ZOOLOGY

Biology:

The term biology is derived from the Greek word **βίος** (bios) = life, and **λογία** (logia) = study of. Therefore, Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy.

Zoology:

The term is derived from Ancient Greek **ζῷον** (zoon) = animal, and **λόγος** (logos) = knowledge or study of. Therefore, Zoology also known as **animal biology**, which is the branch of biology that relates to the animal kingdom, including the structure, embryology, evolution, classification, habits, and distribution of all animals, both living and extinct.

Characteristics of living things

There are seven activities which make organisms different from non-living things:

1. Nutrition

Nutrition is the process by which organisms obtain energy and raw materials from nutrients such as proteins, carbohydrates and fats. Living things take in materials from their surroundings that they use for growth or to provide energy.

2. Respiration

Respiration is the release of energy from food substances in all living cells. Living things break down food within their cells to release energy for carrying out their activities.

3. Movement

All living things **move**. It is very obvious that a cat moves but what about the thorn tree it sits in? Plants also move in various different ways. The movement may be so slow that it is very difficult to see.

4. Excretion

Excretion is defined as the removal of toxic materials, the waste products of metabolism and substances in excess from the body

of an organism. All living things **excrete** to get rid of waste products which might poison the cells.

5. Growth

Growth is permanent increase in cell number and size seen in all living things by using food to produce new cells.

6. Reproduction

All living organisms have the ability to produce **offspring**.

7. Sensitivity

All living things are able to **sense** and **respond** to stimuli around them such as light, temperature, water, gravity and chemical substances.

Whilst many other things carry out one or more of the above processes, only **living organisms** possess **all** of these characteristics.

Levels of Organization

The living world consists of all biotic and abiotic factors that affect life within it. Living things are part of a whole that organize themselves in several levels proceeding from the very small (simple) to the very large (complex), these levels of organization include:

Organization at cellular level

1. **Molecules**
   Molecules consist of several atoms of different elements that joined together into complex cluster known as ***macromolecules*** (biological molecules) including carbohydrates, lipids, proteins, and nucleic acids (DNA & RNA).
2. **Organelles**
   They are tiny compartments within cell assembled from complex of biological molecules which are responsible for specific function in the cell (e.g. nucleus, ribosome, mitochondria, etc.).
3. **Cells**
   They are the smallest unit of life that has all the characteristics of living things (organisms).

Organization at organism level

Organism is a specific ***species*** of plant, animal, bacteria, fungus or other living thing that lives in a specific area. There are two types of organisms:

Unicellular organisms which are composed of single cell such as Bacteria, Amoeba, Paramecium, etc.

Multi-cellular organisms have several types of cells located in different parts of the living organism that carry out specific functions such as animals & plants. Therefore, cells are organized into three levels of complexity:

1. **Tissues**
   They are groups of similar cells that act as a functional unit such as nervous tissue which composed of specialized cells called nerve cells (neurons) and able to carry signals & impulses from one place to another within organism.
2. **Organs**
   Organ is a set of tissues connected that carry out a specific function for a living thing (an example of an organ may include the heart, the lung, the brain, etc.).
3. **Systems**
   The system is a set of organs inside an organism that carry out a specific function (digestion, circulation, respiration, etc.).

Organization at population level

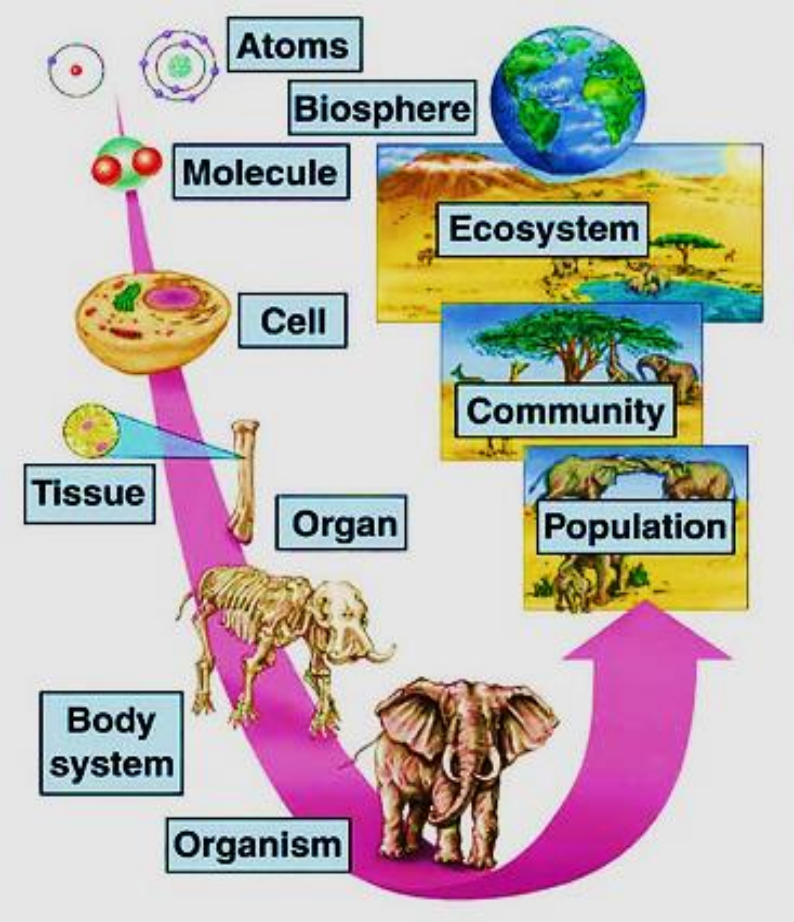
Organisms are organized into several higher hierarchical levels within the living world:

1. **Population**
   Population is a group of organisms of the same ***species*** that live in the same place at the same time. The members of certain species are similar in appearance and able to interbreed. For example, several deer may belong to a population and can interact with other deer in the same area.

2. **Community**
   Community consists of all populations of different species living together in one place (Gees may share their pond with ducks, fish, and many kinds of insects) all interact with each other in a single pond.

3. **Biome = Ecosystem**
   It is the community and its non-living surrounding that may be separated by living or non-living matter (mountain or other boundaries) such as Deserts, oceans, and forests. A deer, rabbit, and all the plant populations that live in a grasslands area and the lake, air, and rocks are part of an ecosystem.

4. **Biosphere**
   It is the part of the Earth that contains all ecosystems.



Organisms in Ecosystems

The study of cooperation and competition for biotic and abiotic parts of the environment needs to know three important things:

- **Habitat** which is the place where an organism lives.
- **Niche** which is the role of each species in its environment.
- **Interactions** which is the relationships between species. Organisms never live alone, but they are always interacting in some form or another with other living things. There are many different types of interactions:

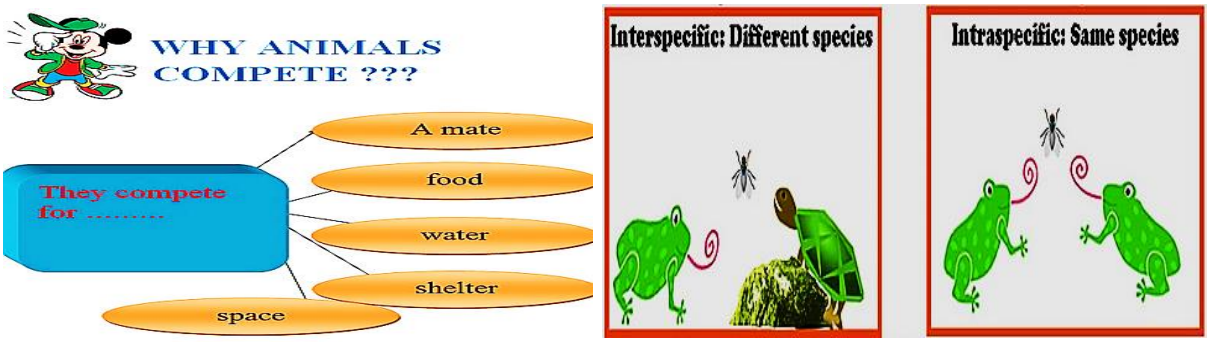
1. **Predation**

   It is the interaction between two different species, the first is benefit and called ***predator*** and the second is killed and called ***prey***, where the predator is trying to eat the prey species while the prey is trying to run away. Some examples of predator and prey are lion & zebra, bear & fish, and grasshopper & leaf.



2. **Competition**

   Competition is an interaction between organisms, in which the fitness of one is lowered by the presence of another ***(competitor).*** It is done to obtain food, mate or shelter either among members of the same species so it is called ***(intraspecific competition)***, or between individuals of different species so it is called (***interspecific competition).*** For example, competition occurs between sparrows and white lizards, in which the sparrows fight for a shelter and the white lizards fight to catch insects. When the food is less, species less suited to compete for resources should either adapt or die out.



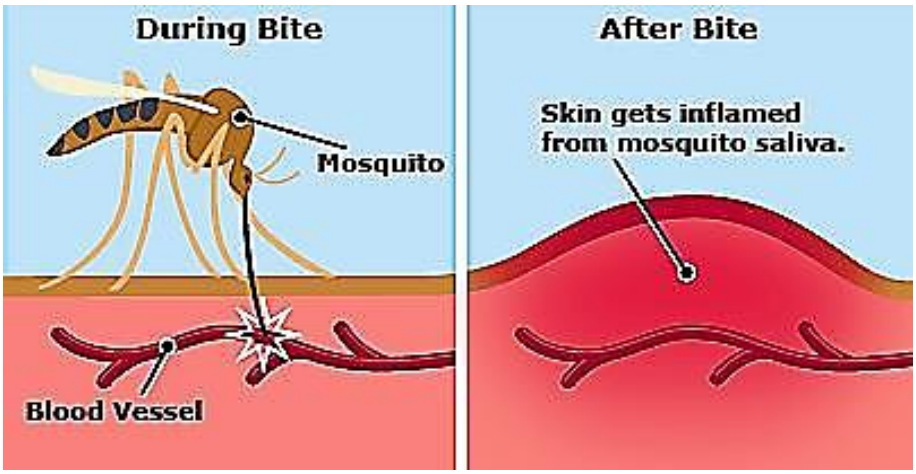
3. Symbiosis (living together)

Symbiosis is a relationship where two or more organisms depend on each other for resources, so each of them known as ***(symbiont)***. In symbiotic relationships, the two organisms aren't trying to kill each other and they aren't trying to fight over food. There are three types of symbiosis:

a) Parasitism

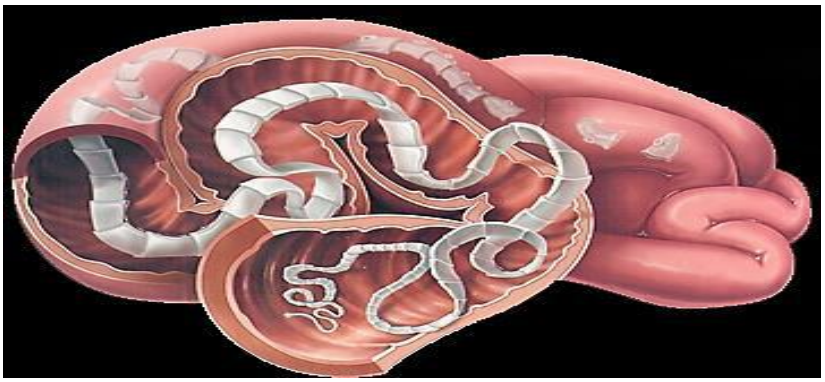
A relationship between two organisms where one organism benefits (known as parasite) while the other is harmed (known as host). Parasites do not kill their host, much smaller than their host, and can be classified into two types:

1) ***Ectoparasites*** that live on the surface of the host such as (mites, ticks, lice, mosquitoes). The mosquito needs to suck the blood from animals for feeding, while the animal that is bitten is harmed because it loses some blood and skin gets inflamed.



