The Blood

Lecture-12-

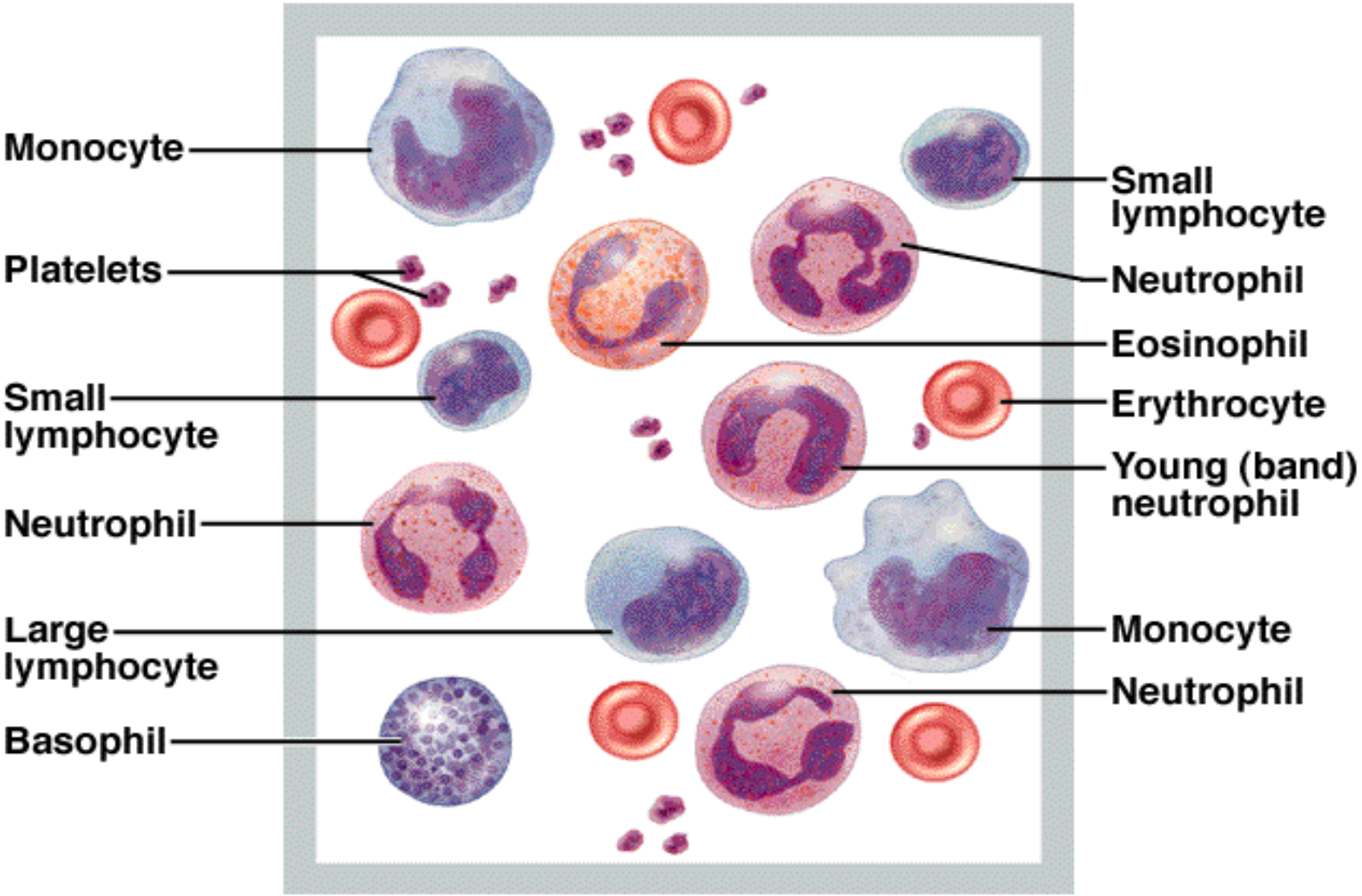
Dr.Aseel I. Ibrahim

Composition of the blood:

1. Plasma.
2. The formed elements (blood cells/ cell fragments).
   - erythrocytes (Red blood cells (**RBCs)**)
   - **platelets** (cellular fragments)
   - leucocytes (White blood cells (**WBCs)**)

Granulocytes	**A granulocytes**
Neutrophil(PMNs)	Monocytes
Eosinophil	Lymphocytes
Basophil	

Formed Elements of Blood



Blood smear

Plasma:

Water 92%,

proteins (Albumin 60%, Globulin 36%, Fibrinogen 4%),

Glucose (dextrose) 70-120 mg/100ml,

Amino acid, 33-51 mg/100 ml

Lactic acid, 6-16 mg/100ml

total lipid

cholesterol

fatty acids

LDL

HDL

triglyceride

phospholipids

Na, K, CL, Ca, Mg

Urea, Uric acid

Erythrocytes:

- **biconcave disc** shape, suited for gas exchange. The shape is flexible so that RBCs can pass though the smallest blood vessels, i.e., capillaries.
- Primary cell content is hemoglobin, the protein that binds oxygen and carbon dioxide.
- no nucleus nor mitochondria.

Hemoglobin consists of : **globin** and **heme** pigment.

Each heme group bears an atom of iron, which binds reversibly with one molecule of oxygen.

Carbon monoxide competes with oxygen for heme binding with a much higher affinity.

- **Oxyhemoglobin:** bound with oxygen, red.
- **Deoxyhemoglobin:** free of oxygen, dark red.

20% of carbon dioxide in the blood binds to the **globin** part of hemoglobin, which is called **carbaminohemoglobin**.

Function: Transport oxygen from the lung to tissue cells and carbon dioxide from tissue cells to the lung. Buffer blood PH.

Production: **hematopoiesis** (whole blood cell production).

erythropoiesis (RBCs production)

- All blood cells, including red and white, are produced in **red bone marrow**.
- All of blood cells including red and white arise from the same type of stem cell, the **hematopoietic** stem cell or **hemocytoblast**.

Regulation of erythropoiesis:

- regulated by renal oxygen content.
- **Erythropoietin,** a glycoprotein hormone, is produced by renal cells in response to a decreased renal blood O2 content.
- Erythropoietin stimulates erythrocyte production in the red bone marrow.
- Dietary Requirements for Erythropoiesis**: Iron, Vitamin B12, & Folic acid.**

The BLOOD group

ABO Basics

- Blood group antigens are actually sugars attached to the red blood cell.
- Antigens are “built” onto the red cell.
- Individuals inherit a gene which codes for specific sugar(s) to be added to the red cell.
- The type of sugar added determines the blood group.

Landsteiner's Rule:

- Individual's will form immune antibodies to ABO blood group antigens they do not possess.
- Substances are present in nature which are so similar to blood group antigens which result in the constant production of antibodies to blood group antigens they do not possess.
- Critical for understanding compatibility between ABO blood groups.

Antibody clinical significance:

- Immunizations are frequently done to protect us from disease.
  - Receive Hepatitis B immunization.
  - Actual bits of hepatitis virus injected.
  - Body recognizes as foreign and produces an immune antibody.
  - Subsequent exposure to real Hepatitis B virus will result in destruction of the virus by immune antibodies.
- ABO antibodies are immune and will result in destroying incompatible cells which may result in the death of the recipient.

Genetics:

- Two genes inherited, one from each parent.
- Individual who is A or B may be homozygous or heterozygous for the antigen.
- Heterozygous: AO or BO
- Homozygous: AA or BB
- Phenotype is the actual expression of the genotype, i.e., group A
- Genotype are the actual inherited genes which can only be determined by family studies, i.e., AO.

Example of Determining Genotype:

- Mom's phenotype is group A, genotype AO
- Dad's phenotype is group B, genotype BO

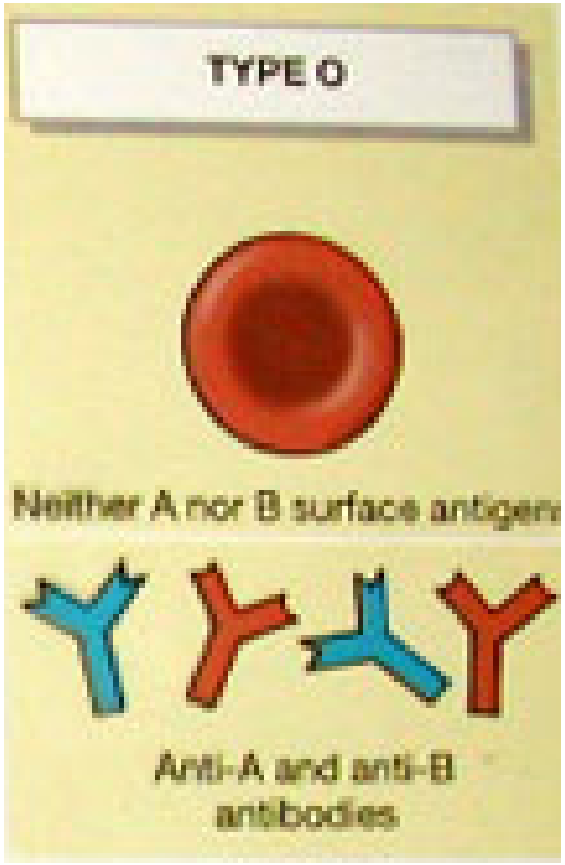
	B	O
A	AB 25%	AO 25% (Group A)
O	BO 25% (Group B)	OO 25% (Group O)

Other Examples:

Mom	Dad	Offspring Blood Group
AA	BB	100% AB
BO	OO	50% each of B or O
OO	OO	100% O
OO	AO	50% each of A or O

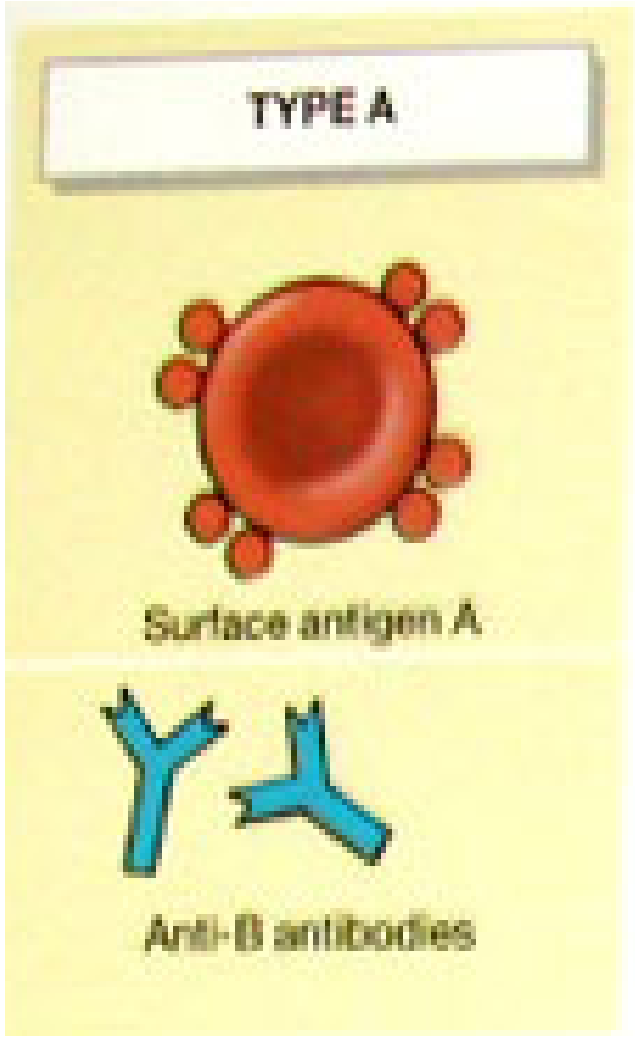
Group O:

- Approximately 45% of the population is group O.
- No A or B antigens present.
- These individuals form potent anti-A and anti-B antibodies which circulate in the blood plasma at all times.



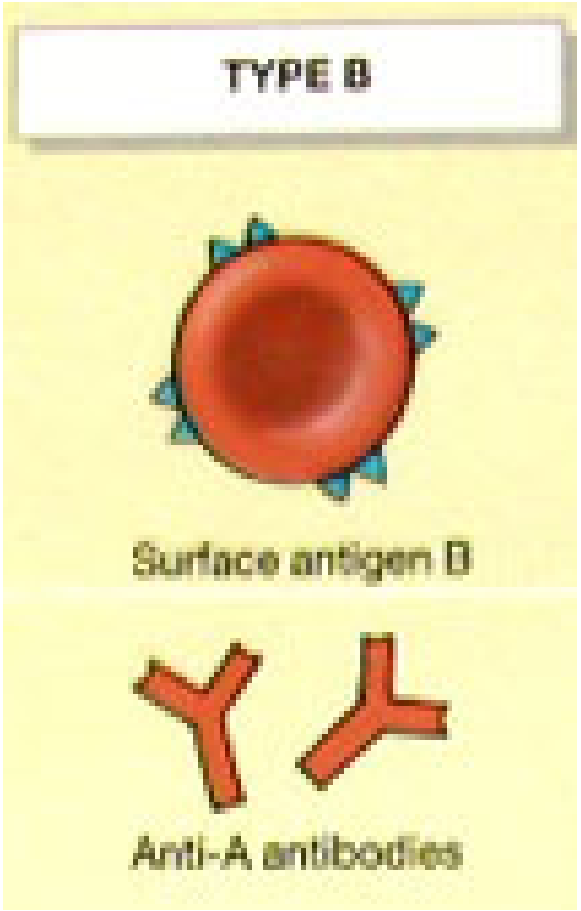
Group A:

- Approximately 40% of the population is group A.
- No B antigens present.
- These individuals form potent anti-B antibodies which circulate in the blood plasma at all times.



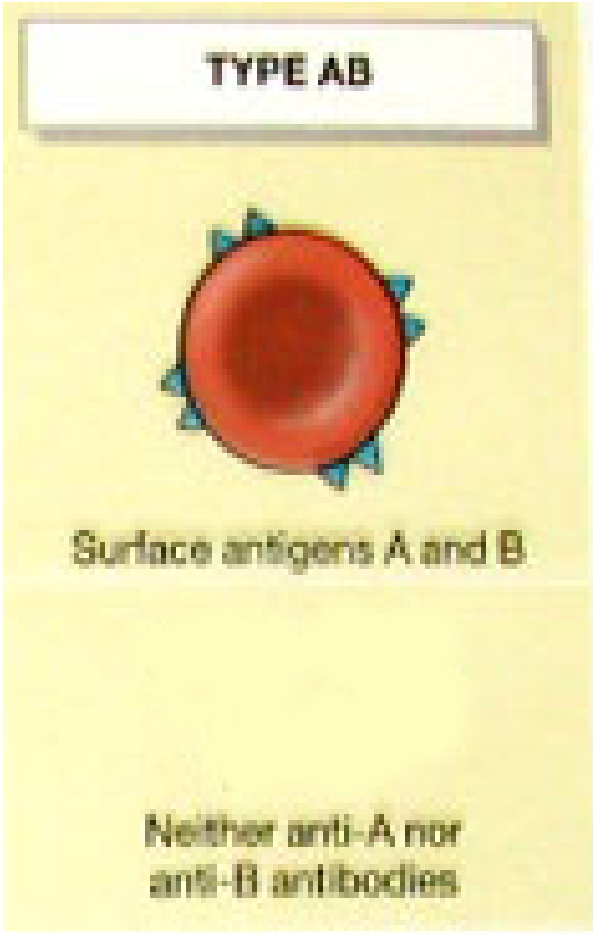
Group B:

- Approximately 11% of the population is group B.
- No A antigens present.
- These individuals form potent anti-A antibodies which circulate in the blood plasma at all times.



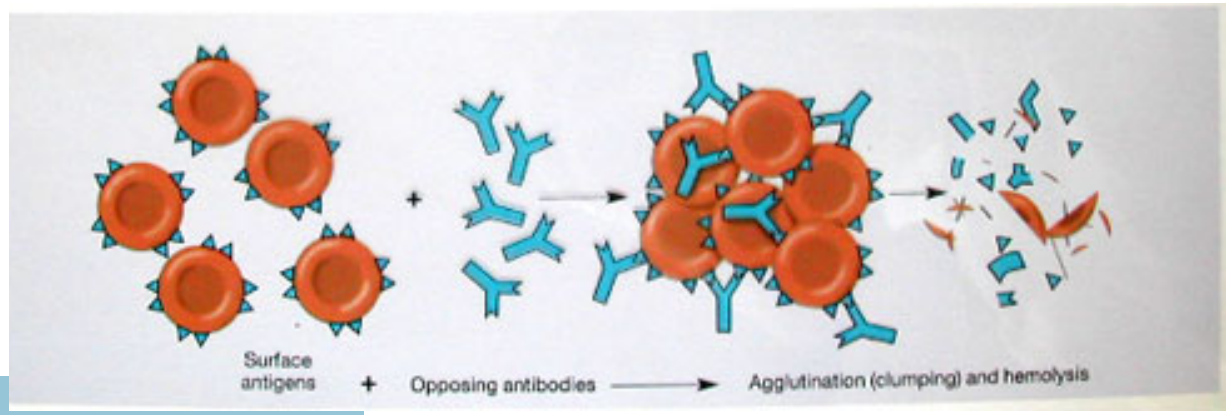
Group AB:

- Approximately 4% of the population is group AB.
- Both A and B antigens present.
- These individuals possess no ABO antibodies.



Hemolysis:

- If an individual is transfused with an incompatible blood group destruction of the red blood cells will occur.
- This may result in the death of the recipient.



Blood Group	Antigens on cell	Antibodies in plasma	Transfuse with group
A	A	Anti-B	A or O
B	B	Anti-A	B or O
AB	A and B	none	AB, A, B or O
O	None	Anti-A & B	O

Rh (D) Antigen:

- Of next importance is the Rh type.
  - Term “Rh” is a misnomer.
  - Rh is a blood group system with many antigens, one of which is D.
- Rh refers to the presence or absence of the D antigen on the red blood cell.

- Unlike the ABO blood group system, individuals who lack the D antigen do not naturally make it.
- Production of antibody to D requires exposure to the antigen.
- The D antigen is very immunogenic, i.e., individuals exposed to it will very likely make an antibody to it.
- For this reason all individuals are typed for D, if negative must receive Rh (D) negative blood.
- The most important patient population to consider is females of child-bearing age.
- If immunized to Rh (D) antigen the antibody can cross the placenta and destroy Rh (D) positive fetal cells resulting in death.
- This is why Rh negative women are given Rhogam after birth of Rh positive baby.

Hemolytic Disease of the Newborn:

A- child is Rh positive.

B- during pregnancy fetal Rh positive RBCs escape into maternal circulation.

C- Mother produces antibodies to Rh (D) antigen.

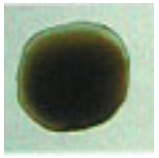
D- Second pregnancy with Rh (D) positive child results in destruction of fetal D positive RBCs.

Slide Blood Typing:

- Very rudimentary method for determining blood groups.
- CANNOT be used for transfusion purposes as false positives and negatives do occur.
- A “false positive” is when agglutination occurs not because the antigen is present, but cells may already be clumped.
- A “false negative” is one in which the cells are not clumped because there are too many cells or not enough reagent.

Interpretation of Slide Typing Testing with Anti-A Anti-Serum:

- If an RBC contains the A antigen the red blood cells will be agglutinated by anti-A, a positive reaction.
- If an RBC does not have the A antigen there will be no clumping, a negative reaction.

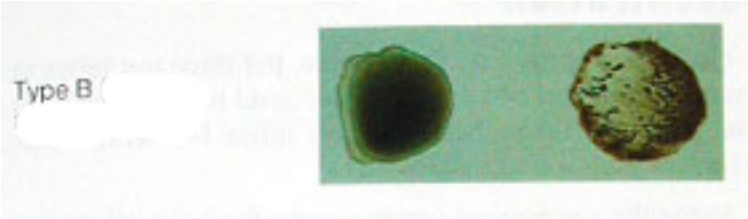


Slide Blood Typing Group A:

- An unknown RBC suspension is added to known anti-sera.
- The left hand of the slide contains anti-A which reacts with the unknown cell.
- The right hand side contains anti-B which does not react with the cell.

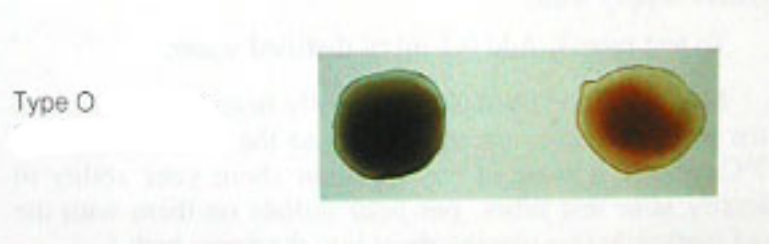
Slide Blood Typing Group B:

- An unknown RBC suspension is added to known anti-sera.
- The left hand of the slide contains anti-A does not react with the unknown cell.
- The right hand side contains anti-B which reacts with the cell.



Slide Blood Typing Group O:

- The left hand of the slide contains anti-A does not react with the unknown cell.
- The right hand side contains anti-B does not react with the unknown cell.



Anti-A	Anti-B	Blood Group
NEG	NEG	O
POS	NEG	A
NEG	POS	B
POS	POS	AB

Gene expression

Lecture -5-

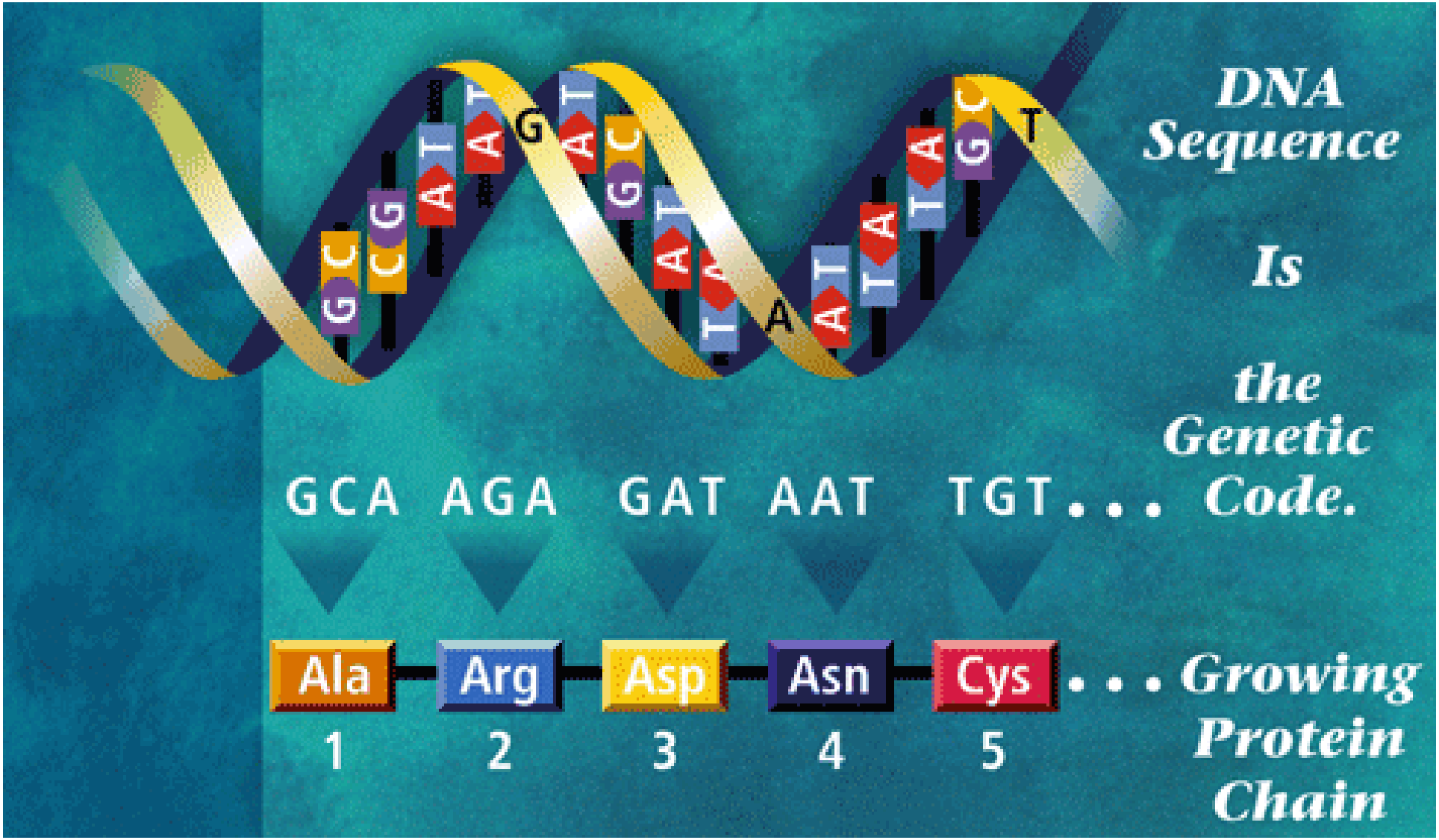
Genes contain a code, a code for making chemicals called proteins, this code, the **genetic code**, lies in the sequence of the bases along one strand of the DNA molecule. There are four bases: **adenine** (A), **thymine** (T), **guanine** (G) and **cytosine** (C). Adenine always pairs with thymine; and guanine always pairs with cytosine: A-T and G-C.

the **genetic code** as a language. Each group of three bases or 'letters' forms a 'word' called a **codon**. Each codon specifies one amino acid, and proteins are made from long chains of amino acids. There are also codon that mark the start and end of the gene.

There are **two stages** in using the genetic code to make a **protein**.

1. **Transcription**: The two strands of the double helix DNA separate and the sequence of bases in one strand - the **template strand** - is used to make a special 'messenger' chemical called messenger RNA (mRNA).

The **template strand** that codes for the protein makes mRNA using the base-pairing rules. There is one difference: **thymine** (T) is replaced with a new base, **uracil** (U).



The DNA double helix, showing base pairs. codons and amino acids.

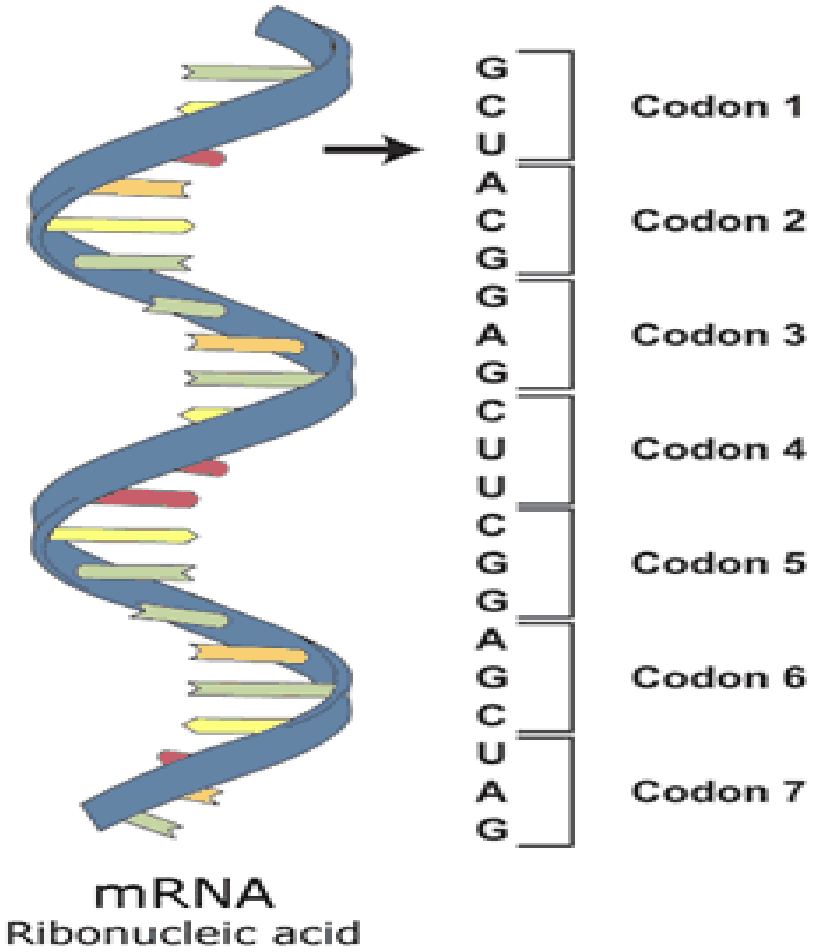


Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion/DIR//VIP/Glossary/Illustration/codon.shtml.

A mRNA molecule, showing the codon

2- Translation: In the second stage, the **mRNA** molecule is used as a template to build a protein. A structure called a ribosome 'reads' the codons as it moves along the mRNA molecule. The ribosome is made from protein and another sort of RNA, **ribosomal RNA** (**rRNA**).Other RNA molecules, called **transfer RNA** (**tRNA**), bind to the ribosome carrying the amino acid that matches each codon. The end result is a chain of amino acids - a protein.

*Changes in the genetic code are known as **mutations** and can have many consequences.*

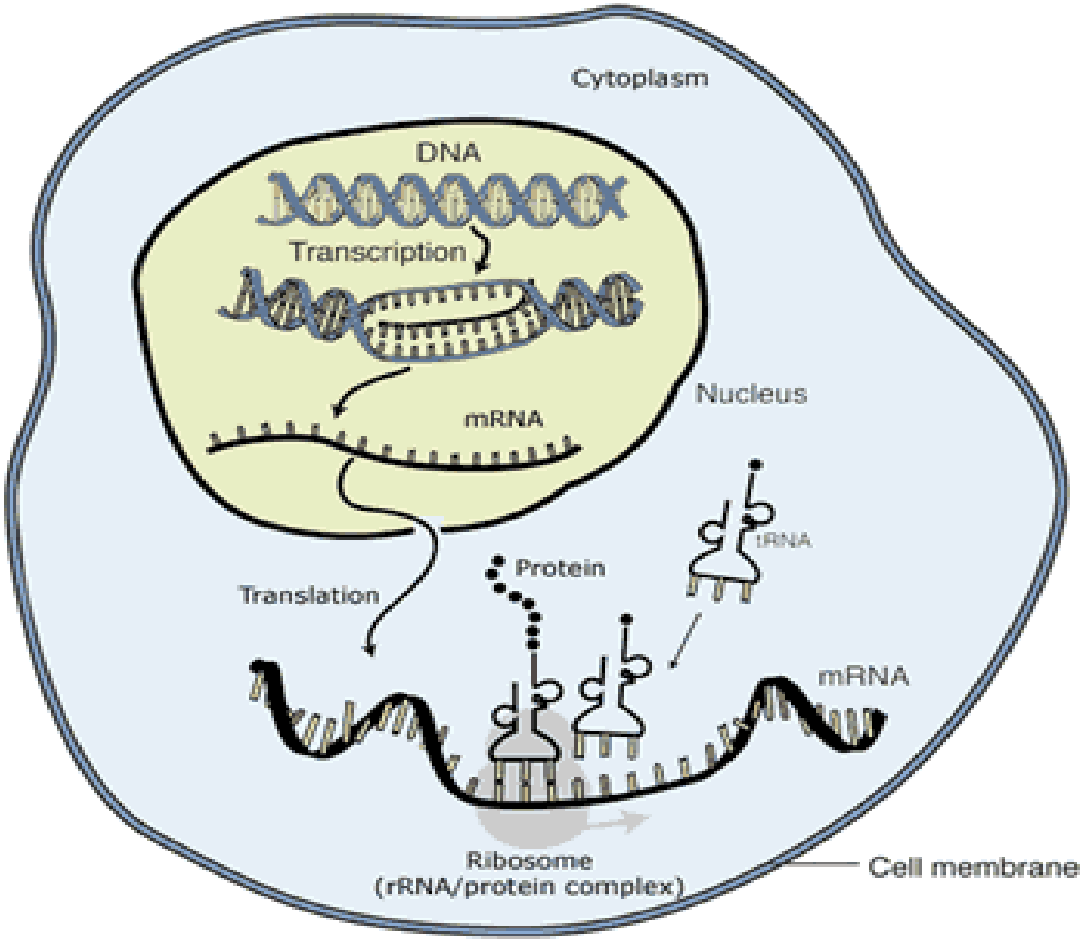


Image adapted from: National Human Genome Research Institute.

The cell showing the processes of transcription and translation

Gene regulation:

- All the cells in our body contain two copies of every gene. But our body contains many different sorts of cells, from muscle cells that help us move to cells in our eye that help us to see.
- Our body can make different sorts of cells using the same set of genes because it can control which genes are used to make proteins. In any cell at any time, some genes are switched on and some genes are switched off. A heart cell will make the proteins needed for a heart cell; a liver cell will make the proteins needed for a liver cell.

- Genes are switched on and off by other proteins called **transcription factors**, which stick to special control sites in the DNA at the start of a gene. These transcription factors are coded for by other genes.
- Genes are often controlled by the activities of other genes. Scientists think that maybe as much as 10 per cent of our genes are responsible for producing transcription factors.

Transcription factors (TF): is a protein that controls the rate of transcription of genetic information from DNA to messenger RNA, by binding to a specific DNA sequence.

- **Their function:**

1. regulate - turn on and off – genes.
2. to make sure that they are expressed in the right cell at the right time and in the right amount throughout the life of the cell and the organism.

- Groups of transcription factors function in a coordinated fashion to direct cell division, cell growth, and cell death throughout life; cell migration and organization (body plan) during embryonic development; and intermittently in response to signals from outside the cell, such as a hormone. There are up to 2600 TFs in the human genome.

- Transcription factors work alone or with other proteins in a complex, by promoting (as an activator), or blocking (as a repressor) the recruitment of RNA polymerase (the enzyme that performs the transcription of genetic information from DNA to RNA) to specific genes.
- Transcription factors are of interest in medicine because transcription factors mutations can cause specific diseases, and medications can be potentially targeted toward them.

Genetics disorder

Lecture. 6

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Genetic Disorders:

Mutations : Changes in the nucleotide sequence of DNA, may occur in somatic cells (not passed to offspring), may occur in gametes (eggs & sperm) and be passed to offspring.

mutations can be either inherited from a parent or acquired. A hereditary mutation is a mistake that is present in the DNA of virtually all body cells. Hereditary mutations are also called germ line mutations because the gene change exists in the reproductive cells and can be passed from generation to generation, from parent to newborn.

Mutations occur all the time in every cell in the body. Each cell has the remarkable ability to recognize mistakes and fix them before it passes them along to its descendants. But a cells DNA repair mechanisms can fail, or become less efficient with age. Over time, mistakes can accumulate.

