope.

5 Electron microscope.

1- Light microscope

I- Illuminating system (source of light):

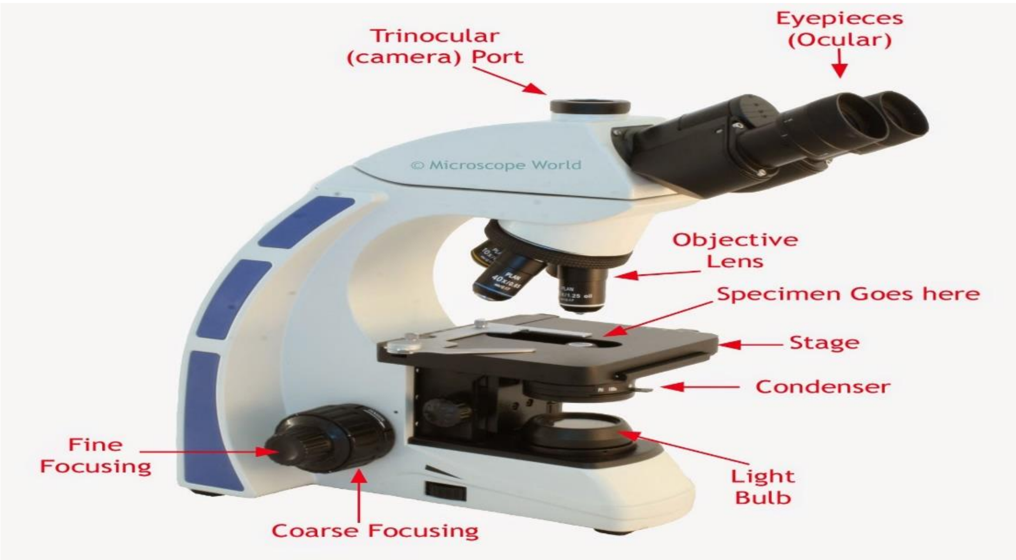
- Day light.
- Electric light.

II- Optical system:

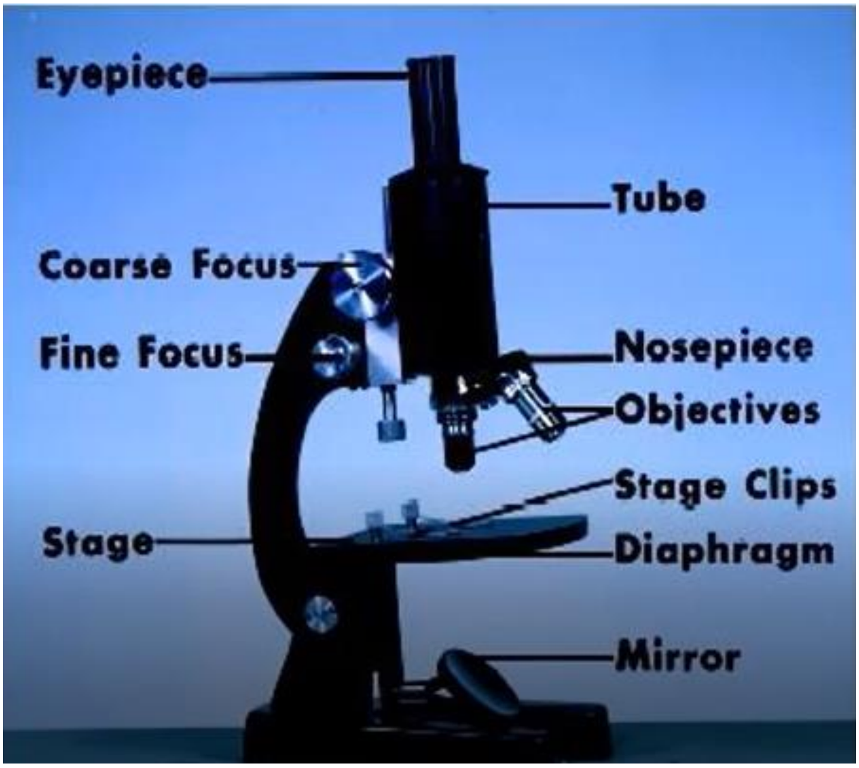
- *Condenser lens:* collect and focus light on the specimen.
- *Objective lenses:* provide initial magnification (x4, x10, x40, x100).
- *An ocular lens (eyepiece):* magnifies the primary

image a second time (x5, x10, x15).

III- Focus adjustment knobs: focus the image by moving the stage up and down.

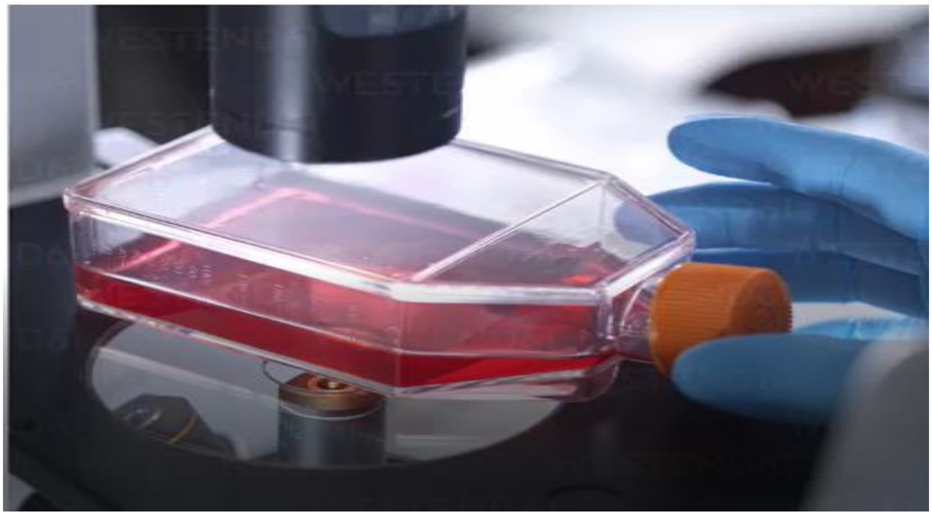


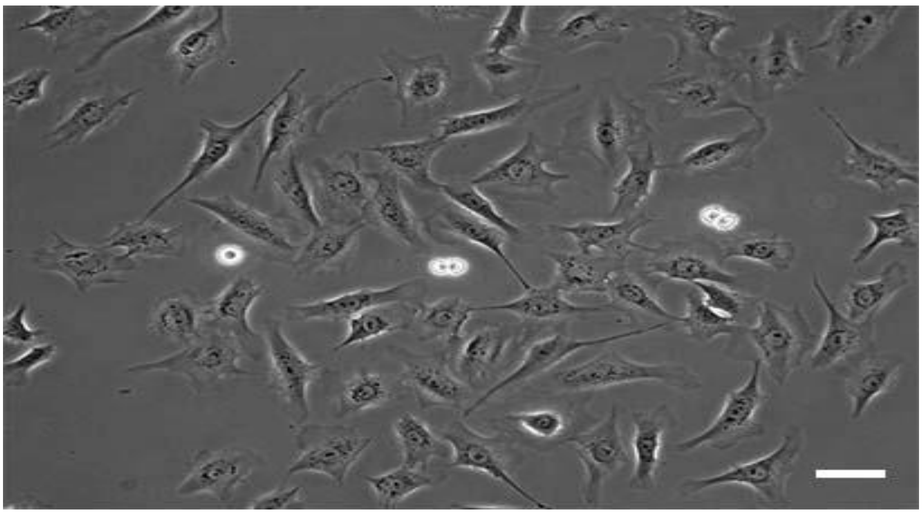
Total magnification= Magnifying power of the objective lens x magnifying power of ocular lens



2- Phase contrast microscope

- **Use:** for unstained living histological specimen.



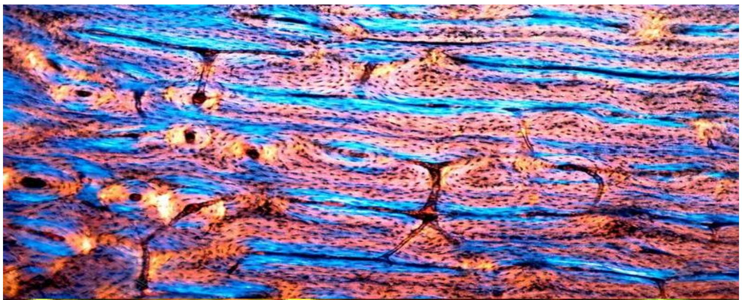


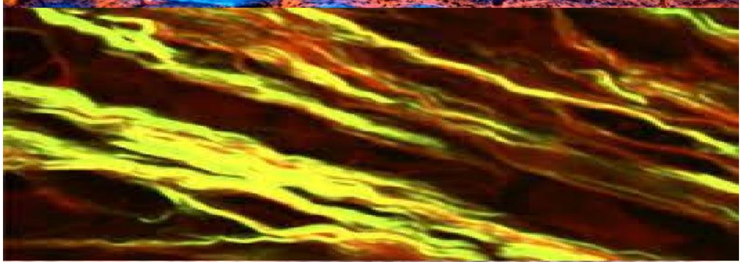
3- Polarizing microscope

- **Use:**

➢ Regularly oriented structures (bone).

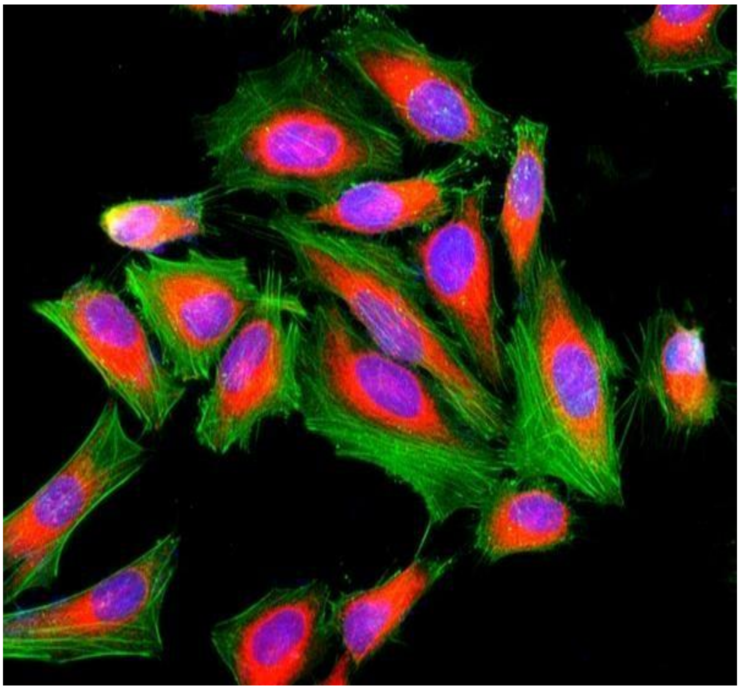
➢ Structures with linear symmetry (collagen, muscle, microtubules, cilia& flagella).





4- Fluorescence microscope

- **Light source:** ultraviolet light source.
- **Stain:** fluorescent stain.
- **Idea:** the specimen absorbs the UV light and emits light of a longer wavelength.
- **Use:** immunohistochemistry.



5- Electron microscope

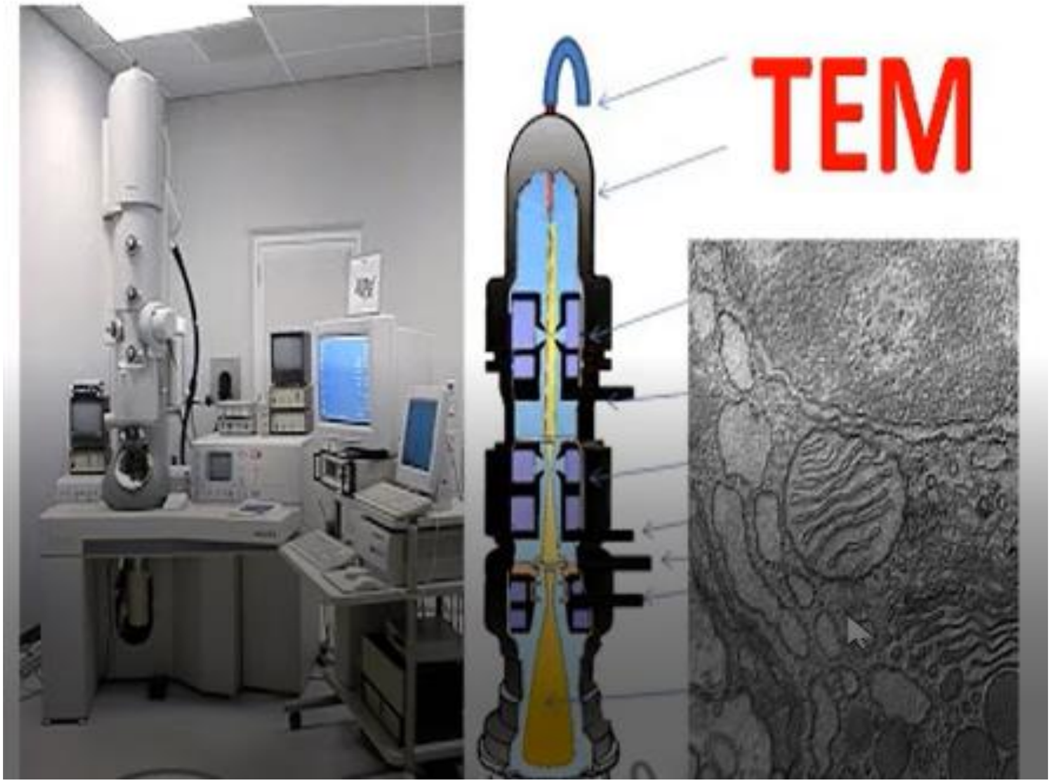
- **Illuminating system:** electron beam.
- **Types:**

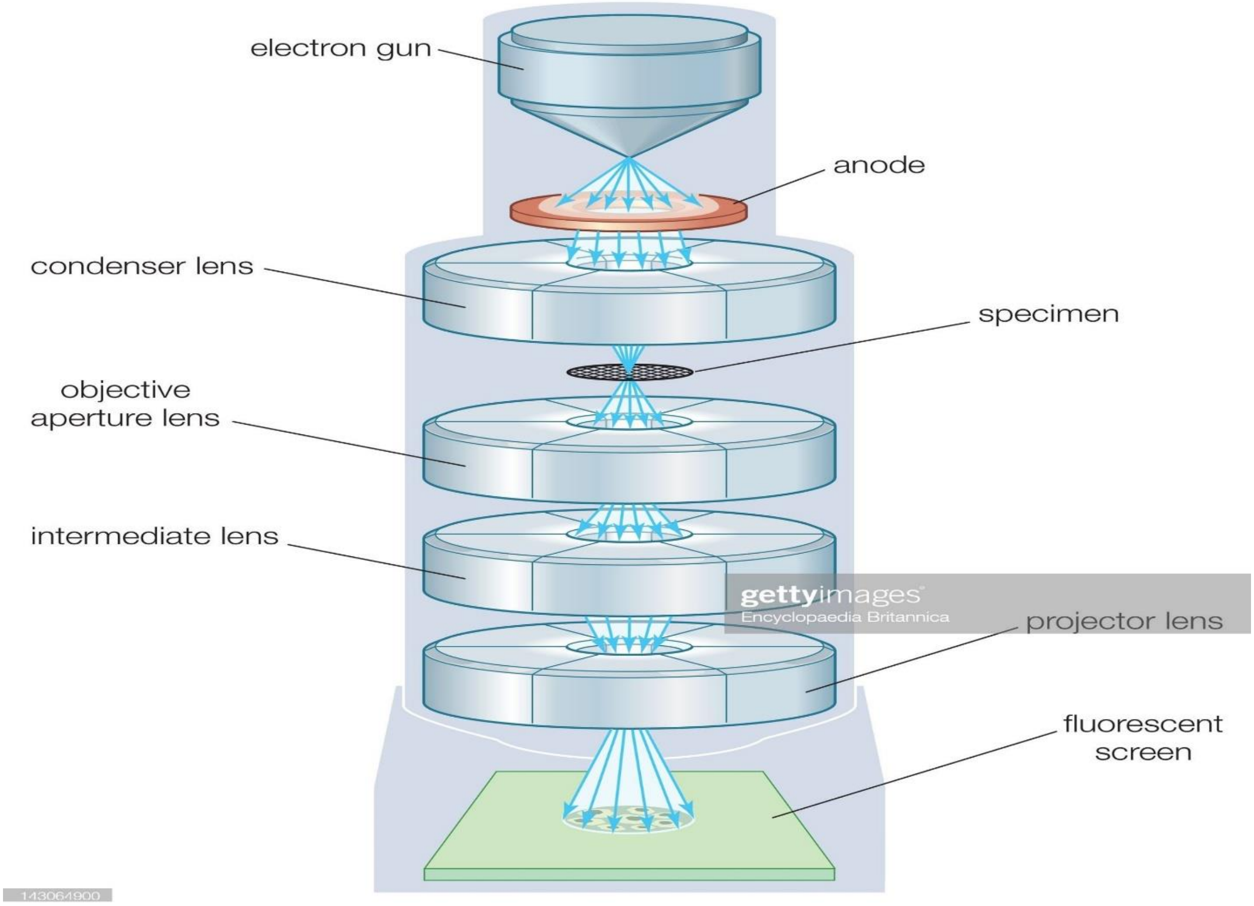
1- Transmission EM:

- It gives details about <u>the cellular and intercellular structures.</u>
- An electron gun at the top of a TEM emits electrons.
- An electromagnetic lens focuses the electrons into a very fine beam.
- This beam then passes through a very thin specimen.
- Another electromagnetic lenses form and magnify the image.
- The final image is viewed on a fluorescent screen.

2- Scanning EM:

- Gets 3-D image of <u>the surface</u> of the specimen.




electron gun
anode
condenser lens
specimen
objective
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projector lens
fluorescent
screen
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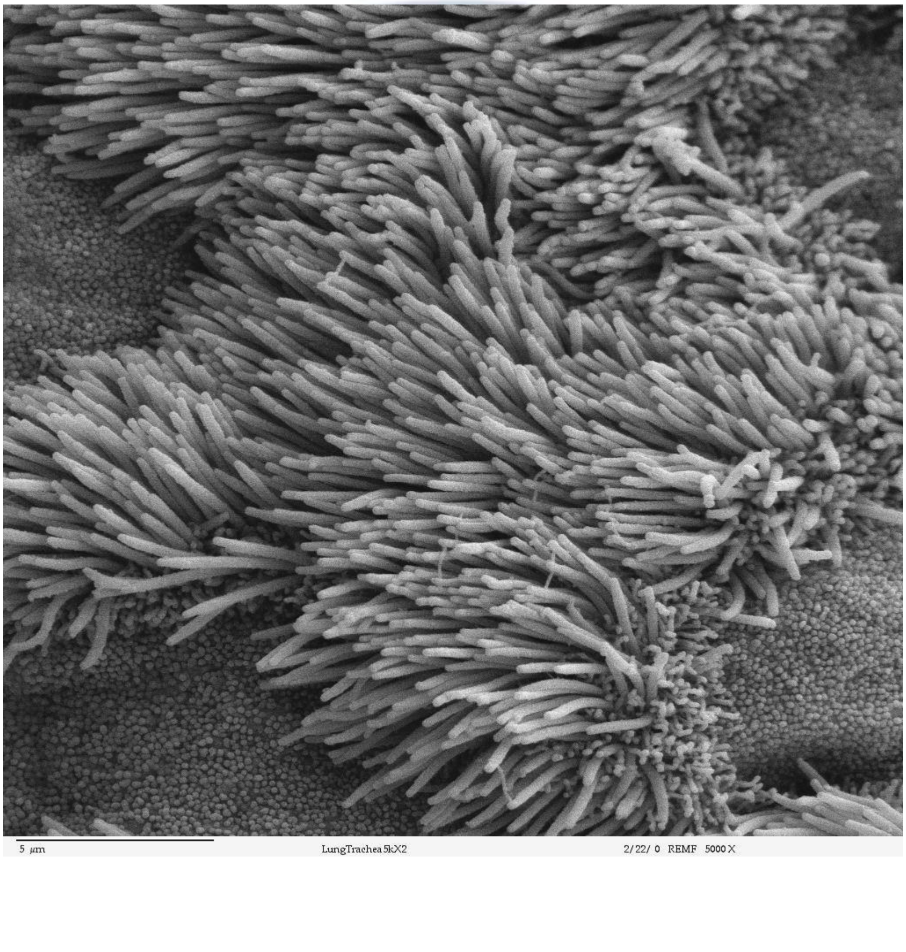
SEM


5 µm
LungTrachea 5kX2
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Type of microscope	LM	EM
1- Source of light	Day or electric light.	Beam of electrons.
2- Lenses	Glass lenses.	Magnetic fields.
3- Magnification	Up to 1500 .	Up to 1000.000.
4- Embedding	Paraffin.	Plastic.
5- Sectioning knife	Rotatory microtome: steel knife.	Ultra microtome: glass or diamond knife.
6- Staining	Any stain.	Lead citrate& osmium tetroxide.
7- Thickness of section	5-9 microns.	50-90 nm.
8- Microphotographs	Colored according to stain.	Black& white.

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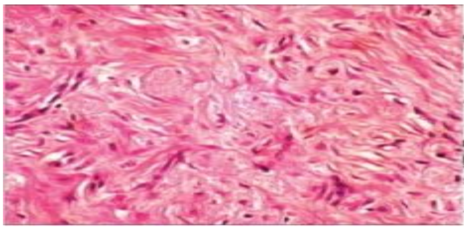
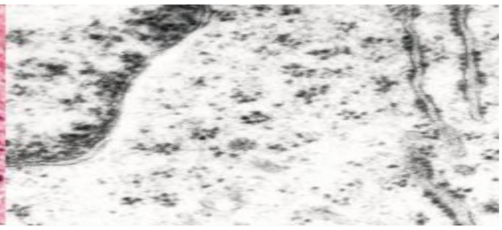
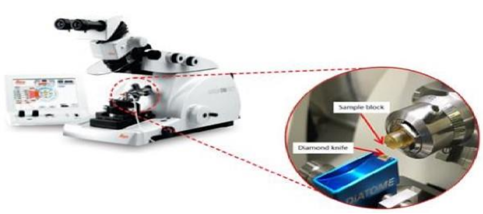
LM	EM
	
	

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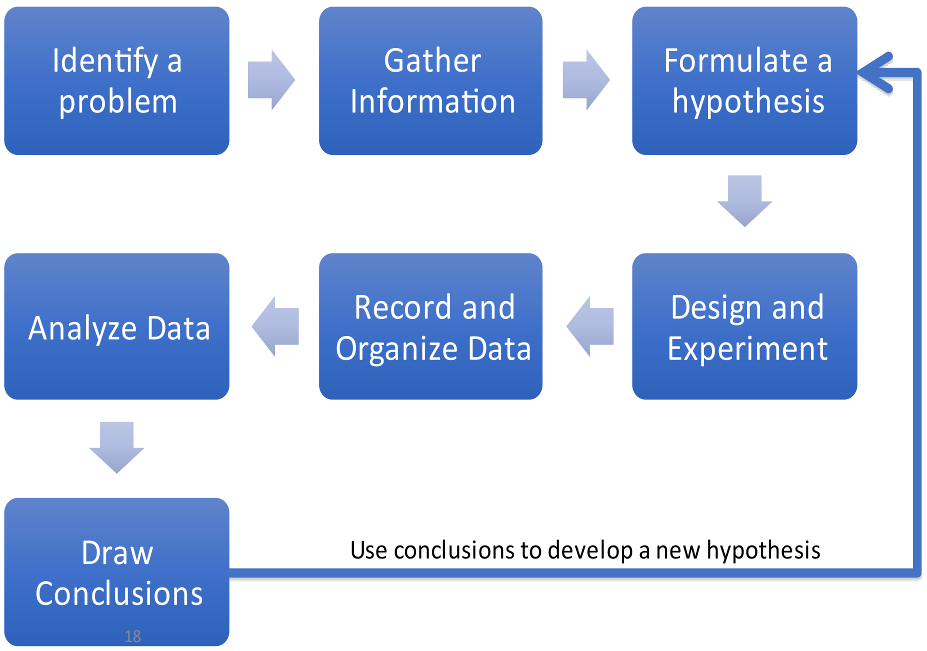
Steps of the Scientific Methods

<u>Introduction</u>

- **A logical, <u>problem solving</u> technique**



<u>Step 1: Identify a Problem</u>

- **Observe the world around you**
  - **Using <u>observations</u>, identify a problem you would like to solve**
    - **Example: Why do termites follow the ink line?**
- **This is a question you DO NOT know the answer to and can't look up.**
- **"Why" and "What would happen if.." are good beginnings of scientific questions.**

Remember?

Observation

- Uses our **senses** to gather information
- **Qualitative**: uses our 5 senses
  - The termites follow a circle made with a blue pen on white paper
- Quantitative: uses **numbers**
  - 3 termites follow a circular blue pen line that is5 cm in diameter

Inference

- A logical interpretation of events based on prior **knowledge** or **opinion**
  - Educated guess
- Termites follow the blue line because the like it.

Do we use observations or inferences when identifying a problem?

Step 2: Gather Information

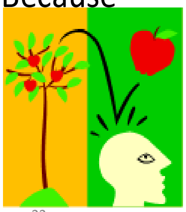
- Use references to do background research
  - Books
  - Journals
  - Magazines
  - Internet
  - TV
  - Videos
  - Interview Experts

- Example: Termites
  - Live underground
  - Don't have compound eyes (can only see light and dark)

Step 3: Formulate a Hypothesis

Hypothesis

- Possible answer to a question that can be tested
- based on **observations** and knowledge
- "If" "Then" "Because" statement



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Example: Termites

- Termites:
  - I hypothesis that ***if*** the termites follow a dark colored pen on a dark background ***then*** they follow the dark pen on a light background ***because*** of the color contrast since they see light and dark, but not color.

Do we use observation or inference to formulate a hypothesis?

Step 4: Develop an Experiment

Materials:

- **A list of all the things you need**
- Supplies

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Procedure

- Step by step instructions
- Identifies the variables used in the experiment

How would you describe how to make a Peanut Butter and Jelly Sandwich to someone who had never done it?

To someone who didn't know what peanut butter or jelly is?

Variables: Independent Variable

- The variable <u>I</u> (the scientist) change or manipulate
- Examples:
  - The color of paper under the termites
  - The color of pen used
  - The brand of pen used

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Variables: Dependent Variable

- Is **<u>measured</u>** in the experiment
- Changes because of the independent variable
- "Depends" on the independent variable
- Examples:
  - Does the termite follow the line (yes/no)
  - How many termites follow the line (whole number)
  - How long do the termites follow the line (time)

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Variables: Constant

- All the factors in the experiments that are kept the **same**
- Everything except the independent variable
- Keeps the experiment 'fair'

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Examples:

- If you test color of paper, keep the color of pen constant
- If you test the smell of pen, keep the color and type of pen constant (only change smell)
- The exact termites used
- The time of day and how long the termites are there
- The shape of the line drawn

Variable:Control

- The normal condition that you compare the other conditions to
- Recreate the conditions you first observed
- Example:
  - Termites in a Pitri dish on white filter paper and draw a blue line with a bic pen in the same shape as before.

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Step 5: Record and Organize Data

- Write all observations and measurements
- Use a table to organize your data
  - List your **independent** variable on the left side
  - Record your dependent variables on the **right side**
    - If you have more than one dependent variable, use a new column for each dependent variable

Independent Variable	Dependent Variable: Did they follow the line?
Blue ink on white paper	Yes/No
Blue ink on black paper	Yes/No

Which one of these independent variables is the control?

28 Which part of the independent variable is the constant?

Step 6: Analyze Data

- "A picture is worth a thousand words"
- Compare and look for trends and patterns using graphs

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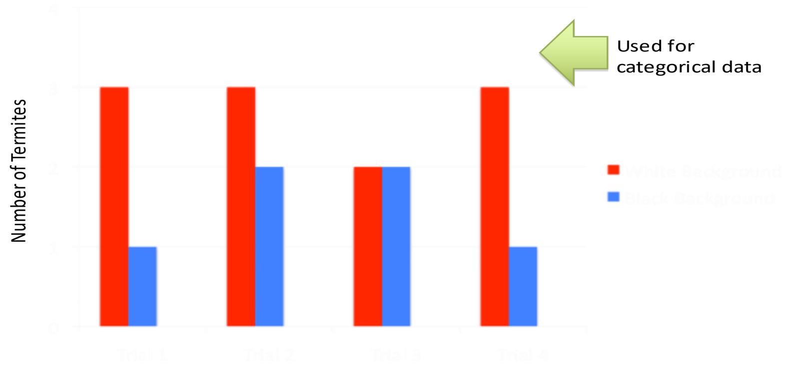
Bar Graph



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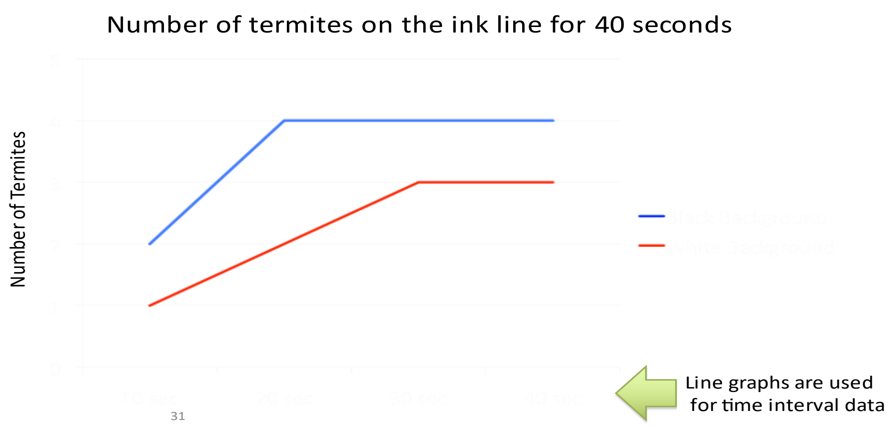
Line Graph



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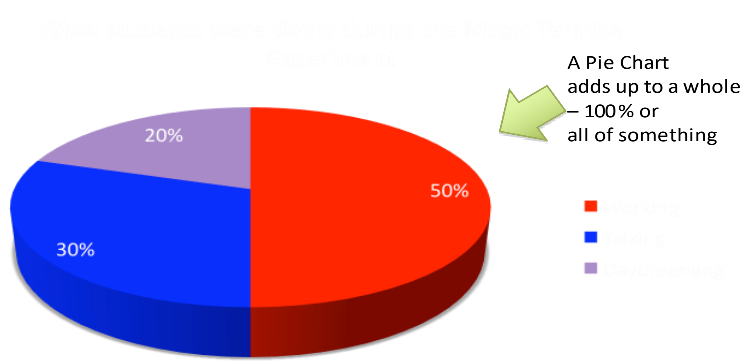
Pie Chart



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Step 7:Make Conclusions

- You must repeat the experiment to make the data valid
- You should run your experiment at least **3** times to confirm your results
  - You can run all the experiments at one time, or run one after the other
- Each separate experiment is called a **Repetition** (or Rep).

How many times?

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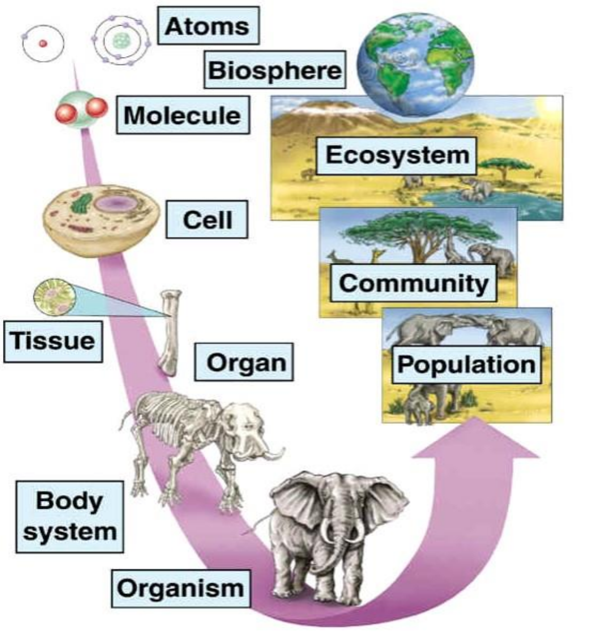
Levels of Organization in BIOLOGY…



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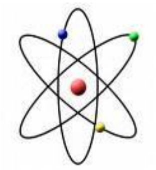
From the smallest level.



1. ATOMS

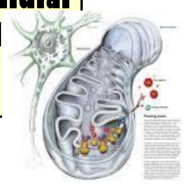
The smallest unit of matter that cannot be broken down into anything simpler by chemical means.

2. Molecules

The smallest units of most compounds formed by the chemical bonding of atoms.

3. Organelles

Specialized structures that perform important cellular functions within cel

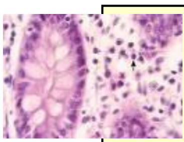


4. Cell

The smallest unit of life collections of living mat enclosed by a barrier th separates them from the surroundings.

35

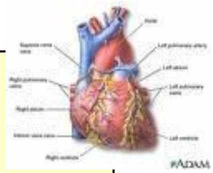
From the smallest level.



5. Tissues

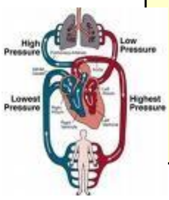
Groups of similar cells that perform a particular function.

6. Organs



Groups of tissues that work together to perform closely related functions.

7. Organ Systems



Groups of organs that work together to perform closely related functions.

8. Organisms

Living things composed cells (multicellular organisms).

Species =a group of organisms so similar to one another that they can breed and produce FERTILE OFFSPRING.

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...to the largest level

9.Population

Groups of individuals of the same species that live in the same area.

10. Community

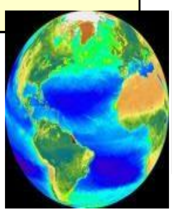
Groups different populations that live together in a defined area.

11.Ecosystem

Groups of all the organisms that live in a particular place, together with their nonliving environment.

12. Biome

Groups of ecosystems that have the same climate and similar dominant communities



13. Biosphere

Part of the Earth in which life exists including land,water,air and atmosphere.

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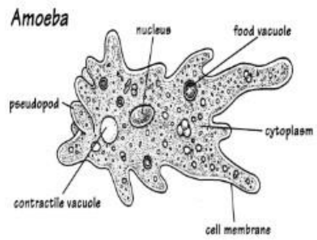
Cytology

Organisms and Cells



- Some organisms are unicellular.
  - This means they are made of only one cell.
  - Examples: bacteria, yeast
- Some organisms are multicellular.
  - This means they are made of many cells.
  - Examples: humans, trees

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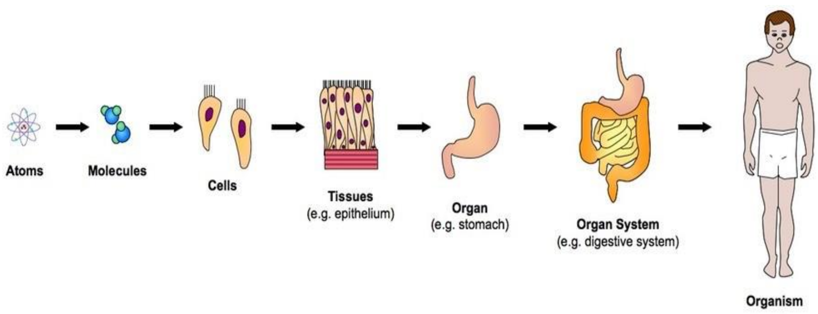
Organisms and Cells

- Unicellular organisms have nothing but a single cell.
- However, multicellular organisms have many more levels of organization to make sure the whole body can work correctly, even when it is doing many things at the same time.



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There are 5 Levels of Organization in Multicellular Organisms:

- 1. Cells
- 2. Tissues
- 3. Organs
- 4. Organ Systems
- 5. Organisms

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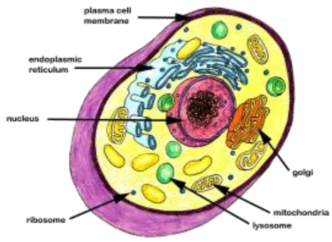
The CELL

The **cell** is the basic unit of life.

Cells are specialized by size and shape for the job they do.

Example: skin cell

The paramecium above is made of only one cell and it must perform all the jobs of the organism.



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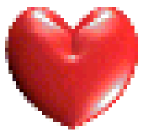
T I S S U E S

Tissues are made of the same type of cells grouped together to do a specific job.

Human Body Tissues

Example: Humans have four kinds of tissue in their Bodies: Epithelia, Muscle, Connective, and Nerve.



Organs

Organs are made up of different tissues that work together to do a job.

Example: a heart is an organ .

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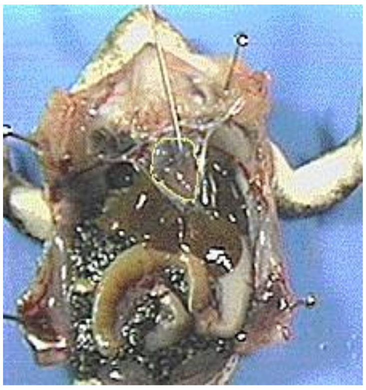
Organ Systems

An organ system is a group of organs working together.

Examples:

- Human organ systems include circulatory, reproductive, digestive, nervous, respiratory.
- Plant organ system-roots, stems, leaves= transport system.



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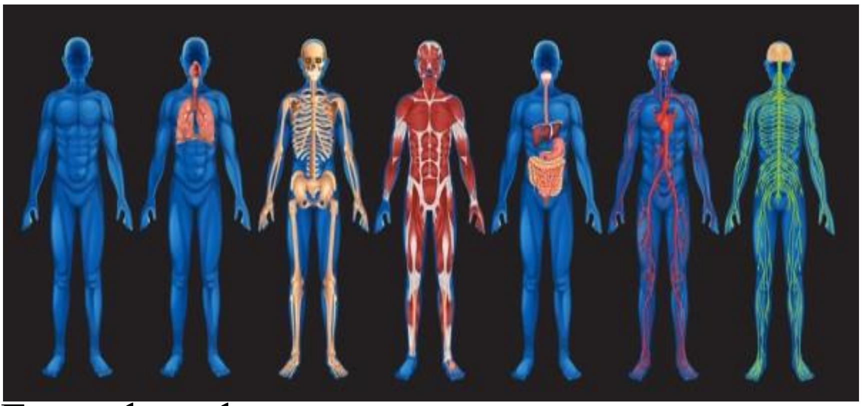
Organisms

All cells, tissues, organs and organ systems working together makes an organism.



Example: a human

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The Cell Theory

The cell theory (proposed independently in 1838 and 1839) is a cornerstone of biology.

All organisms are composed of one or more cells.

Cells are the smallest living things.

Cells arise only by division of previously existing cells.

All organisms living today are descendents of an ancestral cell.

Schleiden

Schwann

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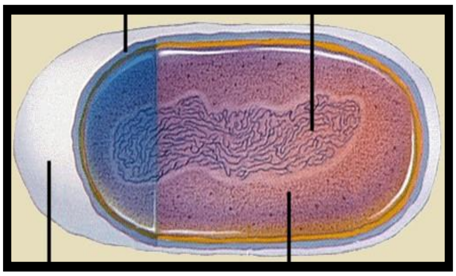
Two Fundamentally Different Types of Cells



A prokaryotic cell

A eukaryotic cell

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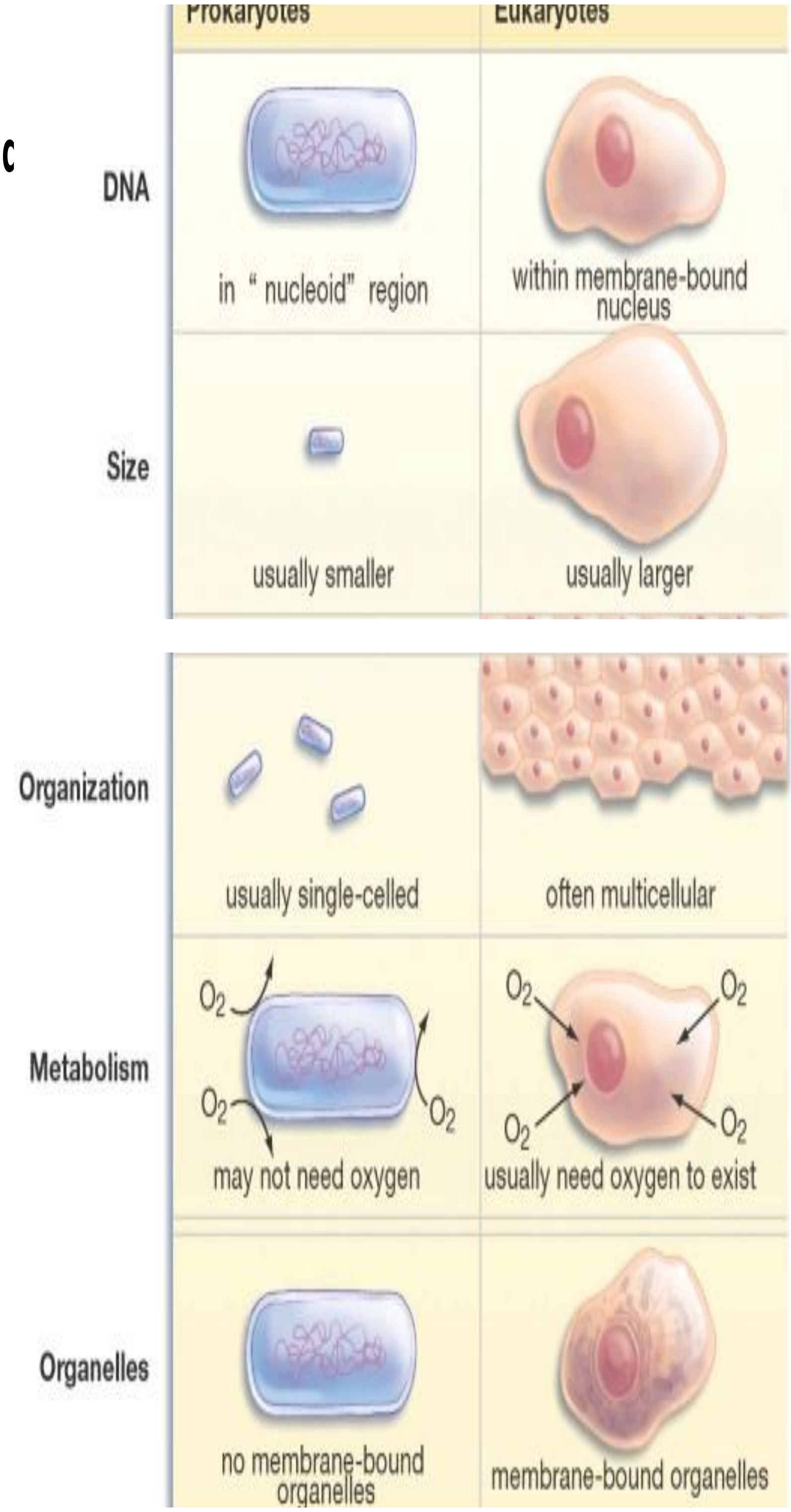
Us vs. Them -Eukaryotes anc Prokaryotes



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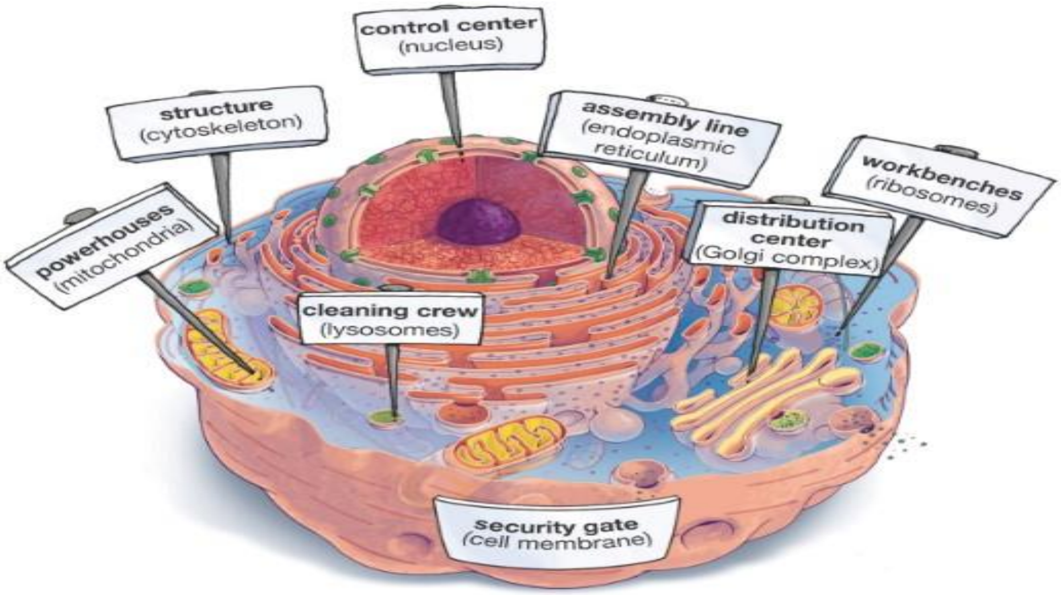
An Idealized Animal Cell



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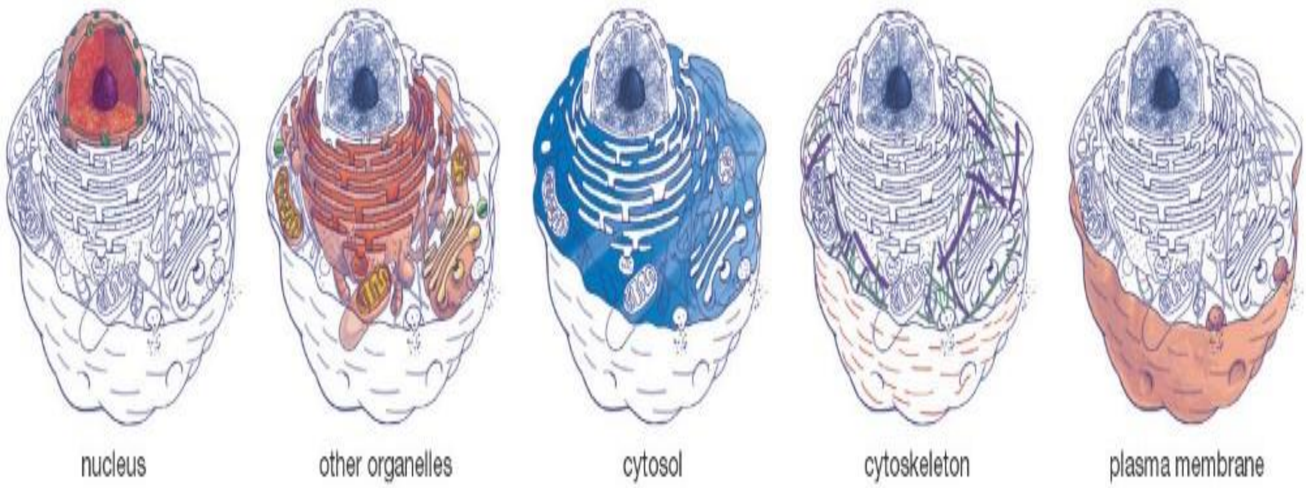
Major Divisions of the Eukaryotic Cell



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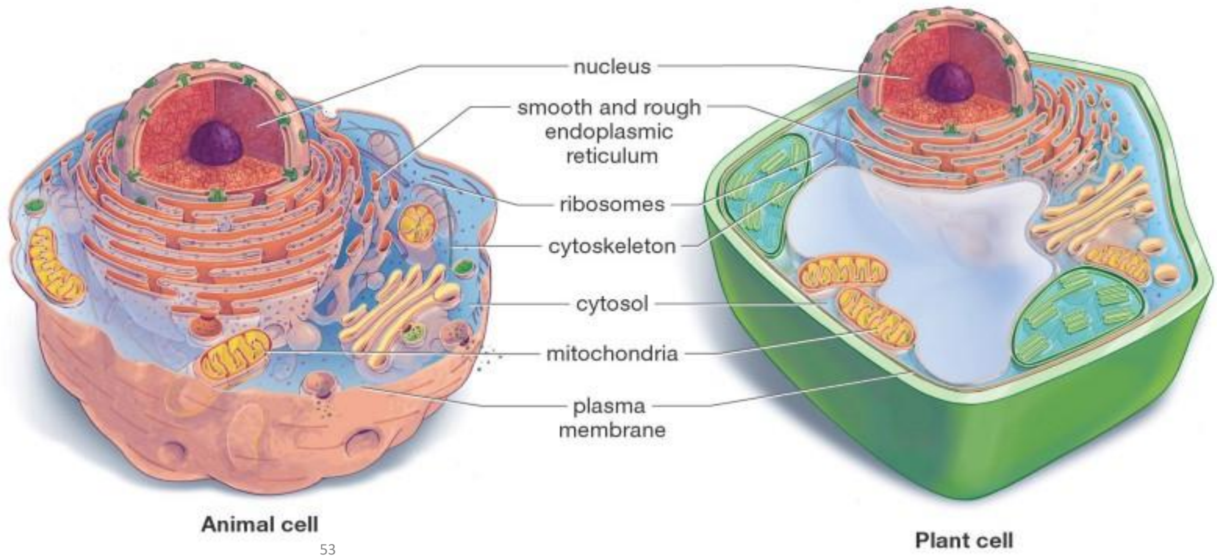
Animal and Plant Cells Have More Similarities Than Differences



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- Give the function (job) of each organelle below

a. Nucleus
b. Cell membrane
c. Mitochondrion
d. Endoplasmic reticulum
e. Golgi body
f. Vacuole
g. Lysosome
h. Cytoskeleton

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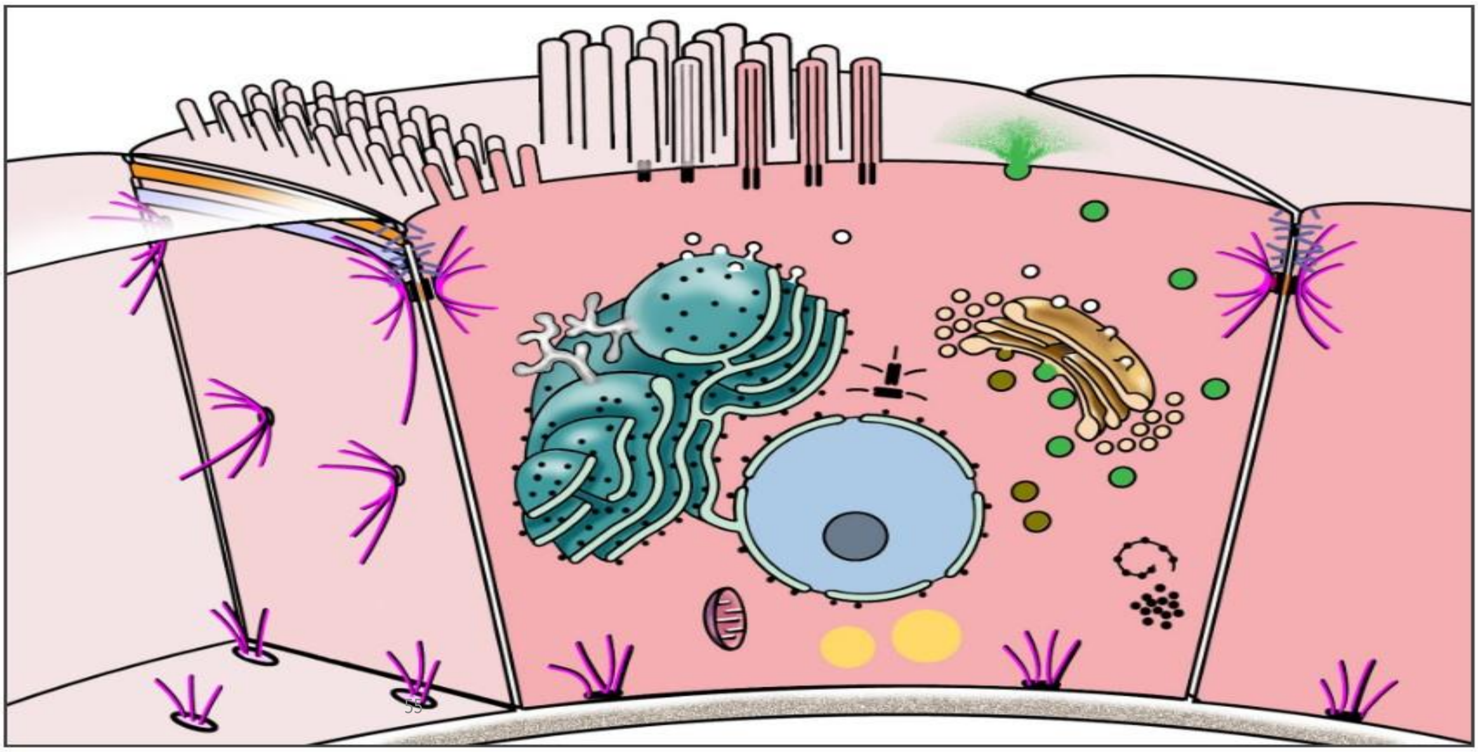
- **Overview of cell structures**

- The cell consists of two major compartments, cytoplasm and nucleus. Located throughout the cytoplasm are membranous organelles, e.g., endoplasmic reticulum, lysosomes and mitochondria, as well as non-membranous organelles, e.g., polysomes and centrioles. The nucleus is surrounded by two membranes which are continuous with the endoplasmic reticulum.