2) ***Endoparasites*** that live inside the host and can exist in one of two forms:

- ***Intercellular parasites*** (inhabiting spaces in the host's body) such as **tapeworms** that lives in the gut of their hosts and steals nutrients from the food in its host's intestine; without a host, the tapeworm is unable to live, but the host suffers from weight loss and decreased energy, as well as many other health problems.



- ***Intracellular parasites*** inhabiting cells in the host's body, such as protozoa, bacteria or viruses.

b) Mutualism

A relationship between two or more organisms in which both organisms benefit, so they are called ***(mutualists***). An example of mutualism is the relationship between the **Egyptian plover** and the **crocodile**, the crocodile lies with its mouth open and the plover flies into its mouth and feeds on bits of decaying meat stuck in the crocodile's teeth. The plover eats a meal and the crocodile gets his teeth cleaned.

c) Commensalism

A relationship in which one organism benefits but the other is neither harmed nor benefit**.** An example is **the remora** (sucker-fish) that lives in close association with sharks or other larger fish. The sucker-fish is small and does not injure (or benefit) the shark, but envoys the shark's protection and lives on the scraps formed as the shark devours its prey.

Other example is the **Cattle egrets**, these birds live near cattle because when the cattle graze, their movements stir up insects. The birds have their insects and the cattle are unaffected.

The Trophic Levels

The trophic level of an organism is the position it occupies in a food chain. The word trophic derives from the Greek ***τροφή (trophē)*** referring to food or feeding.

The three basic ways in which organisms get food are:

1. **Producers (autotrophs)** are typically plants or algae that do not eat other organisms, but pull nutrients from the soil or the ocean and manufacture their own food using energy either from the sun light by a process known as photosynthesis (so they are called ***Photoautotrophs***), or energy stored in chemical compounds by a process known as chemosynthesis (so they are called ***Chemoautotroph*s).**
2. **Consumers (heterotrophs)** are species that cannot manufacture their own food and need to consume other organisms. Animals that eat primary producers (like plants) are called ***herbivores***. Animals that eat other animals are called ***carnivores***, and animals that eat both plant and other animals are called ***omnivores***.
3. **Decomposers (detritivores)** break down dead plant and animal material and wastes and release it again as energy and nutrients into the ecosystem for recycling. Decomposers, such as bacteria, worms, fungi (mushrooms), and others which are feed on waste and dead matter, converting it into inorganic chemicals that can be recycled as mineral nutrients for autotrophs to use again.

Trophic levels can be represented by numbers, starting at level 1 with plants. Further trophic levels are numbered subsequently according to how far the organism is along the food chain:

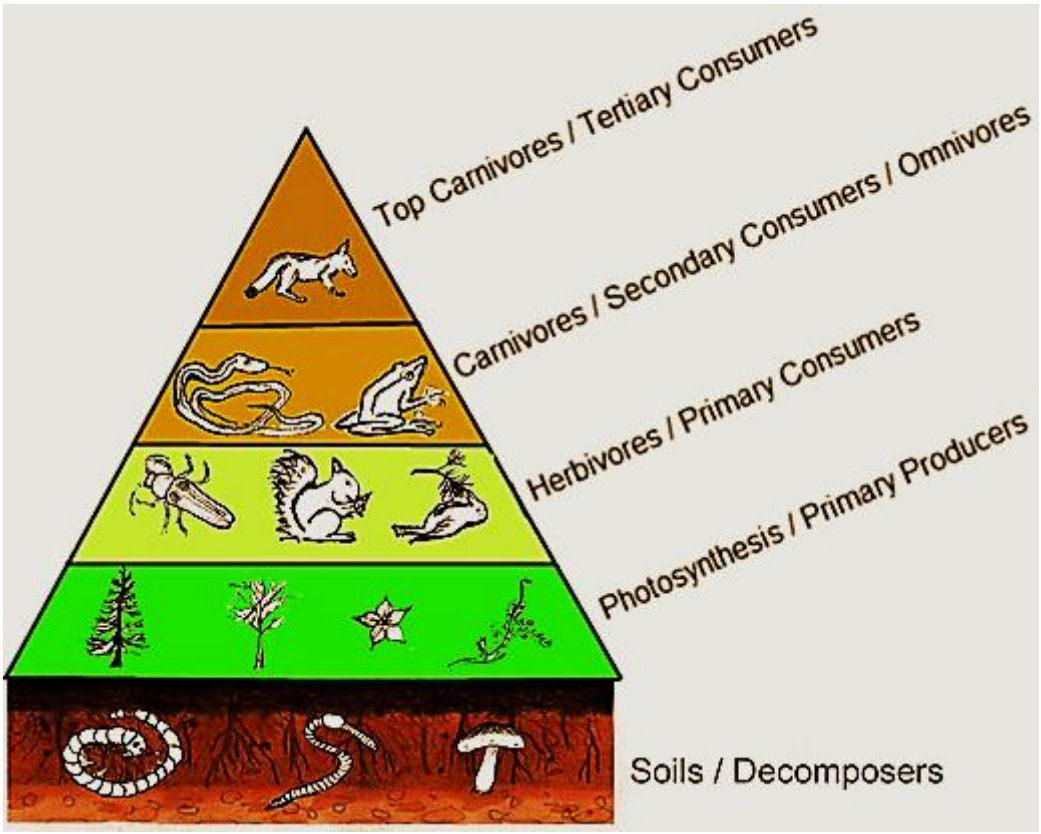
Level 1(Primary producers): Consists of autotrophs (Plants and algae) that make their own food.

Level 2 (***Primary consumers):*** Consists of Herbivores such as cattle that eat plants.

Level 3 (Secondary consumers): Consists of Carnivores that eat herbivores.

Level 4 (Tertiary consumers): Consists of Carnivores that eat other carnivores.

Level 5: ***Apex predators*** that are at the top of the food chain and have no predators.



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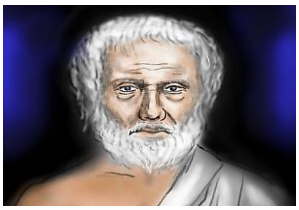
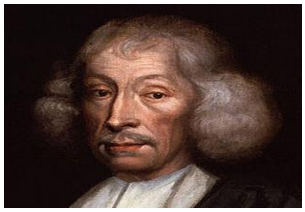
Classification of living organisms

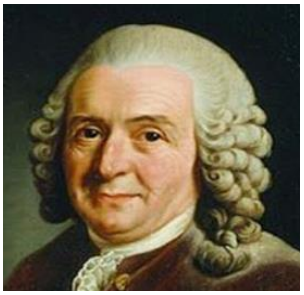
History



Aristotle (384-322 BC) emphasized that animals can be classified according to their way of living, actions, habits and body parts. He is considered as the *'father of biological classification'.*



John Ray (1627 - 1705) divided animals into those with blood and those without blood. He also classified animals based on gills, lungs, claws, teeth and other structures.

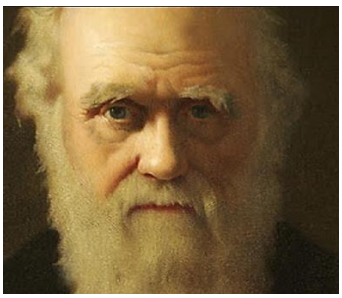


Linnaeus (1707 - 1778) has been called the *father of taxonomy*. He first introduced the hierarchic system, both in animal and plant kingdoms. He followed four categories namely **class**, **order**, **genus**, **species** for the animal world. His greatest contribution to taxonomy was the use of *binomial nomenclature* for all species of animals and plants.

Michael Adanson (1727 - 1806) stressed that classification should be based on many characters as possible in order to develop a new type of taxonomy called *'Numerical Taxonomy'*.

Lamarck (1744 - 1829) made the first attempt to improve Linnaeus system. He arranged animals according to evolution in the form of a branching tree. It was the beginning of the use of *phylogeny in systematics*.

Cuvier (1769 - 1832) insisted that extinct fossil forms should be included in the table of classification. He divided animals into four branches. They are *Vertebrata, Mollusca, Articulata* and *Radiata.*



Charles Darwin in 1859, published his famous work '*Origin of species*'. The new evolutionary concept of Darwin had an immediate acceptance among biologists. The taxonomists were encouraged to learn that evolution theory of Darwin gave meaning to their classifying activities.

Ernst Mayr (1942) considered species as "groups of interbreeding natural populations". The development of modern taxonomy during this period taxonomy was based on population studies. The taxonomists were forced to accept species as a 'population'. Hence the taxonomist started moving from the laboratory to the field. Morphological characters were studied along with other characters such as behavior, sound, ecology, genetics, zoogeography, physiology and biochemistry. Thus taxonomy was transformed into *'**biological taxonomy**'*.

