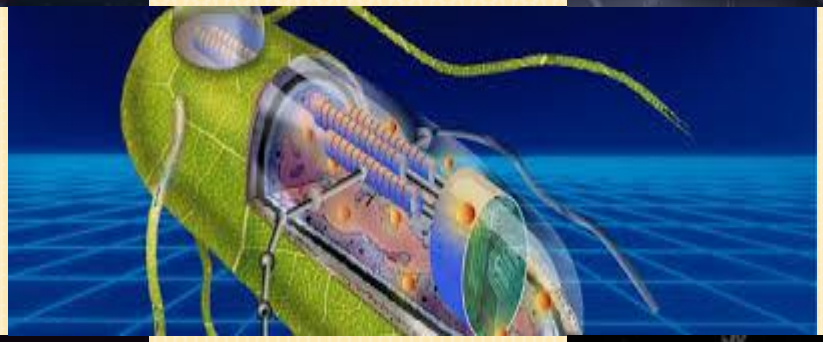
Life Sciences For Engineers



INTRODUCTION TO BIOLOGY

- Biology is a branch of science that deals with the study of life. Scientific study of life.
- (**What is life?** The condition that distinguishes animals, plants and microorganisms from inorganic matter. This includes capacity for growth, reproduction, functional activity, and continual change).
- Biology helps to know about the diversity in the living world, the ways by which it can be conserved, more about ourselves.
- Biology is a vast field. It includes the study of various aspects of living organisms and their interactions with the non-living components.





Branches of Biology

- Biology has three primary branches –Botany, Zoology and Microbiology.
- Some areas of study in these branches: Taxonomy, Morphology, Anatomy, Histology, Cell Biology, Genetics and Physiology.
- Interdisciplinary branches indicate the relationship of Biology with other branches of science like Biophysics, Biochemistry, Biometry and Bioinformatics, Psychology and Socio-biology (involving Biology and Social Sciences).
- Applied branches enable us to apply the knowledge gained from different areas to be used for welfare of man, animals and plants. These include branches like Agriculture, Animal husbandry, Aquaculture, Entomology, Aquaculture, Food technology, Biotechnology, Nano-technology, DNA-technology, Genetic engineering etc .

Life Sciences & Engineering

- Life science engineering concerns the application of engineering principles and practices to living organisms and is used in areas such as stem cell engineering, biochips and biosensors, and molecular bio-computing.
- The living organism is a complex engineering system — it consumes fuel and raw materials, exchanges heat with its surroundings, pumps fluids and carries on numerous chemical reactions and separation processes. It also has a complex sensory system with internal chemical signalling and control mechanisms, information storage and retrieval systems, and diverse movement and chemical/mechanical work capabilities.
- An engineering systems approach based on dynamic pathway modelling is key to understanding overall cellular behaviour. The complex nature of intracellular interactions requires a number of different technologies, such as microarrays, computers and computations, high throughput, and automation, to name a few.

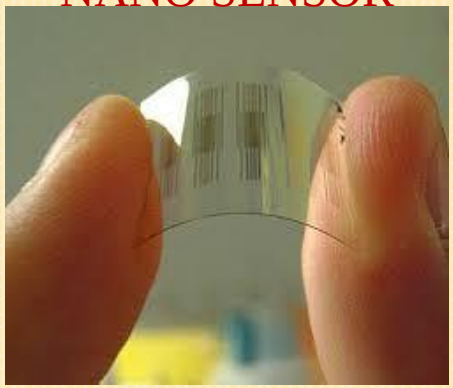
AUTOMATION IN MEDICAL FIELD

Multidisciplinary Nature

- It is a difficult task to try to identify one single discipline which is responsible for the progress that can be seen in a biological system. In fact, it is the combination of various factors, in theory treated independently of one another.
- The pace of technological advance in biology and medicine – across fields like data analysis, computer modelling or bio-imaging is driving the development of new therapies and new diagnostic and measurement tools.
- Life sciences engineers design the instruments necessary for understanding and applying these technologies to the very latest therapeutic methods.

