**D I V E R S I T Y**

The living world is a rich tapestry of diversity, teeming with different kinds of organisms. There is a wide diversity in the flora (plants) and fauna (animals) in the world. Many different habitats exist on the earth. Each habitat has a variety of organisms that live there in different ways. This variety of life is called DIVERSITY.

There are approximately 1.5 million species that exist today *(5% are single-celled organisms; 22% are fungi and plants; 70% are animals).* By far the largest numbers of species are the land dwelling insects. With such a wide range of animals and plants in the planet, also explains diversity.

Organisms may have similar adaptations because they are related to each other e.g. all plants have cell walls and almost all plants have chlorophyll to capture energy from sunlight. All birds have wings and use beaks to get food. All fishes have gills and fins. Organisms that are related to each other may have similar structures even though the structures are used differently.

**CHARACTERISTICS OF LIVING THINGS**

*What makes something “alive”? What characteristics do define life?*

In its broadest sense, biology is the study of living things – the science of life. There are some generally accepted characteristics that are common to all living things, these include:- *(Remember* ***MR NIGER CAD? – Movement, Respiration, Nutrition, Irritability, Growth, Excretion, Reproduction, Competition, Adaptation and Death.)***

**For the purposes of this class, we will collapse and merge some of these to five points as :-**

1. All **living things are made of one or more cells**. A cell is the basic unit of a living thing. Most can perform all processes associated with life. A cell provides all the conditions needed for the chemical reactions of living things. Cells vary in type and function. Life is highly organized from small and simple to large and complex, within cells, within multicellular organisms and among organisms. Here is a hierarchical organization of living things:

**Within Cells Within Multicellular Organisms Among Organisms**

Cell Organism e.g. Bird Ecosystem

Organelle Organ System e.g. N. S. Community

Macromolecule Organ e.g. brain Species

Molecule Tissue Population

1. **Responding to their environment** – all organisms respond to stimuli. Plants grow toward a source of light, and your pupils dilate when you walk into a dark room. Multicellular animals have specialized sense organs and effector organs. Unicellular organisms also with no Nervous System, the reception and response to a stimulus occur in the same cell. Sound is a stimulus. Other stimuli include light, pressure, odors and temperature changes.
2. **Growth, Development and Reproduction** – all organisms are capable of growing (through cell division and cell enlargement) and reproducing new individuals more or less similar in form to the parent organisms by means of sexual or asexual reproduction. These organisms possess hereditary molecules that are passed to their offspring ensuring that the offspring are of the same species.
3. **Regulation** – all organisms need energy to build the substances that make up their cells. All organisms have regulatory mechanisms that coordinate the organisms’ internal functions. These functions include supplying cells with nutrients, transporting substance through the organism and removing wastes. For life to be maintained, a balance must exist between an organism’s energy-producing processes and its energy-using processes. The constant balancing of these two systems within an organism is called **metabolism.***(Nutrition and Excretion)*
4. **Homeostasis –** all organisms maintain relatively constant internal conditions different from their environment, a process called **homeostasis.** This is the regulation by an organism of the chemical composition of its body fluids and other aspects of its internal environment so that physiological processes can proceed at optimum rates e.g. **homoiothermy**– acid-base balance and **poikilothermy** – body temperature.

**CLASSIFICATION OF ORGANISMS**

Living things were initially categorized only into two kingdoms of Animalia and Plantae. A **Kingdom** in the traditional classification systems is the highest category into which organisms are classified. These organisms live in the habitats of land, water and air.

Organisms were classified by defining what makes them similar and different. Classification also helps scientists trace the process of evolution and extinction of organisms.

**KINGDOMS**

The original two kingdoms, Plantae and Animalia have been supplemented by others. As biologists discovered microorganisms and learned more about other organisms, more kingdoms were added. Most modern classification systems recognize five kingdoms which are: **Monera** (bacteria or prokaryotae)**, Protoctista** (protozoa and algae)**, t**he multicellular organisms were split into three kingdoms of **Plantae**, **Fungi** (molds, yeasts), **Animalia** (invertebrates and vertebrates).