Hierarchic System of Classification

In this system of classification the various groups are called **taxa** (singular: taxon). A taxon is a taxonomic group of any rank that is sufficiently distinct to a definite category. Taxonomy from Ancient Greek: [**τάξις** (taxis) = arrangement, and **νομία** (nomia) = method] is the science of classification of organisms based on their evolutionary relationships, using a hierarchical system of grouping by shared features. These groups are arranged from the largest group of organisms to the smallest group of organisms. The largest group is the **kingdom**. Each kingdom is further divided into smaller groups called **phyla** (singular phylum), each phylum is then subdivided into **classes**, **orders**, **families**, **genera**, and finally **species**. This arrangement from Phylum to Species is designated as the ***hierarchic system of classification.***

Binomial system

According to Linnaeus a Species is specified by the combination of both its specific and generic names. Since it requires two names, it is referred to as the **binomial system**. Note that the genus and species names are always either italicized or underlined, with the genus name capitalized and the species name given in lower case. Thus the Scientific **binomial** for wise man is *Homo sapiens.*

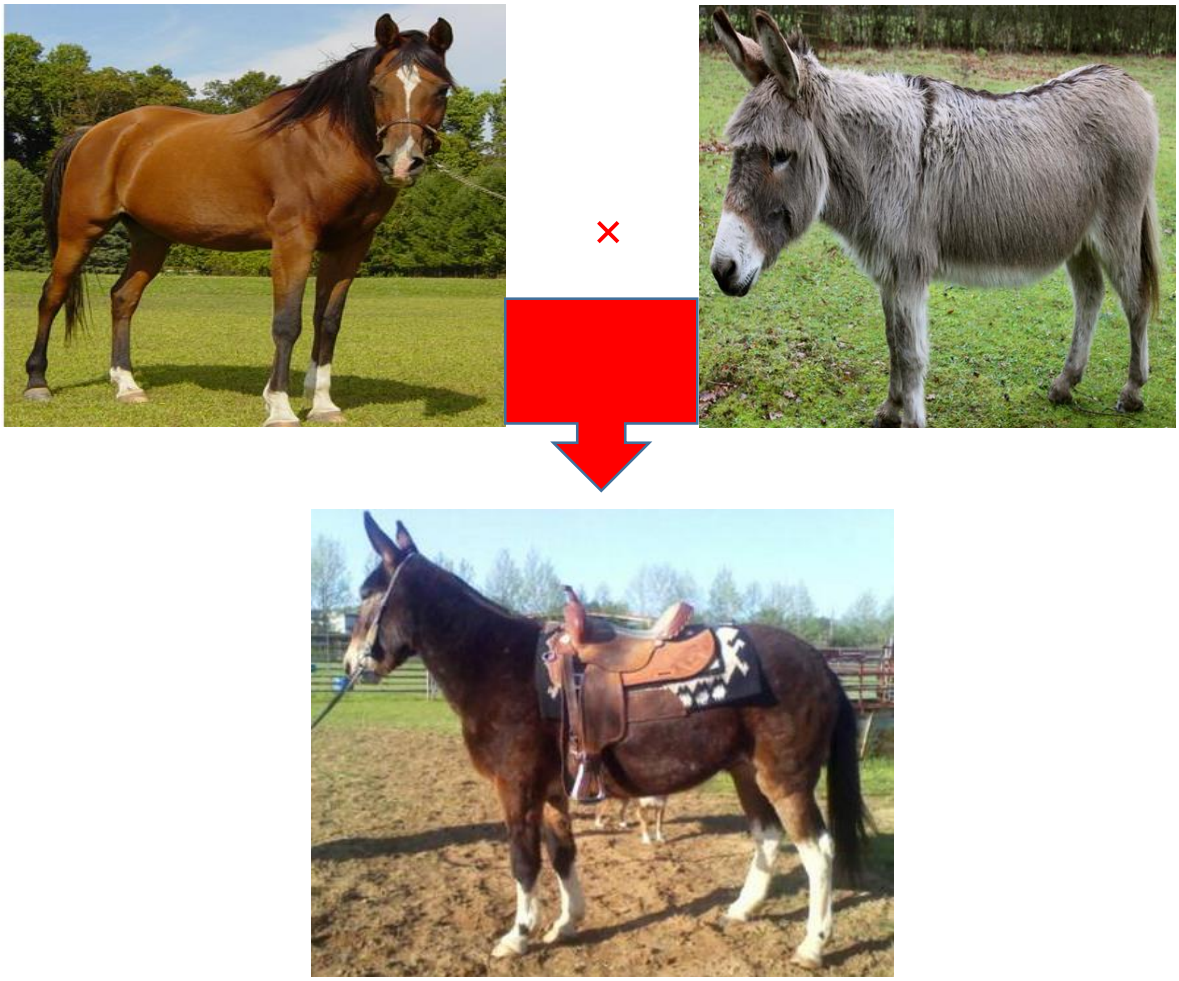
This chart shows the hierarchical system of taxonomy for wise man (*Homo sapiens)*:

Kingdom …… **Animalia** (include all animals)
Phylum …… **Chordata** (include animals with a backbone)
Class …… **Mammalian** (all animals have hair)
Order …… **Primate** (include mammals with hands and feet)
Family …….. **Hominidae** (include apes, and humans)
Genus …… ***Homo*** (include primitive and modern humans only)
Species …… ***sapiens*** (include modern humans only)

The concept of species

The fundamental unit of life on Earth is the species that is the smallest group of organisms and can be defined as a *group of organisms with similar features, and these organisms are capable of breeding and produce fertile offspring.*

For example horses and donkeys belong to the same kingdom, phylum, class, order, family as well as genus but they are from different species. Therefore, if a donkey and the horse happen to breed, they produce an offspring called a ***mule***. The mule is infertile, meaning that it cannot reproduce offspring because it is a product of organisms of different species.



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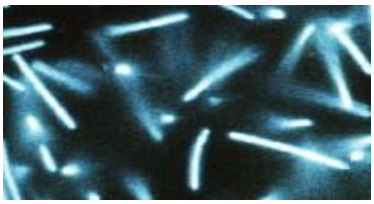
The concept of Kingdom

Kingdom is the highest rank used in the biological taxonomy of all organisms. Until the 20th century, most biologists considered all living things to be classified as either a ***plant*** or ***animal*** kingdom. By the 1970s, a system of Five Kingdoms was made after a distinction between the kingdom of prokaryotic bacteria and the other four eukaryotic kingdoms (plants, animals, fungi, & protists). Now, every living thing comes under one of 6 kingdoms:

1. **Archae bacteria Kingdom**

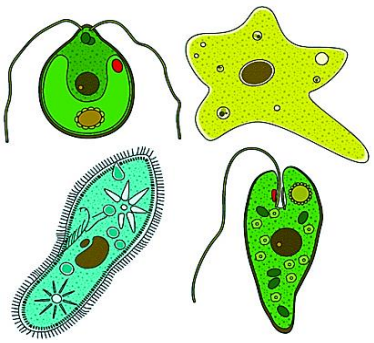


All members of this kingdom are single-celled, prokaryotes (don't have true nucleus), and autotrophs such as ***Methanogen bacteria*** (produce methane gas).

2. **Eubacteria Kingdom**

Members of this kingdom are also single-celled, prokaryotes, but some of them can't make their food ***(heterotrophs),*** others use sun light to make their food ***(photosynthetic autotrophs),*** while the rest don't need sun light to make their food, rather they get energy by breaking down inorganic sulfur and nitrogen compounds ***(chemosynthetic autotrophs).***

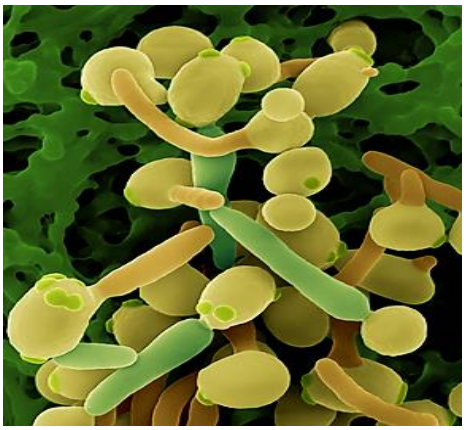
3. **Protista kingdom**



Although they are all eukaryotes, they could be multicellular & unicellular, some of them are microscopic and others are very large. Protista contain both heterotrophs & autotrophs. They include ***Protozoans, Algae, and Molds.***

4. Fungi kingdom

They are all eukaryotes and heterotrophs (either parasitic or mutualistic) and have cell wall made of chitin & glycan, but most of them are multicellular. Examples include mushroom, yeast.

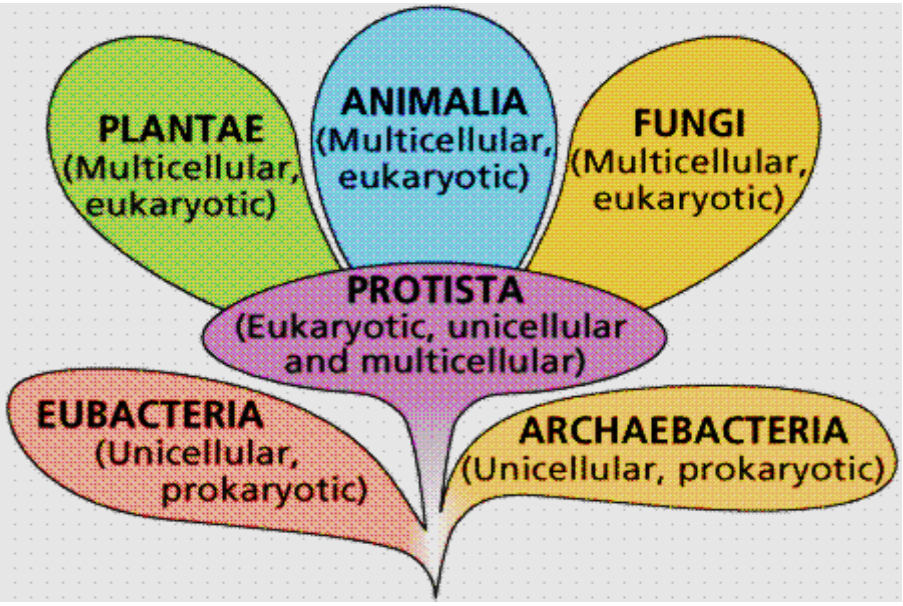


5. Plantae Kingdom

Plants are multicellular and have a cell wall made of cellulose, also all plants are photosynthetic autotrophs and eukaryotes. Examples include trees, herbs, and grasses.

6. Animalia Kingdom

All animals are eukaryotes without cell wall and highly diverse in their structure, size, behavior, mobility, and the way that getting food.



Methods of grouping animals

There are several ways of grouping animals. In all these methods the basic Taxon remains without any change.

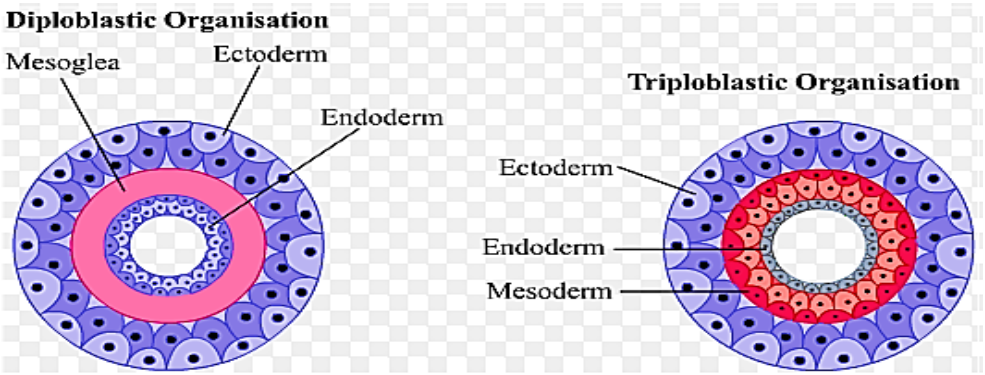
- The earliest method provided by Aristotle which dividing the Animal kingdom into two groups called **Invertebrata** and **Vertebrata**.
- Animals can also be grouped as single celled called **(Protozoans)** and multicellular called **(Metazoans)**.
- In another method the animals are grouped under following three assemblages:

A. Protozoa – They include only unicellular animals (single celled), such as Amoeba, Paramecium, etc.

B. Parazoa – They include multicellular animals without tissue grade, such as Sponges.

C. Eumetazoa – They include multicellular animals with tissue grade, which is subdivided further into two groups:

1. **Diploblastic animals** - having ectoderm and endoderm as two layers in the body wall. Ex: Cnidarian
2. **Triploblastic animals** - having ectoderm, mesoderm and endoderm as three layers in the body wall.