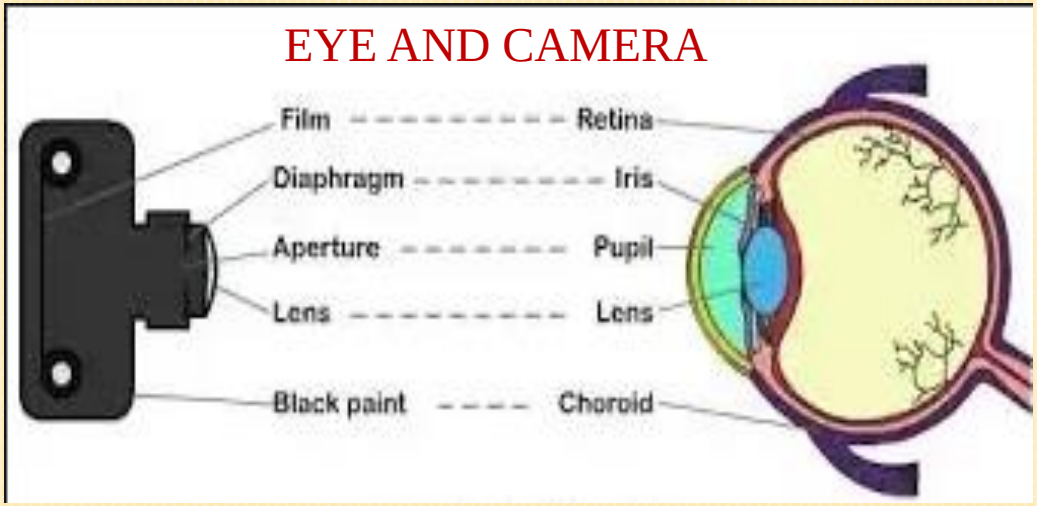
SURGERY

NANO SENSOR



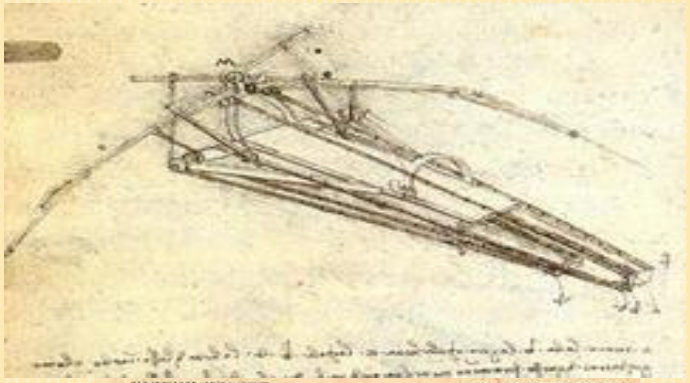
Comparison of Biological Organisms With Man Made Systems

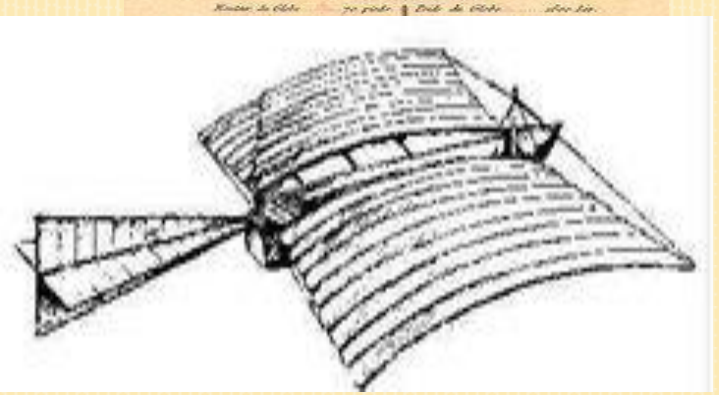
- Human eye and camera lenses both focus an inverted image onto light-sensitive surface.
- In the case of a camera, it‘s focused onto film or a sensor chip and in our eyes on retina.
- Aperture in camera helps to focus light on film, while in our eye pupil help to focus light on retina.
- Both the eye and a camera can adjust quantity of light entering. In a camera, it‘s done with diaphragm, while in our eye, it‘s done by iris.
- Finally, **Retina** is the sensory layer that lines the very back of our eyes. It acts like the imaging sensor chip in a digital camera.
- The retina has numerous photoreceptor nerve cells that help change the light rays into electrical impulses and send them through the optic nerve to the brain where an image is finally received and perceived.