- **Mutation** may be:
- **harmful**, Some type of skin cancers and leukemia result from somatic mutations,
- **Beneficial**, Some mutations may improve an organism's survival

Classes of mutation:

1. Spontaneous mutation.
2. Induced mutation.

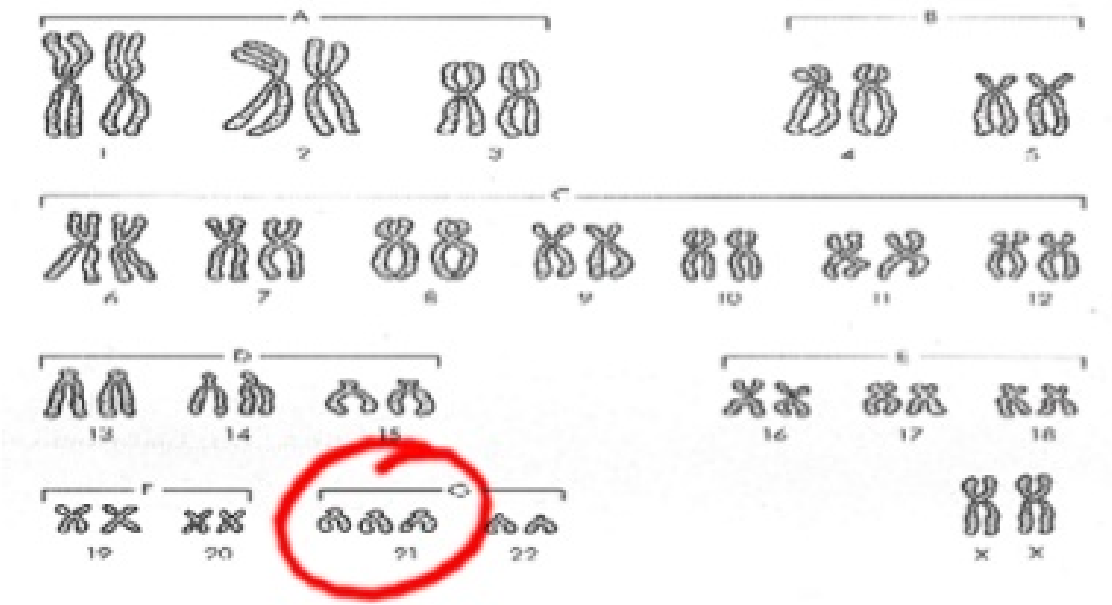
- **Spontaneous**: they are mainly caused during DNA replication or by incorporation of incorrect nucleotide in the growing DNA chain, they occur naturally by changes in DNA sequence during replication.
- **Induced**: are caused by the changes in DNA brought about by some environmental factor called mutagens, e.g: UV light, x-rays, gamma rays.

Chromosome mutation may Involve:

1. Changing the structure of a chromosome.
2. The loss or gain of part of a chromosome.

Down's Syndrome caused by non- disjunction of the 21st chromosome. This means that the individual has a trisomy (3–2lst chromosomes).

Down's Syndrome or Trisomy 21



Sickle Cell Anemia:

- An inherited, chronic disease in which the red blood cells, normally disc-shaped, become crescent shaped. They function abnormally and cause small blood clots. These clots give rise to recurrent painful episodes called "sickle cell pain crises".
- Sickle cell disease is most commonly found in African American populations.

Hemophilia:

the royal disease Hemophilia is the oldest. The severity of known hereditary bleeding hemophilia is related to disorder the amount of the clotting, caused by a recessive factor in the blood.

Diabetes:

- Disease in which the body does not produce or properly use insulin. Insulin is a hormone that is needed to convert sugar, starches, and other food into energy needed for daily life. Genetic mutation can lead to Type 1 diabetes, but no one sure if relative to a specific gene.
- Diabetes Type 1 reveals itself in childhood, Type 2 can be made worse from excessive lifestyle. Warning signs extreme thirst, blurry vision from time to time, frequent urination, unusual fatigue or drowsiness, unexplained weight loss. Diabetes is the leading cause of kidney failure, blindness, and amputation in adults, and can also lead to heart disease.

Color Blindness

- Cause: x-linked recessive 1/10 males have, 1/100 females have. Individuals are unable to distinguish shades of red-green.

INTRODUCTION TO GENETICS:

LECTURE -3-

THE DNA MOLECULE.
NUCLEOTIDES.
CHROMOSOMES VS GENES.
DNA REPLICATION.

- **Genes** contain the information our bodies need to make chemicals called proteins.
- Proteins form the structure of our bodies, as well playing an important role in the processes that keep us alive.
- **Genes** are made of a chemical called DNA, 'deoxyribonucleic acid', is a helix: two long, thin strands twisted around each other like a spiral staircase.
- The sides are sugar and phosphate molecules, the rungs are pairs of chemicals called 'nitrogenous bases'.

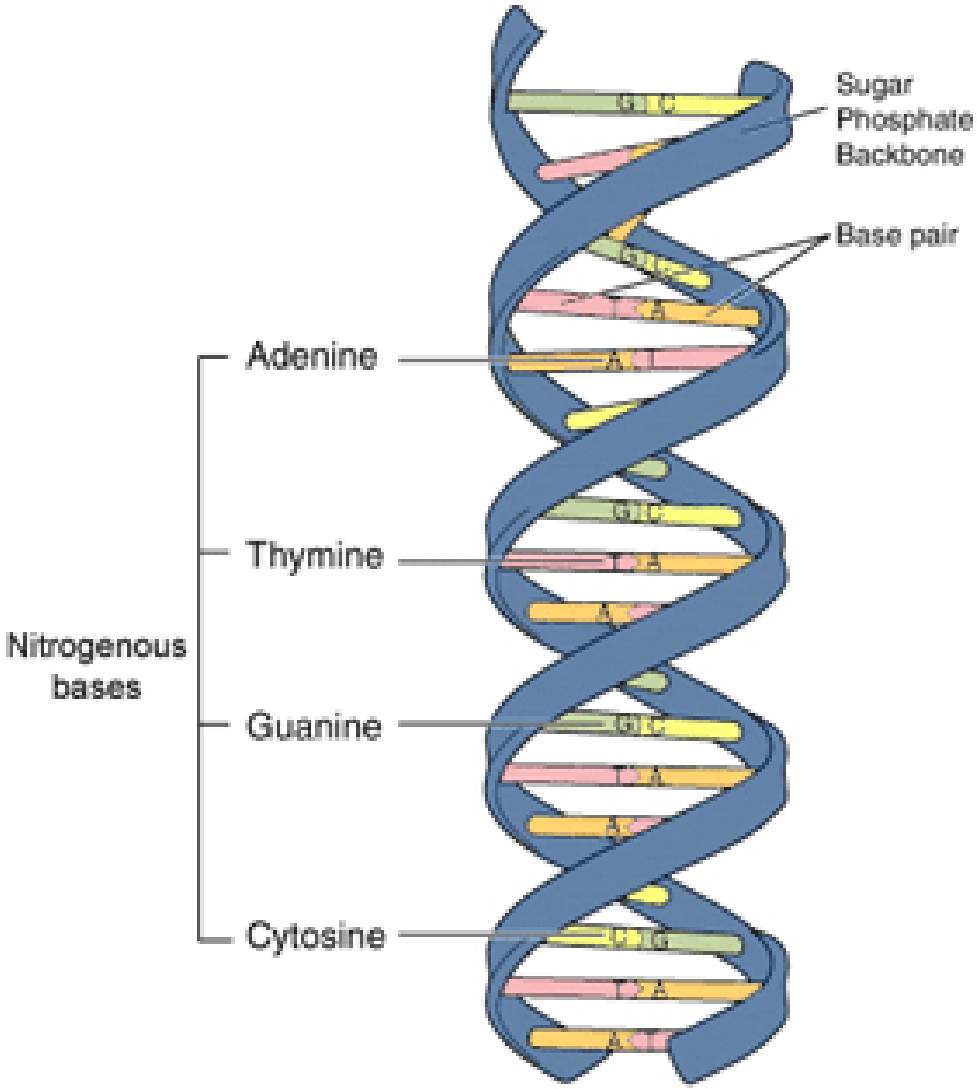


Image adapted from: National Human Genome Research Institute.

THE DNA DOUBLE HELIX SHOWING BASE PAIRS

THE DNA MOLECULE:

- Composed of **2** polymers of nucleotides.
- Polymers are oriented in **antiparallel**.
- DNA contain four types of nitrogen base: **adenine** (A), **thymine** (T), **guanine** (G) and **cytosine** (C). These bases link in a very specific way: A always pairs with T, and C always pairs with G.

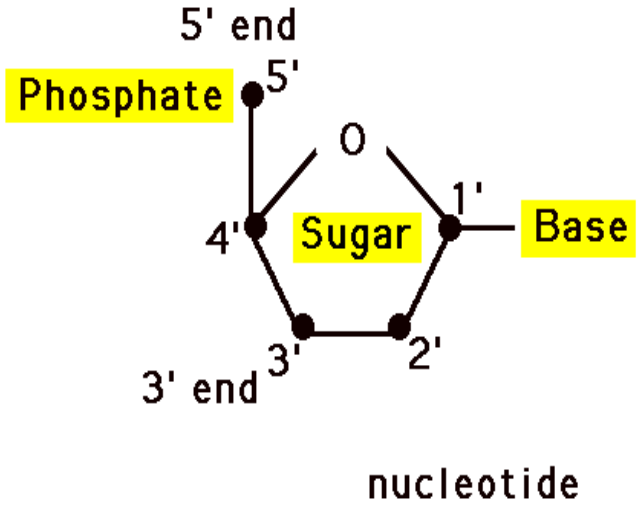
The **DNA** molecule has two important properties:

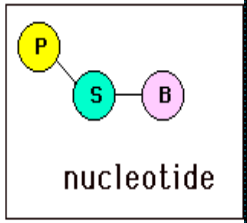
- **It can make copies of itself**. If you pull the two strands apart, each can be used to make the other one (and a new DNA molecule).
- **It can carry information**. The order of the nitrogen bases along a strand is a code - a code for making proteins.

NUCLEOTIDE STRUCTURE OF DNA:

- Each nucleotide of DNA contains:
  - Deoxyribose.
  - Phosphate.
  - Nitrogen base.

(either A, G, C, T)



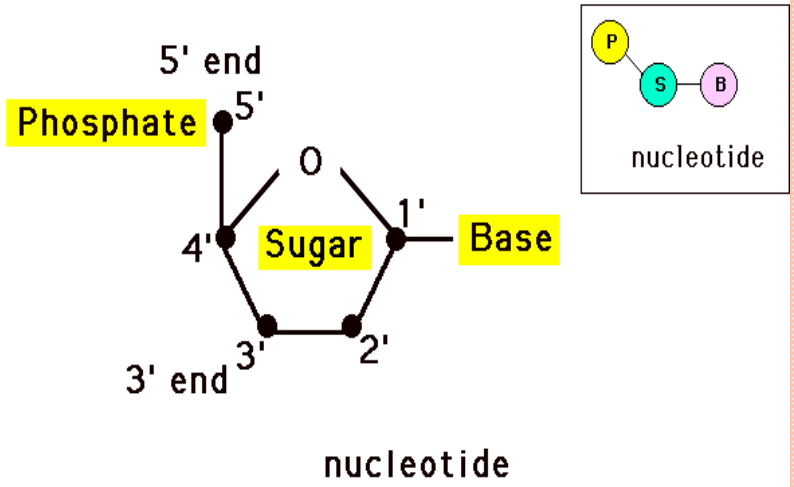


NUCLEOTIDE STRUCTURE OF RNA

- Each nucleotide of RNA contains:
  - Ribose.
  - Phosphate.
  - Nitrogen base

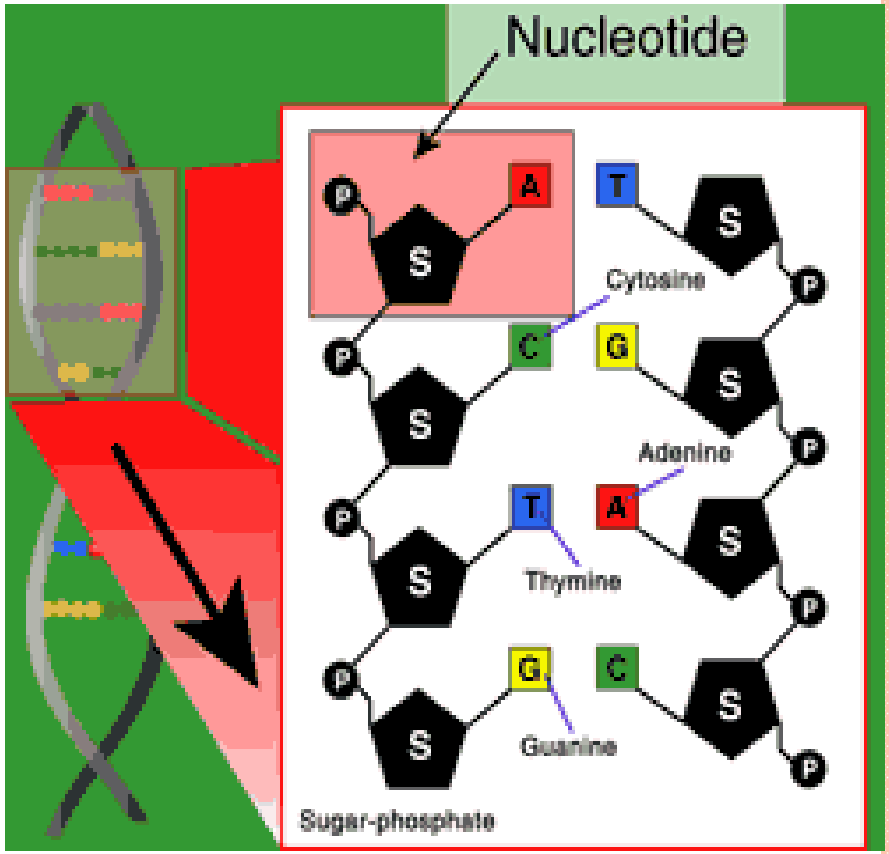
(either A, G, C, U*)

*contains Uracil instead of Thymine

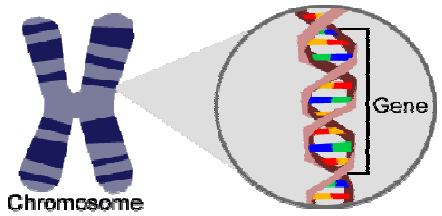


DNA STRUCTURE:

- "Double helix" propsed by Watson and Crick (1953)
- Antiparallel backbones.
- Complementary base pairing:
  - Adenine to Thymine
  - Cytosine to Guanine



Gene is a length of DNA that codes for a specific protein, for example, one gene will code for the protein insulin, which is play important role in helping our body to control the amount of sugar in our blood.

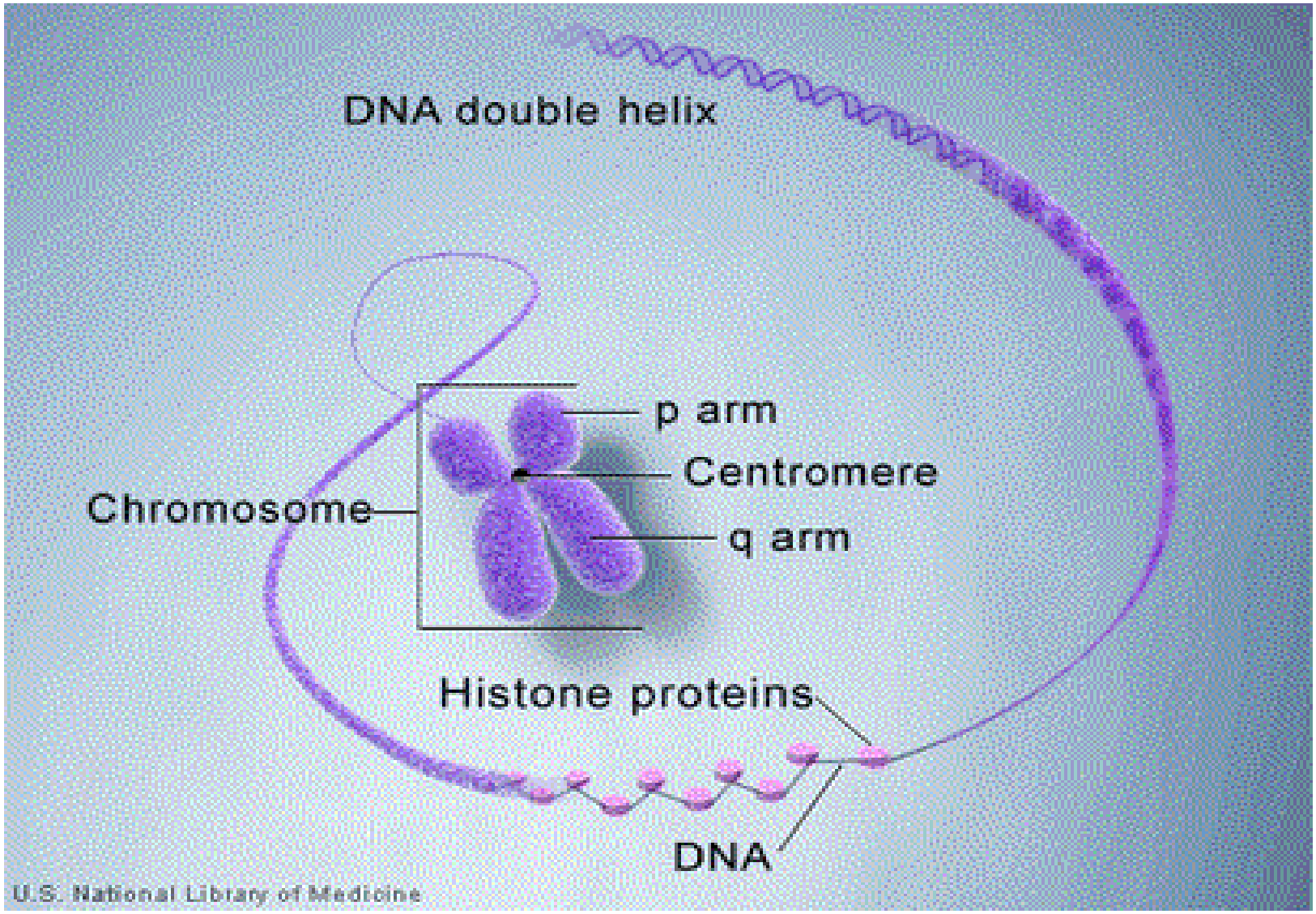


Genes are the basic unit of genetics. Human beings have 20,000 to 25,000 genes. These genes account for only about 3 per cent of our DNA. The function of the remaining 97 per cent is still not clear.

CHROMOSOMES:

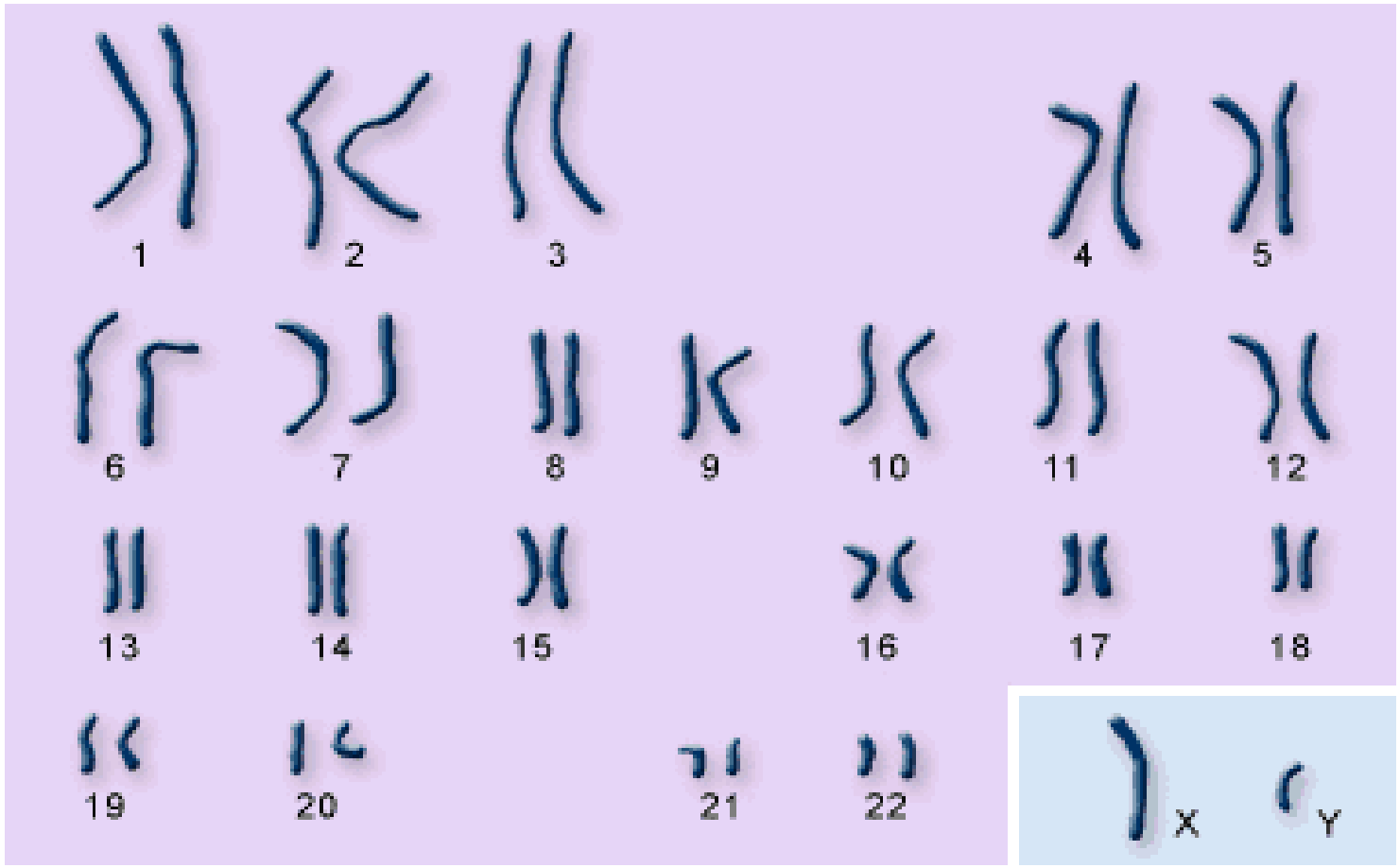
If you took the DNA from all the cells in your body and lined it up, end to end, it would form a strand 6000 million miles long (but very thin). To store this important material, DNA molecules are tightly packed around proteins called histones to make structures called **chromosomes**.

- Humans contain **46** (23 pairs)
  - **44** somatic chromosomes
  - **2** sex chromosomes (X +Y)



THE PACKAGING OF DNA INTO CHROMOSOMES

- Human beings have **23 pairs** of chromosomes in every cell, which makes 46 chromosomes in total. A photograph of a person's chromosomes, arranged according to size, is called a **karyotype**.
- The **sex chromosomes** determine whether you are a boy (XY) or a girl (XX). The other chromosomes are called **autosomes**.
- The largest chromosome, chromosome 1, contains about 8000 genes. The smallest chromosome, chromosome 21, contains about 300 genes. (Chromosome 22 should be the smallest).



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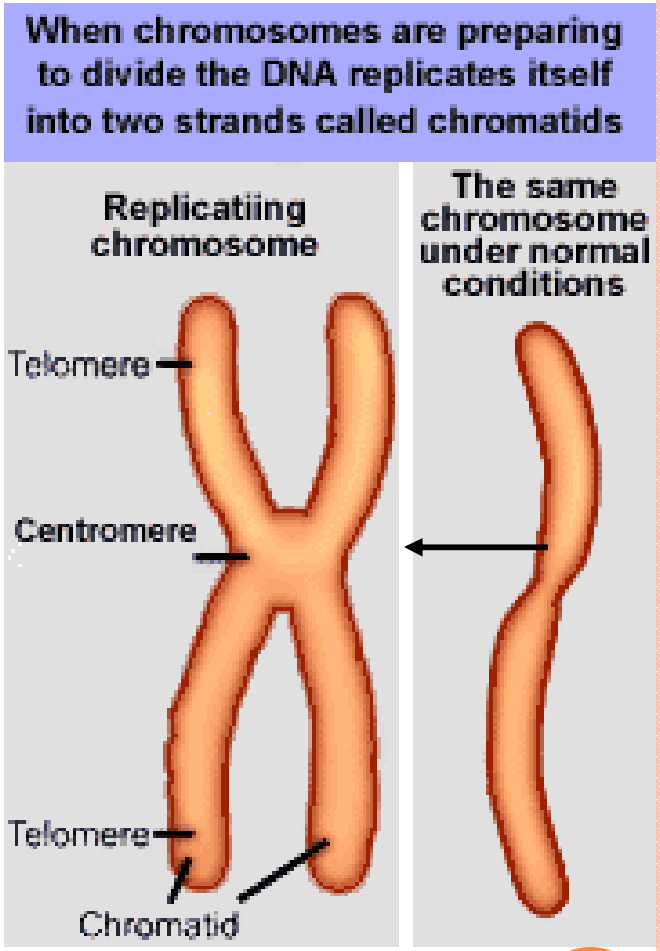
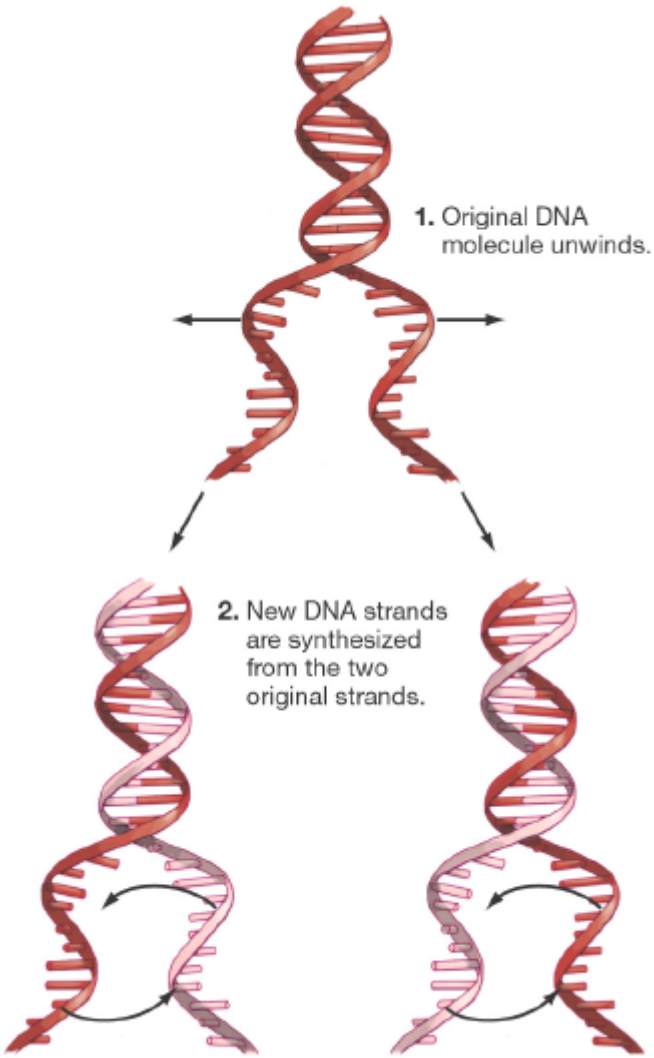
THE KARYOTYPE OF A MALE HUMAN BEING

DNA REPLICATION:

- During the life of the cell, each chromosome of DNA makes a copy of itself
- This must occur prior to cell division to insure each daughter cell gets a complete set





Introduction to immunity

Lec.8

Immunity

1- Introduction.

2- Types of immunity.

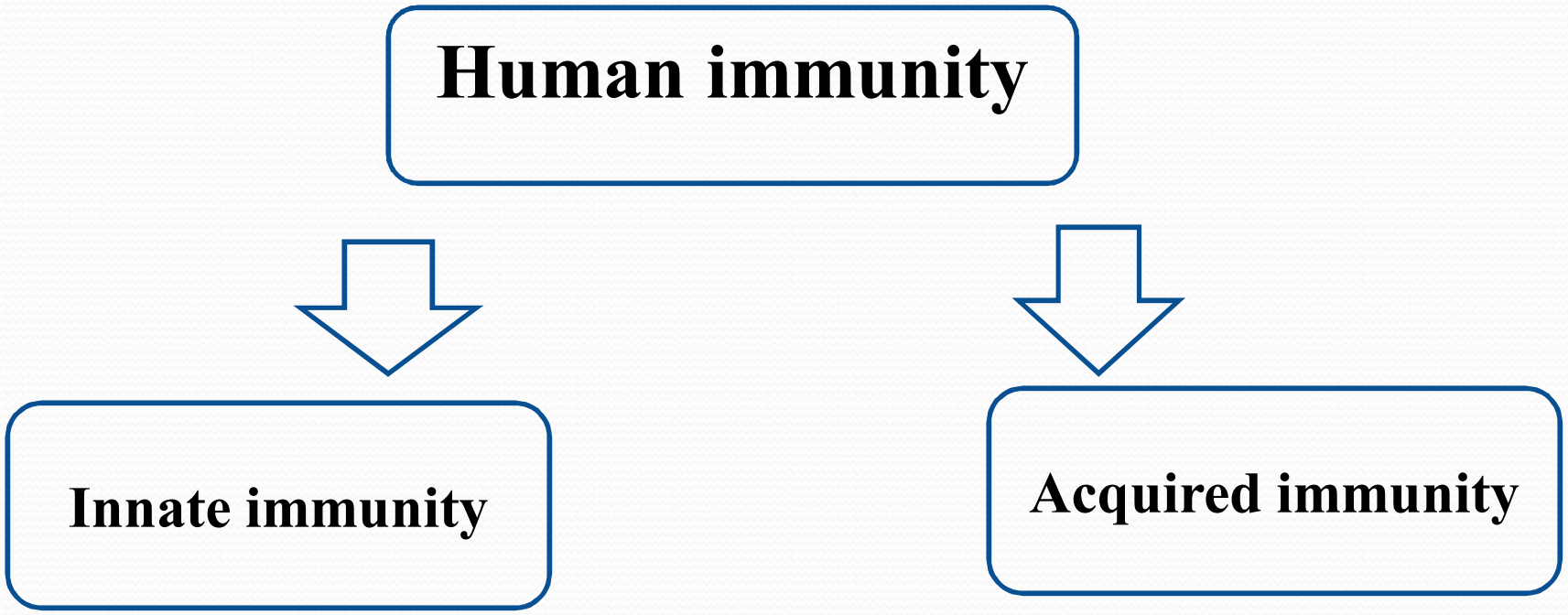
- Innate immunity.

- Acquired immunity.

- Natural immunity.

- Artificial immunity.

- **Immunity:** The term refers to the resistance exhibited by the host towards infection caused by microorganisms and their products(toxins).
- This is based on the property of self and non self recognition. That means immunity is carried out by the process of recognition and disposal of non self or materials that enter the body.
- **Immune response:** is the reaction of the body against any foreign antigen.


Human immunity
Innate immunity
Acquired immunity

Innate immunity:

- It acts as first line of defense against infections, microorganisms and their products before they cause disease.
- It has no relationship with previous bacterial infection and immunization.

- **The various non specific difference mechanisms are present:**

1.Anatomical and physical barriers.

2.Physiological and chemical barriers.

3.Biological barriers.

4.General barriers.

❖The barriers prevent the entry of pathogens to resist infection.

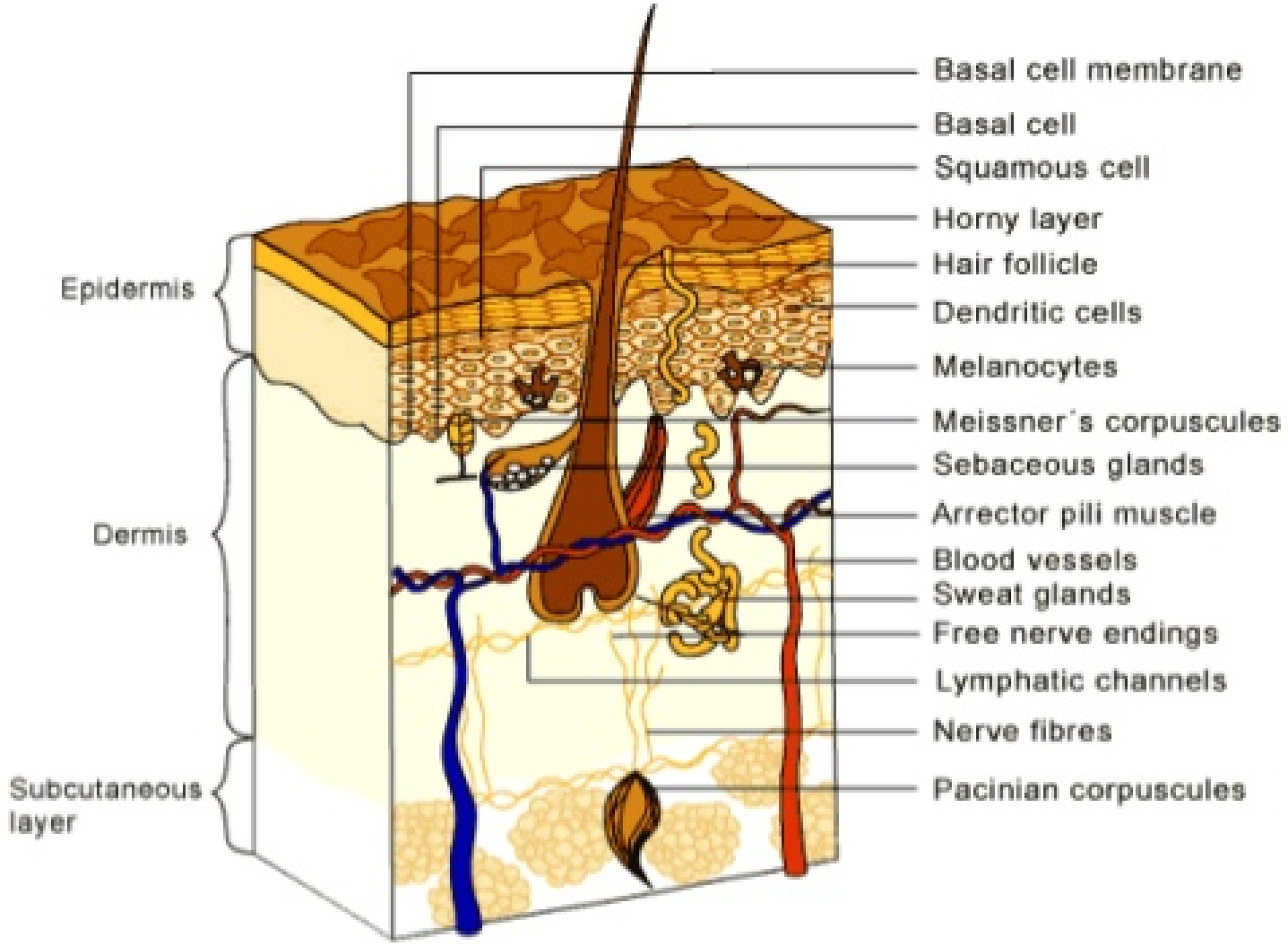
Physiological and chemical barriers:

These include : **skin**, **mucous membrane**, **coughing** and **sneezing**.