- **Cells are the structural units of all living organisms.**
- Although there are approximately 200 different cell types in the body, cells are more alike than different. Specialization of function, (e.g., glandular cells for secretion or muscle cells for contraction) is really an emphasis of a function that all cells possess to some degree. In some cases, cells have become so specialized that some functions are lost altogether (e.g., cell proliferation).
- Cells vary in size and shape according to location and function.
- Cells widely vary in diameter, from the largest, the mature human ovum (120 microns) to the smallest, the red blood cell (7-8 microns).
- Cells vary in internal structure depending upon their function. Specialized cells possess abundant internal structures related to their specific function, e.g., contractile filaments in muscle cells or secretory granules in gland cells.
- Cells vary in their life history, for example, rates of cell renewal.

Functions of cells

As you already know that a cell is a structural and functional unit of living. Let us study 6 of the most vital functions performed by a cell.

1- Structure and Support

You know a house is made of bricks. Similarly, an organism is made up of cells. Though there are certain cells such as collenchyma and sclerenchyma are present for offering structural support however in general too, all cells generally provide the structural basis of all organisms.

2- Growth

In complex organisms such as humans, the tissues grow by simple multiplication of cells. Hence, cells are responsible for the growth of the organism. The entire thing takes place via a process of mitosis.

3- Transport

Cells import the nutrients that are used in the different chemical process which take place inside them. As a result of these processes, a waste product is produced. Cells then work to get rid of this waste. In this manner, the small molecules like such as oxygen, carbon dioxide, and ethanol pass through the cell membrane by diffusion. This method is known as passive transport. On the other hand, the larger molecules like the proteins and polysaccharides, go in and out of the cell via active transport.

4- Energy Production

Organisms need energy to perform different chemical reactions. In plants, the energy comes from the process of photosynthesis while in the animals the energy comes via respiration.

5- Metabolism

Cell is responsible for metabolism that includes all the chemical reactions that take place inside an organism to keep it alive.

6- **Reproduction**

A cell helps in reproduction by the processes of mitosis (in more evolved organisms) and meiosis.

- **Chemical Composition of the Cell**

Chemical compounds in the cell can be divided into two major groups: Organic and Inorganic compounds

Organic compounds are chemical compounds that contain the element carbon. Organic compounds in the cell include carbohydrates, protein, lipids and nucleic acids. Some of these compounds are synthesized by the cell itself.

Water is an inorganic compound which is composed of hydrogen and oxygen. It is an important compound in the cell.

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Table : inorganic chemical compounds in the cell.

Percentage of Body Weight	Element	Usage
65%	Oxygen	This element is obviously the most important element in the human body. Oxygen atoms are present in water, which is the compound most common in the body, and other compounds that make up tissues. It is also found in the blood and lungs due to respiration.
18.6%	Carbon 60	Carbon is found in every organic molecule in the body, as well as the waste product of respiration (carbon dioxide). It is typically ingested in food that is eaten.

9.7%	Hydrogen	Hydrogen is found in all water molecules in the body as well as many other compounds making up the various tissues.
3.2%	Nitrogen	Nitrogen is very common in proteins and organic compounds. It is also present in the lungs due to its abundance in the atmosphere.
1.8%	Calcium	Calcium is a primary component of the skeletal system, including the teeth. It is also found in the nervous system, muscles, and the blood.
1.0%	Phosphorus	This element is common in the bones and teeth, as well as nucleic acids.
0.4%	Potassium	Potassium is found in the muscles, nerves, and certain tissues.
0.2%	Sodium	Sodium is excreted in sweat, but is also found in muscles and nerves.
0.2%	Chlorine	Chlorine is present in the skin and facilitates water absorption by the cells.
0.06%	Magnesium	Magnesium serves as a cofactor for various enzymes in the body.
0.04%	Sulfur	Sulfur is present in many amino acids and proteins.
0.007%	Iron	Iron is found mostly in the blood since it facilitates the transportation of oxygen.
0.0002%	Iodine	Iodine is found in certain hormones in the thyroid gland.

- **The Importance of Organic Compounds in the Cell**
- **Carbohydrates**
  - Supply energy for cell processes
- A means of storing energy
- Give structural support to cell walls
- **Lipids**
- Store large amounts of energy over long periods of time
- Act as an energy source
- Play a major role in the structure of the cell membranes
- Act as a source of metabolic water
- Reduce the loss of water by evaporation

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- **Proteins**
  - Act as building blocks of many structural components of the cell ; required for growth
- Form enzymes which catalyze chemical reactions
- Form hormones which control growth and metabolism
- **Nucleic acids**
- Contain the genetic information of cells
- Play a vital role in protein synthesis

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- **The importance of water in the cell**
- Water is important for life because its chemical and physical properties allow it to sustain life.
- Water is a polar molecule which consists of 2 hydrogen atoms and 1 oxygen atom. A polar molecule is a molecule with an unequal distribution of charges. Each molecule has a positively charged and a negatively charged end. Polar molecules attract one another as well as ions. Because of this property, water is considered the solvent of life.
- It is the transport medium in the blood.
- It acts as a medium for biochemical reactions.
- Water helps in the maintenance of a stable internal environment within a living organism. The concentration of water and inorganic salts that dissolve in water is important in maintaining the osmotic balance between the blood and interstitial fluid.
- It helps in lubrication.
- Water molecules have very high cohesion Water molecules tend to stick to each other and move in long unbroken columns through the vascular tissues in plants.

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Quick review

Definition of a cell	Smallest functional unit within a living organism that can function independently
Components	Plasma membrane, cytoplasm, nucleus, membranous organelles, non membranous organelles
Membranous organelles	Nucleus, Endoplasmic reticulum, Golgi apparatus, mitochondria, peroxisomes, lysosomes, transport vesicles
Non-membranous organelles	Ribosomes, microtubules, cytoskeleton (actin filaments, intermediate filaments, centrioles)

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- ✓ The cell is the structural and functional unit of all tissues. It consists of a mass of protoplasm divided into nucleus and cytoplasm. The cytoplasm is the part of protoplasm located around the nucleus designed to perform synthetic and metabolic activities.
- ✓ The cytolplasmic matrix (cytosol) is the non-organelle component of the cytoplasm occupying the intracellular spaces between organelles and inclusions. It contains any soluble proteins, lipids, carbohydrates and small ions.
- ✓ Cytoplasmic Organelles

They are permanent, living cytoplasmic structures that perform specific functions. Two types of cytoplasmic organelles are recognized: membranous and non-membranous organelles.

► Membranous organelles

The membranous organelles are cytoplasmic organelles that possess a bounding membrane of their own and they include cell membrane, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes.

1- Cell membrane

The cell membrane (plasmalemma or plasmamembrane) is the outer membrane of the cell that acts as a barrier between its internal and external environment.

With light microscope (LM) it is too thin (8-10 nm) to be seen. The cell boundary that is often seen is mainly due to condensation of cytoplasm on the inner aspect of the cell membrane, condensation of the stain (such as silver or PAS) on the carbohydrate-rich coat and obliquity of the sections.

With electron microscope (EM) it appears as a trilaminar structure consisting of outer and inner electron-dense layers separated by an intermediate electron-lucent layer.

The molecular structure of the cell membrane

The most recent and currently acceptable model for the cell membrane is the

Fluid mosaic model

According to this model, the cell membrane is made up of three major components phospholipids, proteins, and carbohydrates.

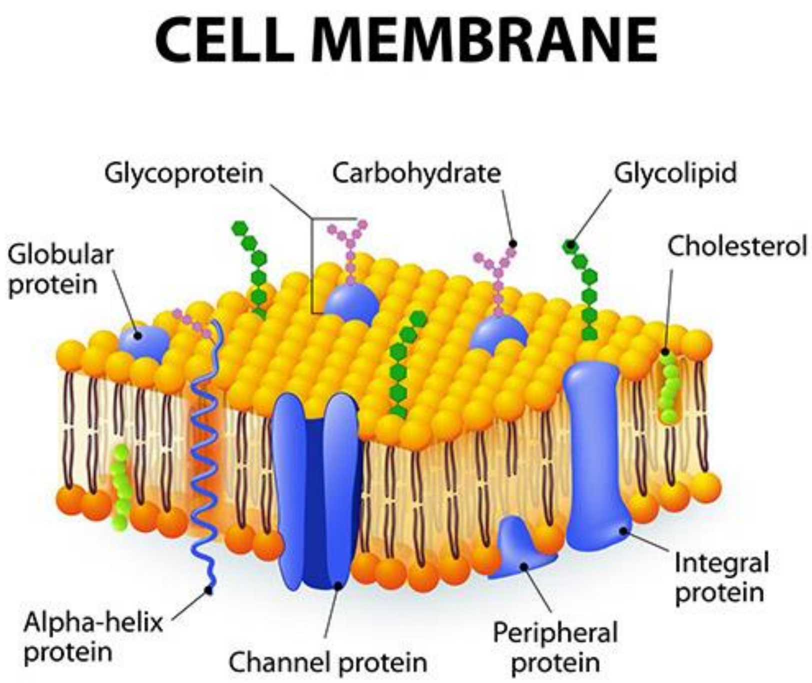
The phospholipids molecules form a central bimolecular layer. Each molecule is formed of two ends; polar or hydrophilic (has affinity with water) end, and non-polar or hydrophobic (has no affinity with water) tail. The phospholipids molecules are arranged with their hydrophilic ends are directed outward, while hydrophobic tails are directed inward toward the center of the membrane.

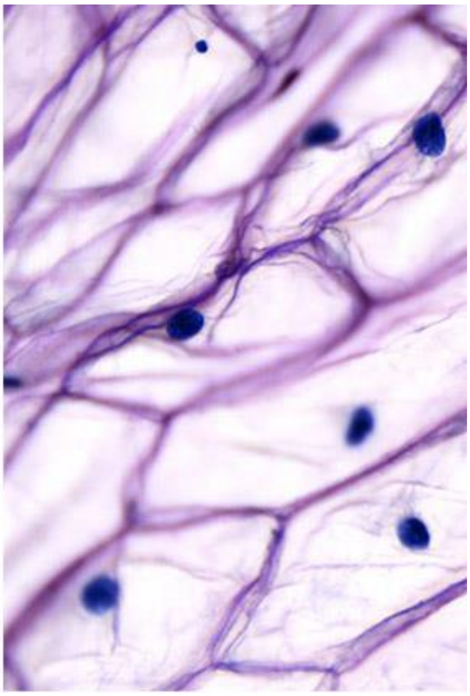
The protein is the second major constituent of the cell membrane. The protein molecules are arranged as globules moving freely within the lipid layer. Two types of protein globules are recognized: intrinsic or integral protein and extrinsic or peripheral proteins.

The intrinsic proteins are firmly attached to the lipid bilayer. Some of them extend throughout the entire thickness of the membrane and constitute transmembrane channels for the passage of water-soluble ions and molecules

The extrinsic or peripheral proteins are only partially embedded to either aspect of the membrane.

The carbohydrate fractions are conjugated with the protein (glycoprotein) and lipid (glycolipid) molecules of the cell membrane. These glycoproteins and glycolipids project from the outer surface of the cell membrane as cell coat or glycocalyx.





Functions of the cell membrane

The cell membrane is the part of the cell that regulate the exchange of molecules and ions between its internal and external environment. This occurs by several ways:

1. Passive Diffusion*:* this involves the entrance of small molecules into the cytoplasm. It depends on the presence of a concentration gradient across the plasmalemma (e.g., diffusion of lipid soluble substances, oxygen, CO2, water and small ions).
2. Facilitated Diffusion*:* this type of diffusion is also concentration-dependent and involves the transport of large water-soluble molecules such as glucose and amino acids. It requires the presence of carriers to which the molecules have to bind in order to pass through the plasmalemma.
3. Active Transport*:* this process requires the utilization of energy provided as ATP. (e.g., sodium-potassium pump).
4. Selective transport*:* it depends on the presence of specific cell surface receptors to pick up specific molecules into the cytoplasm (e.g., hormones).

5. Endocytosis and Exocytosis

Endocytosis involves either the engulfment of solid particles (phagocytosis) or minute droplet of fluid (pinocytosis). The engulfed material is surrounded first by cytoplasmic extensions called pseudopodia. When the particles become surrounded, the plasma membrane fuses and the membrane surrounding the engulfed particles forms a vesicle, known as a phagosome or endocytotic vesicle, which detaches from the cell membrane to float freely within the cytoplasm.

Once the phagosome enters the cytoplasm it fuses with the lysosomes and their contents are subjected to enzymatic digestion.

6. Exocytosis

Exocytosis (Exo = out) is the process by which some membranous vesicles located within the cytoplasm fuse with the plasma membrane and release their contents outside the cell. It occurs in many secretory processes.

Functions of the cell coat (Glycocalyx)

- Mechanical and chemical protection the cell membrane.
- Aids in the induction of immunological (antigen-antibody) response.
- Site for binding of hormones.
- Shares in the formation of intercellular adhesions.
- Contributes to the formation of the basement membrane.
- Cell recognition.

Other functions of the cell membrane include

- Transmission of nerve impulses in muscle and nerve cells.
- Myelin sheath formation (Schwan cell around peripheral nerves).
- Share in the formation of microvilli, cilia, flagella and cell junctions.

2- Mitochondria

Mitochondria are membranous organelles involved primarily in cell respiration and energy production.

With LM, they appear as granules, rod-like or thread-like. Their size rage from 5-10 mm length and 0.5-1 mm in diameter. The number is highly variable according to the energy requirements of the cells. Liver cells (active cells) contain as many as 1000 mitochondria. Small lymphocytes (inactive cells) contain very few.

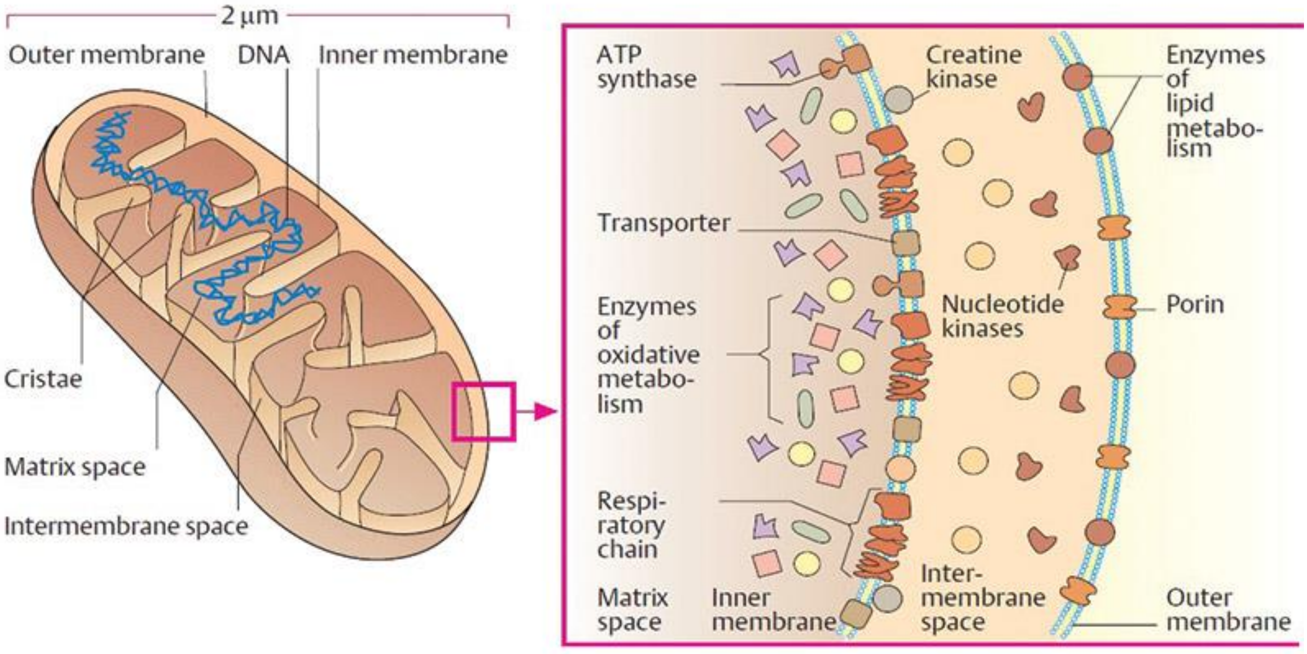
They are motile organelles and localize at intracellular sites of high-energy requirements such as basal regions of ion-transporting cells.

They could be selectively stained with iron hematoxylin, Janus green B in supravital staining of living cells.

With EM, they appear as ovoid or elongated structures bounded by two membranes. The outer membrane is smooth. The inner membrane is thrown into folds called cristae projecting into the inner cavity that is filled with an amorphous substance called matrix. The number of the cristae seen in mitochondria is directly related to the energy requirement of cell.

The inner membrane is covered with tiny spherical projections about 9 mm in diameter supported at narrow stalks. These are called inner membrane spheres or elementary particles and are believed to represent an enzyme known as F1, which couple electron transport to the phosphorylation of ADP.

The mitochondrial matrix is also containing many electron-dense granules called matrix granules that are the sites for Ca^{++} ions storage. The mitochondrial matrix contains DNA and RNA that explain the mitochondrial ability to grow, divide and synthesis some of their proteins.



Functions

- They house the chains of enzymes that catalyze reactions that provide the cells with most of its ATP (adenosine triphosphate).
- On demands, the ATP yields its high-energy phosphate bond to another molecule and become transformed into ADP.
- Within the mitochondrial matrix, ADP is transformed again into ATP. These processes take place within the mitochondrial matrix and inner mitochondrial membranes.
- The matrix contains enzymes of Krebs cycle and fatty acid oxidation. The inner membrane contains the cytochromes and the enzymes involved in ATP production.

- Due to their role in energy production, the mitochondria are likened to powerhouses of the cells.
- Participate in regulation of calcium level within the cytosol.

3- Endoplasmic reticulum (ER)

The Endoplasmic reticulum (Endo=inside; plasm=cytoplasm; reticulum = network) is an irregular network of branching and anastomosing tubules, cisternae and vesicles. Two types of ER are recognized, rough and smooth.

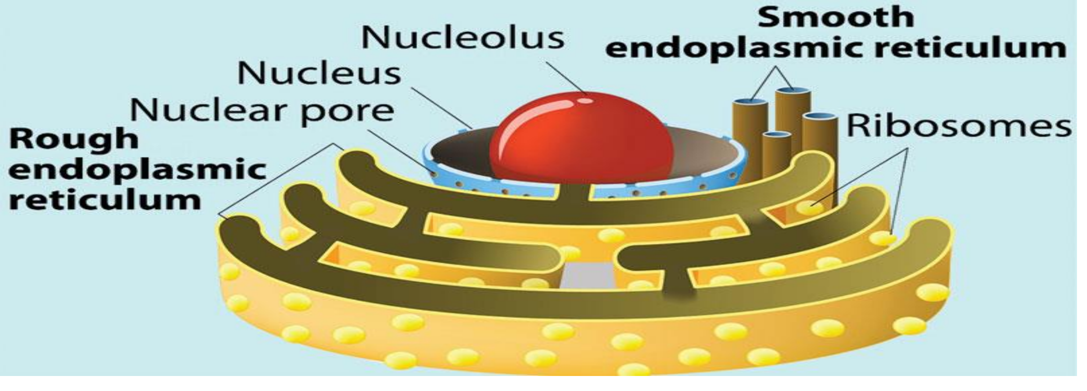
Rough endoplasmic reticulum (rER)

The rough endoplasmic reticulum is a membranous organelle concerned principally with synthesis and secretion of proteins. It is called rough due to the presence of large number of ribosomes attached to its limiting membrane. With LM, it appears as basophilic cytoplasmic areas that are referred to as the ergastoplasm or chromidial substances. The cytoplasmic basophilia may be diffuse (plasma cells), localized (pancreatic acinar cells) or arranged into clumps (Nissl granules in nerve cells) . Aggregates of rER appear basophilic mainly due to the presence of ribosomes on their outer surface .

With EM, it consists of an anastomosing network of tubules, vesicles and flattened cisternae that ramifies throughout the cytoplasm. Much of the surface of the rER is studded with ribosomes giving the reticulum a rough or granular appearance.

Functions:

- Synthesis of proteins for extracellular use (secretory proteins, lysosomal proteins and membrane proteins).
- Glycosylation of proteins to form glycoproteins.



Smooth endoplasmic reticulum (sER)

The smooth endoplasmic reticulum is a membranous organelle consists primarily of a network of branching and anastomosing tubules and vesicles.

It differs from the rER in that its limiting membrane is smooth and devoid of ribosomes. With LM, it does not appear. The cytoplasm of the cells contained abundant sER usually appears acidophilic.

With EM, it appears as irregular network of membranous tubules and vesicles devoid of ribosomes in contrast to the flattened ribosome-studded cisternae of rER. The sER tubules may be continuous with those of rER and Golgi apparatus .

Functions

- Steroid hormone synthesis in the testicular interstitial cells, the cells of the corpus luteum and adrenal cortex cells.
- Drug detoxification in liver cells.
- Lipid synthesis in the intestinal absorptive cells.
- Release and storage of Ca^{++} ions in striated muscle cells.
- Production of HCL in gastric parietal cells.

4- Golgi Apparatus (Golgi complex)

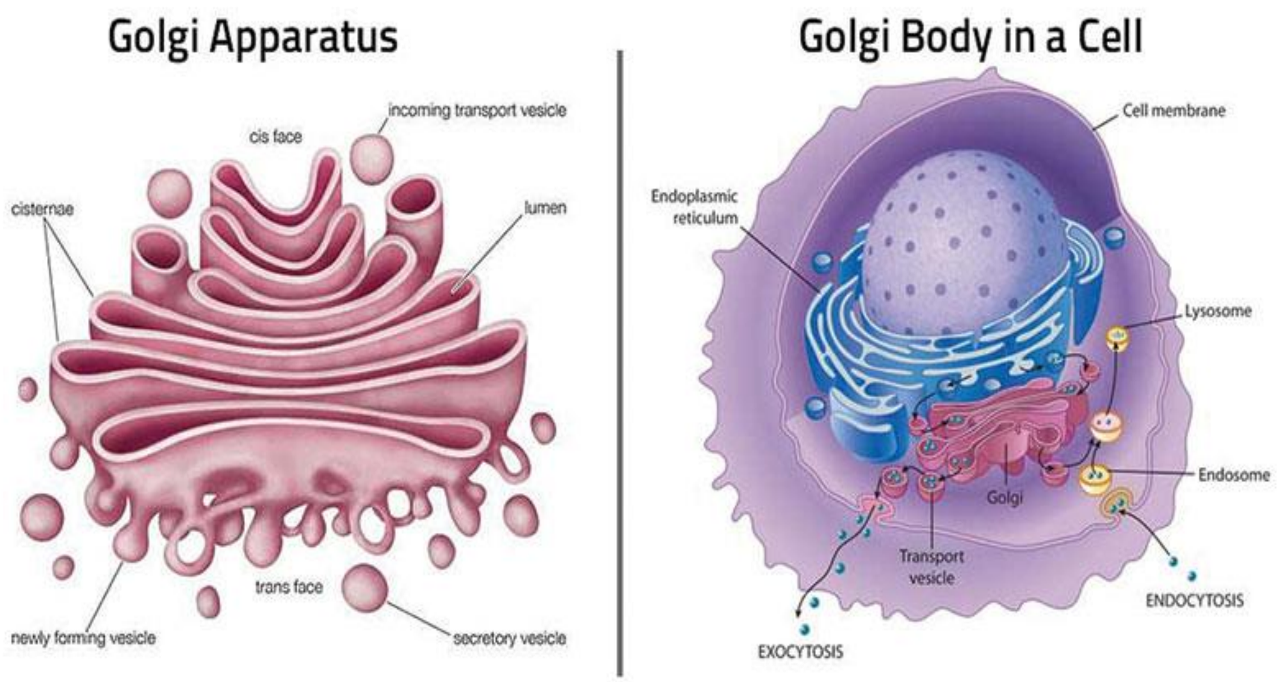
The Golgi apparatus is a membranous organelle concerned principally with synthesis, concentration, packaging and release of the secretory products.

With LM, it can be selectively stained with silver salts or osmium where it appears as a black network located near the nucleus. In H&E sections, it may be visible as a lighter-stained region called negative Golgi image. It is seen to great advantage in secretory cells such as osteoblasts.

With EM, the main structure unit of the Golgi apparatus is a flattened membranous vesicle called Golgi saccule.

The Golgi saccules are arranged in Golgi stacks that contain from 3-10 saccules. Most cell types possess several stacks of Golgi saccules forming an elaborate ramifying network termed the Golgi complex.

Each stack of saccules has 1) a forming face or Cis face that is convex in shape. 2) a maturing face or trance face that is concave. The Cis face is usually associated with a number of small transfer vesicles. The trance face characterized by being associated with much larger secretory granules.



Functions

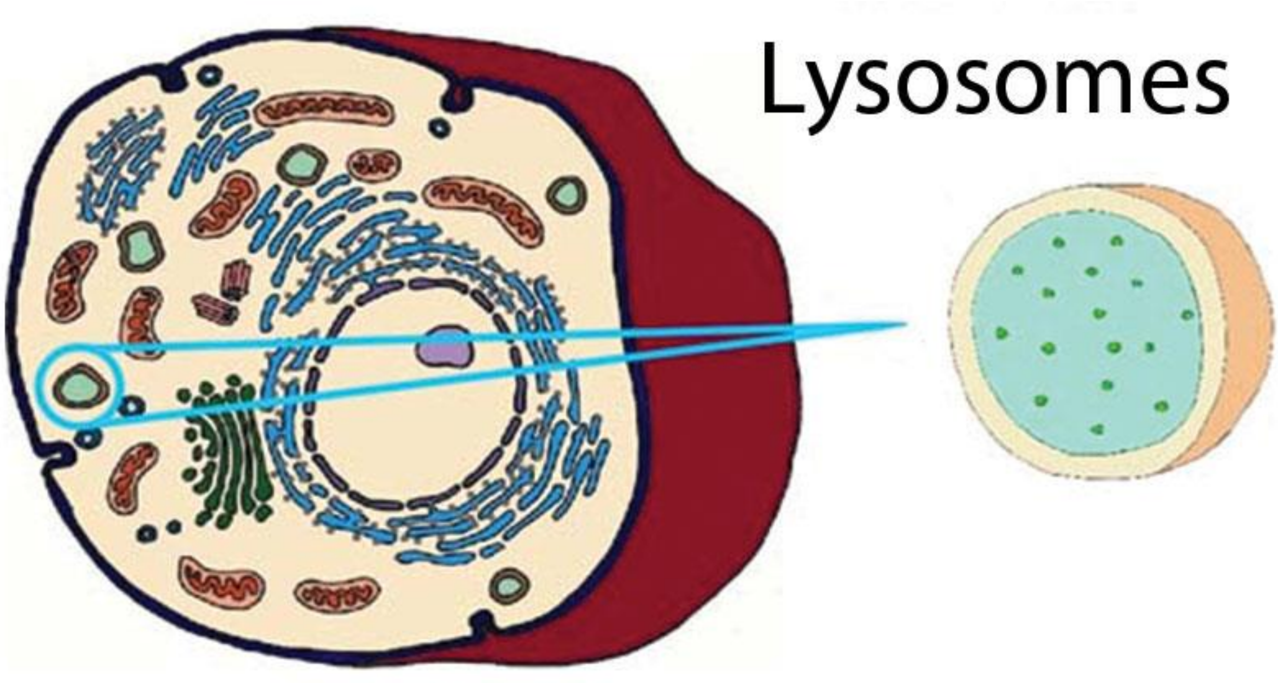
- Packaging and concentration of secretions.
- Modification of the secretory products such as glycosylation and sulfation of proteins to for glycoproteins and sulfated glycoproteins (mucus).
- Production of primary lysosomes.

5- Lysosomes

They are membrane-bounded vesicles (0.2-0.4μm) containing a number (more than 40) of hydrolytic enzymes that are active at acid pH (acid hydrolases) maintained within their interior. This group of enzymes can destroy all the major macromolecules (e.g., proteins and lipids) of the cells.

LM provides no direct evidence for the existence of lysosomes. The lysosomes are resolved at the LM level when their enzyme contents (e.g., acid phosphatase) are stained by histochemical methods.

With EM, the lysosomes appear as spherical membrane-bounded vacuoles with there contents showing varying degree of electron density.



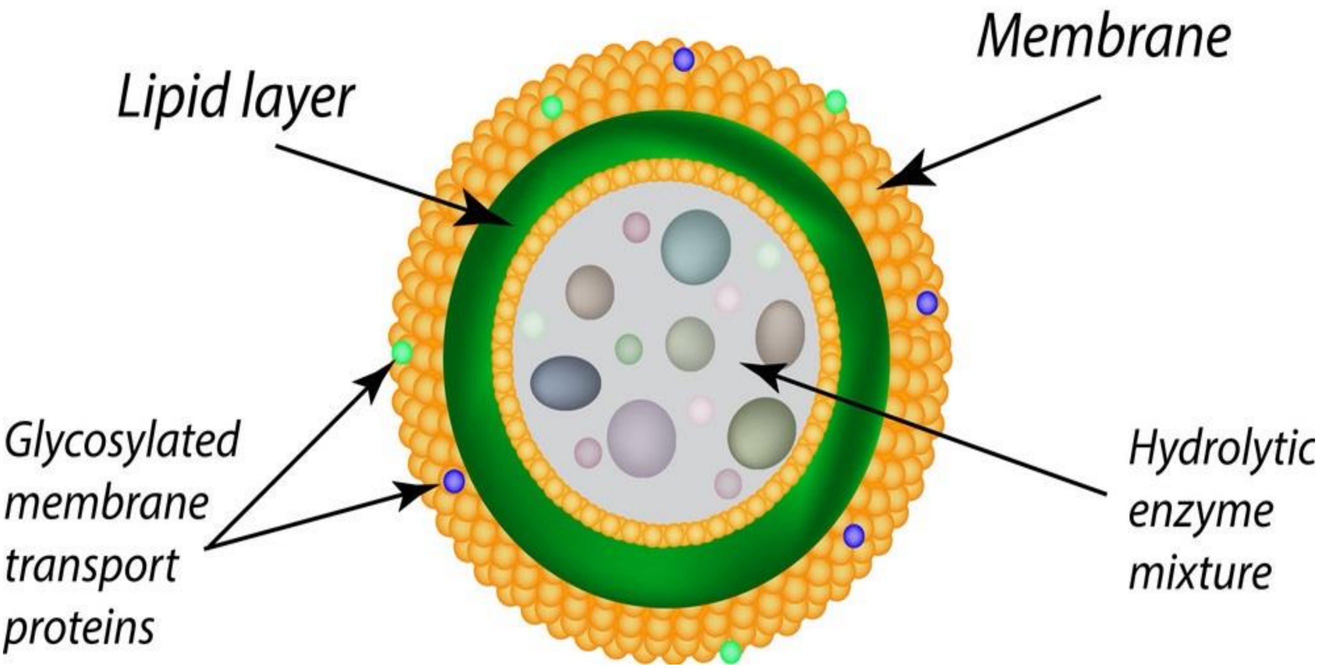
Types of lysosomes

Primary lysosomes are lysosomes freshly formed from the Golgi or sER. They contain nothing but hydrolytic enzymes.

Secondary lysosomes formed as the result of fusion of primary lysosomes with phagosomes. A phagosome is a membrane-bounded vesicle containing either exogenous material (e.g., bacteria) and it is called heterophagosome or endogenous material (e.g., damaged organelle) and it is called autophagosome.

Multivesicular bodies are spherical forms of heterophagosomes. They are membrane-bounded vesicles containing a number of smaller vesicles.

Residual bodies are debris containing vacuoles representing the terminal stage of lysosomal activities. Their contents may either be extruded from the cell by exocytosis or accumulate in the cytoplasm as lipofuscin pigments.



Functions

- Degradation of any exogenous macromolecules (phagocytosis and pinocytosis).
- Disposition of any organelles or cell constituents that are no longer useful to the cell (autophagy).

6- Peroxisomes

Peroxisomes are spherical, membrane-bounded organelles containing peroxide forming enzymes and catalase that are involved in the formation and degradation of intracellular hydrogen peroxide.

With LM, it does not appear. With EM, they are membrane-bounded vacuoles, vary in size and appearance depending on species and cell types. They are relatively large in hepatocytes and kidney cells and small in intestinal cells (microperoxisomes).

In human cell, they contain finely granular matrix of moderate density. In many other species, they have crystalline core called a nucleoid.

Such nucleoid is absent from liver peroxisomes from reptiles, birds, and human being which are species that lack urate oxidase, an enzyme that degrades urates.

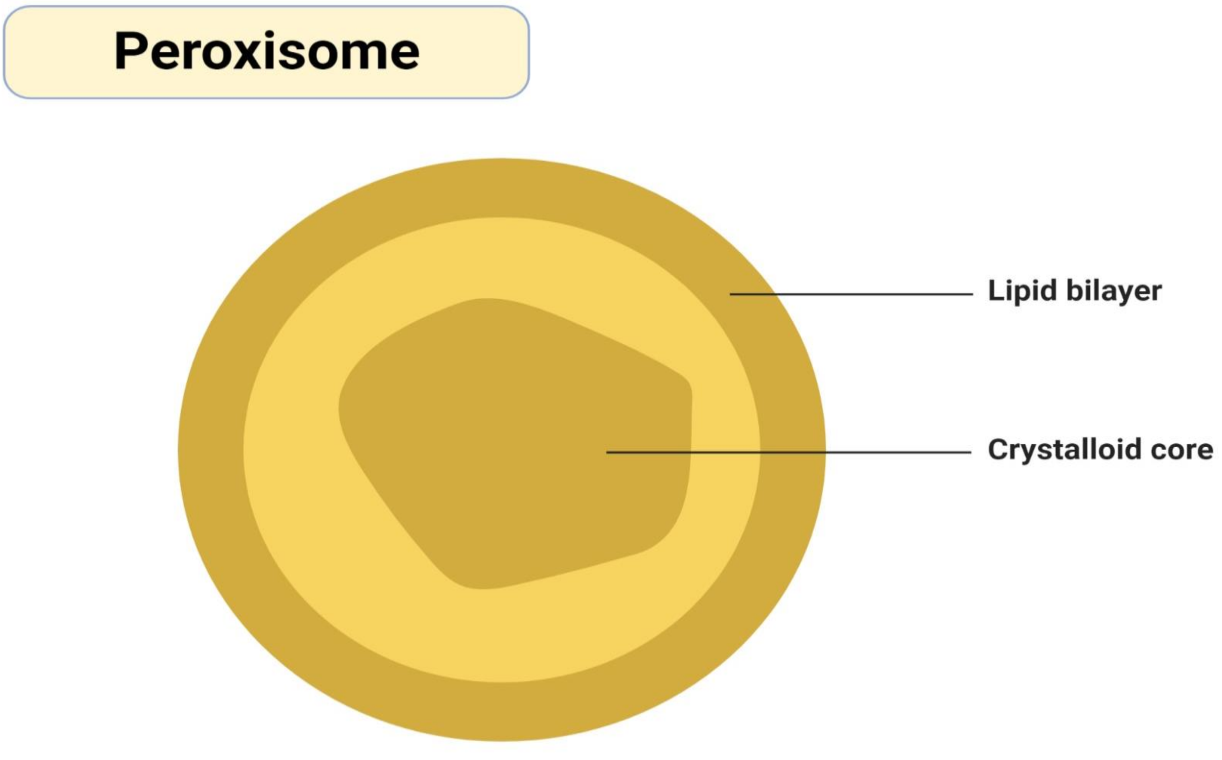


Figure: Peroxisome, Image Copyright © Sagar Aryal, www.microbenotes.com

Functions

- Peroxisomes contain at least three oxidase (D-amino acid oxidase, urate oxidase and catalase).
- The D-amino acid oxidase, urate oxidases are responsible for the production of hydrogen peroxide (H_2O_2).
- The catalase then utilizes the H_2O_2 in oxidation (and therefor, detoxification) of various toxic substances such as phenol, alcohol and fatty acids.

1. Non-membranous organelles

They are cytoplasmic organelles that possess no bounding membrane of their own. They include ribosomes, and centrioles.

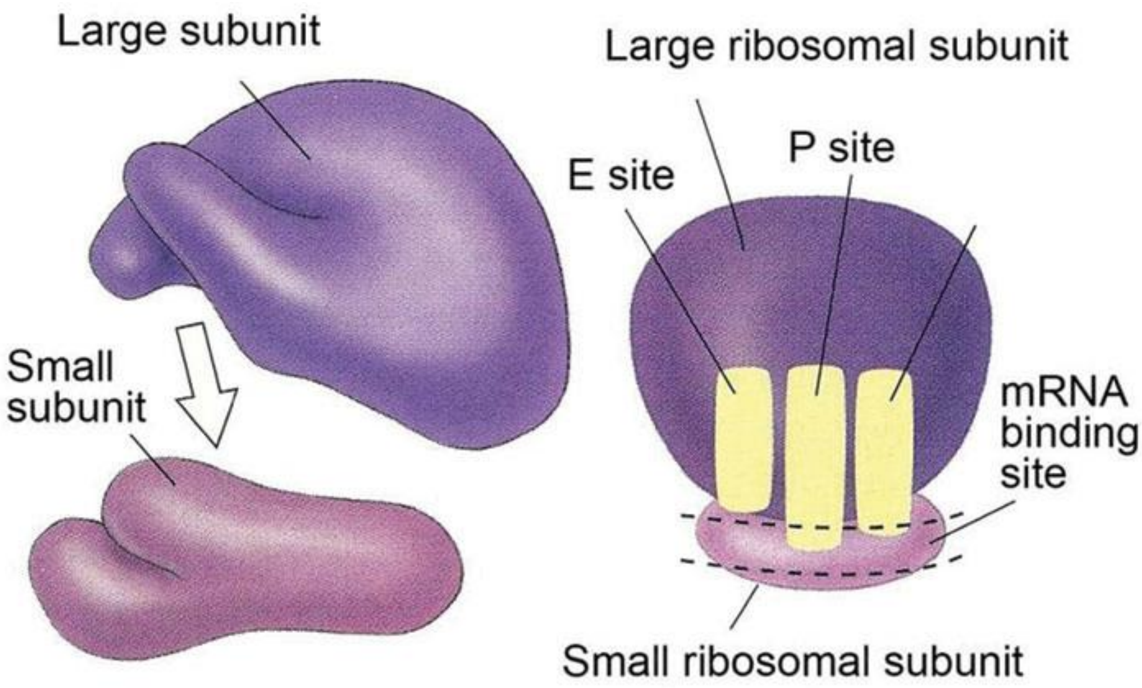
7- Ribosomes

They are rounded ribonucleoprotein particles, 20-30 nm in diameter that provide the intracellular sites where amino acids are linked together to form polypeptide chains (proteins).

With LM they are too small to be seen. However, cell containing abundant ribosomes usually has basophilic cytoplasm. Such cytoplasmic basophilia is largely due to the strong affinity of rRNA for hematoxylin.

With EM, the ribosomes are seen free in the cytoplasm either as separate entities or attached to messenger RNA molecules in small aggregation called polyribosomes or polysomes. Polyribosomes may also be attached to the surface of rER.

Each ribosome composed of a large and a small subunit that are made of rRNA and different types of proteins.



Functions

Free ribosomes are responsible for synthesis of proteins for internal use (cytoplasmic proteins and enzymes).

Attached ribosomes are responsible for synthesis of proteins for external use (secretory or lysosomal enzymes).

8- Centrosome and Centrioles

The centrosome is a specialized zone of cytoplasm contains a pair of centrioles together known as a diplosome, spherical bodies, procentrioles organizer and centriolar satellites that function as microtubular organization center.

With LM, the centrioles are selectively stained with iron hematoxylin where they appear as two tiny dots located close to the nucleus. In some epithelial cells, centrioles are located in the apical cytoplasm immediately beneath the ciliated surface. Such apical centrioles are called basal bodies and from which cilia originate.

With EM, each centriole is a hollow cylinder, closed at one end. The two centrioles of each diplosome are arranged with their long axes at right angles to each

other. The wall of each centriole is made up of nine triplet of parallel microtubules connected to each other by a fine filaments, the protein link.

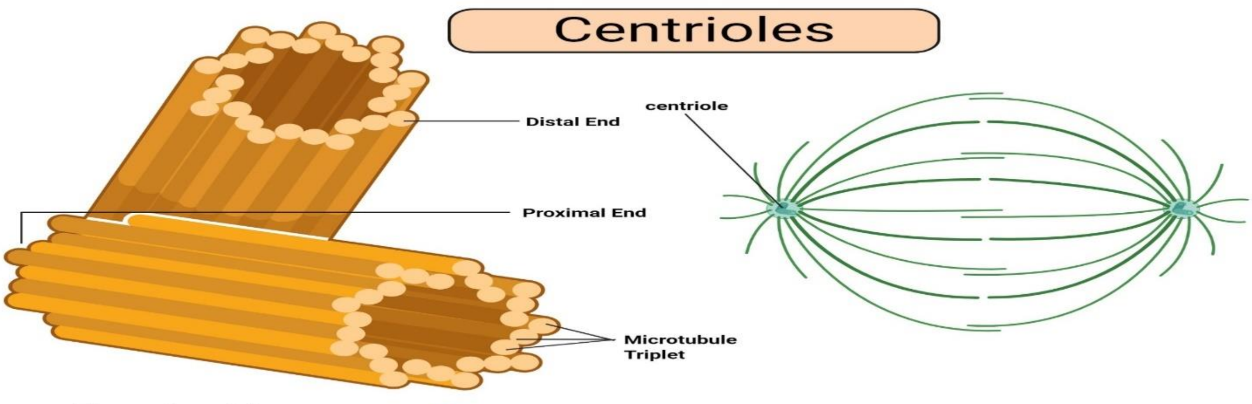


Figure: Centrioles, Image Copyright © Sagar Aryal, www.microbenotes.com

Functions

Formation of mitotic spindle during cell division.