FLYING BIRD AND AIRCRAFT

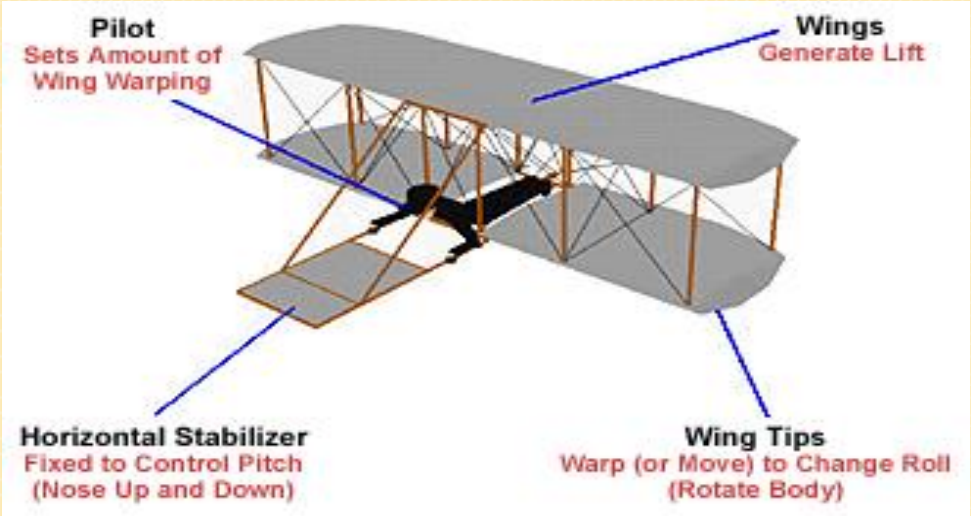
- The dream of flying is as old as mankind itself.
- Men and women tried to navigate the air by imitating the birds. They built wings to strap onto their arm or machines with flapping wings called ***ornithopters***.
- The trouble is, it works better at bird-scale but failed at the much larger scale needed to lift both a man and a machine off the ground.
- In 1783, a few aeronauts made daring, uncontrolled flights lighter air **balloons**, filled with hot air.
- In the nineteenth century an English baronet from the gloomy moors of Yorkshire conceived a flying machine with fixed wings, a propulsion system, and movable control surfaces. This was the fundamental concept of the **airplane**.
- George Cayley built the first true airplane — a kite mounted on a stick with a movable tail. It was crude, but it proved his idea worked, and from that first humble glider evolved the amazing machines that have taken us to the edge of space at speeds faster than sound.





WRIGHT BROTHERS & FIRST FLIGHT

- The Wright brothers were the first to invent aircraft controls that made fixed-wing powered flight possible.
- The Wright Brothers gained the mechanical skills essential to their success by spending time in observing birds in flight. They noticed that birds soared into the wind and that the air flowing over the curved surface of their wings created lift. Birds change the shape of their wings to turn and manoeuvre.
- The Wrights designed their glider by focusing on large birds. It turns out that small birds don't change the shape of their wings when flying, rather they change the speed of their flapping wings. For example, to start a left turn, the right wing is flapped more vigorously. To turn right the speed of flapping is changed to the other wing. To fly straight, both wings are flapped at the same speed.

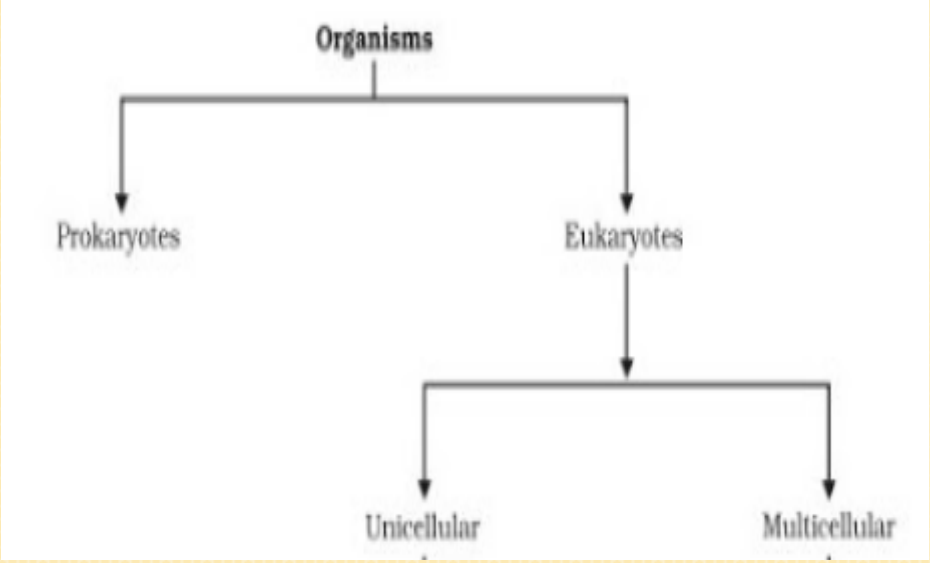


CLASSIFICATION OF LIVING ORGANISMS

- To study the diversity among living organisms in an effective way we need to arrange various kinds of organisms in a systematic manner. The methods of arranging organisms into groups or sets on the basis of similarities and differences is called classification.
- There are 1.8 million known organisms, so classification makes easier to study.
- Living organisms are classified based on the following criteria:
  - Ultrastructure
  - Cellular nature
  - Carbon sources and
  - Energy sources.

