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✶.*Biology*

Biology "***Bios*** = life; ***logos*** = science" is the science which deals with study of living objects. Biology has two branches:

A-Botany or **Plant Biology** "***Botany*** = plants" is the study of plants.

B-Zoology "***Zoon*** = animal "is the study of animals.

✶. *Characteristics of living things*

Living things possess certain properties by which they can be easily distinguished from the non living things. The important characteristics of the living things are the following:

1-*Cellular structure*

Body of living organisms is composed of one or more microscopic structure units called **cells**.

2-*Protoplasm*

A cell is an organized mass of a complex living substance called protoplasm "***Proto*** =first ; ***plasm*** = form". It is composed of water, proteins, sugars, amino acids, fats, nucleic acids and certain mineral substances. All the vital functions of life are performed by protoplasm.

3-*Organized life cycle*

All the living things follow a definite life cycle of birth, growth, maturity, old, age and death.

4-*Fixed life span*

All the living things have a fixed life span which is the period from it's birth into it's death.

5-*Definite size and shape*

Every living thing has got a definite size and characteristic shape. It can be easily recognized from other things.

6-*Movement or Motility*

Most of the animals move bodily from one place to another with the help of certain organs or organelles, this called ***locomotion***.

7-*Metabolism*

A series of chemical processes are constantly going on in side the body of a living things. The sum total of all these chemical processes are called **metabolism** ***"Metabole*** = charge***".*** It comprises two kinds of charge; anabolism and catabolism.

(i)-*Anabolism*: is the constructive process in which complex living matter is built from simple substances and energy is stored.

(ii)-*Catabolism*: is the destructive process in which complex protoplasm breaks down into simple substances and energy is released.

Both anabolic and catabolic processes go on simultaneously in the body of living organism.

.*Metabolism is exhibited by the following life processes:

A-*Nutrition*

All living organisms need food. A regular supply of food is essential for maintenance of the living body. The green plants take simple substances like carbon dioxide and water and convert them into complex carbohydrate in the presence of sunlight. This phenomenon is called **photosynthesis**.

Animals take diffusible and non- diffusible complex organic substances as food. This process is called **ingestion**. The non-diffusible food substances are converted into diffusible forms. This process is called **digestion**.

The digested food is absorbed and distributed to various parts of the body and is ultimately converted into protoplasm. This process is called **assimilation**. The undigested waste matter is passed out of the body as faeces. This process is called **egestion** or **defaecation**.

***Nutrition** *is therefore anabolic process as it help in the building up of the body tissue.*

B-*Respiration*

It is an oxidizing and energy liberating process. It involves intake the oxygen and outgo of carbon dioxide. Oxygen oxidizes the tissue substances, carbon dioxide and water are produced and energy is liberated. This energy is utilized for performance of various bodily functions.

*** *Respiration*** *is thus a catabolic process as it tends to destroy the tissue substances by oxidation.*

8-*Secretion*

The living things produce many useful substances such as enzymes, hormones…etc. These substances are produced in different parts of body and are sent to other parts. This process is called ***secretion***.

9-*Excretion*

The elimination of non-gaseous and nitrogenous waste products produced during metabolism from the body is called ***excretion***.

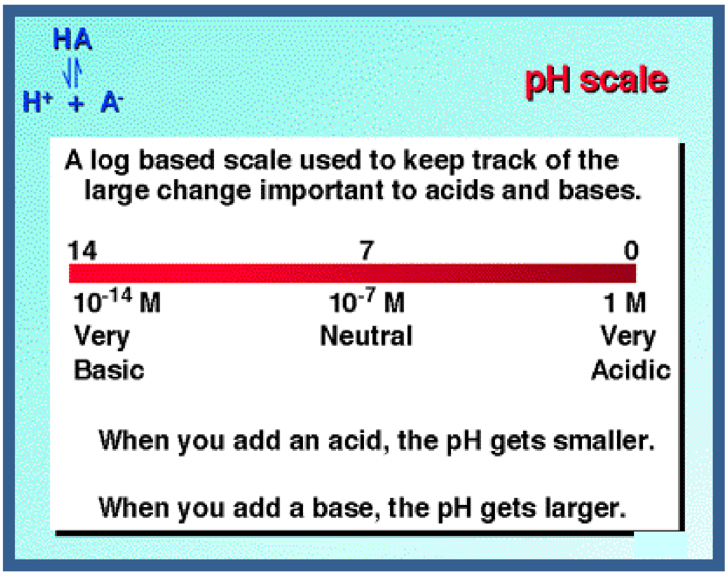
10- *Homeostasis*

Homeostasis is the maintenance of a constant (yet also dynamic) internal environment in terms of temperature, pH, water concentrations, etc. Much of our own metabolic energy goes toward keeping within our own homeostatic limits. If you run a high fever for long enough, the increased temperature will damage certain organs and impair your proper functioning.

Swallowing of common household chemicals, many of which are outside the pH (acid/base) levels we can tolerate, will likewise negatively impact on the human body's homeostatic regime.

Muscular activity generates heat as a waste product. This heat is removed from our bodies by sweating. Some of this heat is used by warm-blooded animals, mammals and birds, to maintain their internal temperatures.

***pH**: the negative logarithm of the H^+ ion concentration. The pH is a measure of the acidity or basic character of a solution. Since it measures a fraction, the larger the pH number, the less H ions are present in a solution.



11-*Irritability or Sensitivity*

It is the power of response to a stimulus. A living organism has the ability to respond to external stimuli such as light ,temperature…etc.

12-*Reproduction and heredity*

Living organisms have the power of producing individuals of their own kind in order to continue their progeny. Since all cells come from existing cells, they must have some way of reproducing, whether that involves ***asexual*** (no recombination of genetic material) or ***sexual*** (recombination of genetic material). Most living things use the chemical **DNA** (deoxyribonucleic acid) as the physical carrier of inheritance and the genetic information. Some organisms, such as retroviruses (of which **HIV** is a member) , use **RNA** (ribonucleic acid) as the carrier.

Asexual reproduction: A method of reproduction in which genetically identical offspring are produced from a single parent; occurs by many mechanisms, including ***fission***, ***budding***, and ***fragmentation***.

Sexual reproduction: A system of reproduction in which two **haploid** sex cells (gametes) fuse to produce a **diploid** zygote.

13-*Coordination*

The body of living organism is composed of a number of parts which work together for the welfare of the organism. Our body is composed of several parts, such as hands, feet, ear…etc. They work together in a team for the benefit of the body.

14-*Adaptation*

The body of living things is perfectly adapted according to the surrounding in which it lives. A fish lives in water, it s body is a boat shaped, it respires in water through the gills.

15-*Healing*

The living things have the power to repair their damaged parts. A wound caused to any part of the body of a living organism is healed in due course.

16-*Regeneration*

It is the ability to replace the lost parts. It is commonly found in plants and some lower animals such as earthworm, sponge and lizard.

17-*Definite individuality*

Every living things possess a definite individuality. It exists as a complete unit and has a separate entity.

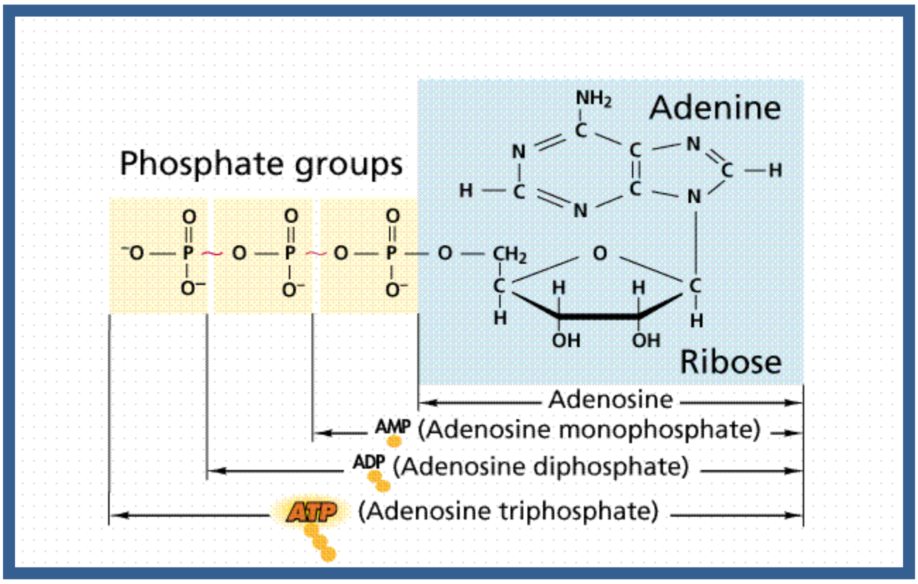
18-*Struggle or competition*

All the living things show struggle for existence. They struggle against each other and against the changed conditions.

19- *Energy acquisition and release*

One view of life is that it is a struggle to acquire energy (from sunlight, inorganic chemicals, or another organism), and release it in the process of forming **ATP** (adenosine triphosphate).

***Adenosine triphosphate* (ATP):** A common form in which energy is stored in living systems; consists of a nucleotide with ribose sugar with three phosphate groups. The energy coin of the cell.



20-*Proper environment*

A living thing lives at a place where proper environment is available. They are not found everywhere.

21- *Growth and development*

Even single-celled organisms grow. When first formed by cell division, they are small and must grow and develop into mature cells. Multicellular organisms pass through a more complicated process of differentiation and organogenesis (because they have so many more cells to develop).

22-*Interactions*

Living things interact with their environment as well as each other. Organisms obtain raw materials and energy from the environment or another organisms. The various types of symbioses (organismal interactions with each other) are examples of this interactions.

Symbiosis: An interactive association between two or more species living together; may be **parasitic**, **commensal**, or **mutualistic**, the relationship between two organisms.

A- *Parasitism* A form of symbiosis in which the population of one species benefits at the expense of the population of another species similar to predation, but differs in that parasites act more slowly than predators and do not always kill the host. A type of symbiosis in which one organism benefits at the expense of the other, for example the influenza virus is a parasite on its human host. Viruses, are obligate intracellular parasites.

B-*Commensalism*: A symbiotic relationship in which one species benefits and the other is not affected.

C-*Mutualism*: A form of symbiosis in which both species benefit. A type of symbiosis where both organisms benefit. The classic example is **lichens**, which is a symbiosis between an alga and a fungus. The alga provides food and the fungus provides water and nutrients.

23-*Death*

The living things ultimately suffer from death.

✶. Branches Of Zoology

Zoology is the science deals with animals. There are several branches of Zoology. They deal with different aspects of animal life. The most important branches of Zoology are following:

1. Morphology

Morphology is the study of external and internal structure of animals. It is studied under two branches: -

a. External morphology: It is the study of external structure of animals.

b. Internal morphology: It is the study of internal structure of animals. It has three sub-branches: -

(i) Anatomy

It is the study of the different parts of internal structure of animal as seen by the naked eye after dissection.

(ii) Histology

It is the study of the microscopic structure of the tissues of which the animal body is composed.

(iii) Cytology

It is the detailed microscopic study of a cell and its contents.

2. Physiology

It deals with the bodily functions of the animals such as nutrition, respiration, excretion, movements, reproduction etc.

3. Taxonomy or Systematic Zoology

It deals with classification and naming of animals.

4. Ecology

It is the study of animals and in relation to their environment such as temperature, water, soil … etc.

5. Embryology

It is the study of development of an animal from egg to adult stage.

6. Paleontology

It is the study of fossils which are the stonefield remains or impressions of the animals which existed in the past.

7. Zoo – geography

It is the study of the distribution of animals in different parts of the world.

8. Pathology

It is the study of animal diseases caused by other animals or plants.

9. Economic Zoology

It deals with economic importance of animals.

10. Evolution

It is the study of origin of new and complex forms from older and simpler forms by modifications due to changed conditions.

11. Genetics

It is the study of **Heredity** and **Variations**. **Heredity** is the transmission of characters from parents to offspring. **Variations** are the differences which occur in structure and functions among individuals of the same species.

12. Eugenics

It is the study of improvements of human races.

13. Euthenics

It is the study of environment and its influence on mankind.

14. Space Zoology

It is the study of survival problems of animals in the outer space.

15. Molecular biology

It is the study of living objects up to molecular level.

16. Natural History

It is the study of habits of animals.

17. Ethology

It is the study of behavior of animals in response to stimuli.

18. Parasitology

It is the study of parasitic forms.

19. Immunology

It is concerned with mechanism involved in the development of resistance by body to infectious diseases.

20. Mycology

It deals with the study of fungi.

21. Virology

It is the study of viruses.

22. Bacteriology.

It deals with the study of bacteria.

Besides this, there are certain specialized branches of Zoology. They deal with particular kinds of animals or their particular systems. The following are some important special branches (**Zoology** *has some important specialized branches*):

(i) Protozoology: It deals with the study of Protozoa (Unicellular animals).

(ii) Helminthology: It deals with the study of worms.

(iii) Entomology: It is the study of insects,

(iv) Malacology: It is the study of Molluscs,

(v) Ichthyology: It is the study of fishes,

(vi) Herpetology: It is the study of snakes and lizards,

(vii) Ornithology: It is the study of birds,

(viii) Mammalogy: It is the study of mammals.

(Ix) Osteology: It is the study of skeleton of animals,

(x) Myology: It is the study of muscular system of animal,

(xi) Syndesmology: It is the study of joints of animals,

(xii) Angiology: It is the study of circulatory system of animals.

(xiii) Splanchnology: It is the study of visceral system of animals,

(xiv) Neurology: It is the study of nervous system of animals

(xv) Endocrinology: It is the study of endocrine glands.

(xvi) Anthropology: It deals with the study of physical and social nature of primitive and modern man.

(xvii) Haematology: It is the study of blood.

The above branches mostly deal with the basic phenomenon of animal life. They are put together as a sub-division of zoology called **pure zoology**.

There is another sub-division of zoology is called **applied zoology**. This includes those branches of zoology which are of economic value to man. The main branches of **applied zoology** are the following:

(i) Medicine: It deals with the study of curing the diseases of man by drugs.

(ii) Surgery: It is the study of removal of human sufferings by surgical operations.

(iii) Dietetics: It is the study of nutrition.

(iv) Dentistry: It is the study of teeth.

(v) Veterinary science: It deals with the study of domestic animals.

(vi) Fishery or Pisciculture: It deals with the study of rearing fish.

(vii) Sericulture: It is the study of rearing silk-worm for silk.

(viii) Apiculture: It deals with the study of bee-keeping for obtaining honey and wax.

(ix) Poultry: It is the study of raising fowl for eggs and meat.

(x) Dairying: It is the study of keeping cattle (buffaloes and cows)

(xi) Piggery: It is the study of keeping pigs for meat for milk and pickles.

(xii) Animal husbandry: It deals with the study of breeding and care of animals,

(xiii) Hygiene: It deals with the health problems of man.

Because of recent researches with new techniques, modern Biology is divided into the following branches :

(i) Molecular Biology: It deals with the study of various aspects of Biology at the molecular level.

(ii) Cellular Biology: It deals with the structure and functions of the cells.

(iii) Organisms Biology: It deals with the anatomy, physiology, ecology and phylogeny of whole organisms.

(iv) Developmental Biology: It is the Study of development, healing and aging of organisms.

(v) Population Biology: It is the study of biological principles *(i.e.* food chains, energy flow ecological crisis etc.) observed in ecosystems.

(vi) Space Biology: It deals with the study of survival problems of plants and animals in the outer space.

(vii) Applied Biology: It is the study of application of biological laws to improve the economy of man and to eradicate diseases.

(viii) Radio-biology: It deals with the study of effects of radioactivity on biological system.

(ix) Marine Biology: It is the study of marine life.

(x) Pollution: It is the study of pollution of water, air and atmosphere and their check and Control measures.

✶. Levels of Biological Organization

♦ *Biosphere*

The sum of all living things taken in conjunction with their environment. In essence, where life occurs, from the upper reaches of the atmosphere to the top few meters of soil, to the bottoms of the oceans. We divide the earth into ***atmosphere*** (air), ***lithosphere*** (earth), ***hydrosphere*** (water), and **biosphere** (life).

Atmosphere The envelope of gases that surrounds the earth; consists largely of nitrogen (78%) and oxygen (21%).

Lithosphere The solid outer layer of the Earth; includes both the land area and the land beneath the oceans and other water bodies.

Hydrosphere The part of the physical environment that consists of all the liquid and solid water at or near the Earth's surface.

♦ *Ecosystem*

The relationships of smaller groups of organisms with each other and their environment. Scientists often speak of the interrelatedness of living things. Since, according to Darwin's theory, organisms adapt to their environment, they must also adapt to other organisms in that environment. We can discuss the flow of energy through an ecosystem from photosynthetic autotrophs to herbivores to carnivores.

♦ *Community*

The relationships between groups of different species(All species or populations living in the same area). For example, the desert communities consist of rabbits, coyotes, snakes, birds, mice and such plants as sahuaro cactus (*Carnegia gigantea*), Ocotillo, creosote bush, etc. Community structure can be disturbed by such things as fire, human activity, and over-population.

Species

One or more populations of interbreeding or potentially interbreeding organisms that are reproductively isolated in nature from all other organisms. Populations of individuals capable of interbreeding and producing viable, fertile offspring.

Populations

Groups of similar individuals who tend to mate with each other in a limited geographic area. This can be as simple as a field of flowers, which is separated from another field by a hill or other area where none of these flowers occur.

Individuals

One or more cells characterized by a unique arrangement of DNA "information". These can be unicellular or multicellular. The multicellular individual exhibits specialization of cell types and division of labor into tissues, organs, and organ systems.

Organ System

Groups of organs that perform related functions. In multicellular organisms, a group of cells, tissues, and organs that perform a specific major function. For example, the cardiovascular system(The human circulatory system consisting of the heart and the vessels that transport blood to and from the heart) functions in circulation of blood.

Organs

Differentiated structures consisting of tissues and performing some specific function in an organism. Structures made of two or more tissues which function as an integrated unit. e.g. the heart, kidneys, liver, stomach.

Tissue

In multicellular organisms, a group of cells performing a specific function. For example heart muscle tissue is found in the heart and its unique contraction properties aid the heart's functioning as a pump.