- **Mucous membrane**: The respiratory , GIT etc. lined by mucous membrane It blocks the microorganisms because of its sticky nature. **coughing** and **sneezing** the mechanical actions may help in driving out the foreign particles that enter the digestive and respiratory
- Human **milk**: this is very rich in antibacterial substances. IgA, they fight against E.coli and staphylococci.

- **Secretion** of the digestive tract: stomach as microbicidal effect. This is due to the presence of HCl in the gastric juice. This HCl is secreted by oxyntic cell lining stomach.
- **Nasal** secretion and saliva.
- **Interferon**.

skin


Basal cell membrane
Basal cell
Squamous cell
Horny layer
Hair follicle
Dendritic cells
Melanocytes
Meissner´s corpuscules
Sebaceous glands
Arrector pili muscle
Blood vessels
Sweat glands
Free nerve endings
Lymphatic channels
Nerve fibres
Pacinian corpuscules
Epidermis
Dermis
Subcutaneous layer

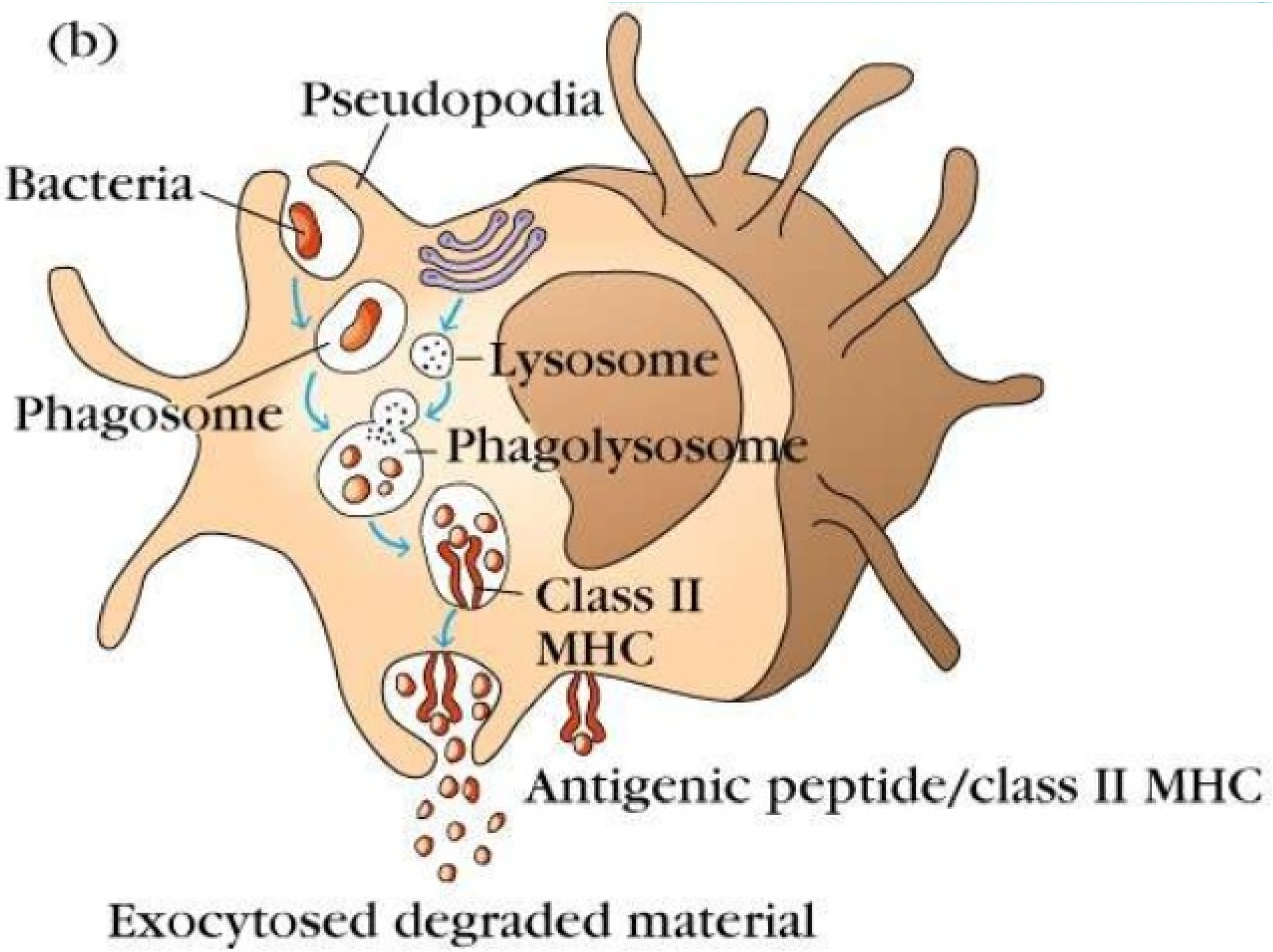
Biological barriers:

- These includes mononuclear phagocytic system which was originally called reticuloendothelial system(RES).
- Biological barriers include **endocytosis**.
- Endocytosis: it is the process in which cells absorb materials from the out side of the environment by engulfing them with their cell membrane.

Types: the absorbing of material from the out side of the environment of cell is commonly divided in to 2 types.

1.Phagocytasis.

2.pinocytosis.


(b)
Pseudopodia
Bacteria
Lysosome
Phagosome
Phagolysosome
Class II
MHC
Antigenic peptide/class II MHC
Exocytosed degraded material

General barriers:

- Age: the very young and very old are most susceptible to infections.

1. Fetus is protected by placental barriers.
2. At old stage people have reduce or loss the host defenses.

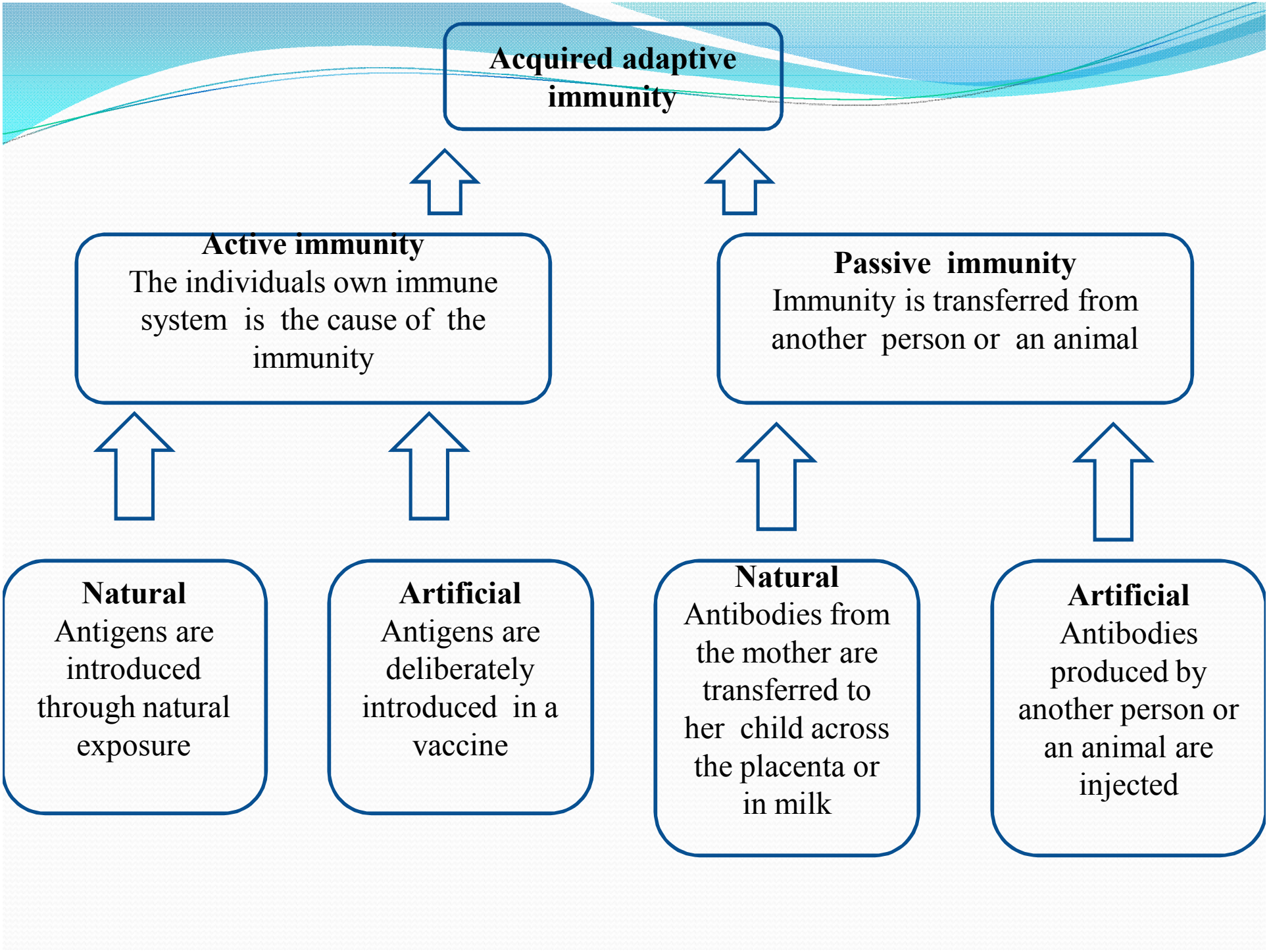
Acquired immunity:

- The acquiring of immunity from out side source is known as acquired immunity.
- It is result of action of 2 major groups of cells. **1.lymphocytes.**

  2.Antigen presenting cells (APC).

This immunity is initiated by the recognition of a foreign antigen and the response to this recognition. It is highly adaptive and has four important features.

1.antigen specificity. **2**.diversity. **3**.immunological memory. **4**.recognition self from non-self.


Acquired adaptive immunity
Active immunity
The individuals own immune system is the cause of the immunity
Passive immunity
Immunity is transferred from another person or an animal
Natural
Antigens are introduced through natural exposure
Artificial
Antigens are deliberately introduced in a vaccine
Natural
Antibodies from the mother are transferred to her child across the placenta or in milk
Artificial
Antibodies produced by another person or an animal are injected

Active immunity:

- It is the production of immunity against particular organisms after exposure.
- **Natural** active immunity: This immunity develops by natural processes like infections. Ex. the infection like small pox are cured by the active function of the immune system.
- **Artificial** active immunity: here instead of natural infections. Infection is created artificially by using various types of vaccines. Ex: polio vaccine, cholera vaccine etc.

Action of lymphocytes and Apc:

- **Lymphocytes**: they poses antigen binding cell surface receptors.
- **Antigen presenting cells**: they have class-2 MHC on their surface and they present antigens to lymphocytes.
- This immune response is of 2 types:

1.humoral immune response (antibodies).

2.cell mediated immune response (T cells).

Passive immunity

- Acquiring of the antibodies passively from an immunized donor to a non-immunized recipient is noun as passive immunity.
- **Natural** passive immunity: it occurs when antibodies are transferred from the donor to the recipient in a natural manner. Ex: Transfer of antibodies from the mother to the fetus through the placenta (IgG Antibodies).
- **Artificial** passive immunity: the transfer antibodies and sensitized lymphocytes from immunized donor to the non-immunized recipient artificially. Ex: antibodies produce in the horse serum and GMOS (genitically modified organisms)

Inflammation

Lecture-13-

Dr. Aseel. I. Ibrahim

Inflammation: is a localized protective response elicited by injury or destruction of tissues.

Or

Is a tissue response to injury. The injury may arise from several causes: mechanical, chemical, heat or cold, or intense radiations.

Inflammation is a common accompaniment of tissue infection by bacteria, fungi, and viruses.

The main symptomes of inflammation:

1- **redness**: is caused by the opening up (dilation) of the blood vessels in the area and thus a greater volume of blood surrounding the injured area.

2- **swelling** (oedema): results from the increased permeability of the capillary walls allowing fluid to escape into the tissue. This is brough about by a chemical called histamin that is released when tissues are damaged.

3- **heat**: is noticeable in the area because of the increased blood volume rising to the surface from inner warmer parts of the body.

4- **pain**: results from a stimulation of nerve endings in the affected area.

W.B.Cs , such as neutrophil enter the inflamed area, move in a amoeboid manner and engulf foreign substances around the affected area, some of which are killed and are found in the pus along with bacteria, tissue cells and living W.B.Cs.

The presence of pus suggests that the body is having some success in destroying the infection.

The type of W.B.Cs that increase in number during an illness tell us the nature of the illness,

Lymphocytes increase during tuberculosis, whooping cough.

Monocytes increase in malaria, and typhoid fever.

Eosinophil increase when we infected with parasites.

Inflammatory response is usually localized and is one of the defenses the body against invaders.

Natural barriers against invasion are: the skin, body secretion, phagocytic cells, inflammatory response and the immune reaction.

Introduction to the Human Biology

Lecture -1-

Dr. Aseel I. Ibrahim

Biology: Scientific Study of Life

Organization of the human body:

i. The chemical organization.
ii. The cellular organization.
iii. The tissue level of organization.
iv. The organ level of organization.
v. The systems level of organization.

Characteristics of Living Things:

1. Living things are highly ordered (or organized).

- Atom: smallest particle into which you may divide an atom and keep
- properties of that atom.
- Molecule: tow or more molecules bonded together.
- Organelle: structures, taken together, make up cells.
- Cell: the simplest entity with all the properties of life.
- Tissue: groups of cells with the same function.
- Organ: group of tissues serving same function.
- Organ System: a group of organs that perform the same function, e.g. the digestive system.
- Organism: species (Example: Humans).
- Population: a group of individuals of the same species in a given area.
- Community: all the populations in a given area.
- Ecosystem : the community plus the nonliving components such as air, water, energy, soil, etc.
- Biosphere: all life on earth.

Characteristics of Living Things:

2. Metabolism - living things must gather and use energy to maintain order.
3. Motility - self propelled motion
4. Responsiveness (sensitivity) - response to their environment. (e.g. detect cold, heat, food, water, etc).

Characteristics of Living Things:

5. Reproduction suite of mechanisms by which they give rise to new organisms.
6. Development - changes from conception to sexual maturity (and even to death).
7. Genes - units of inheritance composed of DNA.
8. Living things evolve - change over time.
9. Adaptiveness - over time genetic modifications that allow organisms to cope with their environment .

Evolution by Natural Selection:

- differential survival and reproduction of organisms in a population with different phenotypes resulting from interactions of the organism and its environment.
  - Phenotype - physical, chemical, or behavioral traits of an organism.
  - Genotype - is an expression of an genetic organisms genotype (its genetic make-up).

Cavities of the human body:

A. Cranial cavity ----- contains the brain.
B. Vertebral cavity ----- contains the spinal cored.
C. Pleural (thoracic) cavity ----contains the lungs.
D. Pericardial cavity-----contains the heart.
E. Abdominal cavity-----contains the stomach, spleen, liver, gall bladder, pancreas, small & large intestines, kidneys and ureters.
F. Pelvic cavity----contains the urinary bldder, colon, rectum and female reproductive organs.

Chemistry of Life:

Chemistry is the study of how matter interacts, thus we need to understand some of the basic rules and ideas about matter to understand how living things work.

Element - is the most basic form of matter from which all things are formed, and it is a substance that cannot be separated into simpler substances by chemical means.

92 occur naturally

13 made by humans

Atoms- small particles that make up elements (central nucleus surrounding shells of energy (nuclear shells).

Compound - combination of two or more elements.

I. Gases.

II. Liquids.

III. Solids.

Life Elements:

Typical living thing composed (99.9% wt) of six elements:

C, H, N, O, P, and S.

Seventeen other elements occur in minute quantities or as traces.

Elements are composed of identical particles are called atoms.
Atoms - smallest particle into which an element can be divided and still have the properties of that element. Main particles that go to make up the atom, and which under normal circumstances do not split-of , are:

I. Protons.
II. Neutrons.
III. Electrons.

Molecule – is two or more atoms joined together by molecular bonds. (grouping of atoms in compounds).

Atom Organization

Atoms are made up of smaller (or subatomic) particles and the three most important are:

Sub-atomic particle	charge	Wt. (amu)	location
proton	+	1	Nucleus
neutron	none	1	Nucleus
electron	-	0	Orbit nucleus

Atomic Variants

1. **Isotopes** – are atoms of the same chemical elements that have different atomic weight. (differ in the number of neutrons in the nucleus, thus changing wt. of element). Ex. Carbon-14.

Radioactive isotopes are unstable, and give off radiation.

2. **Ions** - number of electrons differs from the number of protons, thus giving element net negative or a net positive.

Organic Molecules of cells:

1. Proteins
2. Carbohydrates
3. Lipids
4. Nucleic Acids

Functions of Proteins:

1. Structural proteins - form cell parts, collagen, elastin, keratin, etc.
2. Regulatory proteins - control cell processes, bind to DNA to switch genes on or off .
3. Enzymes - facilitate (help) many chemical reactions; they do this by lowering the amount of energy needed to start the reaction; the enzyme is not permanently altered in the process. catalyzes covalent bond breakage or formation.
4. Hormones - chemical messengers.
5. Transport proteins - carry other substances around cells or from cell to cell.
6. Receptors – hormone and neurotransmitter receptors .
7. Storage – ovalbumin, casein, etc.

Carbohydrates

- Most abundant types organic molecules.
- Function: energy sources & structural components.
- monomers of carbohydrates = isomers of $C_6H_{12}O_6$

Major Categories Carbohydrates

1. Monosaccharides (glucose, fructose, pentose).
2. Disaccharides (maltose, sucrose).
3. Polysaccharides (starch).

Lipids:

- Neutral compounds contain C, H, and O that are not soluble in water.
- Solid at room temperature whereas oils are liquid.
- Made up of glycerol and fatty acids.
- Hydrophobic molecules.
- Function: energy storage, waterproof coatings, chemical messengers.
- Three categories of lipids:
  - Triglycerides (saturated & unsaturated fats)
  - Waxes
  - Phospholipids
  - Steroids

Nucleic Acids

Nucleic Acids - Large macromolecules.

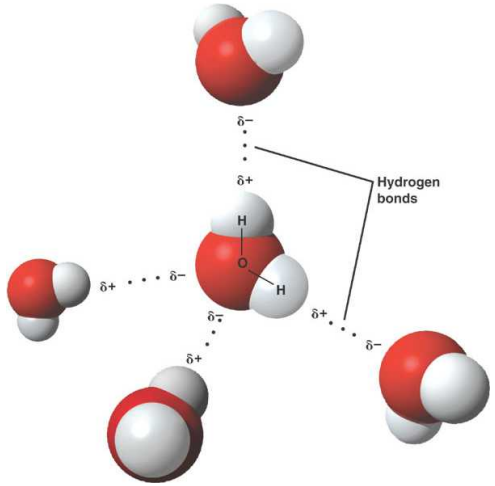
- carry coded genetic information (genes) necessary for making new cells in inheritance.
- Polymers of nucleotides (monomer)
- Two main types:
  - Deoxyribonucleic acid (DNA)
    - Double helix of anti-parallel nucleotide chains
  - Ribonucleic acid (RNA)
    - Single nucleotide chain

Water Molecule:

- Polarity of H_2O allows H bonding.
- Water disassociates into H^+ and OH^-
- Imbalance of H^+ and OH^- give rise to "acids and bases", Measured by the pH.

Acid is a substance that gives off hydrogen ions when dissolved in water.

Base is a substance that accepts hydrogen ions. (thereby increasing the hydroxide ions).



- pH influence charges of amino acid groups on protein, causing a specific activity
- Buffering systems maintain intracellular and extracellular pH.

PH Scale : 0_____7_____14

Acids Neutral Bases

Highest H^+ conc. Lowest H^+ conc.

- Hydrophobic “Water-fearing”
  - Molecule is not polar, cannot form H bonds and is “repelled” from water
  - Insoluble
- Hydrophillic “Water-loving”
  - Molecule is polar, forms H bonds with water
  - Soluble

Lymph and lymphatic system

Lecture-14-

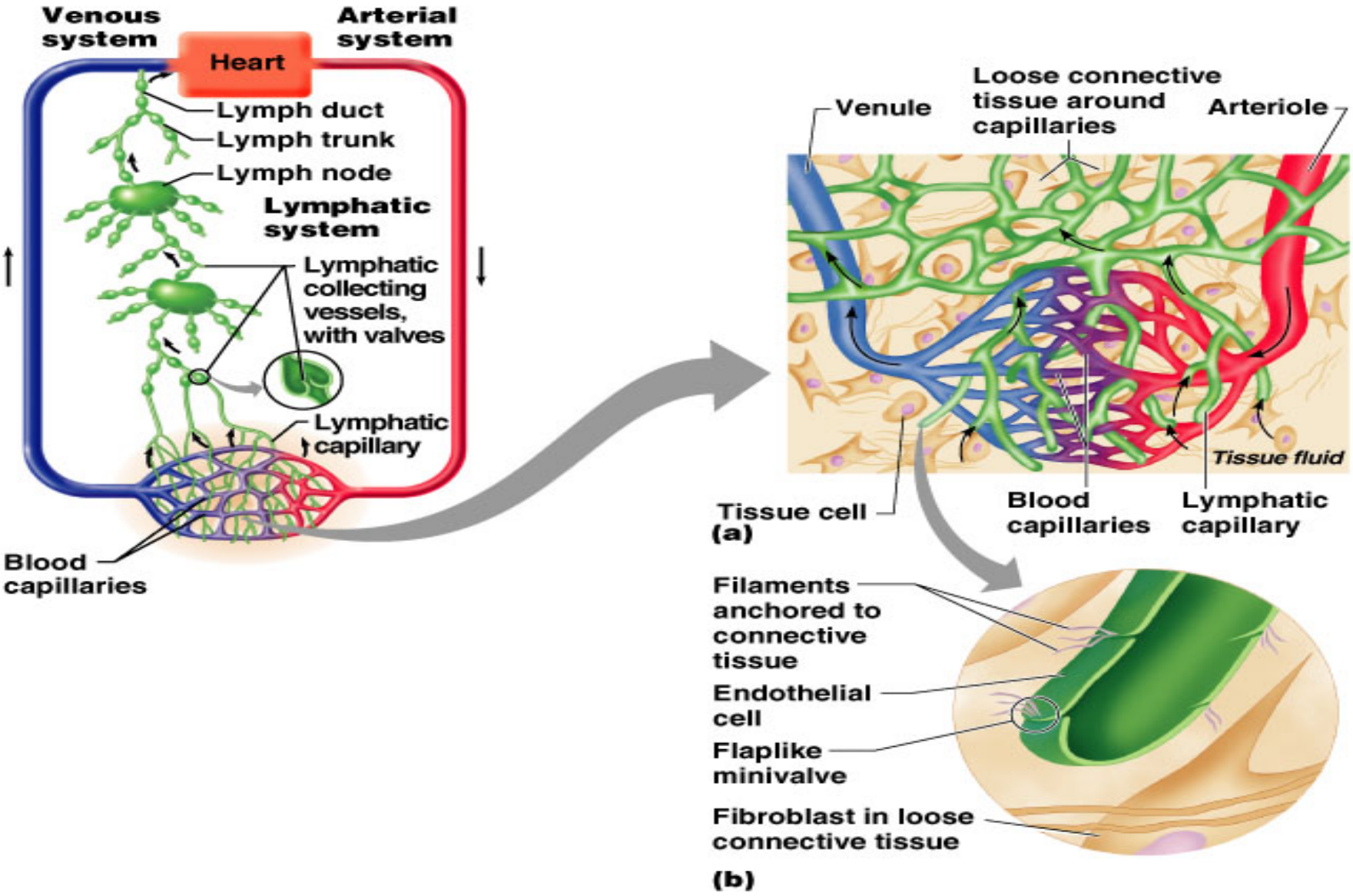
Dr. Aseel I. Ibrahim

Lymph: Tissue fluid (interstitial fluid) that enters the lymphatic vessels.

A network of vessels that collect fluid that has escaped into the tissues from capillaries of the circulatory system.

- Lymph: clear fluid composed mainly of water, electrolytes and some plasma proteins.
- Transported in lymphatic pathway from lymphatic vessels to collecting ducts and end disposed into venous blood.
- When blood circulates in high pressure, the fluid (plasma) portion seeps through thin capillary walls into surrounding tissue.
- This interstitial fluid bathes the cells and is returned to blood through walls of venules.
- The remainder enters a network of thin walled tubes called lymphatic vessels and now is called lymph.

FORMATION AND TRANSPORT OF TISSUE FLUID



Functions of the Lymphatic System:

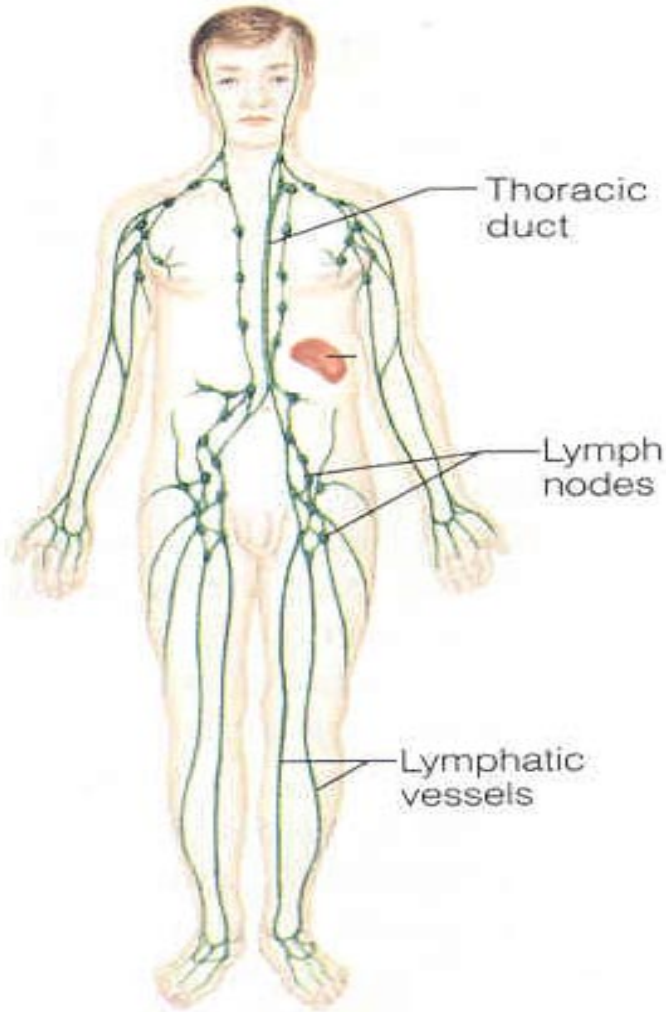
1. **Reabsorbs excess interstitial fluid:**
    1. returns it to the venous blood.
    2. maintain blood volume levels
    3. prevent interstitial fluid levels from rising out of control.

2. **Transport dietary lipids:**
    1. transported through lacteals
    2. drain into larger lymphatic vessels
    3. eventually into the bloodstream.

3. **lymphocyte development, and the immune response .**

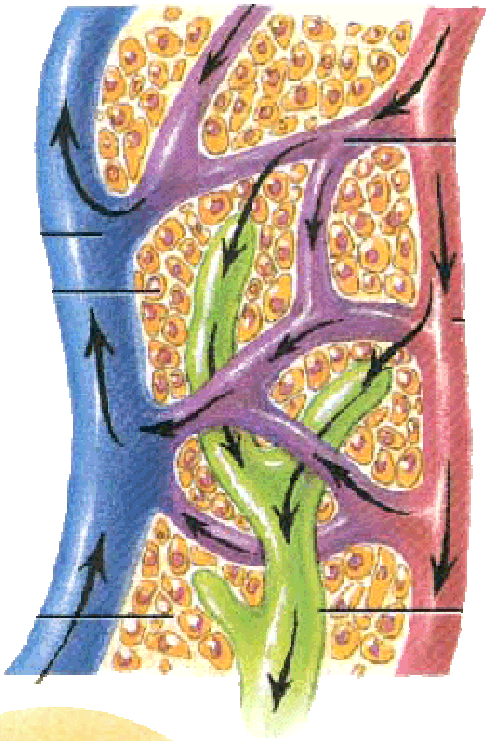
Components of the Lymphatic System:

- **Lymph.**
- **Lymphatic Vessels:**
  - Lymphatic Capillaries.
  - Lymphatic Vessels.
  - Lymphatic Trunks.
  - Lymphatic Ducts.
- **Lymphatic Organs:**
  - Thymus.
  - Lymph Nodes.
  - Spleen.
  - Tonsils.
- **Lymphatic cells**



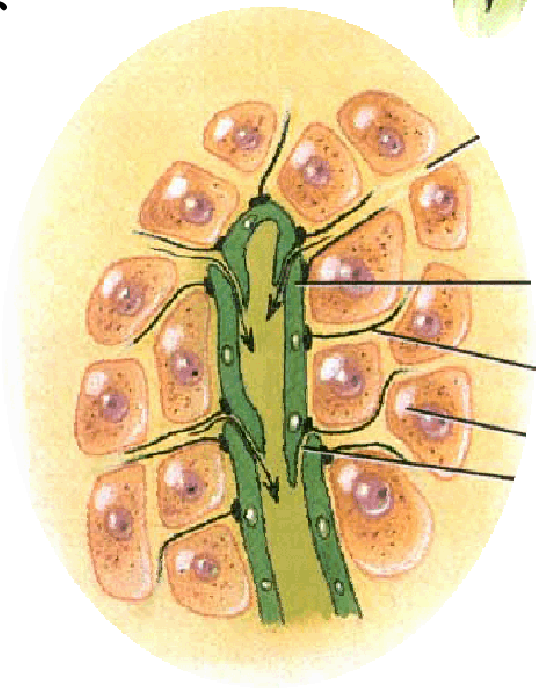
Lymphatic system

Lymphatic Capillaries:



Features of structure :

- Blind end.
- Single layer of overlapping endothelial cells.
- More permeable than that of blood capillary.
- Absent from avascular structures, brain, spinal cord splenic pulp and bone marrow.



Lymphatic Capillaries – Lacteals

The small intestine contains special types of lymphatic capillaries called lacteals .

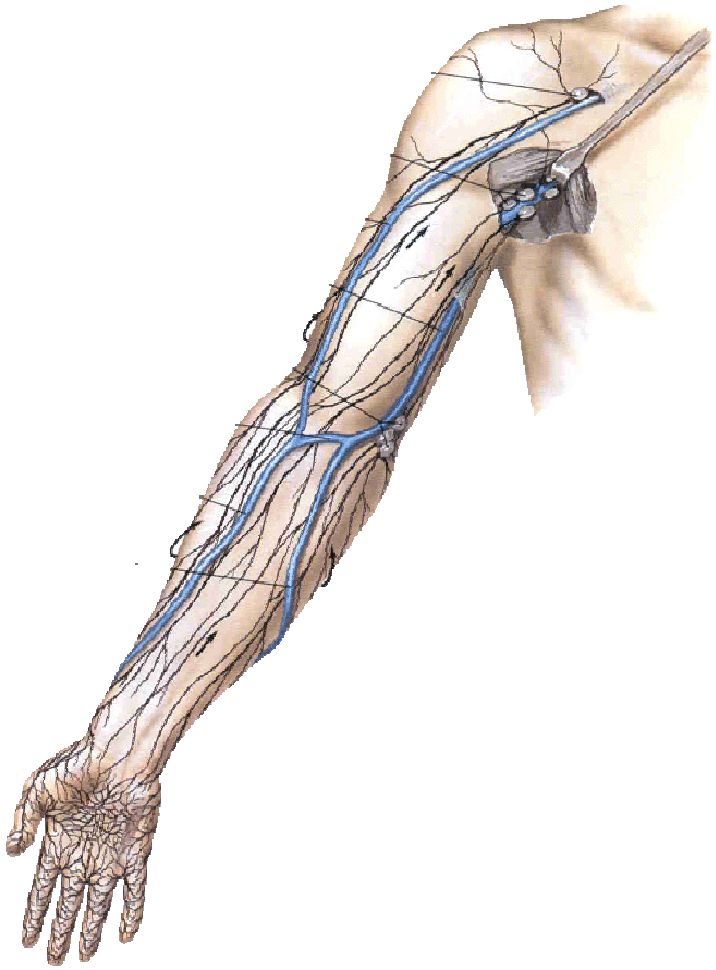
Lacteals pick up not only interstitial fluid, but also dietary lipids and lipid-soluble vitamins .

The lymph of this area has a milky color due to the lipid and is also called chyle.

Lymphatic Vessels:

Features of structure:

1. Three layered wall but thinner than vein.
2. More numerous valves than in vein
3. Interposed by lymph nodes at intervals
4. Arranged in superficial and deep sets



Lymphatic Cells:

Also called lymphoid cells .

Located in both the lymphatic system and the cardiovascular system .

Work together to elicit an immune response .