Microtubular organization center

Ciliogenesis by the formation of procentrioles from the procentrioles organizer.

9- Cytoskeleton

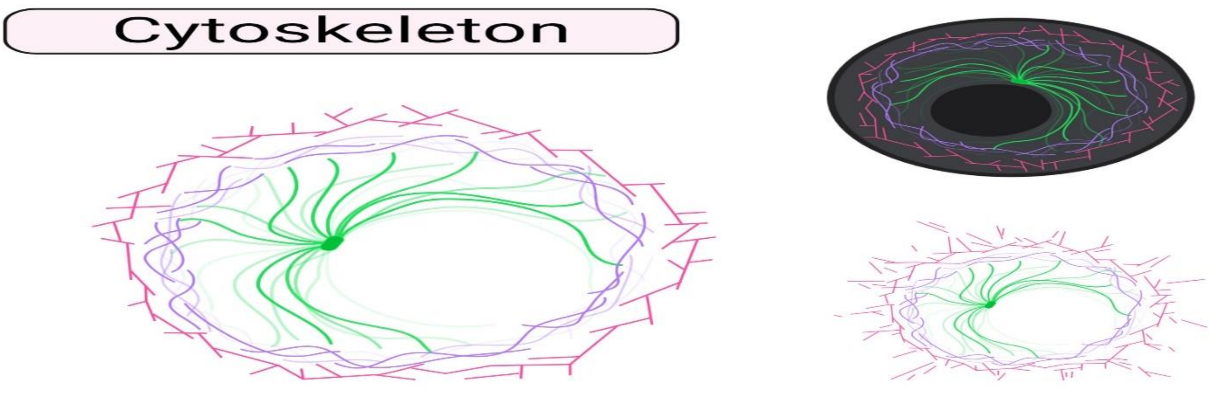
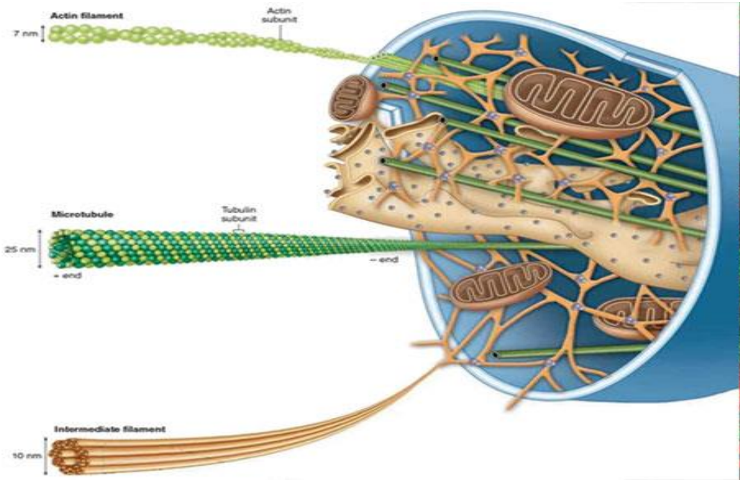
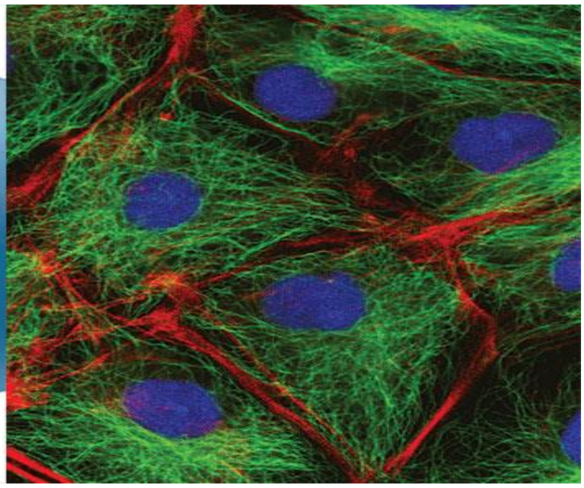


Figure: Cytoskeleton, Image Copyright © Sagar Aryal, www.microbenotes.com

The cytoskeleton is a complex network of minute filaments and tubules located within every cell, that maintain cell shape and stability and are responsible for some cell functions. It includes cytofilaments and microtubules.





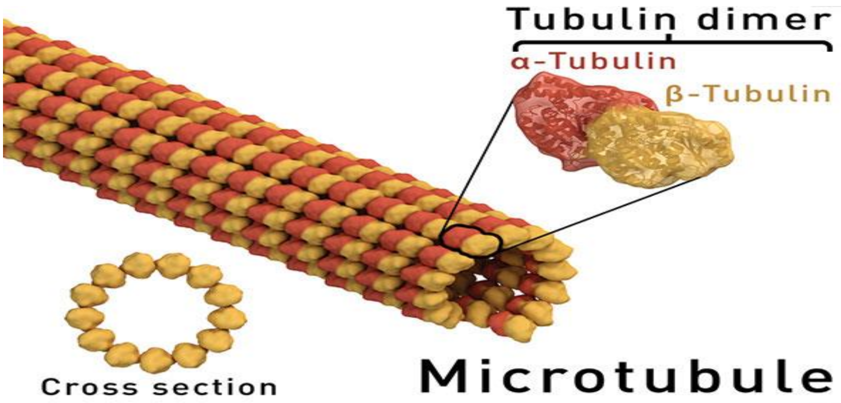
Cytofilaments: are minute thread-like structures of three types:

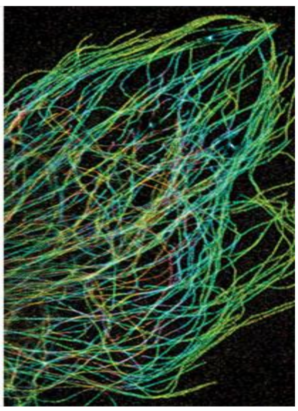
The Actin (thin filaments) is found in muscle cell, in the core of each microvillus, in motile cells such as macrophages and in developing nerve cells. Their diameter is about 5 nm.

The Myosin (thick filaments) occurs mainly in muscle cells in association with actin filaments. They have a diameter of 15 nm.

The Intermediate filaments are 10 nm in diameter and include neurofilaments in neurons, glial filaments in astrocytes and tonofilaments in epithelial cells.

Microtubules





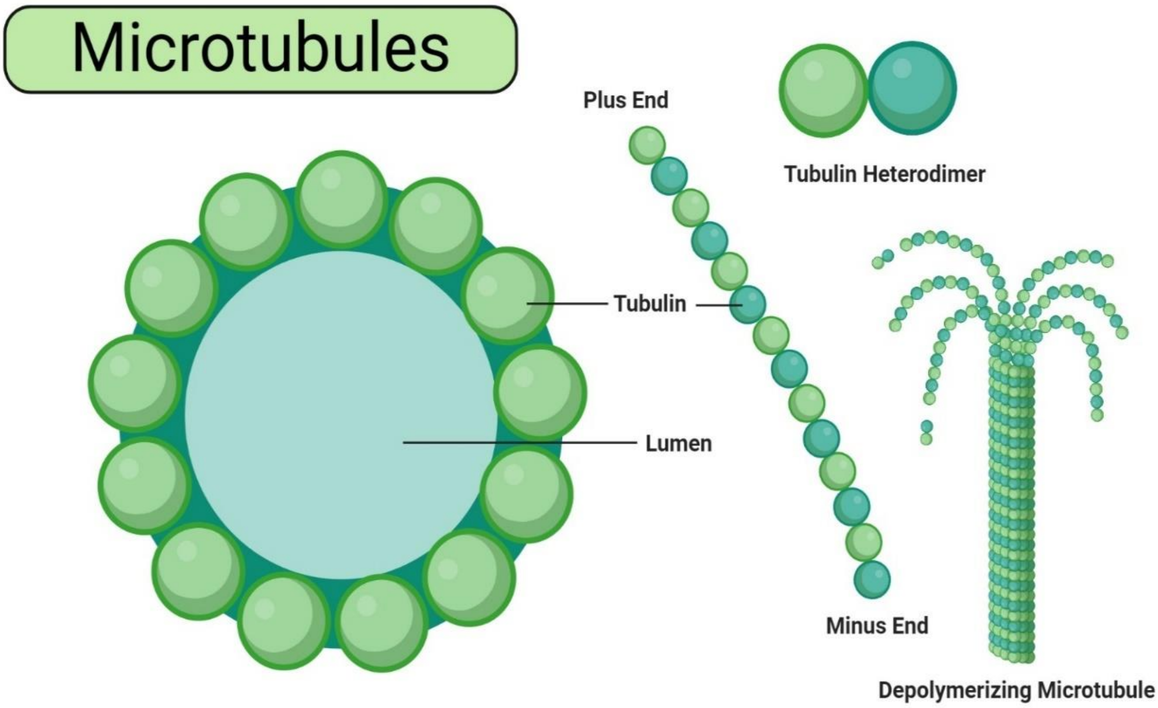


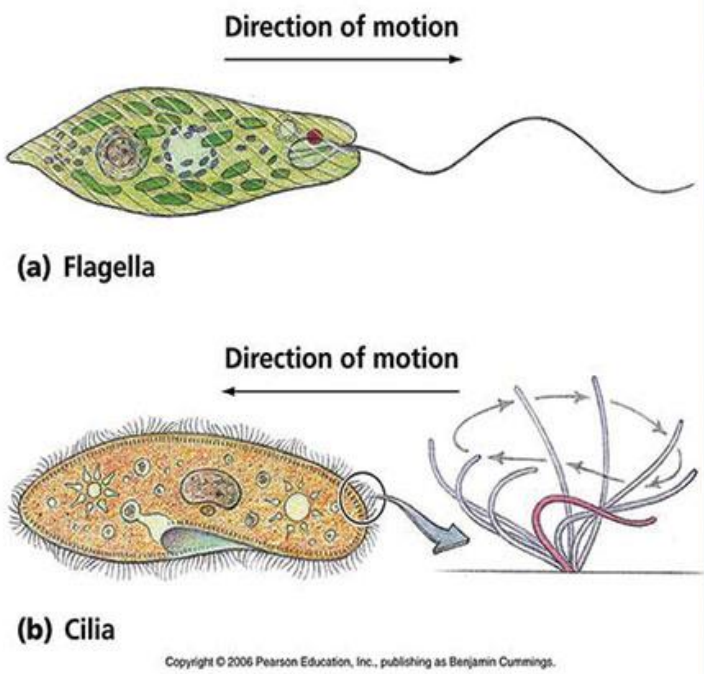
Figure: Microtubules, Image Copyright © Sagar Aryal, www.microbenotes.com

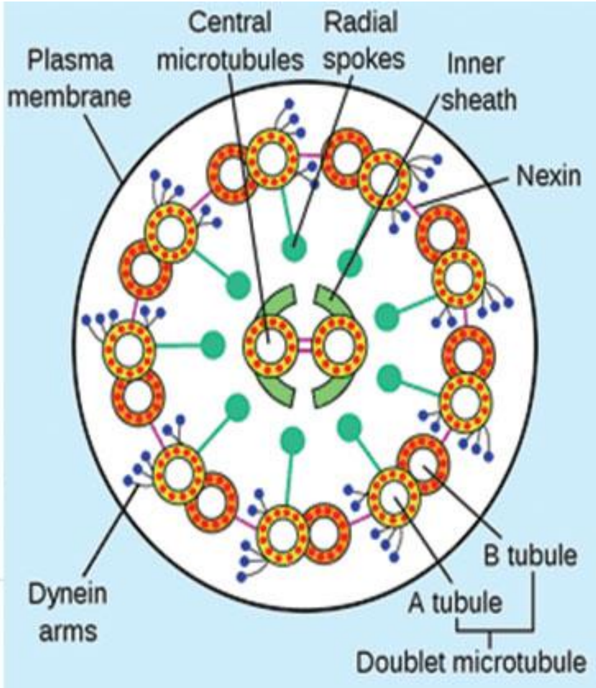
They are hollow tubular structures of variable length with a constant diameter of 25nm. Microtubules are stable permanent structures in cilia, flagella, centrioles and basal bodies. Each microtubule is made up of protein molecules (tubulin) that appear to organize into protofilaments that run parallel to the length of the tubule. A total of 13 protofilaments comprise the wall of a microtubule.

Functions of the cytoskeleton

- It provides the structural support for the plasmalemma, cellular organelles and some cytosol enzyme system.
- It provides the means for the movement of intracellular organelles within the cytoplasm.

- It plays an essential role in cell motility as well as provides the framework of motile structures such as cilia and flagella.
- It is responsible for contractility of the muscle cells.
- It plays an important role in epithelial cell adhesion as well as cell division.





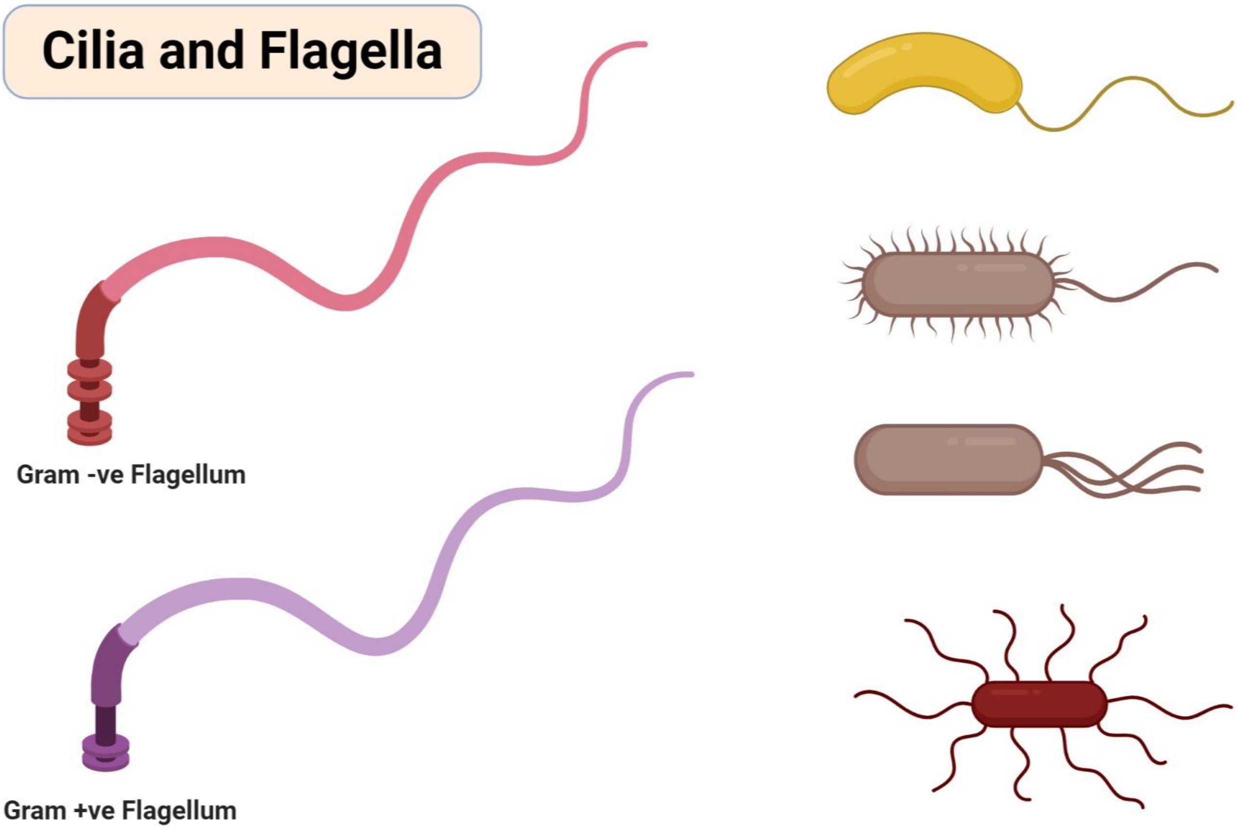
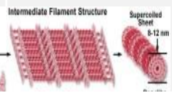


Figure: Cilia and Flagella, Image Copyright © Sagar Aryal, www.microbenotes.com

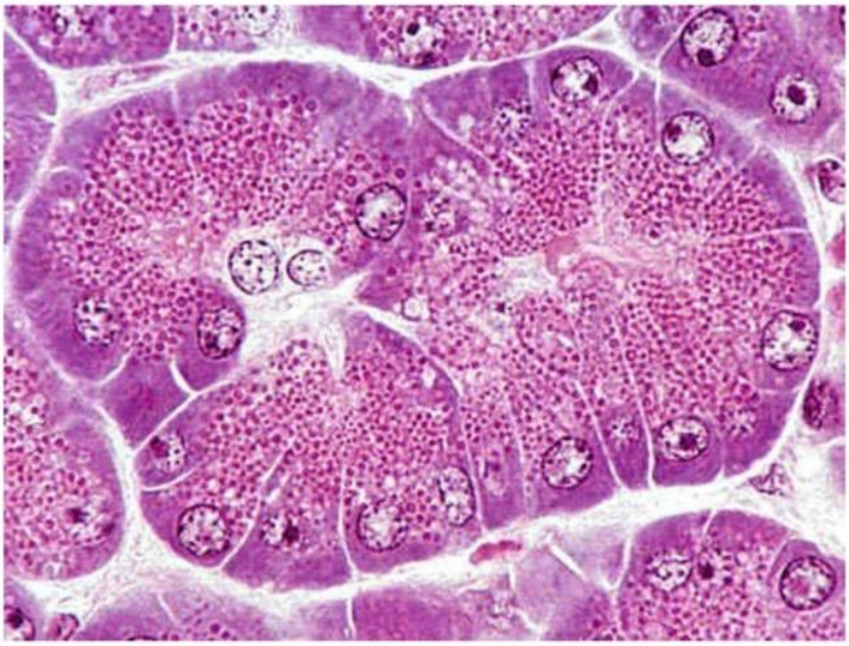
	Microfilaments	Microtubules	Intermediate filaments
1- diameter	7 nm.	25 nm.	10 nm.
2- LM	Seen only by immunohistochemistry.	Seen only by immunohistochemistry	Seen only by immunohistochemistry
3- EM	Thin electron dense filaments.	Fine tubules.	Thicker electron dense filaments.
4- Structural proteins	Monomers of G actin polymerize to form F actin.	Tubulin dimer polymerize to protofilaments. 13 protofilaments form a microtubule,	Woven ropes.
5- Functions	Dynamic 1- Muscle contraction. 2- Contractile ring in cell division. 3- Pseudopodia in migration. 4- Microvilli. 5- Cytoplasmic streaming. 	Dynamic. 1- Transport of organelles& vesicles. 2- Formation of centrioles, cilia & flagella. 	Not dynamic. Structural support. 

10- Cytoplasmic Inclusions

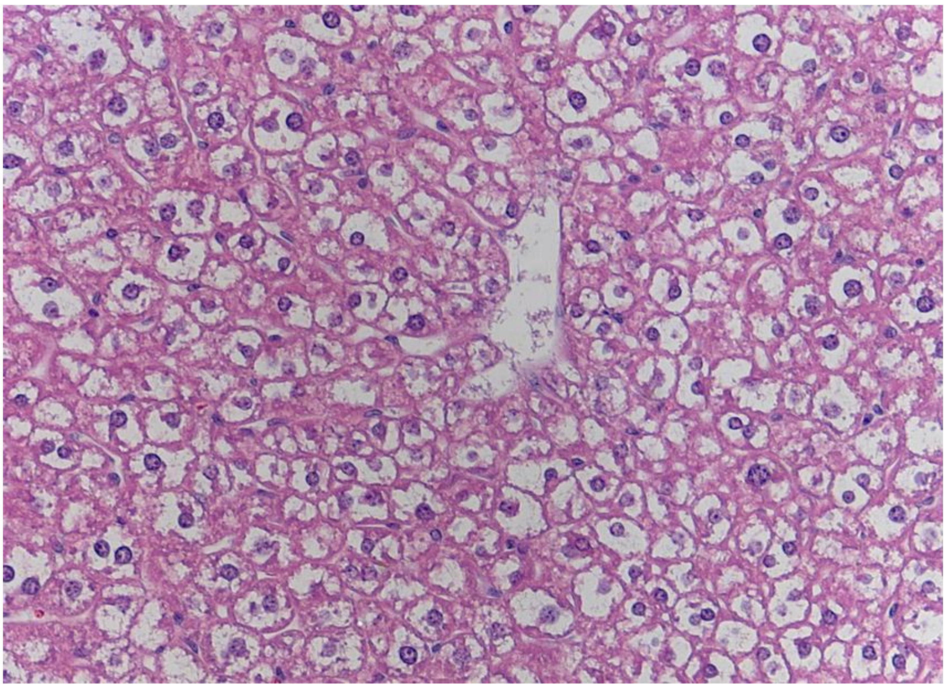
They are temporary lifeless accumulation of metabolites or cell products, such as stored food, pigments and crystals.

1. **Stored food**

Pancreas – Secretory acini w/ zymogen granules



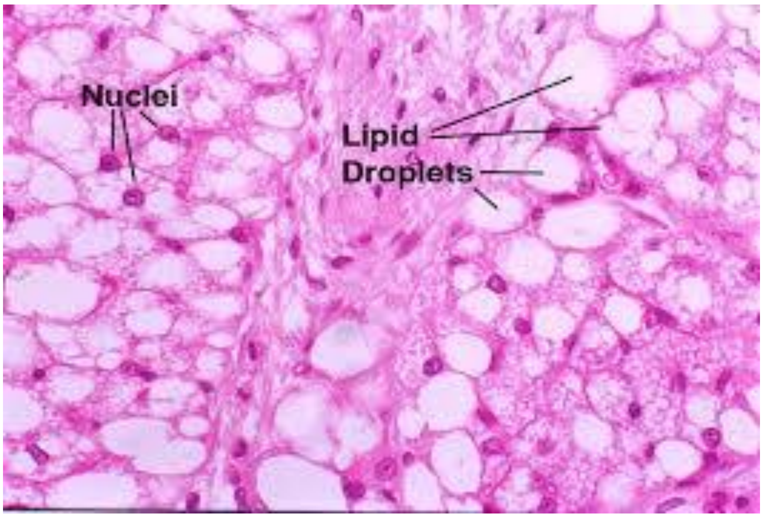
2. **Glycogen**



3. Lipids

The fat cells of adipose tissues and the fat storing cells of the liver store the lipids. Routine processing generally extracts lipids from tissue and therefore, in H&E sections, lipid droplets within cells appear as unstained vacuoles.

Lipids are best demonstrated in frozen sections stained by specific lipid methods such as osmium or sudan III with which lipids are stained black and orange respectively.



4. Pigments

They are substances that have their own color in their nature state.

a. Exogenous pigments

The exogenous pigments are those that have been produced outside the body. They include carotenes, dusts, minerals and tattoo marks.

1. Carotenes

Carotenes are a family of fat-soluble compound found in vegetable such as carrots, tomatoes and vegetable juice. When animals fed on carotene-containing vegetables, it colors its body fat yellow. Carotenes are provitamens and may be converted into vitamin A.

Ingestion of large amount of carotenes cause the skin of the body to appear yellow or even reddish color due to its great contents of carotenes. This condition is called carotenemia (increase carotene level in the blood). It might be confused with the more serious pathological condition called jaundice (caused by increase bilirubin level in the blood).

2. **Dusts**

The lungs of heavy smokers usually blackened due to accumulation of carbon particles in the alveolar macrophages located in the wall of the lung alveoli.

3. **Minerals**

Silver causes a gray pigmentation of the body. Lead can impart a blue line to the gum.

4. **Tattoo marks**

They are inorganic pigments inserted deeply into the skin with needles.

The pigments are ingested by the subcutaneous macrophages and remain permanently within their cytoplasm.

b. **Endogenous pigments**

They include hemoglobin, hemosiderin, bilirubin, melanin and lipofuscin.

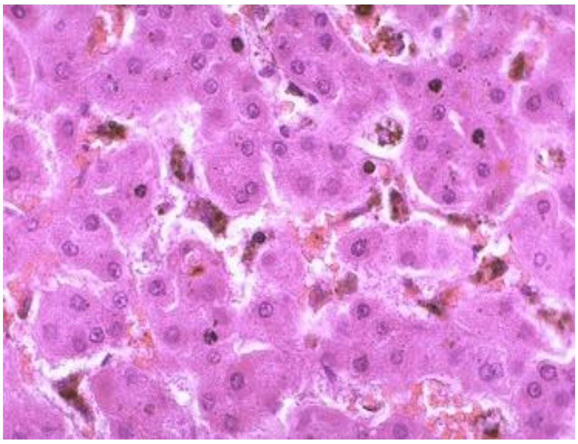
1. **Hemoglobin**

he hemoglobin is an iron-containing pigment of erythrocytes has the function of oxygen transport throughout the body.

2. **Hemosiderin and bilirubin**

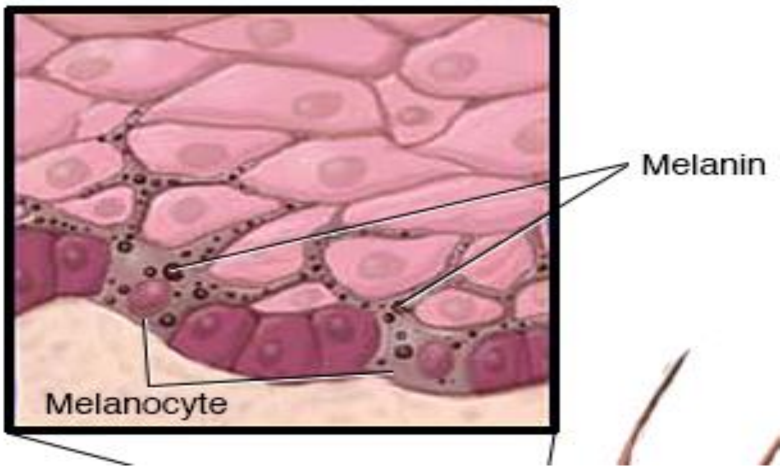
They are formed as the result of degradation of old erythrocytes by the spleen macrophages. Hemoglobin is degraded into hemosiderin and bilirubin. The hemosiderin is a golden brown iron-containing pigment usually seen within the cytoplasm of the splenic macrophages.

The bilirubin is yellowish-brown pigment. It has to be removed from the blood stream by the liver and excreted in bile.



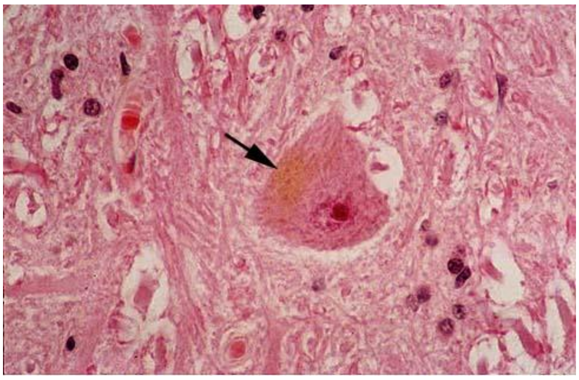
3. **Melanin**

The melanin is a brown-to-black pigment presents in skin, hair and eyes. There is two type of melanin: eumelanin, which has a brownish black color, and phaeomelanin that has a reddish-yellow color.



4. Lipofuscin

The lipofuscin is a golden-brown intracellular pigment represents a normal product of organelle's degradation. It accumulates with increasing age particularly in long-lived cells such as neurons and cardiac muscle cells (hence, they are referred to as age pigments or wear and tear pigments).



c. Crystals

Such as calcium oxalate and calcium carbonate crystals can be seen in the cytoplasm during certain disease conditions.

11. Nucleus

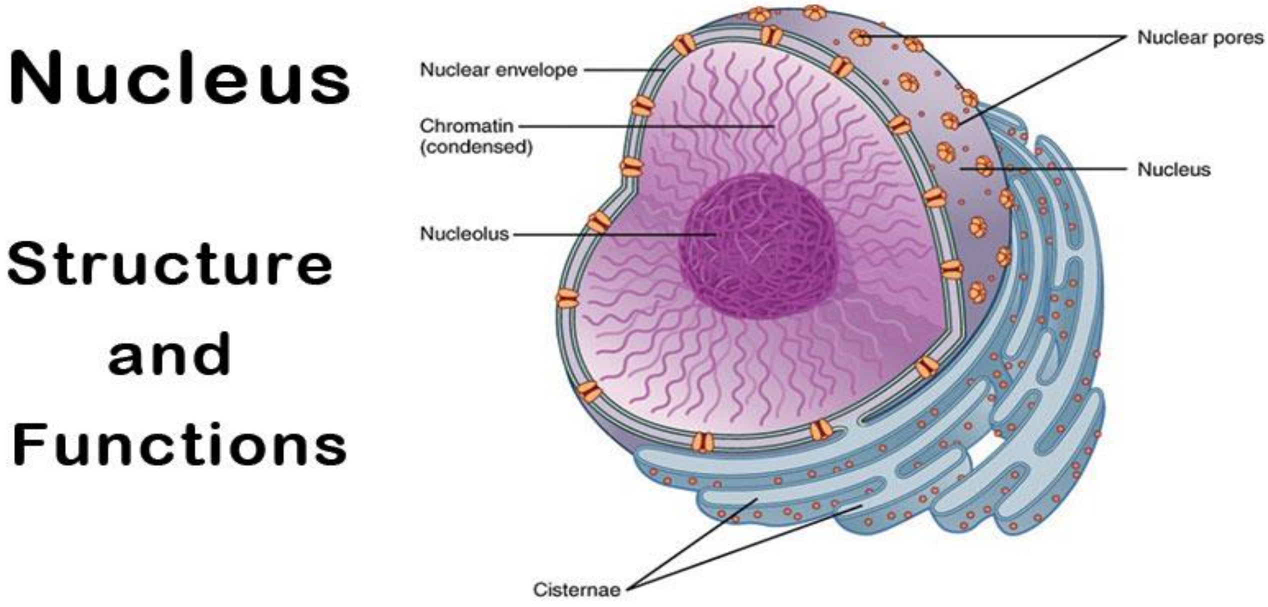
The nucleus is the archive of the cell that carries the genetic information necessary to regulate the different cell functions. It consists primarily of DNA (20% of its mass), DNA-binding proteins, and some RNA.

The DNA-binding proteins are of two major type histones and non-histones. The histones are involved in the folding of DNA strands and regulation of DNA activity. The non-histones are involved in the regulation of gene activity.

The nuclear RNA represents newly synthesized transfer and ribosomal RNA that has not yet passed into the cytoplasm.

With LM, the nuclei appear as basophilic structure located either centrally, eccentric or in a peripheral position. Most commonly nuclei are spherical or ovoid but they may be spindle-shaped (smooth muscle), bean or kidney-shaped (monocytes), or multilobulated (neutrophils).

Most often, cells are mononucleated. Some however, may be binucleated or even multinucleated. The interphase (not engaged in cell division) nucleus consists of nuclear envelope, chromatin, nucleolus and nuclear sap (karyolymph).



1. **Nuclear envelope**

With LM, it appears as a single basophilic line due to the presence of condensed chromatin adherent to its inner surface (peripheral chromatin) as well as ribosomes on the outer surface of the nuclear envelope.

With EM, he nuclear envelope consists of two membranes separated by a perinuclear space 25nm wide.

The outer membrane is continuous with the membranes of both the rER and sER and it may be studded with ribosomes. At the inner surface of the inner membrane, a layer of condensed chromatin known as granular lamina is usually encountered.

Numerous pores through which the nucleus communicates with the cytoplasm interrupt the nuclear envelope. The nuclear pore is guarded by two annuli, an outer and an inner annulus, each with eight globular subunits 15-20 nm diameter, projecting inwards from them are eight radially arranged spokes. In the center of the pore there is a central granule or plug. Such structure is called nuclear pore complex.

2. **Chromatin**

wo types of chromatin are distinguished: heterochromatin and euchromatin.

Heterochromatin

The heterochromatins consist of tightly coiled portions of chromosomes. The genes are repressed and transcription does not occur. It predominates in inactive cells.

With LM, they appear as fine and coarse basophilic granules scattered throughout the different regions of the nucleus.

With EM, it appears as electron-dense areas tend to be clumped around the periphery of the nucleus (peripheral chromatin), around the nucleolus (nucleolus associated chromatin) and also forms irregular clumps throughout the nucleus (chromatin islets).

In females, the inactive X-chromosome forms a small mass located at the edge of the nucleus and is called Barr body.

Euchromatin

The euchromatin is the extended, uncoiled portions of chromosomes in which the transcription of DNA is active. This type of chromatin is found in active cells. With LM, euchromatin is invisible because they are very thin and extended. With EM, they appear as electron-dense nuclear materials represent the parts of the DNA that are active in RNA synthesis.

	Heterochromatin	Euchromatin
1- LM	Dense basophilic clumps.	Lightly stained basophilic areas.
2- EM	Electron dense filaments or granules distributed 1- around nucleolus. 2- associated with inner nuclear membrane. 3- swimming in nuclear sap.	Dispersed fine filaments or granules
3- Function	Inactive part acts as a reserve (transformed into euchromatin when needed).	Active part (transcribed into RNA).
4- Site	Inactive cells.	Active cells e.g. dividing cells.

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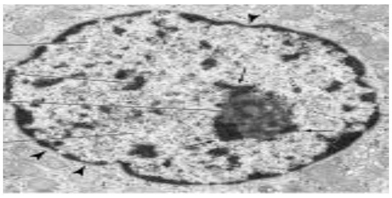


3. Nucleolus

It is a conspicuous, spherical, basophilic structure that is primary concerned with synthesis of ribosomal RNA.

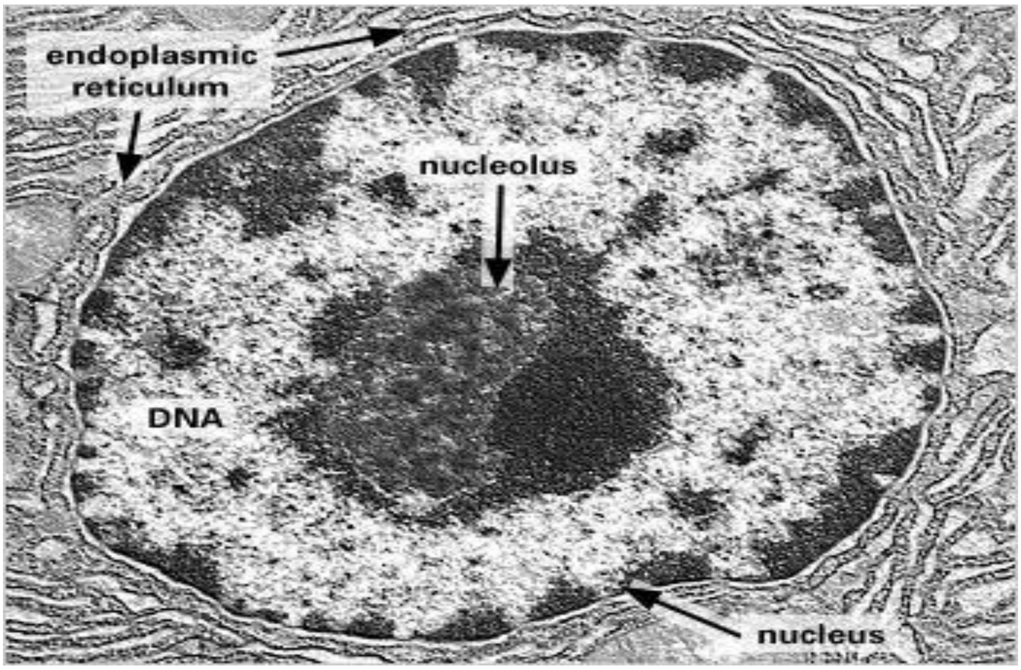
With LM, usually one, sometimes several nucleoli are seen. They are usually basophilic mainly due to nucleolus associated chromatin.

With EM, the nucleolus consists of a sponge showing dark materials of granular (pars granulosa) and fibrillar (pars fibrosa) both form the nucleonema which is ribonucleoprotein permeated by dispersed filaments of DNA (pars amorpha).

The primary function of the nucleolus is the synthesis of ribosomal RNA (rRNA). The genes that code for rRNA are known as nucleolar genes that lie along five different pairs of chromosomes.

4. Nuclear sap (karyolymph)

The nuclear sap is a colloidal solution in which chromatins are suspended. It helps in the movement of RNA (rRNA, tRNA, and mRNA) toward the nuclear pores.



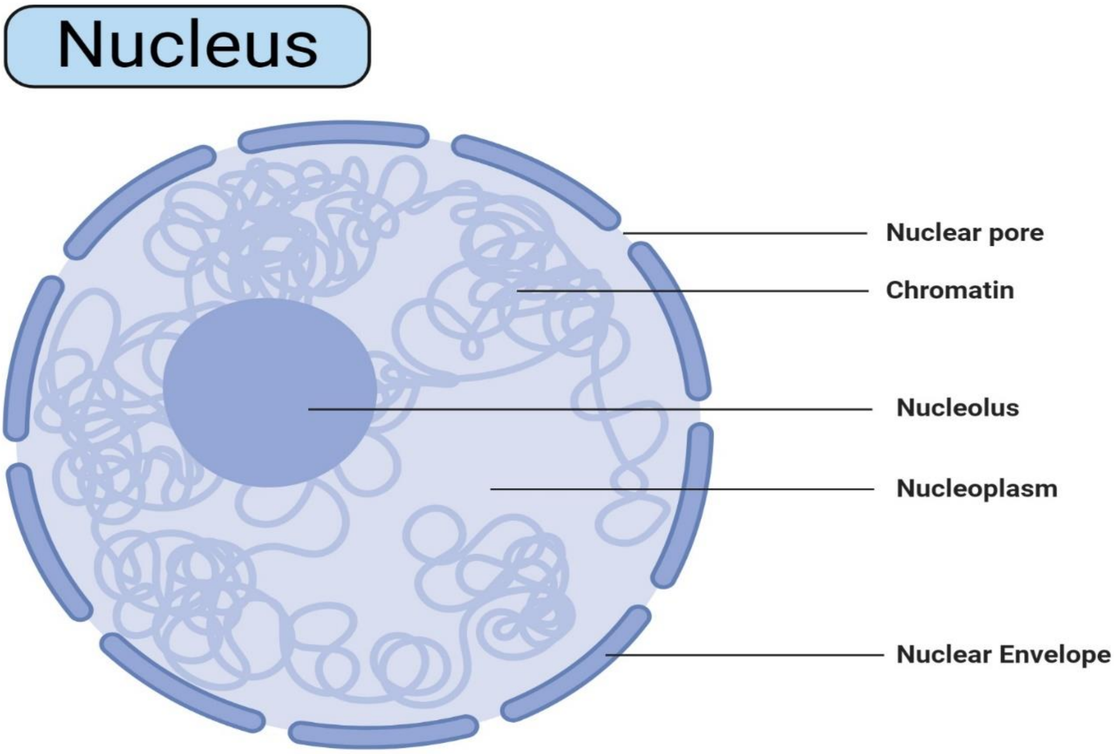
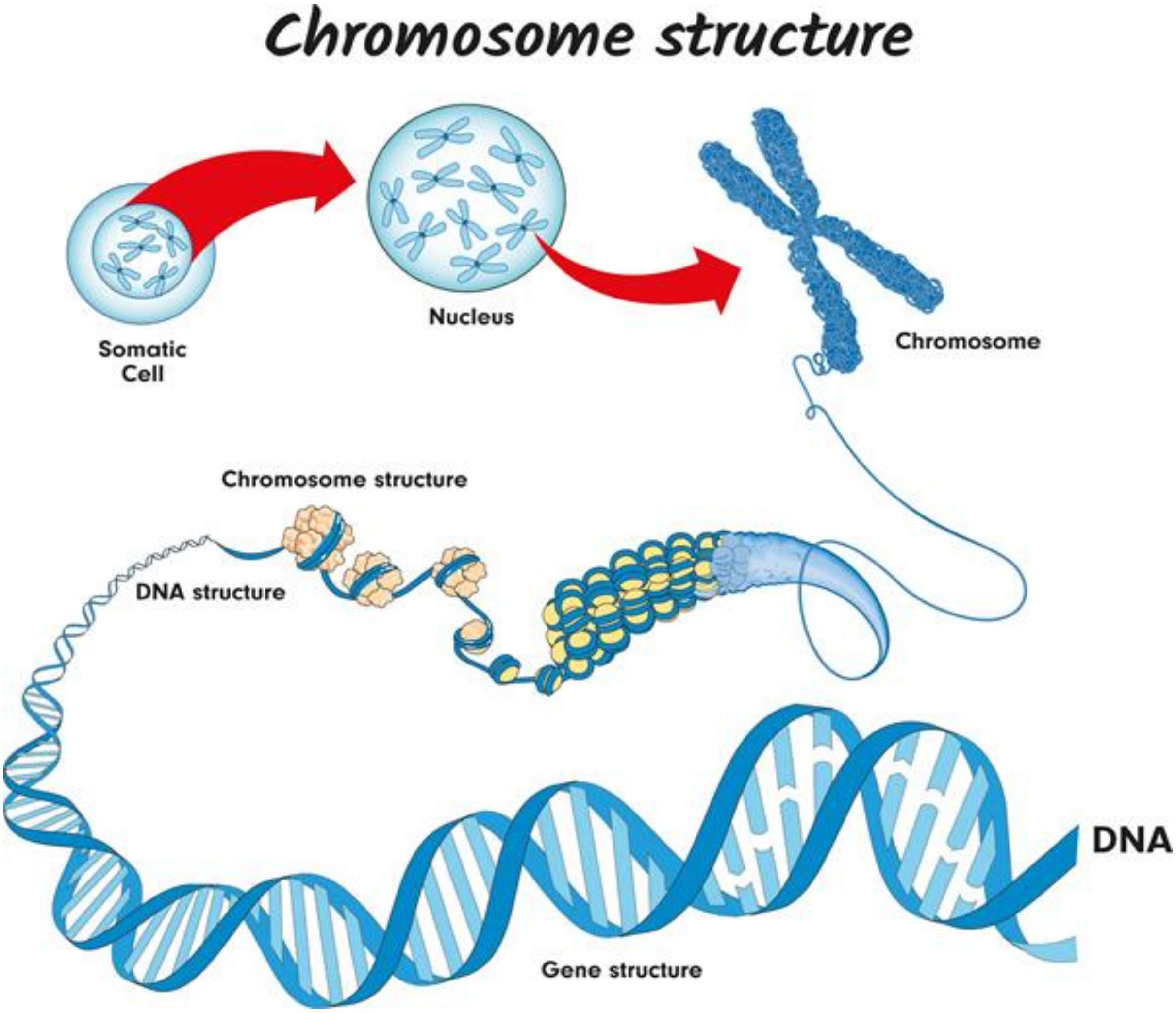


Figure: Nucleus, Image Copyright © Sagar Aryal, www.microbenotes.com

DNA and chromosomes

Inside the nucleus of a cell, there are thread-like structures called chromosomes. Each chromosome is made out of a long, coiled up strand of DNA (genetic material), which means that each chromosome contains many genes.

Normally, there are 46 chromosomes inside the nucleus of each human body cell. Chromosomes are usually found in pairs.



A **diploid** cell contains two complete sets of chromosomes in its nucleus, one from each parent. In humans, all body cells are diploid cells. Human diploid cells have 23 pairs of chromosomes (46 in total). The diploid number is often represented as **2n**, with n being the number of chromosomes. In humans, 2n = 46.

The word **haploid** means half. It describes a cell that contains a single set of chromosomes. The symbol **n** is often used to show the haploid number. In humans, n = 23. Human sex cells (egg and sperm cells) contain a single set of chromosomes, so they are haploid cells.

- Sex cells are also called **gametes**

12- Vacuoles

A vacuole may be described as a space inside the cell that does not contain cytoplasm. It is surrounded by a membrane and filled with a fluid. Vacuoles store various molecules including enzymes, waste products of the cell, water, and even food material depending on the type of cell.

In cases where vacuoles contain waste products of the cell, they are also involved in the exportation of waste from the cell thus protecting the cell from toxicity.

Some vacuoles also play a role in maintaining the internal hydrostatic pressure of the cell as well as regulating pH.

- **Other features of a cell include:**
- **Cell Wall**
- Some books do not consider the cell wall to be an organelle. However, it's one of the most important components of plant cells. The cell wall surrounds the cell membrane and serves to strengthen and protect the cell.
- For instance, in the cells of plant roots, the cell wall protects the cell as they grow deeper in the soil. The cell wall also serves as a filter that controls the movement of molecules in and out of the cell.
- **Cytoplasm** is also not considered as an organelle in some books. However, it is an important component of the cell. Cell cytoplasm is composed of protoplasm in which all the other cell organelles are suspended. Many of the cell processes

(protein synthesis, respiration etc) take place in the cytoplasm. The cytoplasm also plays an important role in the movement of various materials around the cell.

Cell cycle & division

- Definition: it is the alternation between interphase and mitosis.

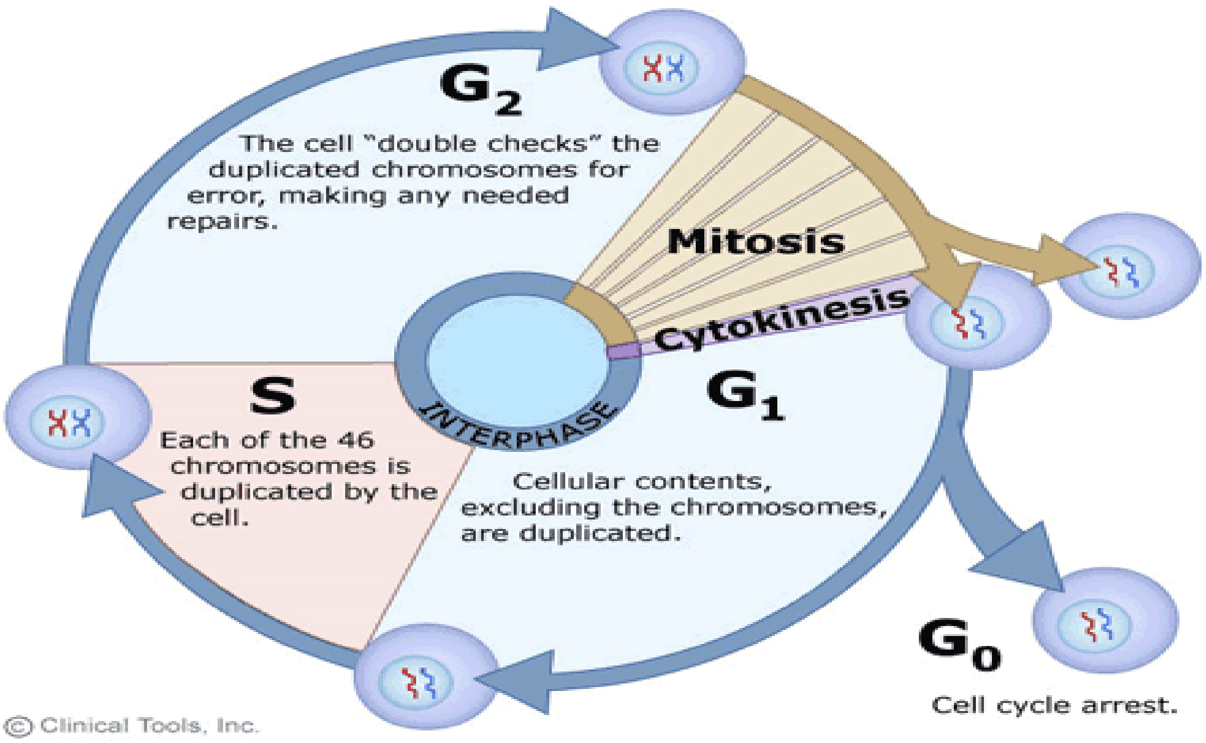
I-Interphase: a longer period:

1- The cell increases in size.