**THE FIVE KINGDOMS**

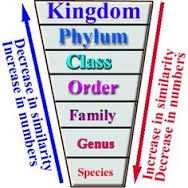
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| --- |
| Kingdoms are a way that scientists have developed to divide all living things. These divisions are based on what living things have in common and how they differ. This system was developed over 2, 000 years ago and has changed drastically over the years. Currently there are five kingdoms in which all living things are divided: Monera Kingdom, Protist Kingdom, Fungi Kingdom, Plant Kingdom, and Animal Kingdom.  **Monera Kingdom** The Monera Kingdom consists of organisms that are made up of one cell. These organisms are called unicellular. These unicellular organisms are made of a very simple cell that often lacks many cell parts, such as a nucleus, that are commonly found in other cells. Bacteria are a type of monera.  **Protist Kingdom** Protists are similar to monera in that they are unicellular. Protists are a bit more complex because they contain a nucleus. They also have moving parts and can move around within their environment.  **Fungi Kingdom** Fungi have their own kingdom because there is no other organism like them. They were once thought to be plants but they differ from plants in one major way. Fungi cannot make their own food. Mushrooms are a type of fungi.  **Plant Kingdom** All plants are a part of the Plant Kingdom. Plants include trees, grass, flowers, and algae. They all share the common characteristic of being able to make their own food using water and sunlight. Because they only require a few simple requirements, plants can grow almost anywhere.   **Animal Kingdom** Organisms in the Animal Kingdom are multicellular and rely on other organisms for food. This kingdom is by far the largest of all the kingdoms. The animals of the Animal Kingdom can be found all over the world and can be any size from very tiny to extremely big. |

**LEVELS OF CLASSIFICATION**

**Carolus Linnaeus (1707 – 1778)** classified all the different kinds of organisms into groups based on similar characteristics. Linnaeus’s system for naming species is called **binomial nomenclature (scientific name)**. Each species has a Latinized name composed of two words (hence binomial) printed in italics (or underlined if handwritten or typed). The first word names the **genus**, which is capitalized; the second word is the **species,** which is peculiar to the species within the genus and is written in lower-case. E.g. *Glossina palpalis* (Tsetse fly).

Taxonomy is the science of classifying living things. A group of organisms at a particular level in a classification system is called a **taxon (**plural, **taxa).**

There are seven major levels of classification. Each successive level contains fewer organisms with more characteristics in common than the level above it. These levels are, from the largest, **kingdom, phylum, class, order, family, genus** and **species. (D**oes **K**im **P**lay **C**hess **O**r **F**ix **G**reat **S**andwiches? Or **K**indly **P**ay **C**ash **O**r **F**urnish **G**ood **S**ecurity.)



**DOMAINS**

Biologists are increasingly adopting a classification of living organisms that recognizes three **domains**, a taxonomic level higher than kingdom. These are **bacteria** containing the true bacteria, **archaea** (archaebacteria) and **Eukarya** (eukaryotes).

**BRIEF DESCRIPTIONS OF THE DOMAINS**

**DOMAIN 1: ARCHAEA**

These are the "bacteria" that live at high temperatures or produce methane. While most archaeans look similar to bacteria under the microscope, the extreme conditions under which many species live has made them difficult to culture.

Archaeans include inhabitants of some of the most extreme environments on the planet. Some live near rift vents in the deep sea at temperatures well over 100 degrees Centigrade. Others live in hot springs, or in extremely alkaline or acid waters. They have been found thriving inside the digestive tracts of cows, termites, and marine life where they produce methane. They live in the anoxic muds of marshes and at the bottom of the ocean, and even thrive in petroleum deposits deep underground. Some archaeans can survive the desiccating effects of extremely saline waters. One salt-loving group of archaea includes *Halobacterium.*

The archaeans can also be called “life extremists” because they live in some of the most extreme environments on earth. Their cell walls lack peptidoglycan and the lipids in their cell membranes are branched.

Examples of Archaea are:

1. **Methanogens** – these obtain their energy by using hydrogen gas (H2) to reduce carbon dioxide (CO*2)* to methane gas (CH4). They are also strict anaerobes. Live in swamps, marshes and the intestines of mammals.
2. **Extremophiles** – are able to grow under conditions that seem extreme to us e.g.:
   1. **Thermophiles** – live in very hot places, typically from 60o to 80oC. Many of them are autotrophs and have metabolisms based on sulfur. For example, *Pyrolobus fumarii* is so heat tolerant that it is not killed by a one-hour treatment in an autoclave.
   2. **Halophiles** – These are salt lovers. They live in very salty places like the Dead Sea. These bacteria require water with a salinity of 15 to 20% compared to 3% salinity of sea water.
   3. **pH-tolerant** archaea grow in highly acidic (pH = 0.7) and very basic (pH = 11) environments.
   4. **Pressure-tolerant**– archaea have also been isolated requiring at least 300 atmospheres of pressure to survive.