Types of lymphatic cells are :

- macrophages
- epithelial cells
- dendritic cells
- lymphocytes

LYMPHATIC ORGANS

Primary organs

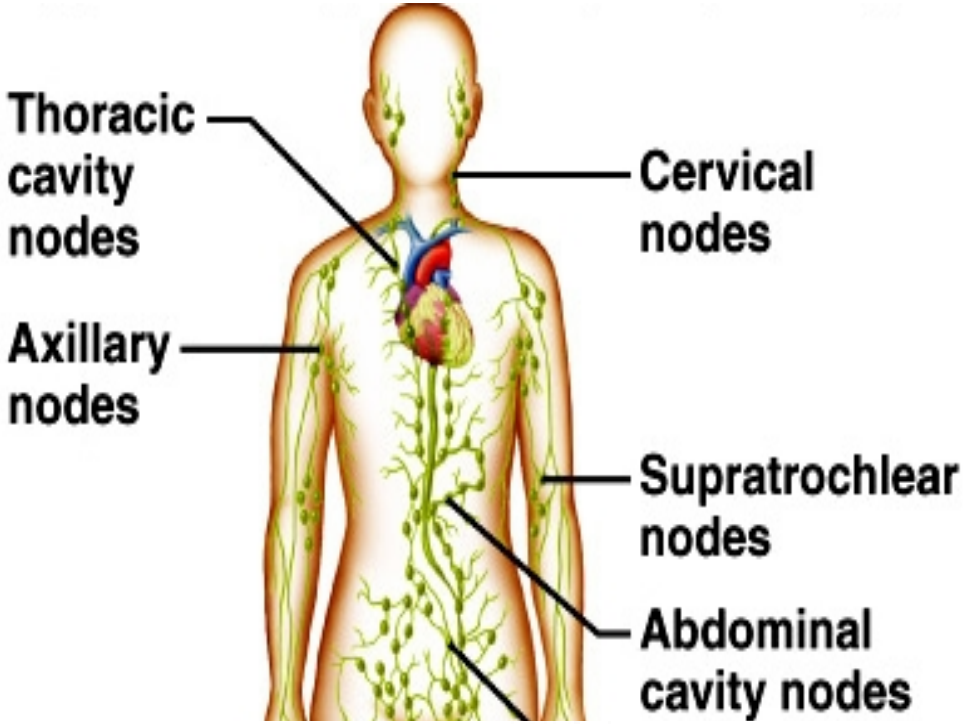
- Red bone marrow
- Thymus gland

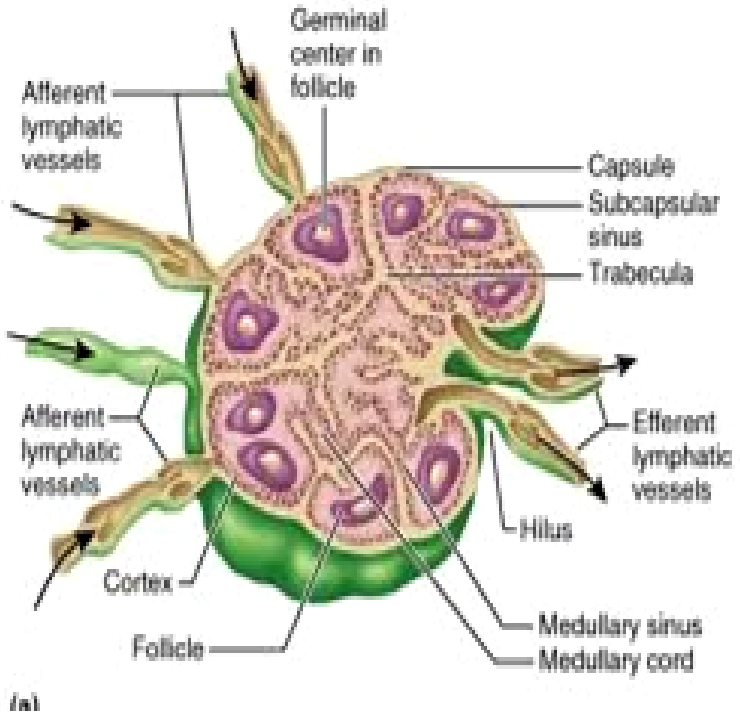
Secondary organs

- Lymph nodes
- Lymph nodules
- Spleen

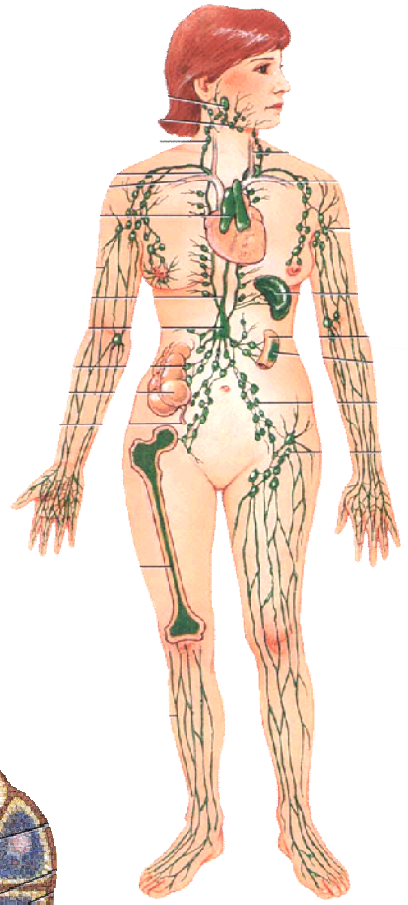
Lymph Nodes

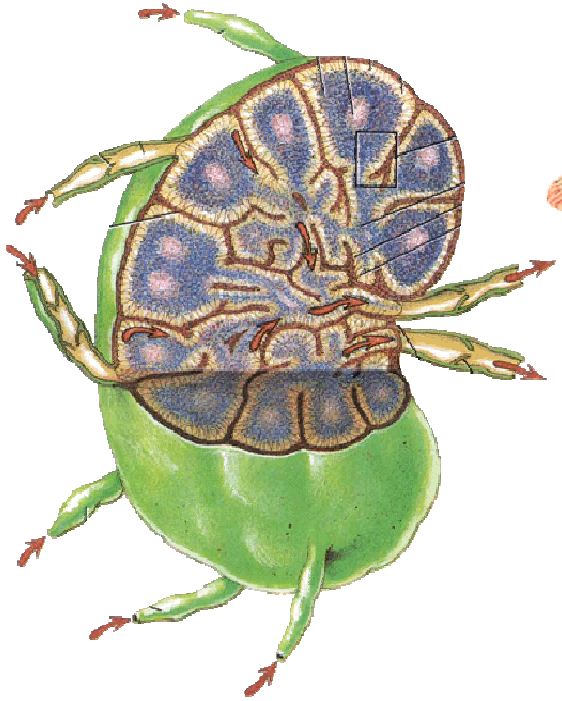
- Small, round or oval
- located along the pathways of lymph vessels .
- Typically found in clusters
- receive lymph from many body regions .
- Lymph nodes are also found individually throughout the body tissues .



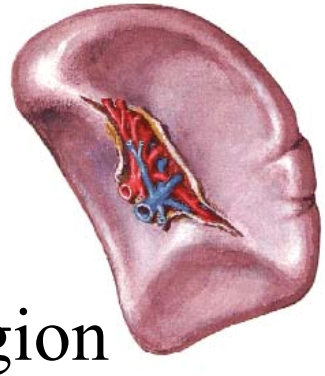


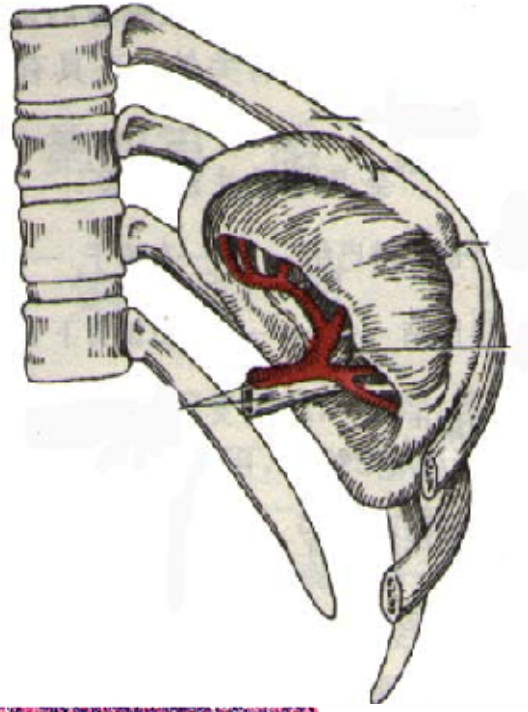
- Bean-shaped bodies
- With afferent vessels (entering at the periphery) and efferent lymph vessels(emerging at the hilus)
- Arranged in groups, along the blood vessels or the flexural side of the joint
- Divided into superficial and deep groups



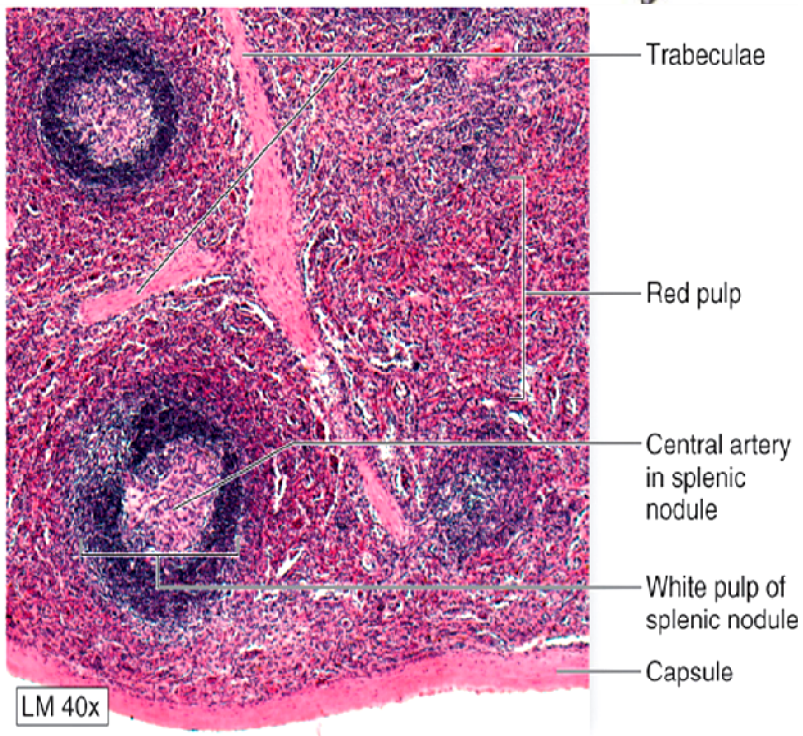


Spleen





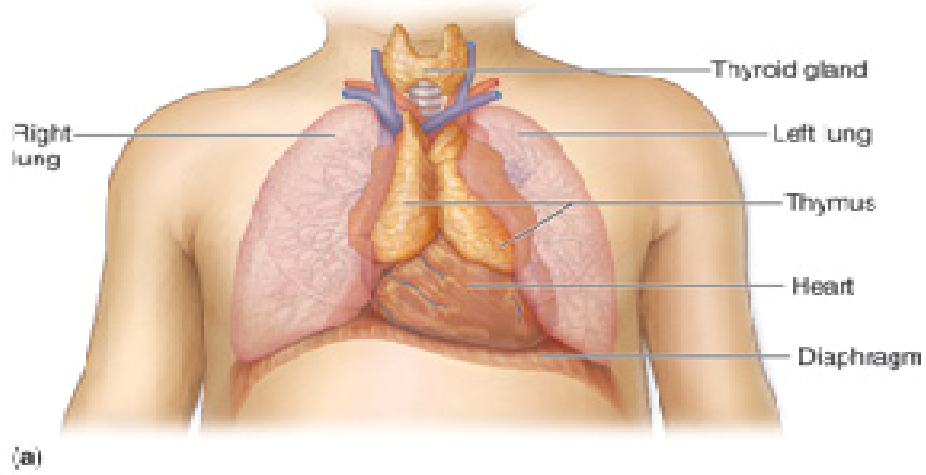
- Location
  - Left epigastric region
- Largest lymphatic organ in the body .
- Can vary considerably in size and weight

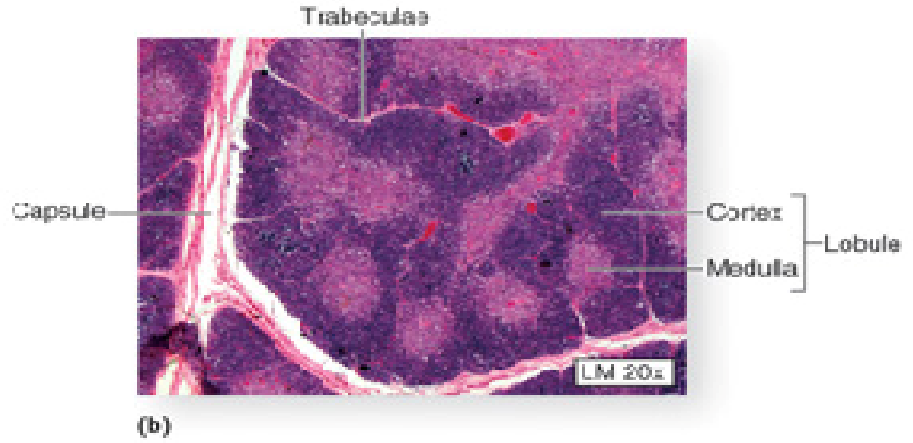


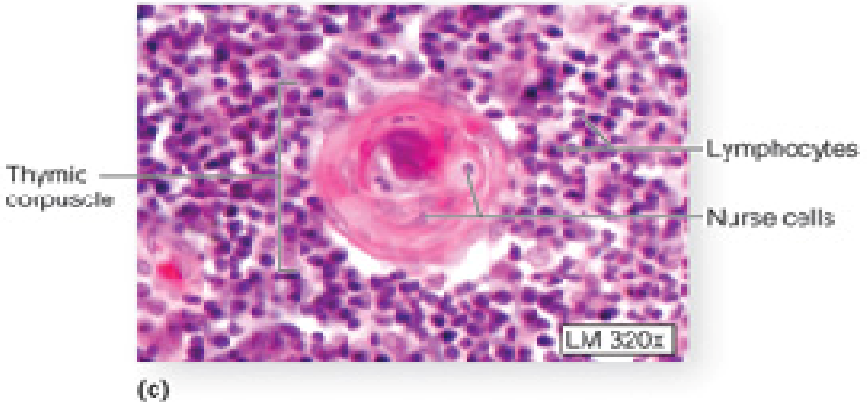
- Function

THYMUS

- Consists of two elongated lobes
- Is a large organ in the fetus
- Occupies the thoracic cavity behind the sternum
- Secrete lymphopoietin







Lymphatic Nodules

- Oval clusters of lymphatic cells with some extracellular matrix that are not surrounded by a connective tissue capsule.
- Filter and attack antigens .
- In some areas of the body, many lymphatic nodules group together to form larger structures.
  - mucosa-associated lymphatic tissue (MALT) or tonsils
  - very prominent in the mucosa of the small intestine, primarily in the ileum
    - Peyer patches
  - also present in the appendix

Tonsils

- clusters of lymphatic cells and extracellular matrix not completely surrounded by a connective tissue capsule.
- Consist of multiple germinal centers and crypts

- Several groups of tonsils form a protective ring around the pharynx .
  - pharyngeal tonsils (or adenoids) in nasopharynx
  - palatine tonsils in oral cavity
  - lingual tonsils along posterior one-third of the tongue

- Reabsorbed by lymphatic capillaries in all body tissues where excessive tissue fluids occur.
- Because of lack of pumping organ, lymph movement is largely dependent on skeletal muscle activity.
- Movement normally constant and smooth, except when obstruction (small clot, tumor) occurs which tend to back up the lymph, and result in edema (fluid accumulation in tissues).

Metabolism

Lecture.10

Dr.Aseel I. Ibrahim

Metabolism: Sum of all the chemical reactions occurring within the body. These chains of chemical reactions that take place within the cell are described as **metabolic pathway.**

Types of Metabolic Reactions:

Anabolic reactions: is the synthesis of chemicals in which smaller molecules are linked together to form large molecules (enzymes, energy).

Catabolic reactions: is the brake down of chemicals with the release of energy that generate ATP, digestion, enzymes used in digestion (extracellular enzymes), absorbed of nutrients into cells they are acted on by intracellular enzymes that only function within the cell.

1. Cellular respiration.
2. Conversion of ADP to ATP.
3. Break down of ATP to released energy.

Enzymes - globular proteins that act as catalysts

Increase reaction rates

Holoenzyme - a two-part enzyme consisting of a protein part and an organic cofactor

Apoenzyme - the protein portion

Coenzyme - the organic cofactor; usually a vitamin

Energy Production:

Oxidation reactions: loss of an electron by an atom or molecule.

Reduction reactions: involves the gain of electrons by a molecule.

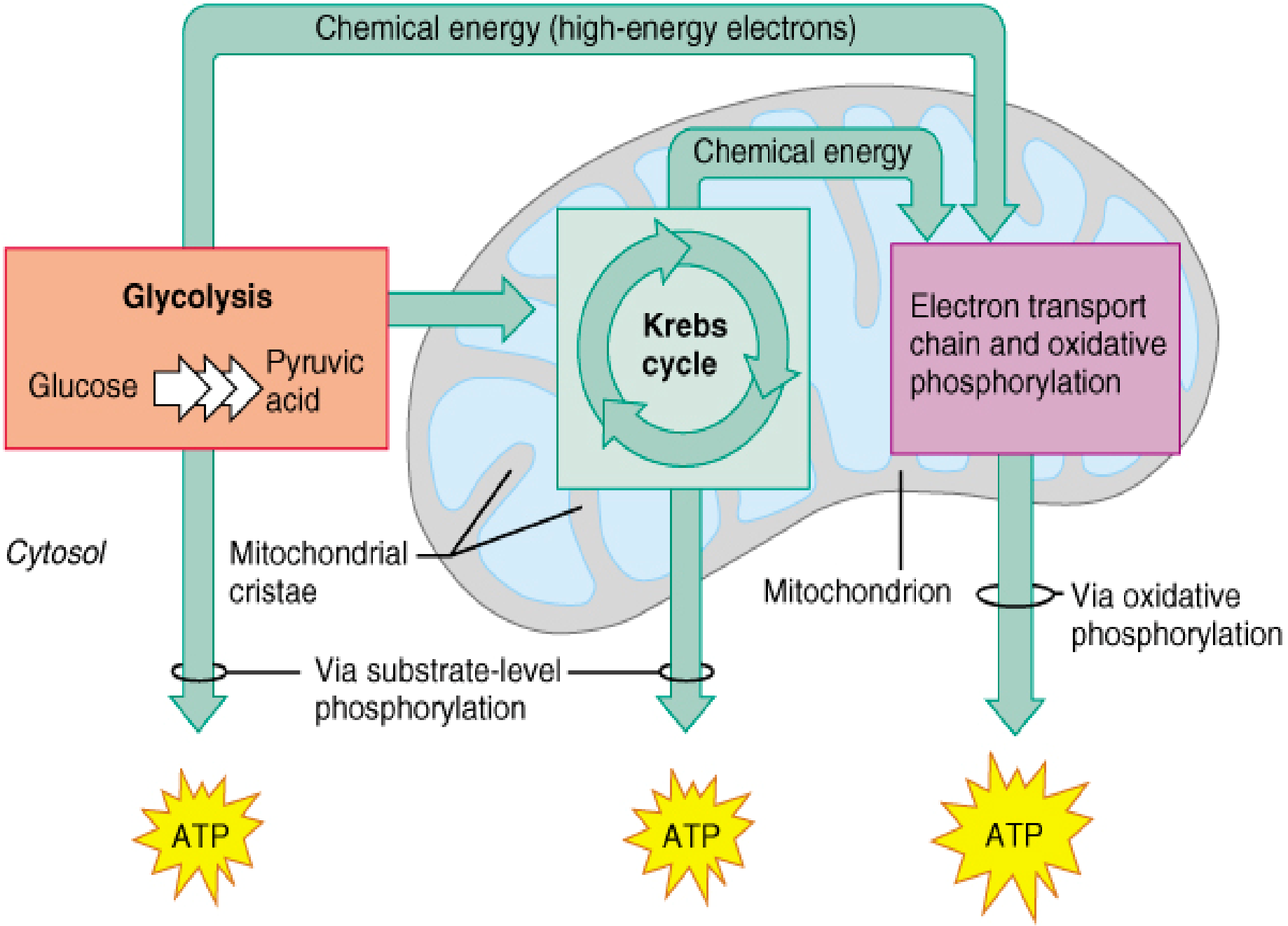
Coupled redox reactions

Cellular Respiration: is the breakdown of absorbed nutrient by oxidation.

Oxidation of Glucose

Glucose Metabolism:

Glycolysis
Acetyl Coenzyme A
Krebs Cycle
Electron Transport Chain



Glycolysis:

- Glucose molecules are broken down into two molecules of pyruvic acid in the cytoplasm of the cell
- Net gain of 2 molecules of ATP
- No oxygen required
- Fate of pyruvic acid depends on the oxygen availability

Acetyl CoA Formation:

Pyruvic acid is decarboxylated by the removal of CO_2 into a two carbon acetyl group. Occurs in the mitochondria of the cell

Krebs Cycle - TCA Cycle:

- Aerobic process (uses O2).
- Takes place in the mitochondria.
- The pyruvic acid produced in glycolysis is acted on by wide range of respiratory enzymes located within the mitochondria.
- Formation of citric acid when oxaloacetic acid combines with acetyl CoA.
- The result is carbon dioxide and water are given off and 38 ATP molecules produced.
- Overall energy supplied in the form of ATP is 38 molecules, of which 95% are produced in the Krebs cycle.

Electron Transport:

Involves electron carrier molecules that will release energy in a controlled way

This energy is used to generate ATP

Occurs inner mitochondrial membrane

Chemiosmosis

Glucose Anabolism:

Glycogenesis: is the synthesis of the insoluble storage compound glycogen from glucose; stimulated by insulin

Glycogenolysis - hydrolysis of glycogen to form glucose; stimulated by glucagon

Gluconeogenesis: is the conversion of protiens and fats to glucose; this happens during shortage of glucose or are starving.

Lipid Catabolism: Lipolysis:

- Hydrolysis of triglycerides into glycerol and fatty acids.
- Glycerol converted to G 3-P and then into pyruvic acid, then into the Kreb's cycle.
- Beta -oxidation of fatty acids occurs forming two-carbon fragments which is then attached to coenzyme A, forming acetyl CoA .

Lipid anabolism: lipogenesis:

- Is the synthesis of fats from fatty acids and glycerol, from amino acids or from glucose.

Protein Metabolism:

- Proteins are converted into substances than can enter the Kreb's cycle by

  deamination - loss of (NH_2) from amino group, which is converted first to NH_3 (ammonia) and then to urea for excretion in the urine.

  decarboxylation - loss of CO_2 molecule

  dehydrogenation - loss of hydrogen atom

Protein synthesis involves transcription and translation

Free Radicals:

charged molecules that become oxidized by combining with oxygen or the removal of hydrogen, causing electron deficiency.

seek to regain the electron by removing it from other molecules, thus oxidizing them.

set up a chain reaction that may damage cell structures such as DNA, cell membranes, or needed enzymes.

- Free radicals may be produced by normal metabolic processes, the immune system in response to disease, exposure to chemicals, toxins, or radiation. Free radical generation may be increased by exercise and stress.

- Damage caused by free radical generation is a major cause of the degenerative effects of aging, may cause cancers, damage to arterial walls leading to heart disease and/or stroke, and lead to other degenerative diseases such as Alzheimer's.

Cell division

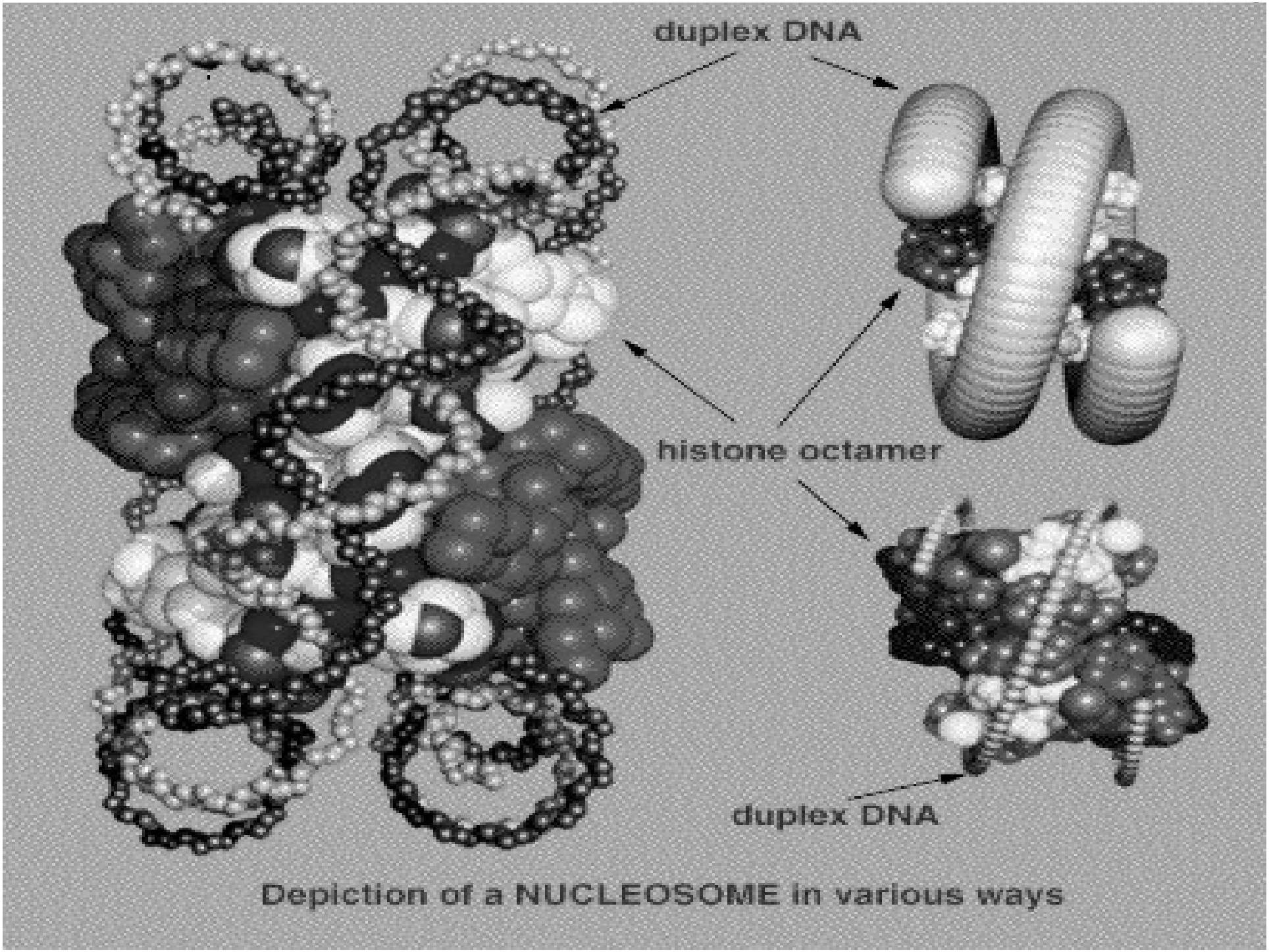
Mitosis and Meiosis

lecture-4-

Chromatin structure:

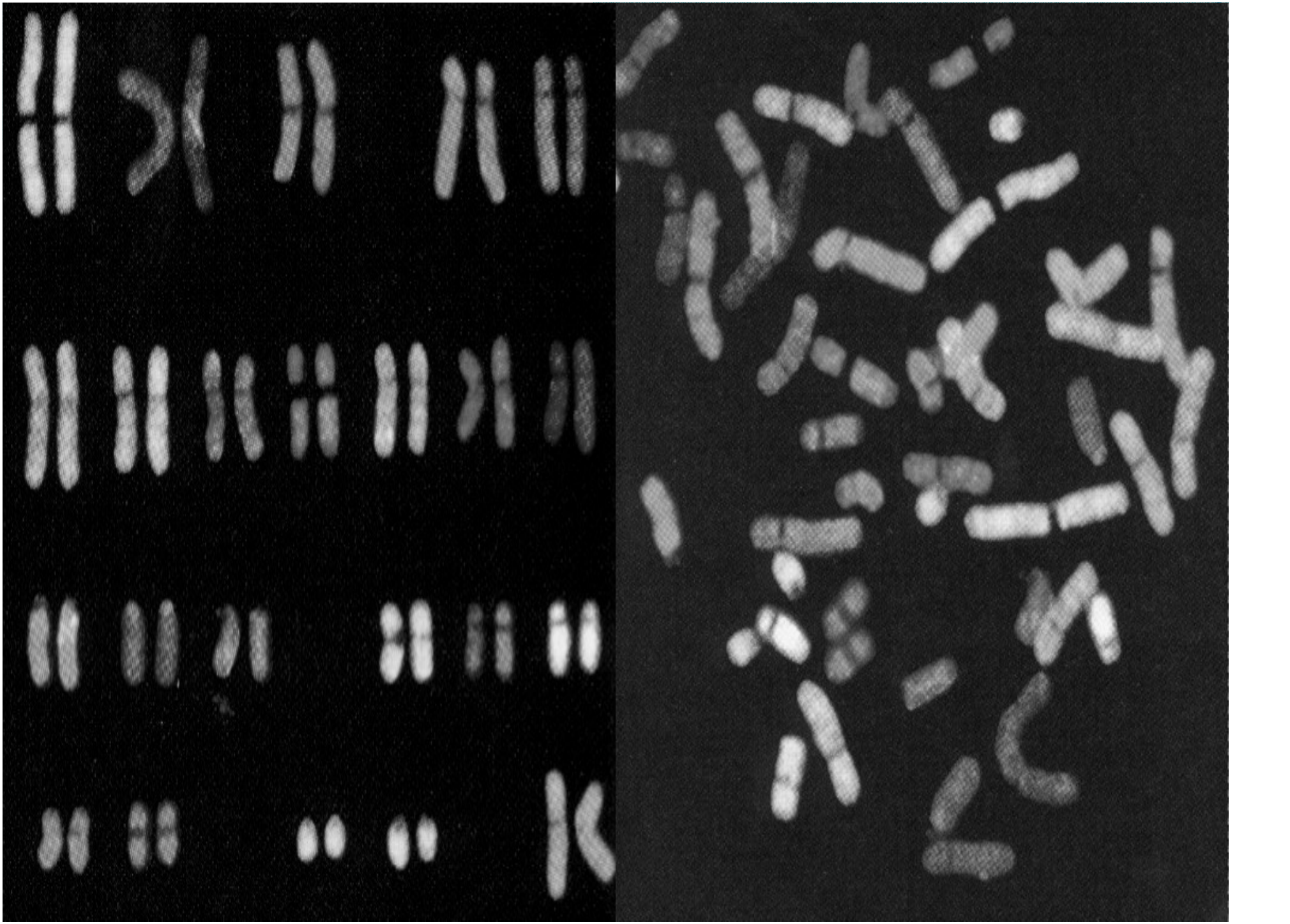
Each chromosome within the nucleus consists of a single molecule of DNA which is complexed with an equal mass of proteins- chromatin is the DNA: protein complement of the nucleus.

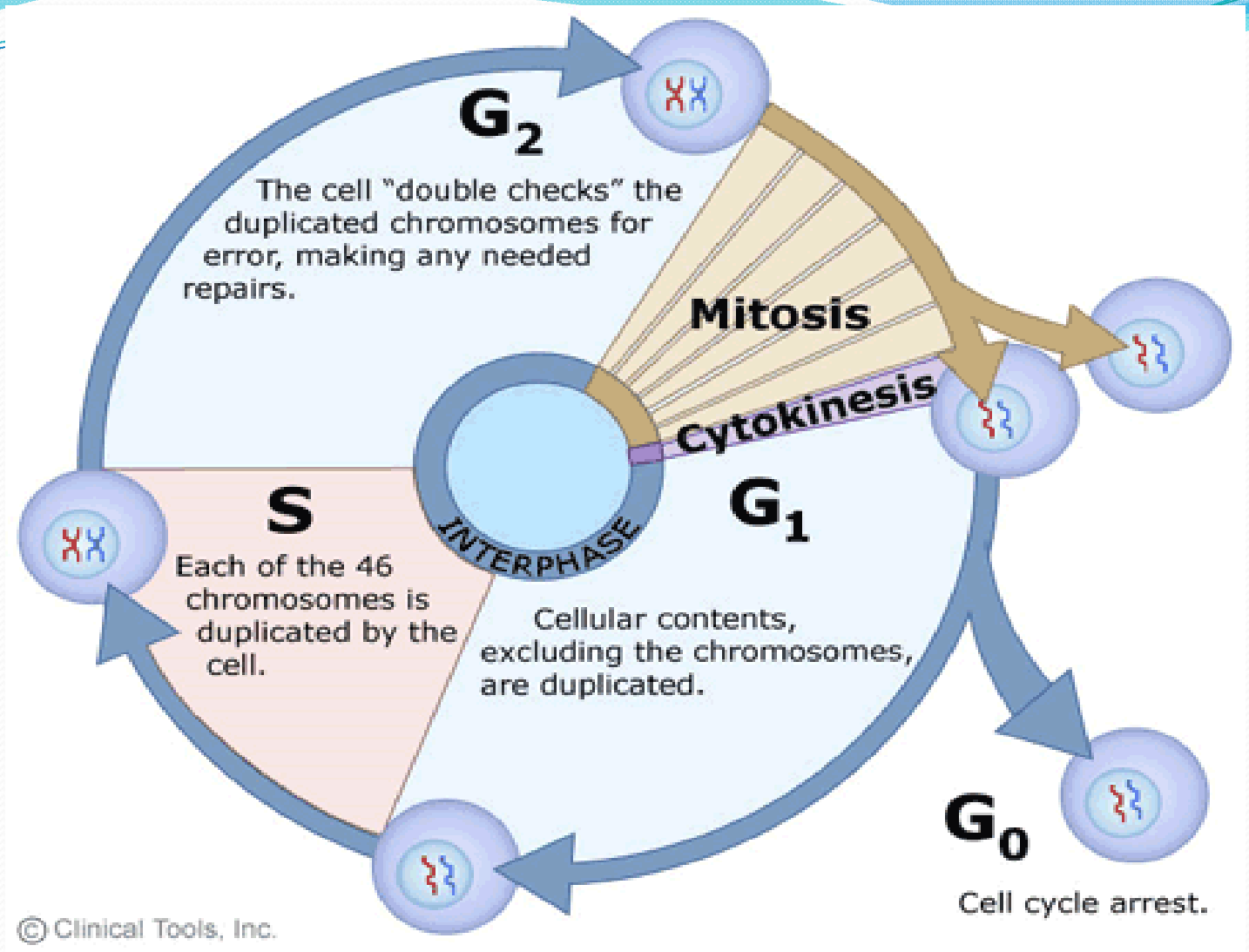
The majority of proteins complexed with DNA are histones. Histones are basic protein.