Cell

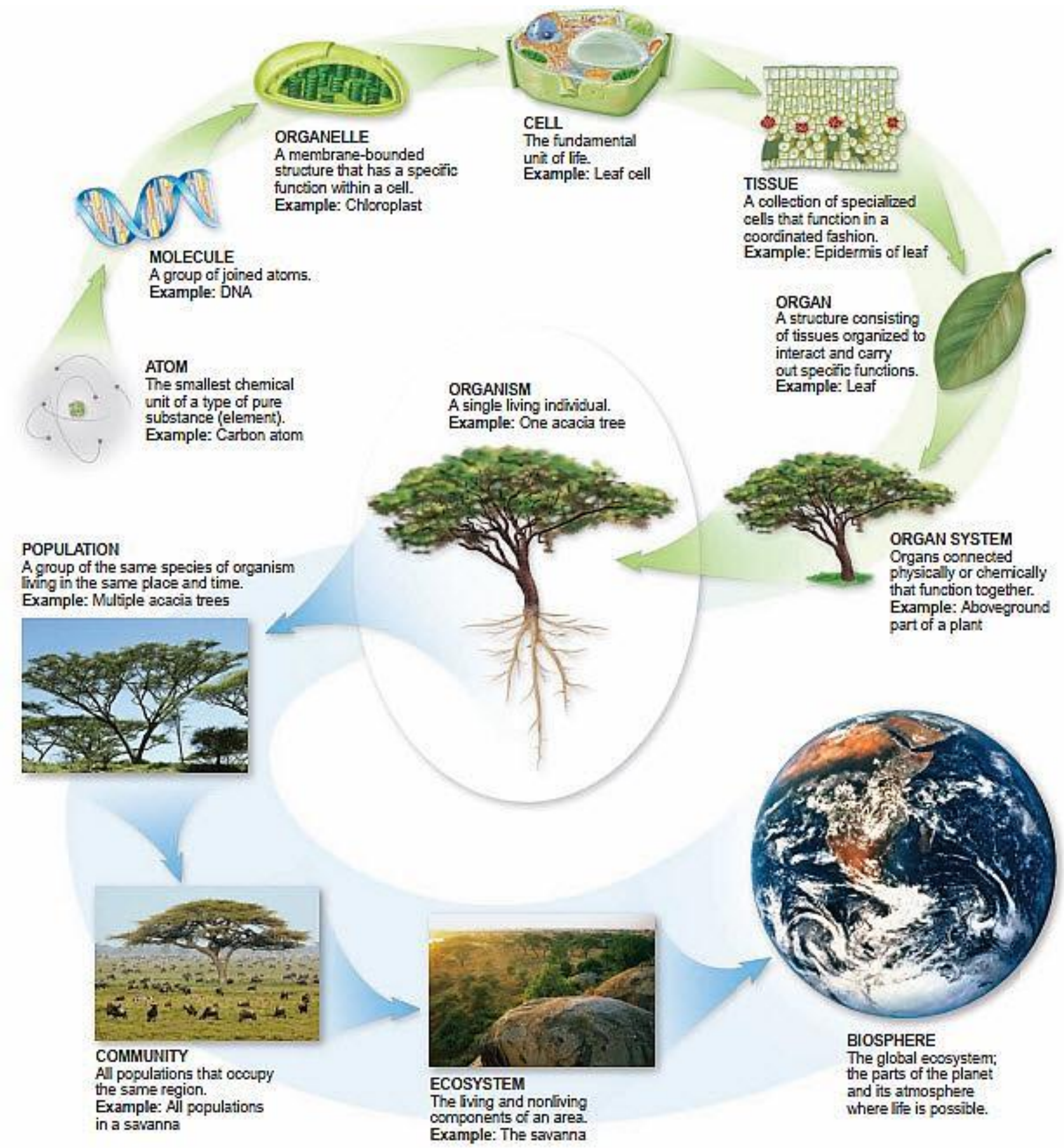
The fundamental unit of living things. Each cell has some sort of hereditary material (either DNA or more rarely RNA), energy acquiring chemicals, structures, etc. Living things, by definition, must have the metabolic chemicals plus a nucleic acid hereditary information molecule.

Organelle

A subunit of a cell, an organelle is involved in a specific subcellular function, for example the ribosome (the site of protein synthesis) or mitochondrion (the site of ATP generation in eukaryotes).

Molecules, atoms, and subatomic particles (Protons, Neutrons & Electrons)

The fundamental functional levels of biochemistry (Chemical processes associated with living things).


ORGANELLE
A membrane-bounded structure that has a specific function within a cell.
Example: Chloroplast
CELL
The fundamental unit of life.
Example: Leaf cell
TISSUE
A collection of specialized cells that function in a coordinated fashion.
Example: Epidermis of leaf
MOLECULE
A group of joined atoms.
Example: DNA
ORGAN
A structure consisting of tissues organized to interact and carry out specific functions.
Example: Leaf
ATOM
The smallest chemical unit of a type of pure substance (element).
Example: Carbon atom
ORGANISM
A single living individual.
Example: One acacia tree
POPULATION
A group of the same species of organism living in the same place and time.
Example: Multiple acacia trees
ORGAN SYSTEM
Organs connected physically or chemically that function together.
Example: Aboveground part of a plant
BIOSPHERE
The global ecosystem; the parts of the planet and its atmosphere where life is possible.
COMMUNITY
All populations that occupy the same region.
Example: All populations in a savanna
ECOSYSTEM
The living and nonliving components of an area.
Example: The savanna

Prokaryotic Cells Are Structurally Simpler than Eukaryotic cells

The basic structural and functional unit of every organism is one of two types of cells-prokaryotic or eukaryotic. Bacteria and archaea consist of **prokaryotic cells**, whereas all other forms of life (protists, fungi, plants, and animals) are composed of **eukaryotic cells**. Eukaryotic cells are distinguished by having a membrane-enclosed nucleus, which houses most of their DNA. The word eukaryote means "true nucleus" (from the Greek ***eu***, true, and ***karyon***, kernel, referring to the nucleus). The word prokaryote means "before nucleus" (from the Greek ***pro***, before), reflecting the fact that prokaryotic cells evolved before eukaryotic cells. They are also, as you shall see, structurally much simpler than eukaryotic cells while sharing some common characteristics.

-The chief distinguishing characteristics of **prokaryotes** are as follows:

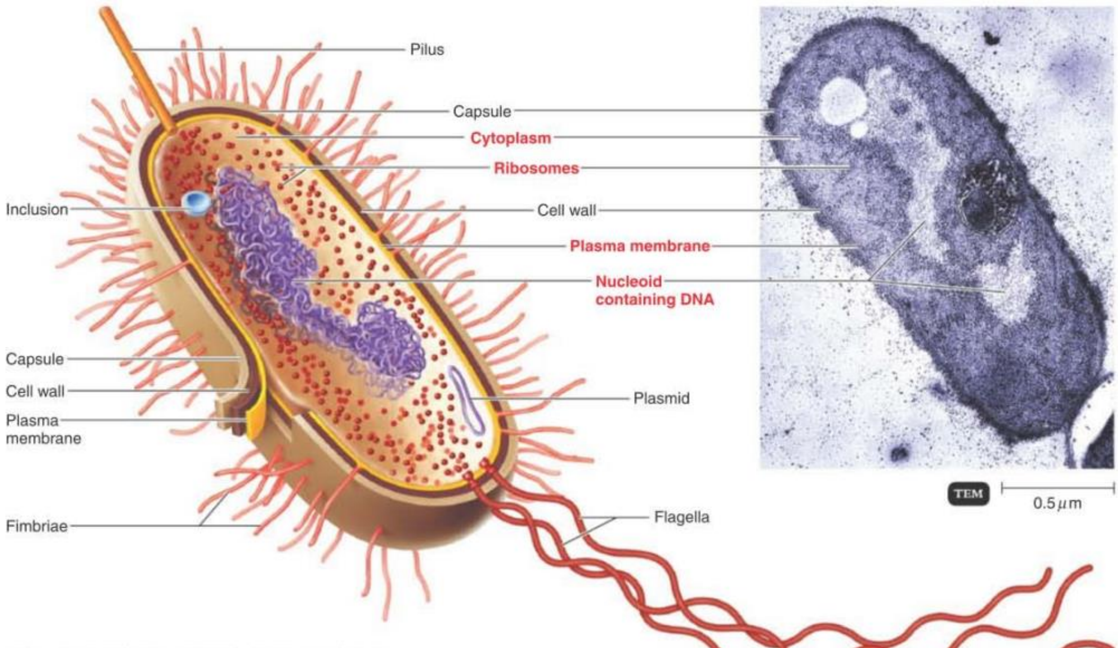
1-Their DNA is not enclosed within a membrane and is usually a singular circularly arranged chromosome. (Some bacteria such as ***Vibrio cholera*** have two chromosomes, and some bacteria have a linearly arranged chromosome).

2-Their DNA is not associated with histones (special chromosomal proteins found in eukaryotes); other proteins are associated with the DNA.

3-They lack membrane-enclosed organelles.

4-Their cell walls almost always contain the complex polysaccharide peptidoglycan.

5-They usually divide by binary fission. During this process the DNA is copied, and the cell splits into two cells. Binary fission involves fewer structures and processes than eukaryotic cell division.



Note that not all bacteria have all the structures shown.
Structures labeled in red are found in all bacteria. Both the

♦-**Eukaryotes** have the following distinguishing characteristics:

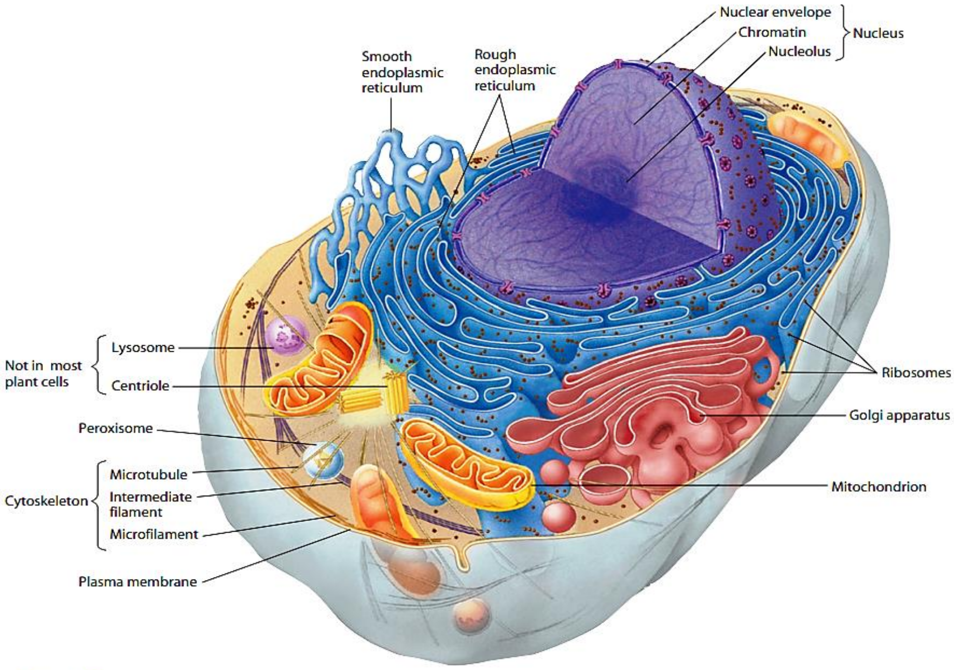
1-Their DNA is found in the cell's nucleus, which is separated from the cytoplasm by a nuclear membrane, and the DNA is found in multiple chromosomes.

2-Their DNA is consistently associated with chromosomal proteins called histones and with nonhistones.

3-They have a number of membrane-enclosed organelles, including mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, and sometimes chloroplasts.

4-Their cell walls, when present, are chemically simple.

5-Cell division usually involves mitosis, in which chromosomes replicate and an identical set is distributed into each of two nuclei. This process is guided by the mitotic spindle a football-shaped assembly of microtubules. Division of the cytoplasm and other organelles follows so that the two cells produced are identical to each other.



▲ **Figure 4.4A** An animal cell

Additional differences between prokaryotic and eukaryotic cells are listed in Table -1:

Table-1 Principal Differences between Prokaryotic and Eukaryotic Cells.

Characteristic	Prokaryotic	Eukaryotic
Size of Cell	Typically 0.2–2.0 µm in diameter	typically 10–100 µm in diameter
Nucleus	No nuclear membrane or nucleoli	true nucleus, consisting of nuclear membrane and nucleoli
Membrane-enclosed Organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, and chloroplasts
Cell Wall	Usually present; chemicall complex (typical y bacterial cell wall includes peptidoglycan)	When present, chemically simple (includes cellulose and chitin)
Cytoplasm	No Cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA)	Usually single circular chromosome; typically lacks histones	Multiple linear chromosomes with histones
Cell Division	Binary fission	Involves mitosis
Sexual Recombination	None; transfer of Dna only	Involves meiosis

.CLASSIFICATION OF ORGANISMS

Organisms are classified according to their degree of similarity, which, in turn, suggests the degree of their evolutionary relationships. The science of classifying organisms is called **taxonomy**. Organisms are classified using specific **taxonomic categories** that range from the largest category containing the greatest number of species (kinds of organisms) to the smallest category containing only one species.

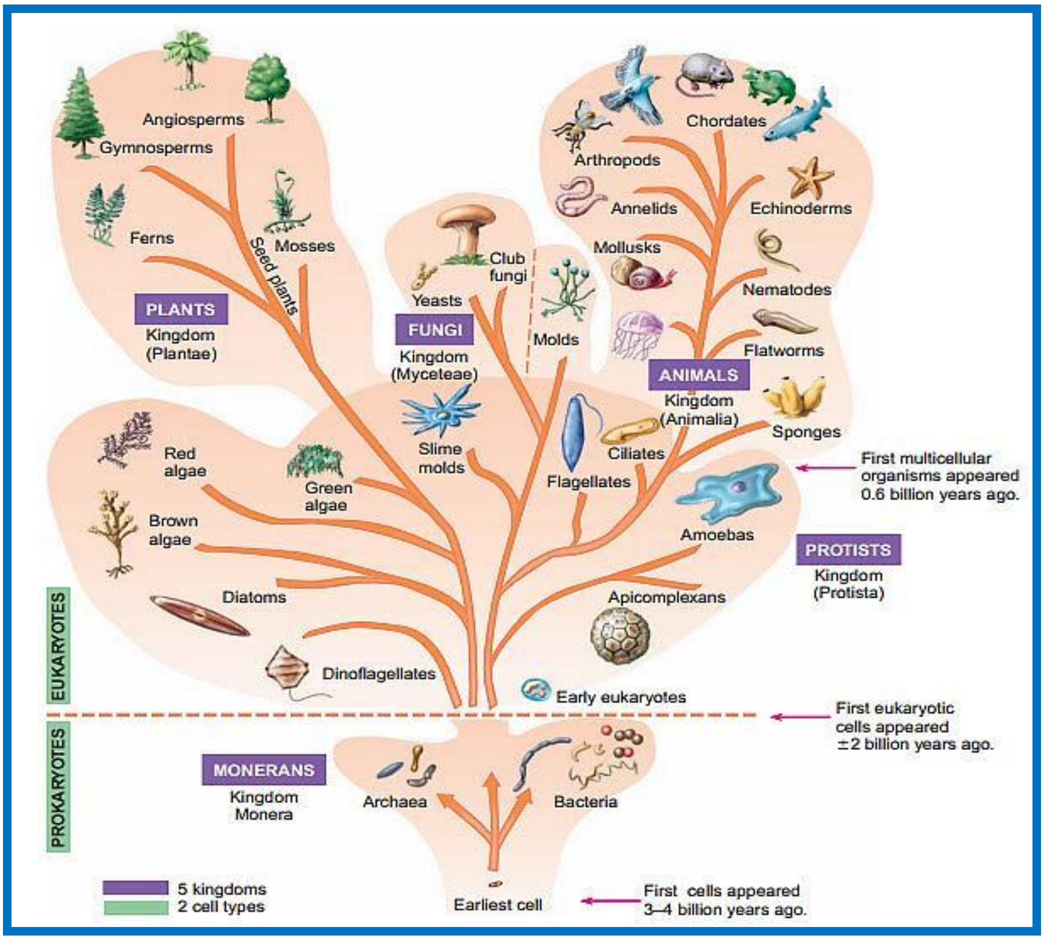
Taxonomy is a dynamic process because new information tends to alter previous ideas of the evolutionary relationships among organisms. There are eight major taxonomic categories used in classifying organisms. In order of decreasing inclusiveness, they are **Domain**, **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus**, and **Species**. Each domain consists of a number of related kingdoms. Each kingdom consists of a number of related phyla, each phylum consists of a number of related classes, and so on. The classification of humans is shown in Table 10.1 as an example.

TABLE 10.1	CLASSIFICATION OF THE HUMAN SPECIES, *HOMO SAPIENS*
Taxonomic Category	*Classification of Humans*
Domain	Eukarya
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	Homo
Species	sapiens

The **scientific name** of an organism consists of both genus and species names. For example, the scientific name for humans is ***Homo sapiens***. Note that the first letter of the genus name is capitalized, whereas the first letter of the species name is not. The scientific name is always printed in italics or underlined when handwritten.

♦. The Five Kingdoms of Life

The earliest classification systems recognized only two kingdoms of living things: animals and plants. But as biologists discovered microorganisms and learned more about other organisms, the number of kingdoms increased. Systematists added kingdoms in recognition of fundamental differences discovered among organisms. Although even at the kingdom level classification remains in flux, most biologists now use the five kingdom system presented here (Figure).



In this system, four of the Kingdoms consist of eukaryotic organisms. The two most familiar kingdoms, **Animalia** and **Plantae**, contain only organisms that have many cells during most of their life cycle. The kingdom **Fungi** contains multicellular forms and the single-celled yeasts, which are thought to have multicellular ancestors. Fundamental differences divide the three multicellular Kingdoms. They differ in their morphologies, in motility, and in their modes of nutrition. Plants are mainly stationary, but some have motile sperm; Fungi have no motile cells. Animals ingest their food, Plants manufacture it, and fungi digest it by means of secreted extracellular enzymes and absorb the digested food. Each of these kingdoms probably evolved from a different single-celled ancestor.