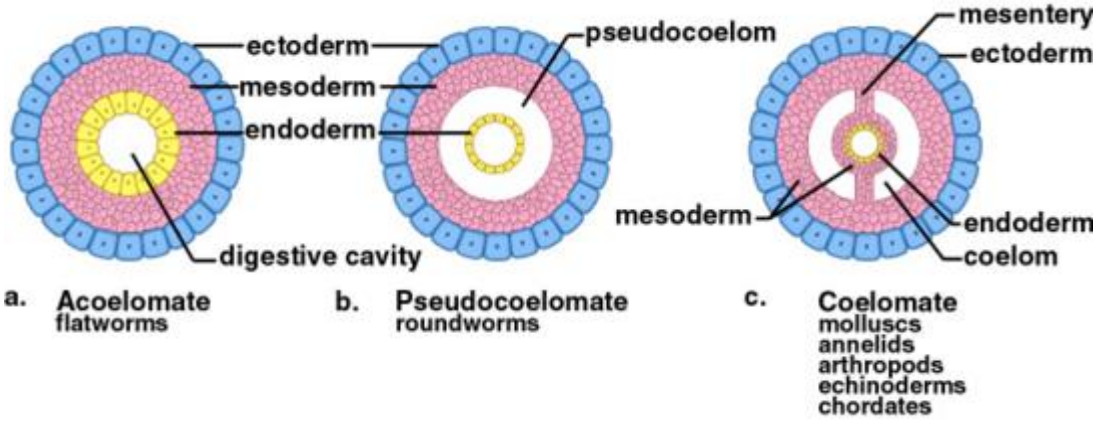


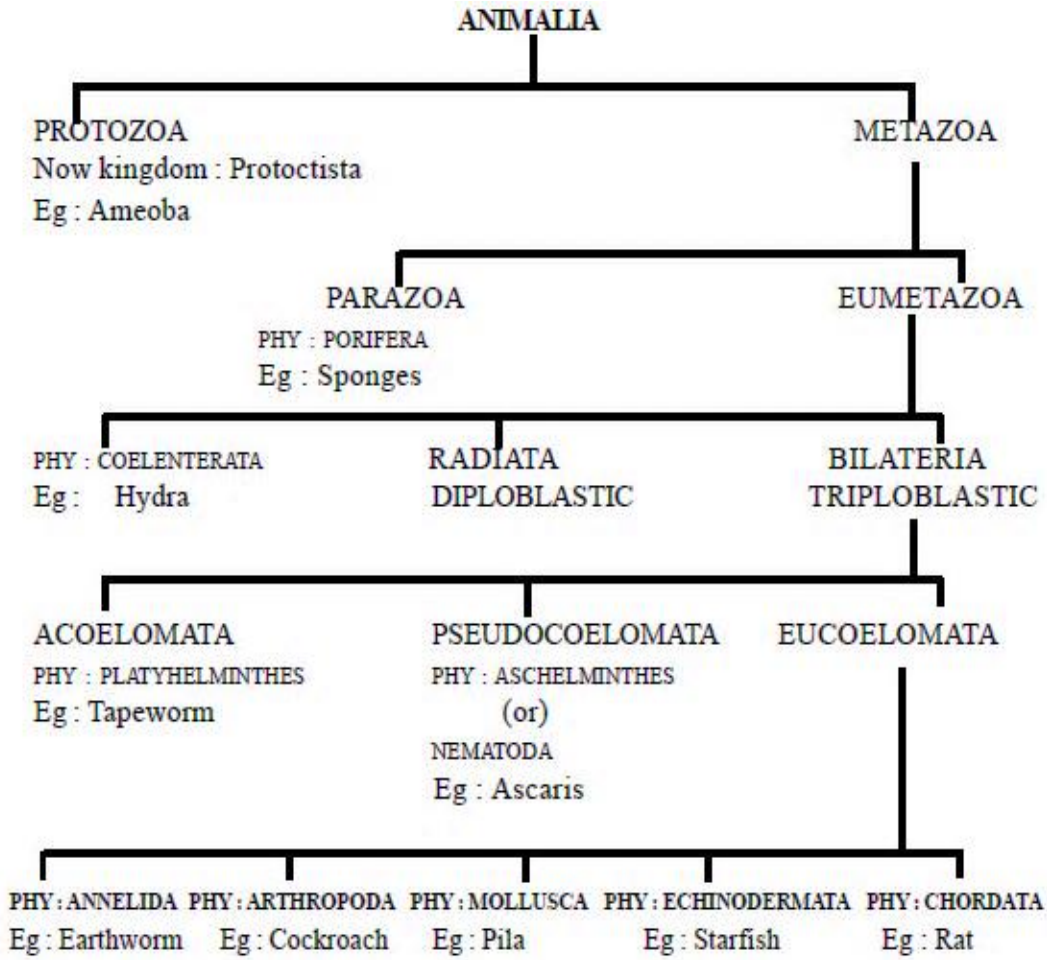
Triploblastic animals which are further divided into three groups based on the presence or absence of body cavity called (**coelom)**:

a) ***Acoelomata*** - no coelom. Ex: Platyhelminthes (flat worms).

b) ***Pseudocoelomata*** - with a false coelom. Ex: Nematoda (round worms).

c) *Coelomata* - with a true coelom, include all the rest of animals, such as Annelida, Echinodermata, Mollusca, Chordata…etc.





Protozoa

Protozoa (meaning "first animals") which are unicellular and heterotrophs of the kingdom Protista. They are possibly evolved from the 1st eukaryotes by ***Endosymbiosis*** (process where one prokaryote lives inside another becoming dependent upon each other). The general characteristics of them include:

- They are eukaryotes and unicellular.
- Most of them are heterotrophs that ingest small food particles & digest it inside food vacuoles containing digestive enzymes.
- They are microscopic and range in size from a few to hundreds of micrometers that live as single cells or in simple colonies that show no differentiation into tissues.
- They are found everywhere; in freshwater, marine, and moist terrestrial habitats that make up part of the ***zooplankton*** & serve as food for animals in marine & freshwater systems.
- There are 65,000 identified species most of them are ***free-living*** and eat bacteria, algae, or other protozoa, while other species are ***parasitic living*** inside their host & cause several diseases.
- Most protozoa are motile (able to move) which is one of the important characteristics used to divide them into major groups.

Cellular Structure and Function

The various forms have a unicellular structure bounded by a thin cell membrane with one or more nuclei. Protozoans carry on all the metabolic functions of animals, such as:

- ***Digestion:*** Some protozoans have complex digestive systems and feed on large food particles, such as other microorganisms. The food is digested by means of enzymes and the wastes transported to the cell surface or stored in ***food***

vacuoles (bubble-like spaces). While others absorb dissolved organic matter through the ***cell membrane***.

- ***Respiration:*** Oxygen diffuses into the cell, where it oxidizes food molecules, producing energy and the organic molecules used for the building and maintenance of the cell, the waste products of this oxidation (CO_2 & H_2O) diffuse out of the cell.
- ***Reproduction*** is usually ***asexua***l, occurring mostly by cell division, or binary fission; some forms reproduce asexually by budding or by the formation of spores (reproductive cells reproduce by multiple fission producing more than two individuals without fertilization). While some species reproduce ***sexually*** by conjugation (opposite mating strains join & exchange genetic material)

- ***Adaptations***
  1) Many protozoa secrete an amorphous material called ***extrusomes*** involved in formation of a capsule or cyst when conditions become unfavorable (no water, pH or temperature changes, nutrient deficiency, decreased oxygen supplies…), that may serve for protection or predation. Then metabolic activity of protozoans resumes when conditions become favorable again.
  2) Some protozoans can detect & avoid obstacles and harmful chemicals in their environment (ex. Eyespots).
  3) Freshwater protozoa have ***contractile vacuoles*** to pump out excess water that moves into the cells by osmosis.

Classification

Protozoan found in the kingdom Protista along with algae, slime & water molds, they are divided into 4 phyla based on their method of movement:

I. **Sarcodina** move by extending fingerlike projections of the cytoplasm known as ***pseudopodia*** (false-foot) that bulges outward from any edge of the cell.

II. **Zoomastigina** move by whip like structures known as ***flagella*** that usually occur one to a few per cell and have an undulating motion.

III. **Ciliophora** move by hair like structures known as ***cilia*** that are shorter and move like oars.

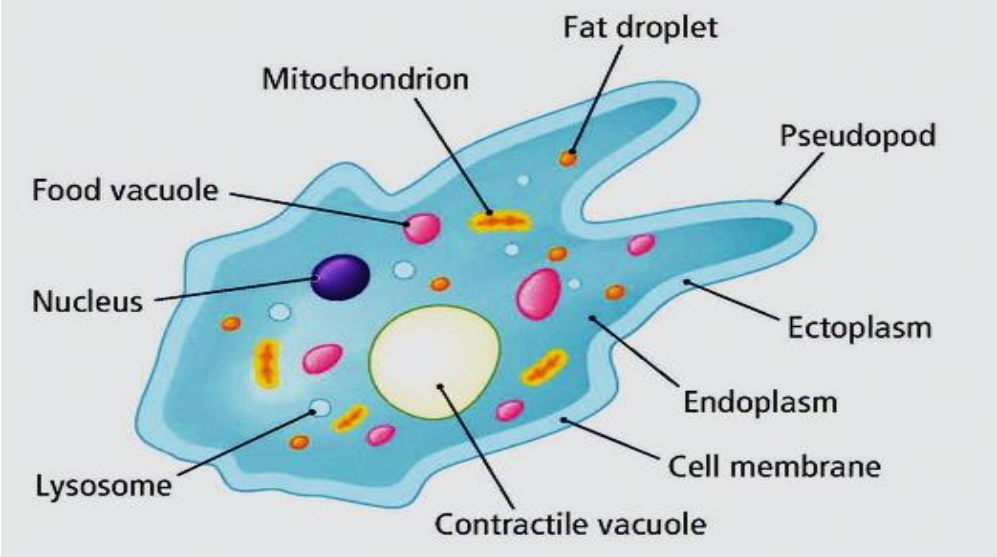
IV. **Sporozoa** are either non-motile or very slow.