Depiction of a NUCLEOSOME in various ways

- **The Cell Division Cycle:**
  - Almost **90%** of the cycle is taken up with **Interphase.**
  - during which DNA in the nucleus is replicated.
  - **Mitosis** and **cytokinesis** only take up 10% of the cycle.
  - **Trillions of cells in human body.**
  - At least 5 trillion cell divisions required from fertilised egg___ adult human.
  - Copy of 3 x 10^9 bases of DNA required for each daughter cell ___each copy must be accurate.
  - Mistakes can lead to disease.
  - Replication machinery enormous
  - approx. 200 proteins involved in replicating the genome.





The cell cycle

- **G1 phase**. The cell grows.

  S phase. The cell makes copies of its chromosomes. Each chromosome now consists of two sister **chromatids**.

  G2 phase. The cell checks the duplicated chromosomes and gets ready to divide.

  M phase. The cell separates the copied chromosomes to form two full sets (mitosis) and the cell divides into two new cells (cytokinesis).

  The period between cell divisions is known as 'interphase'.

  Cells that are not dividing leave the cell cycle and stay in G0.

Mitosis and Meiosis:

- Cells divide into two different ways to make new cells.
- **Mitosis:**

  -division of **somatic** (body) cells.

- **Meiosis:**

  -division of gametes (sex cells (egg & sperm)).

Mitosis:

- Mitosis is used to produce daughter cells that are genetically identical to the parent cells.
- The cell copies - or 'replicates' - its chromosomes, and then splits the copied chromosomes equally to make sure that each daughter cell has a full set.
- A multicellular organism grows by repeated cell divisions.
- These occur using the process of **mitosis**.
- Each cell receives an **identical set of chromosomes**.
- Almost any change in chromosome number is **lethal**.
- There are a few exceptions, one is Down's syndrome where individuals have an extra **chromosome 21**.
- In humans, each cell contains **23 pairs** of chromosomes **23 paternal** chromosomes

  23 maternal chromosomes

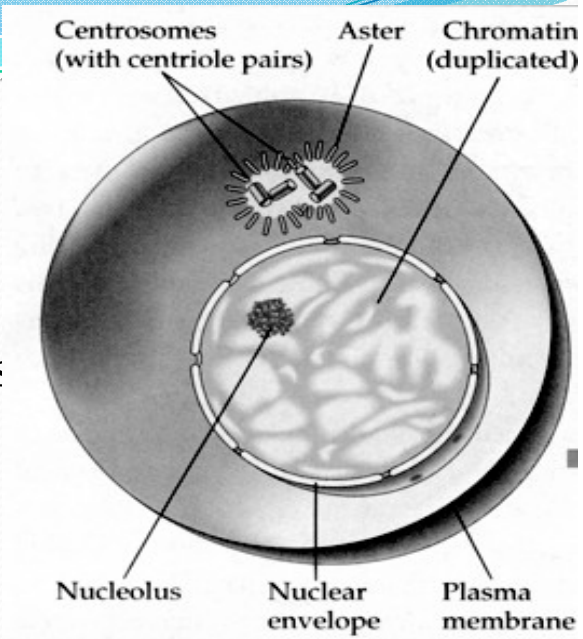
- Our body contains trillions of cells (thousands of millions). But you started life as a single cell - a fertilised egg cell. This cell then divided and divided to make more cells through a process called **mitosis**.
- Mitosis is a way of making more cells that are genetically the same as the parent cell. It plays an important part in the development of embryos, and it is important for the growth and development of our bodies as well.
- Mitosis produces new cells, and replaces cells that are old, lost or damaged.
- In mitosis a cell divides to form two identical daughter cells. It is important that the daughter cells have a copy of every chromosome, so the process involves copying the chromosomes first and then carefully separating the copies to give each new cell a full set.

Mitosis:

1. Interphase.
2. Prophase.
3. Metaphase.
4. Anaphase.
5. Telophase

Interphase:

1. Cell preparing to divide.
2. Before mitosis, the chromosomes are copied. They then coil up, and each chromosome looks like a letter X in the nucleus of the cell. The chromosomes now consist of two sister chromatids. Mitosis separates these chromatids, so that each new cell has a copy of every chromosome.
3. DNA has been replicated but, **chromosomes** not yet visible.



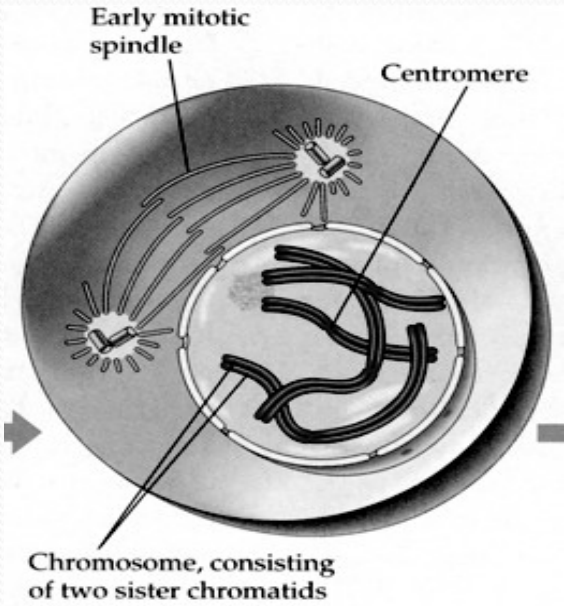
Prophase:

1. Chromosomes condense and thicken
2. & shorten, become visible.
3. Each duplicated chromosome appear as two identical sister **chromatids** joined by a **centromere**.

4- **Centrioles** move to the opposite sides of the nucleus.

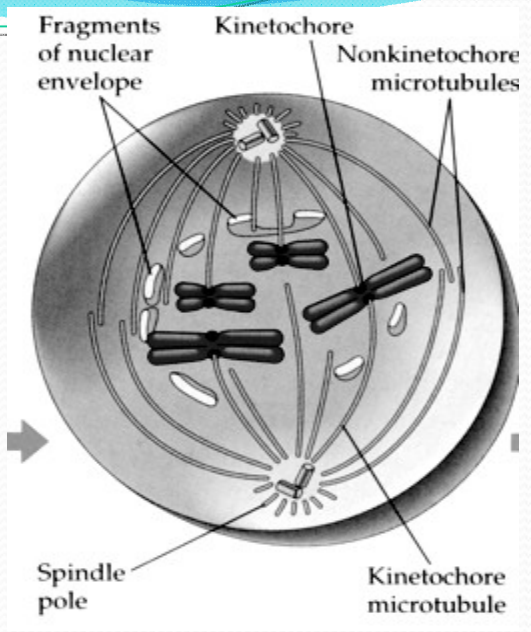
5- Nucleolus disappear.

6- The **mitotic spindle** begins to form.



Prometaphase:

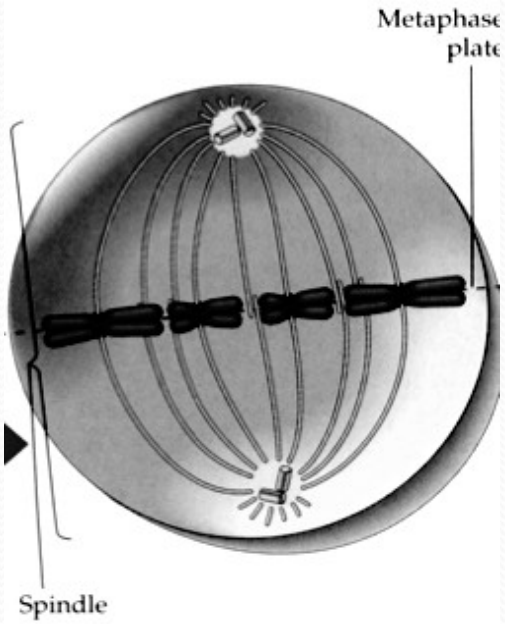
1. The nuclear envelope fragments.
2. The **spindle fibers** become attached to the centre of each chromosome = **kinetochore**.



Metaphase:

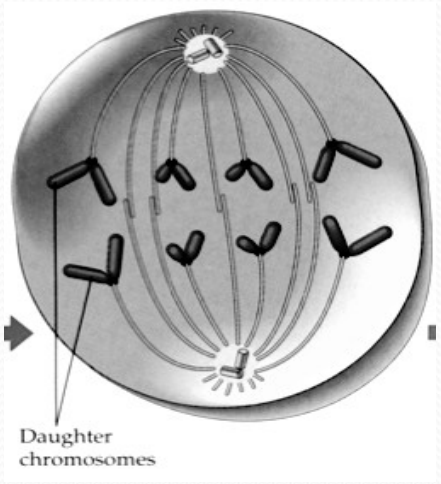
1. The chromosomes assemble at the equator = metaphase plate, become attached to spindle fibers by centromere

2- Homologous chromosomes do not associate.



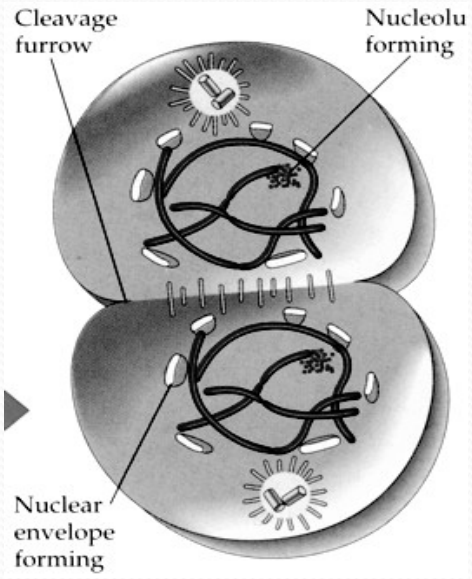
Anaphase:

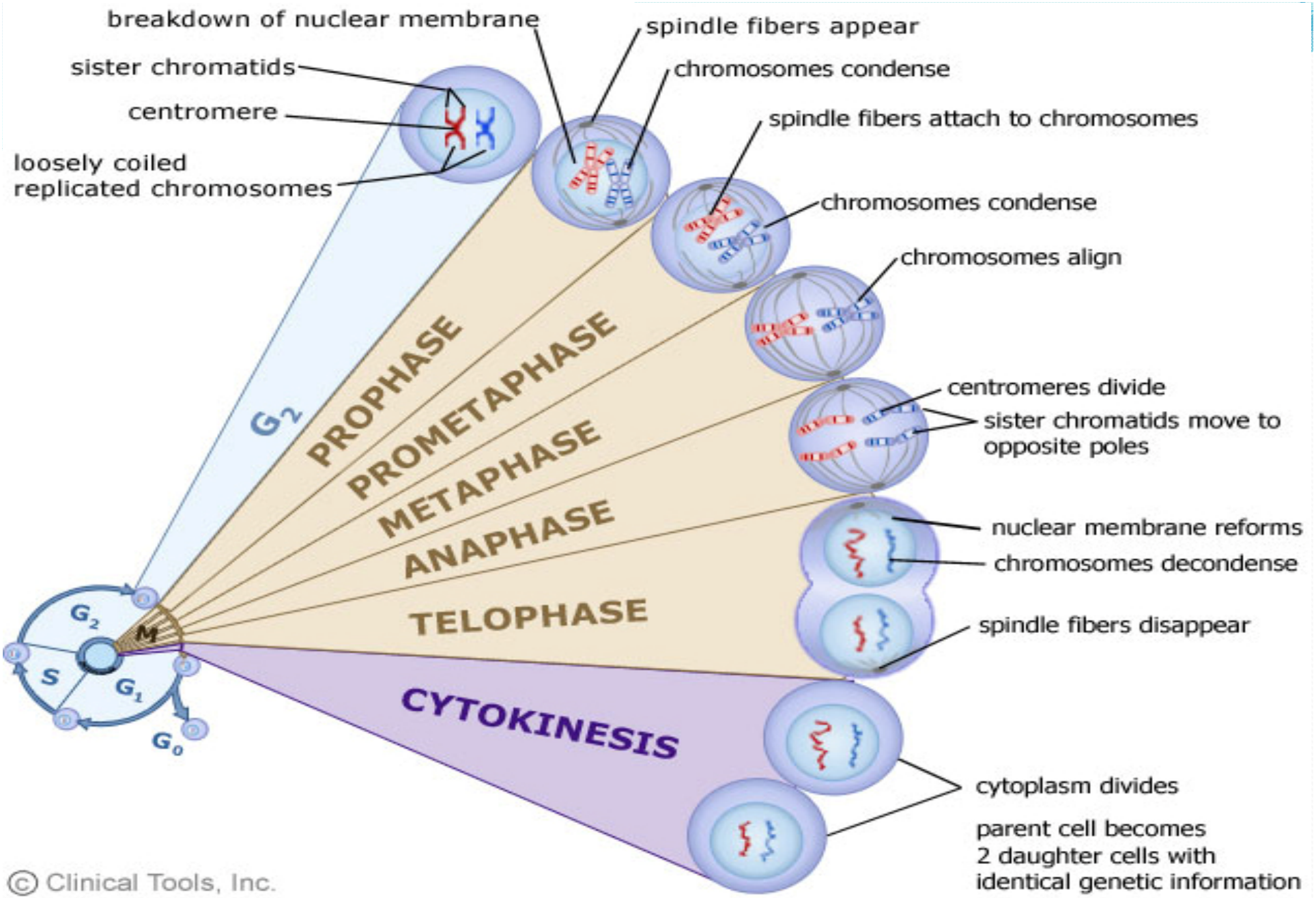
1. The spindle fibres begin to contract.
2. This starts to pull the sister chromatids apart.
3- At the end of anaphase a complete set of daughter chromosomes is found each pole.



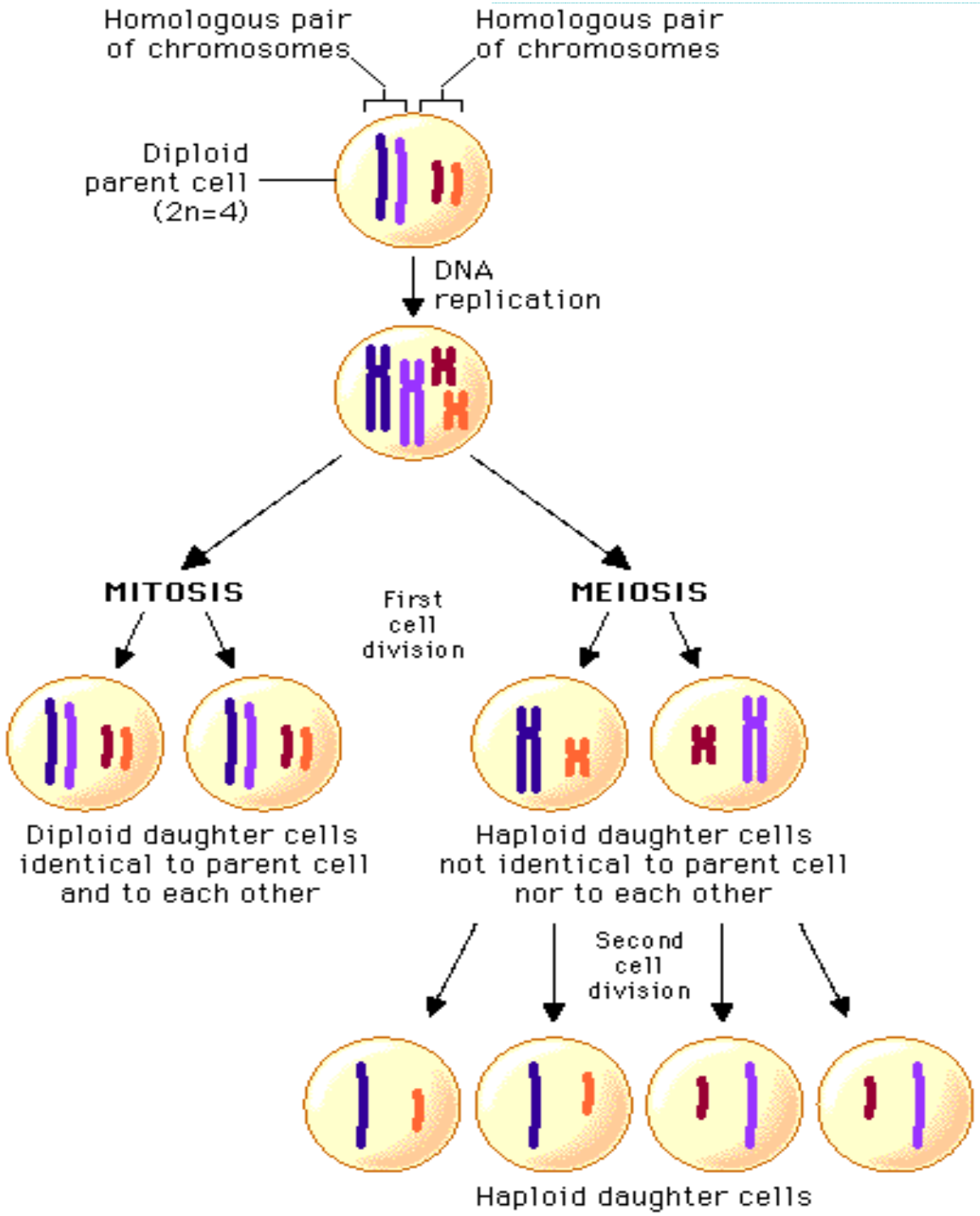
Telophase and Cytokinesis:

1- two chromosomes uncoil.
2- Spindle fibers disintegrate.
3- Centrioles replicate.
4- Nuclear envelopes begin to form around each set of daughter chromosomes.
2- A cleavage furrow divides the cytoplasm in two = **cytokinesis**





The phases of mitosis


Homologous pair of chromosomes
Homologous pair of chromosomes
Diploid parent cell (2n=4)
DNA replication
MITOSIS
First cell division
MEIOSIS
Diploid daughter cells identical to parent cell and to each other
Haploid daughter cells not identical to parent cell nor to each other
Second cell division
Haploid daughter cells

- **Mitosis** cannot be the only type of cell division!
- the chromosome number would double in each generation

Parents 46 + 46

↓

F1 Offspring 92

Next generation 92 + 92

↓

184

Remember changes in chromosome number are usually lethal !

Meiosis:

- Meiosis is used to make special cells - sperm cells and egg cells - that have half the normal number of chromosomes.
- It reduces the number from 23 pairs of chromosomes to 23 single chromosomes.
- The cell copies its chromosomes, but then separates the 23 pairs (homologues chromosomes) to ensure that each daughter cell has only one copy of each chromosome.
- A second division that divides each daughter cell again to produce four daughter cells.
- 4 daughter cells produced.
- Each daughter cell has half the chromosomes of the parent.
- 2 sets of cell division involved, meiosis I and meiosis II.
- Meiosis I separates the matching - or 'homologous' - pairs of chromosomes.
- Meiosis II divides each chromosome into two copies (much like mitosis).

Female (46) Male (46) (Diploid)

meiosis

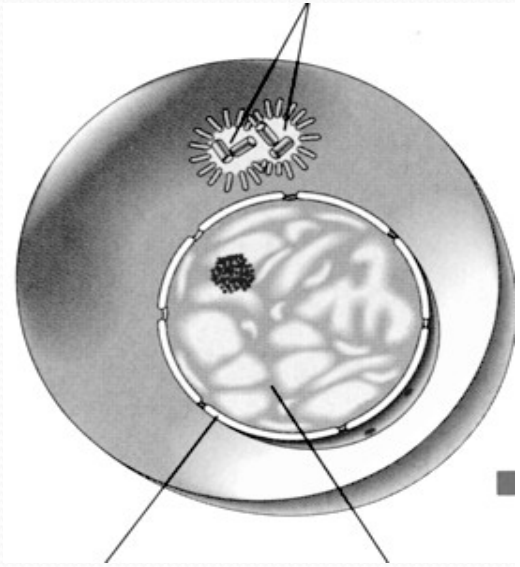
egg (23) + sperm (23) (Haploid)

46 (Diploid)

MEIOSIS I

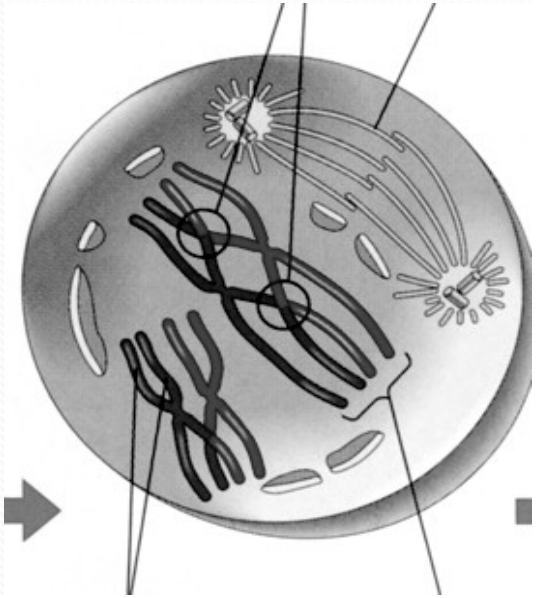
Interphase I

- Each chromosome replicates.
- The result is two genetically identical **sister chromatids.**



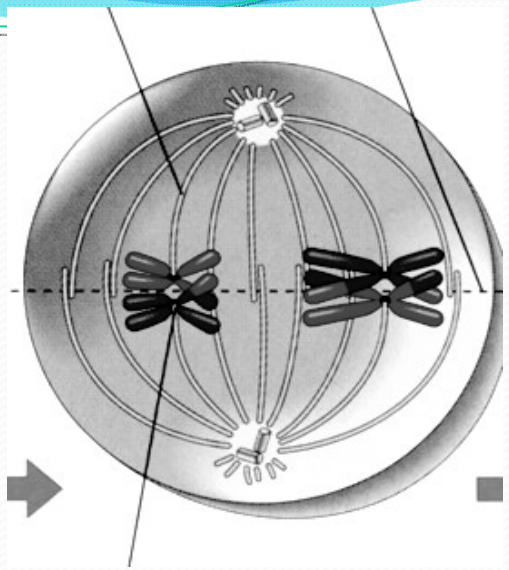
Prophase I (**Crossing-over** recombination)

- **Homologous** chromosomes (each consisting of two sister chromatids) come together as pairs.
- the chromosomes in each matching pair swap some genetic material before they are parted.
- The structure formed is called a tetrad.
- Chromosome segments are swapped between non-sister chromatids at cross-over points called (**crossing-over).**
- These processes produce new combinations of genes in the sperm cells and egg cells.



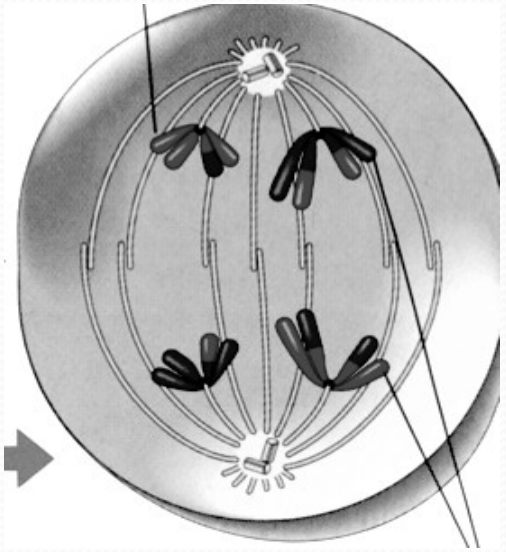
Metaphase I:

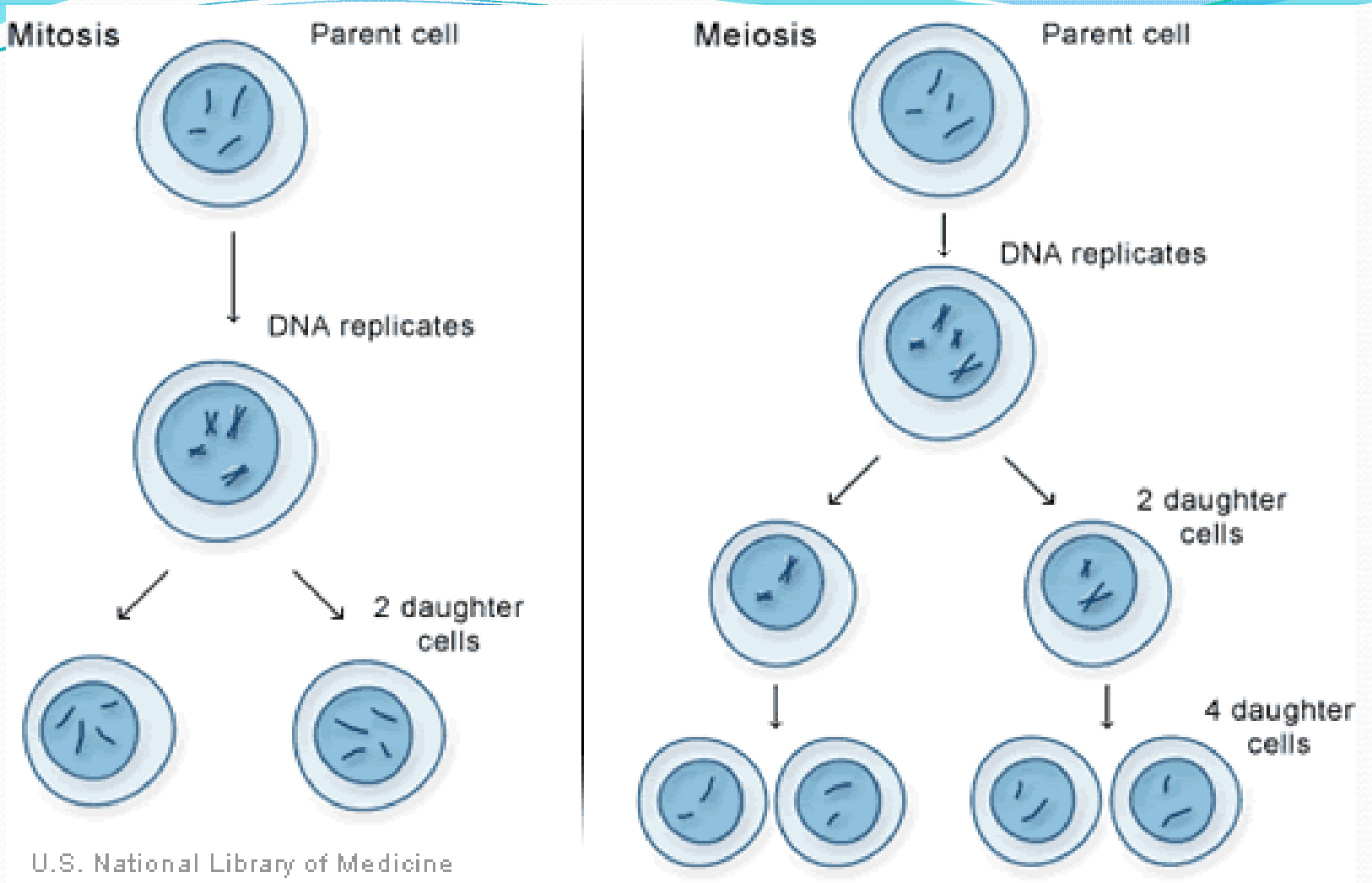
- Chromosomes align on the metaphase plate.
- Chromosomes still arranged as: pairs of homologues.



Anaphase I:

- Sister chromatids remain attached.
- But homologous chromosomes move apart to opposite poles.





Mitosis and meiosis

Meiosis I in Males

Prophase I

chromosomes begin to condense

homologous chromosomes pair

crossing over occurs

recombinant chromosomes

Metaphase I

spindle fibers attach to chromosomes

chromosomes line up in center of cell

Anaphase I

chromosomes start to move to opposite ends of cell as spindle fibers shorten

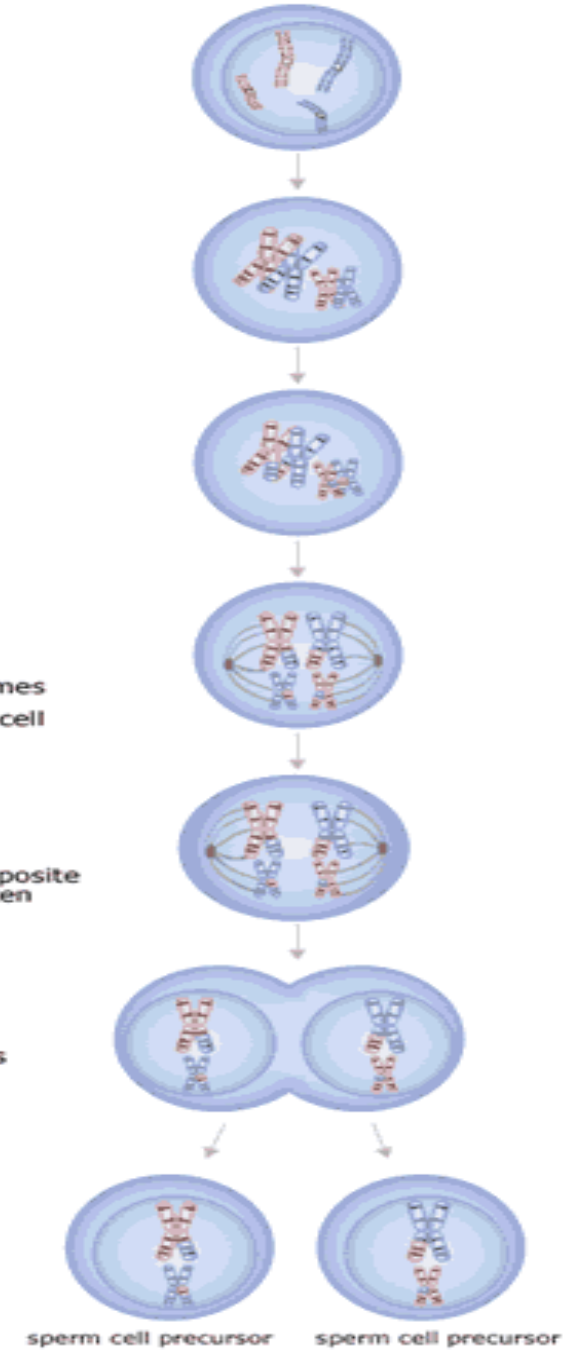
Telophase I

chromosomes reach opposite ends

nuclear membrane forms

Cytokinesis

cell division occurs

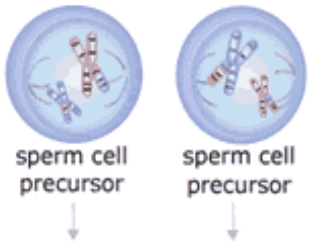


sperm cell precursor sperm cell precursor

Meiosis II in Males

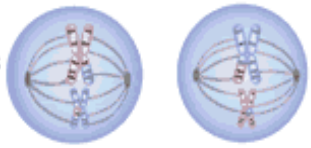
Prophase II

chromosomes begin to condense
nuclear membrane dissolves
spindle fibers form



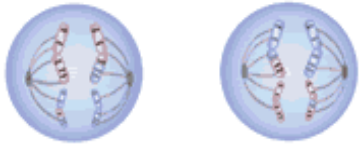
Metaphase II

spindle fibers attach to chromosomes
chromosomes line up in center of cell



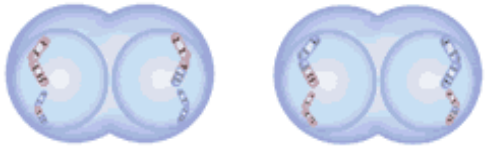
Anaphase II

centromeres divide and sister chromatids move to opposite ends of cell as spindle fibers shorten



Telophase II

chromosomes reach opposite ends
nuclear membrane forms

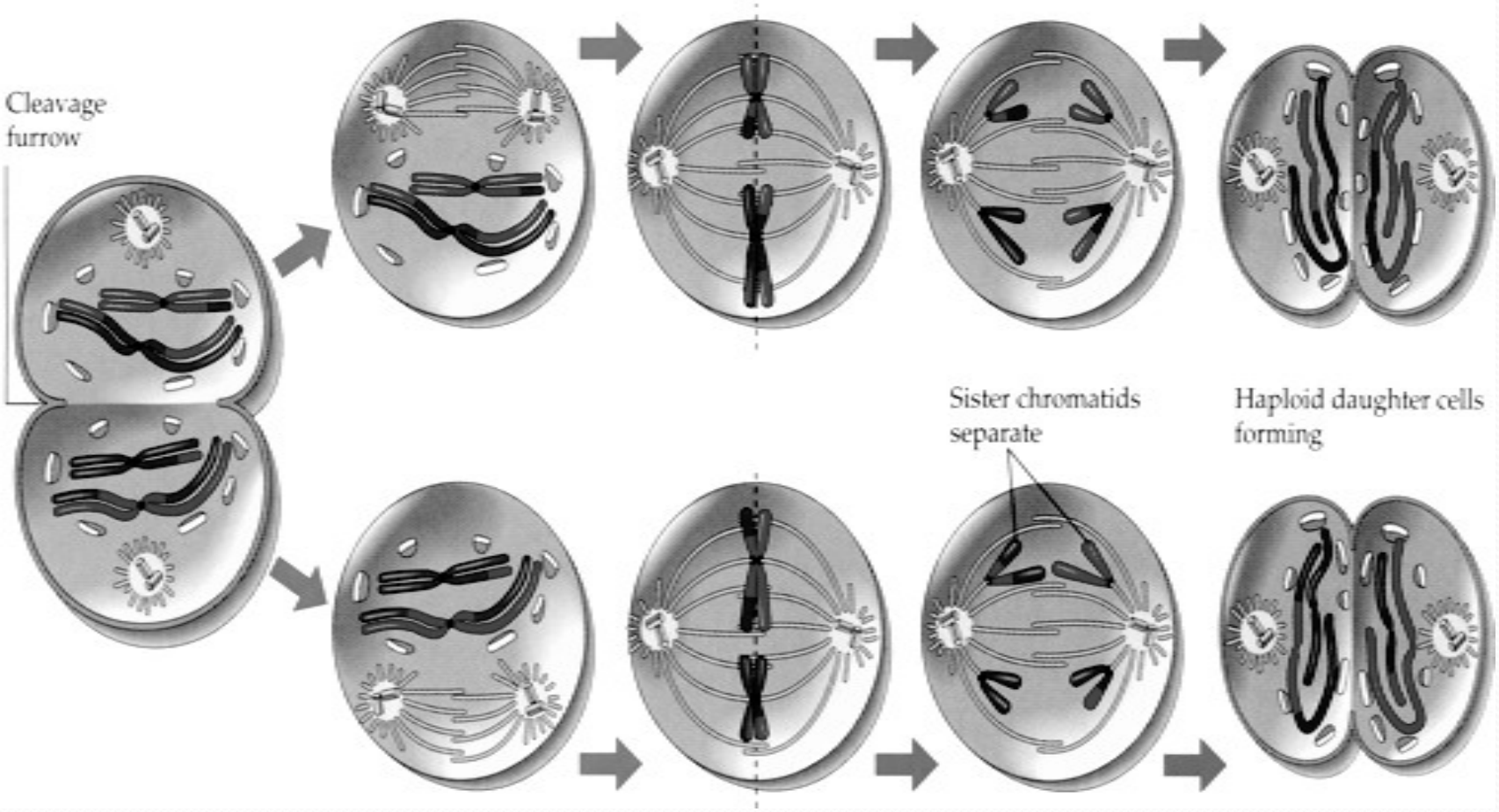


Cytokinesis

cell division occurs

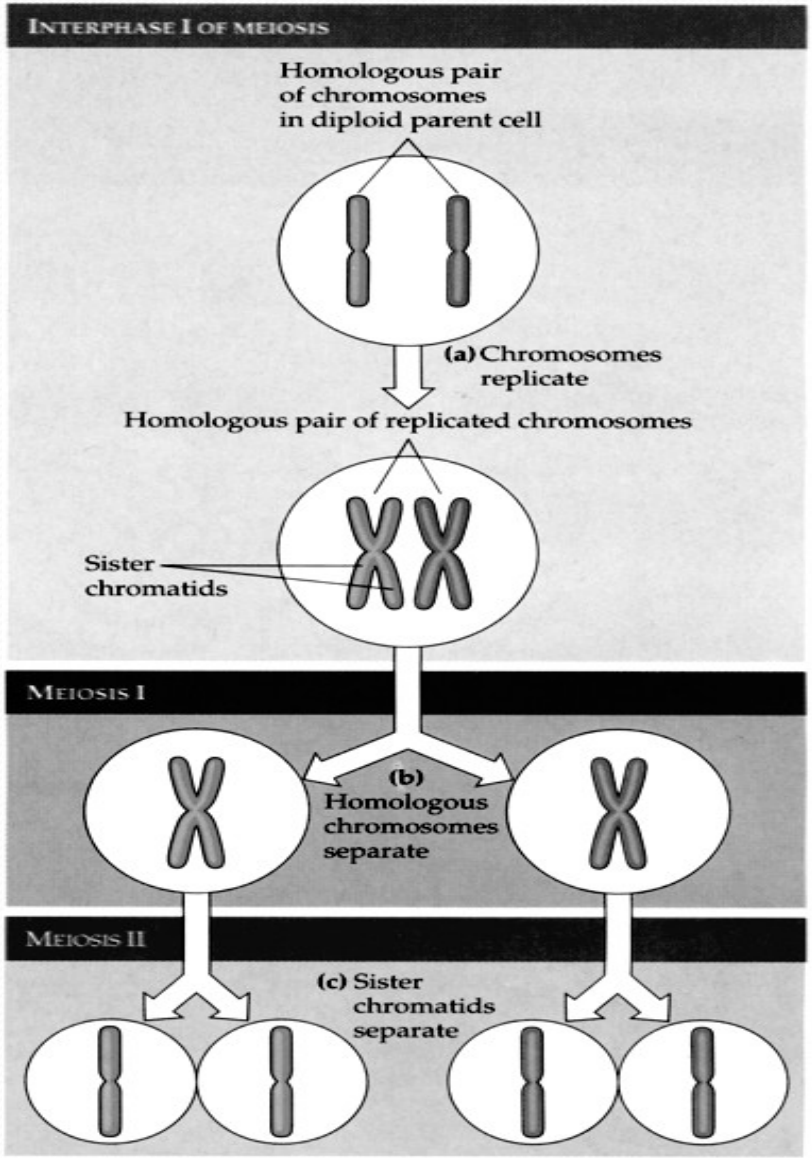
MEIOSIS I | **MEIOSIS II – separation of sister chromatids**

Telophase I | Prophase II | Metaphase II | Anaphase II | Telophase II



4 haploid cells

- **Meiosis**: how the chromosome set is halved?