**DOMAIN 2: BACTERIA**

Bacteria are often accused as the cause of human and animal disease (e. g., *Leptospira*, which causes serious disease in livestock). However, certain bacteria, the actinomycetes, produce antibiotics such as streptomycin; others live symbiotically in the guts of animals (including humans) or elsewhere in their bodies, or on the roots of certain plants, converting nitrogen into a usable form. Bacteria put the tang in yogurt; bacteria help to break down dead organic matter; bacteria make up the base of the food web in many environments. Bacteria are of such immense importance because of their extreme flexibility, capacity for rapid growth and reproduction.

**DOMAIN 3: EUKARYA (EUKARYOTES)**

The Eukaryotes include the organisms that most people are most familiar with - all animals, plants, fungi, and protists. Although they show unbelievable diversity in form, they share fundamental characteristics of cellular organization (have nuclei, mitochondria, and other organelles), biochemistry, and molecular biology. Examples are: a dinoflagellate, a single-celled photosynthetic protist; a palm tree representing the plants; a spider, one of the animals; and a cluster of mushrooms representing the fungi.

Some key characteristics of Eukaryotes are:-

1. Multicellularity – distinct types of cells, tissues and organs can be differentiated within the complex bodies of multicellular organisms. A multicellular organism can do many things according to the different cells.
2. Sexuality – this alternates between **syngamy** – the union of male and female gametes producing a cell with two sets of chromosomes; and **meiosis**, cell division producing daughter cells with one set of chromosomes.

**GSuite Class Notes 2**

**CHARACTERISTICS OF THE FIVE KINGDOMS**

Organisms are divided into five major kingdoms.

## 1. KINGDOM MONERA

The Kingdom Monera includes organisms that are single-celled or unicellular organisms known as bacteria. The kingdom is divided into two groups *Archaebacteria* and *Eubacteria*. These organisms have cell wall which is made up of peptidoglycans. This kingdom includes examples like bacteria, cyanobacteria, and mycoplasma.

General characteristics of the kingdom Monera are as follows:

1. They are primitive organisms.
2. All organisms of the kingdom are prokaryotes (DNA is in double stranded form, suspended in the cytoplasm of the organism, referred to as nucleoid).
3. They are present in both living and non-living environment.
4. They can survive in harsh and extreme climatic conditions like in hot springs, acidic soils etc.
5. They are unicellular organisms.
6. Membrane bound nucleus is absent.
7. A rigid cell wall is present.
8. Membrane bound cellular organelles like mitochondria are absent.
9. Nutrition - *autotrophs* - can prepare their own food, *heterotrophs* - depend on others for food, *saprophytes* - feed on dead and decaying matter, *parasitic* - live on other host cells for survival and cause: *symbiosis* - mutual relation with other organisms, *commensalism* - where one organism is benefited and the other is not affected, *mutualism* - where both the organisms are benefited.
10. Respiration - respiration in these organisms vary, they may be *obligate aerobes* - the organisms must have oxygen for survival; *obligate anaerobes* - the organisms cannot survive in the presence of oxygen; *facultative anaerobes* - these organisms can survive with or without oxygen.
11. Circulation - is through diffusion.
12. Reproduction is mostly asexual, sexual reproduction is also seen. Asexual reproduction is by binary fission, sexual reproduction is by conjugation, transformation and transduction.