2- Performs its normal functions.

3- Replicates its DNA for preparing itself for division.

II-Mitosis: a shorter period during which parent cell gives 2 daughter cells each containing the same number of chromosomes (identical to the parent cell =46 chromosomes).



I-Interphase

First gap phase (G_1 phase)

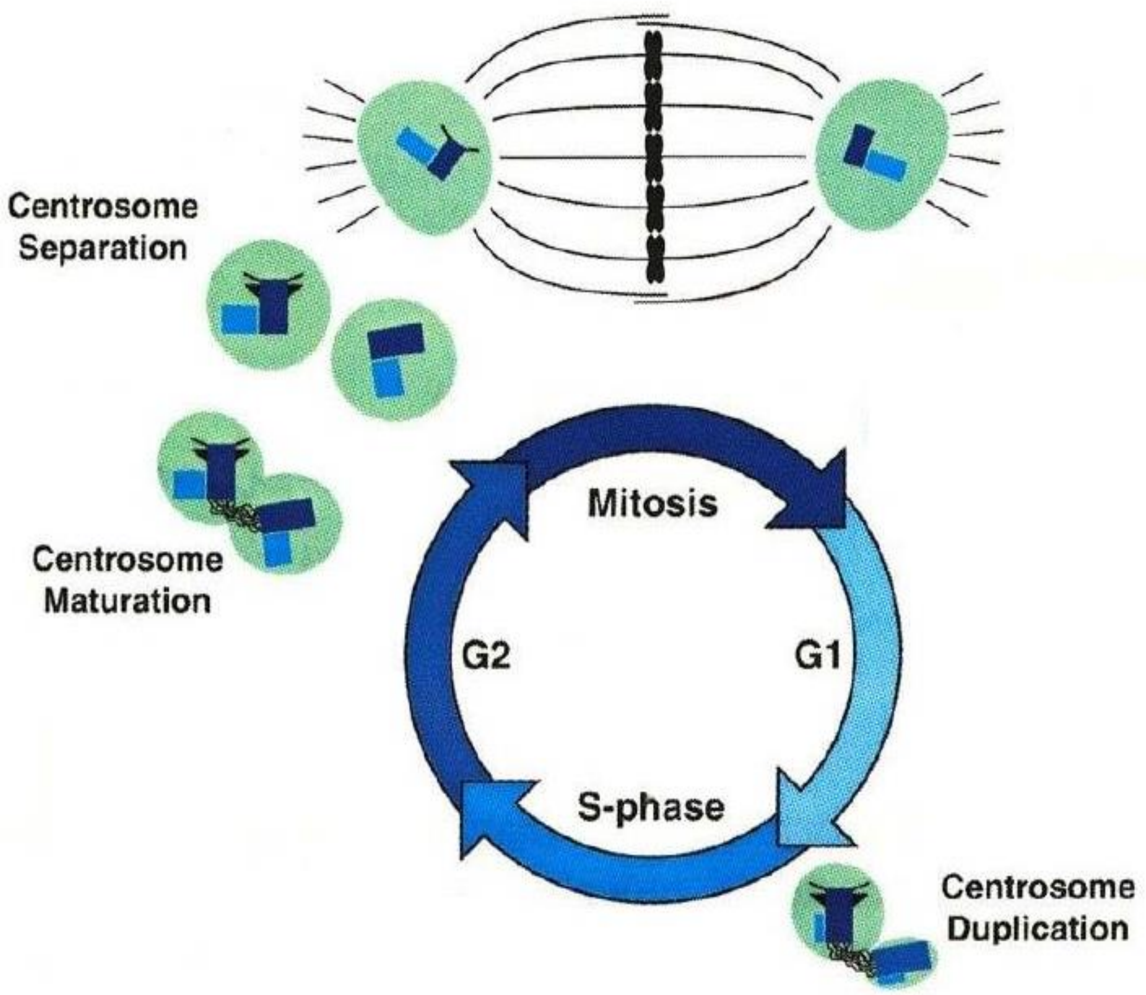
- It is *the longest period* of the cell cycle between the end of mitosis and the beginning of DNA replication:

1- The RNA and protein synthesis occurs.

2- The cell attains its full size.

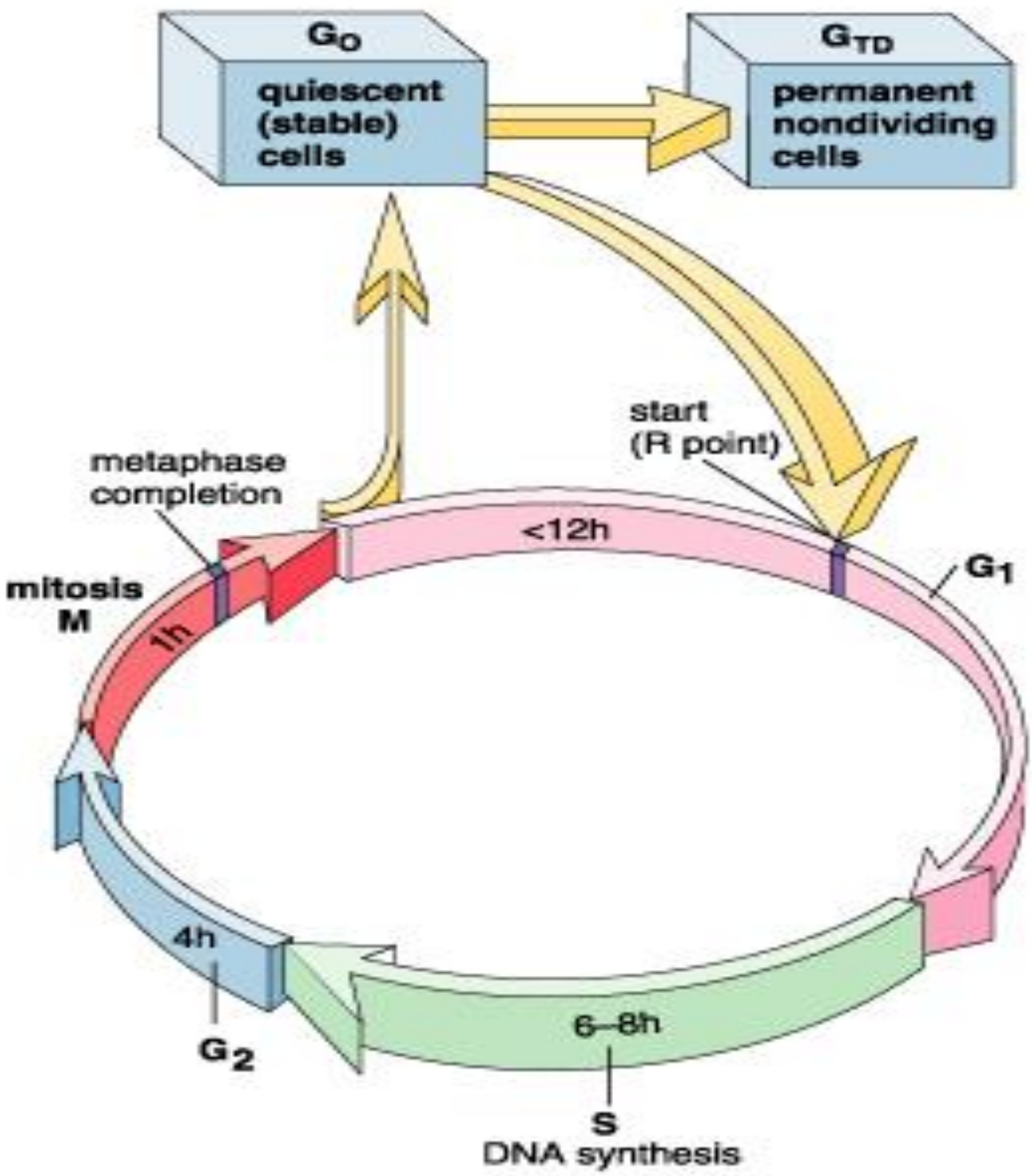
3- The cell performs its function.

4-Duplication of centrosomes occurs near the transition between G_1 and S phase.



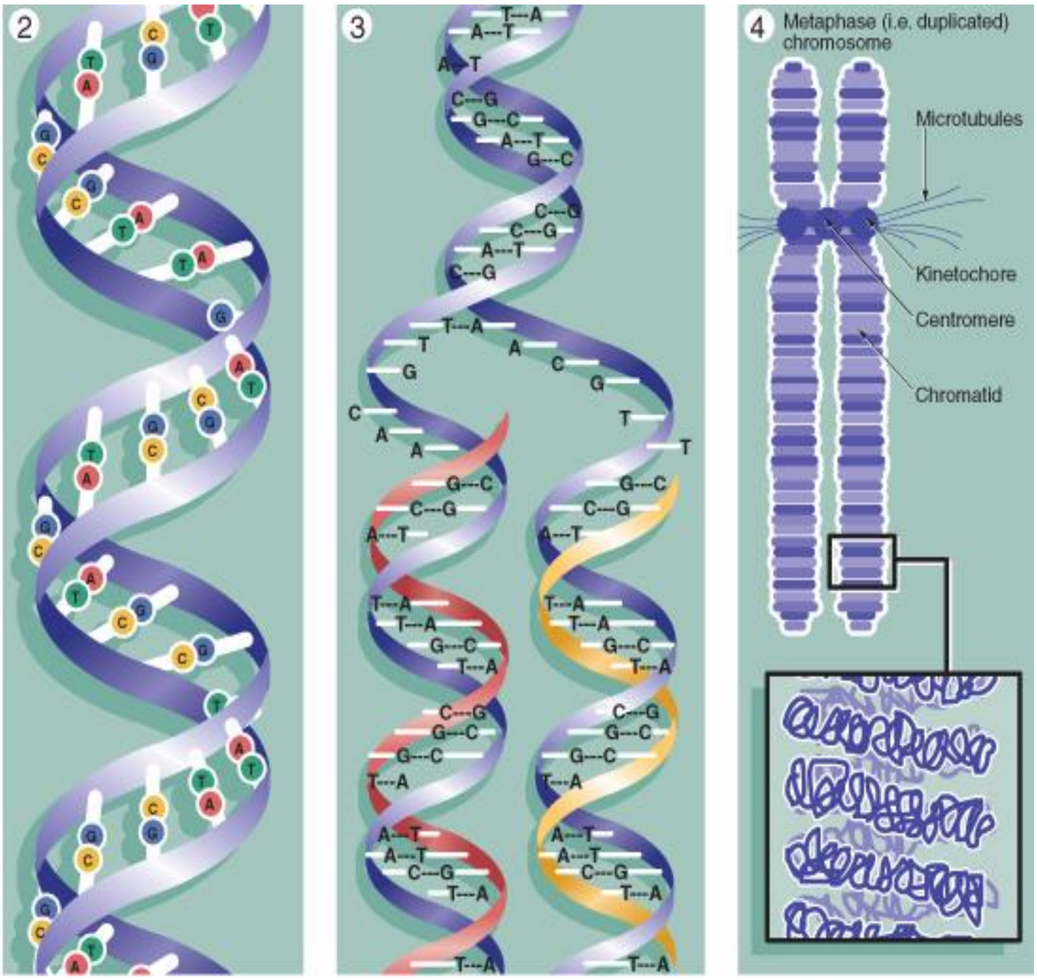
GO Phase

- **Definition**: Differentiation of the cell to carry out specialized function and no longer divide (*outside the cycle*).
- GO may be *permanent* or *temporary*.



DNA synthesis phase (S phase)

- Replication of DNA, thus the amount of DNA is doubled but *not the total chromosomal number*.



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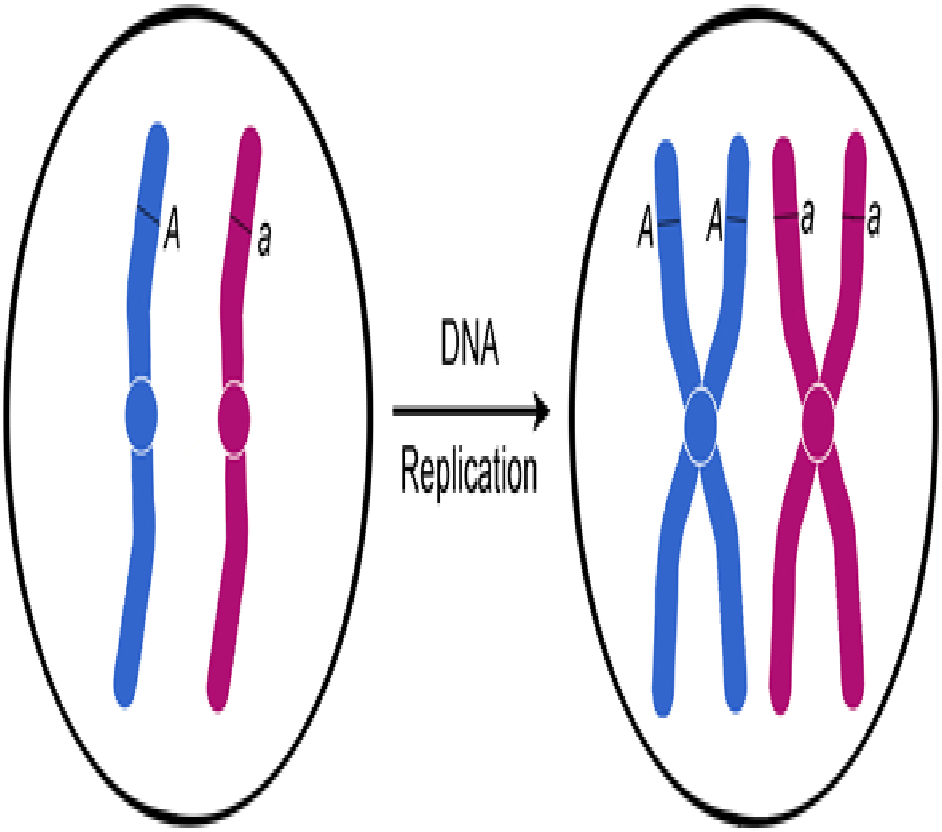
- **Types of chromosomes s-chromosomes** made of one DNA molecule (interphase chromosomes = chromatin or chromatids).
- **d-chromosomes (mitotic chromosomes):** are formed during the S phase. Each d-chromosome is formed of two chromatids, linked at the centromere. Each chromatid is made of a DNA molecule.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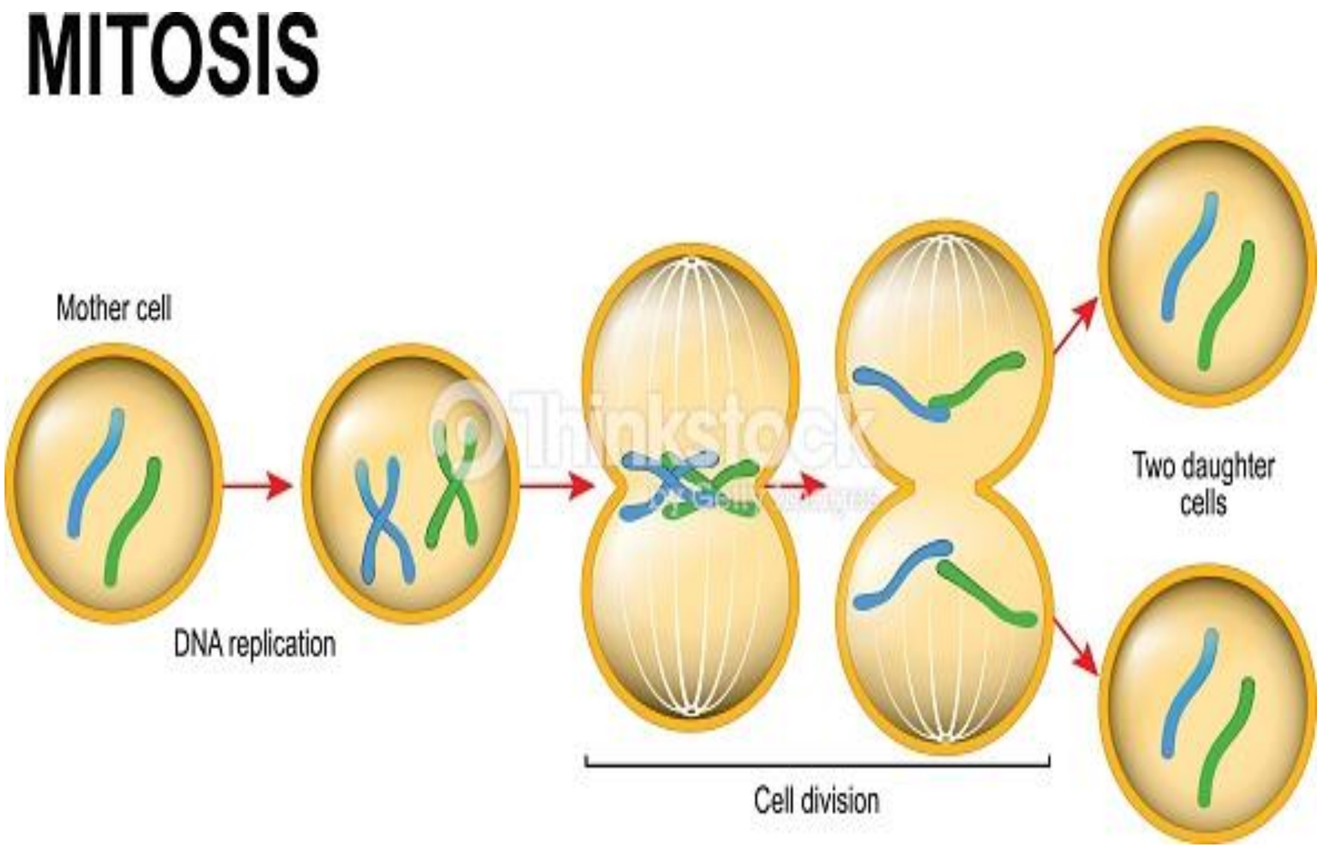
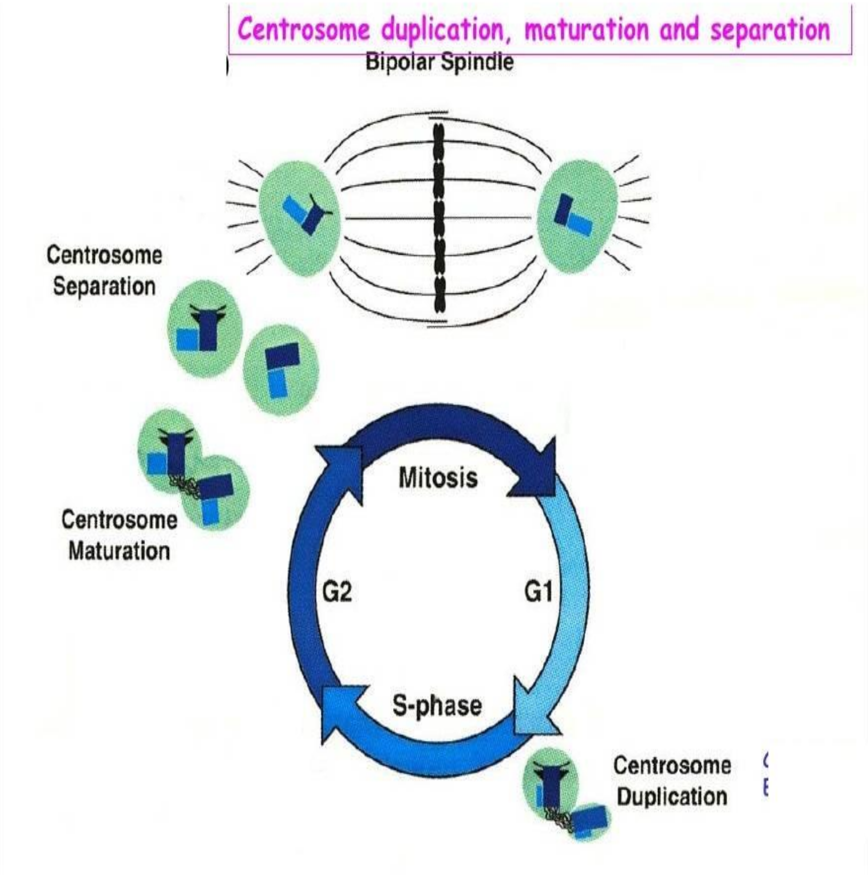

MITOSIS
Mother cell
DNA replication
Cell division
Two daughter cells

Second gap phase (G_2 phase)

- It starts by the end of the DNA replication and lasts until the beginning of mitosis.

1- Proteins and energy essential to mitosis are stored.

2- Duplication of the centrosome is *completed*.



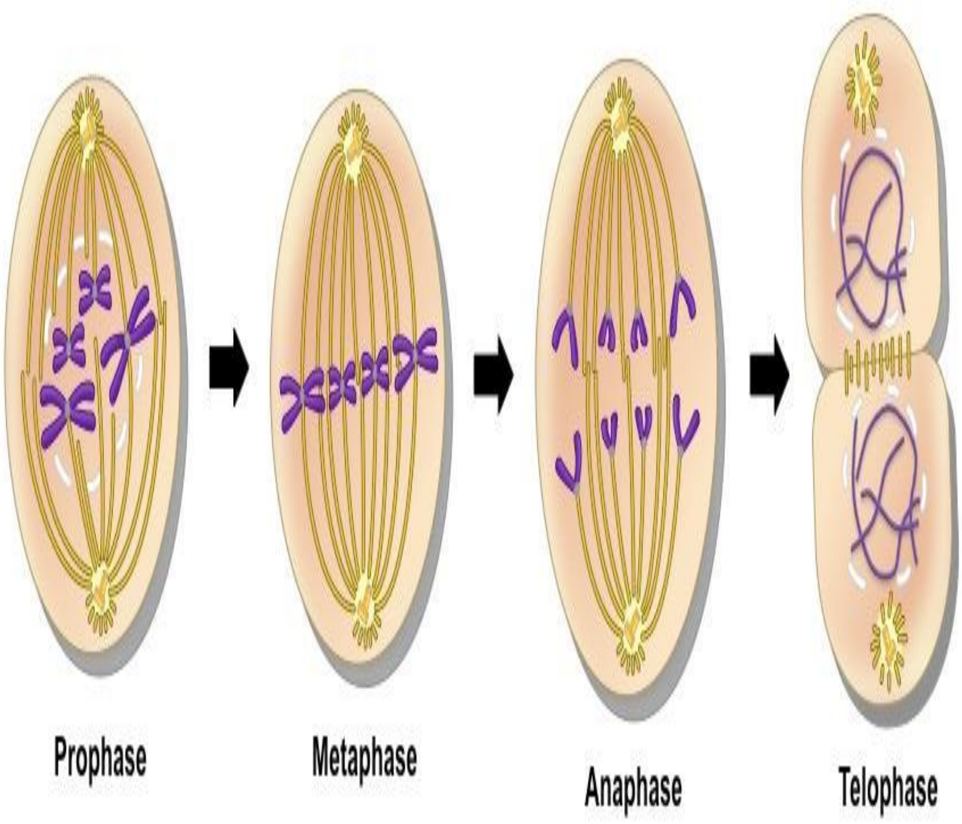
Cell division

Mitosis

- Definition: division of the somatic cell into two daughter cells identical to the mother cell.
- **Function:**

1- Growth and development of the organism.

2- Renewal and repair of cells.



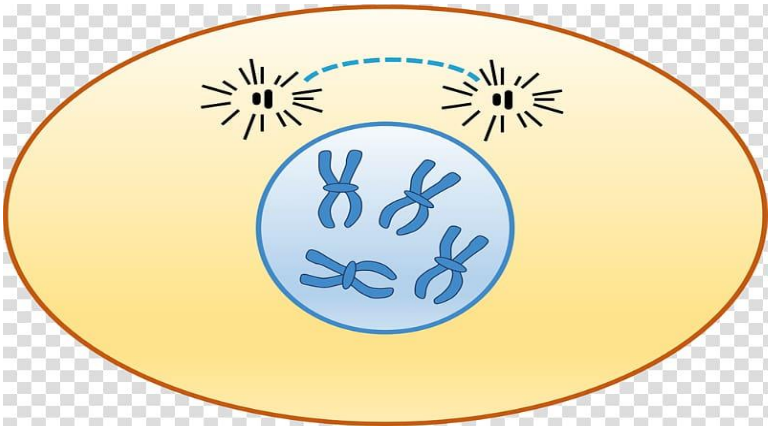
I-Prophase

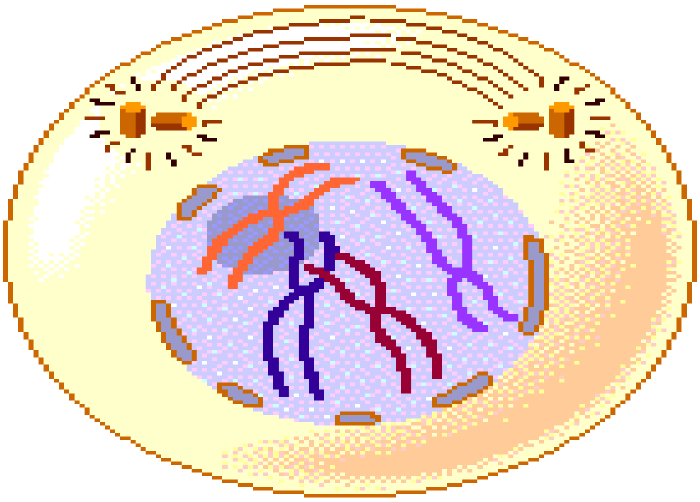
1- The *nucleolus* disappears.

2- Condensation of *chromatin* gives rise to 46 rod-shaped short d-chromosomes.

3- Each pair of *centrioles* migrates to opposite pole of the cell forming the mitotic spindles.

4- The *nuclear envelope* breaks up into small vesicles



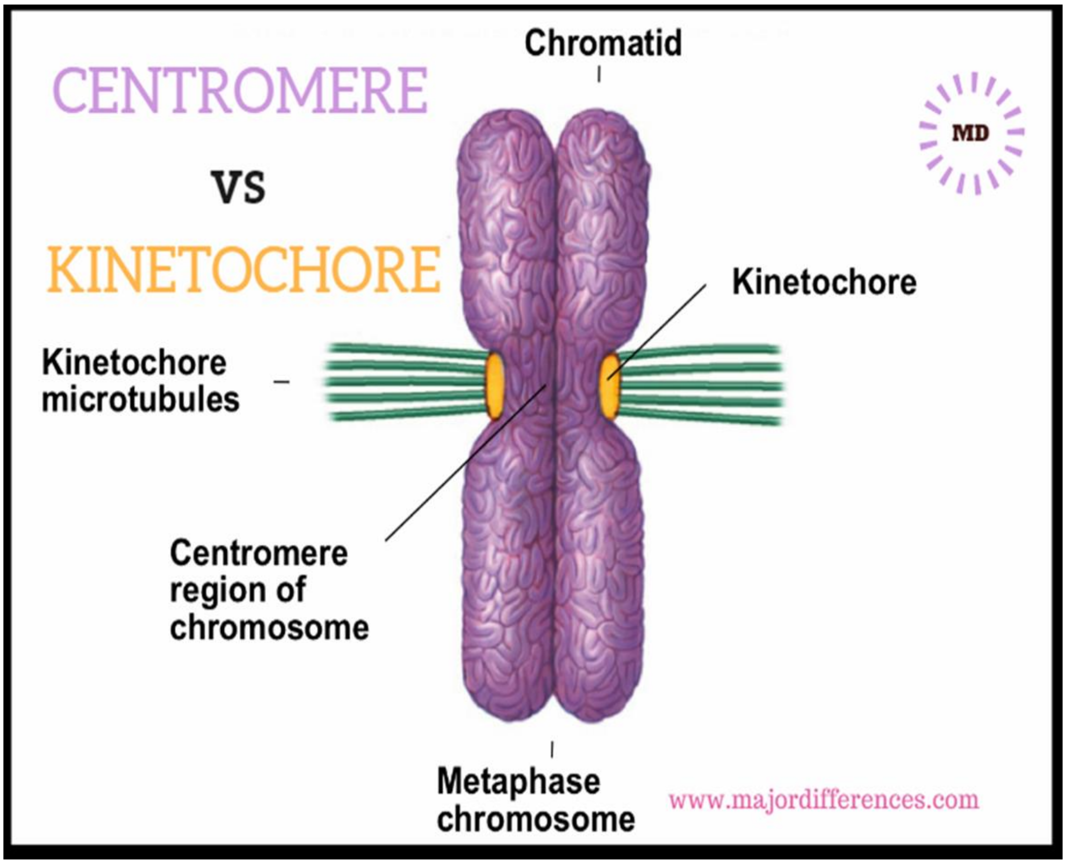


2-Metaphase

1- The 46 d-chromosomes become maximally condensed.

2- The chromosomes *aligned at the equatorial plate* of the cell.

- Each pair of sister chromatid is attached to the mitotic spindles at *the kinetochore*.

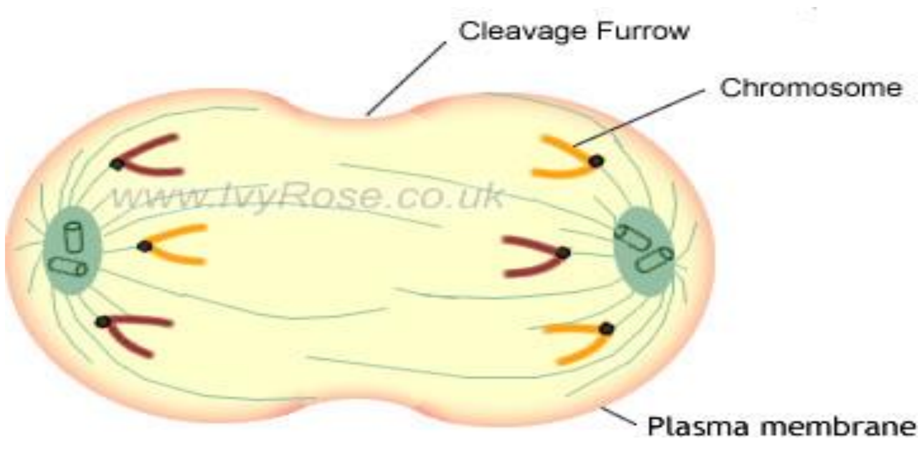


3-Anaphase

1-*Division of the centromere* results in the separation of the sister chromatids.

2- Each 46 chromatids migrate toward the opposite poles of the cell.

3- In late anaphase, *a constriction (cleavage furrow)* develops at the equatorial plate of the cell.



4-Telophase

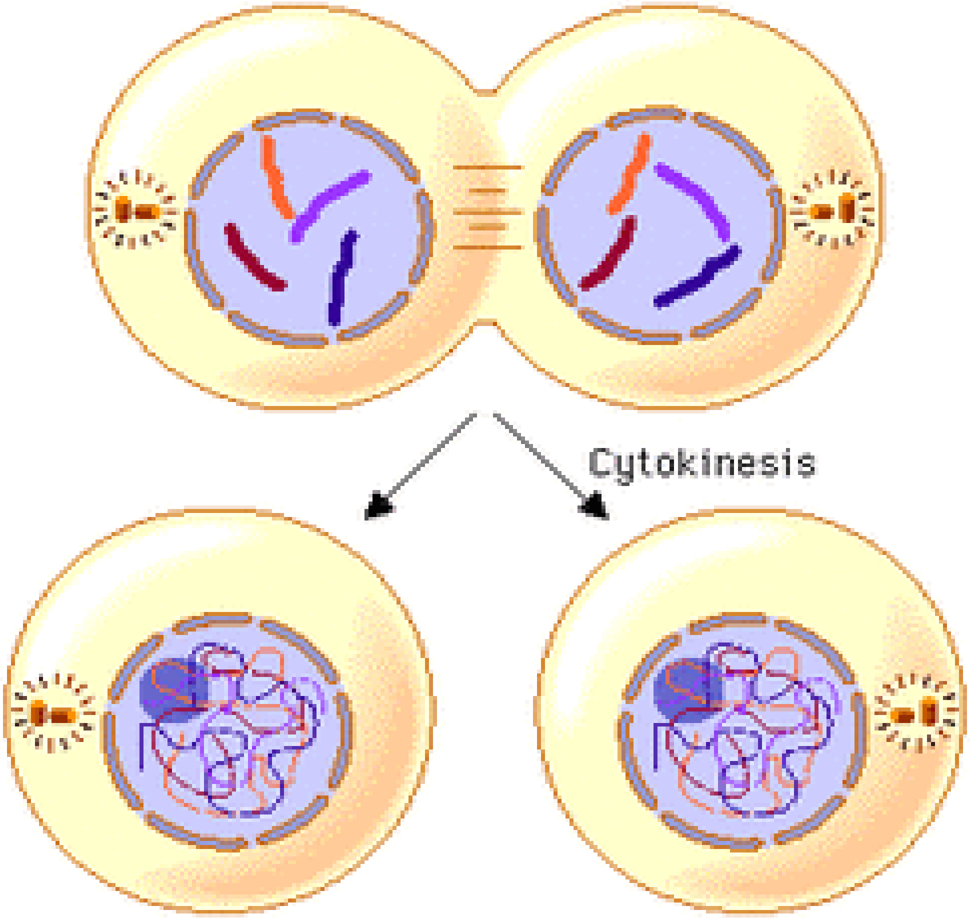
1- The *mitotic spindle* disappears.

2- The *nucleolus* reappears.

3- The *chromosomes* start uncoiling (46 s-chromosomes).

4- The *nuclear envelope* is reformed around the new sets of chromosomes.

5- Division of the *cytoplasm* (cytokinesis): the cleavage furrow becomes deeper due to the formation of a contractile ring of microfilaments until it divides the cytoplasm and its organelles in half resulting into two daughter cells.



Regulation of the cell cycle

- The cell cycle is regulated by growth factors that control cell proliferation to keep its coordination with the needs of the living organism.
- Several ***checkpoints*** control the transition between the cycle stages.
- Checkpoints detect external or internal problems and stop the cycle until the problem solved.

Checkpoints of cell cycle

1-The restriction checkpoint

- It occurs in the G_1 phase.
- It detects *the cell size & its interactions with the surrounding environment*.
- Cells that do not receive appropriate growth stimuli do not progress past this point (G_1 phase) and will be die by apoptosis.

It is the most important checkpoint in the cell cycle

2-DNA damage checkpoints

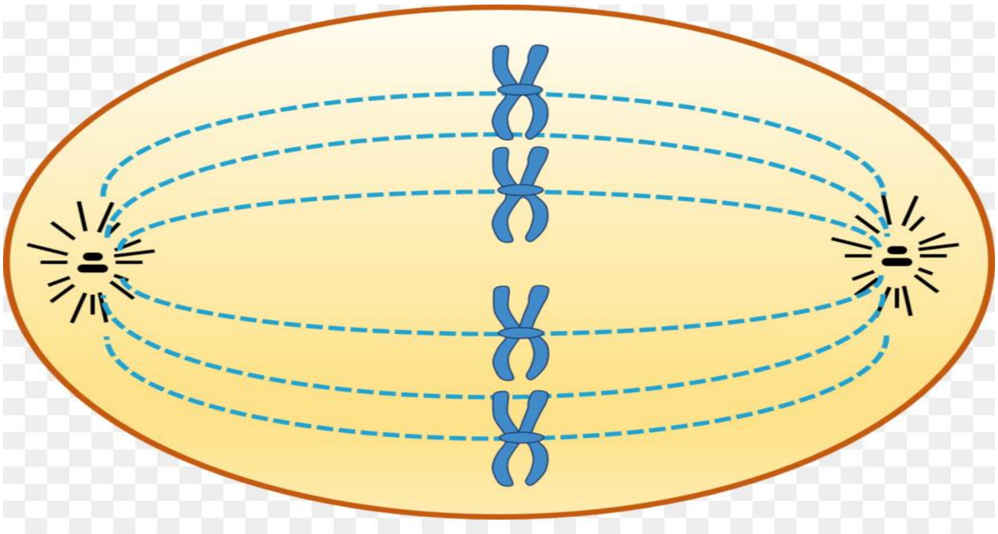
- It occur in G_1, S, and G_2 phases.
- It blocks cell cycle progression until repair of the damaged DNA or cell apoptosis occurs.

3-The unreplicated DNA checkpoint

- It occurs in the G_2 phase.
- It prevents progression of the cycle into the mitosis before complete synthesis of DNA.

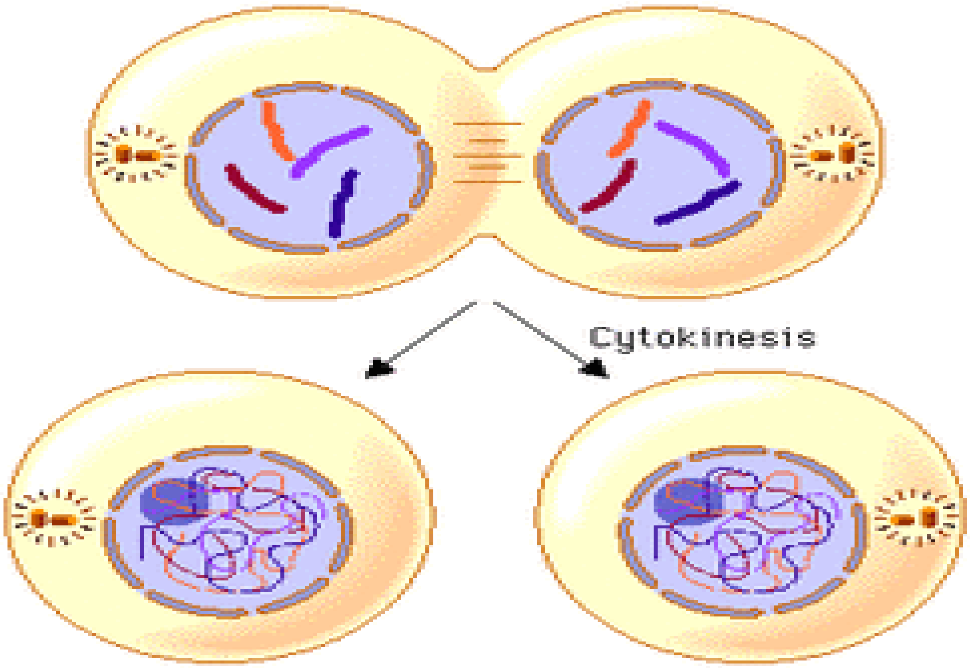
4- The spindle-assembly checkpoint (**the metaphase checkpoint**)

- It occurs in mitosis.
- It prevents entry into anaphase until all chromosomes have attached properly to the mitotic spindle.



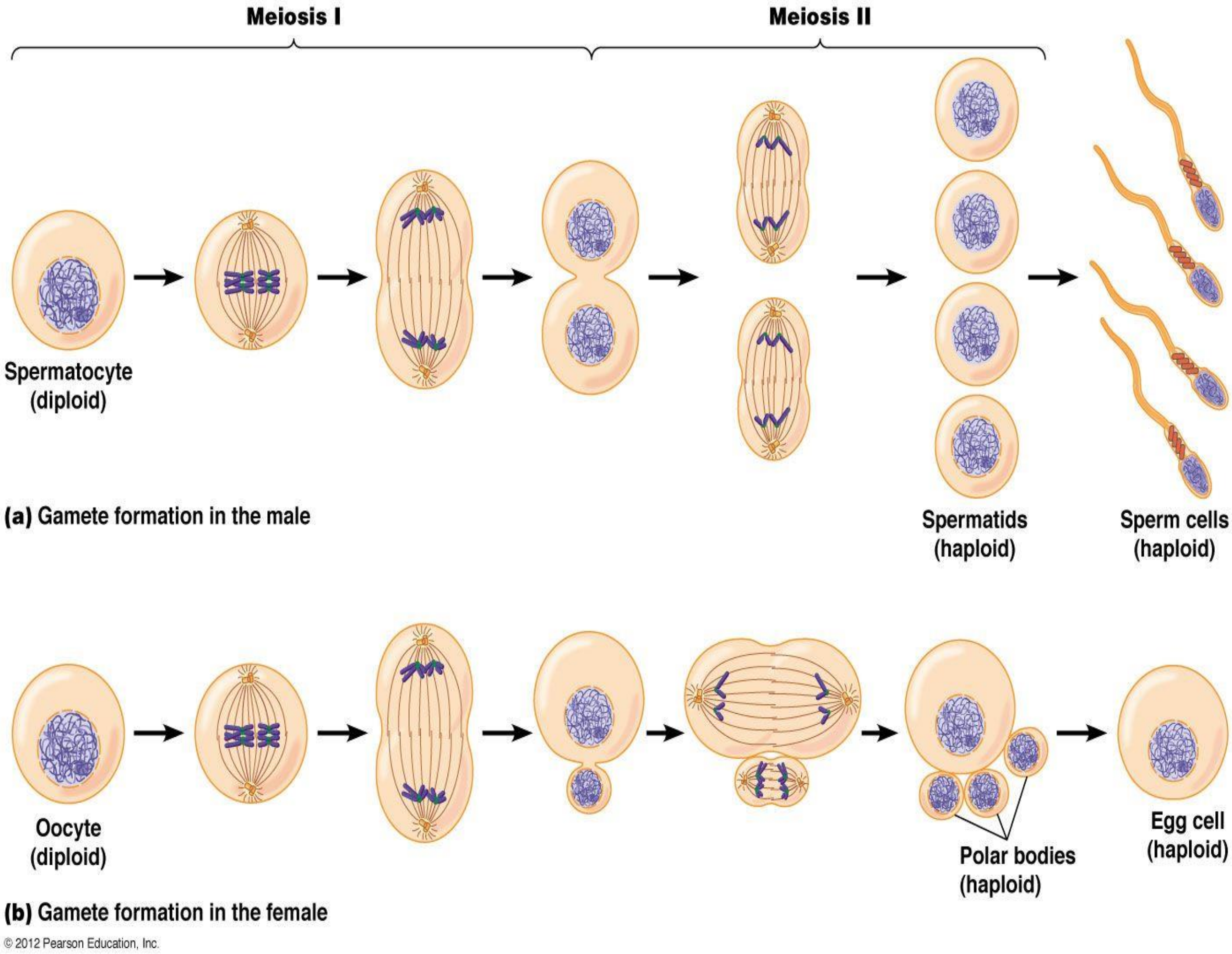
5- The chromosome-segregation checkpoint

- It occurs in telophase.
- It prevents the cytokinesis until all of the chromosomes have been correctly separated.



Meiosis

- It occurs in *germ cells* and results in the formation of gametes.
- It results in formation of *4 daughter cells* (each contains 23 s-chromosomes=haploid number).
- It consists of two successive divisions; *without an intervening S phase*.



I-First meiotic division (reductional division)

is preceded by interphase with an *S phase*, in which the chromosomes are replicated (46 s chromosomes 46 d chromosomes).

<u>1-Prophase I:</u>

A- *Pairing of the homologous chromosomes* occurs forming tetrads(bivalent).

B- Crossing-over occurs between the chromatids of the homologous chromosomes so that each homologous chromosome is no longer solely paternal or maternal but a mixture of both.

3- The nucleolus and the nuclear envelope disappear and the mitotic spindle is formed.

<u>2- Metaphase I:</u>

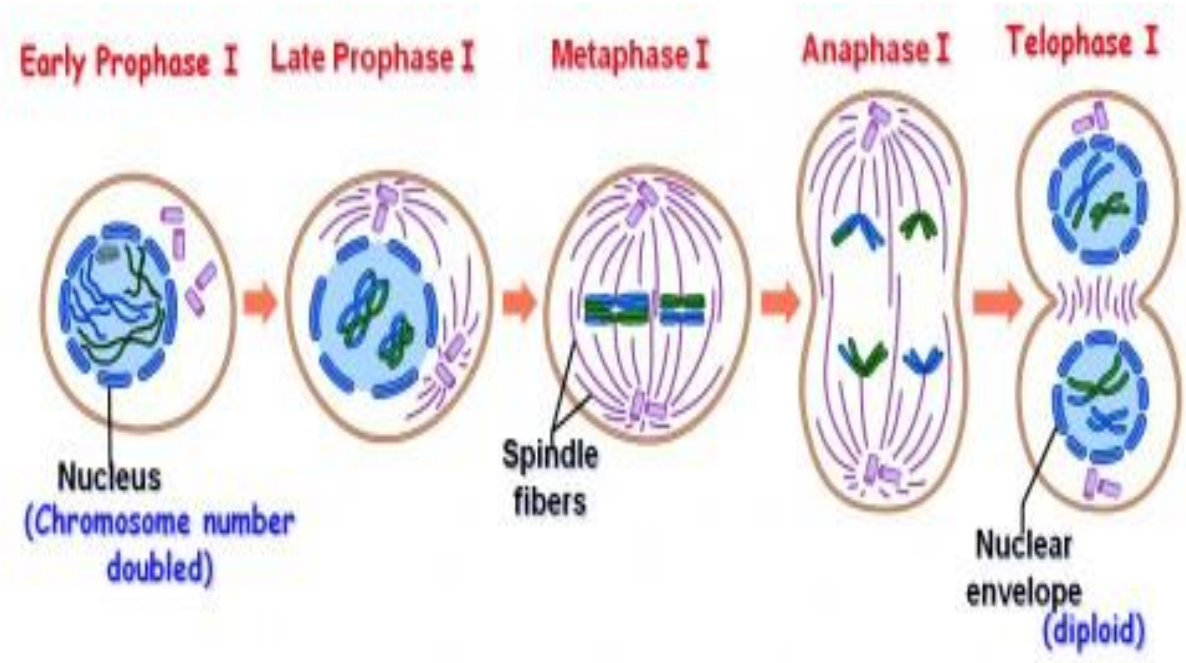
The *paired chromosomes* arrange themselves at the equatorial plate of the cell.

<u>3- Anaphase I:</u>

The centromeres *do not divide*, instead, each chromosome of homologous pairs moves separately towards the opposite poles of the cell.