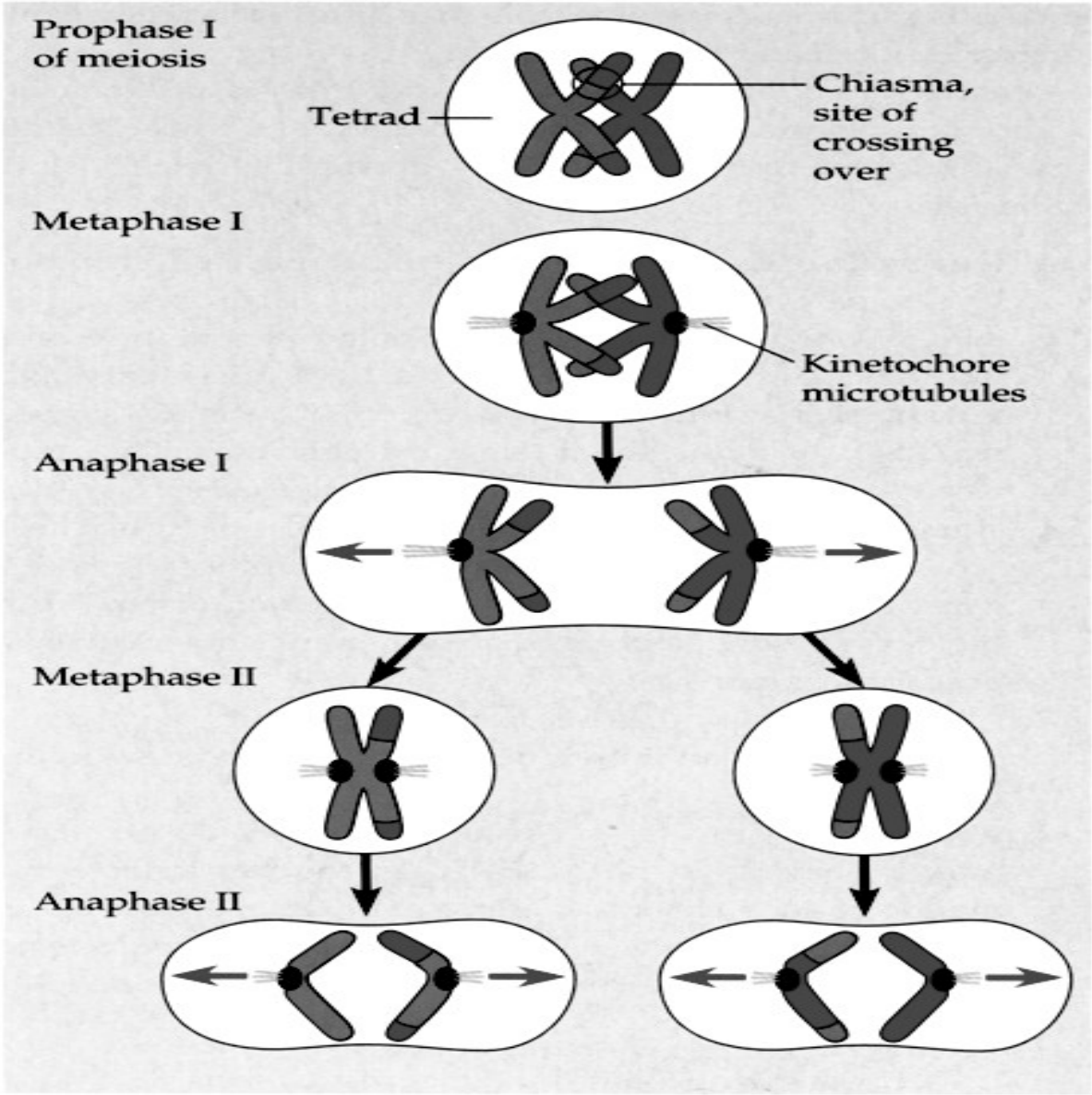
A diploid cell: one pair of homologous chromosomes

Replication of each chromosome chromatids.

Meiosis I:Each cell receives of the homologues

Meiosis II: Each cell receives sister chromatid

The consequences of crossing over: Recombination.



Muscular and nervous tissue:

lecture-9-

Dr.Aseel I. Ibrahim

3. Muscular Tissue

1. **Skeletal**
2. **Cardiac**
3. **smooth**

Skeletal (striated) muscle:

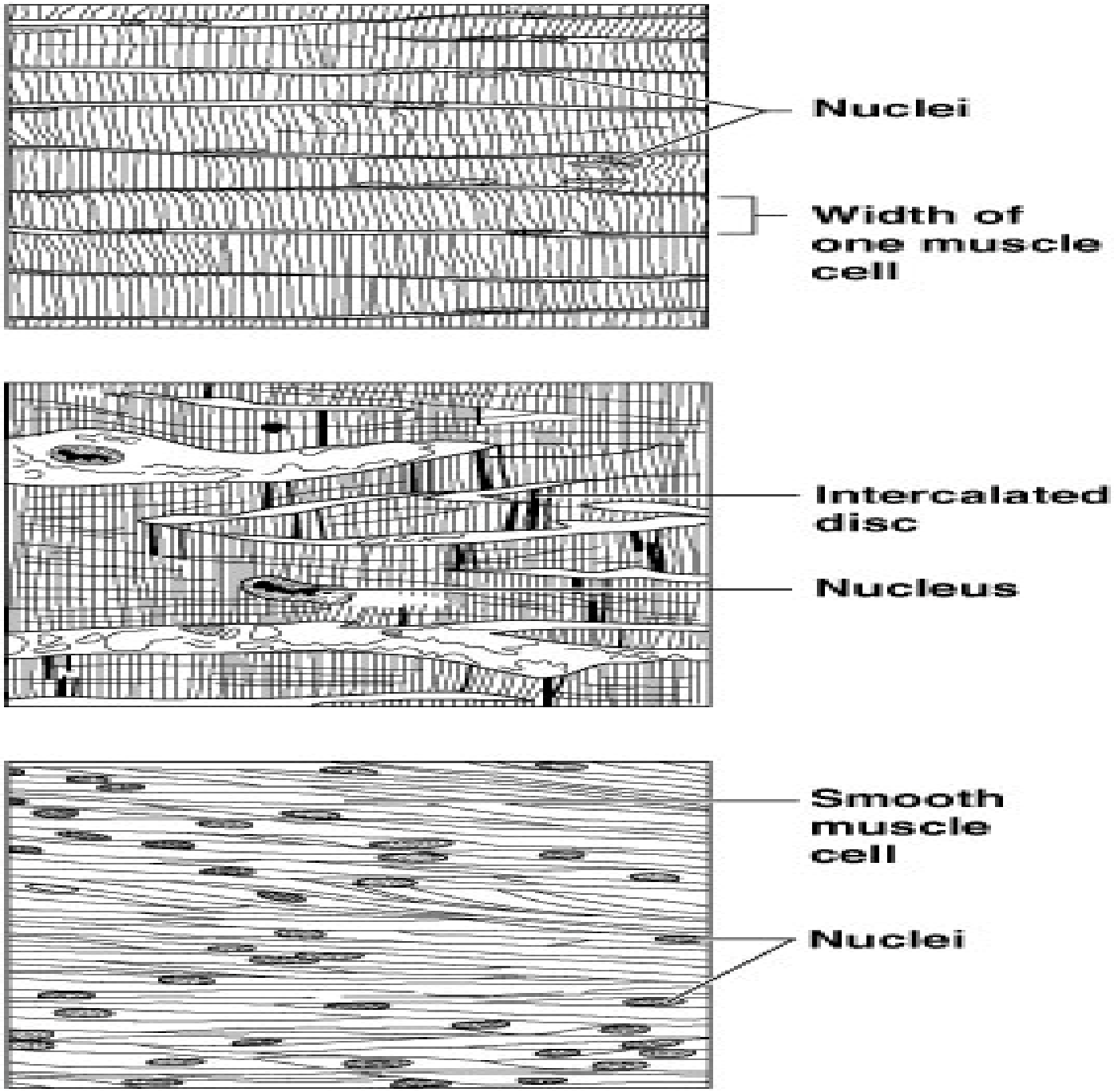
- attaches to bones.
- moves the skeleton.
- **voluntary** - under conscious nervous control.
- striated (striped) appearance.

Cardiac muscle or heart muscle:

- Striated with **intercalated disks.**
- cells only contain a single nucleus.
- under control of autonomic nervous system (**unconscious** control).

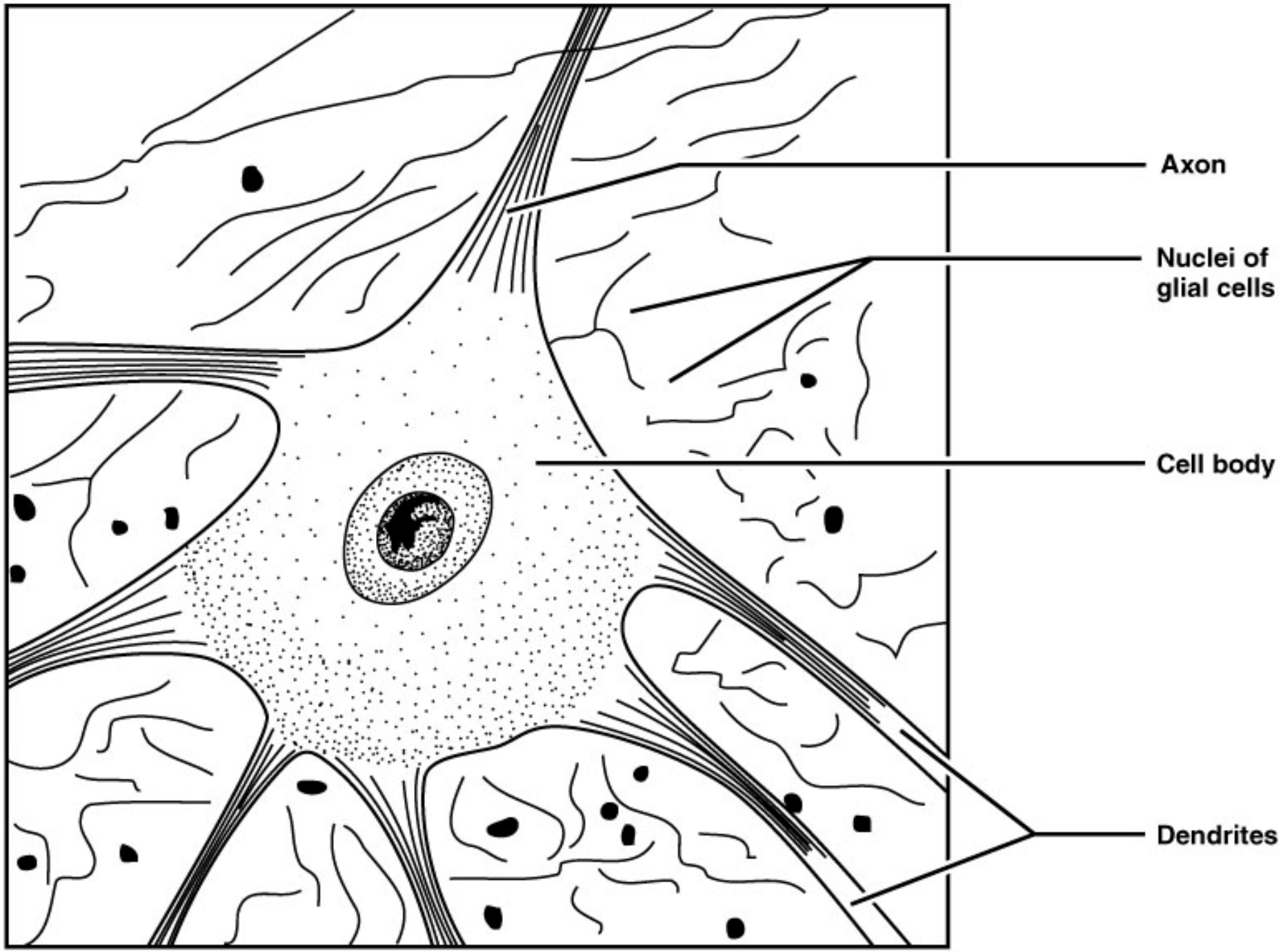
Smooth muscle:

- lacks the striations of skeletal muscle.
- **involuntary** muscle, under autonomic control.
- visceral muscle - operates the gut; found in iris of eye, base of hairs, uterus.



4. Nerve Tissue:

- composed of neuron cells.
- receives information from environment (stimulus) through sensory **receptors**.
- information sent as electrical & chemical signals to brain.
- Brain interprets signals and produces proper response.
- signals are then sent from brain to **effectors** where response is initiated.



Homeostasis ("same state")

- maintenance of physiological conditions required to support the life of the organism

Endocrine System Control:

- acts more slowly than nervous system.
- changes in levels of nutrients in the blood stream trigger the release of hormones.
- hormones effect target tissues or organs.

Body membranes:

- Epithelial Membranes = epithelial layer of cells plus the underlying connective tissue.

Three Types:

1. Mucous membranes
2. Serous membranes
3. Cutaneous membranes (synovial)

1- **Mucous membrane** : (mucosa)

it lines cavities that open to the exterior, such as the Gastrointestinal tract.

- The epithelial layer of the mucous membrane acts as a barrier to disease organisms.
- The connective tissue layer of the mucous membrane is called the lamina propria.
- Found as the lining of the mouth, vagina, and nasal passage.

2- Serous membrane: (serosa)

- membrane lines a body cavity that does NOT open to the exterior and it covers the organs that lie within the cavity.
  a. pleura = lungs
  b. pericardium = heart
  c. peritoneum = abdomen
- The serous membrane has two portions:
  1. parietal portion = lining outside the cavity.
  2. visceral portion = covers the organ.

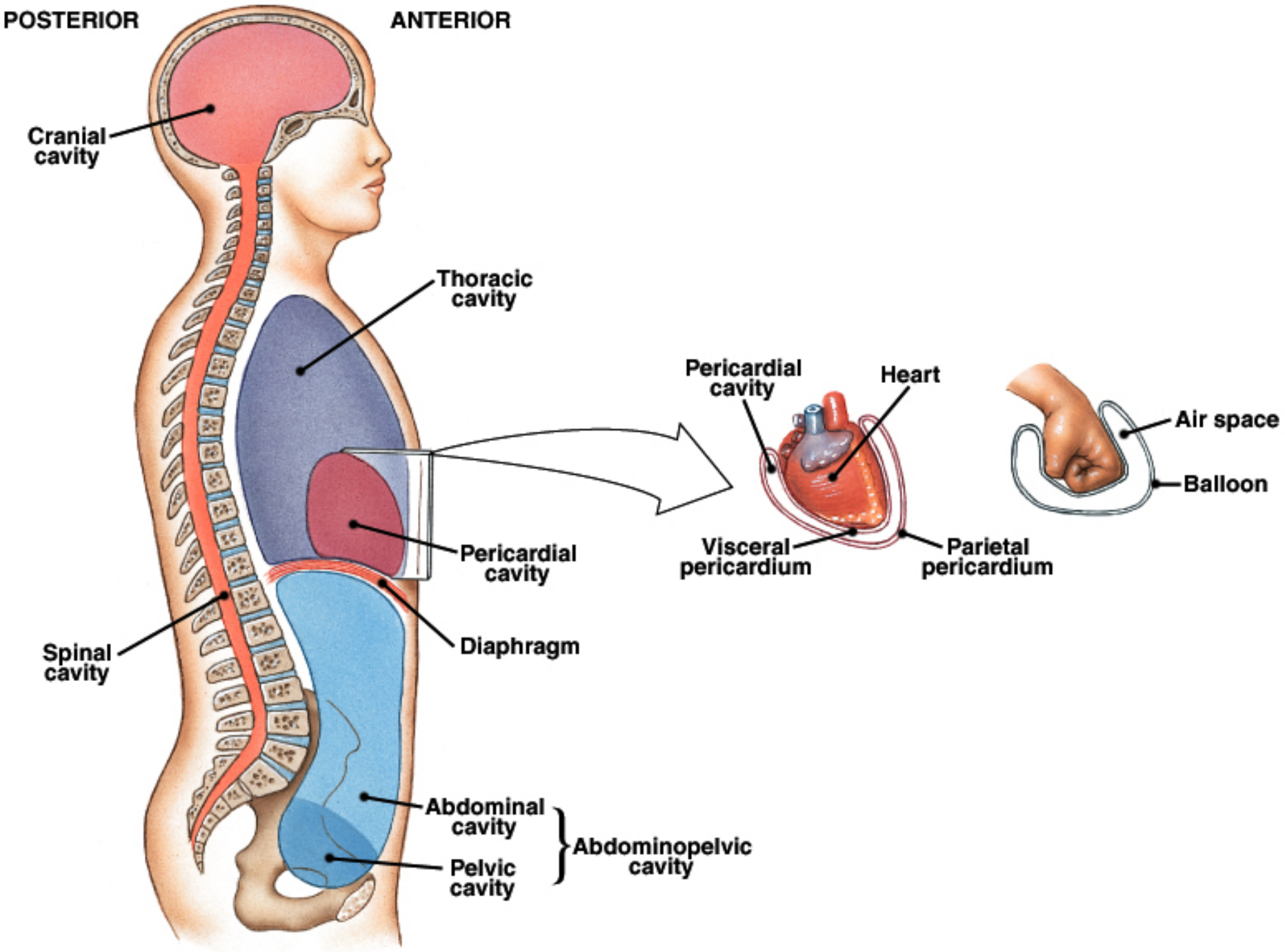
.

Serous membranes epithelial layer secretes a lubricating SEROUS FLUID, that reduces friction between organs and the walls of the cavities in which they are located.

- The serous fluid is named by location:
  - Pleural fluid is found between the parietal and visceral pleura of the lungs.
  - Pericardial fluid is found between the parietal and visceral pericardium of the heart.
  - Peritoneal fluid is found between the parietal and visceral peritoneum of the abdomen.

Cavities of the human body:

A. Cranial cavity ----- contains the brain.
B. Vertebral cavity ----- contains the spinal cored.
C. Pleural (thoracic) cavity ----contains the lungs.
D. Pericardial cavity-----contains the heart.
E. Abdominal cavity-----contains the stomach, spleen, liver, gall bladder, pancreas, small & large intestines, kidneys and ureters.
F. Pelvic cavity----contains the urinary bldder, colon, rectum and female reproductive organs.


POSTERIOR
ANTERIOR
Cranial cavity
Thoracic cavity
Pericardial cavity
Spinal cavity
Diaphragm
Abdominal cavity
Pelvic cavity
Abdominopelvic cavity
Pericardial cavity
Heart
Visceral pericardium
Parietal pericardium
Air space
Balloon

Nutrition and Digestion

Lecture. 8

Dr.Aseel I.Ibrahim

- Food has an impact on life because it supplies **nutrients,** which are substances in food that body needs to function properly such as in growing, in repairing itself, and in having supply of energy.

There are six types of nutrients:

- **Carbohydrates**
- **Fats**
- **Proteins**
- **Vitamins**
- **Minerals**
- **Water**

- **Carbohydrates, fats,** and **proteins** provide **energy** and perform other important functions.
- When our body uses carbohydrates, fats, and proteins, energy is released: **calories.**

Carbohydrates

- Carbohydrates are the **sugars** and **starches** found in foods.
- There are two general types of carbohydrates: **simple** and **complex**.
- **Simple** sugars (**fructose ,glucose, lactose, sucrose).**
- **Glucose** the form of the sugar that goes directly to the bloodstream and provides quick energy. All other sugars must be changed into glucose by the body before the cells can use them.
- Glucose that is not needed immediately is converted by body to **glycogen.**
- **Complex sugars (starches, dietary fibers).**

Fats:

- **Fats** are the nutrients that contains the most concentrated form of energy.
- **Lipids** are substances that are somewhat similar to carbohydrates, but they contain less oxygen and they do not dissolve in water.
- **Cholesterol** is part of cell membranes and nerve tissues, used by body to form vitamin D and other hormones. It is found only in foods that come from animals, such as butter, eggs, and meats. It is not an essential nutrient because the body produces cholesterol in liver.
- Two form of cholesterol (LDL, HDL).

Protein:

- **Proteins** are substances found in every cell. The body needs proteins to build and repair all body tissues. Made up of carbon, hydrogen, oxygen, and nitrogen atoms that are formed into basic units called **amino acids**.
- There are **20** different amino acids. Nine of them are essential, and the other eleven amino acids can be produced by the body.

Vitamins, minerals, and water:

- **Vitamins** help build bones and tissues, and they also help change carbohydrates and fats into energy.
- **fats**-soluble vitamins, **water**-soluble vitamins.
- **Minerals** are used to regulate a wide range of body processes, from bone formation to blood clotting, and they are important for the body structure.
- **Major Minerals**: calcium, phosphorus, magnesium, potassium, sulfur, sodium, and chlorine.
- **Trace Minerals**: iron, iodine, manganese, zinc, copper, and fluorine.
- **Water** carries dissolved nutrients throughout our body and assists in all of its functions such as: digesting foods, removing wastes, regulating temperature.

Digestion:

Occurs in 5 stages:

1: Mechanical processing and motility.

Teeth mechanically break down food into small pieces.**Tongue** mixes food with **saliva: amylase**, breakdown starch, **Mucus** lubricates food for easier swallowing, **Buffer** unsterilized acid to prevent tooth decay, **antibacterial chemicals** to kill bacteria that enter mouth with food.

Epiglottis is a flap-like structure at the back of the throat that closes over the trachea preventing food from entering it.

2: Secretion: oesophagus : Secrete **mucus,** moves food from the throat to the stomach using muscle movement called **peristalsis.** Bring food **(bolus)** to stomach.

Sphincters ring of muscle that encircle tubes (Contraction closes tubes, Keeps acid in stomach).

3: Digestion stomach (temporary storage site for food, the site of initial protein digestion).

Gastric fluid consists of **mucus**, **hydrochloric** acid, **pepsinogens** and other substances.

Movement of food into and out of the stomach is controlled by circular muscles known as **sphincters.**

One at the top of the stomach allows food from the oesophagus to enter and prevents food from going back up into the oesophagus. Another located at the bottom slowly releases partially digested food into the small intestine. Alcohol and some water are absorbed here, the partially digested food is called **chyme.**

4: Absorption (small and large intestine)

Small intestine much of the digestion and absorption of food takes place (bile juice and pancreatic juice**).** Most of the digestive enzymes that act in the small intestine are secreted by the pancreas.

- A duct brings Bile (from Liver and Gallbladder) emulsifies **fat** – disperses in water.
- A duct brings Pancreatic Juice from Pancreas. Contains
  - **- $NaCHO_3$ – neutralizes chyme.**
  - **- enzymes to complete food digestion.**

The small intestine contains **Villi** –absorb nutrients.

segmentation contractions occur in the large intestine and small intestine. the contractions of the intestinal wall move chyme in **both directions** to allow mixing with the secretions of the intestines. Villi increases surface area of small intestine, the **Hepatic Portal Vein** takes all absorbed nutrients (except large fat molecules) from villi to the liver for further processing and storage.

5: Elimination: large intestine, Absorbs water, salts and some vitamins, stores indigestible material for defecation. Bacterial digestion, ferment carbohydrates, protein breakdown, absorbs more water, concentrate wastes.

Accessory gland:

Liver: lobules.

1. monitor and clean blood, produce bile for gallbladder.
2. Detoxify blood, store iron, vitamins A, D, E and K.
3. Regulate blood sugar (glycogen, glycerol, Amino acids), destroys old blood cells.
4. Regulate cholesterol (bile salts).
5. Makes urea which is worked on by kidneys

Gall Bladder: Pouch structure located near the liver

- concentrates and stores bile

Bile duct – a long tube that carries BILE.

The top half of the common bile duct is associated with the liver.

The bottom half of the common bile duct is associated with the pancreas, through which it passes on its way to the intestine.

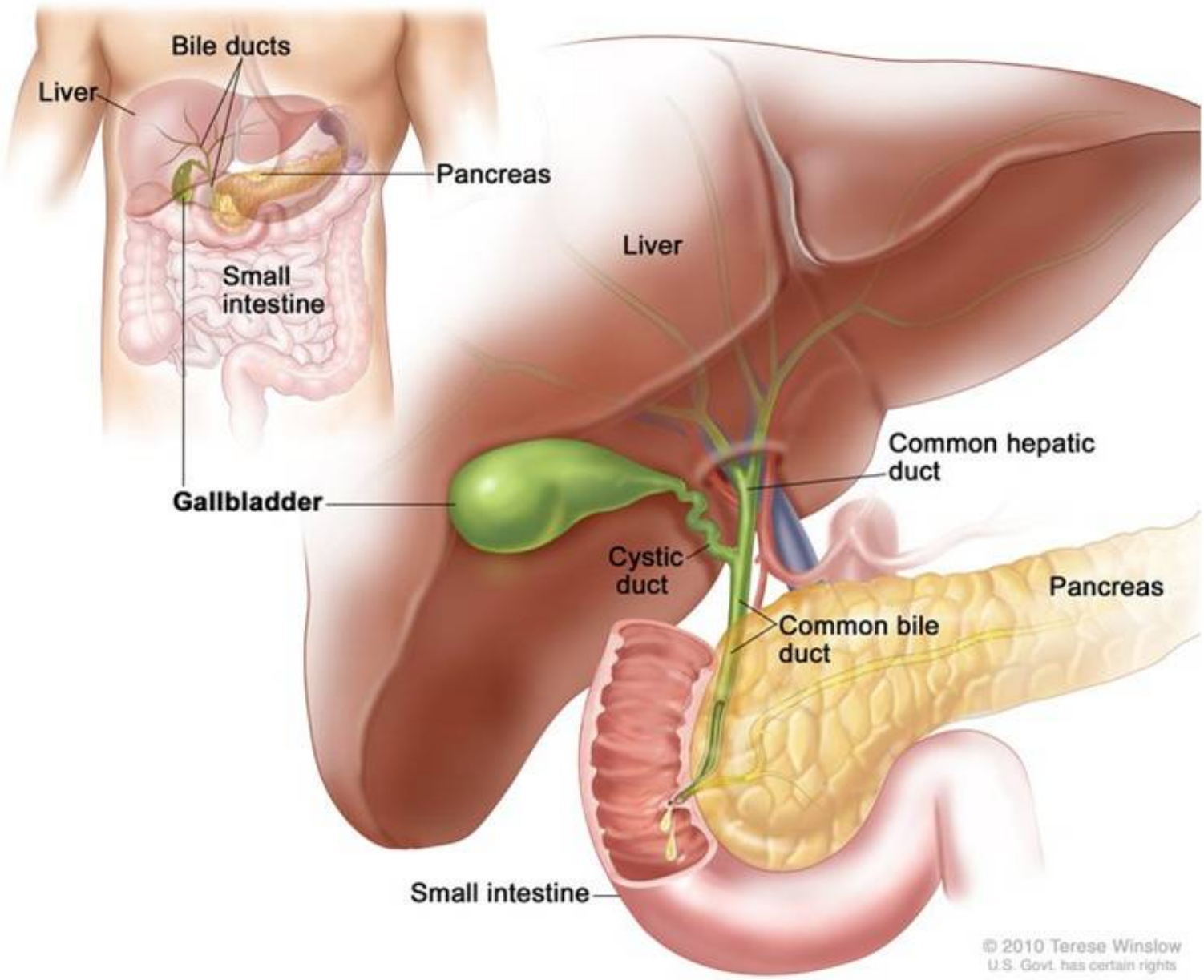
Bile emulsifies lipids (physically breaks apart FATS)

pancreas: An organ which secretes both digestive enzymes (**exocrine**) and hormones (**endocrine**)

Pancreatic juice digests all major nutrient types.

Exocrine pancreas produces $NaHCO_3$, amylase (starch), trypsin (protein) and lipase (fat).

Endocrine pancreas produces insulin and glucagon.


Bile ducts
Liver
Pancreas
Small intestine
Gallbladder
Liver
Common hepatic duct
Cystic duct
Pancreas
Common bile duct
Small intestine
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Respiration

Lecture-11-

Dr.Aseel I. Ibrahim

Respiration: breathing.

Respiratory System: organs that exchange gases with the environment.

Cellular respiration: is the aerobic breakdown of glucose in the mitochondria to make ATP.

Respiratory systems allow human to move **oxygen** (needed for cellular respiration) into body tissues and remove **carbon dioxide** (waste product of cellular respiration) from cells.

Parts of respiratory system include:

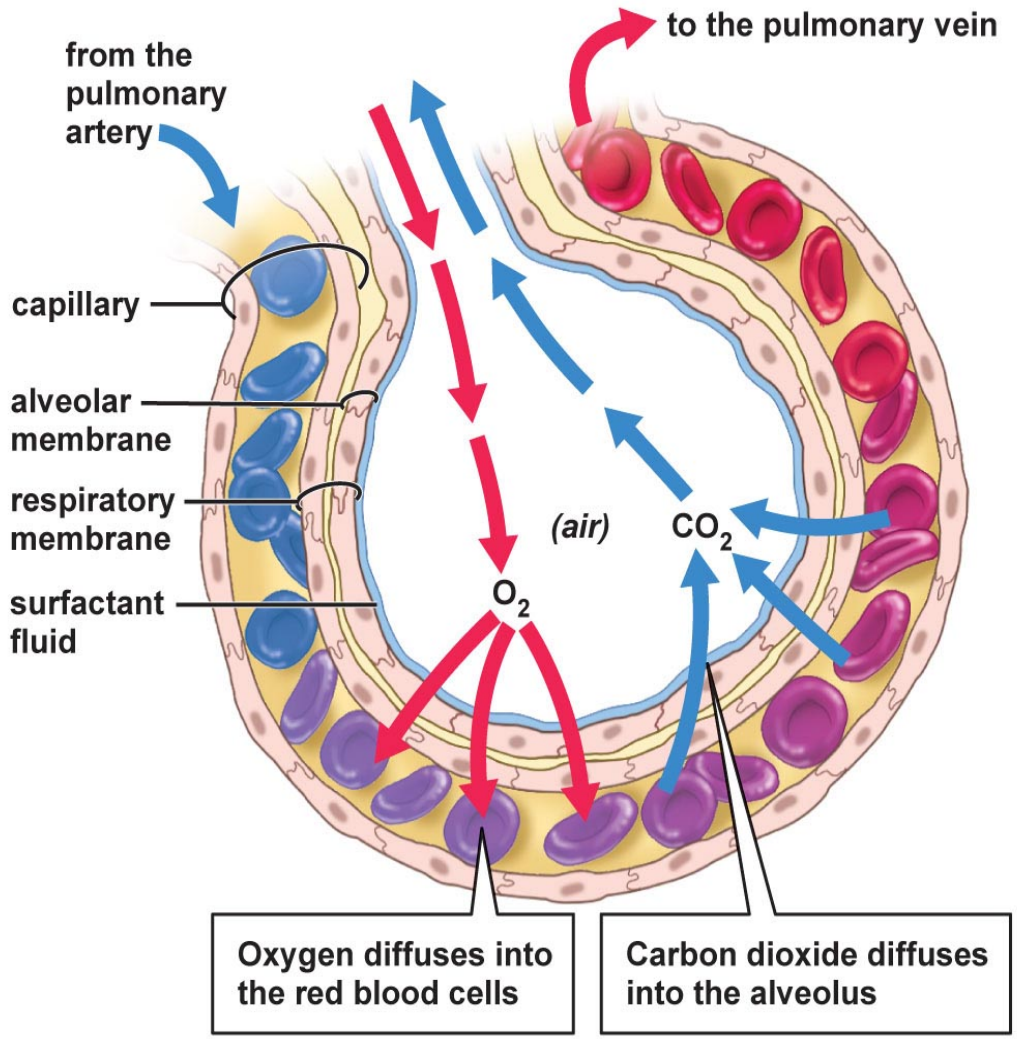
1. Nose.
2. Nasal cavity.
3. Pharynx.
4. Larynx.
5. Trachea.
6. Bronchi.
7. Bronchioles.
8. alveoli.