The large number of unicellular eukaryotes are arbitrarily gathered into a single kingdom, called **Protista**. Protista also includes the algae, all of which are unicellular during important parts of their life cycle and have multicellular morphologies similar to plants.

The fifth kingdom, **Monera**, contains only prokaryotic organisms - vastly different from all other living things. Within this kingdom are two vastly different kinds of prokaryotes,

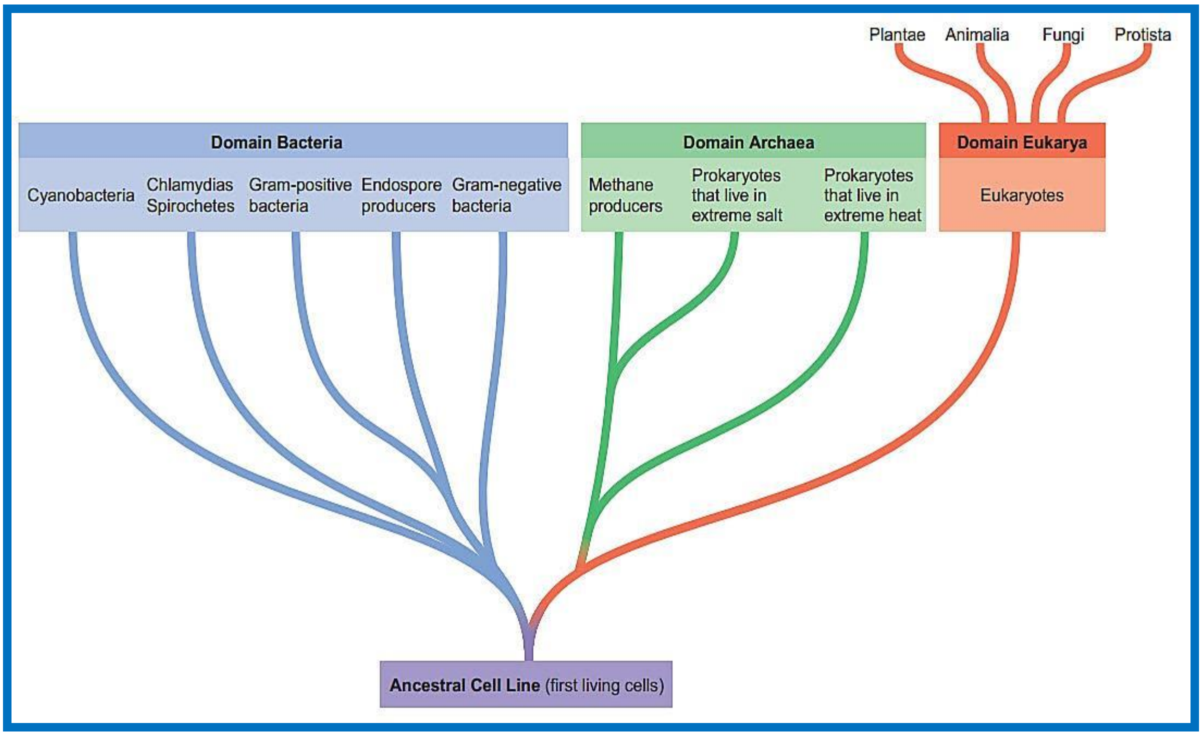
archaebacteria and **eubacteria**, and many biologists believe they should be considered separate Kingdoms.

Five Kingdoms Classification

Five Kingdoms System	Eukaryotes or Prokaryotes	Multicellular or Unicellular
Animals	Animals	Animals
Plants	Plants	Plants
Fungi	Fungi	Fungi
Protista	Protista	Protista
Monera: a-Archaea b-Eubacteria	Monera: a-Archaea b-Eubacteria	Monera: a-Archaea b-Eubacteria

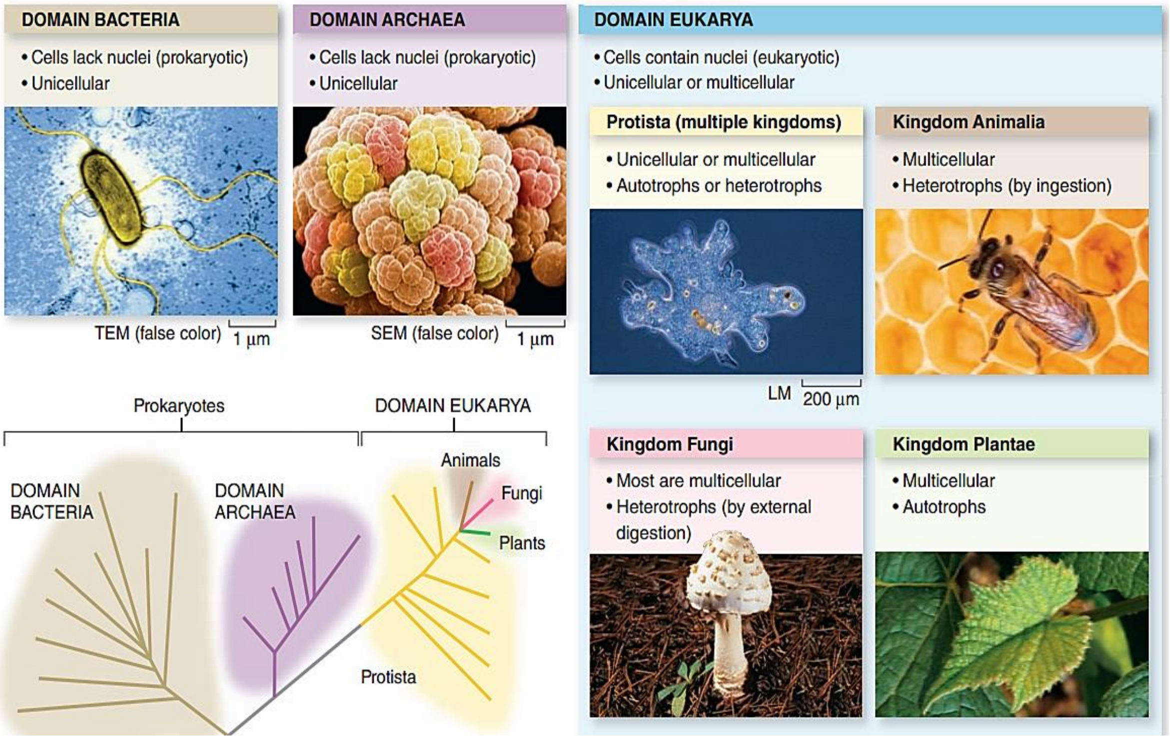
♦. The Three Domains of Life

The use of a domain as the highest taxonomic category has become generally accepted. Its use has resulted from research on the nucleotide sequence in **ribosomal RNA** in prokaryotes**. Carl Woese** and **George Fox** have proposed a system that assigns all organisms to one of three domains, each described by a different type of cell (see figure). The prokaryotic cell types are placed in the **Domains Archaea** and **Bacteria**. Eukaryotes are all placed in the **Domain Eukarya.**



The species in each **domain** are further subdivided into **kingdoms**; figure-1.8 shows the **kingdoms** within **Eukarya**.

Figure 1.8 Life's Diversity. The three domains of life (Bacteria, Archaea, and Eukarya) arose from a hypothetical common ancestor.



Please note that viruses are not included in any of the classification or evolutionary schemes, because they are not cells and their position cannot be given with any confidence. Their special taxonomy is discussed later.

Cavalier and Smith's Classification

The most recent taxonomic classification of bacteria is based on Cavalier and Smith's six kingdoms classification (1998). It is the most accepted classification at present, surpassed the previous five kingdom classification (Whittaker, 1969) and three domain classification (Woese, 1990).

It is a molecular classification. which divides all living structures of the earth into six kingdoms; Bacteria, Protozoa, Chromista, Plantae, Fungi and Animalia.

Taxonomic Classification Of Living Beings

Linnaeus 1735	Haeckel 1866	Chatton 1925	Copeland 1938	Whittaker 1969	Woese et al 1990	Cavalier-Smith 1998
2 Kingdoms	3 Kingdoms	2 Empires	4 Kingdoms	5 Kingdoms	3 Domains	6 Kingdoms
Plants	Animals	Prokaryota	Monera	Monera	Bacteria	Bacteria
Animals	Plants	Eukaryota	Protista	Protista	Archaea	Protozoa
	Protista		Plants	Plants	Eucarya	Chromista
			Animals	Fungi		Plants
				Animals		Fungi
						Animals

Cytology or Cell Biology

The study of ***cells***, their ***origin***, ***structure***, ***function***, ***and pathology***.

The English scientist **Robert Hooke** first observed plant cells with a crude microscope in the late **1600s.** However, it was not until the **1830s** that two German scientists, botanist **Matthias Schleiden** in 1838 and zoologist **Theodor Schwann** in 1839, reasoned that all plants and animals consist of cells. Later, the German pathologist **Rudolf Virchow** extended this idea by contending that cells arise only from other cells. **Virchow's** proclamation was revolutionary because it openly challenged the widely accepted theory of spontaneous generation, which held that organisms arise spontaneously from garbage or other nonliving matter. Since the late **1800s**, cell research has been exceptionally fruitful and provided us with four concepts collectively known as the **Cell Theory:**

1. The cell theory states that all living things are composed of at least one cell and

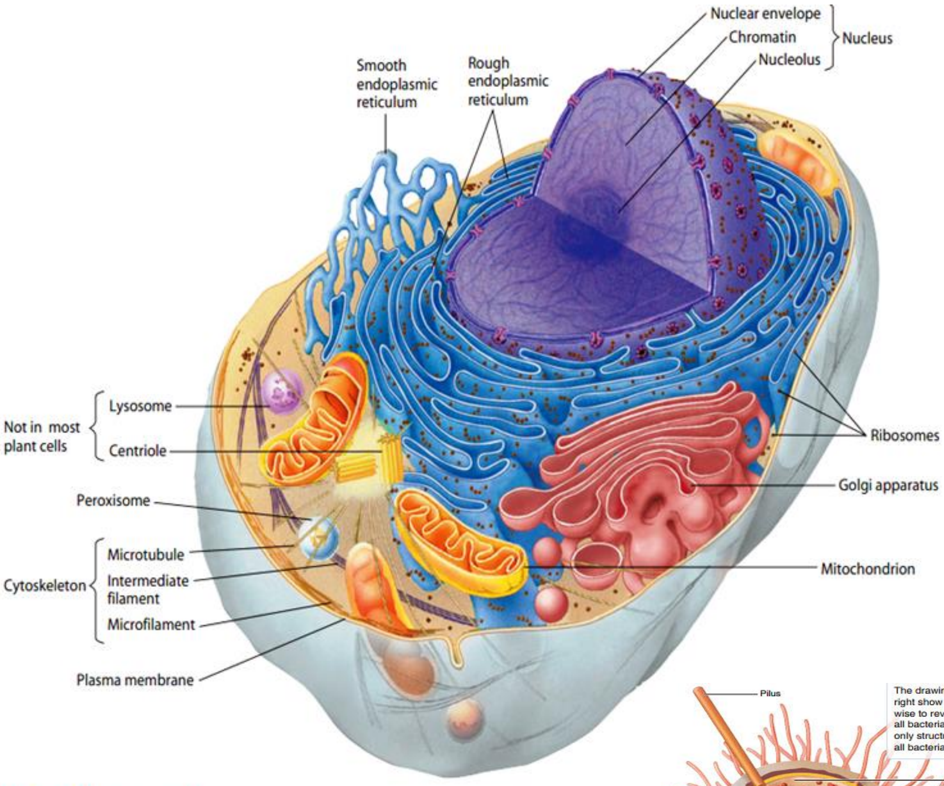
2. that the cell is the fundamental unit of function in all organisms.

3. The chemical composition of all cells is fundamentally alike;

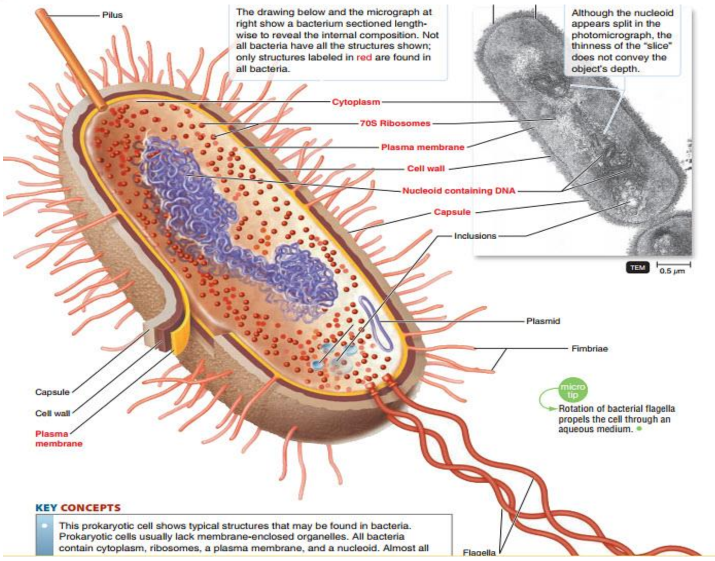
4. all cells arise from preexisting cells through cell division.

Cells are the basic functional units of complex organisms. Although the human body is composed of more than 200 different types of cells, each performing a different function, all cells possess certain unifying characteristics and thus can be described in general terms. Every cell is surrounded by a bilipid plasma membrane, possesses organelles that permit it to discharge its functions, synthesizes macromolecules for its own use or for export, produces energy, and is capable of communicating with other cells.

Protoplasm, the living substance of the cell, is subdivided into two compartments: **cytoplasm**, extending from the plasma membrane to the nuclear envelope, **karyoplasm**, the substance forming the contents of the nucleus.



▲ Figure 4.4A An animal cell



🌢 *The Interior Of Eukaryotic Cells*

The Plasma Membrane

The Cytoplasm

The Nucleus

The Cytoplasm

The cytoplasm forms the main bulk of protoplasm. It is a translucent gelatinous watery fluid. The bulk of the cytoplasm is **water**, in which various inorganic and organic chemicals are dissolved and/or suspended. This fluid suspension is called the **cytosol**. The cytosol contains organelles, metabolically active structures that perform distinctive functions. Additionally, the shapes of cells, their ability to move, and the intracellular pathways within cells are maintained by a system of tubules and filaments known as the **cytoskeleton**.

(i)- Endoplasmic reticulum (ER)

The **endoplasmic reticulum (ER)** is such an extensive network of membranes that it accounts for more than half the total membrane in many eukaryotic cells. (The word ***endoplasmic*** means "within the cytoplasm," and ***reticulum*** is Latin for "little net.") The ER consists of a network of membranous tubules and sacs called cisternae (from the Latin ***cisterna***, a reservoir for a liquid). The ER membrane separates the internal compartment of the ER, called the **ER lumen** (cavity) or cisternal space, from the cytosol. And because the ER membrane is continuous with the nuclear envelope, the space between the two membranes of the envelope is continuous with the lumen of the ER.

- *The endoplasmic reticulum is of two types*:

1. Smooth endoplasmic reticulum: is so named because its outer surface lacks ribosomes Smooth ER has a tubular appearance, and its membrane surfaces appear smooth.

*** Function:**

The smooth endoplasmic reticula have a variety of different functions but often function to produce **lipid** compounds such as phospholipids, steroids, and fatty acids.

Certain kinds of cells have smooth endoplasmic reticulum with a specialized function. The following are some examples:

1- Smooth endoplasmic reticulum is abundant in the **adrenal cortex** and the **testes** where it produces **steroid hormones**.

2- The smooth endoplasmic reticulum of **liver** cells helps detoxify drugs in the blood.

3- Calcium ions needed for contraction are stored in the smooth endoplasmic reticulum of muscle cells.

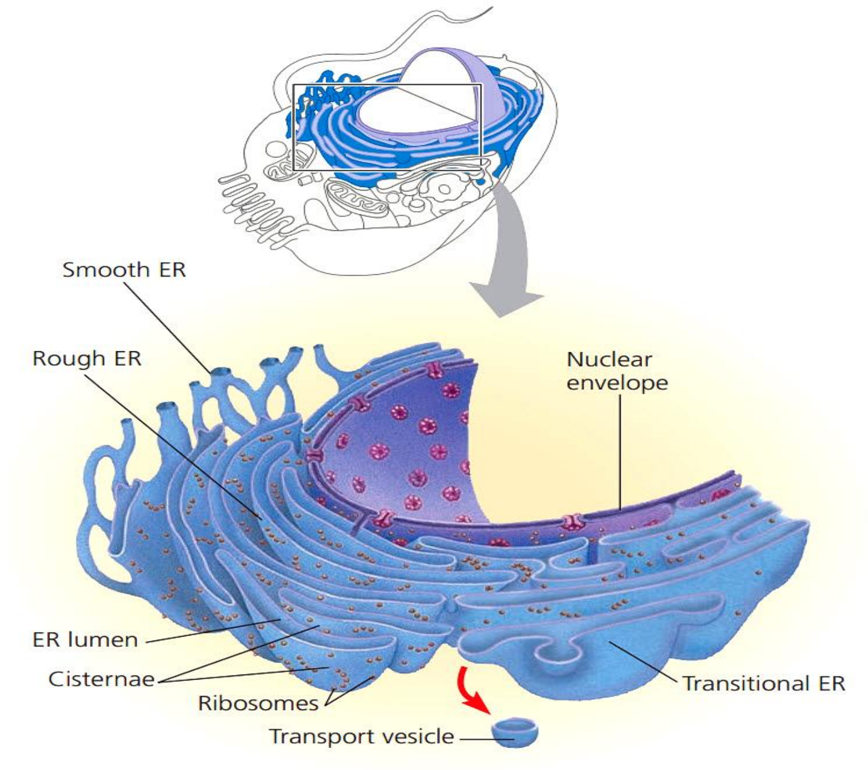
Vesicles are small sacs that pinch off the endoplasmic reticulum or Golgi apparatus (discussed below) and transport molecules to other parts of the cell. Vesicles pinch off the smooth endoplasmic reticulum and carry materials to other parts of the cell such as the plasma membrane or Golgi apparatus.