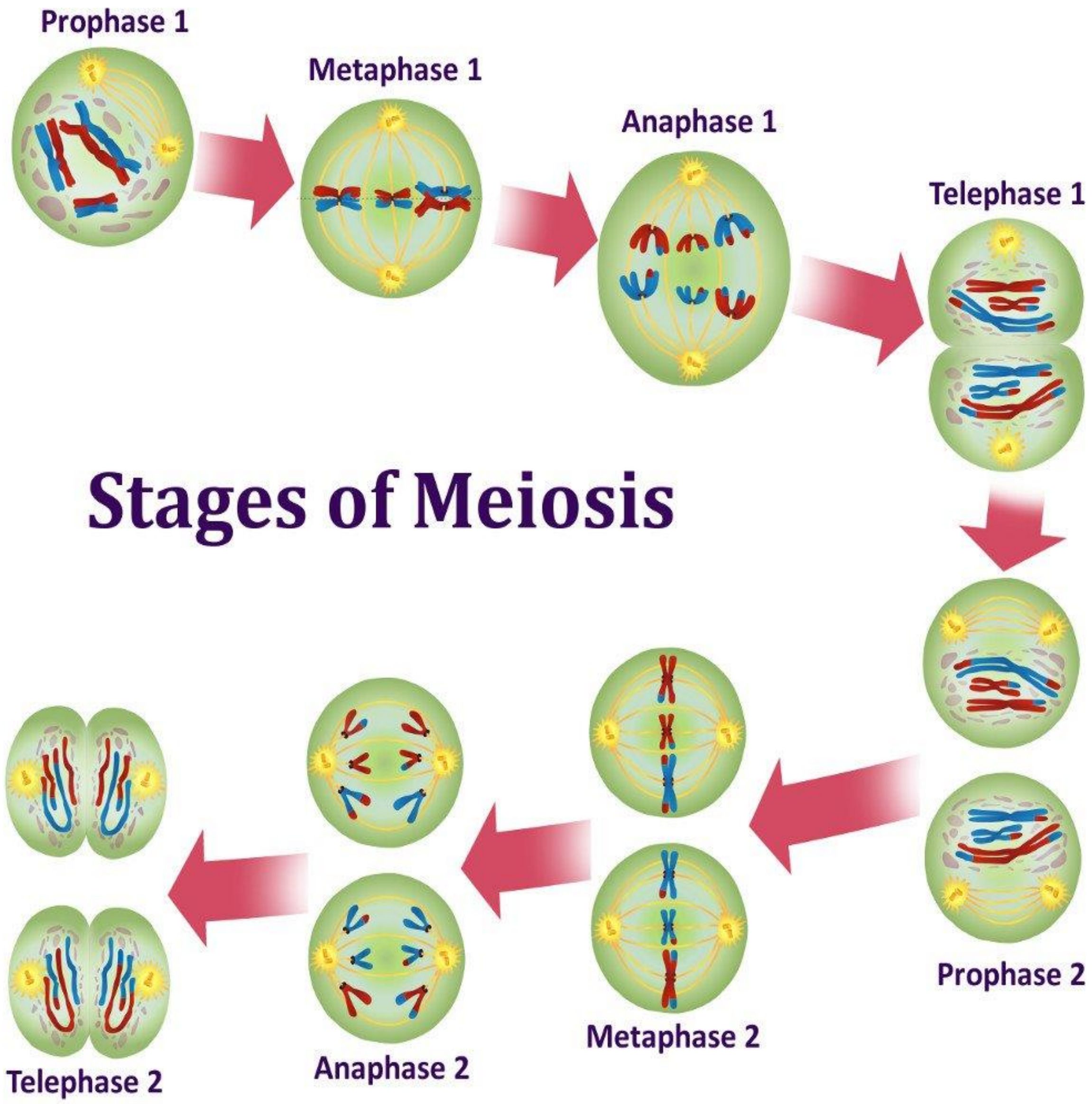
<u>4- Telophase I:</u>

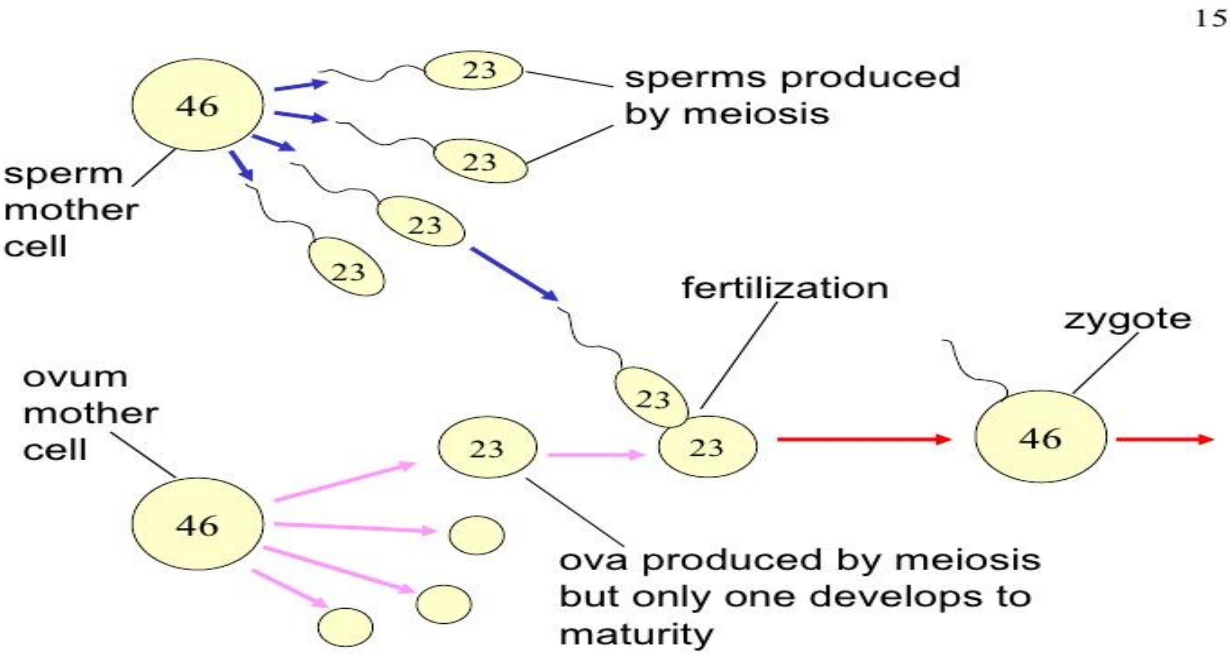
Cytokinesis occurs results in two daughter cells each containing the haploid number (23d-chromosomes).



II-Second meiotic division (equatorial division)

- It is similar to mitosis but, it is *not preceded* by S phase.
- It results information of *4 daughter cells*, each contains 23 s-chromosomes (haploid number).

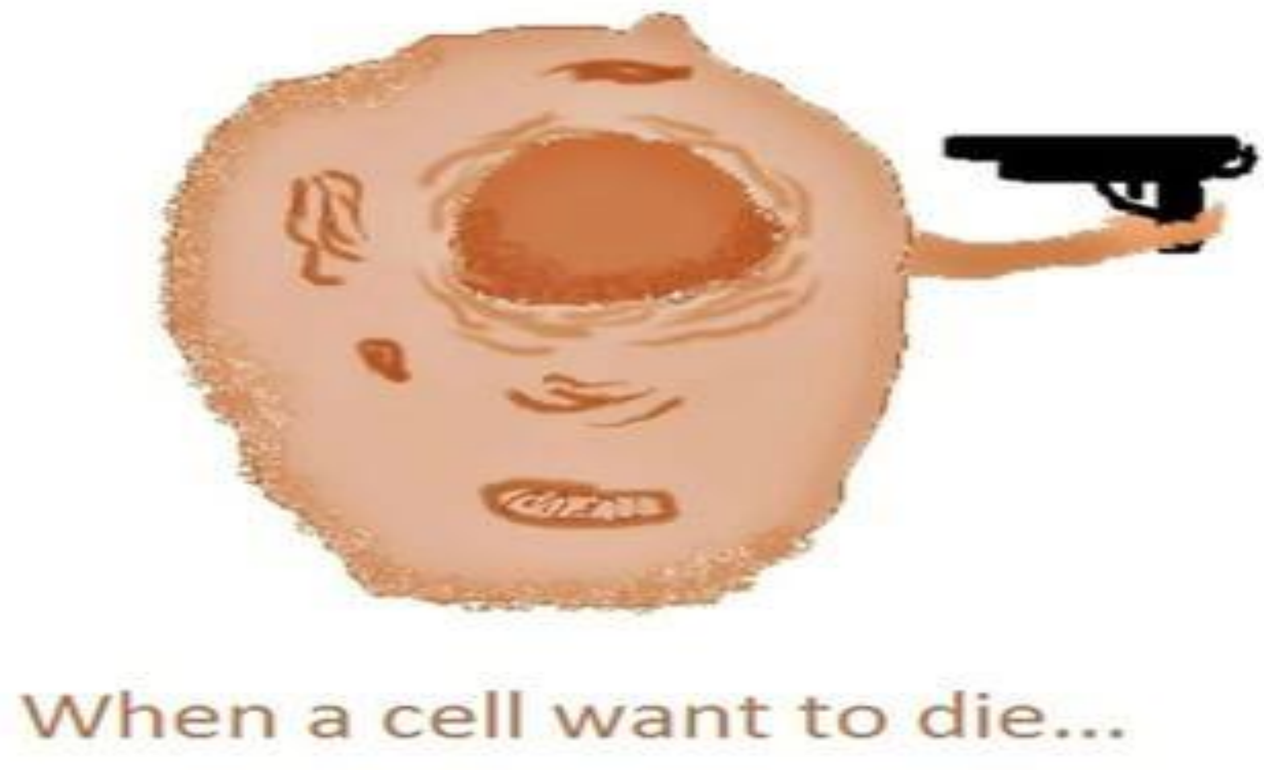




	Mitosis	Meiosis
1-Types of cells	Somatic cells	Germ cells of testis & ovaries
2- Number of division	Single division	2 successive divisions: Meiosis I & Meiosis II.
3- Interphase	Preceded by interphase with S phase	Meiosis I preceded by interphase with S phase, Meiosis II not preceded by S phase.
3- Prophase	No crossing over	Meiosis I: Crossing over occurs
4-Metaphase	46 d chromosomes arranged individually at the equatorial plane of the cells.	In Meiosis I :23 bivalent arranged at the equatorial plane of the cells.
5- Anaphase	Each chromosome divides at centromere into 2 chromatids	In Meiosis I: each chromosome of a bivalent moves apart.
6- Cells produced 156	Two daughter cells with diploid number of chromosomes (46 S) Daughter cells are genetically identical	Four daughter cells with haploid number of chromosomes (23 S) Daughter cells are genetically variable.

	Meiosis I	Meiosis II
1- Preceded S phase	Present (the cell enter the prophase with 46 d chromosomes).	Absent (the cell enter the prophase with 23 d chromosomes).
2- Prophase	Pairing of homologous chromosomes result in 23 tetrad. Crossing over occurs between each tetrad .	No pairing No crossing over.
3- Metaphase	23 tetrad arranged at the equatorial plane of the cells.	23 d chromosomes arranged individually at the equatorial plane of the cells.
4- Anaphase	No division of the centromere. Each chromosome moves independently to the opposite pole of the cell.	Centromere splits so each chromatid moves independently to the opposite pole of the cell.
5- Telophase 157	Cytokinesis results in 2 daughter cells each with 23 d chromosomes.	Cytokinesis results in 4 daughter cells each with 23 S chromosomes.

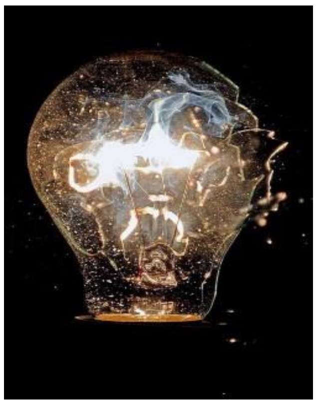
Cell death



Types of cell death

Apoptosis

Necrosis



Necrosis = accidental cell death

- **<u>Causes:</u>** It is a *pathological process* due to e.g. hypoxia, radiation or pathogens such as viruses.
- **<u>Morphological features:</u>**

1- *Damage of the cell membrane* with cell swelling& rupture.

2- Breakdown of cell organelles.

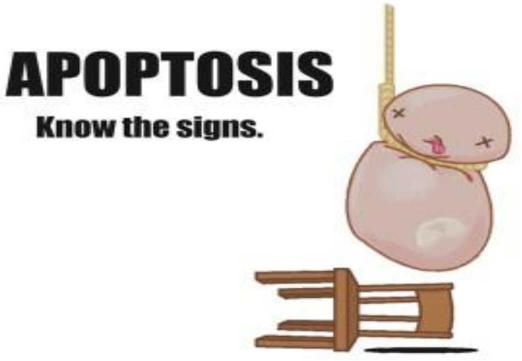
3- Denaturation or coagulation of cytoplasmic proteins.

4- Inflammation with extensive damage of the surrounding tissue.

Apoptosis = programmed cell death

It is a *physiological process* controlled by several genes (loss of mitochondrial function initiates several reactions that lead to cell death).

What makes a cell decide to commit suicide?



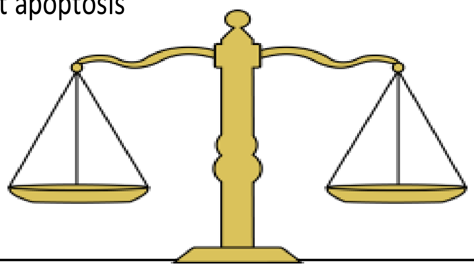
Each cell receives

Positive signals

From other cells and extracellular matrix that inhibit apoptosis

Negative signals

Promote apoptosis

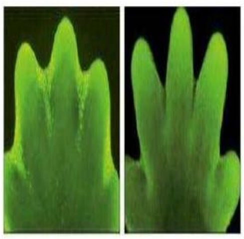


There is a Balance Between them

Receiving of negative signals **OR** **Withdrawal of positive signals** → *Apoptosis*

I-During embryonic development

- Removal of excess cells that have no function e.g. during morphogenesis and for determination of organ size



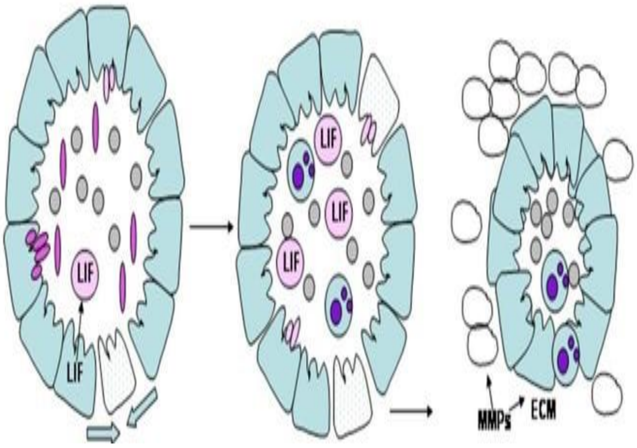
Development of toes

Incomplete apoptosis

II-In adult

1- Hormone-dependent:

- Involution of the endometrium during the menstrual cycle.
- Regression of lactating mammary gland after weaning.
- Regression of prostate in old males.

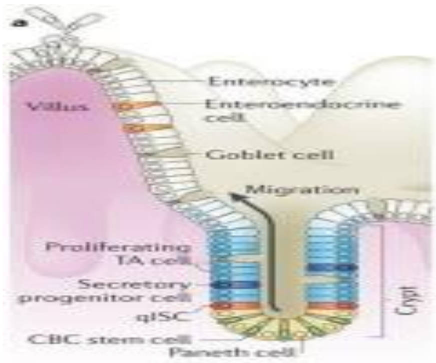


II-In adult

2- Elimination of cells during cell cycle when their DNA damage is not repaired.

II-In adult

3- Maintaining a constant number of cells in proliferating cell populations, e.g. intestinal epithelium.



Morphological features of apoptosis

1- Loss of microvilli and intercellular junctions.

2- Shrinkage of the cell with membrane blebing .

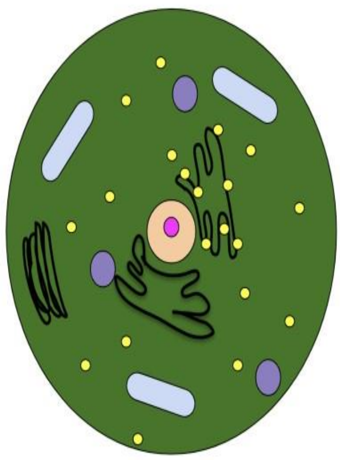
3- Breakdown of DNA with hypercondensation of chromatin and its collapse against the nuclear periphery.

4- Change of cell membrane characters *without loss of its integrity* .

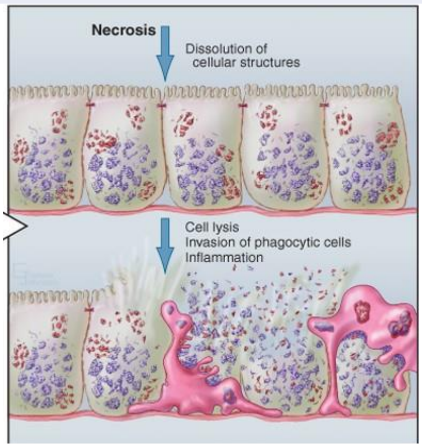
5- Cell organelles remain apparently normal but become clumped inside the cytoplasm.

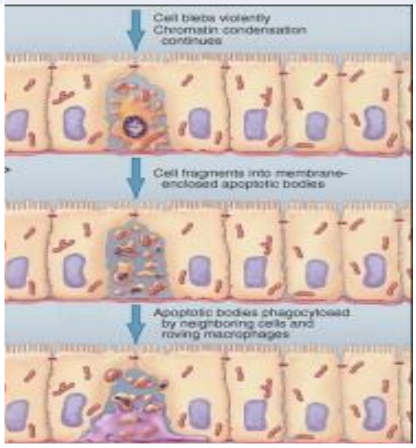
6- Fragmentation of the cell into *apoptotic bodies* that contain fragments of the nucleus, mitochondria and other organelles.

7- The apoptotic bodies are removed by the phagocytic cells.



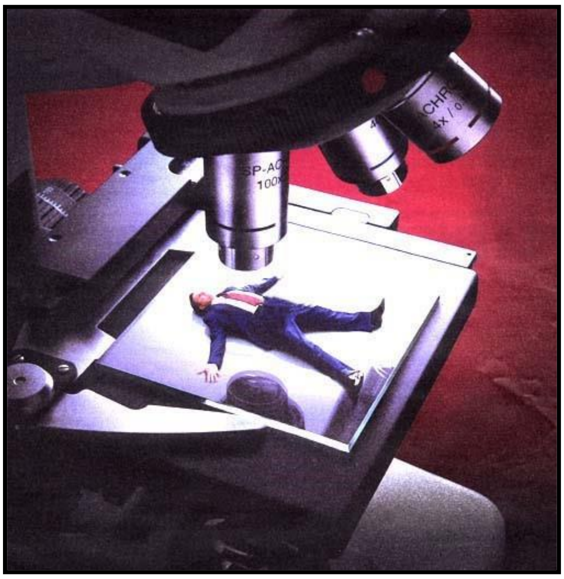
	Necrosis	Apoptosis
1- Type	Pathological.	Physiological.
2- Cell membrane	Damage with loss of its integrity.	Change of some characters without loss of its integrity.
3- Organelles	Broken down.	Intact.
4- Proteins	Denatured or coagulated.	Broken down of DNA with hypercondensation of chromatin.
5- Apoptotic bodies	Absent	Present
6- inflammation	Present	Absent





HISTOLOGY

The study of cells and tissues, a.k.a. micro-anatomy



Tissue Preparation for Light Microscopy

1. Stabilize cellular structures by chemical fixation.
2. Dehydrate and infiltrate tissues with paraffin or plastic.
3. Embed fixed tissues in paraffin or plastic blocks.
4. Cut into thin slices of 3-10 micrometer thick; collect sections on slides.
5. Re-hydrate and stain with Hematoxylin (a basic dye): Stains basophilic structures (e.g. nucleic acids) blue/purple.
6. Counter-stain with Eosin (an acidic dye): Stains acidophilic or "eosinophilic" structures (e.g. proteins, membranes) red/pink.

"H & E" staining is routine, but other dyes and staining techniques may be used to visualize other structures.

Types of tissues (A group of cells that all perform the <u>same</u> specific function)

1. Epithelial Tissue – covers body surfaces and organs, lines body cavities
2. Connective Tissue – binds and supports body parts
3. Muscular Tissue – contracts producing movement

4. Nervous Tissue – responds to stimuli and transmits nerve impulses

1. Epithelial Tissue

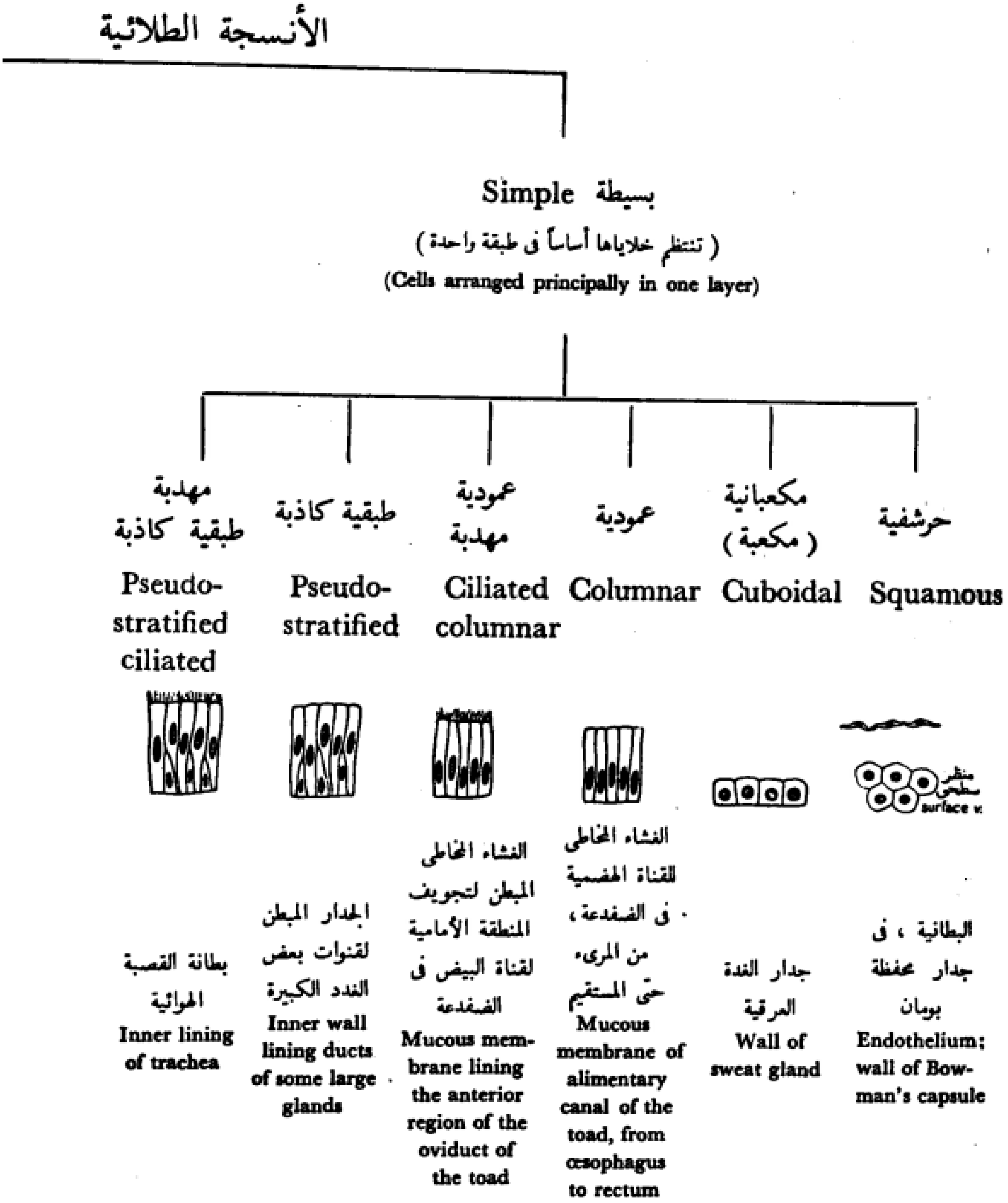
The epithelium is a sheet of aggregated cells of similar type that covers body surfaces, lines hollow organs or modified to form glands or neuroepithelium.

General Features of Epithelium

- It may originate from all three embryonic germ layers (ectoderm, mesoderm and endoderm).
- It is composed of high number of closely applied cells with very little intercellular substances.
- It is separated from the underlying connective tissue by a basement membrane.
- It is avascular, blood and lymph vessels do not penetrate the basement membrane. Thus, it receives its nutritional support by diffusion.
- The epithelial cells have high capacity for regeneration.
- The epithelium can change from one form to another in a process called metaplasia.
- It performs many functions such as protection, secretion, excretion, absorption and sensory reception.

II. Simple epithelium

It consists of single layer of epithelial cells resting on basement membrane.



a. Simple squamous epithelium

It consists of a single layer of thin flat, scale-like cells. On surface view, the cells have an irregular shape with a slightly serrated border. Each cell has a centrally located spherical or oval nucleus.

In a side view, the cells are so flat that they can only recognize by their elongated nuclei that bulge into the lumen. The cytoplasm is scanty and has sparse organelles.

Location: lung alveoli, glomerular capsule of the kidneys, lines the blood and lymph vessels (endothelium*)*, lines the serous membranes (peritoneum, pleura and pericardium) and is called mesothelium, lines the subarachnoid and subdural spaces (mesenchymal epithelium), the anterior chamber of the eye and perilymphatic spaces of the ear.

b. Simple cuboidal epithelium

It consists of a single layer of cube-like cells whose width and heights are nearly equal. In sections, the cells are square with spherical centrally located nuclei. It is usually located in organs that have secretory or absorptive functions.

Locations: thyroid follicles, glandular ducts and kidney tubules.

c. Simple columnar epithelium

It consists of a single layer of tall, narrow cells having greater height than width. The nuclei are oval and are located near the base of the cells.

Locations: simple columnar absorptive with microvili (small intestine, gall bladder), simple columnar secretory (stomach) or simple columnar ciliated (oviducts and bronchioles).

d. Pseudostratified columnar epithelium

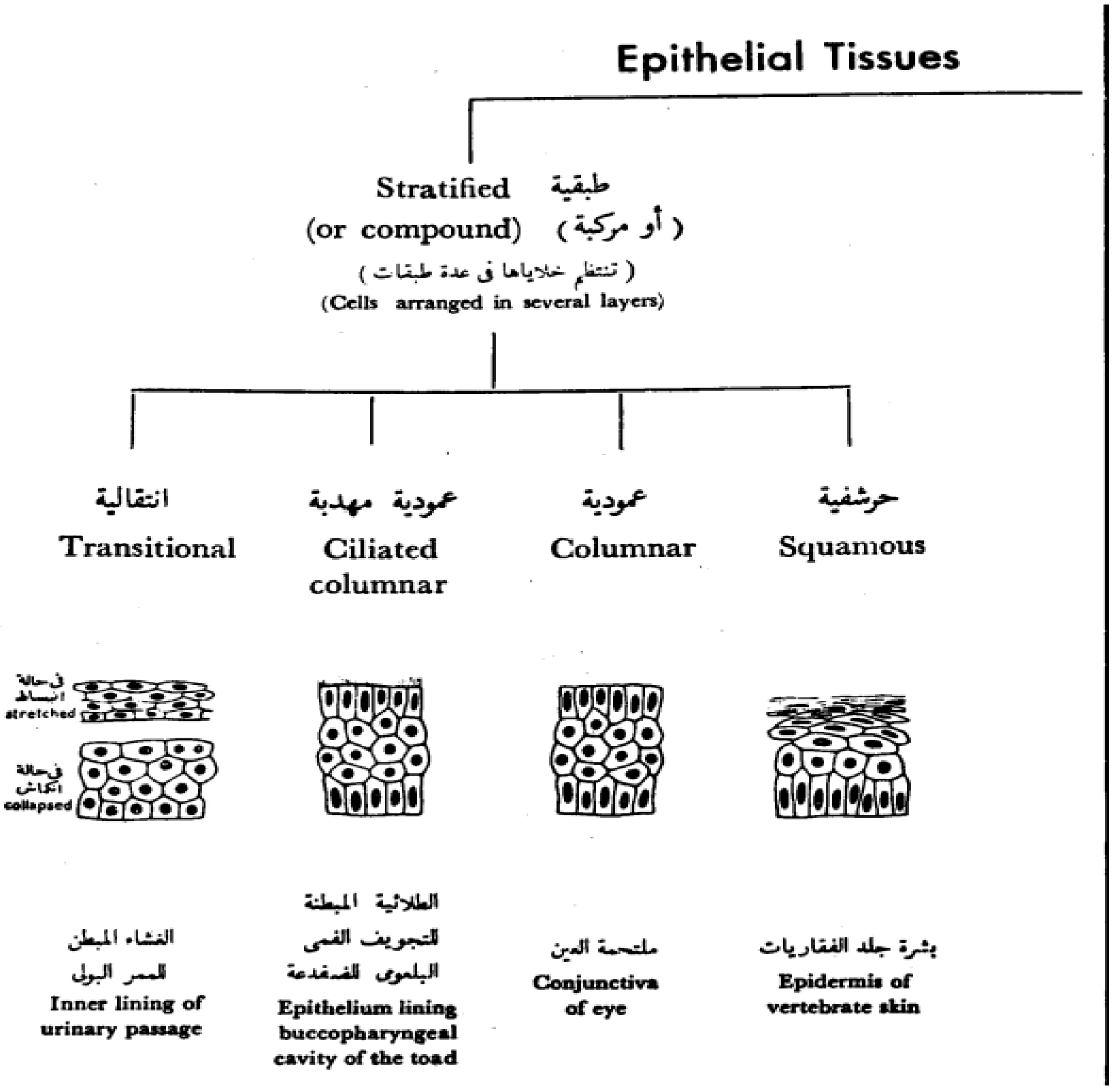
It is composed of single layer of irregular cells. All the cells rest on the basement membrane but not all the cells reach to the luminal surface. The nuclei are located at different levels, thus creating the illusion of cellular stratification. The cells reaching the surface are either ciliated or goblet cells.

The short cell acts as progenitors for the tall cells. The pseudostratified columnar ciliated epithelium may be differentiated from the stratified epithelium by 1) cilia are never exists on stratified epithelium. 2) the apical cytoplasm of the cell forming the pseudostratified epithelium does not contain nuclei.

Locations: in reproductive and respiratory epithelium.

II. Stratified epithelium

It consists of two or more than two layers of cells.



b. Stratified squamous epithelium

It consists of several layers of cells with only the superficial cells having squamous shape.

c. Stratified squamous non-keratinized epithelium

It consists of three layers:

1.Stratum basale is a single layer of cuboidal to columnar cell rest on a wavy basement membrane.

2. Stratum spinosum is composed of several layers of polyhedral cells tightly adhere to each other by numerous desmosomes. In H&E sections, the desmosomal attachments appear as small spiny processes, hence the name of this layer (spiny layer or stratum spinosum). The stratum basale and the deep layer of stratum spinosum are involved in active mitosis, therefor this region is referred to as stratum germinativum.
3. Stratum squamosum is the superficial layer and is made up of few layers of flat squamous cells with ovoid small nuclei.

Locations: oral cavity, pharynx, esophagus, anal canal, and vagina. Such sites are normally subjected to moderate mechanical abrasion and are kept moist by local glandular secretions.

d. Stratified squamous keratinized epithelium

It consists of five layers:

1. Stratum basale: consists of single layer of cuboidal to columnar cells resting on a wavy basement membrane.
2. Stratum spinosum: has the same structure as that of the stratified squamous non-keratinized epithelium.

3. Stratum granulosum consists of few layers of flattened cells having small pyknotic nuclei and rich in keratohyaline granules.

4. Stratum lucidum found only in non-hairy skin. It is a layer of flattened, keratinized cells between the stratum granulosum and stratum corneum. It has a translucent or shiny appearance because the cytoplasm of these cells is rich in protenecious materials called eleidin.

1. Stratum corneum is the outermost layer and consists of dead, keratinized cells. The cells have lost their nuclei and their cytoplasms filled with keratin that is a water-resistant protein.
2. Stratum disjunctum formed of groups of cells in the outermost layer of the stratum corneum that become loose and detach to constitute this layer.

Locations: epidermis, hoof and horns.

e. Stratified cuboidal epithelium

It consists of two or more layers of cells, with only the superficial cells having a cuboidal shape. It is frequently occurs as two-layered epithelium located in the large glandular ducts.

f. Stratified columnar epithelium

It consists of several layers of cells with only the superficial layer having tall columnar cells.

Locations: distal portion of the urethra, parotid and mandibular ducts, lacrimal sac and lacrimal duct.

g. Transitional epithelium

It is a form of stratified epithelium found only in the urinary tract (lines the ureter and urinary bladder). It is highly specialized to resist a great degree of stretch and to withstand the toxicity of urine.

In relaxed state (empty bladder) it is consists of 4-5 layers of cells, the basal layer is cuboidal in shape rests on thin basal lamina . The intermediate layer consists of several layers of polyhedral or pear-shaped cells. The surface cells are large cuboidal or dome-shaped with convex outer surface and concave inner surface. Their nuclei are large, spherical with prominent nucleoli, some cells are binucleated.

In stretched state (full bladder) it appears only as two or three cell layers thickness. The intermediate and surface layers are extremely flattened. The superficial cells have a thicker plasmalemma that acts as a barrier against diffusion of fluid from the subepithelial tissue to the hypertonic urine.

Membrane specialization of epithelia

The basal, luminal and intercellular surfaces of epithelial cells have a variety of specializations.

1. Basal surface
2. Basement membrane

The epithelium is separated from the underlying connective tissue by a thin membrane known as basement membrane . It consists of two layers; basal lamina and reticular lamina.

The basal lamina is synthesized by the adjacent epithelial cells and is located in contact with the epithelial basal plasmalemma. It is composed of type IV collagen embedded in an amorphous matrix of structural glycoprotein called laminin.

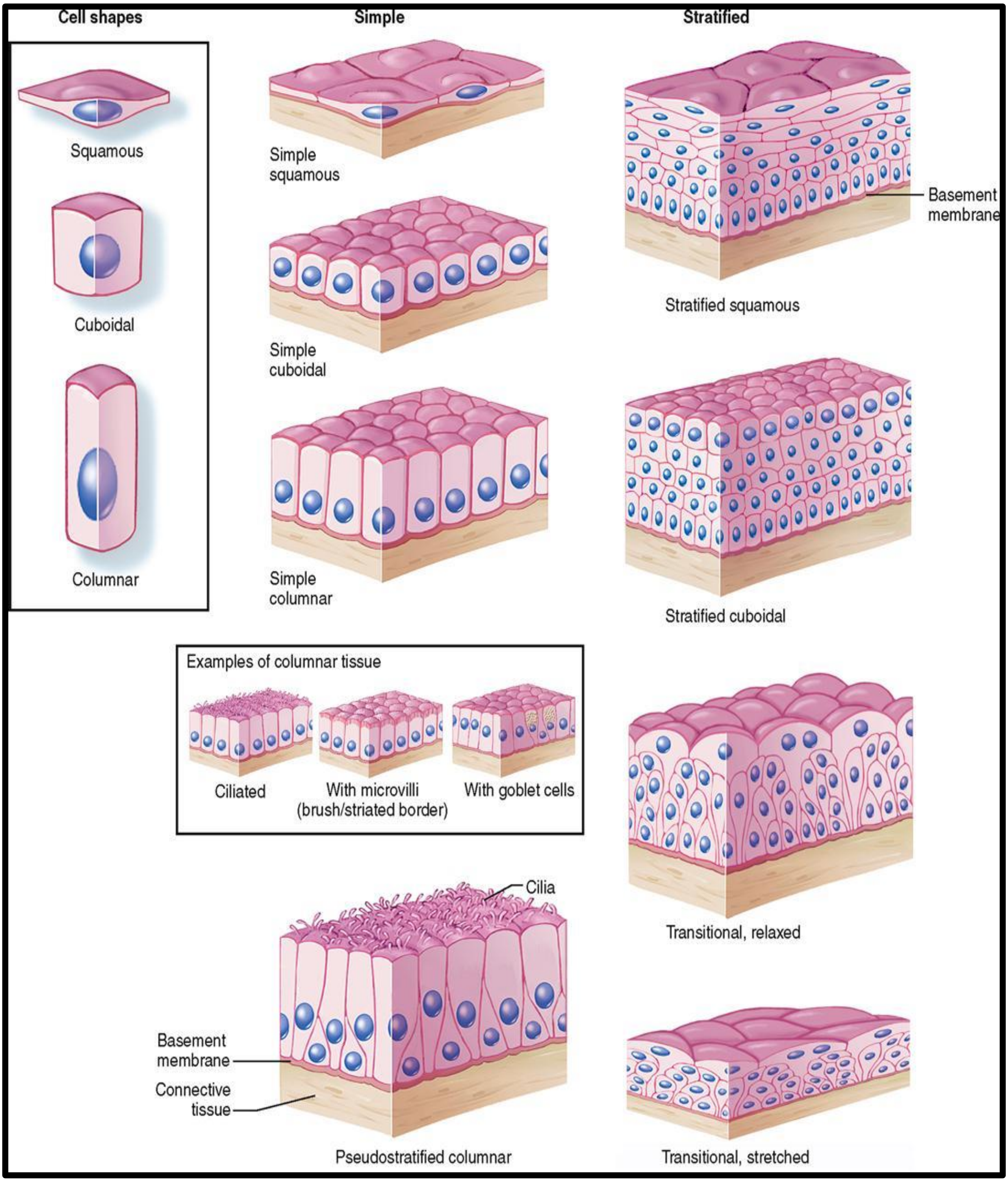
The reticular lamina is derived mainly from the underlying connective tissue and is located deep to the basal lamina. It consists of fine reticular fibers embedded in an amorphous ground substance.

In addition to underlying all epithelia, a basal lamina is found around muscle cells, neurolemmocytes and between epithelia in the renal corpuscle.

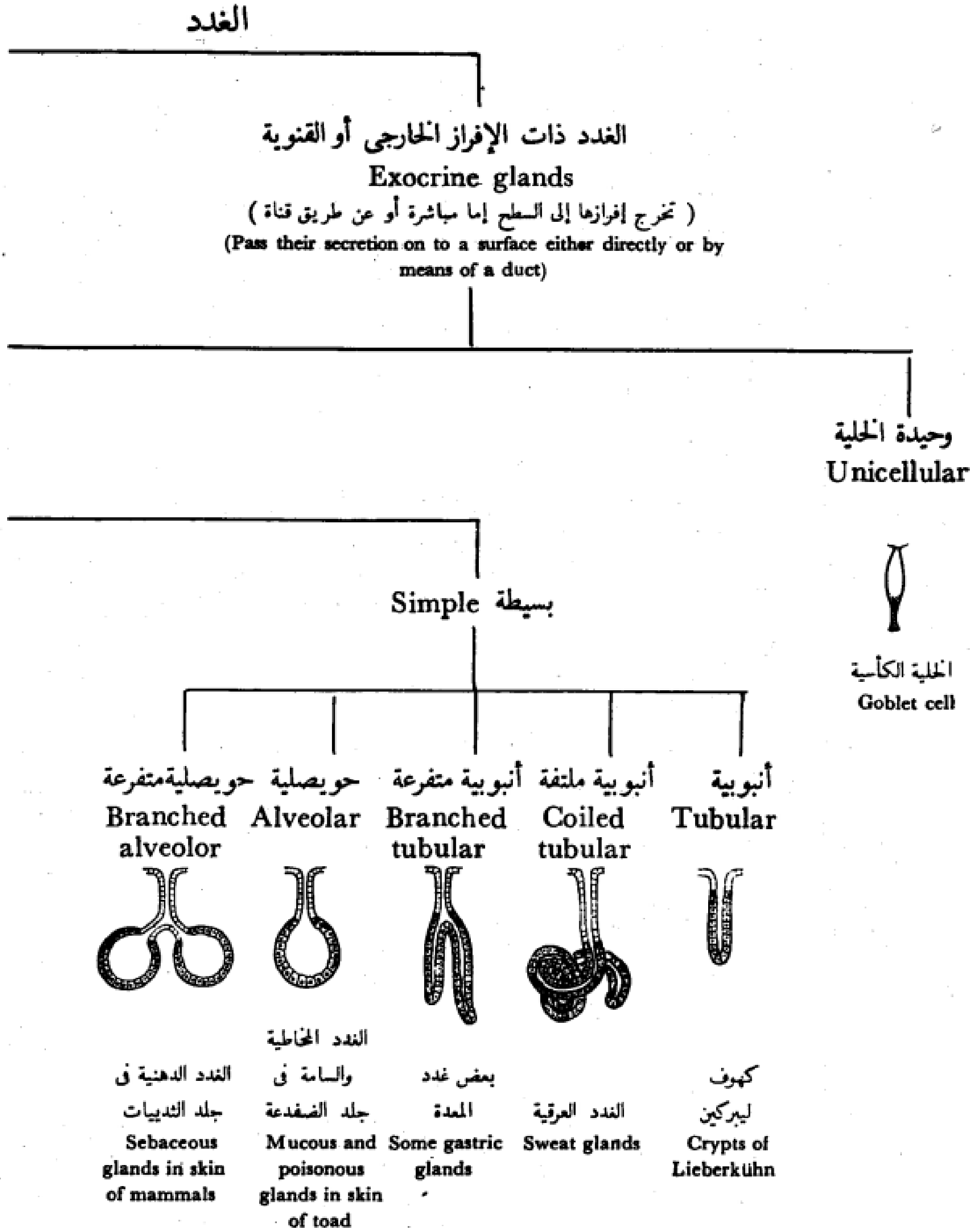
The basement membranes are difficult to resolve in common H&E sections, however, they can be selectively stained with silver (black) or PAS (magenta color).

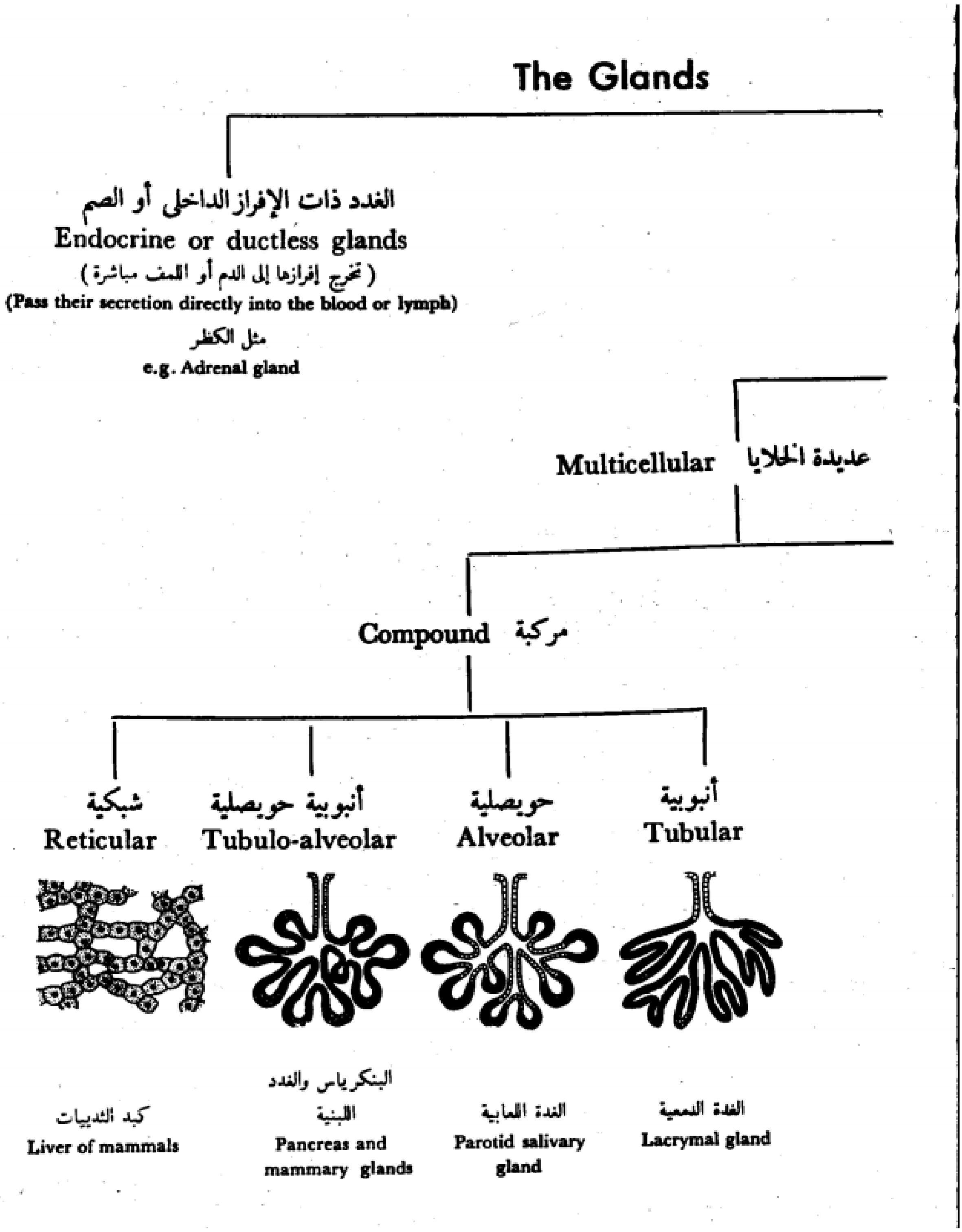
Functions

1. Support epithelial surfaces.
2. It may act as selective filter, such as the glomerular basement membrane of the kidneys.
3. It acts as a selective barrier to passage of cells between epithelia and connective tissue. For example, they permit the passage of the immune cells but prevent epithelial and connective tissue cells.


Cell shapes
Simple
Stratified
Squamous
Cuboidal
Columnar
Simple squamous
Simple cuboidal
Simple columnar
Basement membrane
Stratified squamous
Stratified cuboidal
Examples of columnar tissue
Ciliated
With microvilli (brush/striated border)
With goblet cells
Transitional, relaxed
Cilia
Basement membrane
Connective tissue
Pseudostratified columnar
Transitional, stretched

Glandular epithelium




The Glands
الغدد ذات الإفراز الداخلى أو الصم
Endocrine or ductless glands
(تخرج إفرازها إلى الدم أو اللمف مباشرة)
(Pass their secretion directly into the blood or lymph)
مثل الكظر
e.g. Adrenal gland
Multicellular
عديدة الخلايا
Compound
مركبة
شبكية
Reticular
أنبوبية حويصلية
Tubulo-alveolar
حويصلية
Alveolar
أنبوبية
Tubular
كبد الثدييات
Liver of mammals
البنكرياس والغدد اللبنية
Pancreas and mammary glands
الغدة اللعابية
Parotid salivary gland
الغدة الدمعية
Lacrymal gland

Classification

1. **According to the presence or absence of ducts**
2. Exocrine glands

They are glands that have a duct system to convey their secretory products to the sites of utilization (e.g., salivary glands).

1. Endocrine glands

They do not have a system of duct (ductless). The secretory product (hormone) reaches the site of utilization through blood or

lymph (e.g., pituitary gland and thyroid gland).

2) **According to the number of cells forming the gland**

Unicellular glands

It consists of a single secretory cell in a non-secretory epithelium (e.g., goblet cells).

Multicellular glands

It is composed of more than one cell (e.g., salivary gland).