During inspiration (**inhalation**), the diaphragm and intercostals muscle contract.

During expiration (**exhalation)**, intercostals muscle relax and the diaphragm domes upwards.

Alveoli: are moist, thin-walled pockets which are the site of gas exchange, their wall is lining with oily **surfactant** to prevent the alveolar wall from collapsing and sticking together.

Alveoli and **capillary** forming the respiratory surface, and may share the same membrane.



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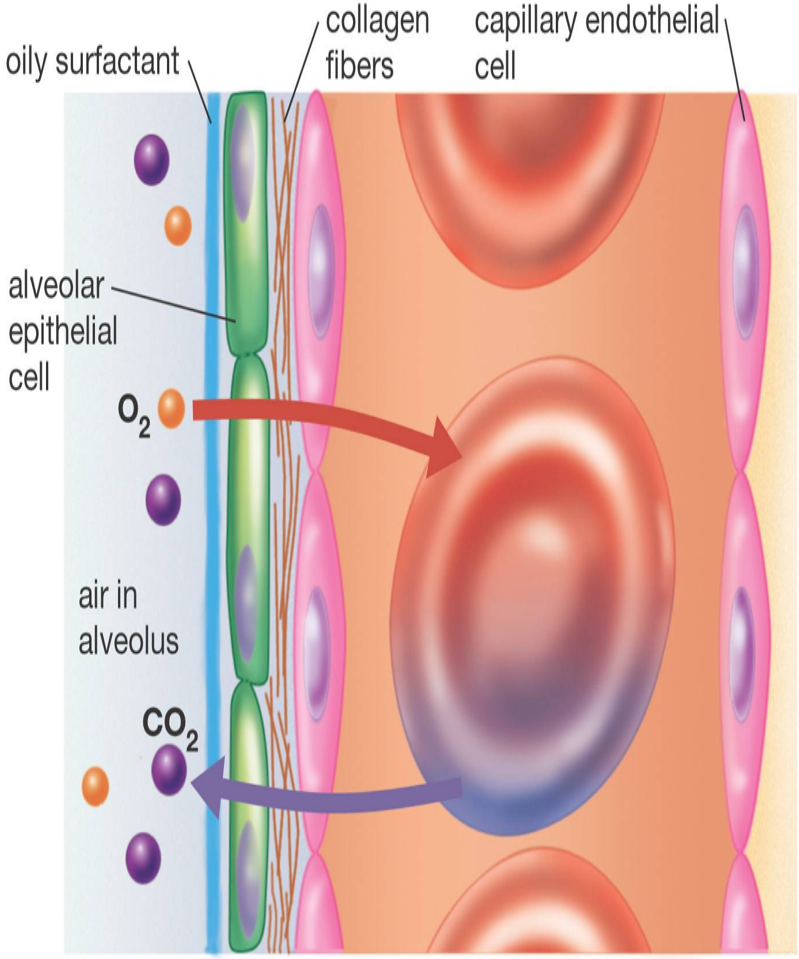

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Gas exchange:

- **Air** entering the lungs contains more **oxygen** and less **carbon dioxide** than the blood that flows in the pulmonary capillaries.
- **Hemoglobin** binds to **oxygen** that diffuses into the blood stream.
- **Carbon dioxide** can **dissolve** in plasma, and about 70% forms **bicarbonate ions.** Some carbon dioxide can bind to hemoglobin for transport.
- **Cells** use up oxygen quickly for cellular respiration and create carbon dioxide during cellular respiration, so CO_2 levels in the cell are higher than in the blood coming to them.

Why the diffusion of O2 from lungs to blood is rapid?

Diseases and disorders of the respiratory system:

1- Bronchitis: inflammation of the bronchi and bronchioles.

Acute bronchitis: short-lasting inflammation of the air passage, start with virus infection of the nose and throat which is followed by bacterial infection of the respiratory passageways.

Chronic bronchitis: long-lasting inflammation of the respiratory tubes.

2- Diphtheria: acute bacterial infection of the mucous membrane of upper respiratory passageways, in which the membrane swell up causing obstruction of the tubes.

3- emphysema: disease of alveoli, Alveoli become dry and brittle, and eventually rupture in which the alveoli is deteriorate and loose their elasticity because of damage by cigarette smoke or other pollutant or asthma.

4- cystic fibrosis: Cystic fibrosis is one of the most common inherited disorders in the Caucasian population in the U.S. CF is caused by mutation of a single gene, the CFTR gene, which controls salt balance in the lungs.

5- tuberculosis: infectious bacterial disease, caused by *mycobacterium tuberculosis*, that causes scars in the lung tissue.

Structure & Function of Cells:

Lecture-2-

MODERN CELL THEORY

Schleiden, Schwann, and Virchow

1. All living things are made of one or more cells
2. Cells are the basic units of life and all the chemical reactions of life occur in cells
3. All cells arise from preexisting cells

Size Limit On Cells

Average size ranges between 10 and 100 μm (a micrometer is a millionth of a meter).

Why are they so small?

Surface Area To Volume Hypothesis:

1. Limited in size by the ratio between their Outer Surface Area and their Volume.
   A small cell has more SURFACE AREA than a large cell for a GIVEN VOLUME OF CYTOPLASM. Volume of cell increases faster than surface area.

As cell size increases, a point is reached where the surface area can no longer service the needs of the volume of the cell. This point is about 100 μm for a spherical cell.

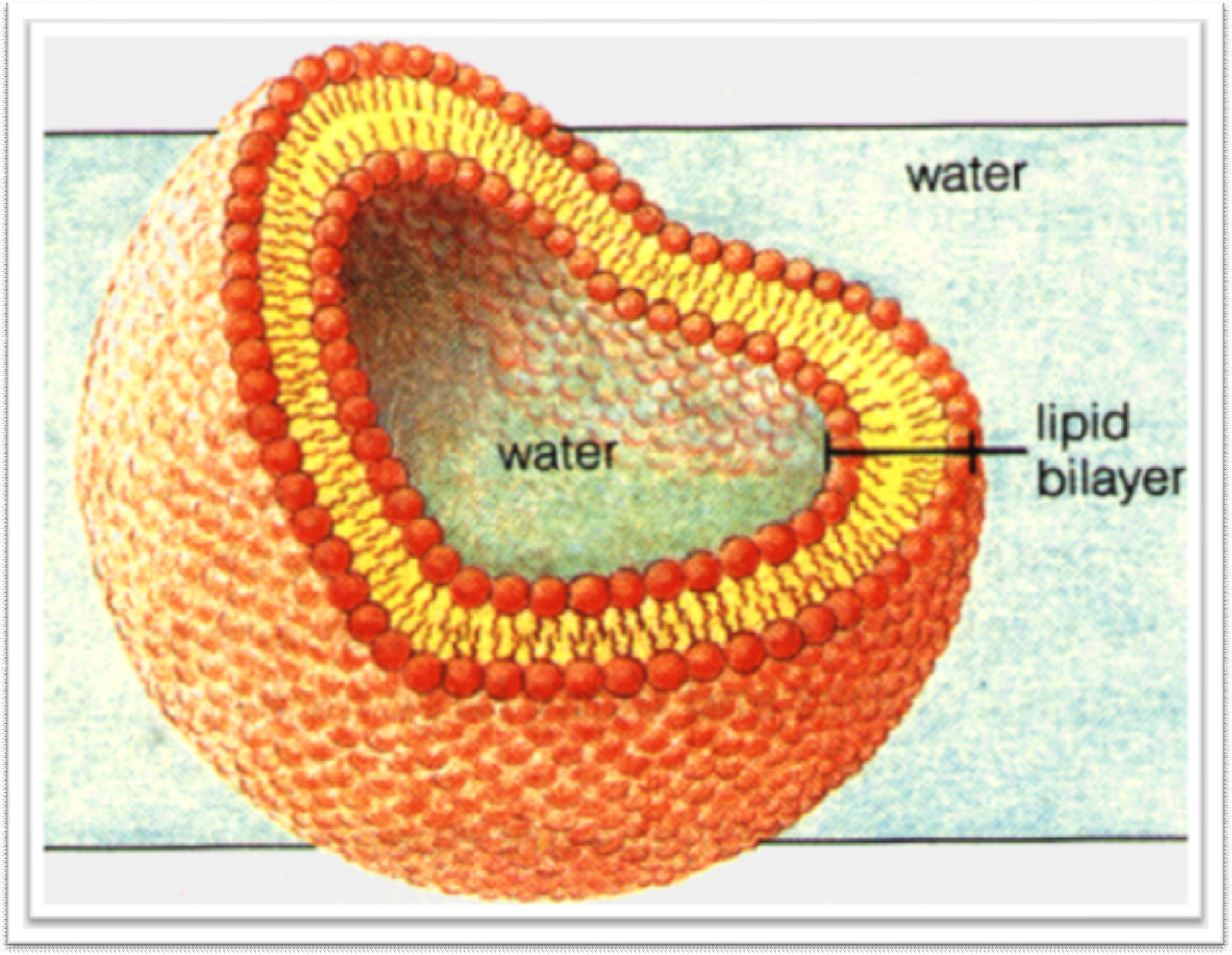
2. The cells nucleus (brain) can only control a certain amount of living, active cytoplasm.

Prokaryotes vs Eukaryotes:

- All Bacteria
- No membrane bound organelles
- No microtubules
- No 9 plus 2 flagella, flagella are single filaments
- single circular DNA molecule (not associated with histone proteins).
- No true sexual reproduction

- Defined nucleus
- DNA stored as chromosomes (with histone proteins)
- Chromosomes regularly divide by Mitosis
- Flagella & cilia have 9-plus-2 pattern of microtubules
- Specialized organelles
- Integrated multicellularity
- Sexual reproduction (different types)

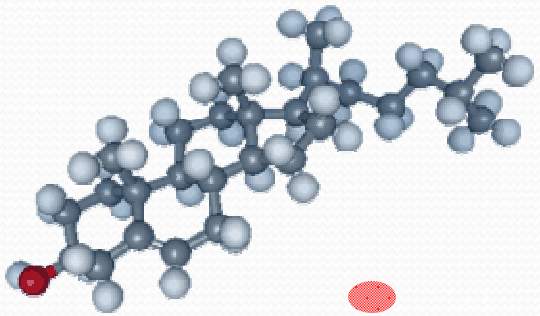
Cell Membrane:

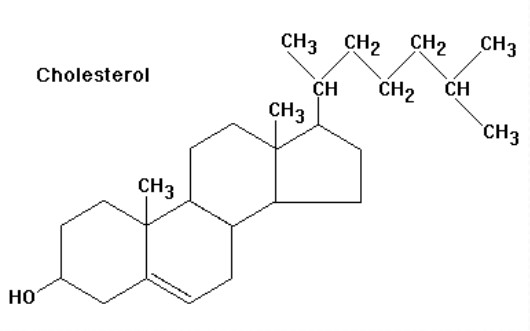


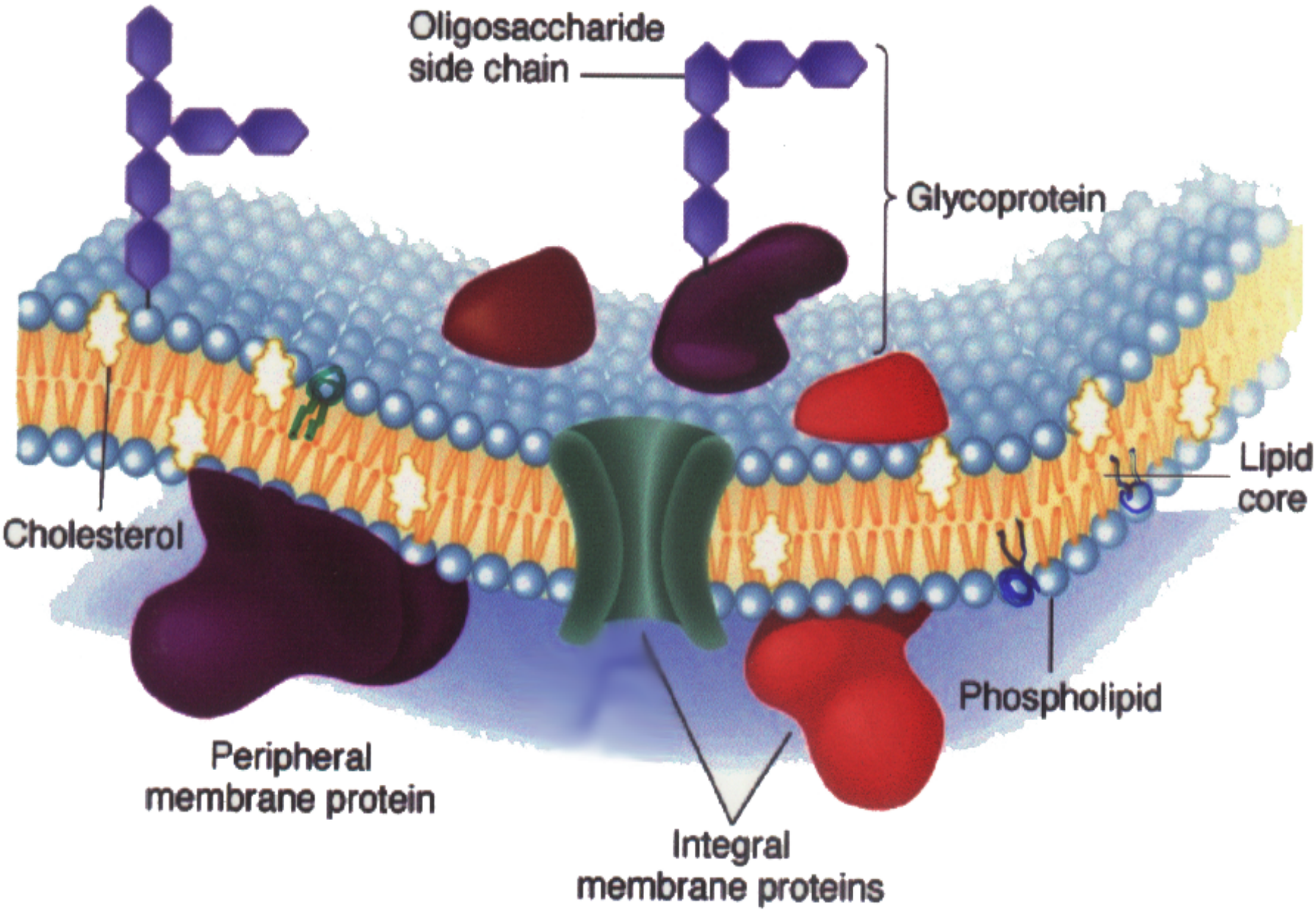
Cell Membrane Composition:

- Plasma Membrane - selectively permeable membrane that is too thin to see with compound microscope, encloses cell and cell organelle, made of hydrophobic and hydrophilic components.
- ExtraCellular Matrix - composed of molecules that serve to bind adjacent cells. The material is a protein called collagen and elastin in animals.

- Integral proteins interact with “lipid bilayer”
  - Passive transport pores and channels
  - Active transport pumps and carriers
  - Membrane-linked enzymes, receptors and transducers
- Sterols stabilize the lipid bilayer
  - Cholesterol






Oligosaccharide
side chain
Glycoprotein
Lipid
core
Cholesterol
Phospholipid
Peripheral
membrane protein
Integral
membrane proteins

Permeability of Plasma Membrane:

- Intracellular fluid
- Extra cellular fluid.
- Differentially permeable membrane - selective

Concentration Gradients:

Concentration gradients: differences in concentration of materials between one area and another.

Materials passively move down …

concentration gradients

Intracellular & Extra Cellular Solutions:

- Solute - the substance being dissolved
- Solvent - that which dissolves another (e.g. water)

- Solution = solute + solvent

- Cellular gradients formed by concentration differences between solutes & solvents inside and out side the cell

Cell Transport:

1. **Passive Transport** - requires no extra energy, materials move down gradients.
   - No ATP energy required!!

   a. **Simple diffusion** - the tendency of materials to move from areas of high to low concentration

Example: How gases such as CO_2 and O_2 move across cell membranes

Dynamic Equilibrium, where molecules are still in motion, but no concentration gradient exists.

b. **Carrier-Facilitated Diffusion** - movement of molecules that are large or electrically charged across membranes facilitated by carrier proteins (aquaporins facilitate the movement of water).

These carrier proteins collectively called permeases and are embedded in the plasma membrane, no energy is used.

Example: Glucose and other chemicals (ions) may enter and leave cells by this way.

c. **Osmosis** - movement of water through a selectively permeable membrane down a concentration gradient.

Note: concentration refers to the relative number of water molecules on either side of the membrane.

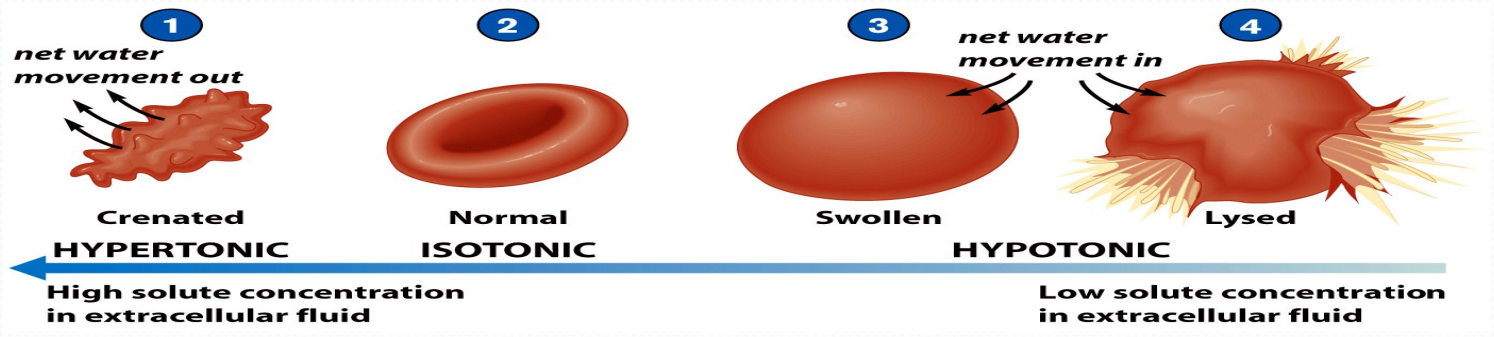
Example: Distilled water will have a higher concentration of solvent than the same volume of water with a solute dissolved in it (e.g. salt water).

Osmosis in Animal Cells:

1. Isotonic solution - there is the same concentration of solute and solvent inside the cell as outside.

2. Hypotonic solution – the fluid outside has a higher concentration of water molecules (or a lower concentration of solute) than inside the cell so water will flow into the cell

3. Hypertonic solution - the fluid outside has a lower concentration of water molecules (or a higher concentration of solute) than inside the cell so water will flow out of the cell



Active Transport:

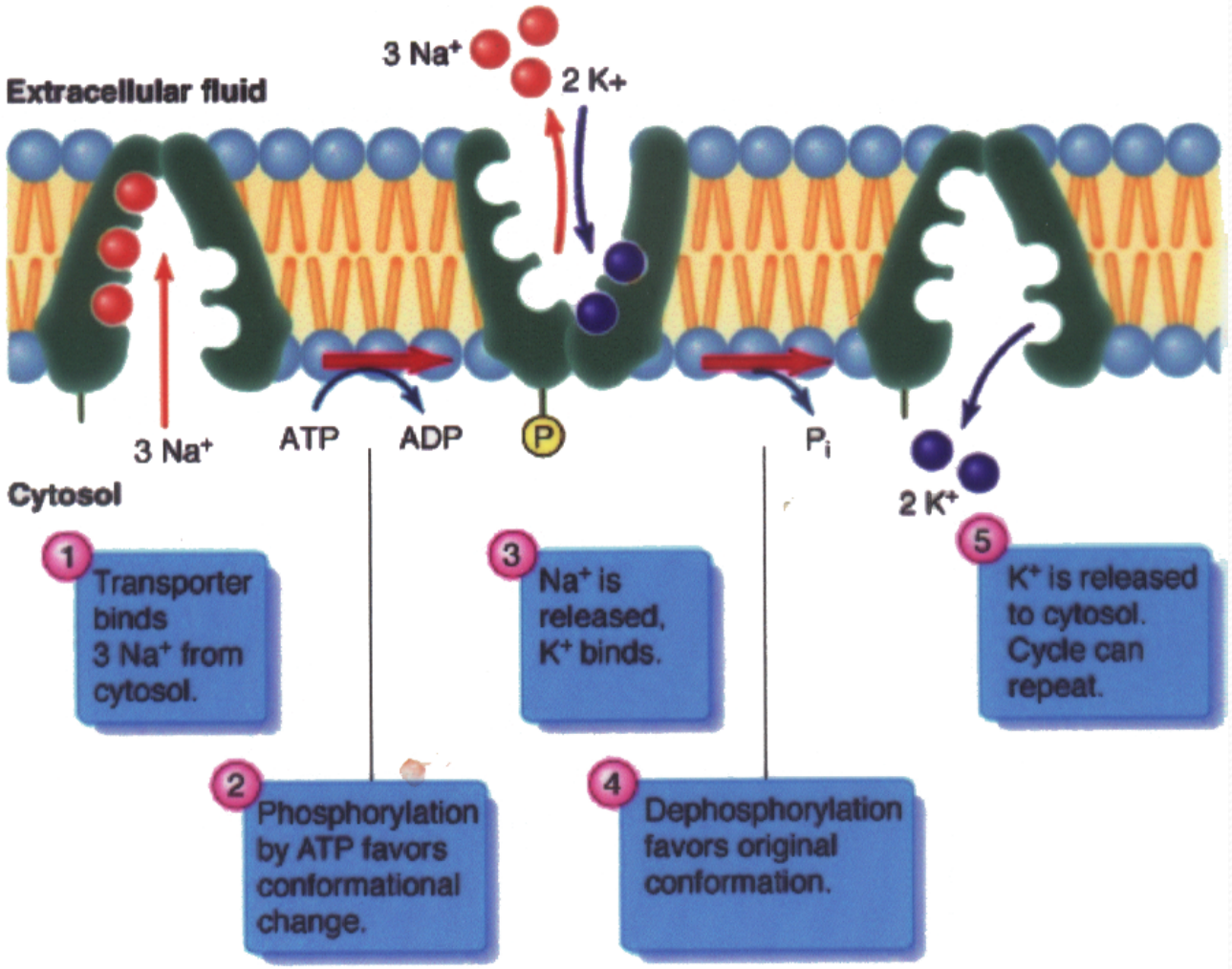
- Energy is required.

ATP-driven pump: uphill transport is powered by ATP hydrolysis (primary)

Light-driven pump: uphill transport is powered by energy from photons (bacteriorhodopsin)

Na^+/K^+ Pump:

- Actively transport Na^+ out of the cell and K^+ into the cell



- Against their electrochemical gradients
- For every 3 ATP, 3 Na^+ out, 2 K^+ in

Endocytosis and Exocytosis:

- Is transport of large molecules.
- **Exocytosis**: membrane vesicle fuses with cell membrane, releases enclosed material to extracellular space.
- **Endocytosis**: cell takes in macromolcules a particulate matter by forming new vesicles from plasma membrane.

their types:phagocytosis: cell engulf a particle.

pinocytosis : cell engulf droplets of extracellular fluid.

Cytoskeleton: 3-D network of small protein fibers extending throughout the cytoplasm. **Support, motility, regulation**

- Suspends organelles in the cytoplasm allowing movement

- Three types:

a. **Microfilaments** - very fine structures.

- important in cell division & cell movement , pull a forces, function in muscle.
- cell organization, amoeboid movement – pseudopodia.

b. **Intermediate fibers** - help maintain cell shape, mechanical support, provides anchorage for many organelles and cytosolic enzymes.

c. **Microtubules** - largest

- intracellular transport, they transport organelles like mitochondria or vesicles, mitotic spindle.

Internal Structures of Cells:

Cytoplasm - semi fluid, that serves as a pool of raw materials. Most (70%) is water, and the rest is proteins (mostly), carbohydrates, and nucleotides, as well as their monomers.

Ribosomes - small structures of non-membrane bound organelles, occurring mostly in the cytoplasm.

- site of protein synthesis
- molecular complexes of ribosomal RNA and proteins.

Nucleus:

- Two chief functions
  a) carry hereditary information
  b) exert influence on ongoing cell activity, helping to to maintain homeostasis.

- Contains DNA in the form of chromatin fibers, during cell division chromatin condensate to chromosomes.

- Nuclear Envelope - double membrane, each membrane is lipid bilayer with protiens, perforated by pores through which RNA passes

- **Nucleolus** - it manufactures ribosomal RNA.

- The nucleus control protein synthesis by sending messengers in the form RNA- mRNA- **transcription**
- Is synthesized in nucleus according the DNA.
- In ribosomes is genetic information translate into the primary structure of a specific protein- **translation**
- **Free ribosomes-** suspended in the cytosol, function of protein in cytosol.
- **bound ribosomes-** are attached to outside membrane of EBR; make protein destined into membrane and for export from the cell(secretion).

Organelles of Synthesis, Storage, and Export

Endoplasmic reticulum - a network of flattened hollow tubules and channels called cisternae, site where cell membrane and exported material is made. ER continuouse with nuclear envelope.

a. **Smooth** ER – cytoplasmatic surface lacks ribosomes, manufactures lipids (phospholipids, steroids), contains enzymes that detoxify certain poisons and drugs, metabolism of carbohydrates (glycogen), lipids, and other non-proteins.
b. **Rough** ER – in these tubules ribosomes are attached to the cytoplasmatic side (proteins are synthesized, that are destined to be secreted to other components of endomembranes system).

Golgi Apparatus

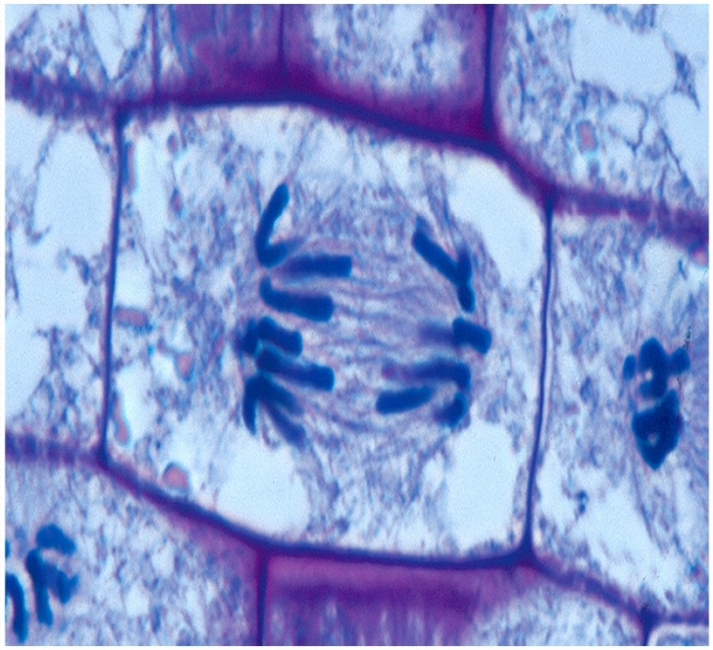
- Collection of flat sacs that sorting cell products, they are modified and stored, transport proteins produced by rough ER to the outside of the cell.

- Secretary vesicles transport material out of organelle via exocytosis.

Two poles are referred to as cis and trans.

Centrioles:

- Found only in animal cells
- Pairs of microtubular organelles found together near the nucleus, at right angles to each other.
- Role in building cilia and flagella
- Play a role in cell division.



Types of Secretory Vesicles

- **Lysosomes** - membrane bounded sac of hydrolytic enzymes that hydrolyze in acidic environment (pH 5) proteins, polysaccharides, fats and nucleic acids

Function: **a**) is intracellular digestion of food particles, smaller organisms and organic components engulfing by phagocytosis and own organic old material by autophagy.

b) act as "suicide bags"

Energy Organelles:

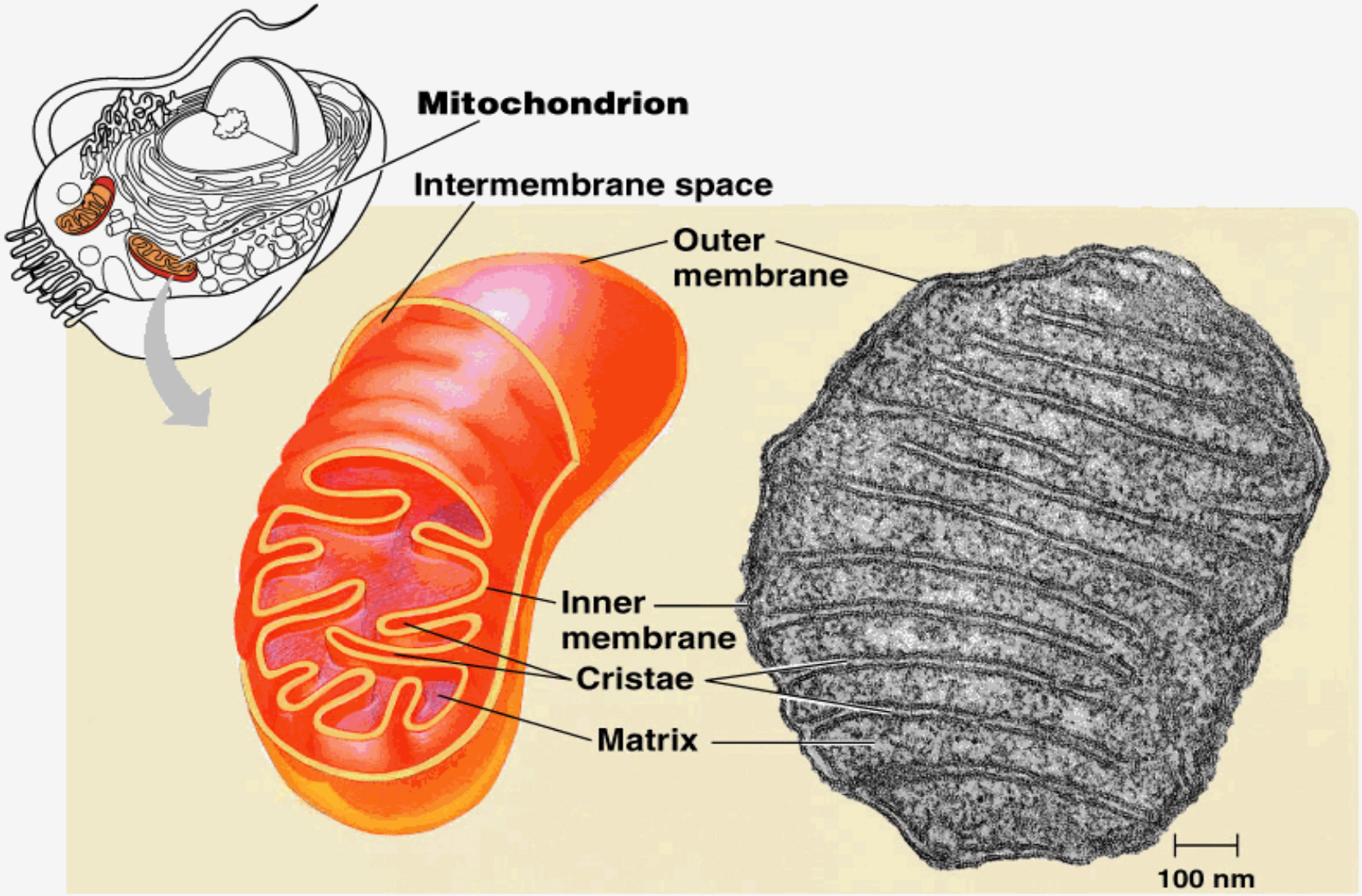
1. Mitochondria - double membrane bound organelle

- ATP is produced here by cell respiration.
- elongate and surrounded by 2 phosphobilipid bilayer with a unique collection of embedded proteins.
- The outer membrane is smooth, the inner membrane is convoluted with infolding called **cristae**

Intermembrane space

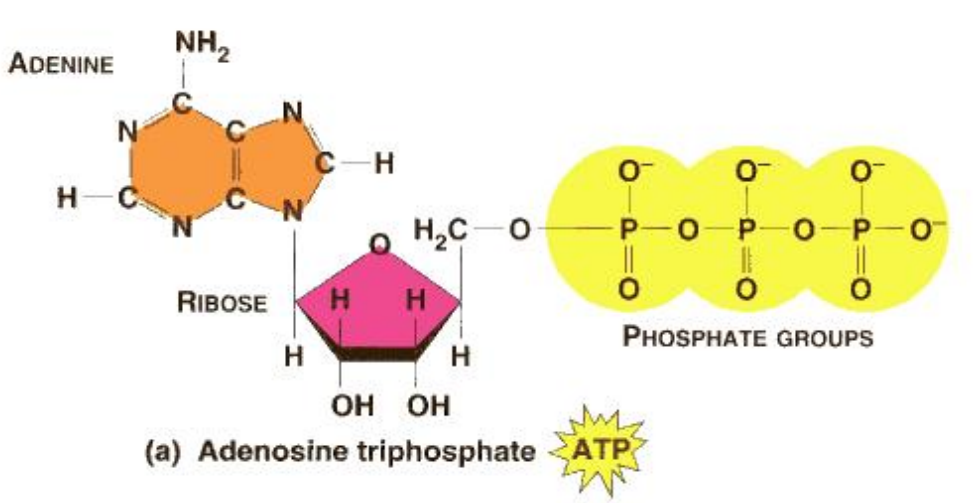
Mitochondrial matrix

- "Power House" of the cell
- Consumes Oxygen, produces CO2
- have their own DNA



What is ATP?