**CLASSIFICATION OF BACTERIA**

1. Bacteria are often classified according to **their shape**. The round or egg-shaped bacteria are called **cocci,** the rod-shaped bacteria are called **bacilli.** The spiral-shaped bacteria are called **spirilla.**
2. Bacteria can also be classified by **whether or not they need oxygen** to live, grow, and reproduce. Those that require oxygen are called **aerobes.** Bacteria classified as **anaerobes** do not need oxygen. **O*bligate aerobes*** - the organisms must have oxygen for survival; ***obligate anaerobes*** - the organisms cannot survive in the presence of oxygen; ***facultative anaerobes*** - these organisms can survive with or without oxygen.
3. **Based on habitat** – we have the halophiles (salty areas), thermophiles (hot springs) and Methanogens (marshy areas).
4. **Based on nutrition** – we have **autotrophic bacteria** (make their own food) are either chemosynthetic or photosynthetic. There are also **heterotrophic bacteria** (depend on others for their own food) are either parasitic or saprophytic.
5. **Based on Gram's staining** - Gram's staining is a test on cell walls developed by Hans Christian Gram. This method helps classify bacteria into Gram positive bacteria and Gram negative bacteria.   
   *Gram Positive Bacteria* - The bacteria's cell wall is made up of protein-sugar complex that takes on purple color during gram staining.   
   *Gram Negative Bacteria –* the gram negative bacteria have an extra layer of lipid on the outside of the cell wall and appear pink during the Gram staining procedure.

**2. KINGDOM PROTISTA**  
Kingdom Protista is a diverse group of eukaryotic organisms. Protists are unicellular, some are colonial or multicellular, they do not have specialized tissue organization. The simple cellular organization distinguishes the protists from other eukaryotes. The cell body of the protists has a nucleus which is well defined and membrane bound organelles. Some have flagella or cilia for locomotion. Reproduction in protists is both asexual and sexual. They live in any environment that contains water.

A protist can simply be defined as any organism that is not a fungus, plant or animal.

**Characteristics**  
General characteristics of Kingdom Protista are as follows:

1. They are simple eukaryotic organisms.
2. Most of the organisms are unicellular, some are colonial and some are multicellular like algae.
3. Most of the protists live in water, some in moist soil or even the body of humans and plants.
4. They have mitochondria for cellular respiration and some have chloroplasts for photosynthesis.
5. Nuclei of protists contain multiple DNA strands.
6. Movement is often by flagella or cilia.
7. Respiration –where cellular respiration is primarily an aerobic process, but some living in mud below ponds or in digestive tracts of animals,are strict facultative anaerobes.
8. Nutrition - they can be both heterotrophic and autotrophic.
9. Flagellates are filter feeding, some protists feed by the process of endocytosis (formation of food vacuole by engulfing a bacteria and extending their cell membrane).
10. Reproduction - some species have complex life cycle involving multiple organisms. E.g. *Plasmodium*. Some reproduce sexually and others asexually.
11. They form cysts in adverse conditions.
12. Some protists are pathogens of both animals and plants. Example: *Plasmodium falciparum* causes malaria in humans.
13. Protists are major components of plankton.

Kingdom Protista are categorized into two taxa:-***Protozoans*** *- animal-like single-celled organisms and* ***Algae*** *- plant-like single or multi-celled organisms.*

**Protozoans - Animal-like Protists**

They have resemblance to animals and are thus known as protozoans. They live in moist and watery environments. The characteristics similar to animals are - their ability to move and their inability to produce their own food (heterotrophs). They differ from animals being unicellular while animals are multicellular.

Protozoans are classified on the way they move into four categories:

* *Sacordinians* - move using pseudopodia.
* *Zooflagellates* - move using flagella.
* *Ciliophorans* - move using cilia.
* *Sporozoans* - forms spores

**Algae - Plant-like Protists**

Plant-like protists have chlorophyll like that in plants. The green substance in their cells enables them to make food by photosynthesis. They produce and release oxygen like the plants.

Examples of Plant-like Protists are  
      Euglenophyta (Euglenas)    
      Chrysophyta (Diatoms)    
      Pyrrophyta (Dinoflagellates)    
      Chlorophyta (Green Algae)    
      Rhodophyta (Red Algae)    
      Phaeophyta (Brown Algae)

## 3. KINGDOM FUNGI

Fungi show a great diversity in morphology and habitat. Fungi are heterotrophic organisms, they obtain their nutrients by absorption. The 'fruit' body of fungus is only seen, while the living body of the fungus is a mycelium, made of tiny filaments called hyphae. Fungi digest their food before it passes through the cell wall into the hyphae. The hyphae secrete enzymes and acids that break down the organic material into simple compounds.