3) According to the morphology of duct and the secretory parts

1. Simple tubular where the duct is not branched and the secretory part is in the form of tubule (e.g., glands of the large intestine).
2. *S*imple acinar or alveolar glands where the duct is not branched and the secretory part is in the form of alveolus or acinus (e.g., sebaceous gland and the glands of skin of amphibians).

1. Simple tubuloalveolar glands where the duct system is not branched and the secretory part is tubular and

alveolar (are rare).

4. Simple branched tubular where the duct is not branched while the tubular secretory part is branched (e.g., glands of the stomach).
5. Simple branched alveolar where the duct is not branched while the alveolar secretory part is branched (e.g., sebaceous glands).

6.Simple branched tubuloalveolar where the duct is not branched while the tubular and alveolar secretory part is branched (e.g., minor salivary glands).

7.Compound tubular glands where the duct is branched and the secretory parts are tubular (e.g., liver).

8.Compound alveolar glands where the duct is branched and the secretory parts are alveolar (e.g., mammary

glands).

9.Compound tubuloalveolar glands where the duct is branched and the secretory parts are tubular and alveolar

(e.g., salivary glands and pancreas).

4) **According to the nature of secretion**

1. Mucous glands

They produce thick, viscous secretions (mucus). The cells of the mucous secretory units are cuboidal in shape and

filled with mucinogen, the precursor of mucus that stain light (foamy or vacuolated) in H&E.

The nuclei are flattened and rest on the basement membrane. The lumen is wide (e.g., palatine glands and the glands of the tongue).

2. Serous glands

They produce thin watery secretion.

The cells of the secretory units are pyramidal in shape. The nuclei are spherical and situated near the center of the cells.

The cytoplasm has two zones, basal zone that appears basophilic due to the presence of rER and apical eosinophilic zone due to the presence of zymogen granules. (e.g., parotid glands and pancreas).

3. Seromucoid or mixed glands

They produce mixed secretions.

They consist primarily of mucous secretory units with crescent-shaped clusters of serous cells (serous demilunes)

located at the periphery of the mucous units.

The serous secretion reaches the lumen through intracellular canaliculi located between the mucous cells. (e.g., submandibular and sublingual salivary glands).

5) According to the mode of secretion

Merocrine glands (secretion without loss)

The cells of which remain intact and not destroyed during the process of secretion. The secretory granules are

discharged by exocytosis (e.g., salivary glands).

Apocrine glands (secretion with apical loss)

The apical parts of the cells are destroyed during the secretory process (e.g., some sweat glands and

mammary glands).

Holocrine glands (secretion with whole loss)

The whole secretory cells are discharged then destroyed to release the secretory product (e.g., sebaceous glands).

2. Connective Tissue

It is one of the basic tissues of the body designed primarily to connect and support various others tissues.

General Features

The connective and supportive tissues are derived from the mesoderm. However, the ectoderm of the head region may also contribute to their formation.

The connective tissues are made up of three main components:

Cells (widely separated from each other)

Fibers (different types)

Amorphous ground substances.

It is well vascularized.

It performs many functions:

a. Mechanical functions: Connection, Support, e.g., bone and Protection e.g., bone and cartilage.

b. Body defenses: Presence of phagocytes, Presence of immunocompetent cells and Physical properties of the ground substances which act against the spread of pathogenic organism.

c. Storage: Water and electrolytes, Fat in adipose tissue.

d. Temperature (heat) regulation: Adipose tissue.

e. Tissue repair: Formation of scar tissue.

The connective tissue proper is formed of:

1. Cells
2. Fibers
3. Amorphous ground substance

1. Connective tissue cells

The cells of the connective tissue are divided into two main groups:

Fixed or permanent cell

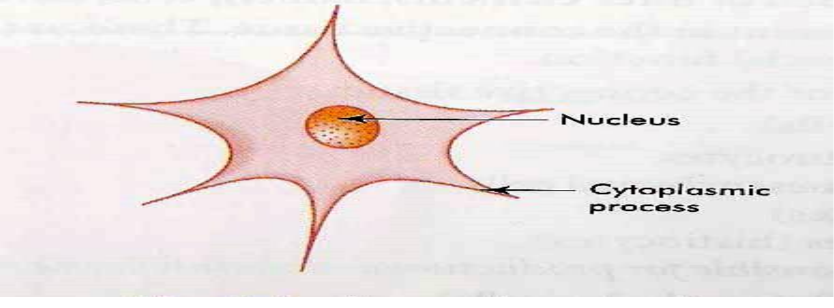
Mesenchymal cells

They have an irregular stellate shape with delicate branching cytoplasmic processes that form an interlacing network throughout the tissue. The nucleus is oval with dispersed chromatin and prominent nucleoli.

Functions

Mesenchymal cells are relatively unspecialized and are capable of differentiation into all types of connective tissue cells including that of the skeleton and smooth muscles.

Some mesenchymal cells remain in mature connective tissue and provide a source for other types of connective tissue cells.



Macrophages (histiocytes)

The connective tissue macrophages may be seen in two forms: fixed macrophage or histiocytes and stimulated or active macrophage.

a. Fixed macrophages or histiocytes

It is considered one of the fixed connective tissue cells. The cells are stellate or fusiform that are difficult to distinguish from fibroblasts.

They could be differentiated from fibroblasts through:

They have smaller and darker nuclei.

They give a strong positive reaction when stained for lysosomal enzymes such as acid phosphatase.

They can be stains vitally with vital dyes such as trypan blue.

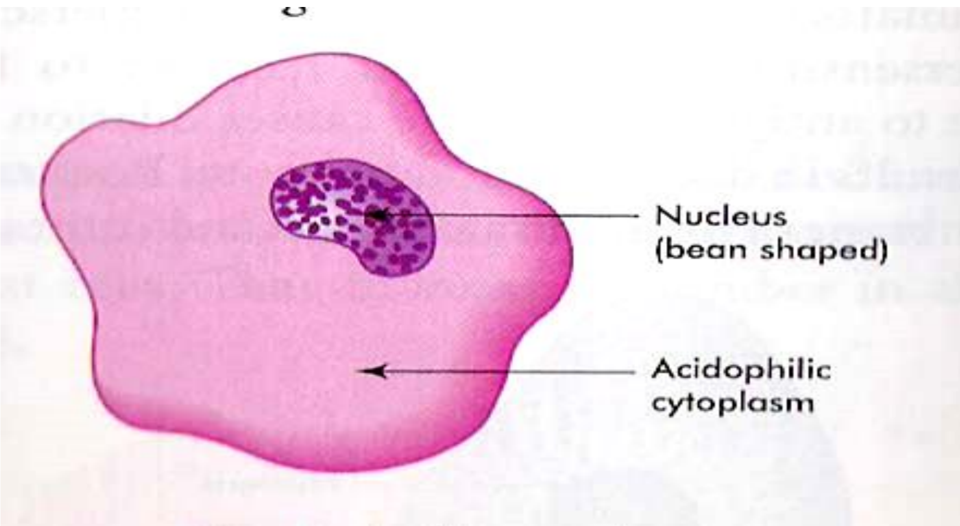
b. Stimulated or active macrophages

They are large ovoid or spherical cells with eccentric kidney-shaped nuclei and foamy cytoplasm.

At the EM level, the macrophage nucleus is indented with heterochromatin typically clumped around the nuclear envelope.

Actively phagocytic cells exhibit irregular cytoplasmic projections or pseudopodia.

The cytoplasm shows well-developed Golgi apparatus, abundant lysosomes, many phagosomes and residual bodies, a few mitochondria and variable amount of free ribosomes and rER.



Functions

Phagocytosis.

Antigen processing and antigen presentation thus participating in both humoral and cell mediated immunity.

Synthesis and secret many substances such as lysozyme (antibacterial agent), interferon (antiviral), interleukin that are essential for the proliferation of T and B-lymphocytes.

Many macrophages can fuse with each other forming large multinucleated cells called foreign body giant cells that can engulf large foreign bodies.

The macrophage and blood monocytes are considered identical. Monocytes circulate in the blood then they migrate to the connective tissue where they are called macrophages.

The macrophages are present practically in all organs, constituting a diffuse system called mononuclear phagocyte system.

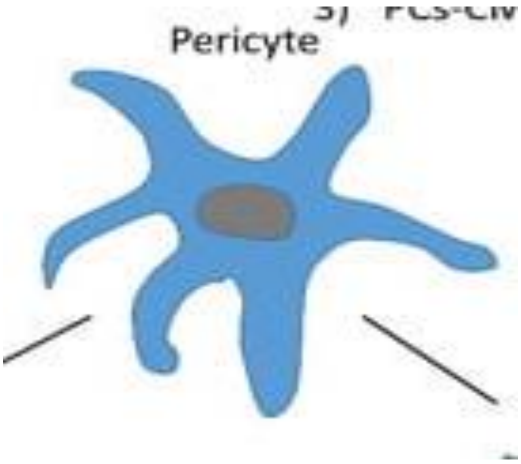
They may have other names such as: osteoclasts in bone; monocytes in blood; dust cells or heart failure cells in lung alveoli; Kupffer cells in liver, and microglia in the central nervous system.

Pericytes

Pericytes are elongated connective tissue cells with long cytoplasmic processes located external to the endothelium of blood capillaries and small venules.

They share a common basal lamina with the adjacent endothelial cells.

They have a fusiform nucleus and scanty cytoplasm that contains many mitochondria, rER, free ribosomes, and small Golgi complex.



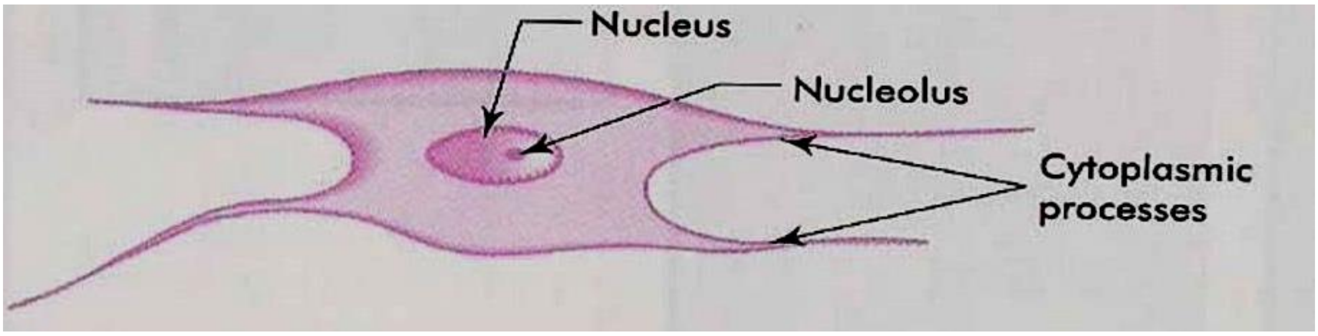
Functions

The pericytes are undifferentiated cells, they serve as progenitor for fibroblasts, osteocytes, chondrocytes and smooth muscle cells.

Fibroblasts and fibrocytes

Fibroblasts or fiber-forming cells are the most common type of fixed connective tissue cells. Active fibroblasts are demonstrated in healing wounds. They have large ovoid lightly stained nuclei with prominent nucleoli. The cytoplasm is extensive and strongly basophilic with numerous interconnected cytoplasmic extensions. At the EM level, the cytoplasm is rich in rER and the Golgi apparatus is well developed.

The inactive fibroblasts (fibrocytes) are smaller and appear spindle in shape with fewer processes. At the EM level, the small quantities of cytoplasm contain sparse network of rER, poorly developed Golgi and few organelles.



Functions

Fibroblasts synthesis and secret the precursors of collagen (tropocollagen), elastin (tropoelastin), the glycosaminoglycans, and all other extracellular components.

They are the principal cells involved in wound repair and growth of connective tissue.

Free, wandering or visitant cells of connective tissue

Adipose cells (Adipocytes)

There are two types of fat cells; white (monolocular) and brown (multilocular).

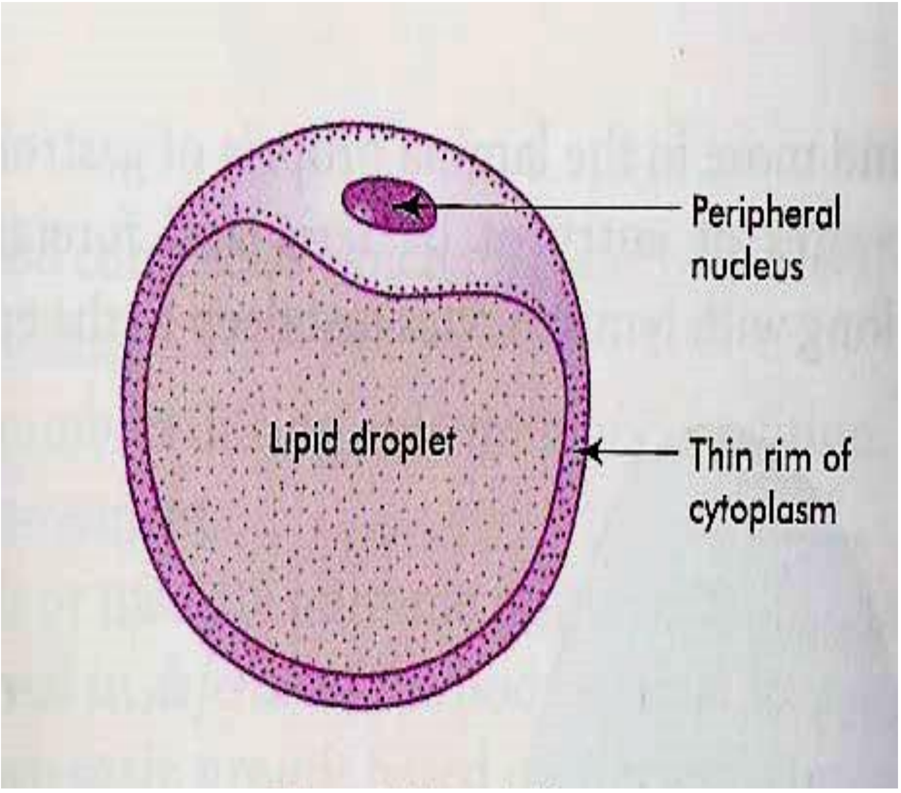
The white adipocytes are polygonal or spherical in shape. The cell occupied by a single large lipid droplet surrounded by a thin rim of cytoplasm.

The nuclei are flattened and displaced to on side. In H&E sections, fat is dissolved during the dehydration and clearing processes.

Fat cells appear as large clear spaces surrounded by thin layer of cytoplasm giving the cells a signet ring appearance. With EM, the lipid droplet is surrounded by a thin layer of cytoplasm contains a flattened nucleus, a small Golgi apparatus, rER and mitochondria. The lipid inclusion is not membrane-bounded, but the cytoplasm adjacent to its surface often contains microfilaments.

The white fat cells tend to occur along the coarse of blood vessels and they may also occur either singly or in-groups within the loose connective tissue layers.

The brown adipocytes are smaller than white one, the nuclei are oval, eccentricity located and surrounded by a significant amount of strongly acidophilic cytoplasm.



They could be differentiated from the white adipose tissue on the basis of:

Lipid is stored as multiple, small droplets (multilocular fat cells) that give the cytoplasm a vacuolated appearance.

Brown adipocytes have relatively large amount of cytoplasm contains abundant mitochondria that are rich in cytochromes, which give the brown color of this tissue.

Brown adipose tissue is more vascular than the white one.

Mast cells

Mast cells are found in the loose connective tissues specially that of the skin and intestine, particularly in association with blood vessels. They are large polymorphic, spherical or ovoid cells with spherical centrally located nuclei. The nuclei are completely obscured by numerous large metachromatic granules (they take a different color than that of the dye used. (e.g., when stained with toluidine blue they take red color). This property is known as metachromasia.

With EM, the granules are membrane-bounded and contain dense amorphous materials. The cytoplasm contains a prominent Golgi complex, cisternae of rER, free ribosomes and mitochondria.

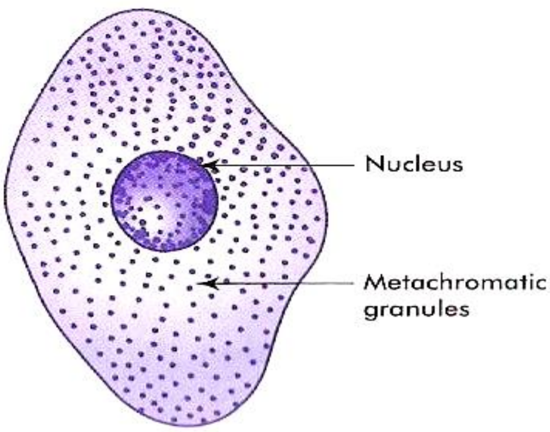


Fig. 4.6 Mast cell

Functions

The surface of the mast cell contains specific receptors for immunoglobulin E (IgE). In allergic and anaphylactic reactions, the interaction of foreign antigen with the antibody bound to the surface of mast cells induces the release of the chemical mediators stored in mast cell granules that promote the immediate hypersensitivity reaction or anaphylaxix.

The granules of the mast cells contain histamine, heparin, ECF-A (eosinophil chemotactic factor for anaphylaxis) and serotonin in rat and mouse. The histamine causes dilatation of small vessels and increases capillary permeability. The serotonin is a vasoconstrictor. The heparin is a potent blood anticoagulant.

Plasma cells

Plasma cells are spherical, oval or pear-shaped cells with spherical, eccentric nucleus. The nuclear chromatin is condensed peripherally giving the nucleus a characteristic “cartwheel” appearance. The cytoplasm is strongly basophilic with a prominent negative Golgi image.

With EM, the cytoplasm contains a prominent Golgi apparatus, abundant rER with dilated cisternae contain electron-dense spherical inclusion known as Russel bodies, free ribosomes and mitochondria.

They are located in the loose connective tissue specially that of the digestive, respiratory and female reproductive system. Plasma cells develop from B-lymphocytes.

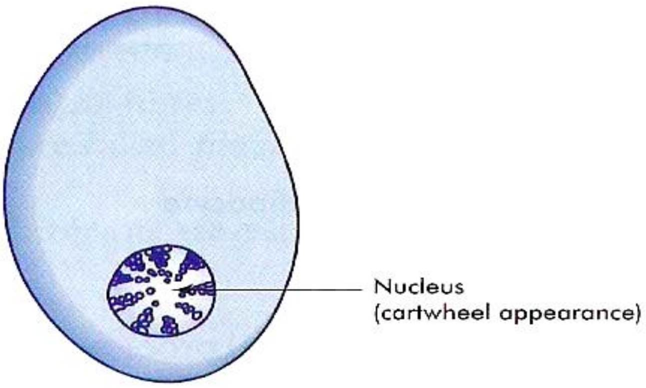


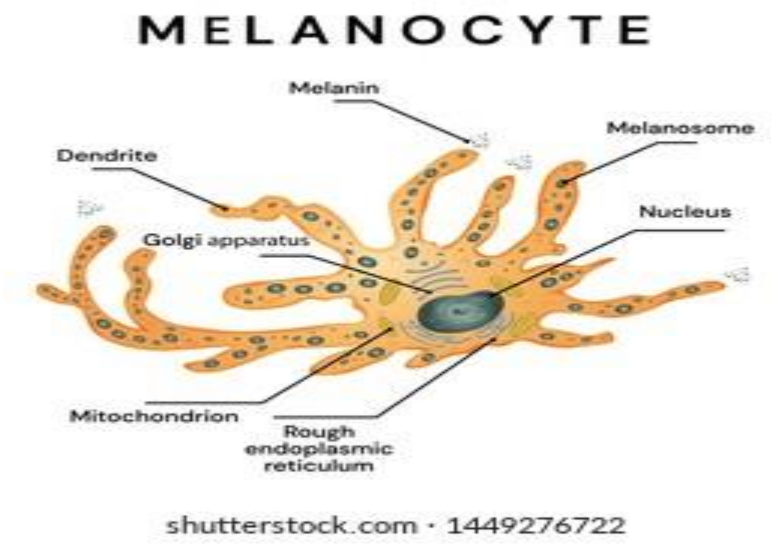
Fig. 4.5 Plasma cell

Functions

Production of antibodies.

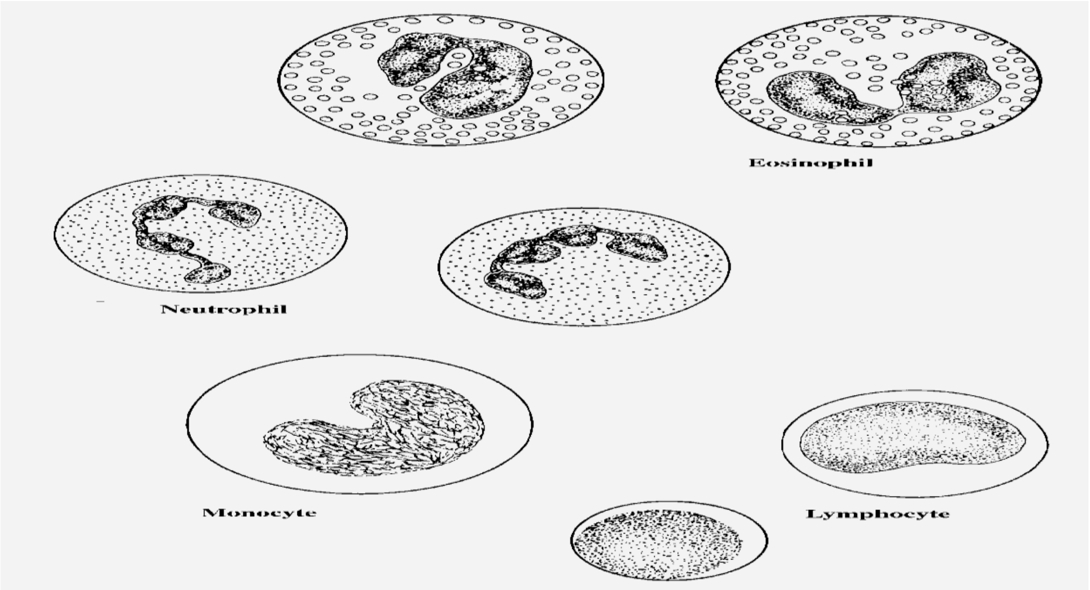
Melanocytes

Melanocytes are derived from neural crest. They are large pigmented cells with numerous long branching processes. They occur in epidermis, uterine caruncles of sheep, meninges, choroid and iris.



Other connective tissue cells

They include lymphocytes, monocytes and granulocytes (especially eosinophils and neutrophils).



2. **Connective tissue fibers**

White collagenous fibers

They are called white because they have a white color when fresh, called collagenous because on boiling they become hydrated and yield gelatin (glue). (Kolla=glue).

They are destroyed with weak acids and alkalis and digested by pepsin and collagenase (which is an enzyme produced by the testis and some pathogenic bacteria).

With LM, they are arranged into wavy bundles. The bundles may branch, but the individual fibers do not. They are acidophilic, they stain pink with H&E; red with Van Gieson's; green with Masson's trichrome stain and blue with Mallory stain.

With EM, they are formed of bundles of microfibrils know as collagen fibrils. The fibrils are formed of tropocollagen molecules, and they have a characteristic periodicity repeated at 64 nm intervals.

This periodicity is due to the unique arrangement of tropocollagen molecules where they are arranged in end-to-end manner with each molecule overlapping the adjacent one by one quarter of its length.

Collagen is secreted into the intercellular matrix as tropocollagen molecules that polymerize to form collagen of 5 different types:

Collagen type I

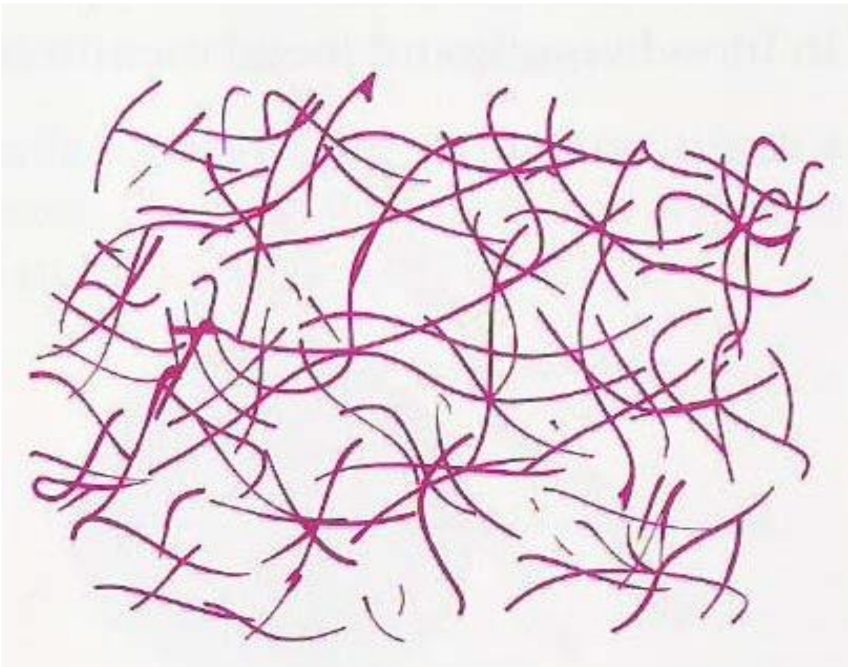
It constitutes about 90% of total collagen in the body. It is found in fibrous connective tissue, skin tendon, ligaments and bone. The tropocollagen molecules are arranged to form fibers. Parallel collagen fibers are further arranged into strong bundles. These bundles are visible with LM and are responsible for the great tensile strength of this type.

Collagen type II

It is found in hyaline cartilage and consists of collagen fibrils dispersed in the ground substance.

Collagen type III (reticular fibers)

They form delicate supporting network in liver and lymphoid organs.



Collagen type IV and V

They do not form fibrils; type IV collagen is present in basement membranes and type V is found in small amount in most connective tissue.

Yellow elastic fibers

Elastin is a rubber-like material that is arranged as fibers and discontinuous sheets (in the wall of arteries). When present in sufficient number, elastic fibers give a yellow color to the fresh tissue (e.g., ligamentum nuchae of ruminants).

Elastic fibers are resistant to boiling and to hydrolysis by acid or alkali. They are also resistant to digestion by trypsin, but elastase from pancreas will digest it.

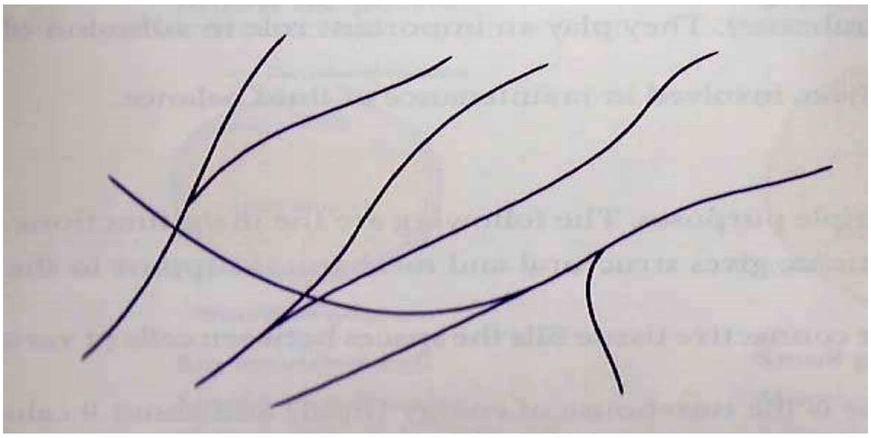
The elastic fibers can be stretched as much as 2.5 times their original length, to which they return when, released. They are found in organs whose normal function requires great elasticity such as vocal cords, lung, ligamentum nuchae, skin and arteries.

They are not identified in H&E sections but the large elastic fibers in elastic ligaments and the elastic sheets in arterial walls are seen as highly refractile light pink strands.

They can be selectively stains by Verhoeff's stain, orcein (brown) and resorcin fuchsin (blue).

With EM, elastic fibers have two main components: Elastin that appears as an amorphous protein of low electron density. Microfibrils that are embedded in the periphery of the fibers and occurring in small fascicles in its interior.

They are synthesized by fibroblasts and smooth muscle cells as tropoelastin. The microfibrils are secreted prior elastin and provide scaffolding on which elastin forms fibers and sheets.



Reticular fibers

The reticular fiber form delicate network rather than coarse bundles around capillaries, muscle cells, nerve, adipose cells and liver cells. They also constitute the fibrous supporting tissue of endocrine, lymphoid and blood forming organs.

With LM, reticular fibers are not visible in H&E sections but can be selectively stains black by silver impregnation (hence the term argyrophilic or argentaffin fibers) or with the periodic acid-schiff (PAS) reagent.

With EM, they are actually individual collagen fibrils (type III collagen) coated by glycoproteins. They have the same 64-periodicity typical of collagen fibrils.

3. Ground substance

The ground substance is an amorphous gel-like material composed of polysaccharide chains (glycosaminoglycans) bound to protein.

With LM, in H & E sections, they are not visible when present in low concentration. However, at higher concentration (as in hyaline cartilage), they stain basophilic. When stained with toluidine blue or crystal violet, they are metachromatic (take a different color than the color of the dye used). The ground substance includes two major groups:

Non-sulfated glycosaminoglycans (hyaluronic acid)

The hyaluronic acid consists of long molecule that form a network whose spaces are filled with tissue fluid forming gel-like material. The hyaluronic acid predominate in loose connective tissue, vitreous humor, synovial fluid and umbilical cords.

Sulfated glycosaminoglycans

Chondroitin-4-sulfate and chondroitin-6-sulfate are abundant in cartilage, bone, skin, and cornea.

Dermatan sulfate is found in skin, tendon, ligamentum nuchae, sclera and lung.

Keratan sulfate is present in cartilage, bone and cornea.

Heparan sulfate in arteries and lung.

Heparin in mast cells, in lung, liver and skin.

Functions of the ground substance

The glycosaminoglycans and proteoglycans are highly hydrophilic. The tissue fluid within the meshes permits the diffusion of nutrients and metabolites between the connective tissue cells and circulatory system.

The gel-like nature of the hyaluronic acid is thought to act as a barrier against the spread of bacteria that may enter the tissues. Invasive bacteria produce the enzyme hyaluronidase that facilitates their spread.

Types of Connective tissue

I) Embryonic connective tissue

Mesenchyme

The mesenchyme is primitive embryonic connective tissue from which all other connective tissue types are derived. It consists of primitive mesenchymal cells that have an irregular, stellate shape with delicate branching cytoplasmic processes that form an interlacing network throughout the tissue. The extracellular material consists of non-sulfated amorphous ground substances with no fibers.

Mucous connective tissues

The mucous connective tissue is found in many parts of the embryo especially under the skin and in the umbilical cord “Warton’s Jelly”.

In adults, it is found in omasal laminae and in the comb and wattles of the chickens. It consists of large stellate, fibroblasts with branching and anastomosed cytoplasmic processes. Few macrophages and lymphoid cells are also present. The ntercellular substance is rich in mucin and contains thin collagenous fibers which increase with age.

II) Adult connective tissues

Loose (ordinary or areolar) connective tissue

It is the most widely distributed type of connective tissue in the adult animals. It consists of all types of connective tissue cells, fibers that are embedded in non-sulfated amorphous ground substances. The cells are relatively more abundant than fibers that are loosely arranged leaving comparatively wide spaces in between.

The loose connective tissue is present around blood vessels and nerves and between muscle bundles. It supports the epithelial lining of gastrointestinal tract, respiratory and urinary tracts, also forms the deeper layers of skin and occurs as loose interstitial packing in many other organs.

1. Dense connective tissue

The fibers are more abundant than cells and amorphous ground substances. According to the arrangement of its fibrous component, two types are identified:

2. Dense irregular connective tissue

It is formed of the same cell types like the loose connective tissue (all connective tissue cell type), although fibroblasts usually predominate, they are inactive with highly condensed nuclei and minimal cytoplasm.

The collagen fibers predominate, and they are arranged in coarse irregular interwoven bundles with very narrow space in-between.

It is found in lamina propria of the initial portion of the digestive tract, the capsule of the lung, the capsule of various organs (spleen, liver, kidney, testis), fascia, joint capsule and dermis.

3. Dense regular connective tissue

a. Dense regular collagenous (tendon)

The tendon consists of bundles of parallel collagen fibers that are bounded together by sparse, loose connective tissue contains small blood vessels, nerves and active fibroblasts (peritenteneum interna).

The peritenteneum interna is continuos with the peritendineum externa that is a loose connective tissue capsule that cover the outer surface of the tendon.

The active fibroblasts that are located in the loose connective tissue layer between the bundles are responsible for the repair of tendons whenever the needs arise.

The fibrocytes located between the collagen fibers are inactive cells and appear as long, flat cells with wing-like cytoplasmic processes extending between adjacent collagen fibers, giving them a stellate appearance (bird cells) in cross sections.

b. Dense regular elastic (Elastic ligaments)

It consists of branching and interconnected parallel elastic fibers surrounded by loose connective tissue (e.g., ligamentum nuchae and the elastic fascia of the abdominal muscle of herbivores).

4. Reticular connective tissue

It is made up of stellate reticular cells and a complex network of delicate thin branched and anastomosed reticular fibers.

It forms a delicate supportive framework for many highly cellular organs such as endocrine glands, liver and lymphoreticular organs (tonsils, spleen, and lymph nodes).

5. Adipose tissue

It is a special type of connective tissue designed to perform

many functions such as mechanical protection, thermal

insulation and body metabolism. There are two types of adipose

tissue white and brown adipose tissues.

6. White adipose tissue

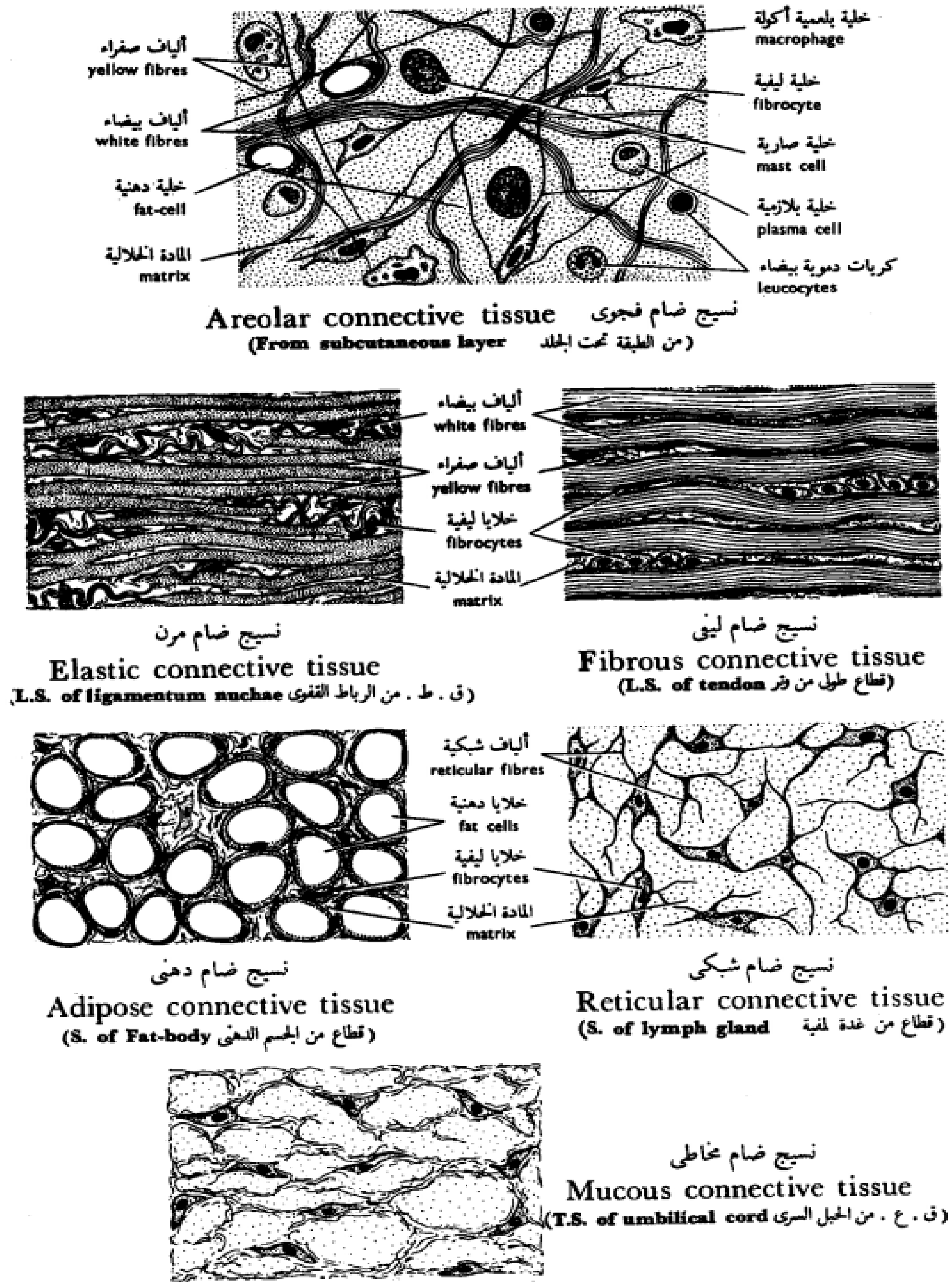
It is distributed throughout the body especially in the deep layer of the skin and around the kidneys. White fat is divided by septa of loose connective tissue into clusters of adipose cells known as lobules. A delicate network of collagen and reticular fibers that support a dense capillary plexus and nerve fibers surrounds each adipocyte. In addition, the narrow intercellular spaces contain a few fibrocytes, mast cells, and scanty amorphous ground substance.

Fat stored in adipocytes as single large droplet (monolocular fat cell) which occupies most of the cytoplasm. The nucleus is compressed and displaced to one side of the cytoplasm giving the cells their characteristic signet ring appearance.

7. Brown adipose tissue

It is a highly specialized form of adipose tissue found in newborn mammals, rodents and some hibernating animals, where it plays an important part in body temperature regulation.

The brown adipose tissue is more vascular than the white ones. The brown adipocytes are smaller than white one, the nuclei are oval, eccentricity located and surrounded by a significant amount of strongly acidophilic cytoplasm.



شكل ٣٩ ـ الأنسجة الضامة الأصيلة
FIG. 39 - CONNECTIVE TISSUES PROPER

Skeletal Connective tissue

1- Cartilage

The cartilage is a semi-rigid, flexible, avascular form of connective tissue designed to perform a supportive function. It is composed of cells and matrix (fibers and amorphous ground substance).

Types of cartilage

1. Hyaline cartilage

The hyaline cartilage consists of:

Perichondrium

It is a vascular connective tissue capsule that invests the external surface of cartilage. It is composed of two layers: a) Outer fibrous layer, composed of dense irregular connective tissue containing blood vessels and nerves. b) Inner cellular or chondrogenic layer made up of chondroblasts that are actively involved in production of matrix during cartilage growth and regeneration.

Cartilage cells

Chondroblasts (cartilage forming cells)

They are found mainly in the inner chondrogenic layer of the perichondrium. They are oval or spindle-shaped cells with oval euchromatic nuclei. The cytoplasm is basophilic rich in ribosomes, rER and Golgi saccules. They secrete matrix around themselves and become deeply buried in the cartilage matrix where they are called chondrocytes.

Chondrocytes (mature cartilage cells)

They are located in tiny spaces within the cartilage matrix known as lacunae.

Beneath the perichondrium, chondrocytes are small and their lacunae are elliptical with their long axes parallel to the surface.

Deep within the cartilage, the cells are larger and polyhedral with short processes. They have a spherical nucleus wit one or mare nucleoli. The cells accumulate glycogen and lipid in their cytoplasm those appear vacuolated.

Some lacunae contain only one cell; others contain two, four, or sometimes six cells. These multicellular lacunae are called cell nests or isogenous groups because each cluster is the progeny of one cell.

Matrix

The hyaline cartilage matrix is an amorphous gel consists mainly of sulfated glycosaminoglycans that are strongly basophilic, PAS positive and metachromatic.

The fibrous component represented by fine collage fibrils made up of type II collagen that has the same index of refraction as the amorphous ground substance, therefore, they can not be seen in common H&E sections.

The hyaline cartilage occurs in many places such as articular surface, fetal skeleton, nasal septum, larynx, trachea and bronchi.

2. Elastic cartilage

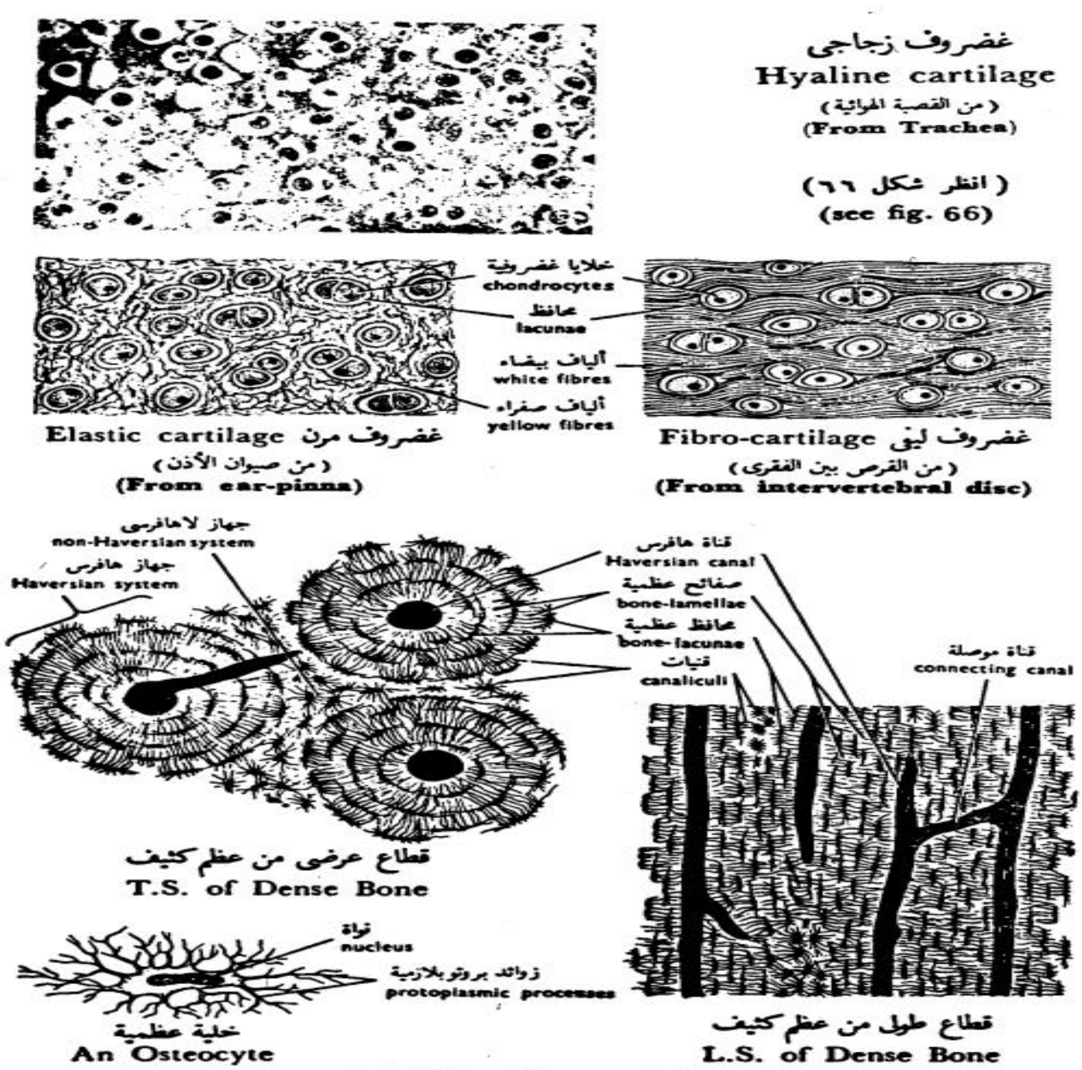
The histological structure of the elastic cartilage is similar to that of the hyaline cartilage except: 1) cell nests are few. 2) The matrices contain a dense network of elastic fibers that are visible in H&E sections.

The elastic cartilage occurs in the external ear and external auditory canal, the epiglottis, corniculate and cuneiform cartilage of the larynx.

3. Fibrocarlilage

It is a transitional form between hyaline cartilage and dense regular connective tissue. It consists of regular parallel bundles of collagen fibers separated by encapsulated chondrocytes that occur singly, in pairs or sometimes form rows. The ground substances are little and only found around the chondrocytes. The fibrocartilage is found in the intervertebral discs, menisci of the stifle joint and at the attachment of tendons and bones.

Calcification of the cartilage matrix may occur in aging and during bone development. In this case, diffusion is blocked and the cartilage cells die.



شكل ٤٠ – الأنسجة الهيكلية
FIG. 40 – SKELETAL TISSUES

2- Bone

The bone is a specialized form of connective tissue in which the extracellular components are mineralized. Like other connective tissues, bone is composed of cells (osteogenic cells, osteoblasts, osteocytes, osteoclasts) and matrix (a mixture of collagen fibers, ground substance and mineral salts).

Bone cells

Osteogenic cells

They are undifferentiated cells found in the endosteum, the inner osteogenic layer of the periosteum and the lining of the osteonal canal. The cells have pale-staining oval or elongated nuclei and little acidophilic or faintly basophilic cytoplasm.

They develop from the mesenchymal cells and they are capable in times of need (i.e. bone growth or fracture repair) to divide and transform into any of the other bone cells.

Osteoblasts (bone forming cells)

They are small, ovoid branching cells. During active bone formation, they are arranged in an epithelial-like layer of cuboidal cells connected to each other by short slender processes.

The nucleus is oval, eccentric (at the cells end away from the bone surface), and euchromatic with prominent nucleolus.

The cytoplasm is deeply basophilic and shows a negative Golgi image near the nucleus.

With EM, the cytoplasmic features reflect a high rate of protein synthesis with abundant rER and prominent Golgi apparatus.

Functions

Osteoblasts are responsible for the formation of organic components of bone matrix (osteoid tissue).

They secrete matrix vesicles that participate in the nucleation of crystalline bone minerals.

Resorption of osteoid tissue (unmineralized matrix).

Osteocytes (mature bone cells)

The osteocytes are the principal cells of mature bone. They are located inside lacunae within calcified bone matrix. They are less active than osteoblasts and can not divide inside their lacunae. The cell body is flattened with numerous cytoplasmic processes that extend through tiny channels within the bone matrix called canaliculi.

The processes of the adjacent cells are interconnected with each other via gap junctions permitting flow of ions and small molecules between blood and osteocytes.

With LM, the nuclear and cytoplasmic characteristics are similar to those of osteoblasts except the Golgi region is less prominent and the cytoplasm is less basophilic.

With EM, the rER and the Golgi are still prominent, however, osteocytes situated deeper in bone matrix may have less prominent rER and Golgi saccules.

Functions

Preserve and maintain the integrity of the bone matrix.

Osteoclasts

They are large (about 50 mm) multinucleated cells lining in depressions on the bone surface called Howships lacunae. With LM, the cell has an irregular shape with an acidophilic foamy cytoplasm. The part of the cell border facing the bone surface has striated border-like structure.

With EM, the striated border seen with LM is formed of: 1) Ruffled border that is made up of branching finger-like processes projecting from the cell membrane. 2) Collagen fibrils exposed through extracellular digestion of bone matrix.