2- Rough endoplasmic reticulum: It consists of rough membranes because the ribosomes are attached to them. The ribosomes attached to the rough ER are known as **bound ribosomes** to differentiate them from **free ribosomes**, which are suspended in the cytosol.

*** Function:**

The rough ER functions in **protein synthesis**, especially proteins that are to be secreted to outside the cell (example: hormones). **Proteins** enter the lumen (interior) of the endoplasmic reticulum while being synthesized.

In addition to protein synthesis, the rough endoplasmic reticulum also functions in the modification of newly formed proteins. For example, some enzymes may add carbohydrate chains forming glycoproteins. Other enzymes function to fold the newly-synthesized proteins into their proper shape.



(ii)- Golgi complex or Golgi apparatus

The **Golgi complex** (also known as the **Golgi body** or **Golgi apparatus**) was first described in 1898 by Italian microscopist Camillo Golgi, who found a way to specifically stain this organelle. This membrane system modifies and sorts proteins that it receives from the ER and then packages them into transport vesicles destined to different components of the endomembrane system.

In many cells, the Golgi complex consists of stacks of flattened membranous sacs called **cisternae** (sing., **cisterna**). Each cisterna has an internal space, or lumen. The Golgi complex contains a number of separate compartments as well as some that are interconnected.

Each Golgi stack has three areas, referred to as the **cis** face, the **trans** face, and a medial region in between. Typically, the **cis** face (the entry surface) is located nearest the nucleus and receives materials from transport vesicles bringing molecules from the ER. The **trans** face (the exit surface) is closest to the plasma membrane. It packages molecules in vesicles and transports them out of the Golgi.

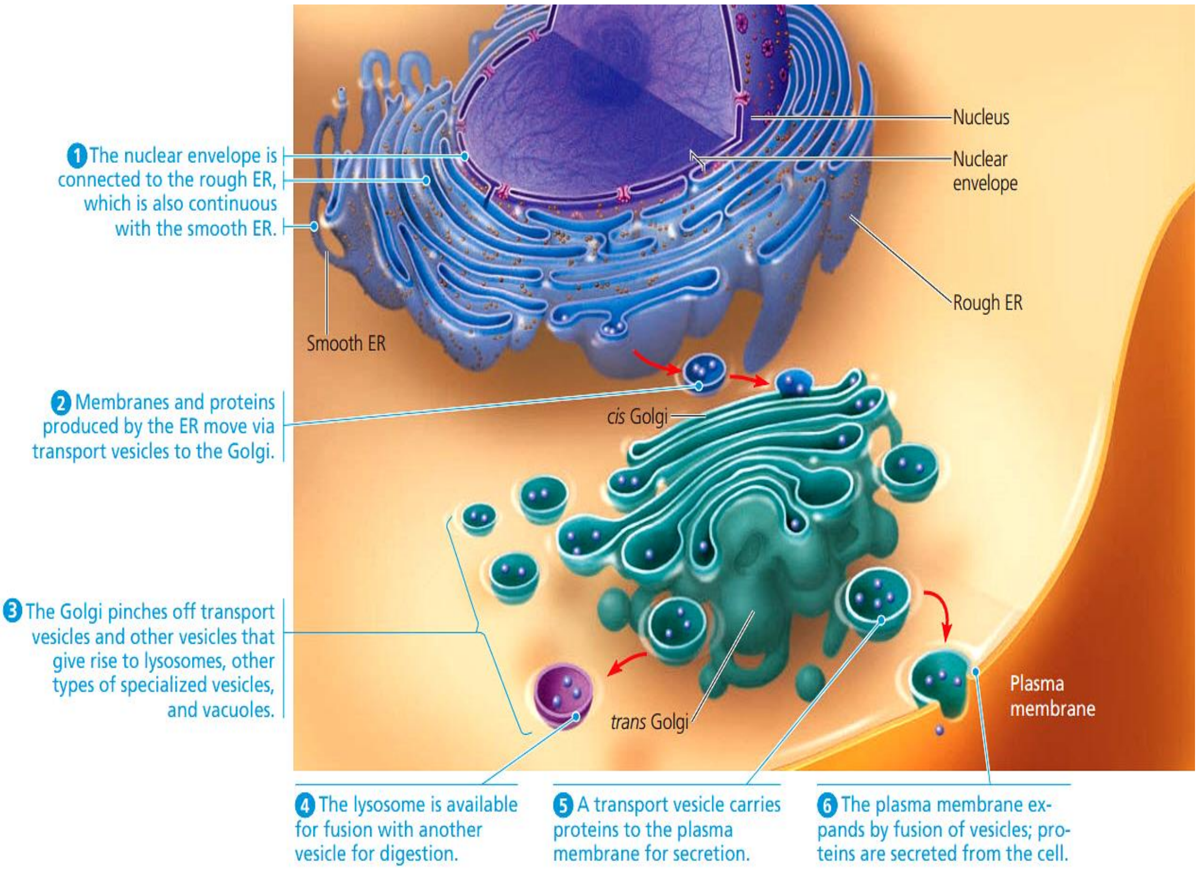


Figure 6.15 Review: relationships among organelles of the endomembrane system. The red arrows show some of the migration pathways for membranes and the materials they enclose.

BioFlix® Animation: Endomembrane System

(iii)- Ribosomes

Ribosomes are organelles that can be found free in the cytosol or attached to certain cytoplasmic membranes. These small particles contain the enzyme activities necessary to form peptide bonds, which join amino acids to produce proteins. Each ribosome has two main components: a large subunit and a small subunit.

When the two ribosome subunits join in a complex with an mRNA molecule, they function as manufacturing plants that assemble polypeptides. Cells that actively produce large amounts of proteins may have millions of ribosomes, and the cell can change the number of ribosomes present to meet its metabolic needs.

Ribosomes are molecular machines made up of both **proteins** and **RNA** molecules (called ribosomal RNA or rRNA). The two subunits of each eukaryotic ribosome actually consist of more than 80 different proteins and three different rRNA molecules. Ribosomes in eukaryotes about 1/3 larger than those in prokaryotes.

* **Function:** Ribosomes the seat of protein synthesis.

(iv)- Lysosomes

They are small membranous fluid-filled vesicles. They contain digestive enzymes and are meant for destroying foreign materials which enter the cell. Lysosomes can also break down damaged organelles (such as mitochondria) that have been captured in vesicles in a process called **autophagy**, allowing their components to be recycled or used as an energy source.

Hydrolytic enzymes and lysosomal membrane are made by rough ER and then transferred to the Golgi apparatus for further processing. They fuse with other vesicles formed around material that has entered the cell, allowing the digestion of the vesicle contents. For example, bacteria that are engulfed by white blood cells are destroyed by enzymes contained within the lysosomes.

Cells also use lysosomes to kill themselves. This important process occurs during the formation of fingers during embryonic development, the reduction in the size of a tadpole tail as it matures, and the abscission of tree leaves in the autumn.

(v)-Peroxisomes

All eukaryotic cells contain peroxisomes, organelles that contain several types of enzymes that dispose of toxic substances. Although they resemble lysosomes in size and function, peroxisomes originate at the ER (not the Golgi) and contain different enzymes high levels that the proteins condense into easily recognized crystals.

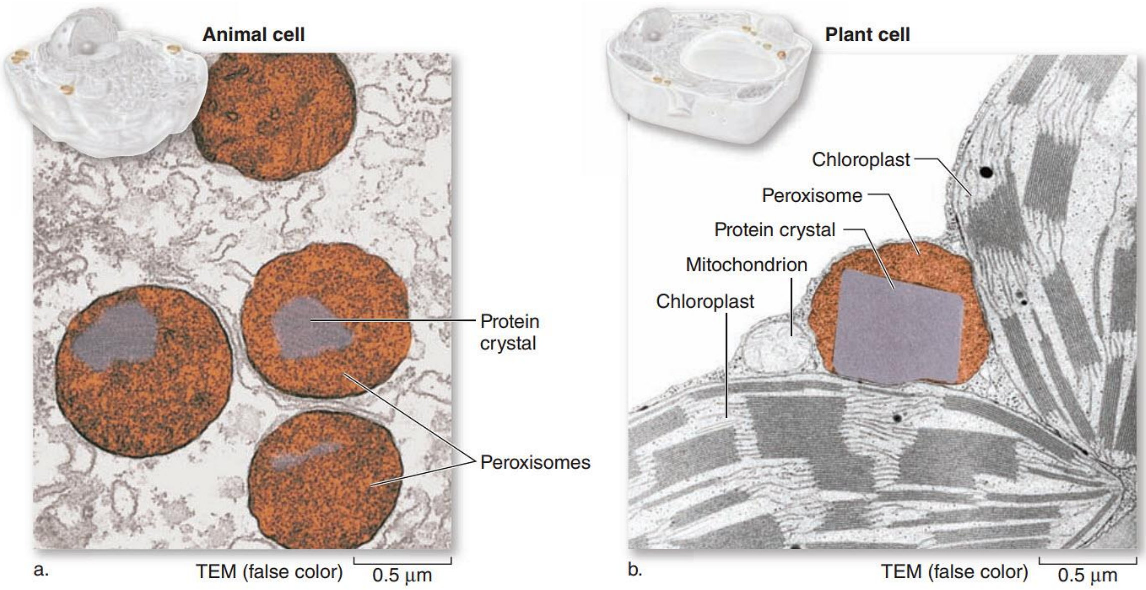


Figure 3.18
Peroxisomes. Protein crystals give peroxisomes their characteristic appearance in (a) an animal cell and (b) a plant cell.

Peroxisomes protect cells from toxic byproducts. For instance, some of the reactions in the peroxisome (and other organelles) produce hydrogen peroxide(**H_2O_2**). This highly reactive compound can produce **oxygen free radicals** that can damage the cell. To counteract the free-radical buildup, peroxisomes contain the enzyme **catalase**, which rapidly splits excess hydrogen peroxide to water and oxygen, rendering it harmless.

$$2H_2O_2 \xrightarrow{\text{---- Catalase ----}} 2H_2O + O_2$$

Peroxisomes are found in large numbers in cells that synthesize, store, or degrade lipids. One of their main functions is to break down fatty acid molecules. Peroxisomes synthesize certain phospholipids that are components of the insulating covering of nerve cells. In fact, certain neurological disorders occur when peroxisomes do not perform this function.

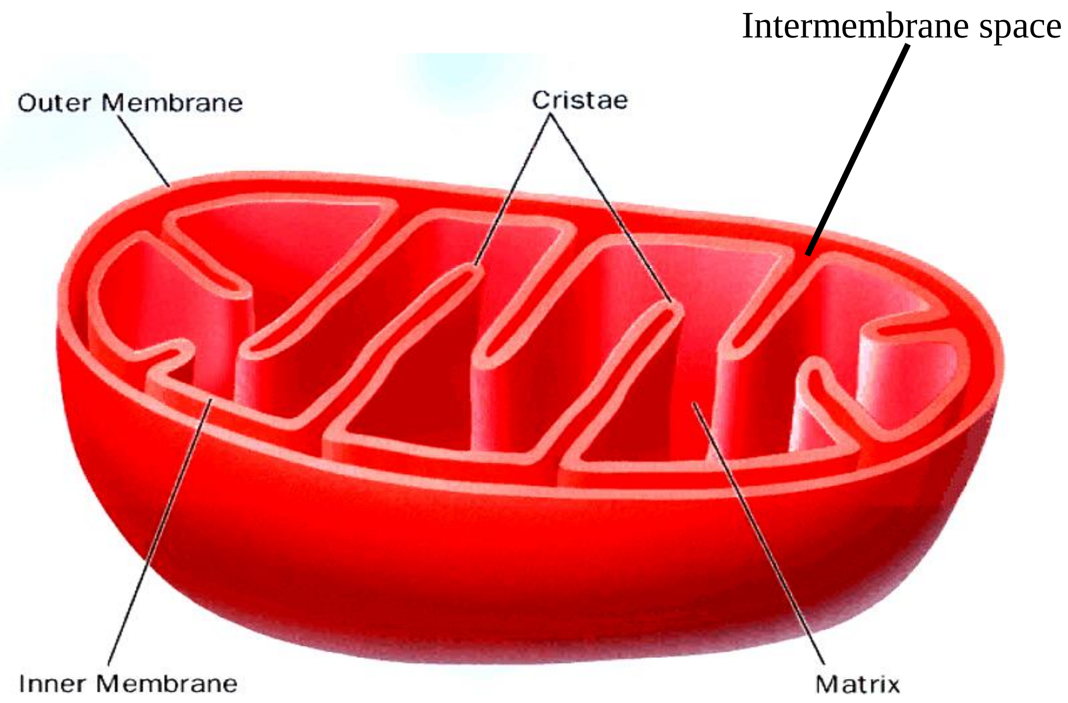
When yeast cells are grown in an alcohol-rich medium, they manufacture large peroxisomes containing an enzyme that degrades the alcohol. Peroxisomes in human liver and kidney cells detoxify certain toxic compounds, including ethanol, the alcohol in alcoholic beverages.

In plant seeds, specialized peroxisomes, called **glyoxysomes**, contain enzymes that convert stored fats to sugars. The sugars are used by the young plant as an energy source and as a component for synthesizing other compounds. Animal cells lack **glyoxysomes** and cannot convert fatty acids into sugars.

(vi)- Mitochondria

Virtually all eukaryotic cells (plant, animal, fungal, and protist) contain complex organelles called **mitochondria** (sing., **mitochondrion**). These organelles are the site of aerobic respiration, an oxygen-requiring process that includes most of the reactions that convert the chemical energy present in certain foods to ATP. During aerobic respiration, carbon, hydrogen, and oxygen atoms are removed from food molecules, such as glucose, and converted to carbon dioxide and water.
Some cells have a single large mitochondrion, but more often a cell has hundreds or even thousands of mitochondria (More than 1000 mitochondria have been counted in a single liver cell); the number correlates with the cell’s level of metabolic activity. For example, cells that move or contract have proportionally more mitochondria per volume than less active cells.

Each of the two membranes enclosing the mitochondrion is a phospholipid bilayer with a unique collection of embedded proteins. The outer membrane is smooth, but the inner membrane is convoluted, with infoldings called **cristae**. The inner membrane divides the mitochondrion into two internal compartments. The first is the **intermembrane space**, the narrow region between the inner and outer membranes. The second compartment, the **mitochondrial matrix**, is enclosed by the inner membrane. The matrix contains many different enzymes as well as the mitochondrial DNA and ribosomes. Enzymes in the matrix catalyze some of the steps of cellular respiration.



The folds, called **cristae** (sing., crista), extend into the matrix. Cristae greatly increase the surface area of the inner mitochondrial membrane, providing a surface for the chemical reactions that transform the chemical energy in food molecules into the energy of ATP. The membrane contains the enzymes and other proteins needed for these reactions.

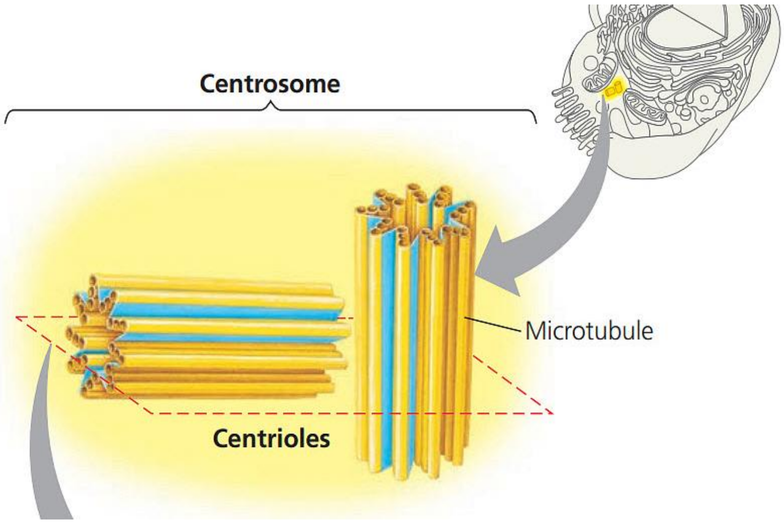
Mitochondria play an important role in programmed cell death, or apoptosis. Unlike necrosis, which is uncontrolled cell death that causes inflammation and damages other cells, apoptosis is a normal part of development and maintenance. For example, during the metamorphosis of a tadpole to a frog, the cells of the tadpole tail must die. The hand of a human embryo is webbed until apoptosis destroys the tissue between the fingers. Cell death also occurs in the adult. For example, cells that are no longer functional because they have aged or become damaged are destroyed by apoptotic mechanisms and replaced by new cells.

Each mitochondrion in a mammalian cell has 5 to 10 identical, circular molecules of DNA, accounting for up to 1% of the total DNA in the cell. Mitochondrial DNA mutates far more frequently than nuclear DNA. Mutations in mitochondrial DNA have been associated with certain genetic diseases, including a form of young adult blindness, and certain types of progressive muscle degeneration.

(vii). Central apparatus (Centroşeme)

It lies near the nucleus in animal cells. It has one or two rounded **centrioles** surrounded by a little amount of differentiated, homogenous cytoplasm called **centrosphere**. Under electron microscope, the centriole appears to be a small hollow rod consisting of nine triplet fibrils (Each fibril of a centriole is further made of three tubules) without any central fibril. When two centrioles are present, they lie at right angles each other.

The centrioles are duplicated before cell division and may play a role in some types of microtubule assembly.



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Biology Lec.8
Assistant professor Ahmed Saadoun Jal'oot

3.3 A Membrane Separates Each Cell from Its Surroundings

A cell membrane is one feature common to all cells. The membrane separates the cytoplasm from the cell's surroundings. The cell's surface also transports substances into and out of the cell (see chapter 4), and it receives and responds to external stimuli. Inside a eukaryotic cell, internal membranes enclose the organelles.