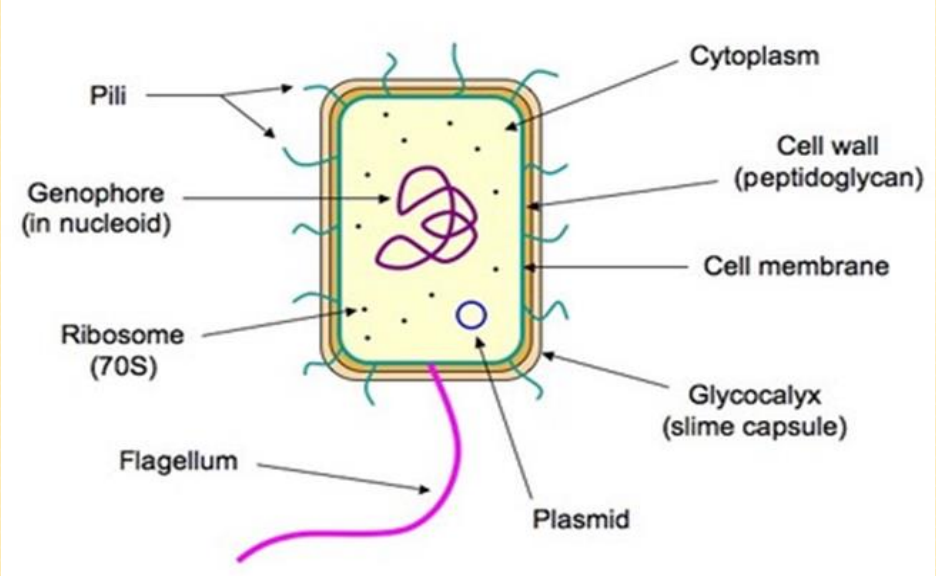
CLASSIFICATION BASED ON ULTRA STRUCTURE

- Based on the difference in cellular organization and biochemistry, the living organisms has been divided into two groups namely Prokaryotes and Eukaryotes.



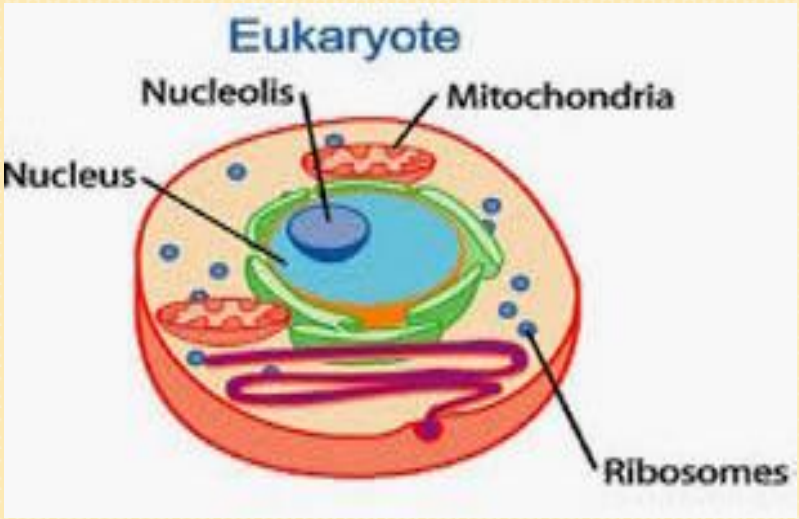
PROKARYOTES:

- Bacteria are prokaryotic microorganisms that do not contain chlorophyll. They are unicellular and do not show true branching.
- The prokaryotic cells have the following characteristics such as
- These has no organelles, all the action takes place in the cytosol or cytoplasmic membrane.
- Most bacteria possess peptidoglycan, a unique polymer that makes its synthesis a good target for antibiotics. Protein synthesis takes place in the cytosol with structurally different ribosome's.