Osteoclasts originate from blood monocytes, which fuse with each other to form multinucleated osteoclast.

Functions

Degradation of mineralized bone matrix through:

Focal decalcification through production of organic acids (carbonic, lactic and citric) to generate local acidic environment capable of dissolving calcium from the bone matrix.

Extracellular digestion of the organic components of the bone matrix through liberation of acid hydrolase to the extracellular matrix.

Bone matrix

It consists of organic and inorganic elements:

Organic matrix

It is made up of a mixture of glycoprotein ground substance and type I collagen.

Inorganic matrix

It consists of mineral salts, mainly calcium phosphate that is deposited as submicroscopic hydroxyapatite crystals within the collagen fibers.

Types of bone

Compact bone

This type forms the dense wall of the shaft or diaphysis of the long bone

Cancellous or spongy bone

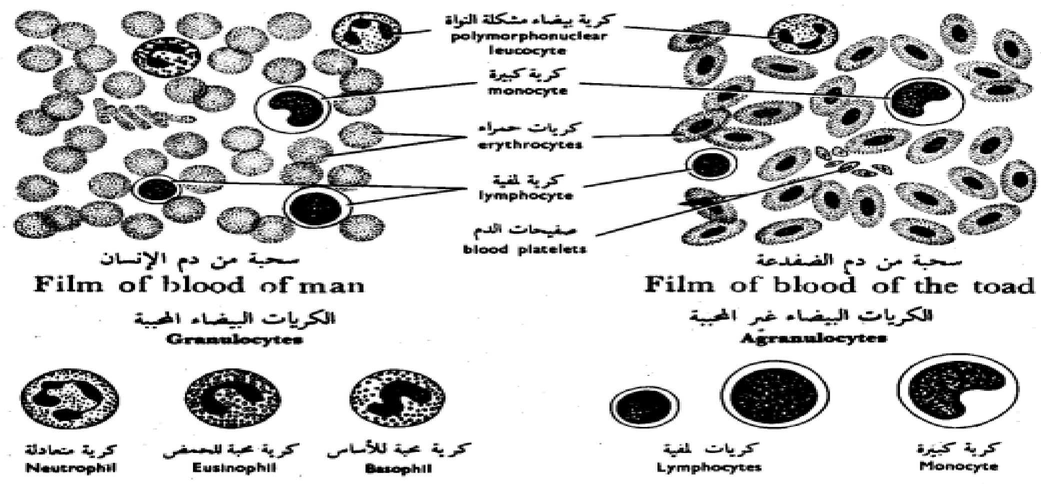
The cancellous bone is composed of a network of bony trabecullae separated by interconnecting spaces containing bone marrow. The trabecullae are thin and composed of bone matrix with lacunae containing osteocytes, which exchange metabolites via canaliculi with blood sinusoids in the marrow cavity.

The trabecullae are lined by endosteum that contains osteogenic cells, osteoblasts and osteoclasts. Cancellous bone forms the epiphysis of the long bone and the cores of flat and irregular bone.

Vascular connective tissue

Blood

Blood is one of the body fluid that is formed of a variety of cells suspended in a fluid medium, the plasma.



شكل ٤١ ـ الأنسجة الوعائية
FIG. 41 - VASCULAR TISSUES

Blood cells

The blood cells are grouped into three main categories: red blood cells (erythrocytes), white blood cells (leukocytes) and blood platelets (thrombocytes).

2- Red blood cells (Erythrocytes)

The mature red cells of domestic mammals are non-nucleated , biconcave discs.

In pig and goat, red blood cells have no biconcavity and therefore appear as flattened discs.

In tylopoda (camels and ilama), they are elliptical, biconcave and non-nucleated. In birds, reptiles, fishes and amphibian, they are oval, biconvex and nucleated.

The size of RBCs range from 4-7 mm, the largest erythrocyte is found in the dog (7mm) and the smallest in the goat (4 mm).

The number of the RBCs varies among species, in dog is about 7 million/mm3, cattle 6.3 million, goat 14 million and horse 9.5 million.

With LM, the erythrocytes in a stained blood smear are stained pink due to their high content of hemoglobin. They have a central pale staining region due to their biconcave disc shape.

The erythrocytes sometimes adhere to each other via their broad surface and become arranged in long chains similar to a stack of coins. This arrangement is called rouleaux.

With EM, the shape of the erythrocytes depends on the plane of section through the cell. The cytoplasmic content of erythrocytes appears electron dense due to the iron atoms of hemoglobin.

When placed in hypotonic solution (lower concentration than plasma), the RBCs swell and ruptures. This is called hemolysis.

In hypertonic solution (higher concentration than plasma), the cell volume diminishes and the cells become crenated.

The life span of erythrocytes is about 120 days. Spleen, bone marrow and liver phagocytes engulf old RBCs. The iron of the hemoglobin is reused in formation of new cells. The porphyrin portion is used to form bilirubin or bile pigment.

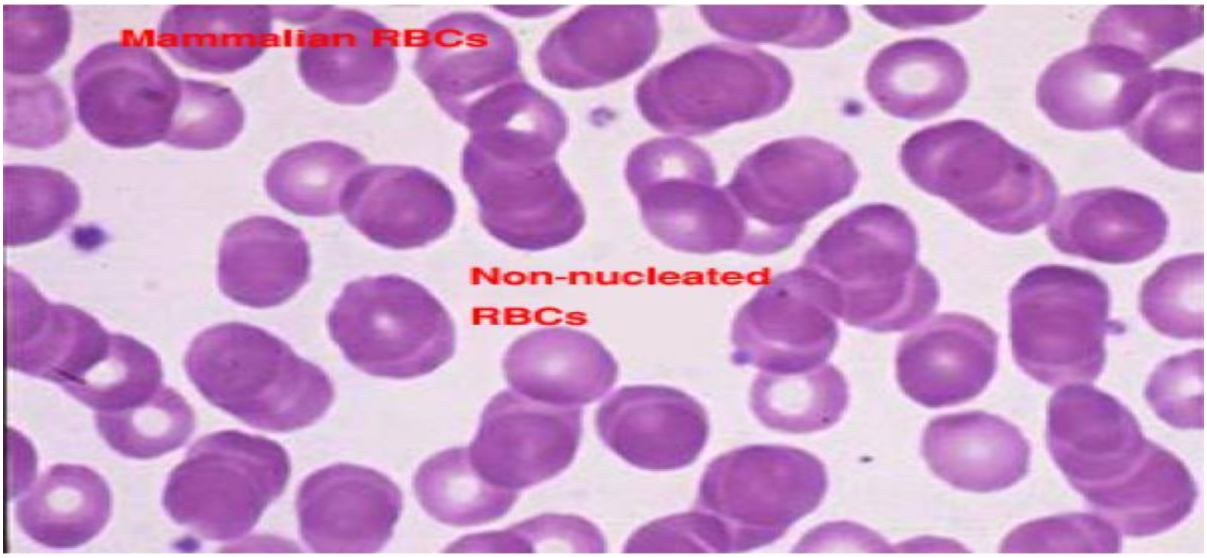
The erythrocytes are highly adapted to their function that is the transport of oxygen and carbon dioxide:

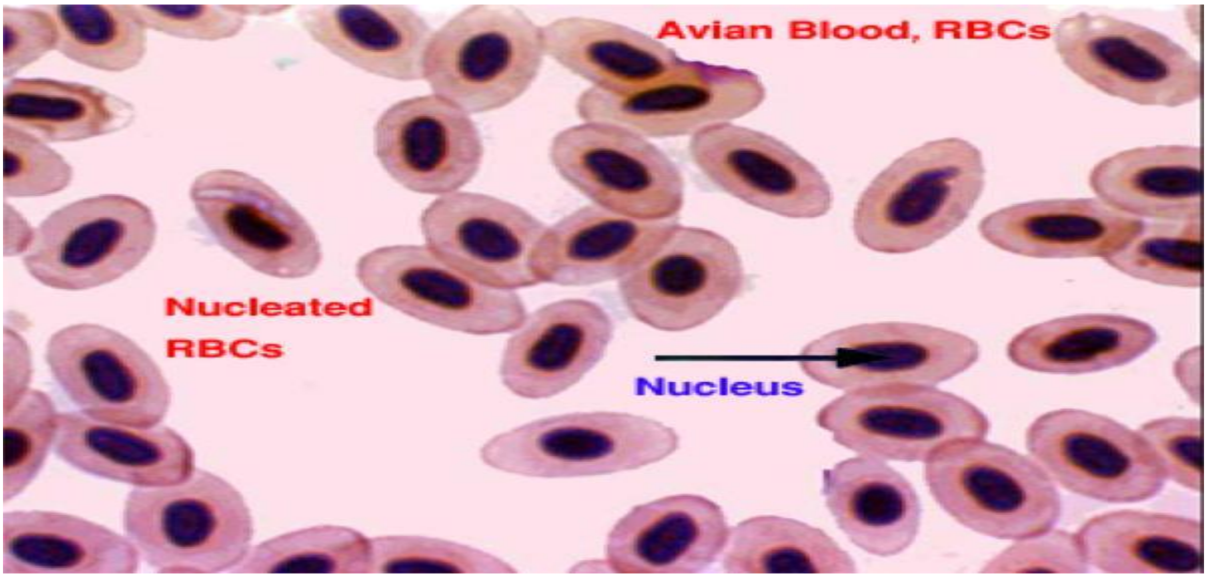
The plasma membrane is highly selective. It is permeable to water and electrolytes, but it is impermeable to hemoglobin.

The elasticity of the plasma membrane allows the erythrocytes to deform and pass through the smallest capillaries (2-4 mμin diameter).

The biconcave shape provides a large surface area relative to cell volume, which greatly enhance gaseous exchange.

Before release into the circulation, the nucleus is extruded and by maturity, all cytoplasmic organelles degenerate which give more space to carry more hemoglobin.





Reticulocytes

They are immature RBCs that are released into the peripheral circulation from the bone marrow. They are slightly large than mature RBCs and when stained with supravital dyes such as brilliant cresyl blue, blue-stained fine networks are seen inside their cytoplasm. This is due to ribosomal RNA still remaining in their cytoplasm. The number of reticulocytes increases in circulation after blood loss.

3- White blood cells (leukocytes)

There are five cell types of the WBCs that are subdivided into two main groups:

Granulocytes

Neutrophils

They are the most common type of leukocytes and account for about 28 % (cattle) and 70 % (dog) of the total leukocytic count. The mature cell is about 10-12 μm in diameter.

In mature cell, the nucleus is lobulated or segmented consists of 2-5 lobes connected by fine chromatin strands. Young neutrophil has U-V- or S-shaped, non-segmented nucleus and is called band or non-segmented cells. Band cells increase in number during bacterial infection.

In female neutrophils, the quiescent X-chromosome or Barr bodies appear as a small drumstick-shaped appendage of one of the nuclear lobe. The cytoplasm contains purplish granules called azurophilic granules that are large lysosomes. Numerous smaller specific granules, are also present but they are poorly stained.

With EM, neutrophil has few cytoplasmic organelles. The specific granules are relatively smaller rod-like containing bactericidal substances (phagocytins) and alkaline phosphatase. The non-specifics (azurophilic granules) are larger in size and fewer in number. They are considered lysosomes containing hydrolytic and peroxidase enzymes. Besides, glycogen granules are found. Actively migrating cells protrude pseudopodia, which are cytoplasmic extensions of the cell contain a few glycogen granules but are largely devoid of organelles.

Functions

Phagocytosis of invading microorganisms particularly bacteria.

They are the main WBCs type involved in acute inflammatory response. Dead leukocytes are called pus cells.

Eosinophils

They account for 1-6 % of the total leucocytic counts. The cell size range from 12-15 µm. Eosinophil has a bilobed, less deeply stained nucleus. The cytoplasm is packed with coarse, large, refractile, eosinophilic granules.

With EM, the cytoplasm is filled with large, ovoid, specific granules containing dense crystalloid in the long axis of the granules (dog, cat and goat). They are membrane-bound and their matrix contains a variety of hydrolytic enzymes including histaminase. Other cytoplasmic organelles such as mitochondria, rER and Golgi are relatively sparse.

Functions

The number of eosinophils in circulating blood increases during parasitic infestations and allergic conditions.

Phagocytosis of the antigen-antibody complex.

Deactivate histamine produced during inflammatory or allergic response.

Basophils

They are about 10-12 μm in diameter. They are the least common cell types that constitute less than 1% of the total leucocytic count. The nucleus is bilobed and completely obscured by numerous large deeply basophilic granules.

With EM, the bilobed nucleus is clearly visible and the cytoplasm is filled with membrane-bound electron dense granules.

Functions

The specific granules of the basophils contain heparin, histamine, other inactive amines, and slow reacting substance of anaphylacsis (SRS-A).

The contents of the specific granules are released by exocytosis in response to interaction of antigen with antibodies attached to the basophil cell membrane.

Heparin is anticoagulant. Histamine causes dilatation of small blood vessels and increase capillary permeability leading to exudation of fluid. SRS-A Cause contraction to the smooth muscle cells.

Agranulocytes

Lymphocytes

They are the second most common leukocytes in circulating blood. They account for 20-45% of the total leukocytic counts A round, densely stained nucleus and a relatively small amount of pale basophilic non-granular cytoplasm characterize them. According to their size, there are three types: small (6-8 µm), medium (8-10 µm) and large (10-14 µm).

With EM, the nucleus is small spherical and often slightly indented. The little cytoplasm contains a few mitochondria, a rudimentary Golgi apparatus, little or no rER and large number of free ribosomes accounting for the LM basophilia. Azurophilic granules (lysosomes) are also present.

On the basis of their functional properties, small lymphocytes are classified into two main groups: T and B-lymphocytes. Their functions will be considered with the immune system.

Monocytes

They are the largest members of the white blood cell series that account for 2-10% of the total leucocytic count. They are highly motile cells and migrate into connective tissue where they are called histiocytes or tissue fixed macrophages. The large eccentricity located nucleus is bean or kidney-shaped with less densely stained chromatin than that of other leukocytes.

With LM, The cytoplasm is extensive and is filled with azurophilic granules (lysosomes. It has a frosted-glass appearance.

With EM, lysosomes are abundant, the Golgi is well developed, rER is diffuse and mitochondria are abundant than other leukocytes. It is also rich in microtubules and microfilaments. Pseudopodia are prominent reflecting their capacity for ameoboid movement and phagocytosis.

Function

The principal function of the macrophage is phagocytosis and destruction of the cellular debris.

Antigen presentation and antigen processing thus participating in both humoral and cell-mediated immune response.

4- Blood platelets (thrombocytes)

They are small, non-nucleated cells formed in the bone marrow by budding from the cytoplasm of huge cells called megakaryocytes. In birds, platelets are nucleated hence they are called thrombocytes.

With LM, they are round or oval biconvex discs about 2-3 μm in diameter.

The cytoplasm has a purple-stained granular appearance due to its high contents of organelles. The organelles are concentrated towards the center of the cell (granulomere). The peripheral cytoplasm (hyalomere) contains microfilaments and microtubutels arranged underneath the plasmalemma. It has few organelles and is very poorly stain.

With EM, the cytoplasm is rich in membrane bound granules of two types: 1) very dense granules are sparse and contain serotonin, ADP, ATP and calcium. 2) Alpha granules which are more common and contain hydrolytic enzymes.

Functions

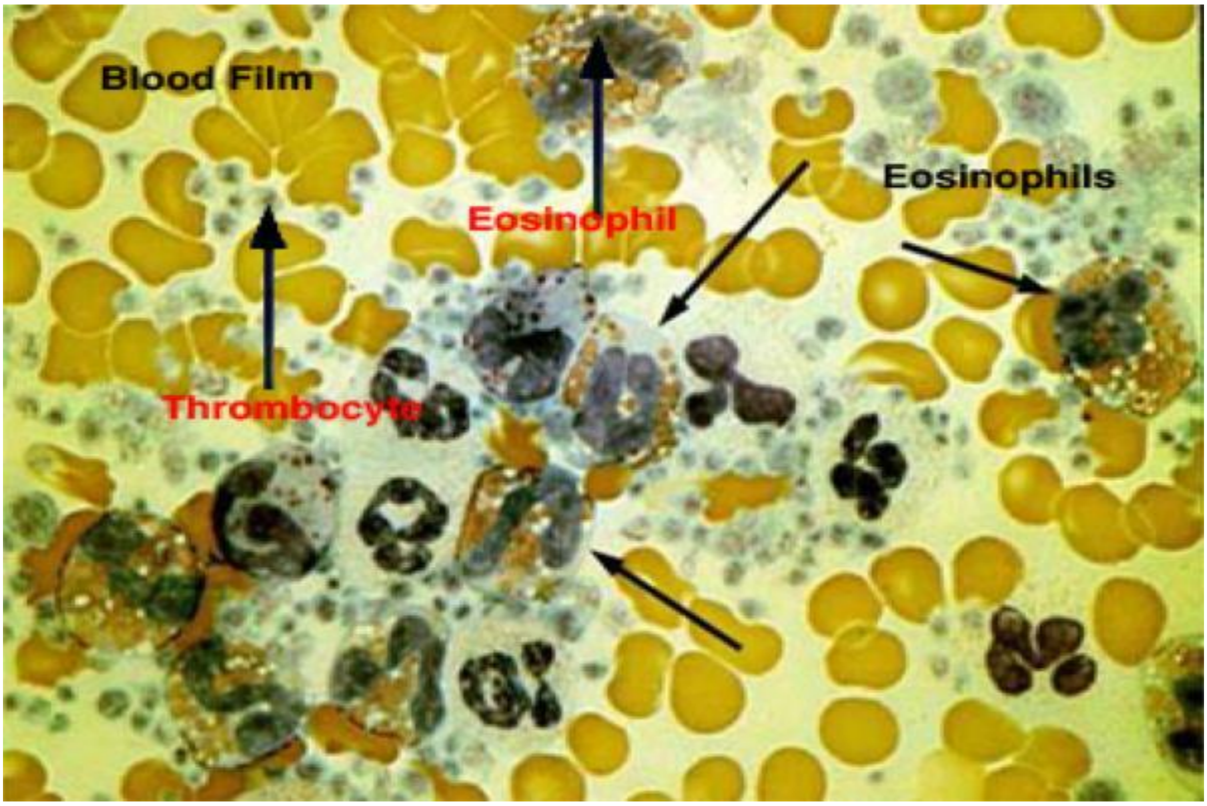
Blood clot formation.

Release serotonin that reduces the blood flow by constricting the damaged vessels.

Function

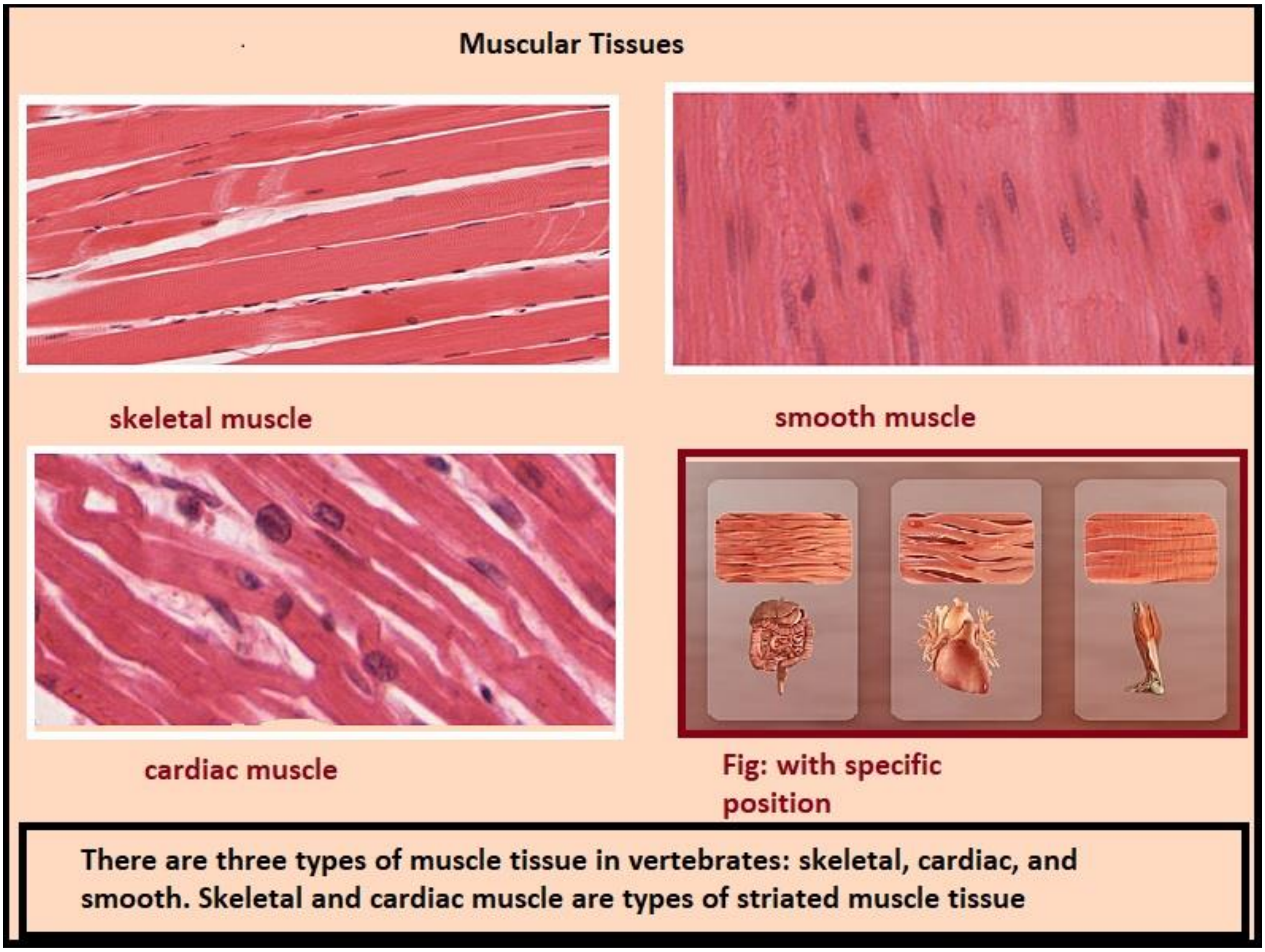
The principal function of the macrophage is phagocytosis and destruction of the cellular debris.

Antigen presentation and antigen processing thus participating in both humoral and cell-mediated immune response.



3. Muscular tissue

It is one of the four basic types of tissues primarily responsible for locomotion and movement of the various body parts.



General features

Muscle cells are long and narrow; therefore they are called muscle fibers or myofibers.

Muscle fibers are highly specialized for contractility, which occurs due to the presence of contractile proteins within their cytoplasm.

Muscle fibers originate primarily from the mesoderm, except the muscle of the iris, and myoepithelial cells that are ectoderm.

Special terms are used for muscle fibers: plasmalemma = sarcolemma; cytoplasm = sarcoplasm; endoplasmic reticulum = arcoplasmic reticulum; mitochondria = sarcosomes.

Muscle tissue is a composite tissue where it contains a minimal amount of connective tissue beside its principal cells.

There are three types of muscle tissue: skeletal, cardiac and smooth muscles.

Skeletal muscle (Striated and voluntary myofibers)

They are found in all skeletal muscles, tongue larynx, pharynx and eye. It is called skeletal because its contraction moves some parts of the skeleton; voluntary because its contraction is under conscious control, and striated because under microscope, its fiber shows alternating dark and light bands called cross-striation.

A skeletal muscle is composed of skeletal myofibers and connective tissue. A sheath of dense connective tissue called epimysium encloses the entire muscle. From the epimysium, thin collagenous septa extend inward to divide the muscle into a number of bundles or fascicles. These septa are called the perimysium. The perimysium is continuous with the endomysium that is a delicate connective tissue layer surrounds each individual myofibers.

At least five cell types are found within the bundle of the skeletal muscle: myofibers, endothelial cells, fibroblasts and myosatellite cells.

The connective tissue in between the myofibers is needed for two reasons: 1) through which blood vessels, lymphatics and nerve enter or leave the interior of the muscle. 2) At the ends of the muscle, the connective tissue elements merge to form tendons that anchor the muscle to other structures such as bone or cartilage.

Cardiac muscle (Striated and involuntary)

It is called cardiac because it constitutes most of the heart although some cardiac muscle can also be found in the wall of pulmonary vein and vena cava.

Cardiac myofibers are striated, however, the striation is less distinct than that of the skeletal myofibers due to: irregular branching shape of the fiber, the less myofibrils content and the abundance of non-contractile sarcoplasm. They are involuntary, they contract spontaneously without any nerve supply. The rate this inherent rhythm can be modulated by autonomic and hormonal stimuli.

Structure of cardiac muscle

At the LM level, the cardiac myofibers are long (50-100 mm), cylindrical cells that are branched and anastomosed forming a network. They are traversed at intervals by dark-staining structures called intercalated discs that extend across the fiber in a stepwise manner.

Most of the cells have one nucleus and at most two nuclei. The nuclei are oval and centrally located within the cell. Like the skeletal muscles, the cytoplasm is acidophilic and striated consisting of an alternated dark and light bands.

The cells are surrounded by delicate connective tissue containing fibroblasts, pericytes and dense capillary network necessary to meet their high metabolic demands. Myosatellite cells are absent.

In TS, the cardiac muscle fibers are spherical or oval with aregular diameter of about 20 mm containing single central nuclei.

At the EM level, the fine structure of the cardiac muscle is similar to that of the skeletal muscle except:

Cardiac myocytes has a less extensive sarcoplasmic reticulum and does not form dilated terminal cisternae.

Purkinje fibers

They are modified cardiac muscle fibers designed for rapid conduction of nerve impulses. They differ from the ordinary cardiac muscle fibers in the following aspects:

They are larger in size.

The nucleus is smaller and eccentricity situated.

The cytoplasm is paler, vacuolated because it is rich in glycogen.

The myofibrils are fewer and concentrated at the periphery.

The T tubules are absent.

Smooth muscle (Visceral muscle)

Smooth muscles are found in the walls of hollow viscera and blood vessels. It is called smooth because it has no cross striations, involuntary because its contraction can not be elicited at will and visceral because they are found in visceral organs.

Structure of smooth myofibers

At the LM level, the smooth muscle cell is elongated, spindle-shaped with pointed ends. It has a diameter of 3-10 mm with length ranges between 30-500 mm.

The cytoplasm is acidophilic and contains only one nucleus. The nucleus is elongated and centrally located in the cytoplasm at the widest part of the cell. During contraction, the nuclei may appear spiral in shape .

The smooth muscle fibers are bound together into irregular branching bundles. Within the bundles, individual muscle fibers are arranged parallel to each other with the thick part of the cell lying against the thin parts of adjacent cells. A sheath of delicate connective tissue containing capillaries and few nerve fibers invests each muscle bundle.

The cytoplasm is filled with parallel thin (actin) and thick (myosin) filaments. The filaments do not have the arrangement seen in the sarcomeres.

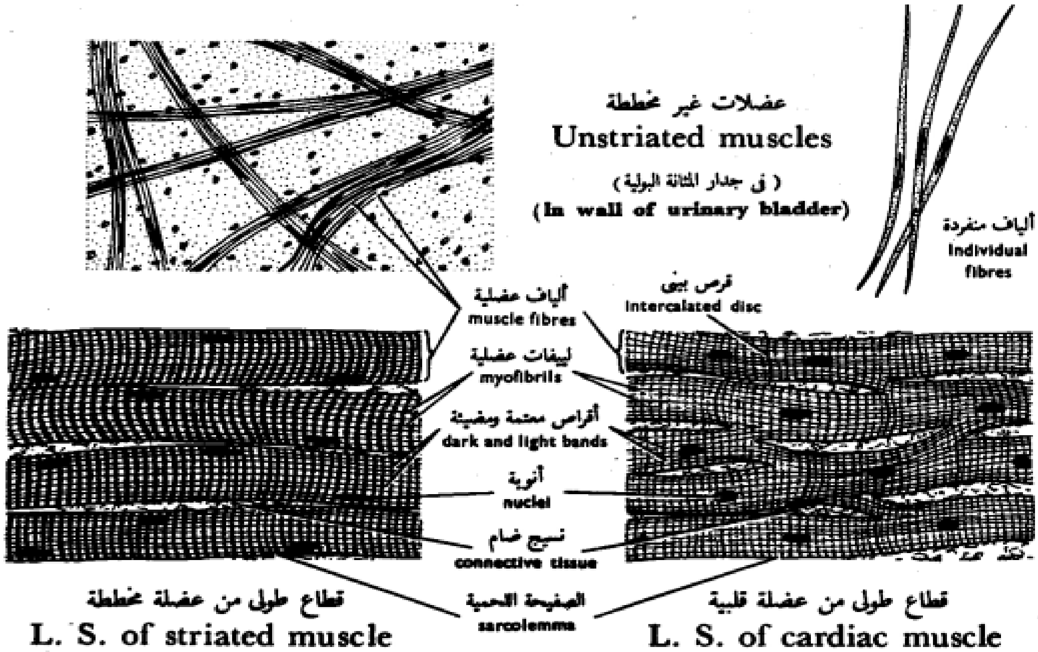
Intermediate filaments (desmin, vimentin and synemin) are also located within the cytoplasm.

Functions

Contraction of the smooth muscle is an inherent property however, it can be modulated be autonomic nervous system.

The smooth muscle maintains prolonged partial contraction (tonus) in the wall of arterioles that is necessary to keep normal blood pressure in the blood capillaries.

In the small intestine, the smooth muscle cell undergoes continuous rhythmic constrictions passing along the tract propelling the lumenal contents distally.



شكل ٤٢ ـ الأنسجة العضلية
FIG. 42 - MUSCULAR TISSUES

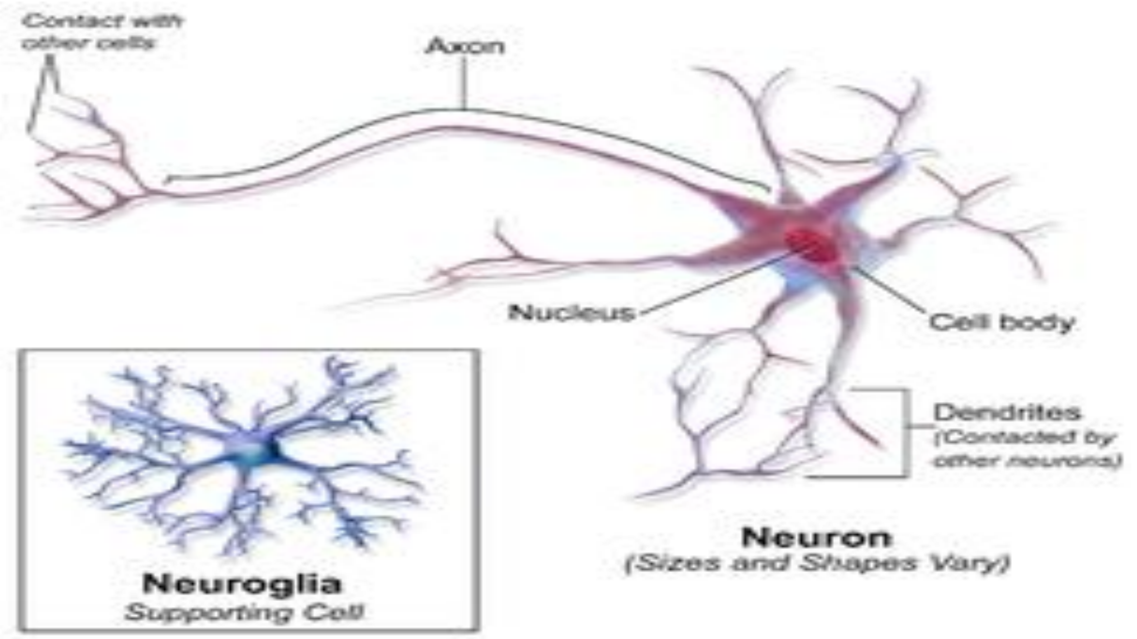
4. Nervous tissue

It is one of the four primary basic tissues.

It consists of two types of cells:

1- Neurons (nerve cells)

2- Neuroglia (supporting cells).



Neural Tissue

Neuron=Nerve cell

- It is *the structural and functional unit* of the nervous tissue.
- It is characterized by:

1- Excitability: they respond to environmental changes by generation of action potential or nerve impulse.

1- Conductivity: they are capable of propagation of nerve impulse to other neurons, muscles& glands.

Histological structure of the neuron

I- Cell body (perikaryon, soma)

- It is composed of:

1- Nucleus: euchromatic.

2- Cytoplasm: contains:

- Nissl bodies

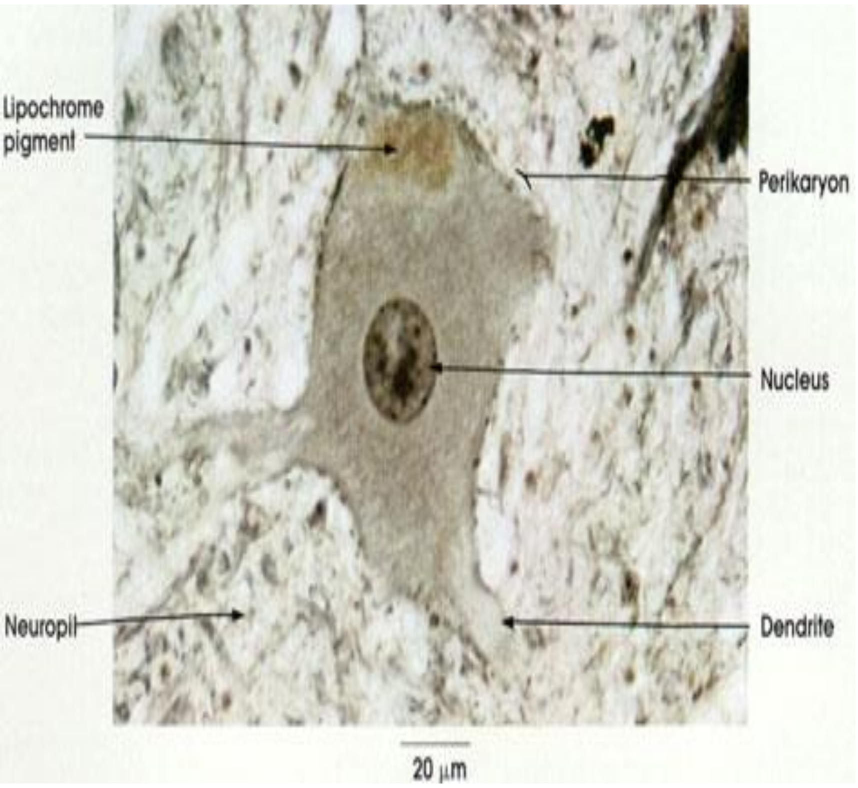
  -LM: basophilic granules.

  -EM: aggregates of ribosomes and rER.

  -Function: protein synthesis.

  - Distribution: in the cell body *<u>except</u>* in the region of axon hillock.

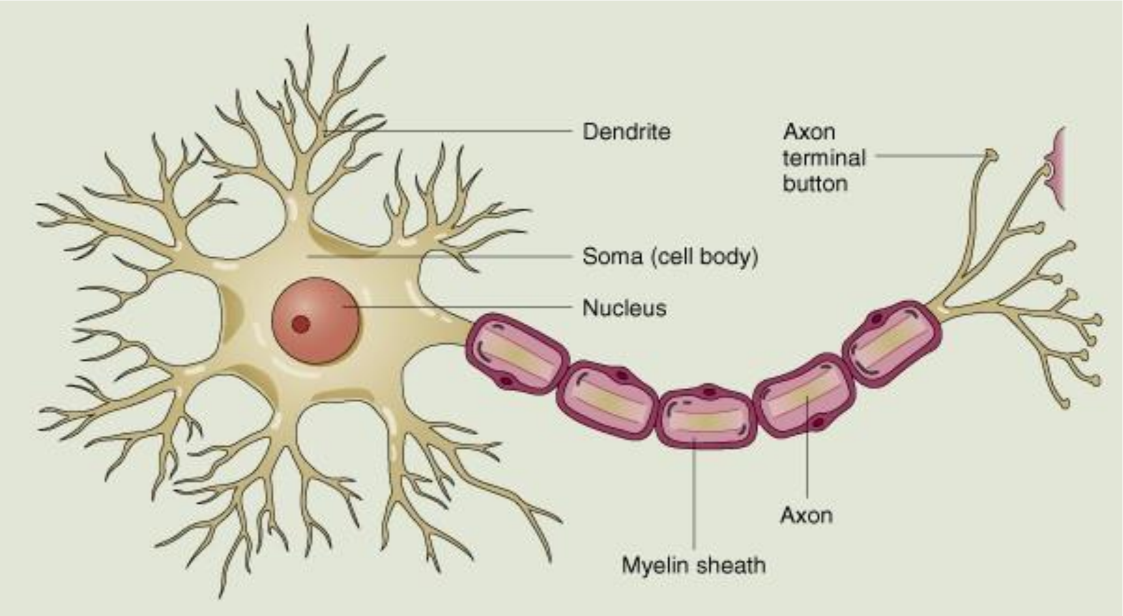
- Large perinuclear Golgi apparatus: for packaging of neurotransmitters into synaptic vesicles.
- Cytoskeleton: formed of neurofibrils that include neurofilaments and microtubules playing a role in the transmission of nerve impulses.
- Inclusions: lipofuscin pigments and lipids.



II- Cell processes

1- Axon:

- Origin*:* from the axon hillock.
- Number: always single.
- Direction of impulses*:* conducts nerve impulses away from the cell body.
- Shape*:* long, with a regular cylindrical shape.
- Branching*:* no branches except at axon termination forming terminal arborizations. It may give off collaterals arising at right angles.
- Structure*:* the axoplasm contains few organelles (neurofibrils, synaptic vesicles and mitochondria). Nissl bodies are *absent*.
- Surrounding sheath*:* axolemma may be surrounded by sheaths according to the type of nerve fiber.

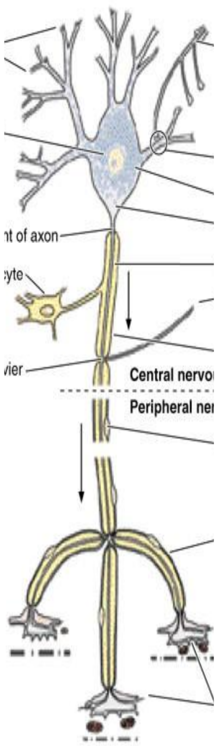


2- Dendrite:

- Origin*:* from any part of the cell body.
- Number: usually multiple (in multipolar neurons).It may be single (in bipolar neurons).
- Direction of impulses: conducts nerve impulses towards the cell body

- Shape: short, thick near its origin and tapers towards its end.
- Branching*:* many branches arising at acute angles, having short spines for synapses.
- Structure*:* contains most of the organelles as in the perikaryon *except* the Golgi apparatus. Nissl bodies are present.
- Surrounding sheath*:* not surrounded by sheaths.

	The axon	The dendrite
1- Origin	Arises from axon hillock	Arises from any part of the cell
2- Direction of the impulse.	conducts nerve impulse away from the cell body	conducts nerve impulse toward the cell body
3- Number	Always single	Usually multiple (in multipolar neurons).It may be single (in bipolar neurons)
4- Length	Long	Short
5- Thickness	Thin with a constant diameter.	Thick near its origin and tapers as it goes toward its end.
6- Branching	Does not branch except at its termination (terminal arborization). It may give off collaterals arising at right angles.	Many branches arising at acute angles, having short spines.
7- Organelles present	Contains few organelles (neurofibrils, vesicles and mitochondria. Nissl granules are absent.	Contains most of the organelles as in the perikaryon except Golgi. Nissl granules are present
8- Surrounding structures	It may be surrounded by sheaths.	It is not surrounded by sheaths



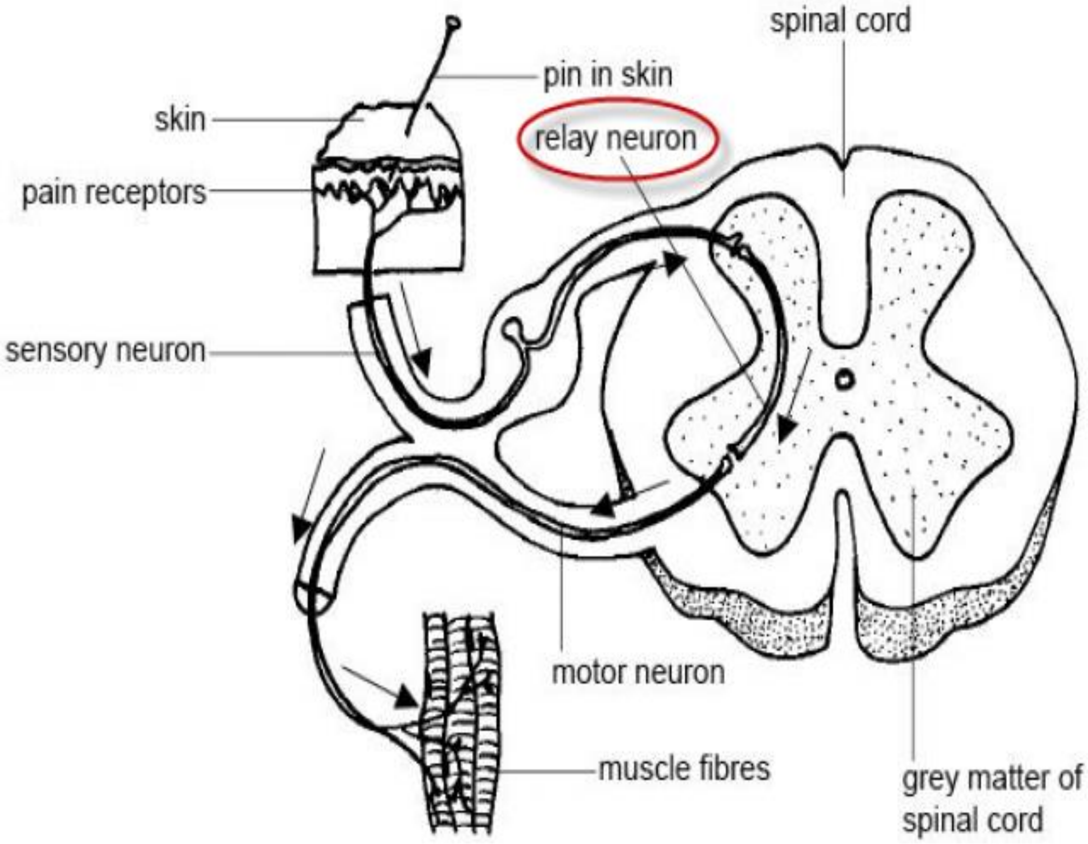
Classification of the neurons

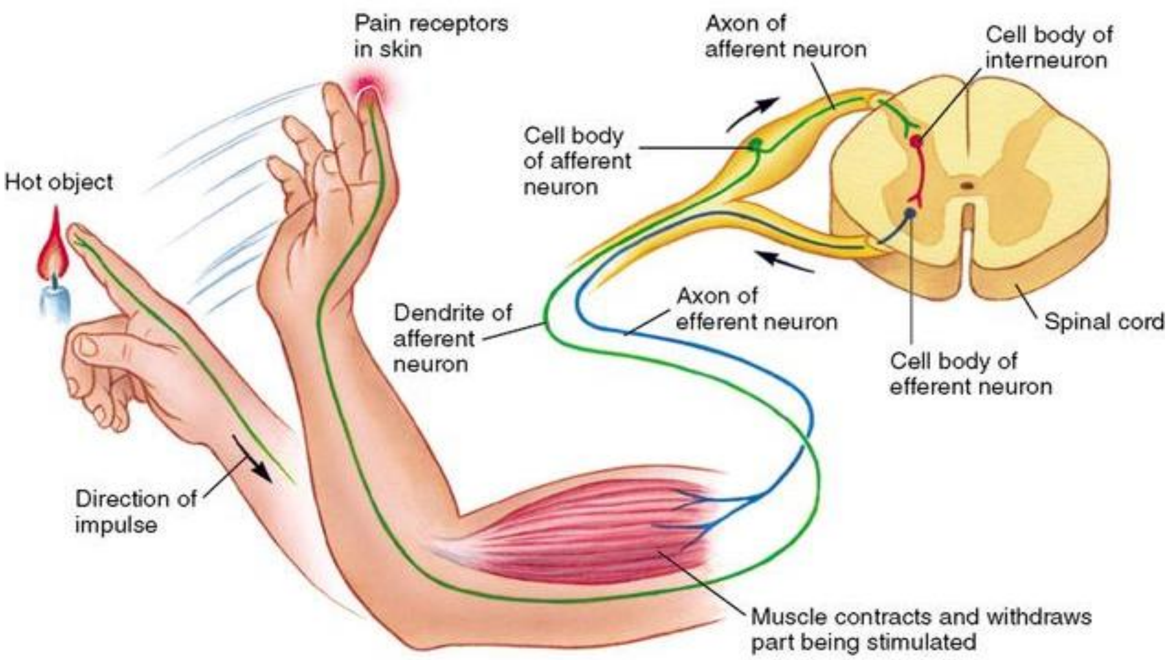
I- Functionally

1- Sensory neurons: they carry impulses from receptors to the CNS.

2- Motor neurons: they carry impulses from CNS to the effector organs.

3- Interneurons (association neurons): act as a link between sensory and motor neurons in CNS only.





II-Morphologically

- Neurons are classified according to the number of their processes into:

1- Unipolar: have only one cell process.

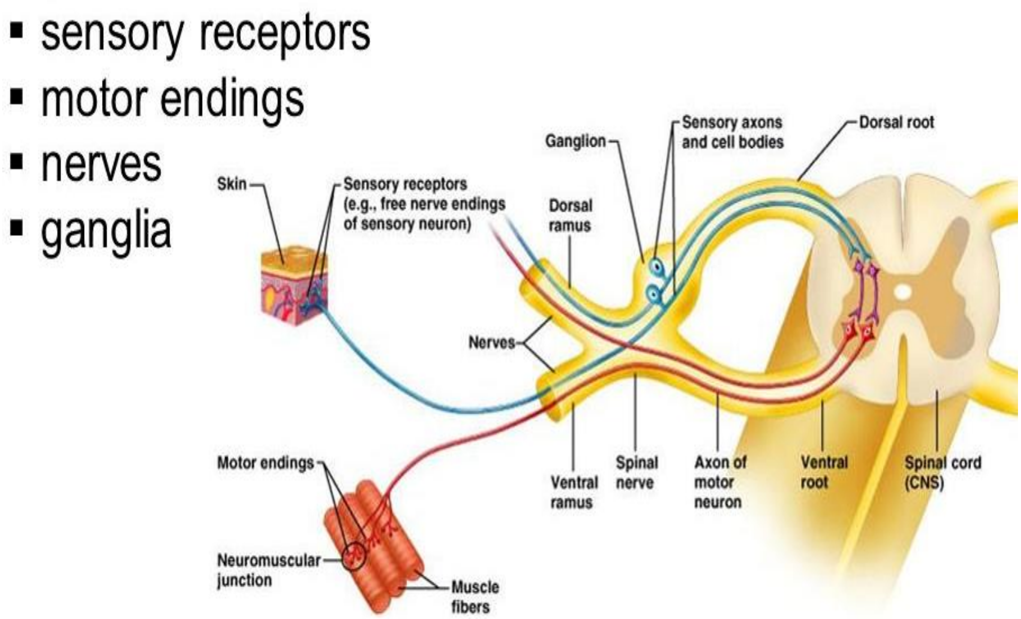
- Site: present in the embryonic stage.