The cell membrane is composed of phospholipids, which are organic molecules that resemble triglycerides (figure 3.10). In a triglyceride, three fatty acids attach to a three-carbon glycerol molecule. But in a **phospholipid,** glycerol bonds to only two fatty acids; the third carbon binds to a phosphate group attached to additional atoms. ▸ triglycerides, p. 34

This chemical structure gives phospholipids unusual properties in water. The phosphate "head" end, with its polar covalent bonds, is attracted to water; that is, it is hydrophilic. The other end, consisting of two fatty acid "tails," is hydrophobic. In water, phospholipid molecules spontaneously arrange themselves into the most energy-efficient organization: a **phospholipid bilayer** (figure 3.11). In this two-layered, sandwichlike structure, the hydrophilic surfaces (the "bread" of the sandwich) are exposed to the watery medium outside and inside the cell. The hydrophobic tails face each other on the inside of the sandwich, like cheese between the bread slices. Unlike a sandwich, however, the bilayer forms a three-dimensional sphere, not a flat surface.

Thanks to the phospholipid bilayer, a biological membrane has selective permeability. The hydrophobic interior of the phospholipid bilayer prevents ions and polar molecules from passing freely into and out of a cell. The membrane does not, however, block lipids and small, nonpolar molecules such as O_2 and CO_2.

Cell membranes consist not only of phospholipid bilayers but also of sterols, proteins, and other molecules (figure 3.12). The cell membrane is often called a **fluid mosaic** because many of the proteins and phospholipids are free to move laterally

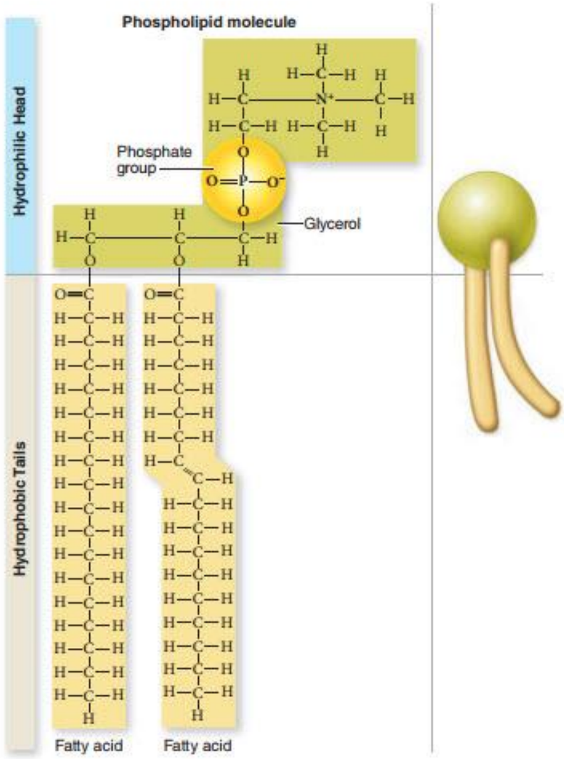


Figure 3.10 Membrane Phospholipids. A phospholipid molecule consists of a glycerol molecule attached to a hydrophilic phosphate "head" group and two hydrophobic fatty acid "tails." The drawing at right shows a simplified phospholipid structure.

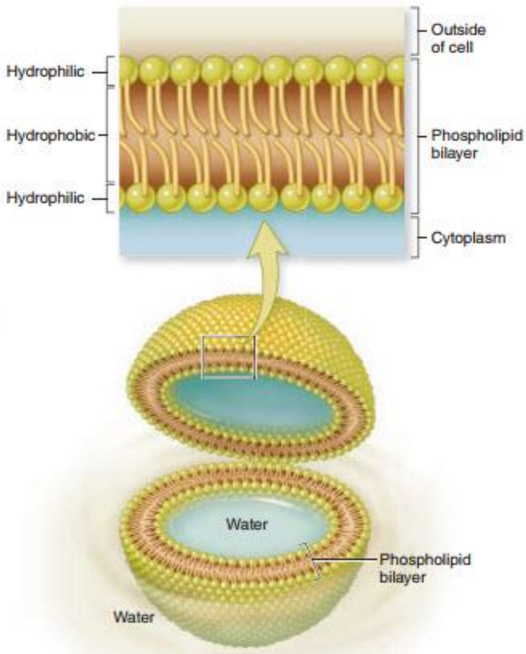


Figure 3.11 Phospholipid Bilayer. In water, phospholipids form a bilayer. The hydrophilic head groups are exposed to the water; the hydrophobic tails face each other, minimizing contact with water. A sphere of phospholipids forms the basis for the cell membrane.

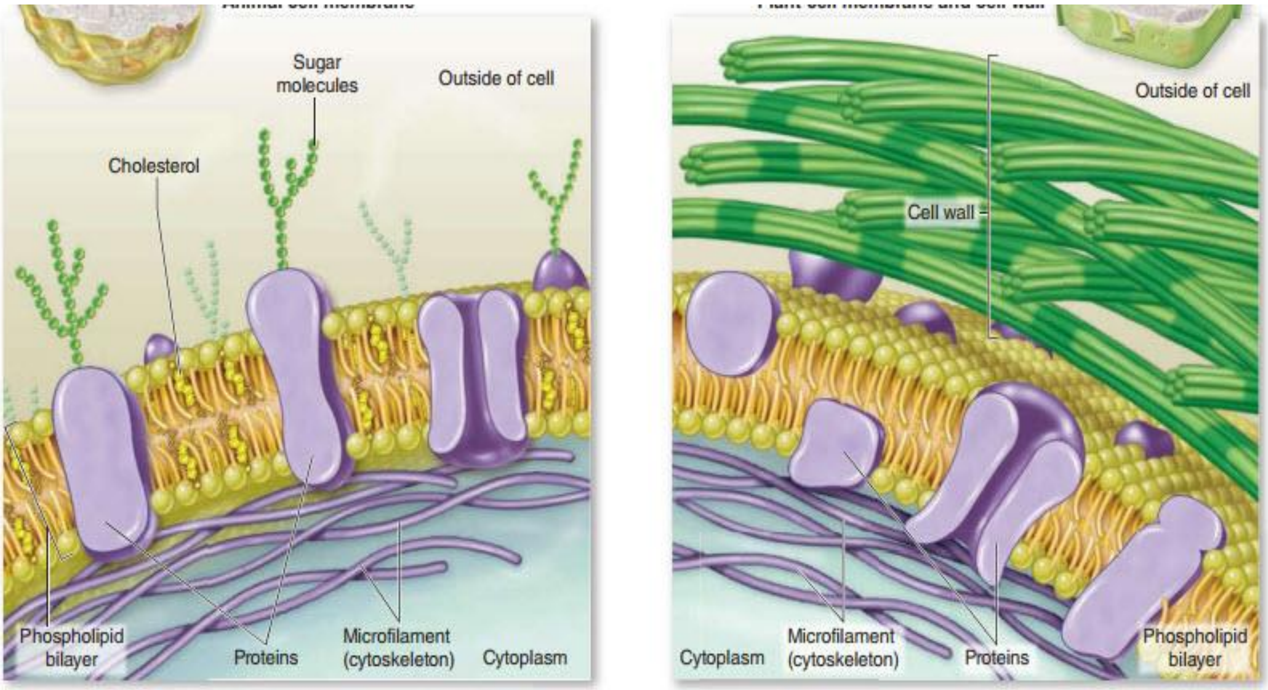


Figure 3.12 **Anatomy of a Cell Membrane.** The cell membrane is a "fluid mosaic" of proteins embedded in a phospholipid bilayer. Note that animal cell membranes contain cholesterol, but plant cell membranes do not. The outer face of the animal cell membrane also features carbohydrate (sugar) molecules linked to proteins. A cell wall of cellulose fibers surrounds plant cells.

within the bilayer. Sterols, including cholesterol in animal cell membranes, maintain the membrane's fluidity.

Whereas phospholipids and sterols provide the membrane's structure, proteins are especially important to its function. Researchers estimate that about one third of every organism's genome encodes membrane proteins. Some of the proteins lie completely within the phospholipid bilayer, whereas others extend out of one or both sides. Their functions include:

- **Transport proteins:** Transport proteins embedded in the phospholipid bilayer create passageways through which water-soluble molecules and ions pass into or out of the cell. Section 4.5 describes membrane transport in more detail.
- **Enzymes:** These proteins facilitate chemical reactions that otherwise would proceed too slowly to sustain life. (Not all enzymes, however, are associated with membranes.)
  ‣ enzymes, p. 78
- **Recognition proteins:** Carbohydrates attached to cell surface proteins serve as "name tags" that help the body recognize its own cells. The immune system attacks cells with unfamiliar surface molecules, which is why transplant recipients often reject donated organs. Surface structures also distinctively mark cells of different tissues in an individual, so a bone cell's surface is different from that of a nerve cell or a muscle cell.
- **Adhesion proteins:** These membrane proteins enable cells to stick to one another.
- **Receptor proteins:** Receptor proteins bind to molecules outside the cell and trigger a reaction inside the cell. The receptor protein HER2, described in this chapter's opening essay, receives signals that stimulate cell division.

Understanding membrane proteins is a vital part of human medicine, in part because at least half of all drugs bind to them. One example is omeprazole (Prilosec). This drug relieves heartburn and gastric reflux by blocking some of the transport proteins that pump hydrogen ions into the stomach. Another is the antidepressant drug fluoxetine (Prozac), which prevents receptors on brain cell surfaces from absorbing a mood-altering biochemical called serotonin.

3.3 Mastering Concepts

1. Chemically, how is a phospholipid different from a triglyceride?
2. How does the chemical structure of phospholipids enable them to form a bilayer in water?
3. Where in the cell do phospholipid bilayers occur?
4. What are some functions of membrane proteins?

✓ Functions of the cell membrane:

1- Maintaining the structural integrity of the cell.

2- Controlling movement of substances in and out of the cell (selective permeability).

3- Regulation cell-cell interactions.

4- Recognition, via receptors, antigens, and foreign cells as well as altered cells.

5-Acting as an interface between the cytoplasm and the external milieu.

6- Establishing transport systems for molecules.

7- Transducing extracellular physical or chemical signals into intracellular events.

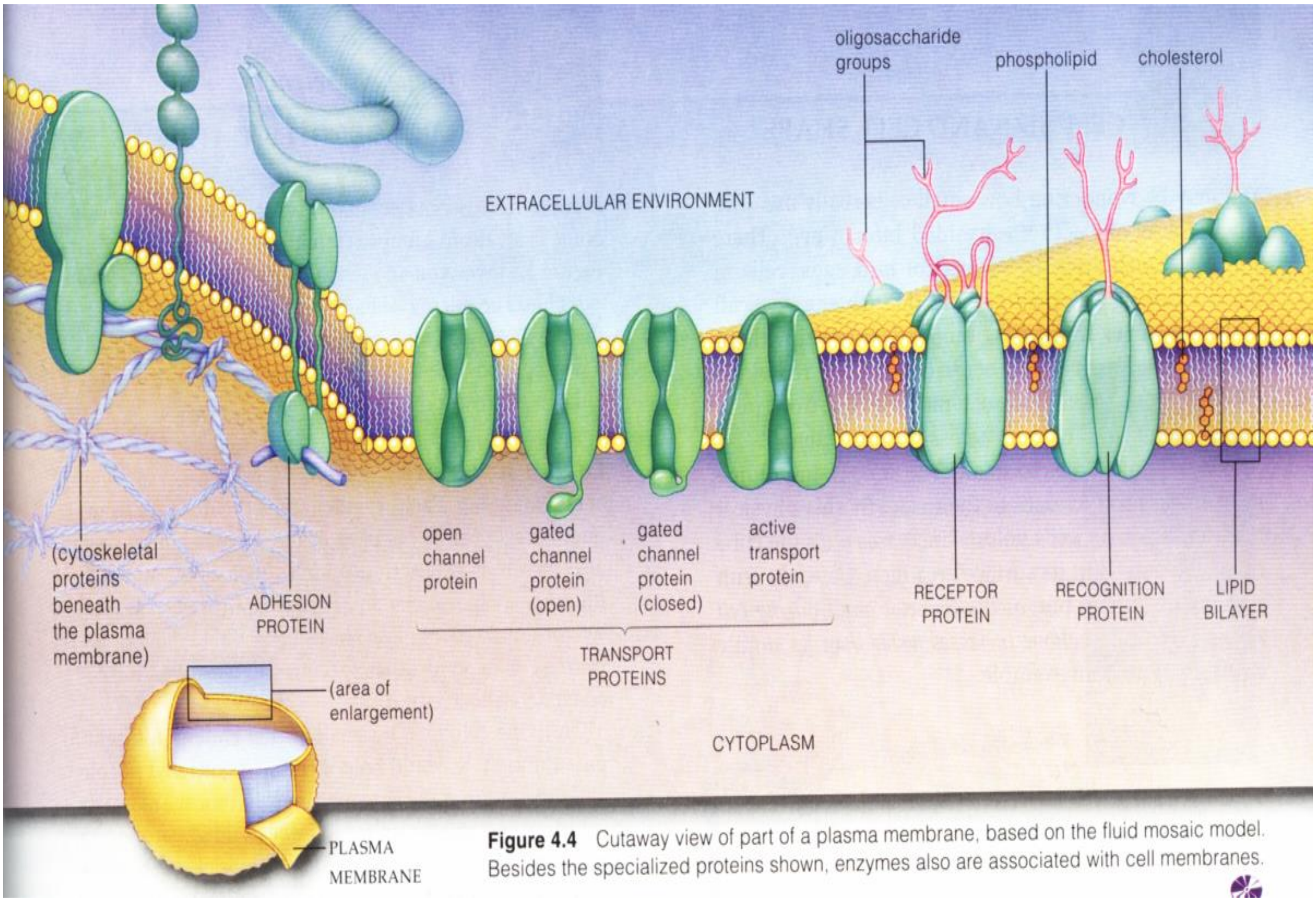
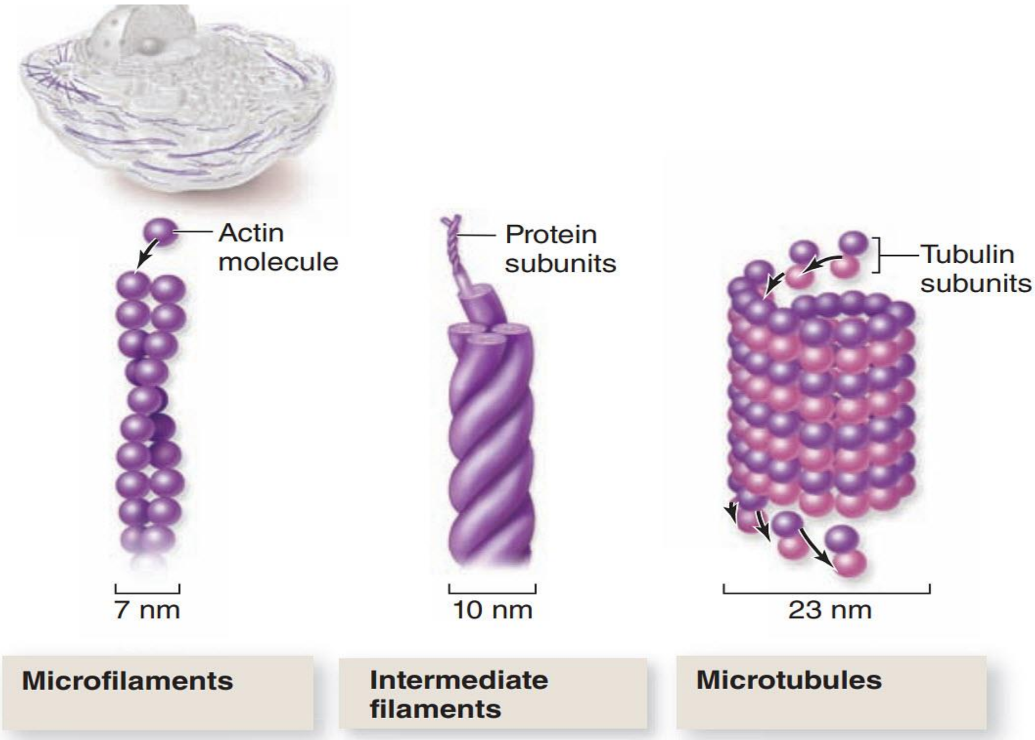


Figure 4.4 Cutaway view of part of a plasma membrane, based on the fluid mosaic model. Besides the specialized proteins shown, enzymes also are associated with cell membranes.

(viii)-The Cytoskeleton Supports Eukaryotic Cells

The cytoskeleton is a system of interconnected fibers, threads, and lattices in the fluid part of the cytoplasm of eukaryotic cells. The system gives cells their internal organization, shape, and capacity to move.

The cytoskeleton includes three major components: **microfilaments**, **intermediate filaments**, and **microtubules**. They are distinguished by protein type, diameter, and how they aggregate into larger structures. Other proteins connect these components to one another, creating an intricate meshwork.