- Nucleotides
  - "Carry" chemical energy
    easily hydrolyzed
    phosphoanhydride bonds



- Combine to form coenzymes (coenzyme A (CoA)
- Used as signaling molecules (cyclic AMP)

Vacuoles - Small in animal cells (storage)

- Functions:

a) taking up space; pushing other organelles closer to the plasma membrane & give cell its shape.

b) store waste products to be released later or to prevent other organisms from eating them.

c) in some single-celled organisms, they are used to eliminate water (Contractile Vacuole).

Tissues & Organs of Humans

Lecture -7-

Dr. Aseel I. Ibrahim

Basic Human Tissue Types:

1- Epithelial tissue.

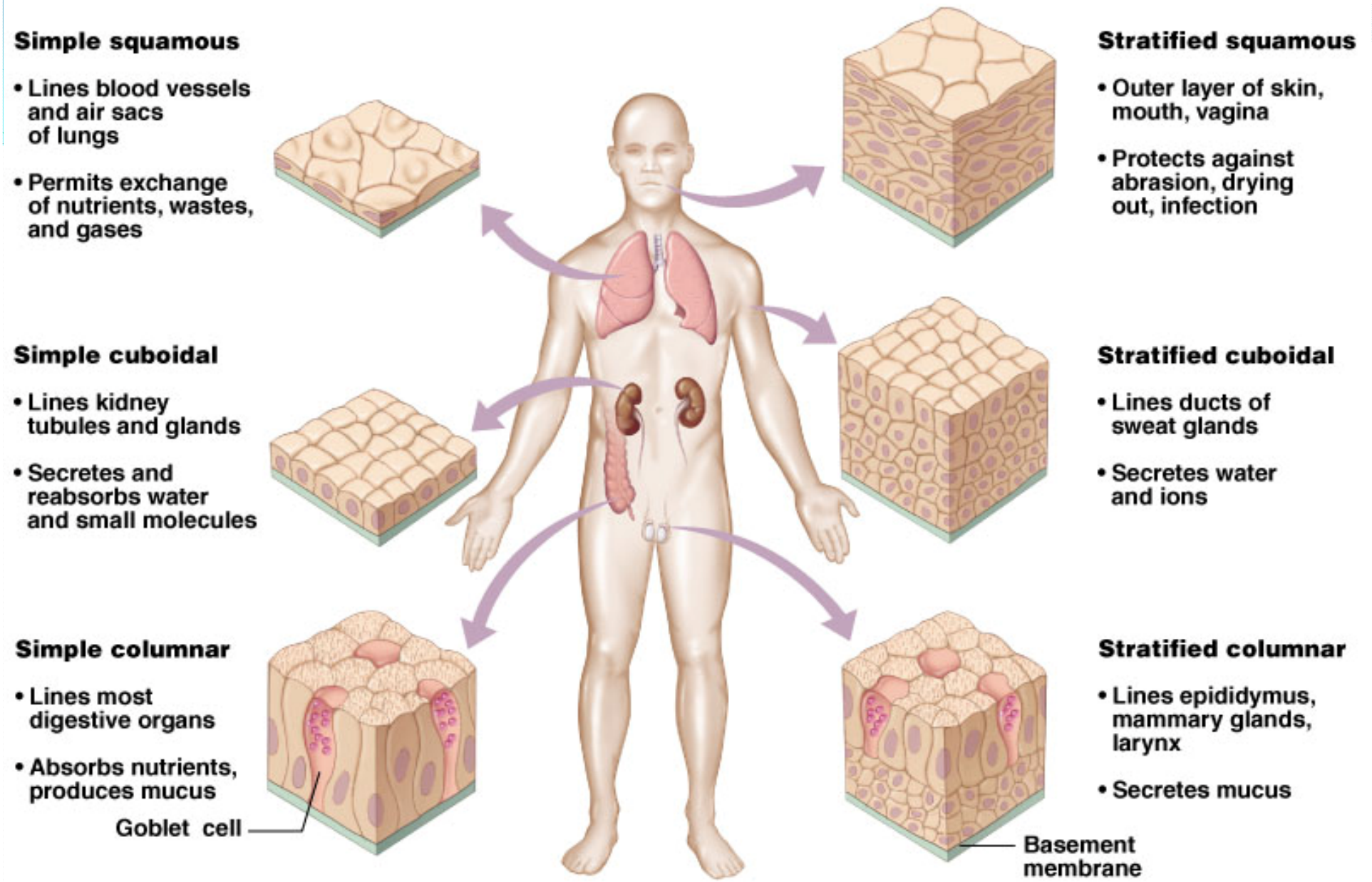
2-Connective tissue.

3- Muscle tissue.

4- nervous tissue.

1. Epithelial tissue

- sheets of tightly packed epithelial cells.
- covers outside of the body (skin or epidermis) & lines organs & cavities inside body (endothelium).
- classified by numbers of layers & shape of cells.
- function to:
  - a) absorb nutrients.
  - b) lubricate a surface.
  - c) secrete chemicals - glands.



(a) Most epithelial tissues line or cover surfaces or body cavities

Glands:

- Exocrine glands: secretion into ducts to exterior of body

- Endocrine glands: secretion into the blood to carry chemical messages throughout the body

2. Connective Tissue:

- Not tightly packed, **cells** are scattered throughout an extracellular **matrix**.
  - matrix may be liquid, solid, or jelly-like
- **Functions**: bind & support other tissues
- Main component matrix fibrous protein **collagen**.
- Tissue examples: cartilage, bone, & blood.

True connective tissue cells:

- **Fibroblasts**: Secrete both fibers and ground substance of the matrix (wandering).
- **Macrophages**: Phagocytes that develop from Monocytes (wandering or fixed), amoeboid cells that roam matrix eating bacteria and dead cells.
- **Plasma Cells**: Antibody secreting cells that develop from B Lymphocytes (wandering).
- **Mast Cells**: Produce histamine that help dilate small blood vessels in reaction to injury (wandering).
  - promote inflammation.
  - begin the healing process.
- **Adipocytes**: Fat cells that store triglycerides, support, protect and insulate (fixed).

Types of coonective tissues:

1- Loose Connective Tissue

Function - bind epithelia to underlying tissues, hold organs in place, or transport of materials.

Types of loose connective tissues:

1- **Areolar** C.T.: Widely distributed under epithelia. Consist of three types of fibers:

1- Collagen fibers: Large fibers made of the protein collagen and are typically the most abundant fibers. Promote tissue flexibility; keeps flesh on bone.

2- Elastic fibers (elastin): Intermediate fibers made of the protein elastin. Branching fibers that allow for stretch & rubbery.

3- Reticular fibers: Small delicate, branched fibers that have same chemical composition of collagen. Forms structural framework for organs such as spleen and lymph nodes.

Areolar C.T. found in subcutaneous layer, mucous membranes, around blood vessels, nerves and organs; their function, **strength, support and elasticity.**

2- Adipose tissue: contains cells which store fat, bound in a fibrous matrix; cells shrink or swell.

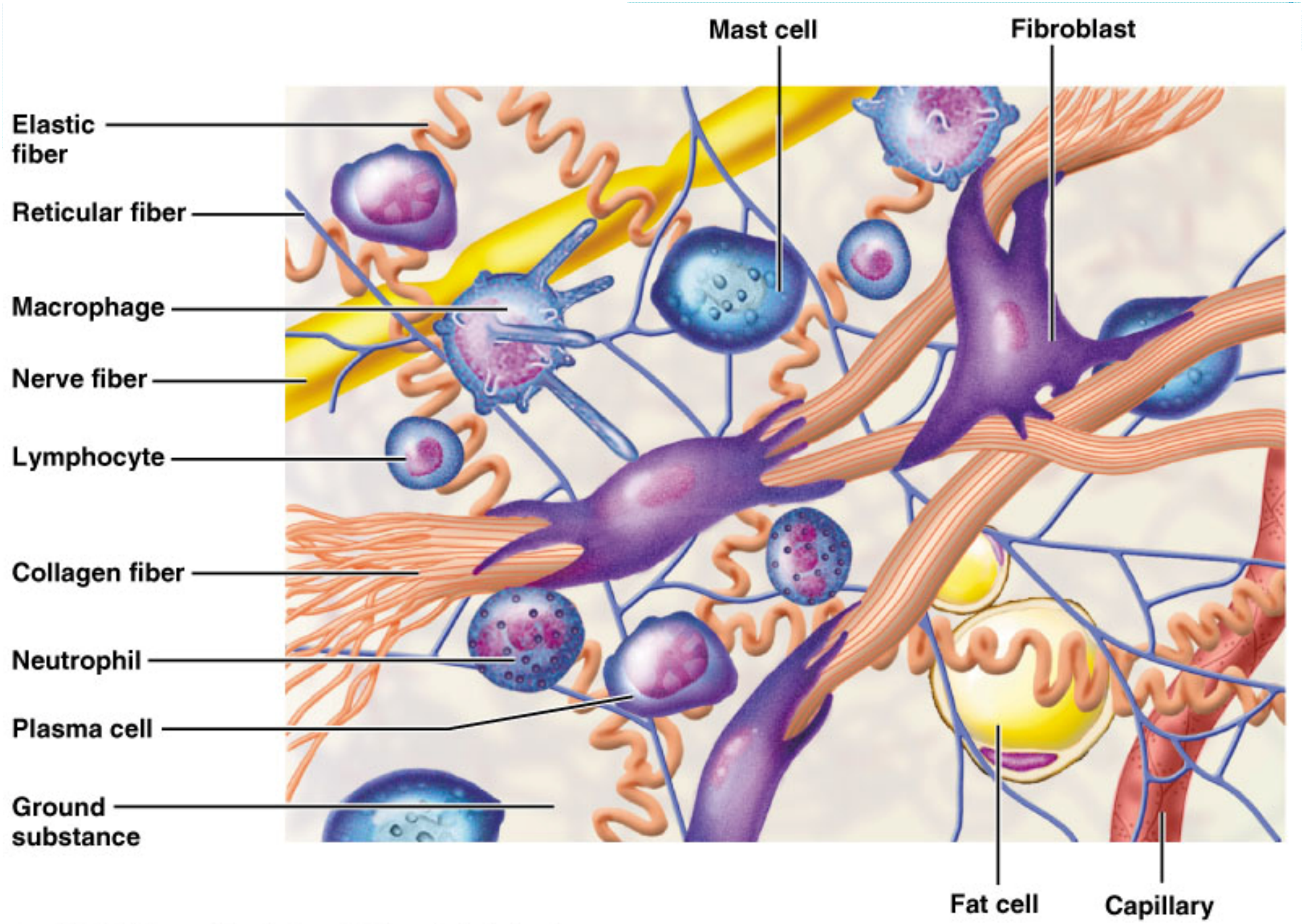
-They store energy in the form of triglycerides (lipids).

-Found in subcutaneous layer, around organs and in the yellow marrow of long bones.

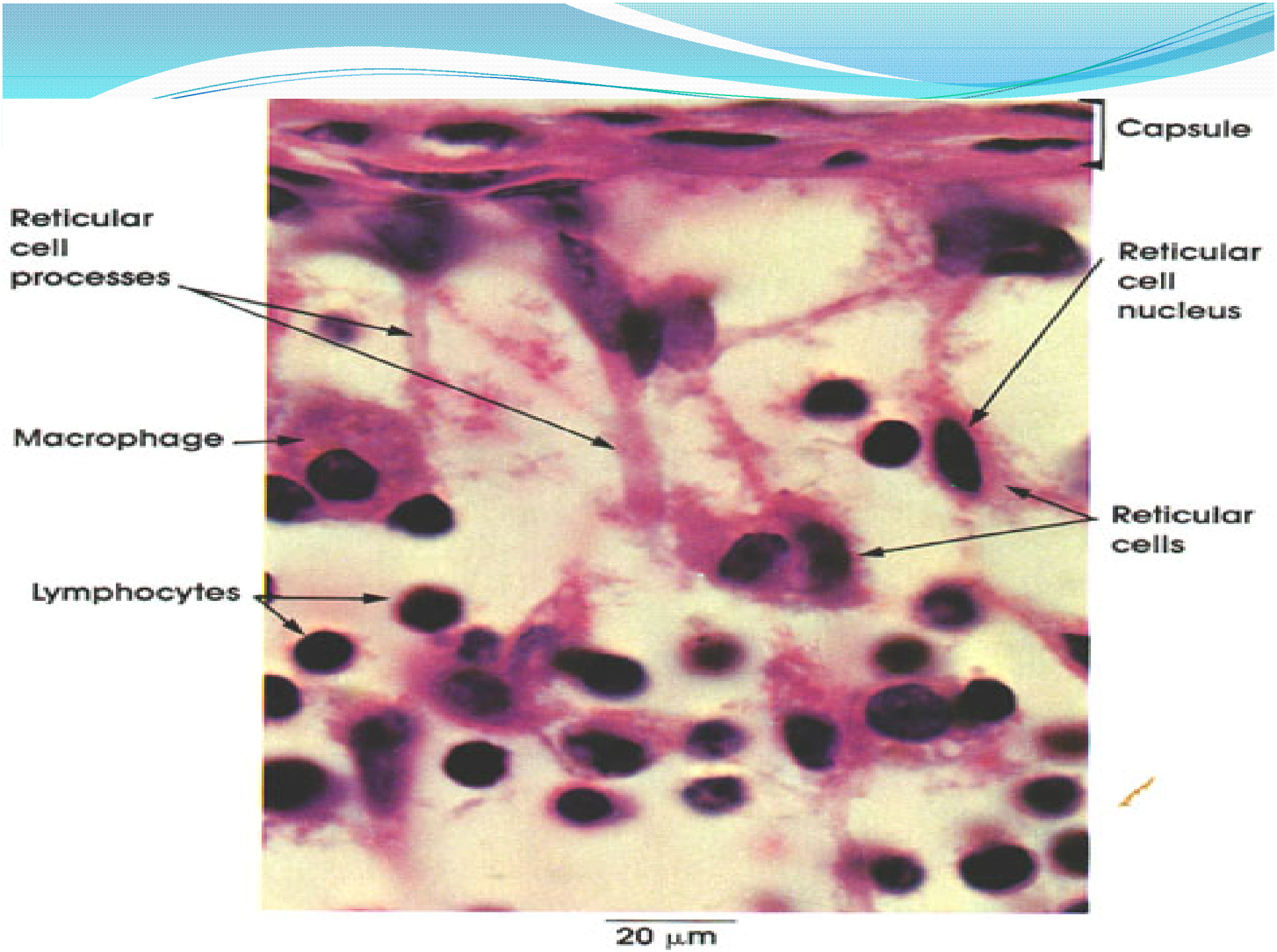
-Function: **supports, protects** and **insulates**, and serves as an **energy reserve.**

3- Reticular C.T.:

- Consists of fine interlacing reticular fibers and reticular cells.
- Found in liver, spleen and lymph nodes.
- Function: forms the framework (stroma) of organs and binds together smooth muscle cells.



Histology Lab Part 3: Slide 11


Capsule
Reticular cell processes
Reticular cell nucleus
Macrophage
Reticular cells
Lymphocytes
20 μm

2- Dense connective tissue:

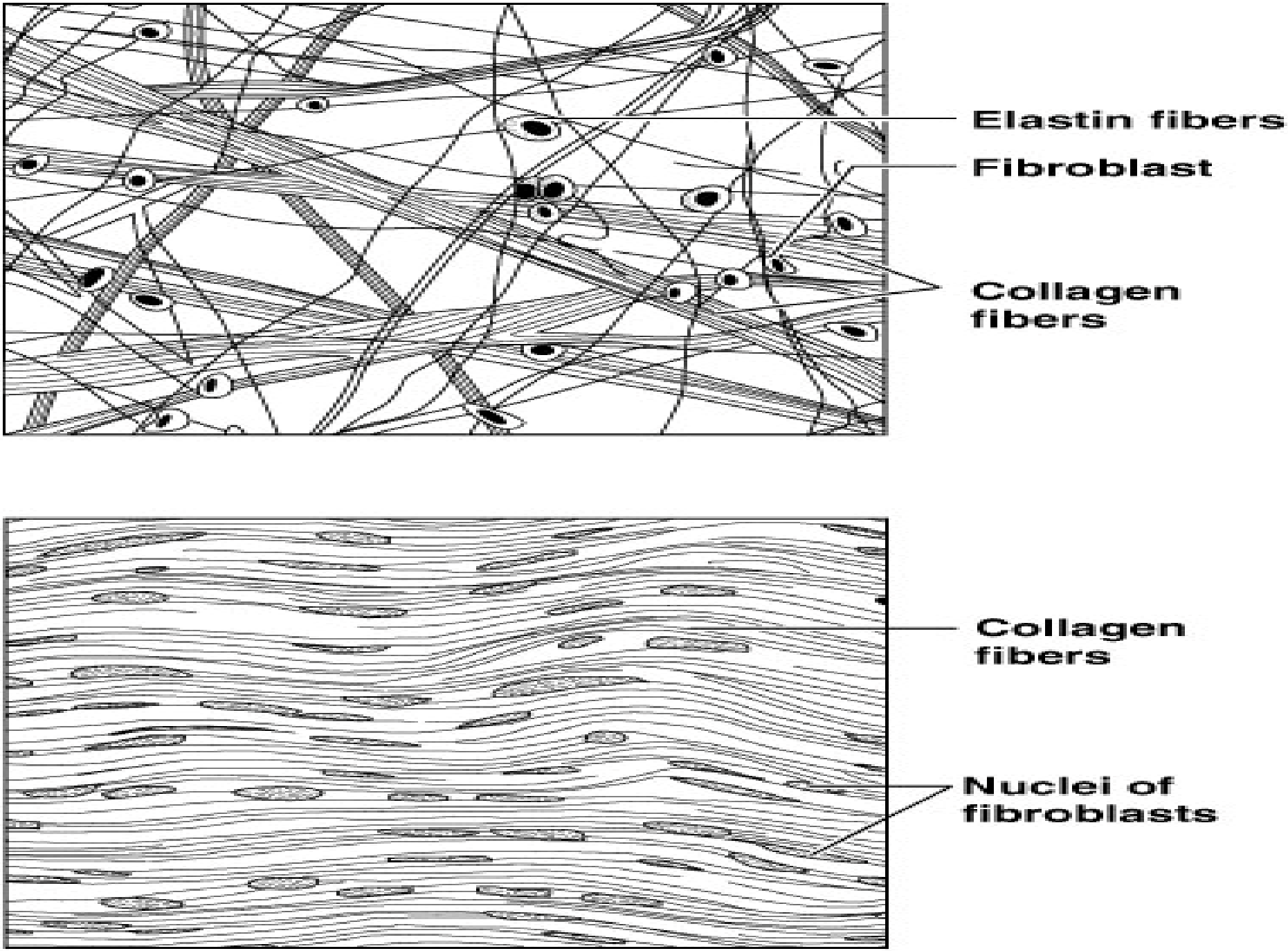
- contains more numerous and thicker fibers and far fewer cells than loose C.T.

1. Dense regular C.T.:

- consists of bundles of collagen fibers and fibroblasts.
- forms **tendons (**connect muscle to bone), and **ligaments (**connect bone to bone).
- Function: provide strong attachment between various structures.

2. Dense Irregular C.T.:

- consists of randomly-arranged collagen fibers and a few fibroblasts.
- Found in dermis of skin, and heart valves.
- Function: provide strength.



Supportive C.T.:

Cartilage:

- Jelly-like matrix (chondroitin sulfate) containing collagen and elastic fibers and chondrocytes surrounded by a membrane called the perichondrium.
- Unlike other C.T., cartilage has NO blood vessels or nerves except in the perichondrium.
- The strength of cartilage is due to collagen fibers and the flexibilty is due to the presence of chondroitin sulfate.
- Chondrocytes occur within spaces in the matrix called lacunae.

- **Types of cartilage:**

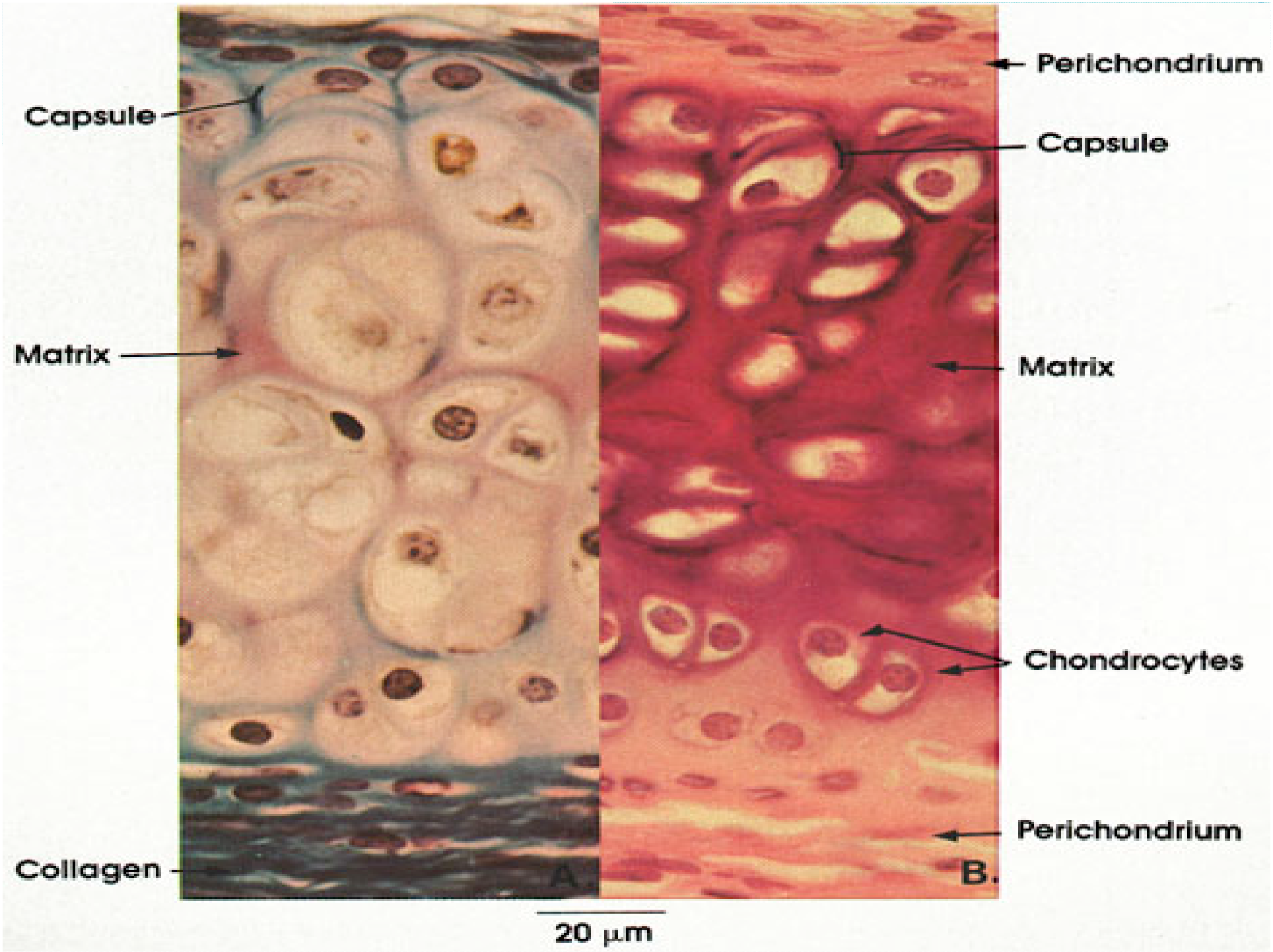
1- Hyaline cartilage.

2- Fibro cartilage.

3- Elastic cartilage.

1- Hyaline cartilage:

- Fine collagen fibers embedded in a gel-type matrix, chondrocytes inside lacunae.
- Found in embryonic skeleton, at the ends of long bones, in the nose and in respiratory structures.
- Function: flexible, provides support, allows movement at joints.

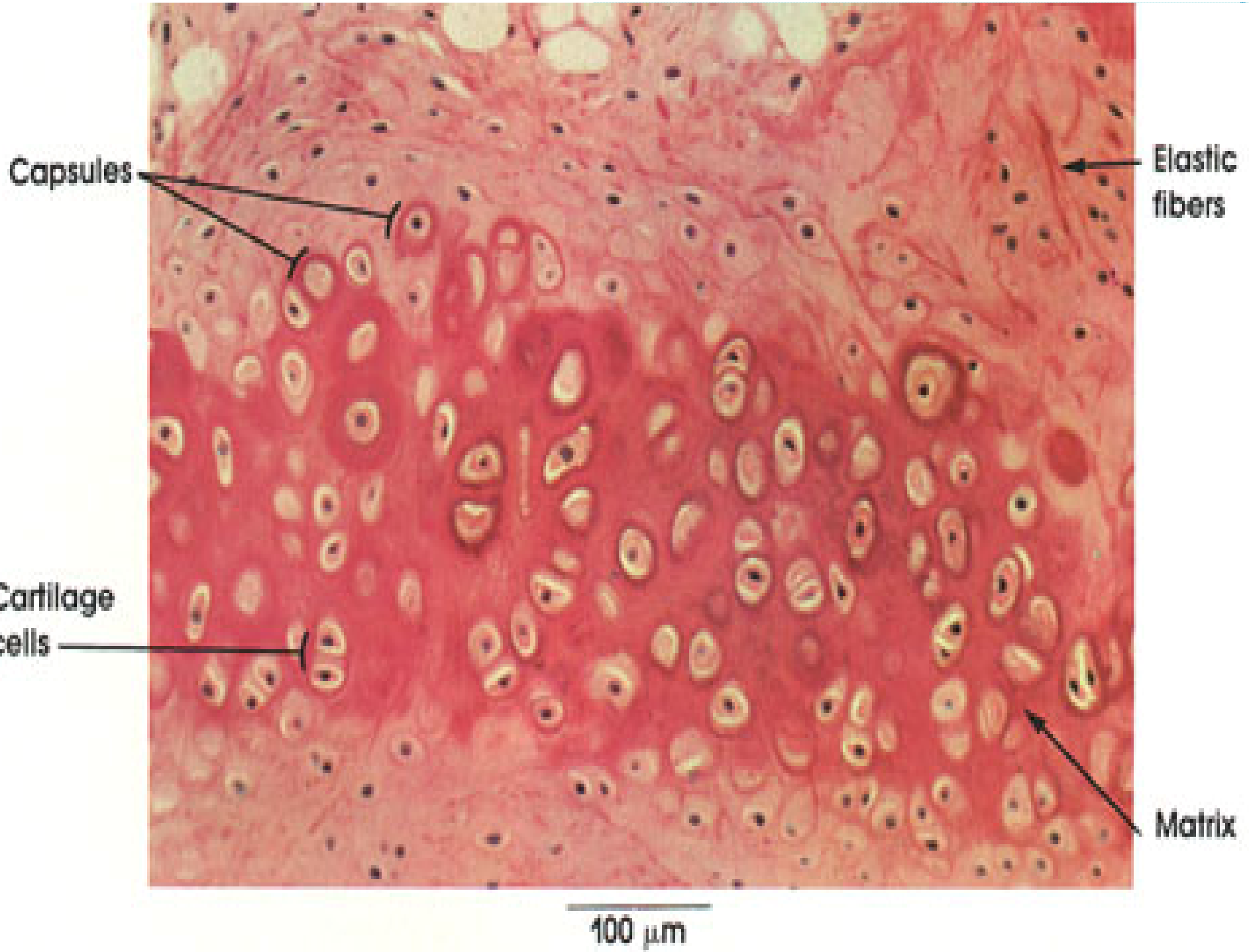

Capsule
Matrix
Collagen
A.
Perichondrium
Capsule
Matrix
Chondrocytes
Perichondrium
B.
20 μm

2. Fibro cartilage:

- contains bundles of collagen in the matrix that are usually more visible under microscopy.
- Found in the intervertebral discs.
- Function: support, and absorbs shocks.

3. Elastic Cartilage:

- Threadlike network of elastic fibers within the matrix.
- Found in external ear, epiglottis.
- Function = gives support, maintains shape, allows flexibility


Capsules
Elastic fibers
Cartilage cells
Matrix
100 μm

Bone tissue: four cell types make up osseous tissue:

- Osteoprogenitor cells.
- Osteoblasts.
- Osteocytes.
- Osteoclasts.

Osteoprogenitor cell:

- unspecialized stem cells undergo mitosis and develop into osteoblasts.
- found on inner surface of periosteum and endosteum.

- **Osteoblasts**:
  - bone forming cells.
  - found on surface of bone.
  - no ability to mitotically divide.
  - collagen secretors.

- **Osteocytes:**
  - mature bone cells.
  - derived form osteoblasts.
  - do not secrete matrix material.
  - cellular duties include exchange of nutrients and waste with blood.

Osteoclasts:

- found in pits in the bone surface.
- breaks down bone tissue.
- growth, maintenance and bone repair.

Abundant inorganic mineral salts:

- Tricalcium phosphate in crystalline form called hydroxyapatite

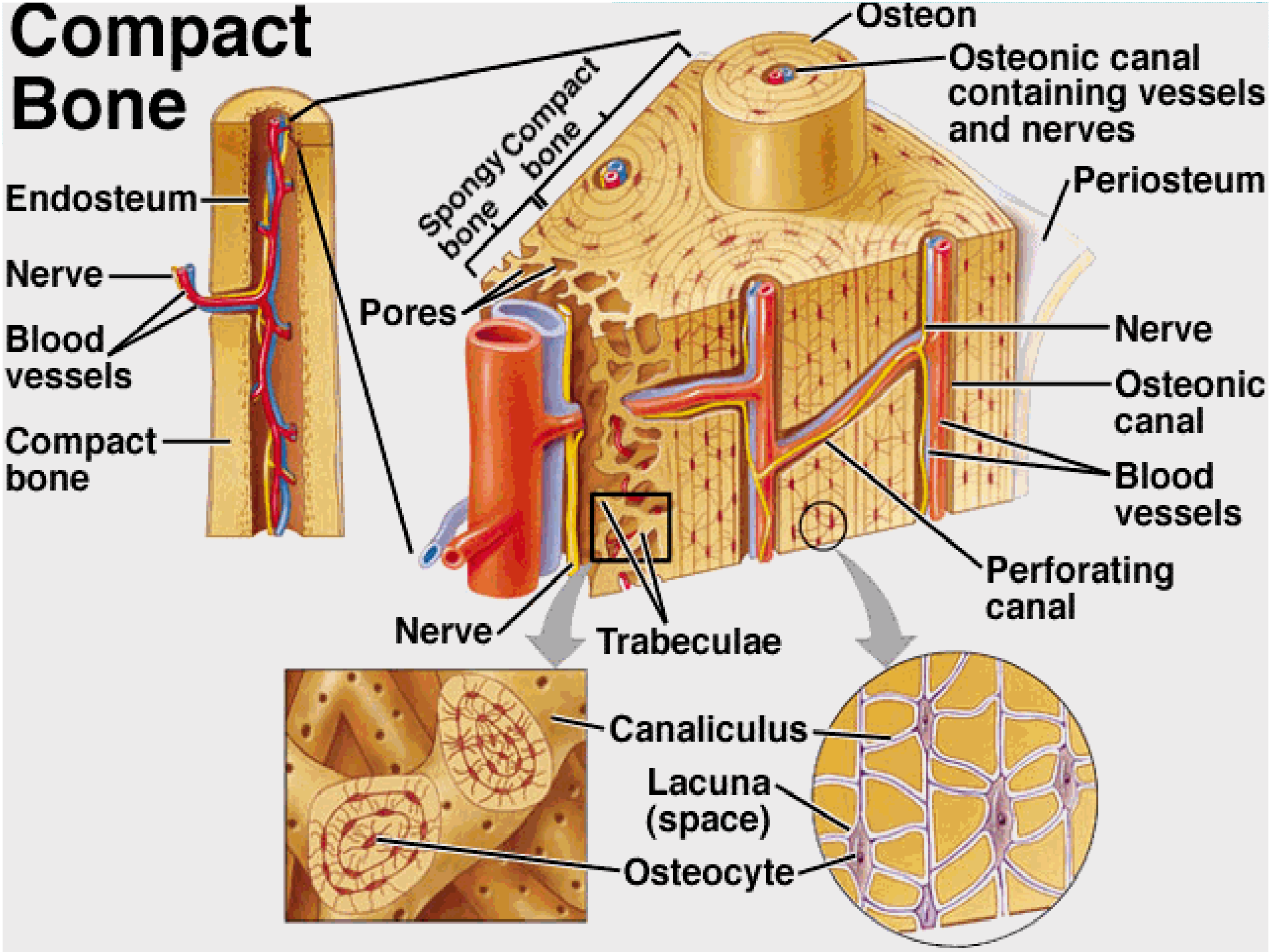
$$Ca_3(PO_4)_2(OH)_2$$

- Calcium Carbonate: $CaCO_3$
- Magnesium Hydroxide: $Mg(OH)_2$
- Fluoride and Sulfate

Compact bone: (**Osteon**) external layer

- ✓ called lamellar bone (groups of elongated tubules called lamella).
- ✓ majority of all long bones.
- ✓ blood vessels and nerves penetrate periosteum through horizontal openings called perforating (Volkmann's) canals.
- ✓ central (Haversian) canals run longitudinally. Blood vessels and nerves.
- ✓ around canals are concentric lamella.
- ✓ osteocytes occupy lacunae ("little lakes") which are between the lamella.
- ✓ radiating from the lacunea are channels called canaliculi. (finger like processes of osteocytes)

- ✓ Lacunae are connected to one another by canaliculi.
- ✓ Osteon contains: - central canal.
  - surrounding lamellae.
  - lacunae.
  - osteocytes.
  - canaliculi.


Compact Bone
Endosteum
Nerve
Blood vessels
Compact bone
Spongy bone
Compact bone
Pores
Osteon
Osteonic canal containing vessels and nerves
Periosteum
Nerve
Osteonic canal
Blood vessels
Perforating canal
Nerve
Trabeculae
Canaliculus
Lacuna (space)
Osteocyte

Function of bone:

1. supports the body (against gravity).
2. attachment point for muscles.
3. protects organs e.g. ribcage, skull.
4. some bones produce red blood cells.
5. acts as a reservoir for calcium.

- **Blood** : matrix is liquid (plasma), transport.