Phylum	Common Name	Locomotion	Nutrition	Examples
Sarcodina	Sarcodines	pseudopodia	heterotrophic; some parasitic	*Amoeba* *Radiolaria*
Ciliophora	Ciliates	cilia	heterotrophic; some parasitic	*Paramecium* *Balantidium*
Zoomastigina	Zoo flagellates	flagella	heterotrophic; some parasitic	*Trypanosoma* *Leishmania* *Giardia*
Sporozoa	Sporozoans	(None in adults)	heterotrophic; some parasitic	*Plasmodium* *Toxoplasma*

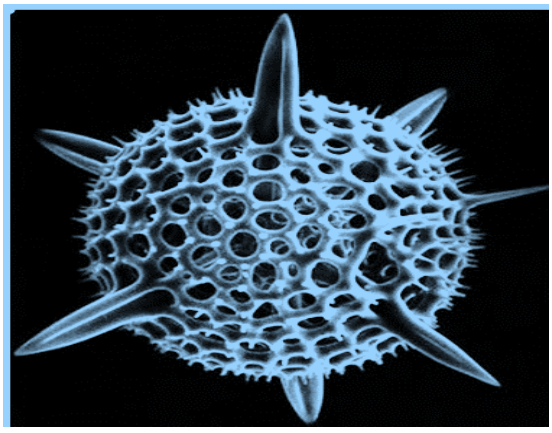
I. ***Phylum Sarcodina:***

- Includes hundreds of species of ***amoebas*** found in freshwater, marine, & moist soil habitats and usually reproduce ***asexually.*** Their cytoplasm consists of clear, outer ***ectoplasm*** and granular, inner ***endoplasm.***
- They move when the inner endoplasm pushes the outer ectoplasm forward to make arm like structure called "false foot" or ***pseudopodia*** in a process called ***amoeboid movement.***
- Sarcodines also use their pseudopods for feeding by surrounding & engulfing food particles in a process called ***phagocytosis,*** then this part of the cell membrane pinches together forming a ***food vacuole***, enzymes enter the food vacuole & digest the food, while undigested food & wastes leave by ***exocytosis.***

- Most Sarcodines have ***contractile vacuoles*** to pump out excess water, while Oxygen & carbon dioxide diffuse through the cell membrane.



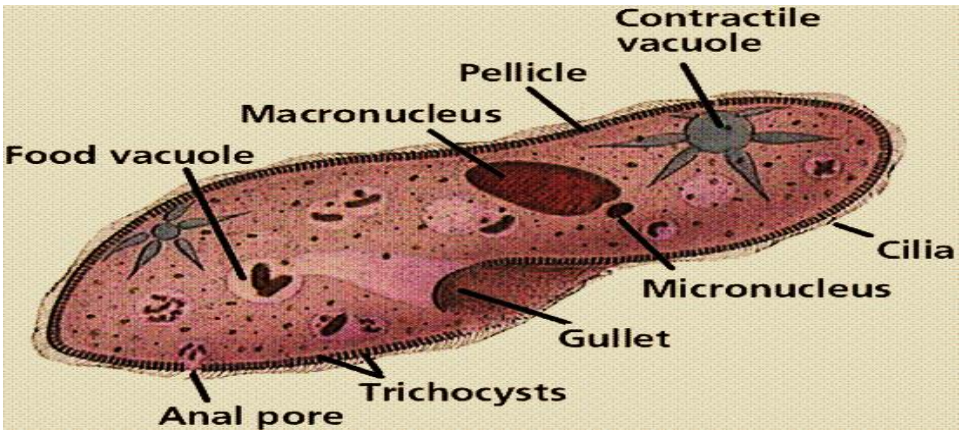
- Sarcodines may form hard, protective, inactive ***cysts*** when conditions become unfavorable (lack of nutrients, heat…), and can be react to stimuli such as light.
- Some marine Sarcodines have hard shells made of *silica* & have sticky pseudopodia to trap food called (**Radiolarians) or** made of *calcium carbonate* form limestone or chalk with holes through which pseudopodia extend called **(Foraminiferans).**



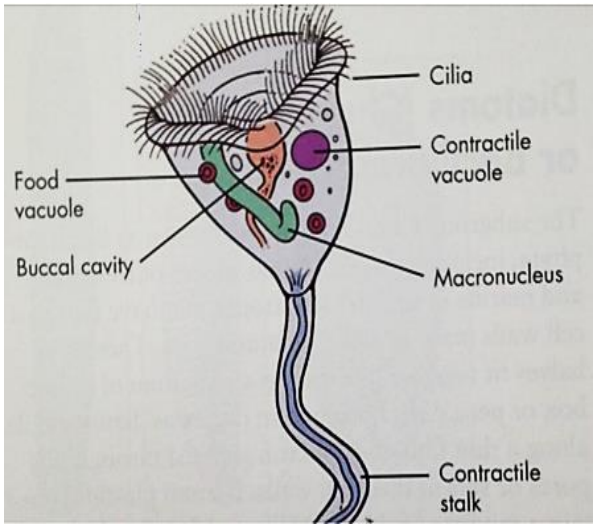
- Some Sarcodines are parasitic for higher animals including human such as ***Entameba histolytica*** cysts in untreated water supplies cause ***amoebic dysentery*** which can be fatal.

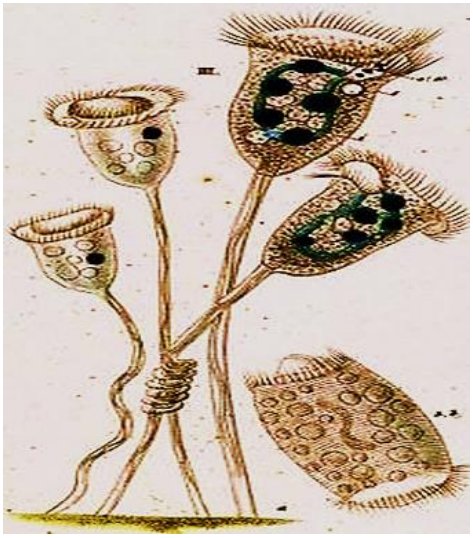
II. *Phylum Ciliophora*

- They are the largest group of protozoans and also called ***ciliates*** because they move by short, hair like structure called **cilia** lining the cell membrane.
- Most found in **freshwater**, but some are marine and called ***plankton*** & serve as a food source. They form protective **cysts** to survive unfavorable conditions.
- They have two types of nuclei; the larger one called ***macronucleus*** that control all activities including asexual reproduction by mitosis, while the smaller called ***micronucleus*** which control only sexual reproduction by conjugation when two organisms join together & exchange DNA.
- The most common example of ciliates is ***Paramecium*** found in freshwater and has elastic covering of cell membrane called ***pellicle*** made of protein for protection. They reproduce asexually by mitosis & sexually by conjugation. Paramecium use cilia to swim & obtain food *(algae & bacteria).* Cilia sweep food into ***oral groove*** and enters short tube called ***gullet*** into ***food vacuoles*** where it's digested, then wastes leave through ***anal pore.*** However, the water excess pump out via 2 ***contractile vacuoles.*** Paramecium has tiny toxic darts called ***trichocysts*** to capture prey.



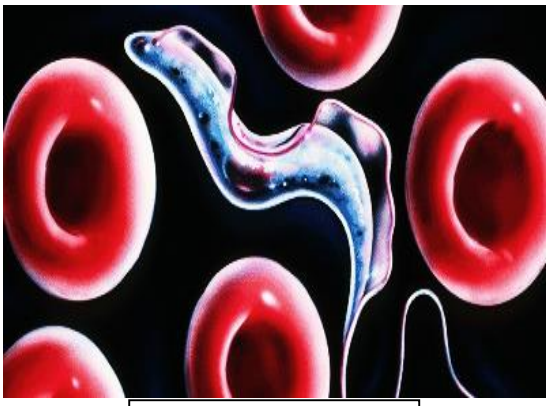
- Another example of ciliates is ***Vorticella*** which is cup shaped protozoan with cilia at the top, and has **coiled stalk** to raise & lower the organism for attachment to surfaces. They are mostly lived in colonies.





III. *Phylum Zoomastigina*

They may be freshwater or marine, also called ***Zoo flagellates*** because have one or more whip-like ***flagella*** to move. Some are **parasites** such as several species of ***Trypanosoma*** that have one flagellum and destroy human's red blood cells & causes fatal African sleeping sickness. Other such as ***Trichonympha*** have several flagella and lives symbiotically inside termites & digests cellulose.

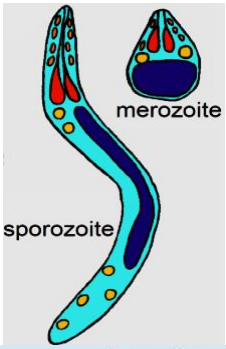


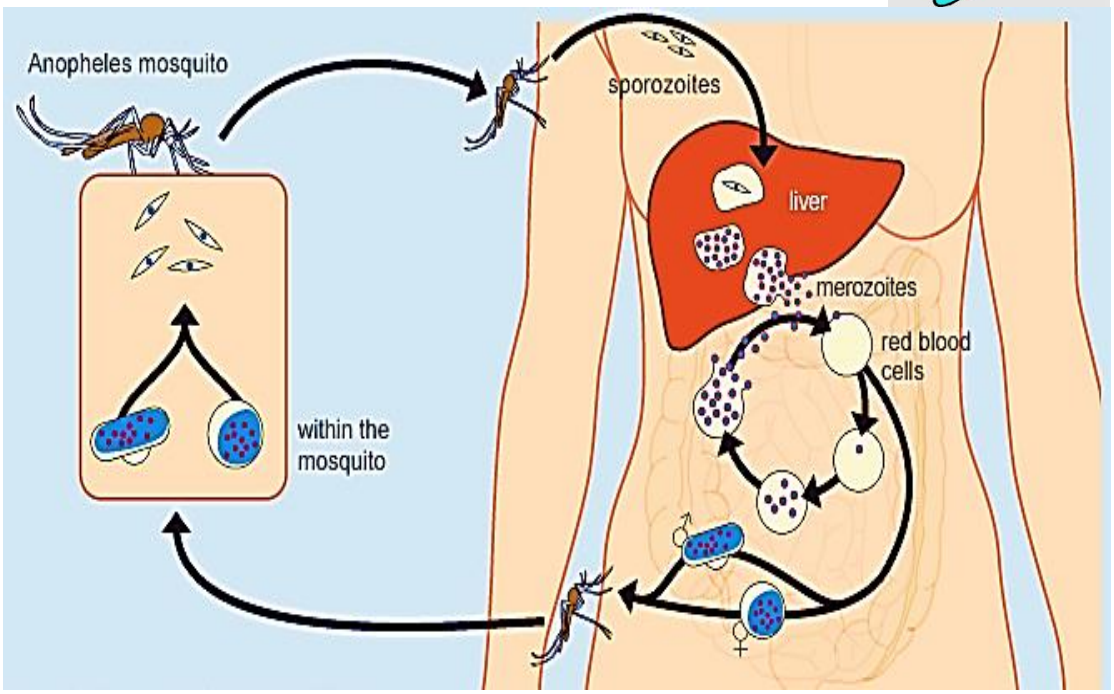
Trypanosoma

Trichonympha

IV. *Phylum Sporozoa*

Sporozoans are non-motile, commonly parasitic on vertebrate animals using one or more hosts. Probably the best known sporozoan is ***Plasmodium spp.*** that cause malaria. Immature sporozoans are called ***sporozoites*** that live in body fluids of hosts and transmitted by mosquitoes. *Plasmodium* sporozoites enter the bloodstream, travel to the liver, divide & form spores called ***merozoites*** that invade red blood cells where they multiply, eventually escaping from the ruptured cells & later form eggs & sperm that fertilize to form new sporozoites that migrate to the salivary glands of mosquitoes where they can be passed on to another person. Therefore, sporozoans reproduce asexually by forming spores & sexually by fertilization of egg and sperm.