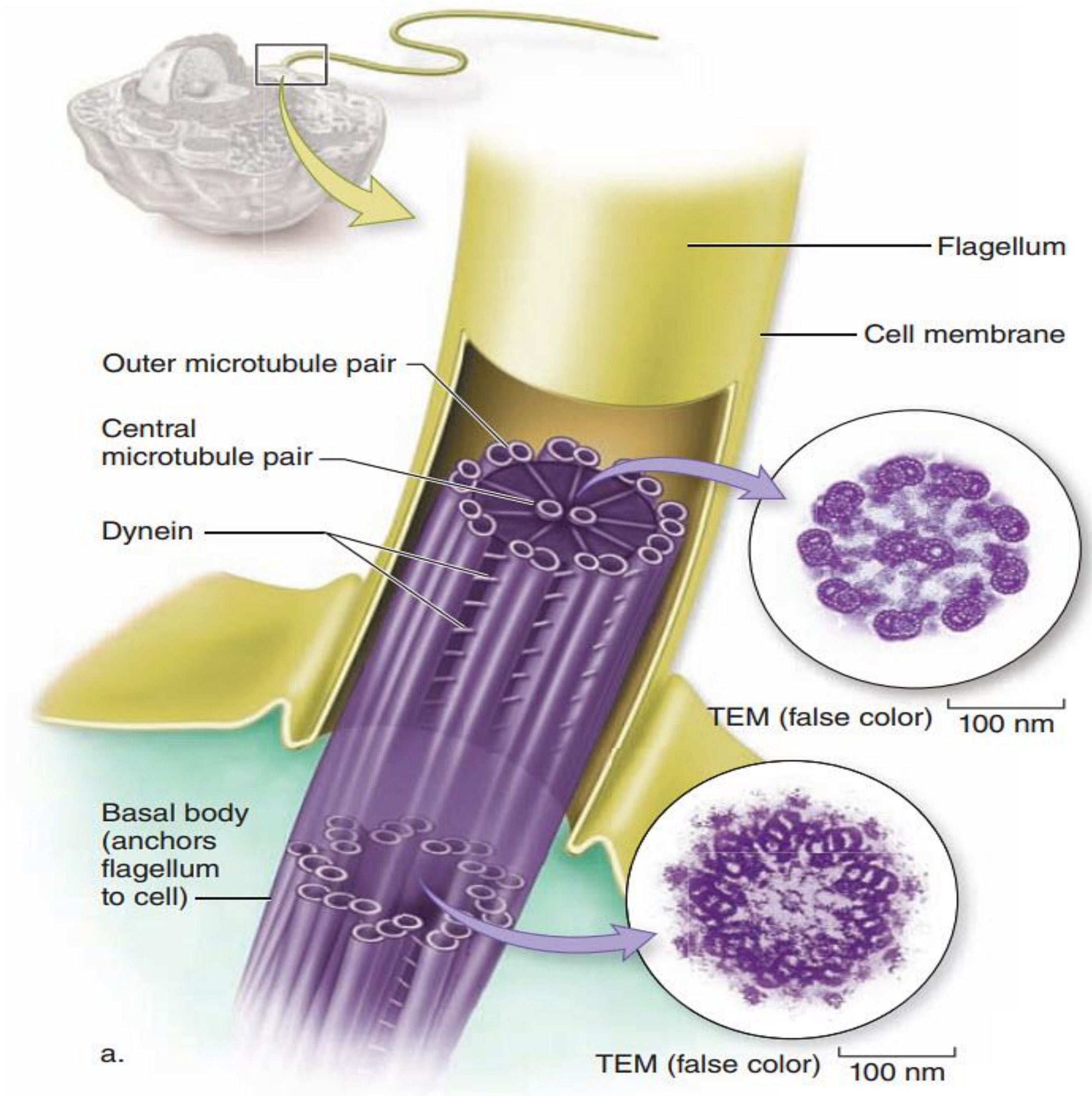
The thinnest component of the cytoskeleton is the **microfilament**, a long rod composed of the protein **actin**. Each microfilament is only about 7 nanometers in diameter. **Actin microfilament** networks are part of nearly all eukaryotic cells. Muscle contraction, for example, relies on actin filaments and another protein, myosin. Microfilaments also provide strength for cells to survive stretching and compression, and they help to anchor one cell to another.

Intermediate filaments are so named because their 10-nanometer diameters are intermediate between those of **microfilaments** and **microtubules**. Unlike the other components of the cytoskeleton, which consist of a single protein type, intermediate filaments are made of different proteins in each specialized cell type. They maintain a cell's shape by forming an internal scaffold in the cytoplasm and resisting mechanical stress. Intermediate filaments also help bind some cells together.

A **microtubule** is composed of a protein called **tubulin**, assembled into a hollow tube 23 nanometers in diameter. The cell can change the length of a microtubule rapidly by adding or removing tubulin molecules.

Microtubules have many functions in eukaryotic cells. For example, in next chapter describes how microtubules pull a cell's duplicated chromosomes apart during cell division. Microtubules also form a type of "trackway" along which organelles and proteins move within a cell. Some organisms, such as chameleons and squids, can change colors quickly by using this process to rearrange pigment molecules in their skin cells.

In animal cells, structures called centrosomes organize the microtubules (Plants typically lack centrosomes and assemble microtubules at sites scattered throughout the cell). The centrosome contains two centrioles. The centrioles apparently form the basis of structures called **basal bodies**, which in turn give rise to the extensions that enable some cells to move: **cilia** and **flagella**.



Cilia are short and numerous, like a fringe. Some protists, such as the ***Paramecium*** have thousands of cilia that enable the cells to “swim” in water. In the human respiratory tract, coordinated movement of cilia sets up a wave that propels particles up and out; other cilia can move an egg cell through the female reproductive tract.

Unlike cilia, **flagella** occur singly or in pairs, and a flagellum is much longer than a cilium. **Flagella** are more like tails, and their whiplike movement propels cells. Sperm cells in many species (including humans) have prominent flagella.

Cilia and **flagella** have the same internal structure. A basal body anchors the appendage inside the cell. The external portion is constructed of nine microtubule pairs surrounding two separate microtubules, forming a pattern described as “9 + 2.” A protein called **dynein** connects the outer microtubule pairs and links them to the central pair, a little like a wheel. **Dynein** molecules shift in a way that slides adjacent microtubules against each other. This movement bends the cilium or flagellum. (The **bacterial flagellum** has a different structure).

***In generally, functions of the cytoskeleton include*:**

1- Establishes cell shape

2- Provides mechanical strength

3- Locomotion

4- Chromosome separation in mitosis and meiosis.

(vi)- Nucleus

It is the dense spherical body which lies usually in the center of cytoplasm. Unlike the cell itself, a nucleus has two outer membranes, one wrapped around the other. This double-membrane system is called a **nuclear envelope**. It consists of two lipid bilayer in which numerous protein molecules are embedded. It surrounds the fluid portion of the nucleus called **nucleoplasm**. It is a specialized mass of cytoplasm. It contains dissolved phosphorus , ribose sugar, proteins , nucleotides and nucleic acids.

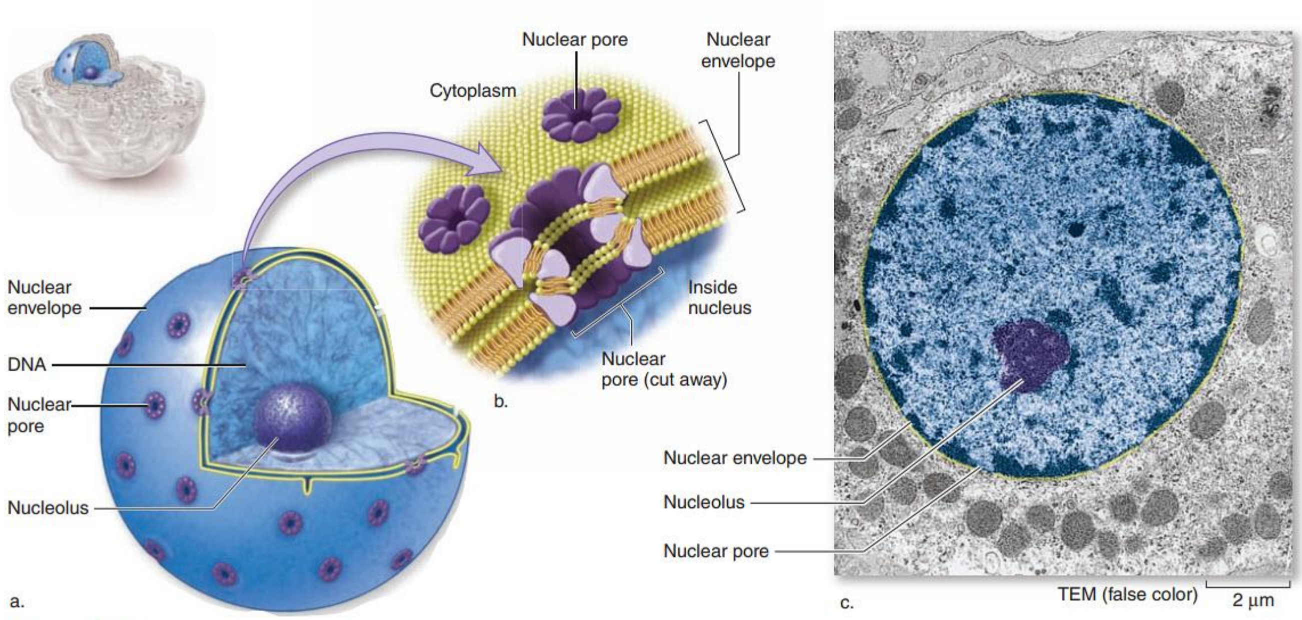
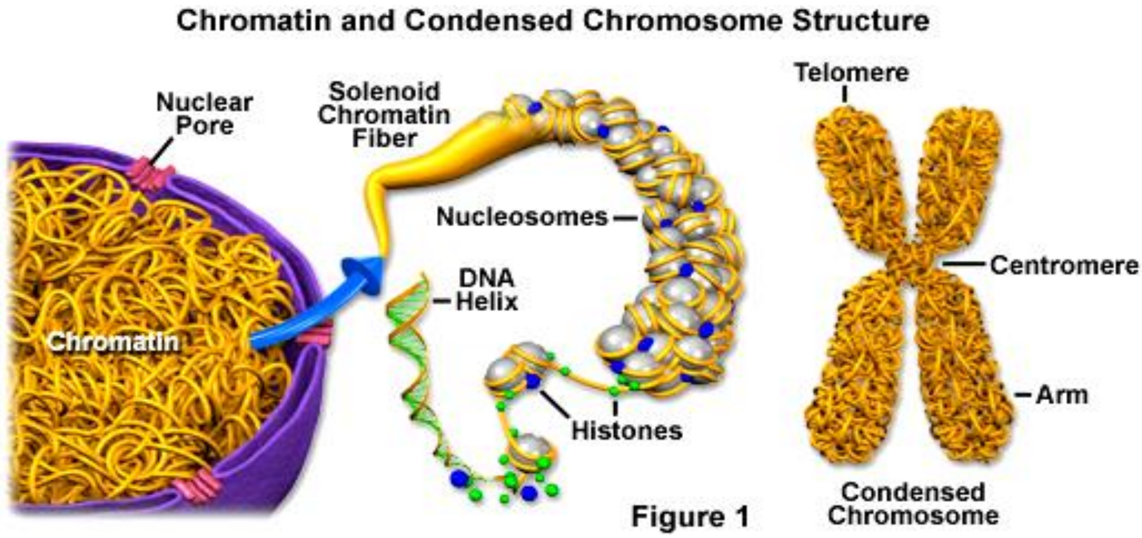


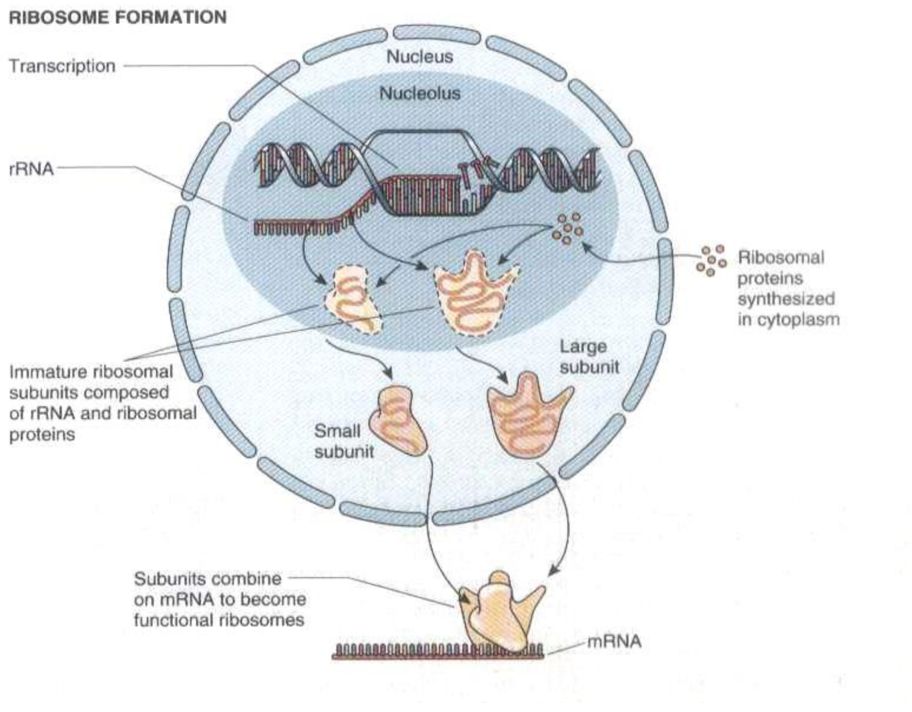
Figure 3.14 The Nucleus. (a) The nucleus contains DNA and is surrounded by two membrane layers, which make up the nuclear envelope. (b) Large pores in the nuclear envelope allow proteins to enter and mRNA molecules to leave the nucleus. (c) This transmission electron micrograph shows the nuclear envelope and nucleolus.

Nuclear envelope has very fine submicroscopic pores called **Nuclear pores**. Nuclear pores are highly specialized channels composed of dozens of types of proteins. Traffic through the nuclear pores is busy, with millions of regulatory proteins entering and mRNA molecules leaving each minute.

In the nucleoplasm lies a network of chromatin threads called **chromatin reticulum**. During cell division, the chromatin reticulum appears in the form of chromosomes. Each chromosome also bears a now-stainable swelling called centromere. They are visible only in the early stages of mitosis and meiosis.



In the nucleoplasm also present one or more spherical bodies called **nucleoli** (singular: **nucleolus**). The nucleolus is a dense, dark-staining rounded body. It has no limiting membrane. It is composed of a great number of protein and RNA molecules. These particular materials are subunits from which ribosomes are built. The subunits pass through nuclear pores and reach the cytoplasm. In times of protein synthesis , intact ribosomes form (each two subunits) in the cytoplasm.



Thus the function of nucleolus is a ribosome production factory, designed to fulfill the need for large-scale production of rRNAs and assembly of the ribosomal subunits.

- Chromosomes

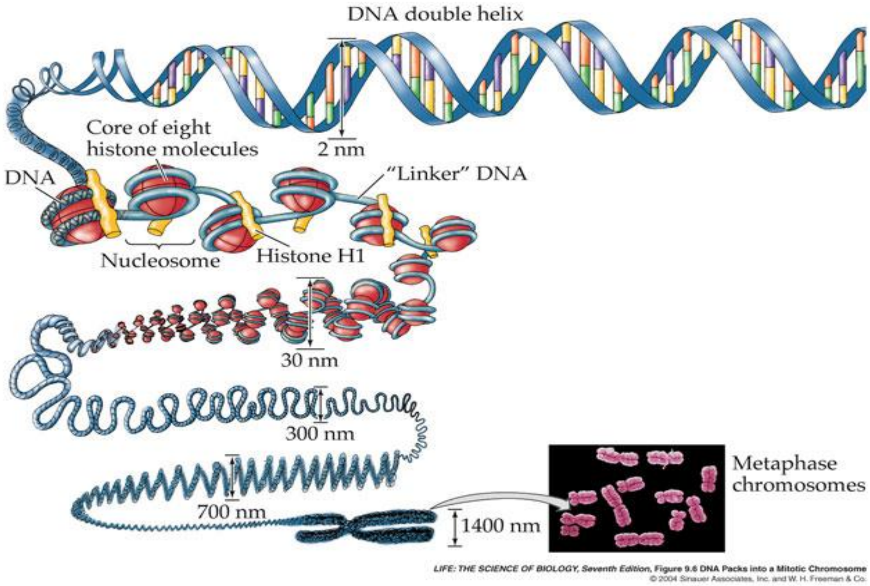
They are most important nuclear components. They control on the various biochemical and physiological activities in a cell. They replicate during cell division and gamete formation. They are concerned with the transmission of characters from parents to offspring. They play an important role in variations, heredity, mutations and evolution.The morphology of a chromosome can be best studied at metaphase or anaphase of cell division.

- *Number*

The number of chromosomes in a nucleus varies in different species, but it is constant in a species. The number of chromosomes varies from 2 (in *Ascaris megalocephala*) to 3200 (in a protozoon 'Aulacantha').

-*Structure*

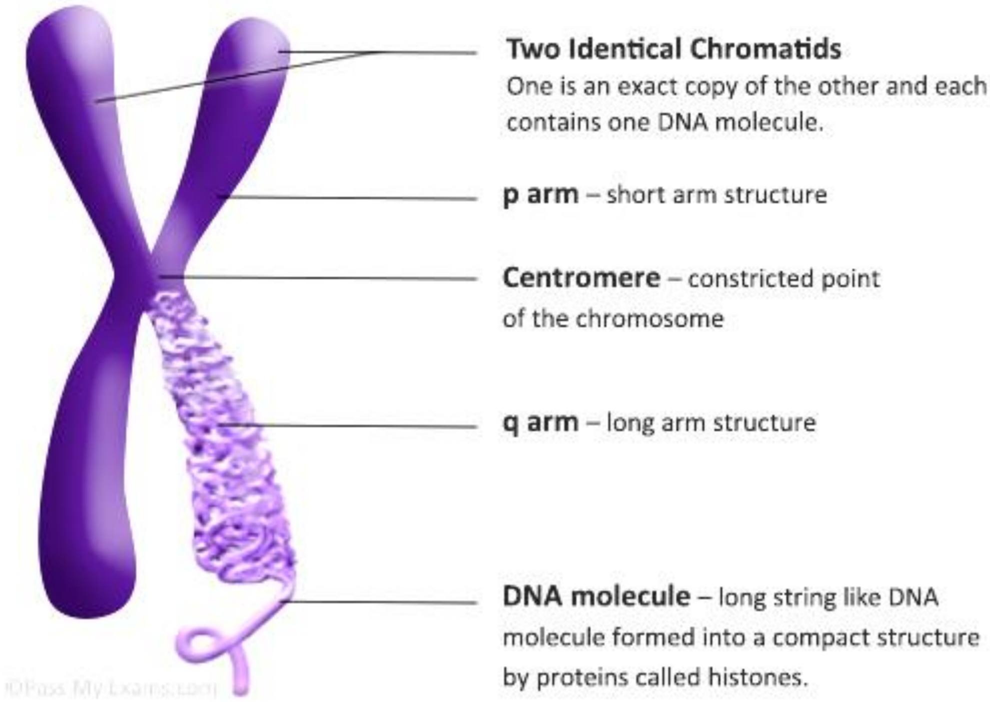
Chromosomes are structures composed of condensed DNA and associated proteins. When DNA condenses, the molecule becomes wrapped around proteins called histones. The histones are then arranged in a coiled pattern to produce a larger fiber. This larger fiber is further compacted by looping to produce looped domains. The looped domains are coiled and compacted to produce chromosomes.