## Characteristics

General characteristics of fungi are as follows:

1. Fungi are eukaryotic organisms.
2. They are non-vascular organisms.
3. They reproduce by means of spores.
4. Depending on the species and conditions both sexual and asexual spores may be produced.
5. They are typically non-motile.
6. Fungi exhibit the phenomenon of alteration of generation.
7. The vegetative body of the fungi may be unicellular or composed of microscopic threads called hyphae.
8. The structure of cell wall is similar to plants but chemically the fungi cell wall is composed of chitin, (plants is made of cellulose).
9. Fungi are heterotrophic organisms.
10. Nutrition in fungi - they are saprophytes, or parasites or symbionts.
11. Reproduction in fungi is both by sexual and asexual means. Sexual state is referred to as **teleomorph**, asexual state is referred to as **anamorph**.

## Classification

Based on the spore case in which the spores are produced, fungi are classified into four divisions.  
1. **Division Ascomycota: Sac Fungi**

The sac-fungi produce spores in small cup-shaped sacs called asci, hence the name ascomycota. The mature sac fungi spores are known as ascospores, they are released as the tip of the ascus breaks open. Yeast is the most common one-celled fungi.

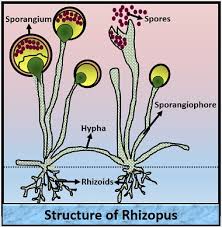


2. **Division Basidiomycota: Club Fungi**

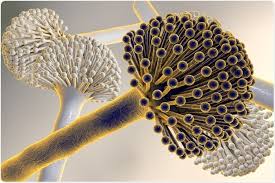
Basidiomycota includes the mushrooms, puff-balls, smuts, rusts and toadstools. The spores are borne on a club-shaped spore case called basidium. Example: *Agaricus* (mushroom), *Ustilago* (smut), and *Puccinia* (rust fungus).



1. **Division Zygomycota: Zygote forming Fungi**These fungi are usually found on cheese, bread, and other decaying food. They are zygote forming fungi, hence the name zygomycota. The spores are produced in round-shaped case called sporangium. Example: *Mucor*, *Rhizopus* (the bread mould) and *Albugo*.



**4. Division Deuteromycota: Imperfect Fungi**These organisms are known as imperfect fungi because they lack sexual reproduction. They reproduce by asexual spores known as conidia. Most of the fungi cause diseases to humans like ringworm, athlete's foot. Economically important imperfect fungi are *Penicillium* and *Aspergillus*.



**GC NOTES 3**

**LEVELS OF ORGANIZATION OF LIFE**

**Nonliving Levels:**

1. ATOM (element)
2. MOLECULE (compounds like carbohydrates & proteins)
3. ORGANELLES (nucleus, ER, Golgi …)

**Living Levels:**

1. CELL (makes up ALL organisms)
2. TISSUE (cells working together)
3. ORGAN (heart, brain, stomach …)
4. ORGAN SYSTEMS (respiratory, circulatory …)
5. ORGANISM
6. POPULATION (one species in an area)
7. COMMUNITY (several populations in an area)
8. ECOSYSTEM (different communities, forest, prairie …)
9. BIOME (Tundra, Tropical Rain forest…)
10. BIOSPHERE (all living and nonliving things on Earth)

**CELL**

All living organisms are made up of small units of protoplasm surrounded by a surface membrane in animals and a non-living wall in plants and bacteria. This unit of protoplasm is termed ‘**Cell**’ and it is the basis for **structure**, **function**, and **biological** processes of all known living organisms. The cell is the unit of structure and function because it serves as the building blocks of life and is also capable of performing all biological activities.

The discovery of cell by **Robert Hooke** in 1665 was possible due to advancement in the magnification technology i.e. development of the microscope by **Anton van Leeuwenhoek.**

The first observation of cells was made in 1665 by English scientist Robert Hooke, who used a crude microscope of his own invention to examine a variety of objects, including a thin piece of cork. Noting the rows of tiny boxes that made up the dead wood’s tissue, Hooke called them “CELLS”. At about the same time, the Dutch maker of microscopes, Anton van Leeuwenhoek pioneered the invention of one of the best microscopes of the time. Using his invention, Leeuwenhoek became the first to observe, draw, and describe a variety of living organisms such as bacteria, unicellular organisms and sperm swimming in semen.