Phylum: Porifera

The phylum Porifera represents the only phylum of the ***Parazoa*** (those without true tissues) in the Kingdom Animalia. Sponges constitute the Phylum Porifera which include more than 5000 animal species, mostly marine, but includes about 150 fresh water inhabitants also. They found in all seas, wherever there are rocks, shells, or coral to provide a suitable substratum. Most sponges prefer relatively shallow water, but some groups live in deep water.

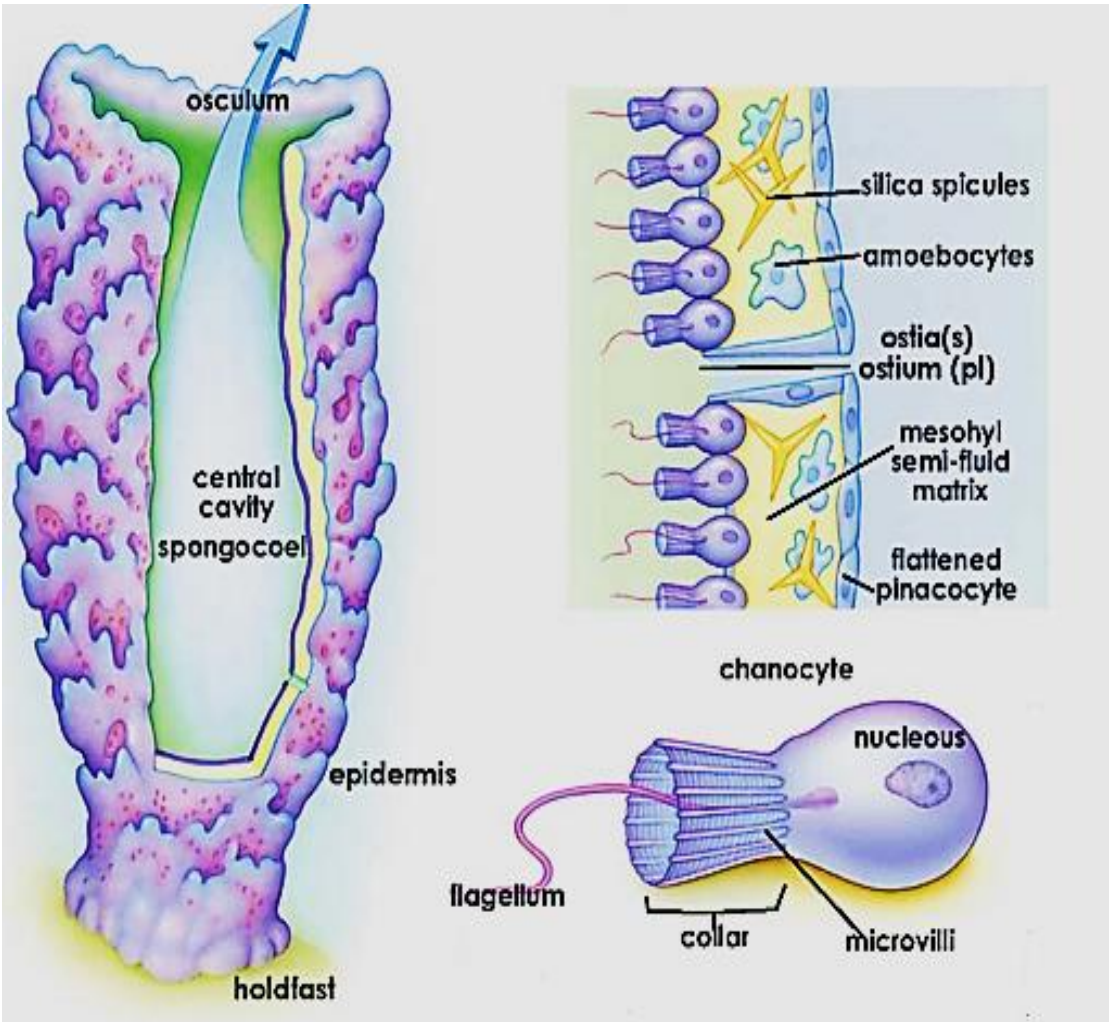
Structure of Sponge

The body wall of sponge encloses large cavity called ***spongocoel***. The water enters the spongocoel through numerous pores in the wall called ***ostia*** and leaves the spongocoel through a large aperture called ***osculam***. The body wall consists of jelly-like substance called ***mesohyl*** sandwiched between two thin layers of cells:

1. **The outer layer** is made up of two types of cells:
   a) ***Pinacocytes*** are plate-like cells, form much of the epidermis of sponges and cover the exterior and some interior surfaces, and also digest food particles that are too large to enter the ostia, while those at the base of the animal are responsible for anchoring it.
   b) ***Porocytes*** are tube-like cells that form closable inlet valves around **ostia** and can change their size (they are contractile) and can therefore change the size of the openings of the ostia thus controlling the flow of water through the sponge.
2. **The inner layer** is made completely of vase - shaped cells called ***choanocytes***. These cells have a ring with a collar of fine fibrils connected by microvilli surrounding the base of a single flagellum, which is used to propel water through the pores of the sponge into a central body cavity, and then out of the sponge via a central opening.

The second function of a choanocytes is to trap food, mainly bacteria, on its collar, and absorb it by phagocytosis.

3. **Mesohyl** is semifluid matrix supported by the skeletal elements with cells called ***Archaeocytes*** which are able to move by use of pseudopodia so they also called ***Amoebocytes.*** These cells are even change into another cell type to perform their main functions:
   - **a)** Pick up food vacuoles from choanocytes and digest it, then carry the nutrients to the cells that need them.
   - **b)** Carry O_2 to other cells, and eliminate waste products.
   - **c)** Convert into **egg** ***& Sperm*** for sexual reproduction and even in formation of asexual reproductive ***gemmules***.
   - **d)** Support the skeleton of sponge by converting into ***spongioblast*** that secretes the spongin fibers, and into ***scleroblast*** that secretes spicules, and also into **collencyte** that secretes collagenous fibrils.



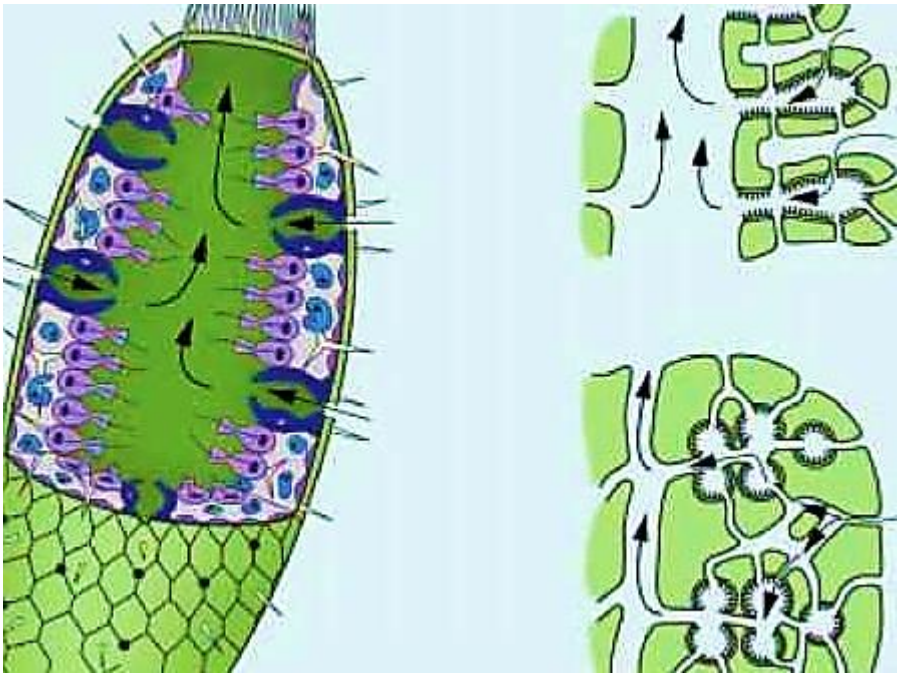
Water Flow & Sponge Shape

Most of the canals system are lined with choanocytes to keep the water flowing through the canals in the correct direction (enters the ostia to spongocoel and leaves through osculum) by beating their flagellum. There are three main types of canal system in sponges that result in different shapes:

1. ***Asconoid sponges***
   - It is the simplest body structure in sponges because canals run straight from ostia to spongocoel.
   - All the spongocoel is lined with choanocytes
   - Thin body wall, and Sponge diameter seldom exceed 1 mm.
   - Live in groups in shallow seas.

2. ***Syconoid sponges***
   - It is slightly complicated because canals are branched and do not run straight, whose walls are lined by choanocytes.
   - Spongocoel not lined with choanocytes.
   - The body wall become thicker, and Sponge diameter reach to a few centimeters.
   - Normally do not live in groups.

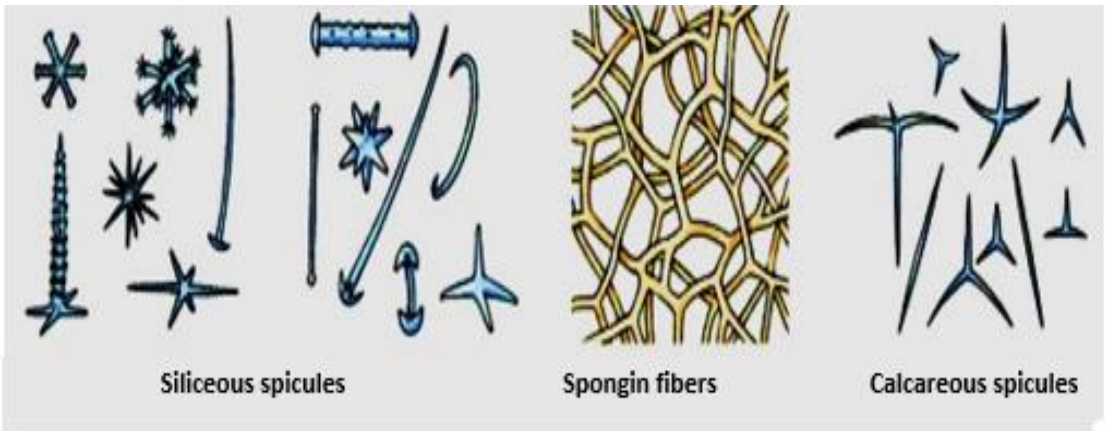
3. ***Leuconoid sponges***
   - It is more complicated because canals being longer and more branched and lead to special chambers whose walls are lined by choanocytes, but no choanocytes in the canals.
   - There is no real spongocoel just a central canal leading to the osculum.
   - Grow in any direction with a diameter over than 1 meter.
   - Live in large groups.