EUKARYOTES:

- Fungi, algae, slime moulds and protozoa are eukaryotes.
- These cells are characterized by having a distinct, membrane bounded nucleus.
- Eukaryotic cells contains a variety of structures and cell organelles.



DIFFERENCE BETWEEN PROKARYOTES & EUKARYOTES

PROKARYOTES	EUKARYOTES
No membrane bound nucleus	Membrane bound nucleus
Cell walls made of peptidoglycan (Thickness of wall depends on whether the cell is Gram +ve or -ve)	Cell walls, if present, made of cellulose (chitin in fungi)
No membrane bound organelles	Membrane bound organelles (compartmentalisation)
Have pili & fimbriae (for adhesion) and flagella (for propulsion)	Have cilia or flagella (for movement)
Mucilaginous capsule	No mucilaginous capsule present (numerous internal structures present including microtubules, ER, Golgi, secretory vesicles etc)
Cell size ranges from 0.5um to 100um	Cell size ranges from 10 - 150um

CELLULAR BASIS OF LIFE

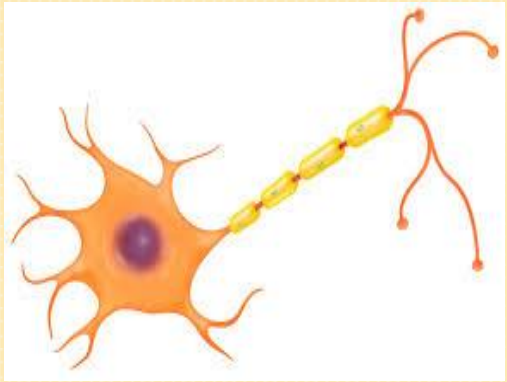
- All organisms are made of cells. Cells function differently in unicellular and multicellular organisms.

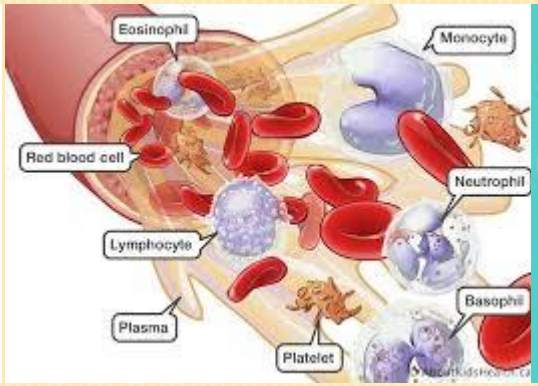
Unicellular Organisms:

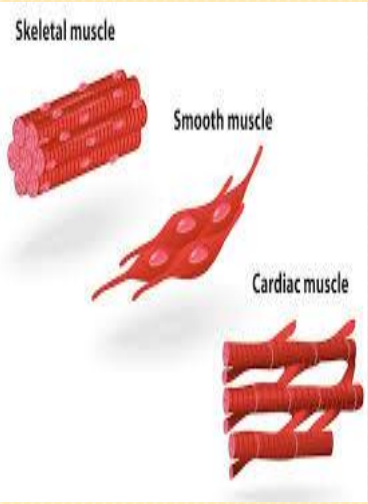
- Unicellular organisms are made up of only one cell that carries out all of the functions needed by the organism.

Multicellular Organisms:

- Multicellular organisms are composed of more than one cell, with groups of cells differentiating to take on specialized functions. In humans, cells differentiate early in development to become nerve cells, skin cells, muscle cells, blood cells, sperm cells and other types of cells.