In 1838, a German botanist named **Matthias Schleiden** concluded that all plants were made of cells. In 1839, a German zoologist named **Theodore Schwann** concluded that all animals were made of cells. Working together, Matthias Jakob Schleiden and Theodore Schwann recognizing the fundamental similarities between plant and animal cells in 1839, proposed the revolutionary theory (cell theory) that gave rise to modern biology.

In 1855, a German medical doctor named **Rudolph Virchow** observed, under the microscope, cells dividing and reasoned that all cells come from other pre-existing cells by cell division.

**The Cell Theory**

The cell theory states that:

1. All living organisms are composed of one or more cells.
2. The cell is the most basic unit of life.
3. All cells arise from pre-existing, living cells, by biogenesis.
4. Energy flow (metabolism and biochemistry) occurs within cell
5. Heredity information (DNA) is passed on from cell to cell.
6. All cells have the same basic chemical composition in organisms of similar species.

**The cell structure:**

Cells are of different kinds, different sizes, shapes and forms. However, they all tend to possess the following features:

1. **Cell membrane:** that keeps the inside and outside separate.

2. **DNA-containing region:** that holds the instructions to run the processes of life.

3. **Cytoplasm:** a semi-fluid region containing the rest of the cell’s machinery.

**Cell size**

Cells are visible only with a microscope. However, a few types of cells such as egg cells, nerve cells in a giraffe can be seen without the aid of a microscope. Cells are limited in size by the ratio between their outer surface area and their volume. This means that if a cell keeps the same shape as it grows, its volume will increase more rapidly than its surface area. At some point, its surface area becomes too small to allow nutrients, oxygen, and other materials to enter the cell quickly enough to meet the cell’s needs.

**Shape**

Cells come in variety of shapes reflecting diversity of functions. Skin cells for example are flat covering the body’s surface. Also White blood cells can change shape (leave the blood, enter the areas surrounding blood vessels, so they can do their job of attacking invaders like bacteria). Other specialized cells found in living organisms include epithelial cell, White blood cell, Nerve cell, Smooth muscle fiber, Spermatozoon, Parenchyma cells of plant etc.

**CLASSIFICATION OF LIVING CELLS**

Living cells can be classiﬁed into different classes. However, the two basic classes are:

1. **Prokaryote**, from the Greek words ‘pro’ (before) and ‘karyon’ (nucleus), and
2. **Eukaryote**, from ‘eu’ (true) and ‘karyon’ (nucleus).

**Prokaryotic cell**

These cells were the first form of life on Earth, they are characterized by having vital biological processes including cell signaling and being self-sustaining. They are simpler and smaller than eukaryotic cells, and lack nucleus and other membrane-enclosed structures. Prokaryotes include two of the domains of life, **bacteria** and **archaea**. The DNA consists of a single chromosome that is in direct contact with the cytoplasm. Most prokaryotes are the smallest of all organisms ranging from 0.5 to 2.0 µm in diameter.

**The structure and function of prokaryotic cell organelles**

**Capsules**

These are slimy or gummy secretions of some bacteria (gram negative) outside the cell membrane and cell wall. The capsule may be of polysaccharide or polypeptide bi-layer that is covalently bonded to the **peptidoglycan** of the cell wall.

**Function**

Unites bacteria into colonies, enable bacteria to stick to surfaces such as teeth, mud rocks etc. provides additional protection to the organism.

**The Cell Wall**

This is a semi rigid structure that lies outside the cell membrane. Its main chemical component is **peptidoglycan** (murein from murus). In bacteria this may be porous, yet it does not contribute in regulating the entry of material in to the cells.

**Functions**

* Maintains shape of the organism
* Prevents the cell from bursting when ﬂuids ﬂow into the cell by osmosis.
* The outer membrane acts as a coarse sieve and exerts little control over the movement of substances into and out of the cell.

**Periplasmic space**

This is a gap between the cell wall and the cell membrane. Its components include **peptidoglycan**, **digestive** enzymes, and transport **proteins**.

**Function**

* Destruction of potentially harmful substances
* Transportation of metabolites (byproduct of metabolism) into the bacterial cytoplasm.