Sponge skeleton

Mesohyl of sponges is stiffened by skeleton of two components:

1. ***Spongin Fibers*** form a fibrous network and normally works in conjunction with the spicules.
2. ***Spicules*** are crystals produced from compounds precipitated by scleroblast cells in the sponge tissue. Spicules are either calcareous (calcium carbonate) or siliceous (silicate salts). The spicules serve at least two roles in the sponge: a kind of mesh-work internal skeleton, and as a protective device against predation. Spicules vary in shape from simple rods to three-dimensional stars up to six rays.



Classification of Sponges

Sponges are classified according to the kind of spicules into three classes:

1. **Calcarea (calcareous sponges):**
   They have spicules of calcium carbonate that have 1, 3 or 4 rays, without spongin fibers. They found as asconoid, syconoid, or leuconoid.

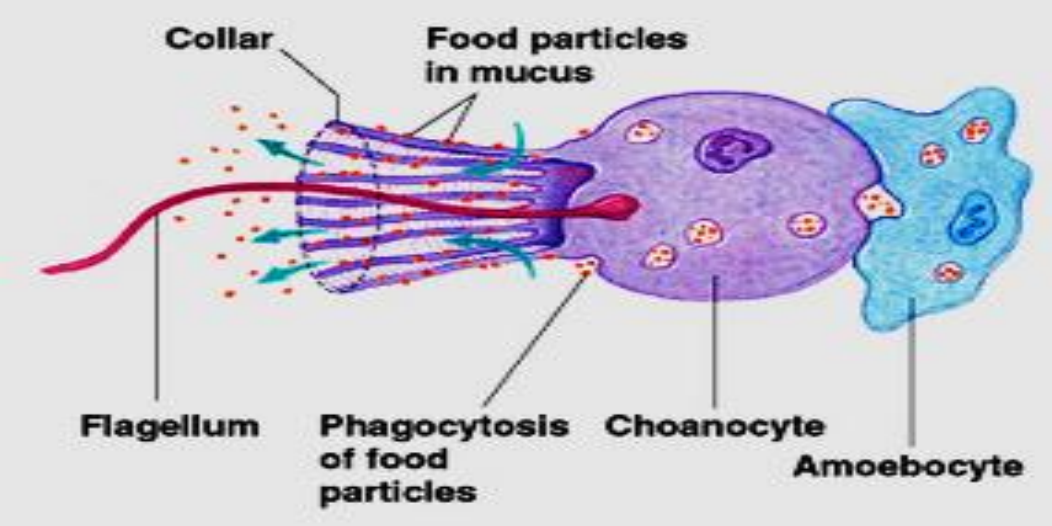
2. **Hexactinellida (glass sponges):**
   The glass sponges have spicules made from silica that are 6 rayed, without spongin fibers and can be found in leuconoid shape only.

3. **Demospongiae (demosponges):**
   The demosponges have spicules made from silica and they have 1, 2, or 4rays joined by meshwork of spongin fibers. They are found as leuconoid shape only.

Sponge Feeding

There are several methods of feeding:

- Most marine species of sponges filter food particles out of the water. Large particles that cannot enter the ostia are consumed by ***pinacocytes*** in a process called ***phagocytosis***. Since the smallest particles are by far the most common, ***choanocytes*** typically capture 80% of a sponge's food supply, then ***archaeocytes*** transport food packaged in vesicles from cells that directly digest food to those that do not.

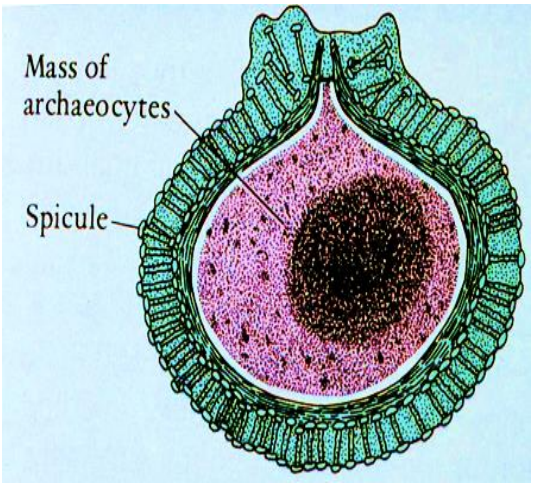


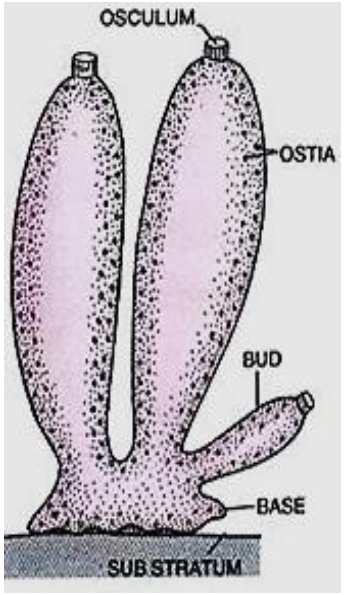
- A few species are ***carnivorous*** sponges that live in waters where the supply of food particles is very poor, so they prey on crustaceans and other small animals.

- Freshwater and many of marine species sponges host photosynthesizing organisms such as cyanobacteria & green algae as ***endosymbionts*** within archaeocytes and other cells, and benefit from nutrients produced by them.

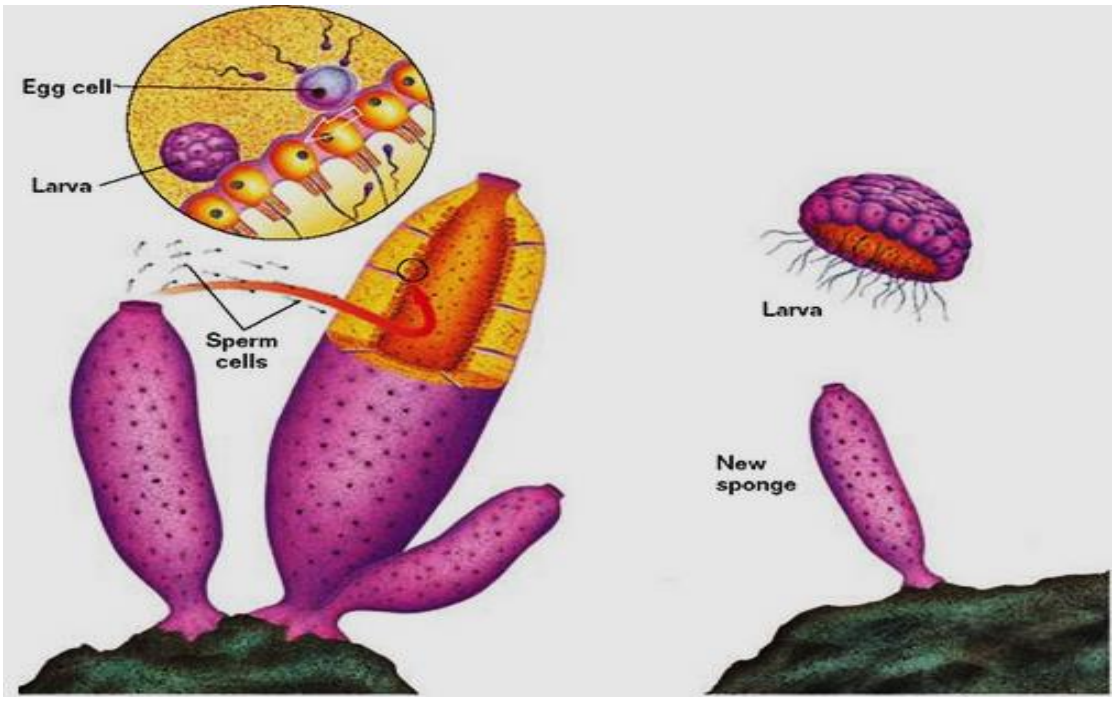
Sponge Reproduction

Asexual reproduction occurs by *budding* or by *fragmentation*. Pieces of sponge are able to regenerate into whole new sponges. The buds may remain attached to the parent or separate from it, and each bud develops into a new individual. Freshwater sponges, as well as several marine species, form resistant structures called *gemmules* that can withstand adverse conditions such as drying or cold and later develop into new individuals. Gemmules are aggregates of sponge ***archeocytes*** and food, covered by a hard coating containing spicules or spongin fibers. When a gemmule germinates, the archeocytes round the outside of the cluster and transform into other cell types needed to make a functioning sponge.





Sexual reproduction also occurs. Most sponges are *hermaphrodites* (function as both sexes, the same individual producing eggs and sperm), but in some species the sexes are separate. ***Sperm***s are produced by choanocyte, while ***Eggs*** are formed by transformation of archeocytes, or of choanocytes in some species. ***Fertilized eggs*** either released into the water or retain until they hatch into a swimming larvae. The larvae are flagellated and swim about freely for a short time. After settling and attaching to a suitable substrate, the larvae develop into young sponges.

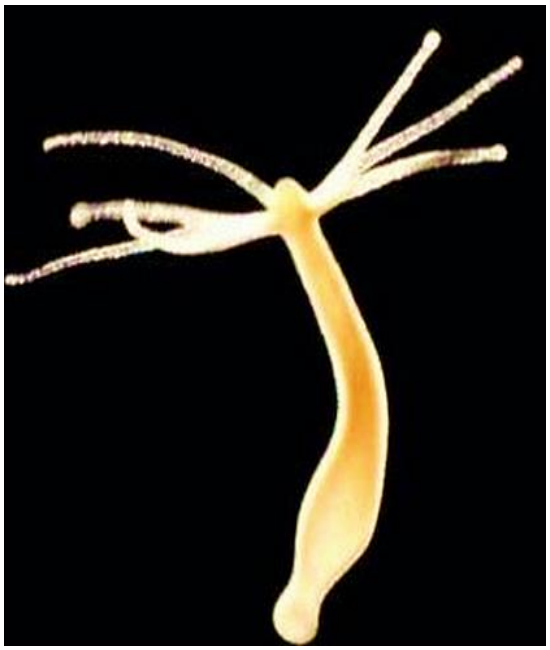


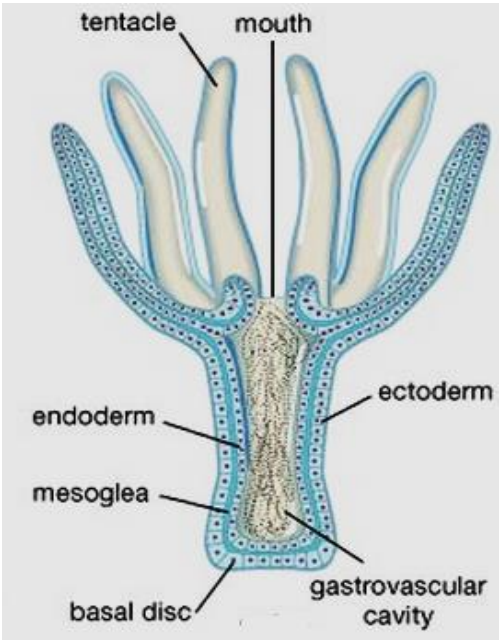
Phylum: Coelenterata (Cnidaria)

The name Cnidaria comes from the Greek word "***cnidos***" which means stinging nettle. Phylum Cnidaria formerly known as coelenterata (Gr. ***Koilos*** = hollow, ***enteron*** = gut) take its name from the large cavity in the body that serves as the intestine. Coelenterates are the simplest of ***metazoans*** includes about 9000 species, some are found in fresh water, but the greater number are marine.