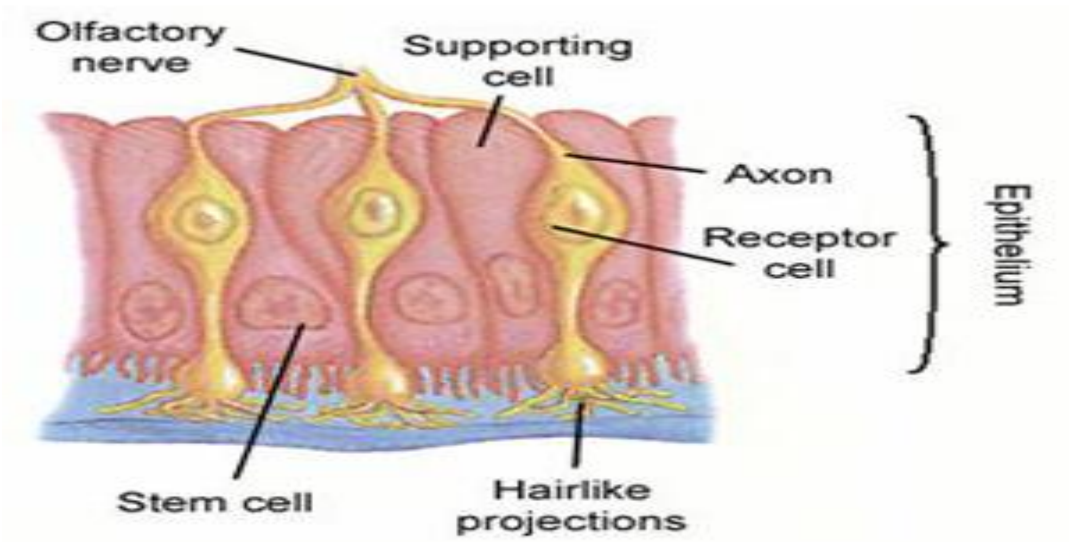
2- Pseudounipolar: have a single process that divides like the letter T into two branches (both are axons).

- Site: in the cranio spinal ganglia.

3- Bipolar: have two processes, one is an axon and the other is a dendrite.

- Site: the olfactory neurons present in the olfactory mucosa of the nose.





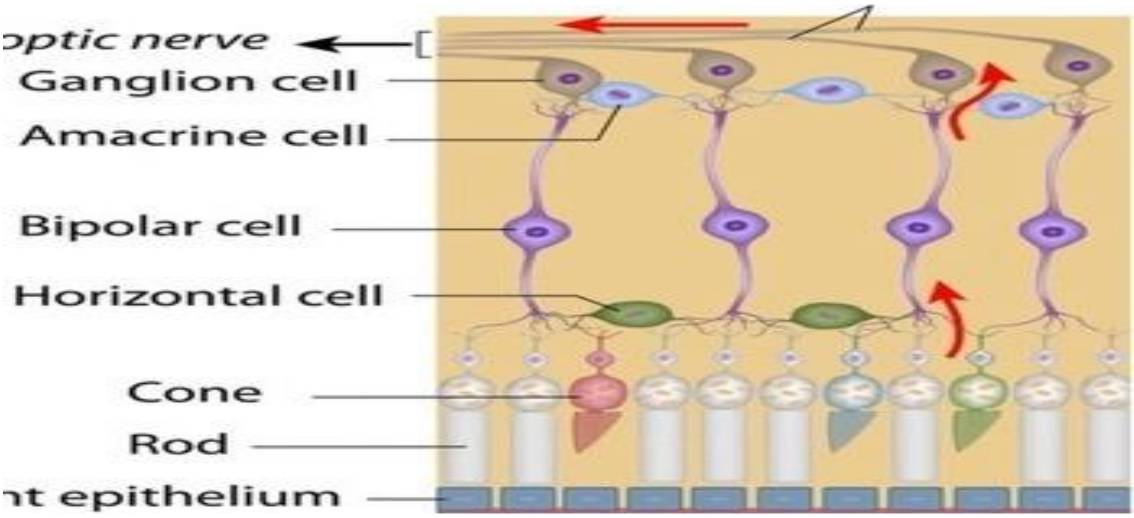
4- Multipolar: have more than two processes. These are classified according to the shape of their perikaryon into:

A-Stellate neurons: they are the anterior horn cells of the spinal cord and the autonomic ganglion cells.

B- Pyramidal neurons: in the cerebral cortex.

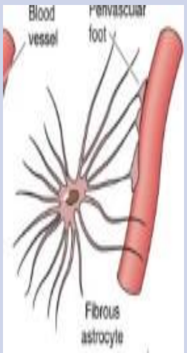
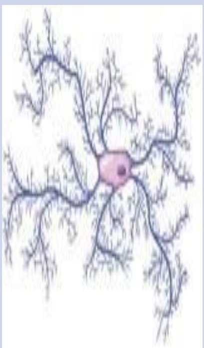
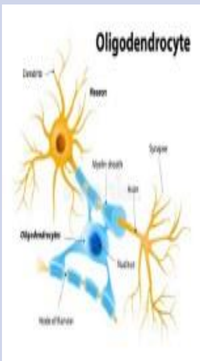
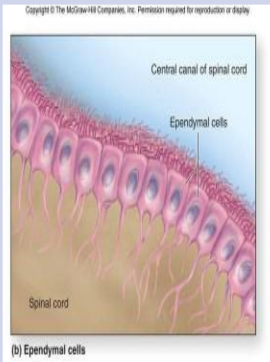
C- Pyriform neurons: in the cerebellar cortex (Purkinje cells)& the retina (ganglion cells).

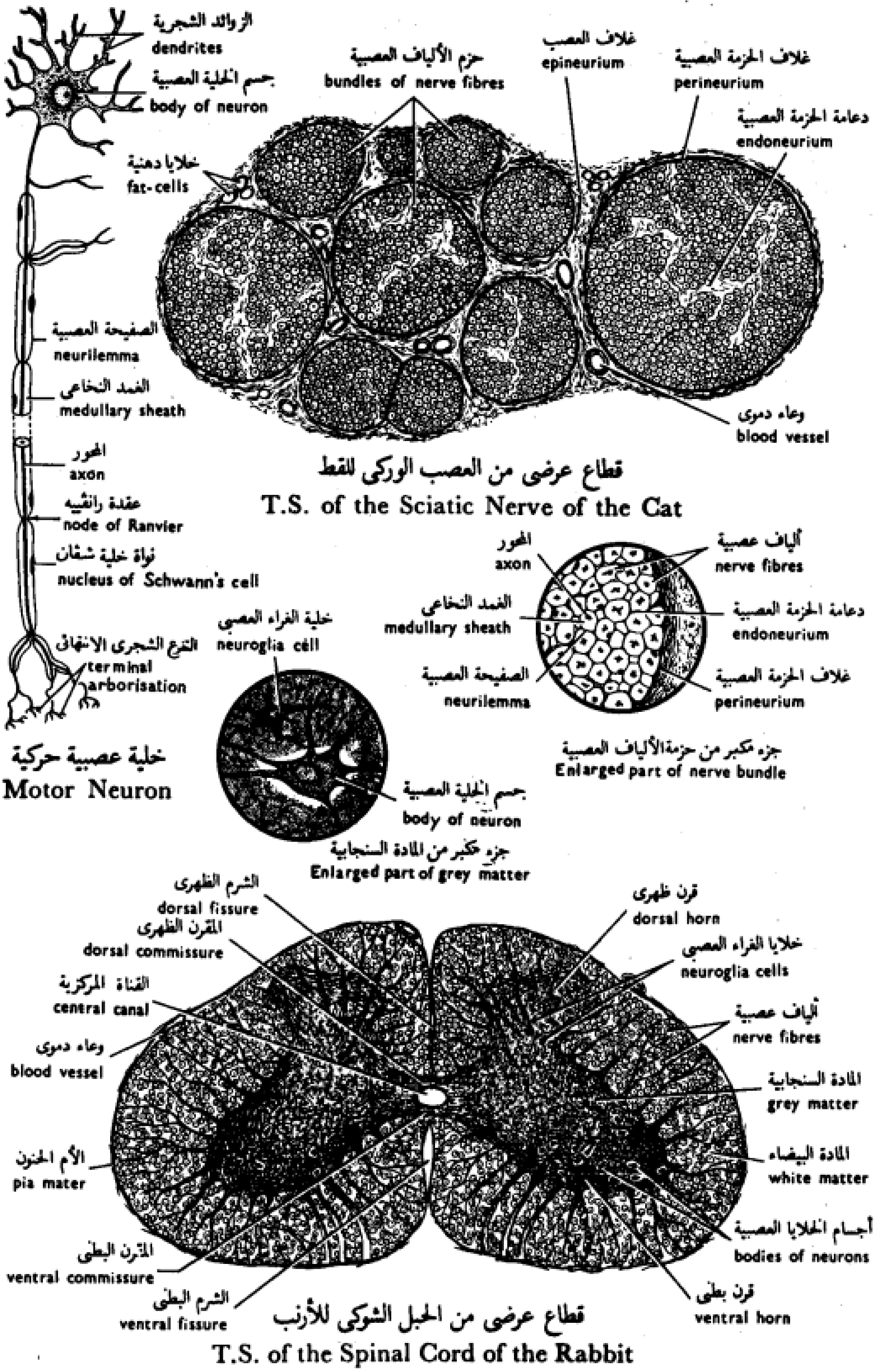
D- Granule cells: in the cerebellar cortex.



Nerve fiber

- Definition: It is an axon enveloped by a special sheath.
- It differs in the enveloping sheaths according to whether the fibers are part of the central or peripheral nervous system.

	Astrocyte =Macroglia	Microglia	Oligodendrocyte	Ependymal cell
LM: Shape	•Large stellate. •Multiple processes,end by foot like expansion on the blood vessels.	•Small, oval. •Processes arising from the two poles. The cell body and the processes have minute spines.	•Small cells. •Few short processes. • They are aligned in rows between the axons in the white matter.	•Epithelial-like cuboidal cells, lining the brain ventricles and the central canal of the spinal cord. •Apically have microvilli and few cilia, while basally have numerous infoldings without a basement membrane.
Function	•Supportive •nutritive •Metaboloic •Formation of blood brain barrier.	Phagocytosis of bacteria,apoptotic and malignant cells.	Formation the myelin sheath in the white matter of CNS	Formation of cerebro-spinal fluid.
				

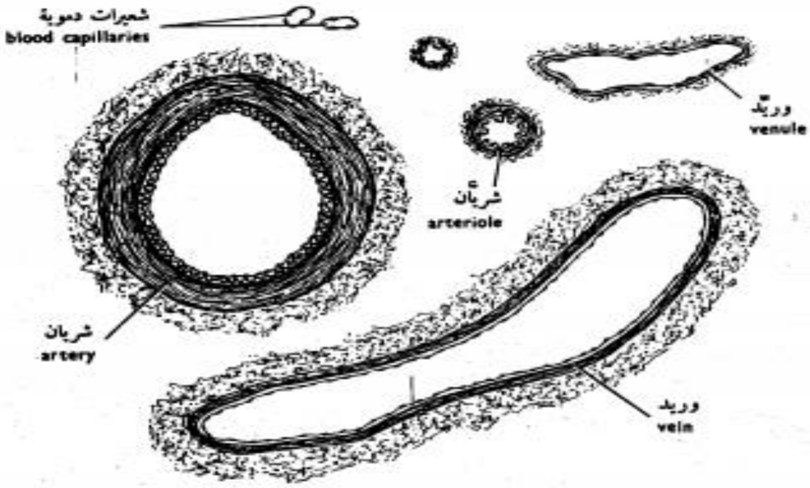


شكل ٤٣ - الأنسجة العصبية

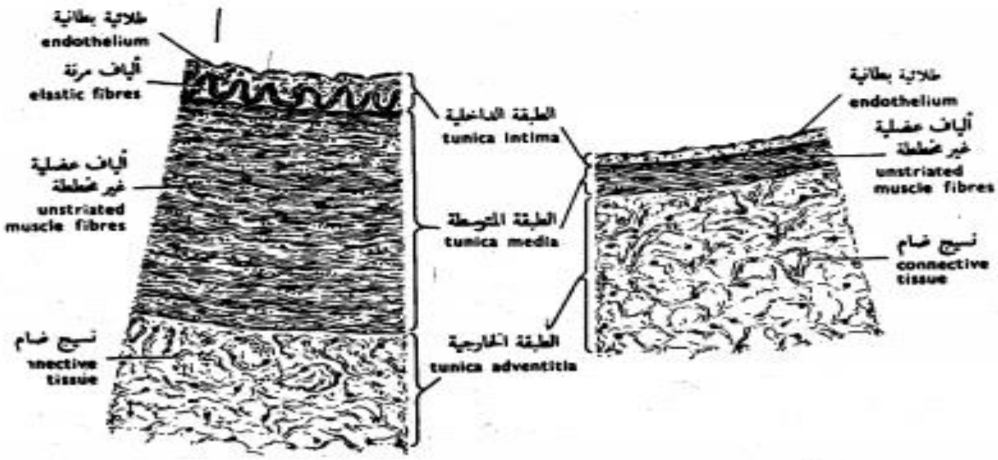
FIG. 43 - NERVOUS TISSUES

The Organs

Blood vessels



قطاعات عرضية من أوعية دموية مختلفة
T.S. of different Blood Vessels

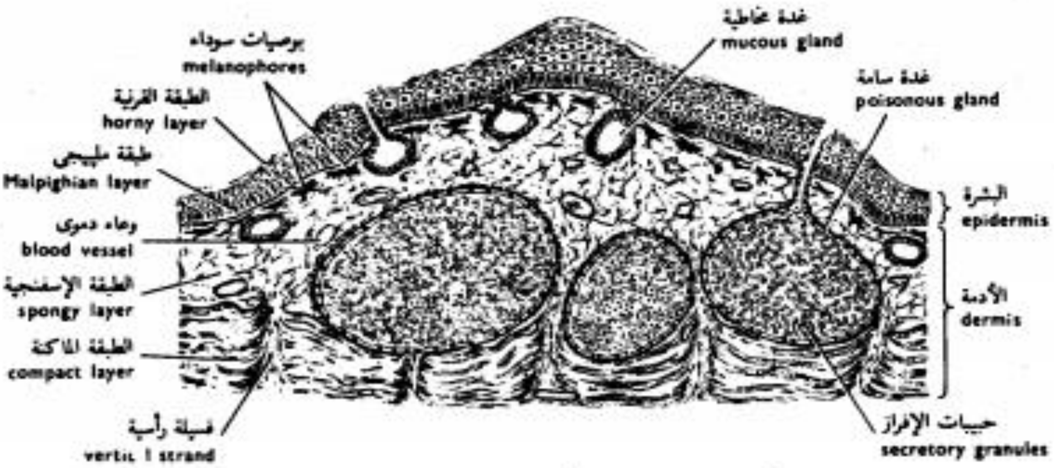


جزء من قطاع عرضي من جدار شريان
Sector of the wall of an Artery

جزء من قطاع عرضي من جدار وريد
Sector of the wall of a Vein

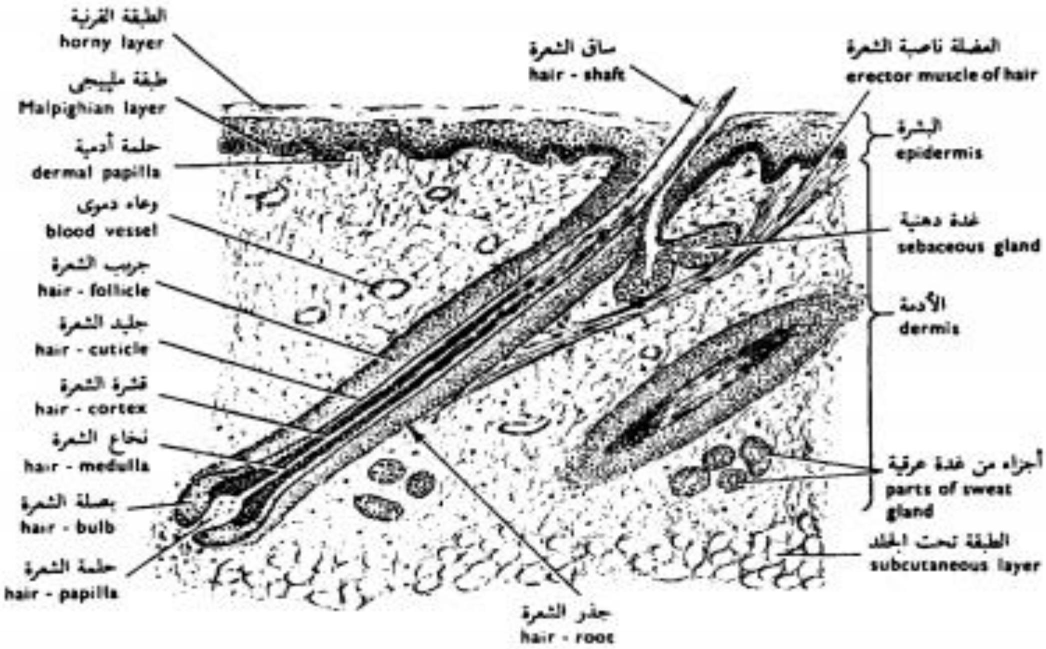
شكل ٤٤ ـ الأوعية الدموية
FIG. 44 - BLOOD VESSELS

Skin



شكل ٤٥ ـ قطاع رأسي من جلد الضفدعة

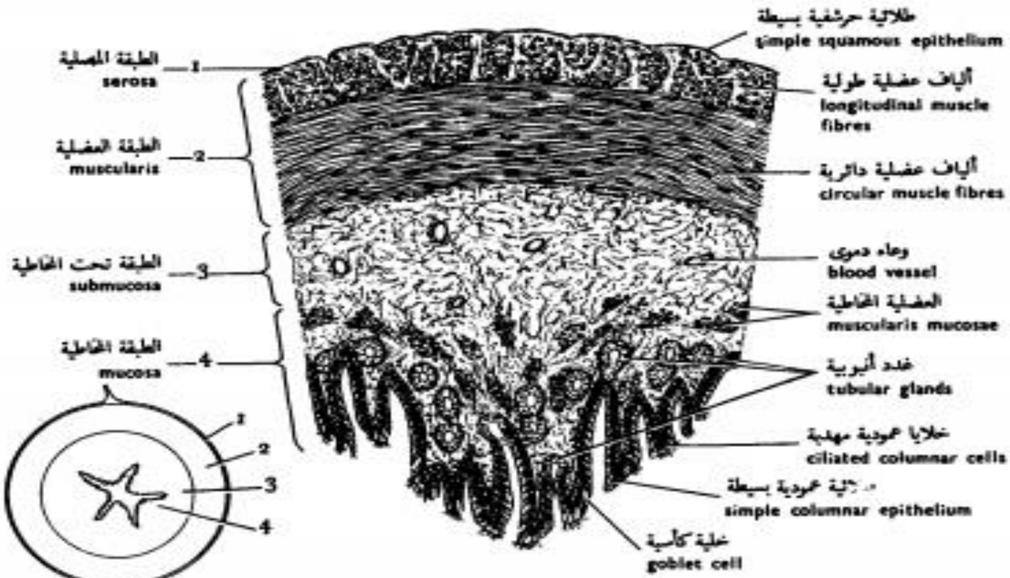
FIG. 45 - V.S. OF THE SKIN OF THE TOAD



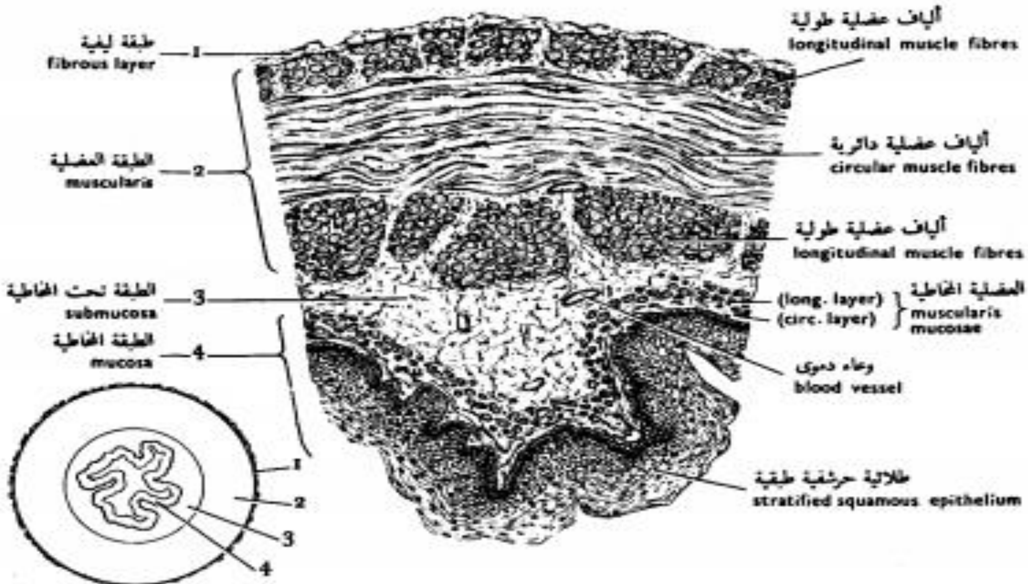
شكل ٤٦ ـ قطاع رأسي من جلد الخنزير

FIG. 46 - V. S. OF THE SKIN OF THE PIG

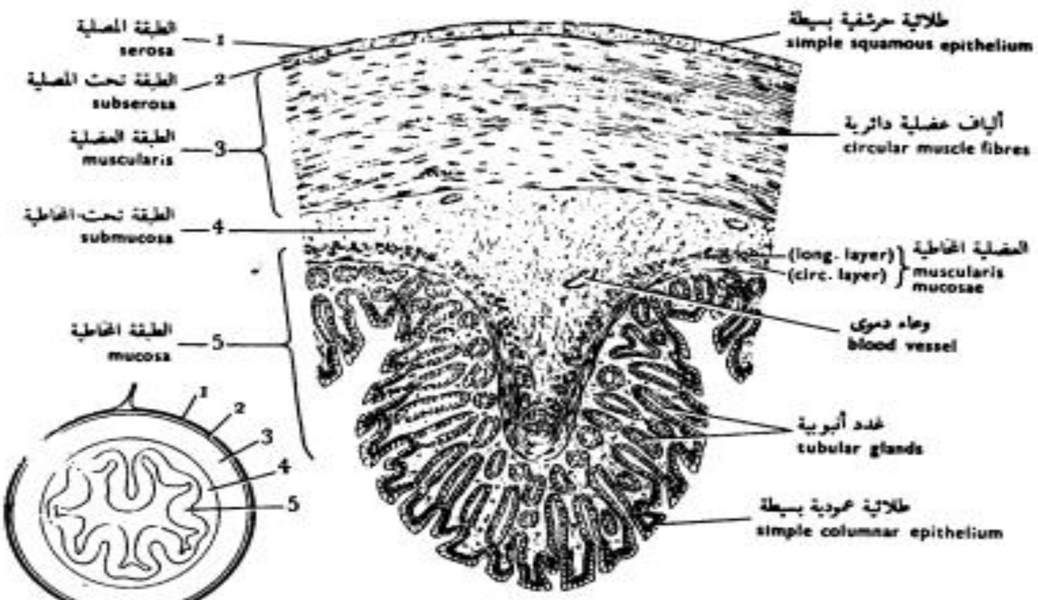
Digestive tract



شكل ٥٢ - قطاع عرضي من مرىء الضفدعة
FIG. 52 - T.S. OF THE OESOPHAGUS OF THE TOAD

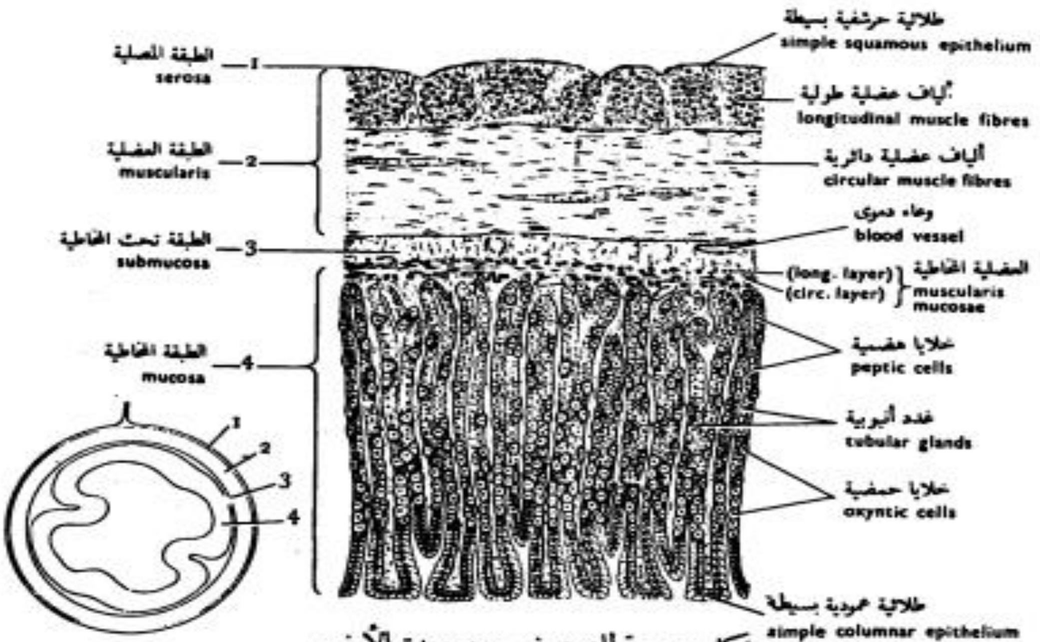


شكل ٥٣ - قطاع عرضي من مرىء الأرنب
FIG. 53 - T.S. OF THE OESOPHAGUS OF THE RABBIT



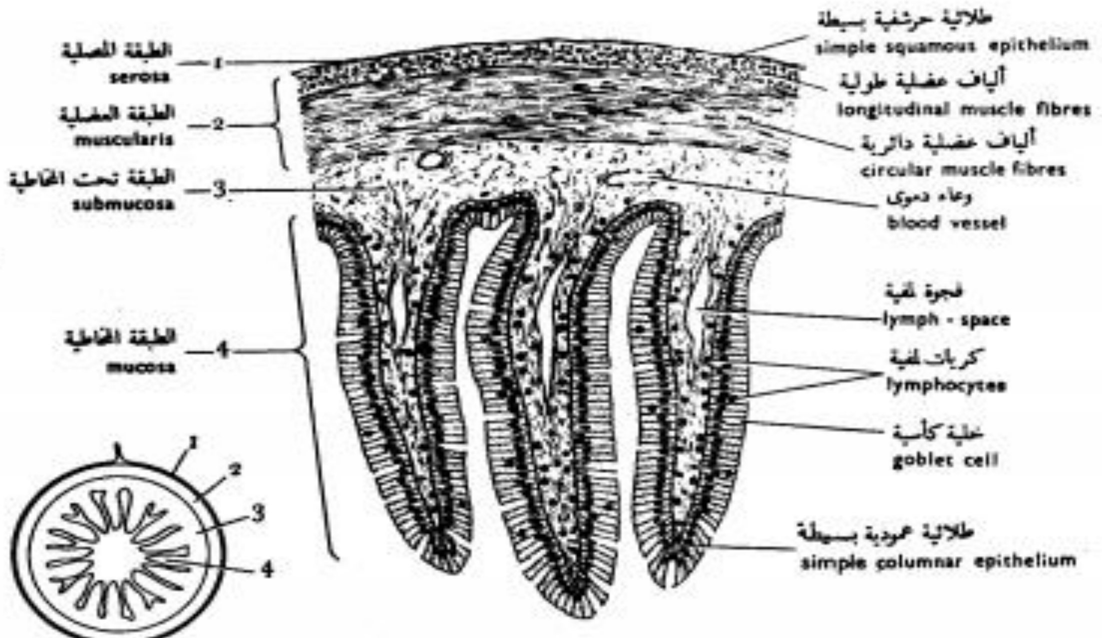
شكل ٥٤ ـ قطاع عرضى من معدة الضفدعة

FIG. 54 – T.S. OF THE STOMACH OF THE TOAD



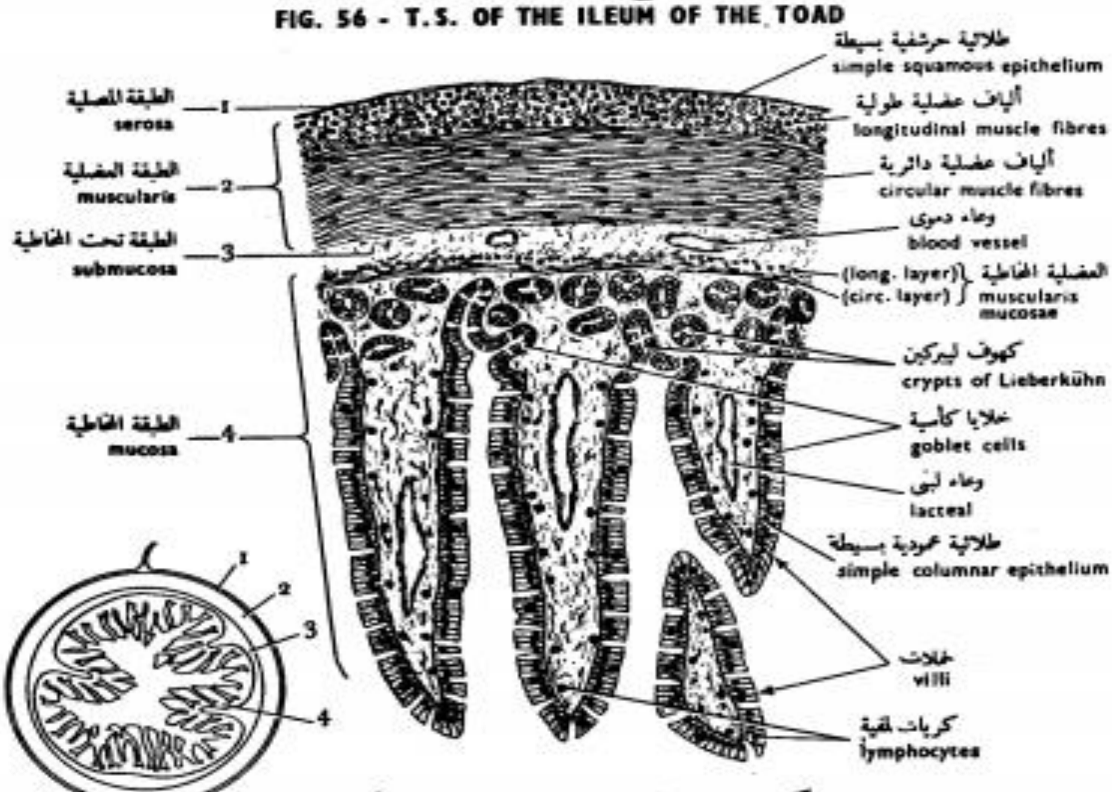
شكل ٥٥ ـ قطاع عرضى من معدة الأرنب

FIG. 55 – T.S. OF THE STOMACH OF THE RABBIT



شكل ٥٦ - قطاع عرضى من لفائفى الضفدعة

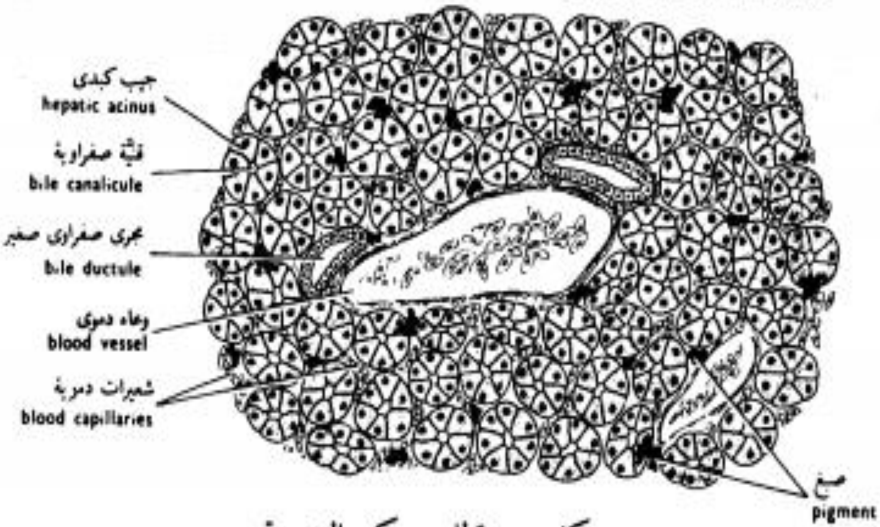
FIG. 56 - T.S. OF THE ILEUM OF THE TOAD



شكل ٥٧ - قطاع عرضى من لفائفى الأرنب

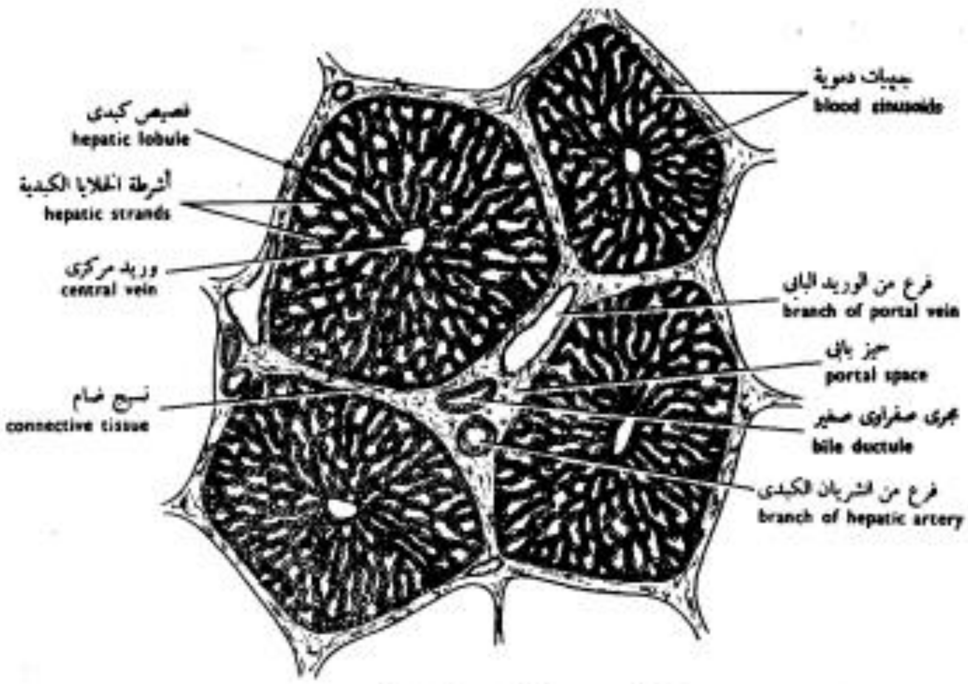
FIG. 57 - T.S. OF THE ILEUM OF THE RABBIT

Liver



شكل ٥٩ ـ قطاع من كبد الضفدعة

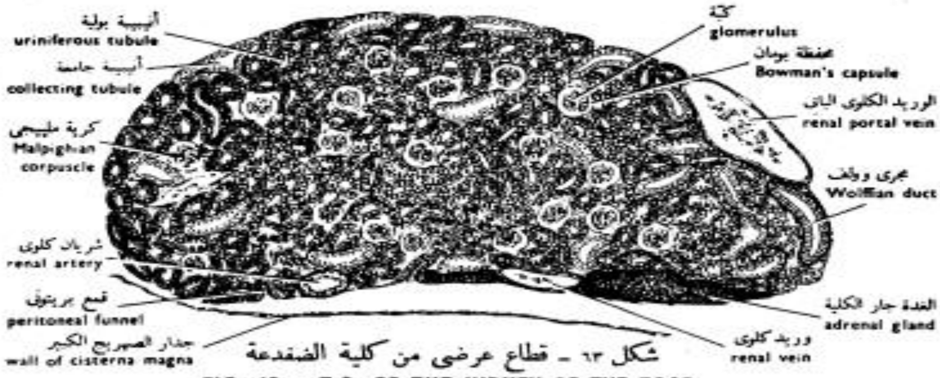
FIG. 59 - S. OF THE LIVER OF OF THE TOAD



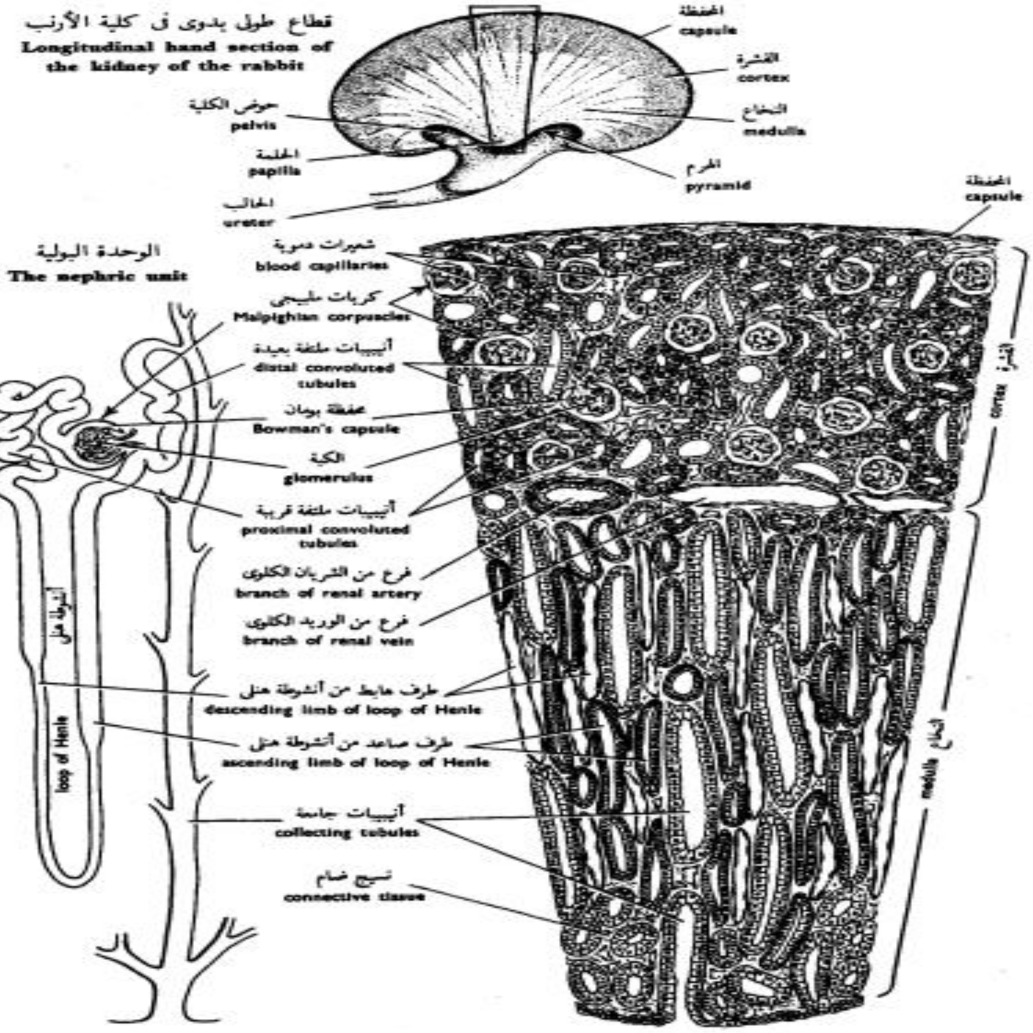
شكل ٦٠ ـ قطاع من كبد الخنزير

FIG. 60 - S. OF THE LIVER OF THE PIG

Kidney

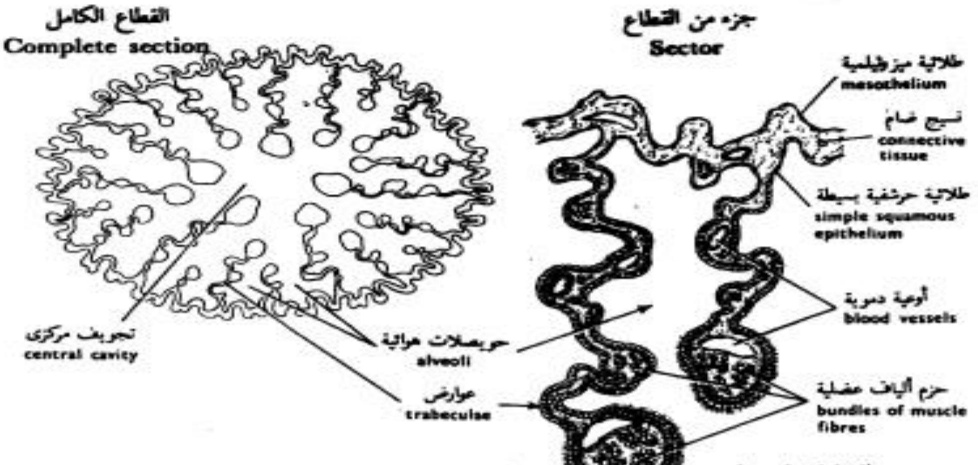


شكل ٦٣ ـ قطاع عرضى من كلية الضفدعة
FIG. 63 - T.S. OF THE KIDNEY OF THE TOAD



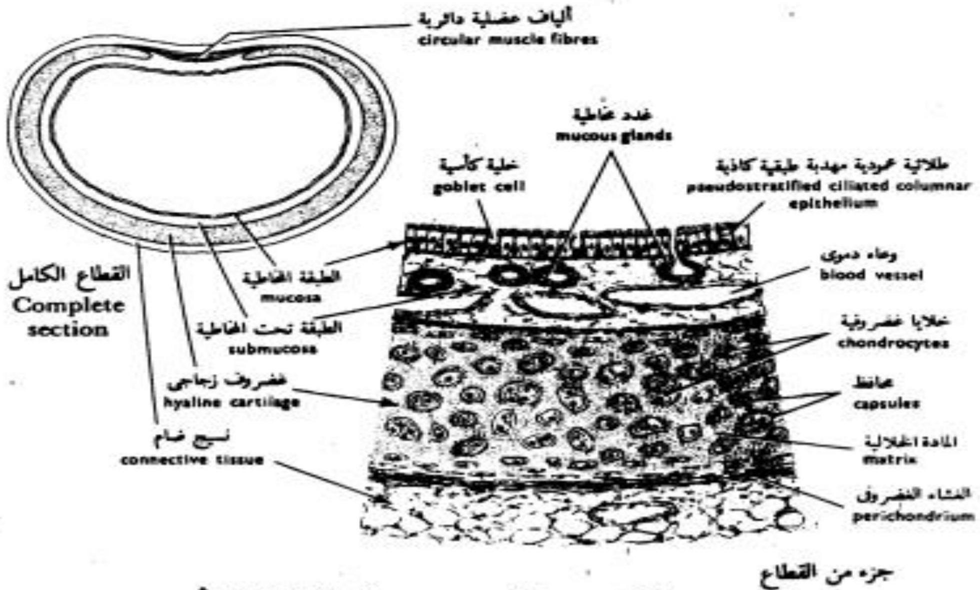
شكل ٦٤ ـ قطاع عرضى من كلية الأرنب

Lung



شكل ٦٥ - قطاع عرضى من رئة الضفدعة

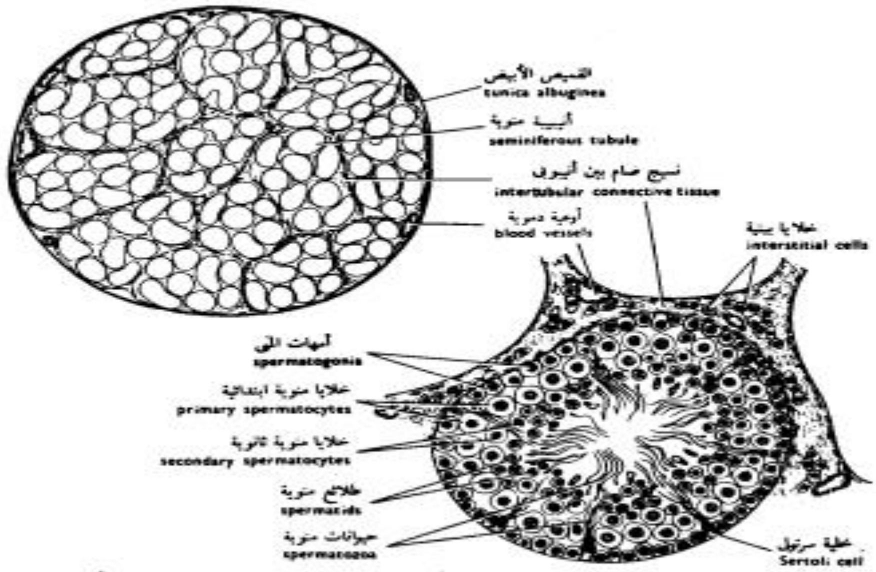
FIG. 65 - T.S. OF THE LUNG OF THE TOAD



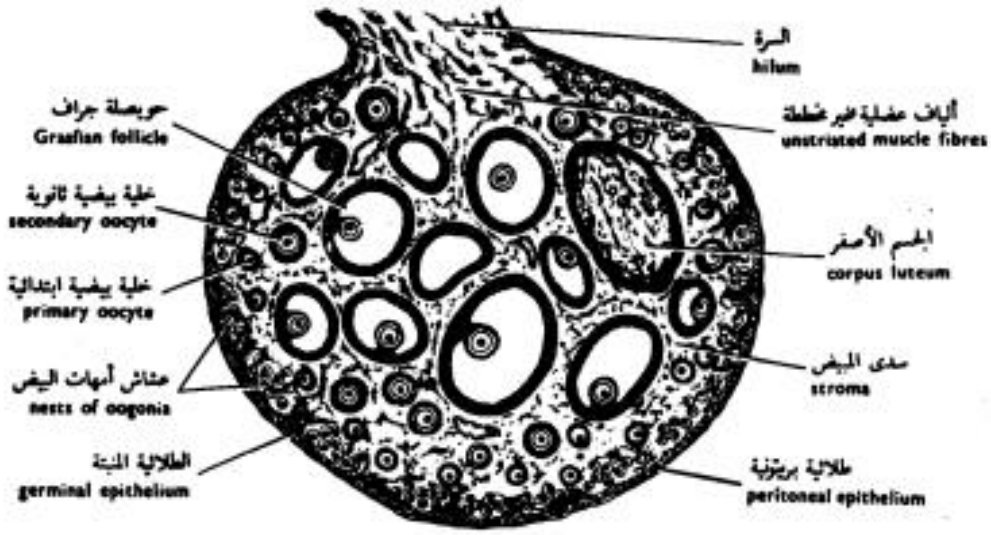
شكل ٦٦ - قطاع عرضى من القصبة الهوائية للأرنب

FIG. 66 - T.S. OF THE TRACHEA OF THE RABBIT

Testis and Ovary



شكل ٦٧ ـ قطاع عرضى من خصية الفأر
FIG. 67 - T.S. OF THE TESTIS OF THE RAT



شكل ٧١ ـ قطاع عرضى من مبيض القطة
FIG. 71 - T.S. OF THE OVARY OF THE CAT

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