**The Cell Membrane**

The cell membrane, or plasma membrane, is a living membrane that forms the boundary between a cell and its environment. The main components are **phospholipids** and **proteins**. The phospholipid molecule consists of a polar head that contains phosphate group and two non-polar hydrocarbon tails. These membrane phospholipids usually form a bilayer with each of the phosphate ends of the lipid molecules extending toward the membrane surface, and the fatty acid ends extending inward. The charged phosphate ends of the molecules are hydrophilic (water-loving) and thus can interact with the watery environment. The fatty acid ends, on the other hand consists largely of nonpolar hydrocarbon chains, that are hydrophobic and forms a barrier between the cell and its environment. The protein molecules that are interspersed between the phospholipids and which extends through the entire membrane, acts as carriers or form channels through which materials enter and leave the cell.

**Functions**

* The main function is to regulate the movement of materials into and out of a cell.
* In bacteria, this membrane also performs some functions carried out by other structures in eukaryotic cells such as syntheses of **cell wall** components, DNA **replication**, secretion of **proteins**, carries on **respiration**, and captures energy as ATP.
* It also contains bases of appendages (ﬂagella)
* Finally, some proteins in the bacterial cell membrane respond to chemical substances in the environment.

**INTERNAL STRUCTURES**

**Cytoplasm**

This is a semifluid area that is bounded by the cytoplasmic or cell membrane. It constitutes about **four-fifth** water and one fifth dissolved substances such as **enzymes**, **proteins**, **carbohydrates**, **lipids**, **inorganic** ions, and other suspended substances that include **chromosomes** and some **ribosomes**. Many chemical reactions, both anabolic and catabolic, occur in the cytoplasm.

**Ribosomes**

Ribosomes consist of **RNA** and **protein**. They are abundant in the cytoplasm of bacteria, often grouped in long chains called polyribosomes. They are nearly spherical and stain densely; they contain large and small subunits. Whole bacterial ribosomes, which are smaller than eukaryotic ribosomes, have a rate of **70S**, and their subunits have rates of **30S** and **50Svedberg**.

**Functions** Ribosomes serve as sites for protein synthesis.

**Nuclear Region**

One of the key features differentiating prokaryotic cells from eukaryotic cells is the absence of a nucleus bounded by a nuclear membrane. Instead of a nucleus, bacteria have a nuclear region, called **nucleoid**. The centrally located nuclear region (nucleoid) consists mainly of DNA, but has some **RNA** and **protein** associated with it.

**Inclusions**

Bacteria can have within their cytoplasm a variety of small bodies collectively referred to as **inclusions**. Some are called **granules** while others **vesicles**. Granules, although not bounded by membrane, contain substances such as **glycogen** or **polyphosphate** that are densely compacted and do not dissolve in cytoplasm. Glycogen is used for energy while Polyphosphate, supplies phosphate for a variety of metabolic processes. Vesicles on the other hand are membrane bound and contain **lipid** deposit that serve as storehouses of energy and as sources of carbon for building new molecules.

**Endospores**

Vegetative cells of some bacteria, such as ***Bacillus*** and ***Clostridium***, produce resting stages called endospores that help the organism to survive. They are formed within cells, and contain very little water. They are highly resistant to heat, drought, acids, bases, disinfectants, and radiation. An endospore consists of a core, surrounded by a cortex, and a spore coat, and in some species, a delicately thin layer called the exosporium. The core has an outer core wall, a cell membrane, nuclear region, and other cell components. Endospores are capable of surviving adverse environmental conditions for long periods, some for over 10,000 years (there are claims that endospores sealed in amber have survived for over 25 million years).

**External Structure**

In addition to cell walls, many bacteria have Flagella and pili that extend from the cell membrane through the cell wall and beyond it.

**Flagella**

This is a long, thin, helical appendage that is made up of protein. It is used for movement in most bacteria. Bacteria can have one or more flagella attached to different locations in different species.

**Pili**

Pili (singular: pilus) are tiny, hollow projections. They are used to attach bacteria to surfaces and are not involved in movement. Bacteria can have two kinds of pili (1) long conjugation pili, or F pili (also called sex pili), and (2) short attachment pili, called ﬁmbriae (ﬁm`-bre-e; singular: ﬁmbria). Conjugation pili (or sex pili), found only in certain groups of bacteria, attach two cells and may furnish a pathway for the transfer of the genetic material DNA. This transfer process is called conjugation. Transfer of DNA furnishes genetic variety for bacteria, as sexual re- production does for many other life forms.