A chromosome consists of two longitudinal, identical chromatids which are held together by o non-stainable area called **centromere**. The narrow constricted region bearing the centromere is called **primary constriction** or **Kinetochore**.

The two chromatids are formed from a single filament by replication during interphase. During metaphase, the chromosome gets attached to the spindle fiber by this centromere. It is also related with the chromosomal movement during cell division.

One Chromosome



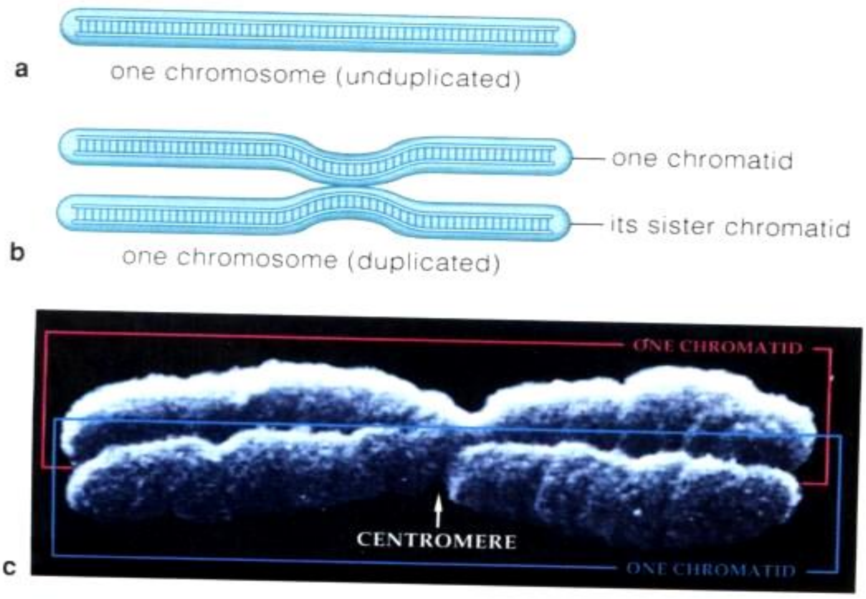
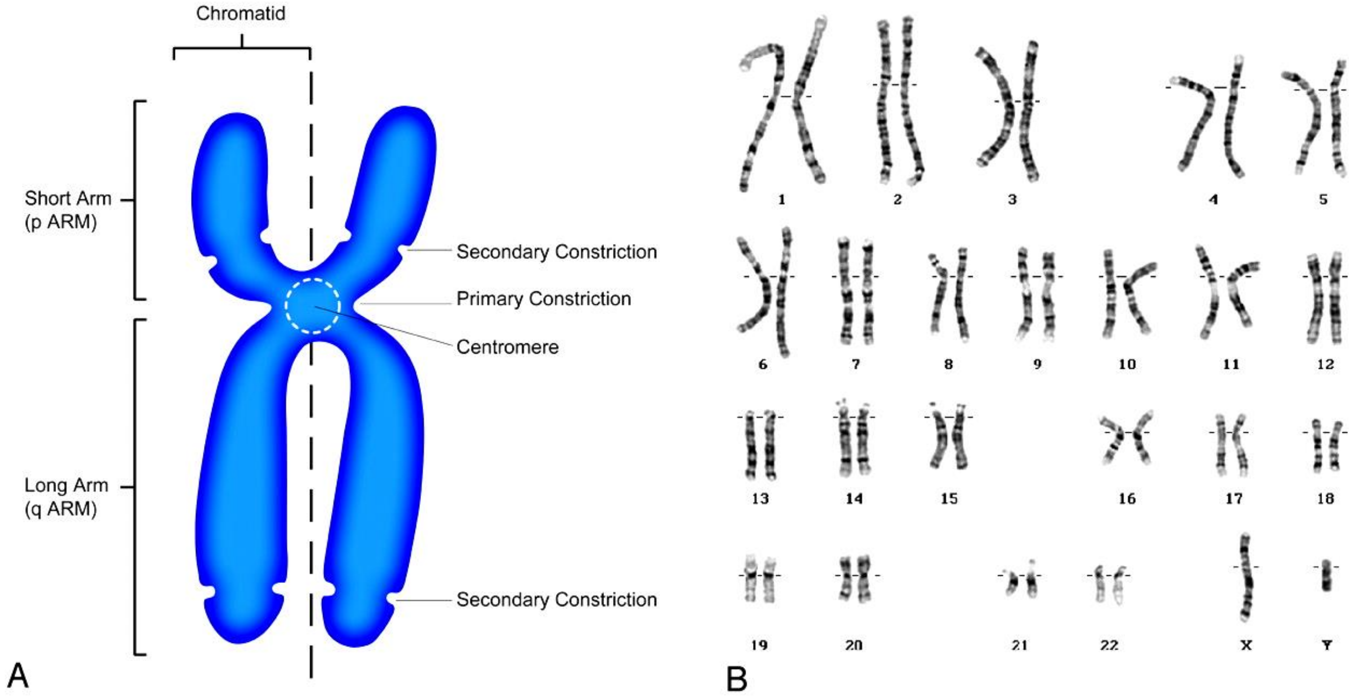


Figure 8.2 (**a**,**b**) Sketches of a chromosome in the unduplicated and duplicated states. Chromosomes are duplicated before cell division. (**c**) This scanning electron micrograph shows a human chromosome in the duplicated state: it consists of two sister chromatids attached at the centromere.

Recently it has been observed that two structures called **Kinetochores** (Primary **constriction** and **Secondary constriction**).



-Shape and types

1- Metacentric chromosome

The centromere lies in the middle. The chromosome appears V shaped at anaphase (**D**).

2- Sub-metacentric chromosome

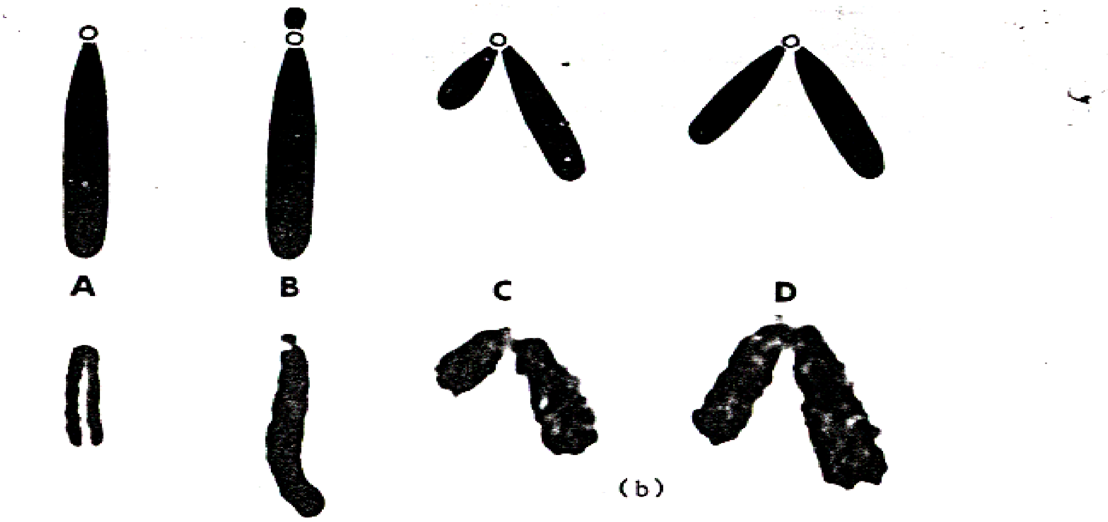
The centromere lies slightly away from the middle and the arms are slightly unequal. The chromosome appears L or J shaped at anaphase (**C**).

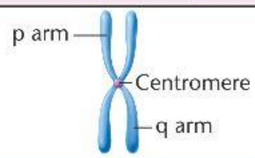
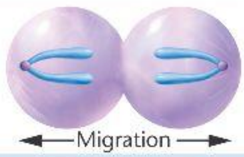
3- Telocentric chromosome

The Centromere lies at the end of an arm. The chromosome appears i shaped at anaphase (**A**).

4- Sub-telocentric (or acrocentric) chromosome

The centromere lies near the end of an arm at anaphase (**B**).



Centromere location	Designation	Metaphase shape	Anaphase shape
Middle	Metacentric		
Between middle and end	Submetacentric		
Close to end	Acrocentric		
At end	Telocentric		

- Gene

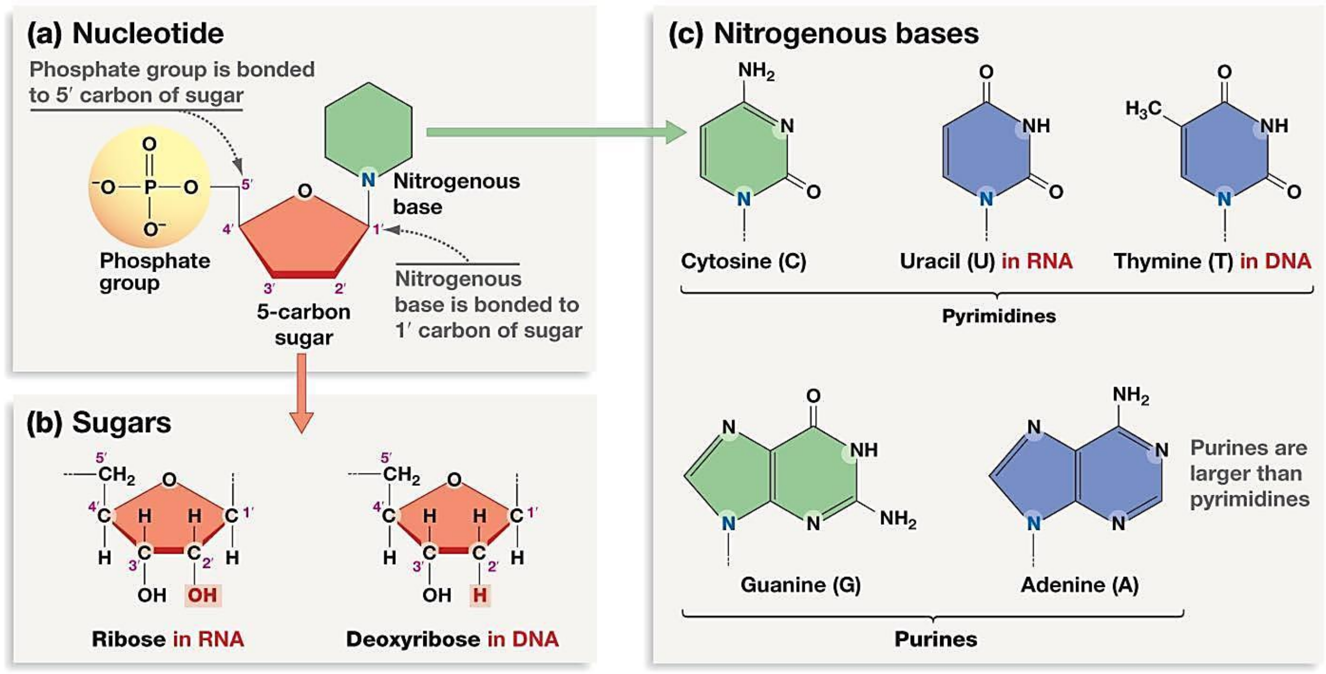
The gene is a unit of heredity. In biology, a gene is a sequence of nucleotides in **DNA** or **RNA** that encodes the synthesis of a gene product, either RNA or protein. It has a specific position on the chromosome. This position is called **gene locus**.

Genes make up segments of the complex DNA molecule that controls cellular reproduction and Function. There are thousands of genes in the chromosomes of each cell nucleus; they play an important role in heredity because they control the individual physical, biochemical and physiologic traits inherited by offspring from their parents. Through the genetic code of DNA they also control the day-to-day functions and reproduction of all cells in the body. For example, the genes control the synthesis of structural proteins and also the enzymes that regulate various chemical reactions that take place in a cell.

- Nucleic acid as a Genetic Material

Nucleic acids extremely complex, long-chain compounds of high molecular weight that occur naturally in the cells of all living organisms. They form the genetic material of the cell and direct the synthesis of protein within the cell.

Nucleic acids are composed of repeating smaller units, called **nucleotides**, which are made up of a **pentose sugar**, a **nitrogenous base**, and a **phosphate group**. There are two major classes of nucleic acids: **Deoxyribonucleic acid (DNA)** whose pentose sugar is deoxyribose, and **Ribonucleic acid (RNA)** whose pentose sugar is ribose. The major purine and pyrimidine bases in the nucleic acids are **Adenine(A)**, **Guanine (G)**, and **Cytosine (C)**, which occur in both, and **Thymine (T)** in DNA and **Uracil(U)** in RNA.



RNA is present in both the nucleus and the cytoplasm of many cells. Most of the cytoplasmic RNA is associated with ribosomes, which are the site of protein synthesis. RNA molecules perform several functions in the cell, depending on the type of RNA molecule and its specific properties. There are three types of RNA molecule:

1. Ribosomal RNA (rRNA).

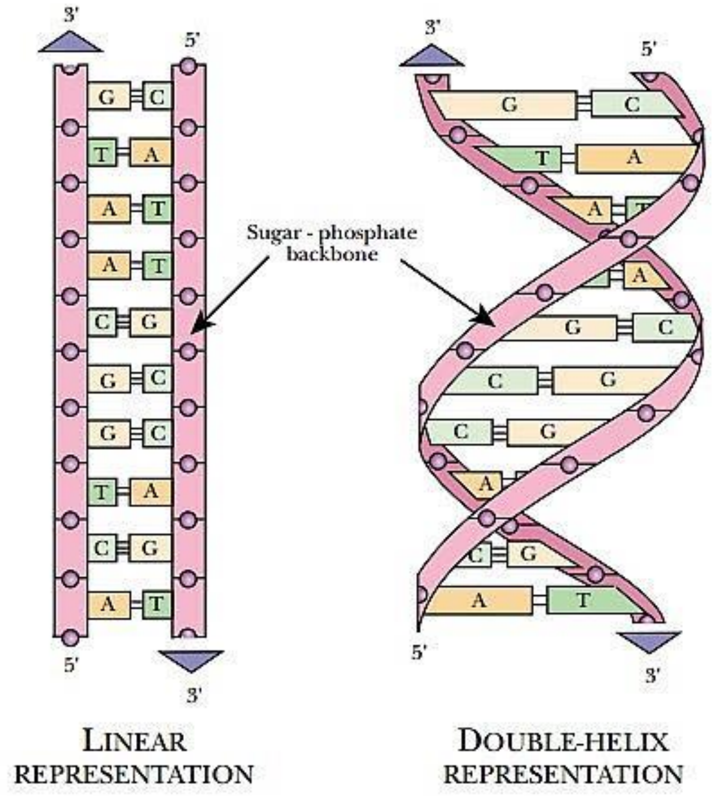
2. Messenger RNA (mRNA).

3.Transfer RNA (tRNA).

DNA is a major constituent of chromosomes in the nuclei of all cells. Its chief function is to provide a genetic message that is encoded in the sequence of bases.

FIGURE
Representations of Double Stranded DNA

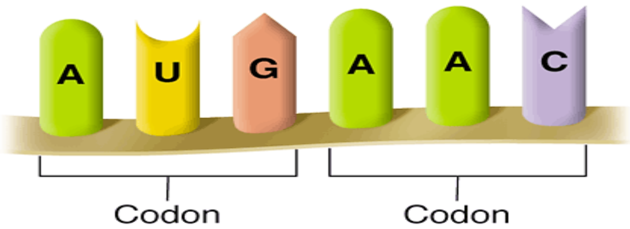
On the left DNA is represented as a double line consisting of two complementary strands. Actually DNA forms a double helix, as shown to the right.



-The Genetic code

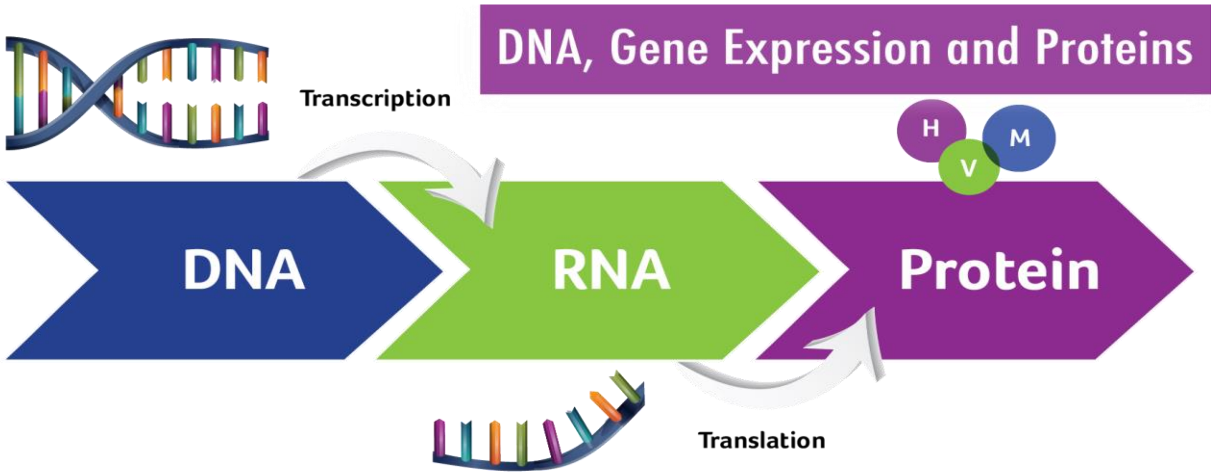
The arrangement of nucleotides in the polynucleotide chain of a chromosomes it governs the transmission of genetic information to proteins i.e., determines the sequences of amino acids in the polypeptide chain making up each protein synthesized by the cell.