Body Structure

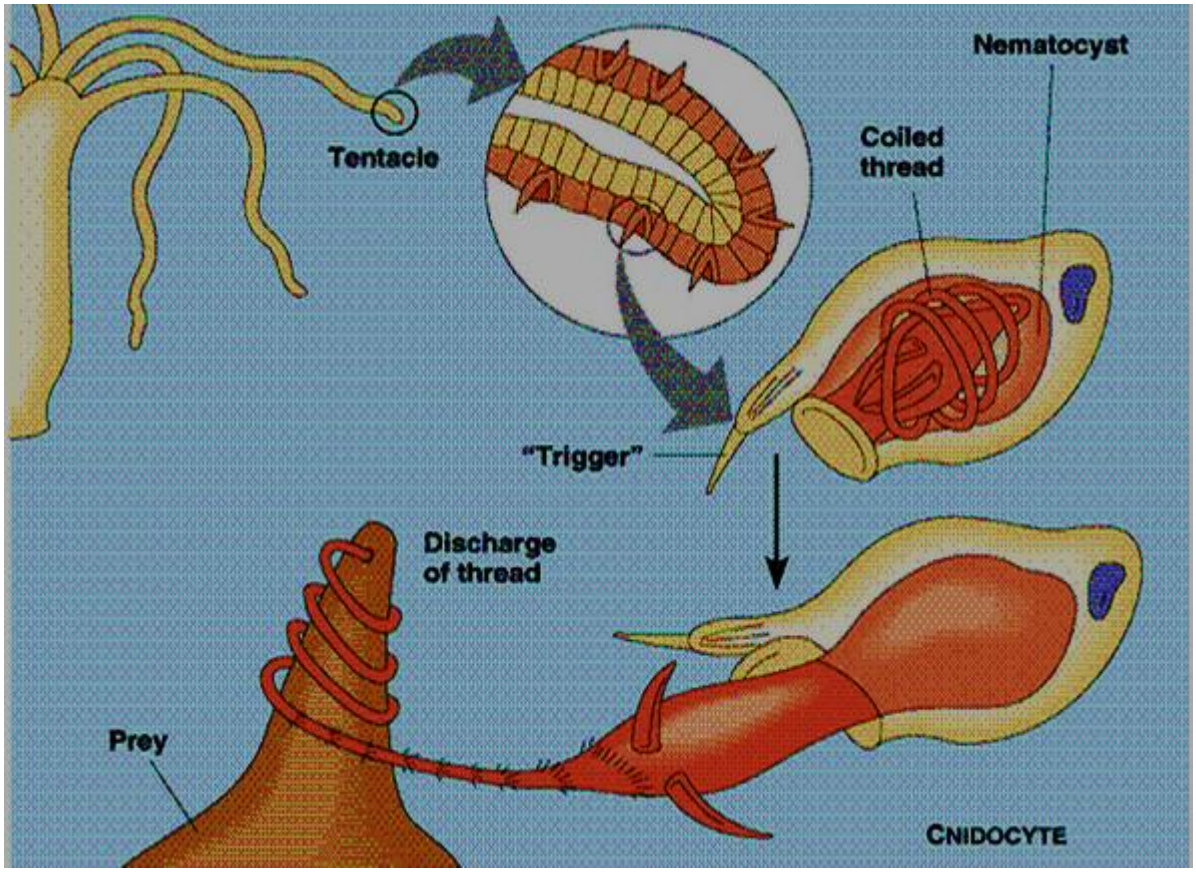
The body of coelenterates is radially symmetrical with oral and aboral ends but without definite head. They are diploblastic animals because their body is formed of two layers, the outer layer is called the **ectoderm**, while the inner layer is called **endoderm** that is separated from the ectoderm by a non-cellular **mesoglea** which is a jelly-like substance. A central cavity called ***gastrovascular cavity*** which opens to exterior by the mouth, but anus is absent. They are acoelomates because there is no separation between the digestive cavity and the general body cavity. A round the mouth there are several processes known as ***tentacles*** which are elongate, flexible, tactile and contain huge number of ***cnidocytes.***





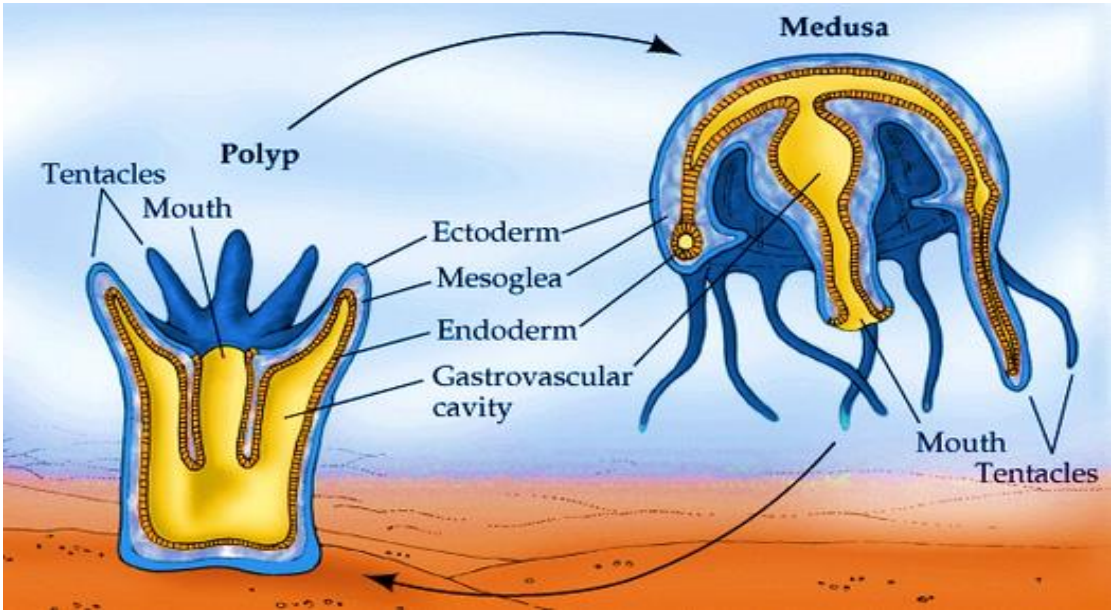
Cnidocyte (cnidoblasts, or nematocytes)

Cnidocyte means 'nettle cell' which is a type of venomous cell unique to the phylum Cnidaria found in the ectoderm particularly in tentacles that provides a means to catch prey and defend themselves from predators. Each cnidocyte cell contains an organelle called a ***cnidocyst*** (***nematocyst***), which comprises a bulb-shape capsule containing a coiled hollow thread-like structure attached to it. The externally-oriented side of the cell also has a hair-like trigger called a ***cnidocil.*** When the trigger is activated, hollow thread penetrates the target organism, and the toxic content of the nematocyst is injected into the target organism. The rapid activity of the injected neurotoxins immediately paralyzes the mobile prey, thus allowing the sessile cnidarian to devour it.



Polymorphism

Many coelenterates exhibit ***polymorphism*** which refers to the occurrence of structurally and functionally more than two different types of individuals within the same organism. In this phylum, organisms exist in two different body forms namely, a ***polyp***, and a ***medusa.*** The polyp is cylindrical and usually fixed and represents the asexual stage. The medusa is umbrella like and usually free swimming and represents the sexual phase.



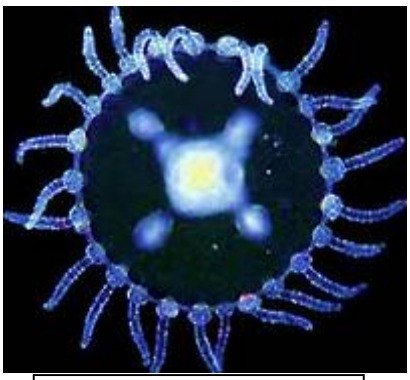
Classification of Cnidaria

The Phylum is divided into 4 Classes:

1. **Hydrozoa (meaning water-animals)**
   The Hydrozoans live attached to the bottom of freshwater and marine with their tentacles and mouth pointing up. Some are solitary, meaning that they live alone, but some are colonial, meaning that they live in groups. Most hydrozoans alternate between a polyp and a medusa stage (such as ***Obellia***), while few of them never goes through a medusa stage and spends its entire life as a polyp (such as ***Hydra***).

Hydra (polyp shape)

Obellia (polyp shape)



Obellia (medusa shape)

2. Anthozoa (meaning flower animals)

Anthozoans include anemones and coral reef usually live at the bottom of the ocean in a polyp form only. ***Anemones*** are often very colorful and have hundreds of tentacles that wave in the water currents while the main part of their body remains attached to a surface. They are pretty to look at, but deadly to fish that swim too close. ***Coral reef*** is smaller and live in colonies, that made of hundreds or thousands of polyps live together, sharing living tissue and food resources.

Anemones

Coral reef

3. Scyphozoa (bowl animals)

Scyphozoans include a group of animals called true ***jellyfish*** that range in size from a twelve millimeters to more than two meters across, and may have tentacles over 40 meters long. Their life cycle involves an alternation between sessile *polyp* phase and a free-swimming *medusa* stage, but the medusa stage usually predominates. ***Aurelia*** is an example of jelly fish, they swim around the ocean with their mouth and tentacles pointing down. True jellyfish are graceful, and sometimes deadly creatures. Their stings may cause skin rashes, muscle cramps, or even death. Jellyfish are not important as a food source, though they are eaten in some countries.

Aurelia

4. Cubozoa (Box jellyfish)

Cubozoans received their name due to the square shapes of their bells. In general, box jellies are similar in form to the "true" jellyfish, but they can swim pretty fast, and also possess eyes, with a set consisting of six eyes located at each side of their bells (making for a total of four eye clusters). These eyes allow them to see where they are going, maneuver around objects or animals which they find uninteresting or dangerous. Their tentacles are evenly spaced out in four sets, as well. Today, there are about 20 known species found in tropical and semitropical waters. The Australian stinger ***Chironex fleckeri*** is among the deadliest creatures in the world, having caused human fatalities. Which is also known as the **Australian sea wasp**.

Chironex fleckeri

Reproduction of Cnidarians

All Cnidaria can reproduce ***asexually*** by various means, some produce ***buds***, others divide down the middle or ***regenerating*** if their bodies are divided into segments or are attacked by predators. ***Sexual reproduction*** often involves a complex life cycle with both polyp and medusa stages. The fertilized egg grows to a larva (called ***planula***) which swims until it finds a good site, and then becomes a polyp.