Genetic information is coded in **DNA** by means of four bases : two purines (**adenine** and **guanine**) and two pyrimidines (**thymine** and **cytosine**). Each adjacent sequence of three bases (a **codon**) determines the insertion of a specific amino acid." In **RNA**, **uracil** replaces **thymine**".



- Gene expression

Gene expression is the transfer of genetic information from DNA into mRNA molecule and then translated into a protein molecule.



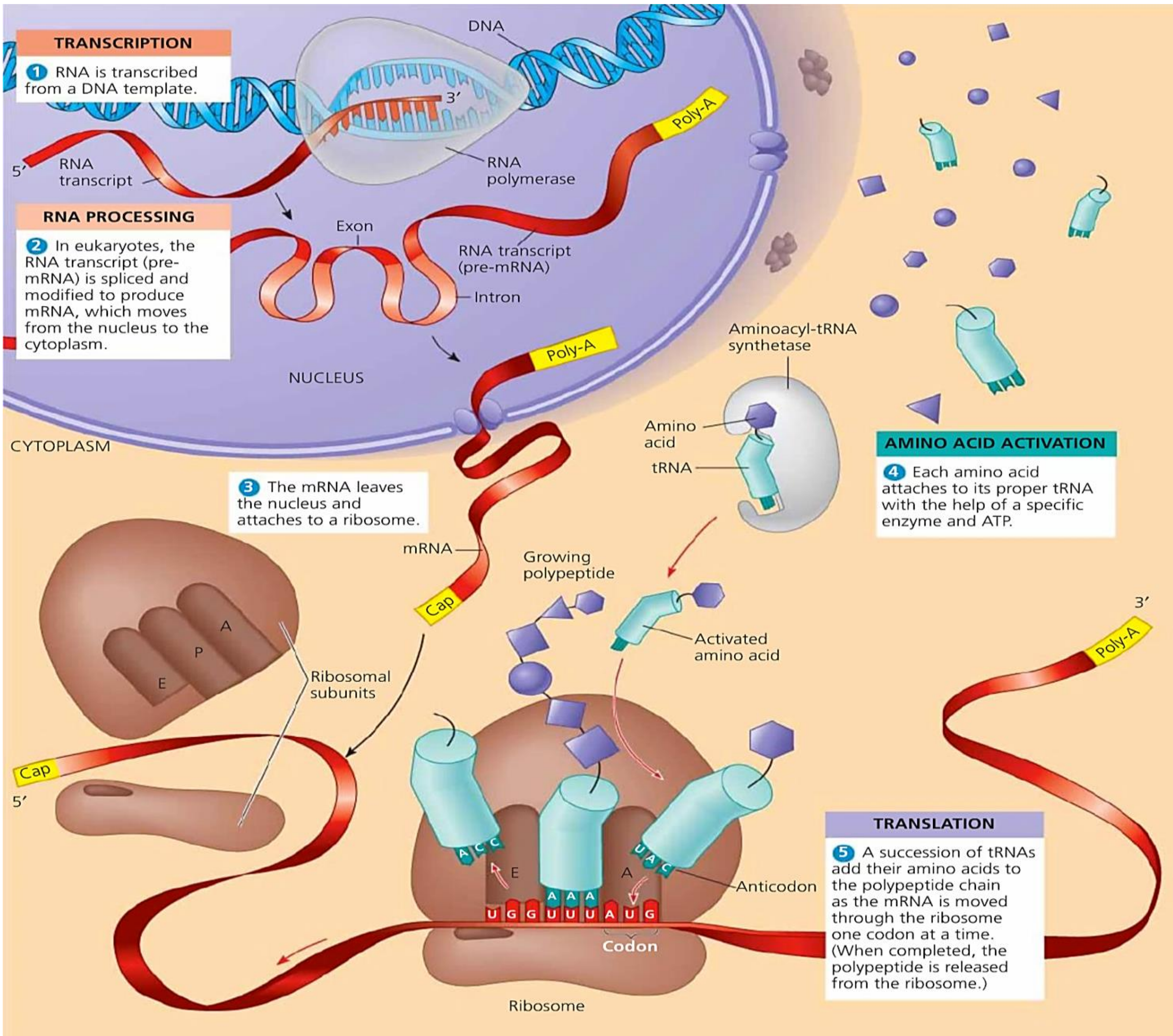
- **Transcription**: the Synthesis of mRNA using a DNA (the Antisense strand) as a template, catalyzed by an RNA polymerase; the base sequences of the mRNA and the DNA template are complementary.

- **Translation**: the synthesis of a polypeptide using messenger RNA as a template, and complex process involving ribosomes and transfer RNAs; every three bases (a codon) along the mRNA beginning with the start codon specifies one amino acid in the polypeptide chain.

- **Proteins**: are simply long chains of **amino acids** that take on different folding or coiling patterns depending on their length and sequence of amino acids.

Essential functions of proteins are shown in the below table

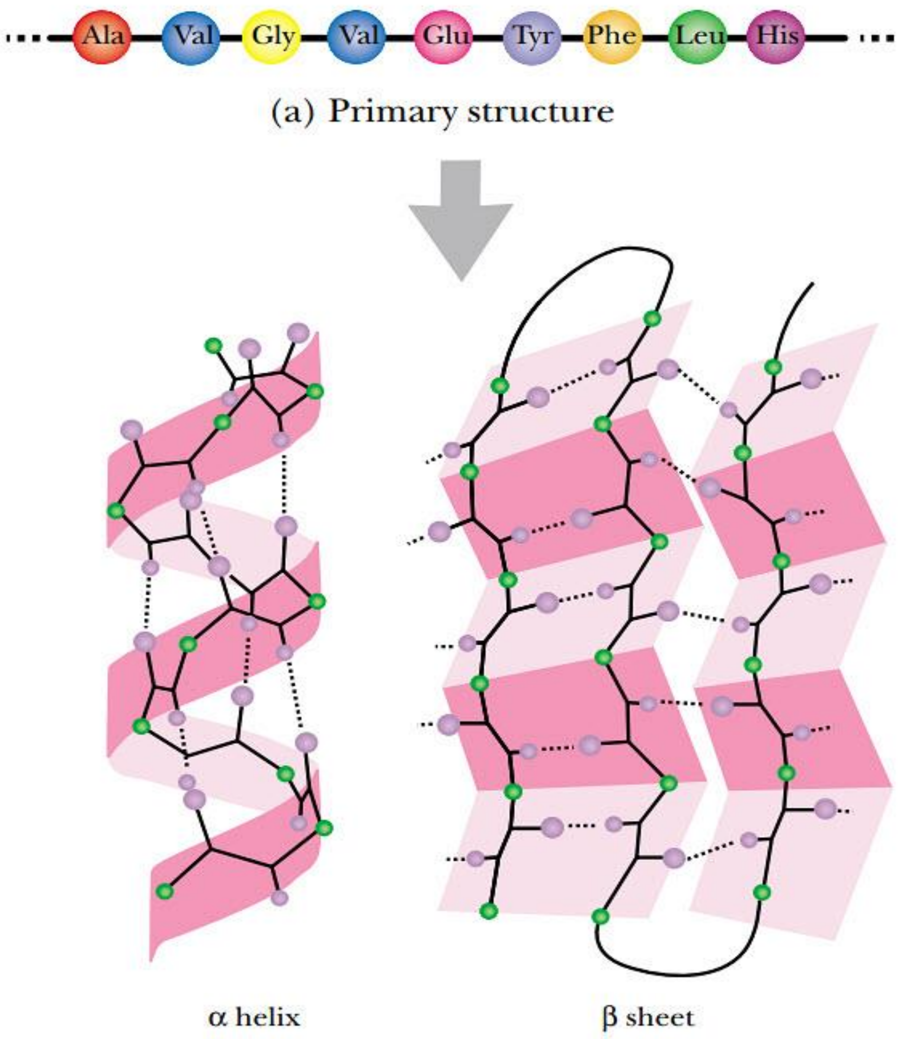
Protein Type	Function
Antibody	Bind to specific foreign particles to protect the body
Enzyme	Carry out nearly all chemical reactions within a cell. Assist in formation of new molecules by reading genetic information stored in DNA
Messenger	Transmit signals to coordinate processes between cells, tissues and organs
Structural Component	Provide cellular bodily structure and support
Transport/storage	Bind and transport atoms and molecules within cells and the body



- The Structure of Proteins Has Four Levels of Organization

For a protein to be functional, the polypeptide chains must be folded into their correct 3-D structures. The structures of biological polymers, both protein and nucleic acid, are often divided into levels of organization.

A- Primary structure, is the linear order of the monomers—i.e., the sequence of the amino acids for a protein, or of the nucleotides in the case of DNA or RNA.



(b) Secondary structures

B- Secondary structure is the folding or coiling of the original polymer chains by means of hydrogen bonding. Although DNA is not a protein, hydrogen bonding between base pairs forms the famous double helix. In proteins, hydrogen bonding between peptide groups results in several possible helical or wrinkled sheet-like structures.

C- Tertiary structure

The polypeptide chain, with its preformed regions of secondary structure, is then folded to give the final 3-D structure. This level of folding depends on the side chains of the individual amino acids. In certain cases, proteins known as **chaperonins** help other proteins to fold correctly. As there are 20 different amino acids, a great variety of final 3-D conformations is possible. Nonetheless, many proteins are roughly spherical.

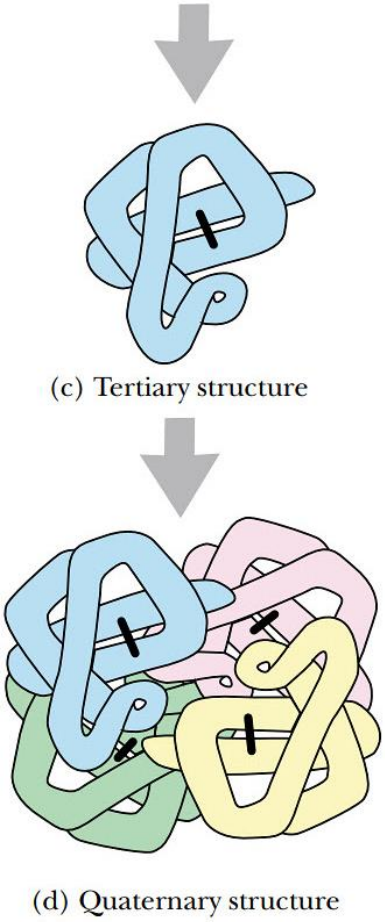


FIGURE 3.26 ***Four Levels of Protein Structure***

The final protein structure is best understood by following the folding process from simple to complex. The primary structure is the specific order of the amino acids (a). The secondary structure is due to regular folding of the polypeptide chain due to hydrogen bonding (b). The tertiary structure results from further folding of the polypeptide due to interactions between the amino acid side chains (c). Finally, the quaternary structure is the assembly of multiple polypeptide chains (d).

D- Quaternary structure is the assembly of several individual polypeptide chains to give the final structure.

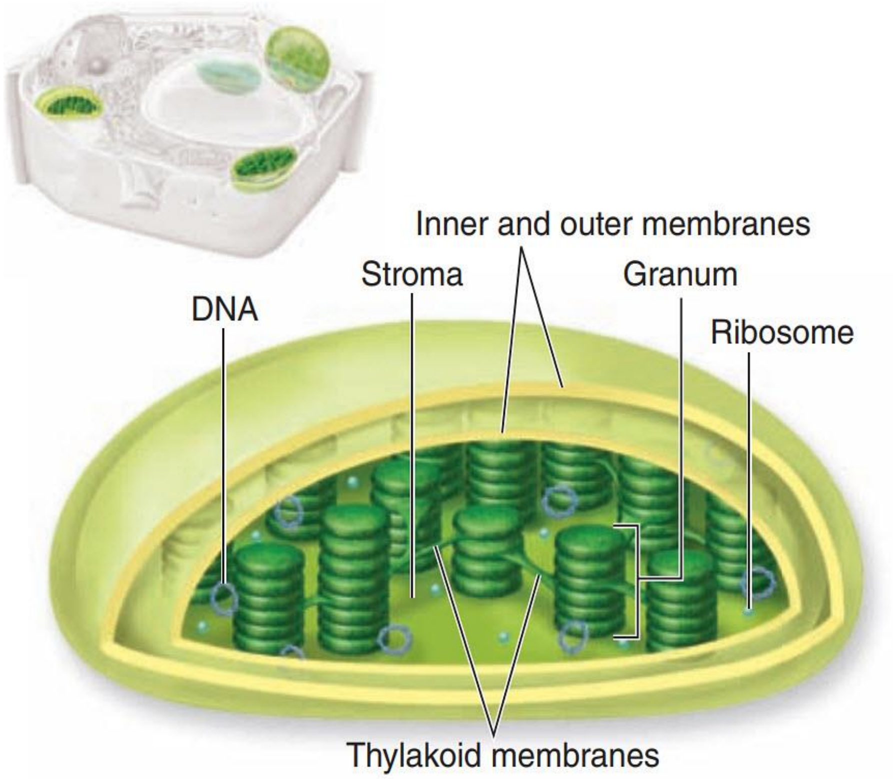
Not all proteins have more than one polypeptide chain; some just have one, so they have no quaternary structure.

(ix)- SPECIALIZED PLANT ORGANELLES

-Chloroplasts and Other Plastids

Many plant cells contain **plastids**, a general category of organelles that specialize in **photosynthesis** or function in storage. Three types are common in different parts of plants. They are the ***chloroplasts***, ***chromoplasts***, and ***amyloplasts***.

Of all eukaryotic cells, only the photosynthetic ones have chloroplasts. These organelles convert sunlight energy into the chemical energy of ATP, which is used to make sugars and other organic compounds. Chloroplasts commonly are oval or disk-shaped. Their semifluid interior, the **stroma**, is enclosed by two outer membrane layers. In the stroma is a third membrane called the **thylakoid membrane**. It is folded into a system of interconnecting, disk-shaped compartments. In many chloroplasts, these compartments stack, one atop the other.



The first stage of **photosynthesis** starts and ends at a thylakoid membrane. Many light-trapping pigments, enzymes, and other proteins carry out the reactions. They work together to absorb light energy and "store" it in the form of **ATP**. Then, in the stroma, ATP energy is used to make sugars, then starch and other organic compounds, from carbon dioxide and water. Clusters of new starch molecules (starch grains) may briefly accumulate in the stroma.

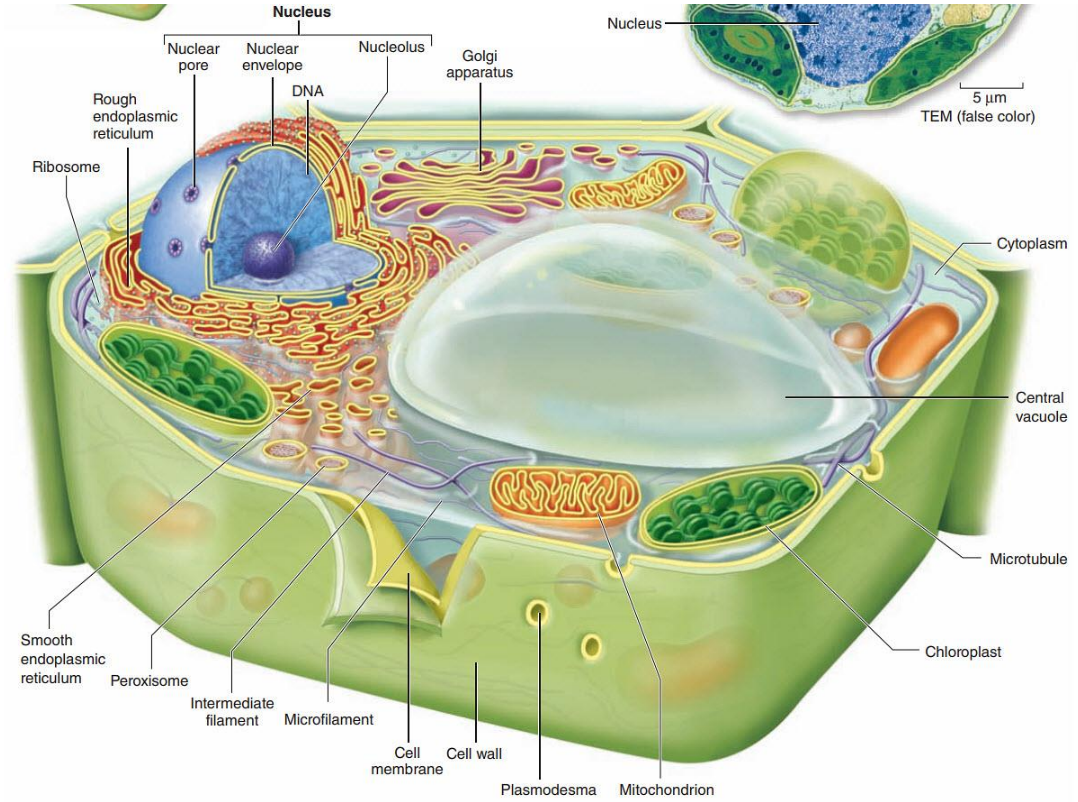
The most abundant photosynthetic pigments are **chlorophylls**, which reflect or transmit green light. Others include **carotenoids**, which reflect or transmit yellow, orange, and red light. The relative abundances of the different pigments influence the colors of plant parts.

Unlike chloroplasts, **chromoplasts** lack chlorophylls but have an abundance of **carotenoids**. They are the source of red-to-yellow colors of many flowers, autumn leaves, ripening fruits, and carrots and other roots. The pigment colors commonly attract animals that pollinate plants or disperse seeds.

Amyloplasts lack pigments. Often they store starch grains and are abundant in cells of stems, potato tubers (underground stems), and seeds.

- Central Vacuole

Many mature, living plant cells have a **central vacuole**. This fluid-filled organelle stores amino acids, sugars, ions, and toxic wastes. As it enlarges, it causes fluid pressure to build up inside the cell and so forces the cell's still-pliable cell wall to enlarge. Hence the cell itself enlarges. And as its surface area increases, so does the rate at which water and other substances can be absorbed across the plasma membrane.



In most cases, the central vacuole increases so much in volume that it takes up 50 to 90 percent of the cell's interior. The cytoplasm ends up as a very narrow zone between the central vacuole and plasma membrane.