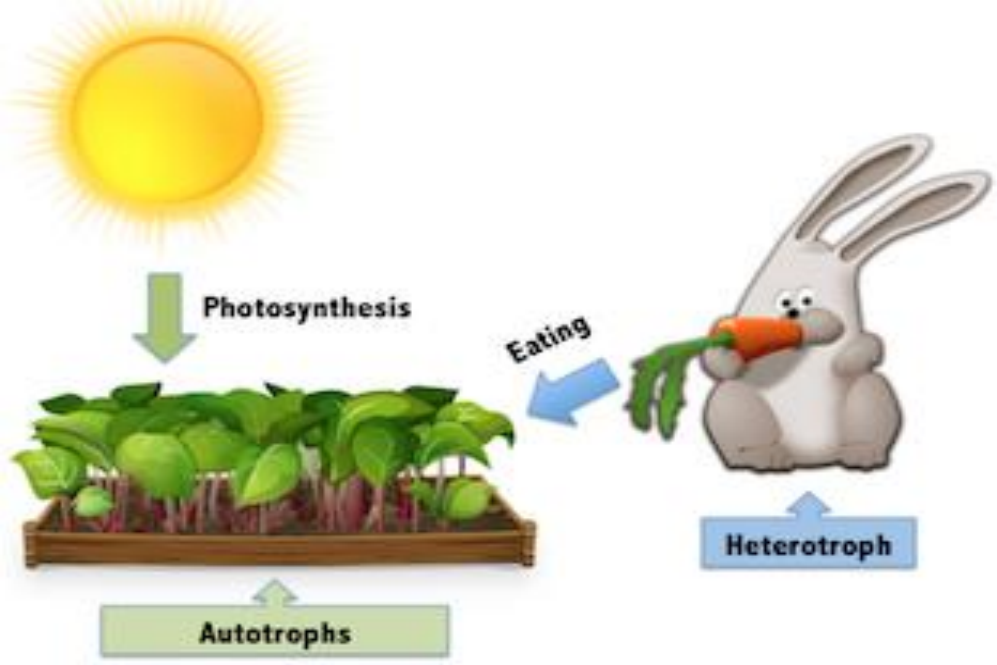






CLASSIFICATION BASED ON CARBON SOURCES

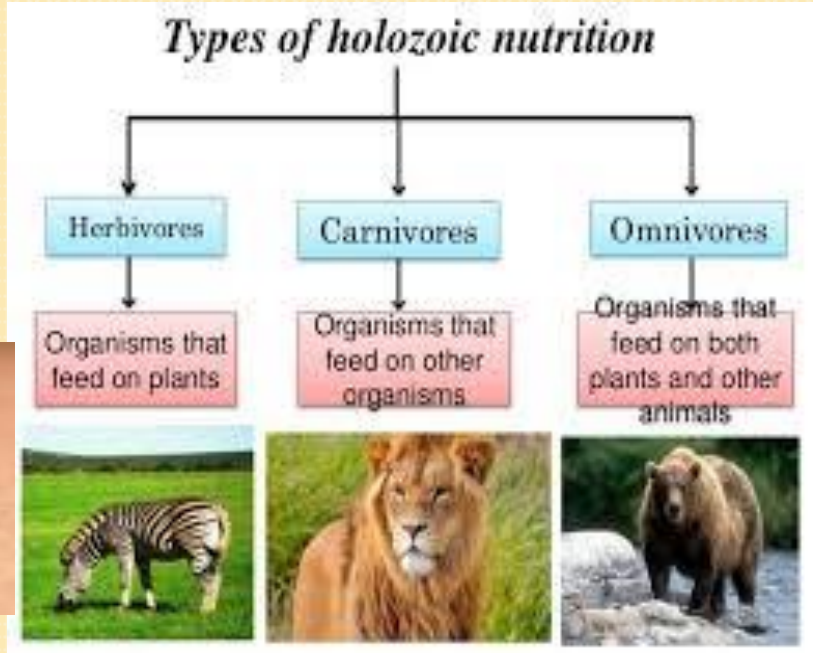
- Organisms can be identified according to the source of carbon & energy sources they use for metabolism.
- Based on carbon sources of various organisms the organisms are classified as
- **Autotrophs** (“self”):- These organisms convert inorganic carbon dioxide into organic carbon compounds. Ex: plants and cyanobacteria and
- **Heterotrophs** (“other”):- These organisms depend on more complex organic compounds as nutrients. Ex: Humans to many prokaryotes.



HETEROTROPHS

- Based on energy intake of food and digestion of organic substances derived from plants and animals heterotrophs are further classified as.
- Saprophytic nutrients: These organisms obtain their food from dead organic matter of dead plants and animals. Example: Fungi and many bacteria.
- Parasitic nutrients: These organisms derives their food from the body of another living organism (called host) without killing it. Example: Plasmodium and round worms.
- Holozoic nutrients: These organisms takes the complex organic food materials into its body by the process of ingestion; the ingested food is digested and then absorbed into the body. Example: Human beings.

  These holozoic nutrients are further classified based on the type of food as: Herbivores Carnivores & Omnivores



CLASSIFICATION BASED ON ENERGY SOURCES

- All organisms need energy that is derived from the transfer of electrons, but the source of electrons differs between various types of organisms.
- Based on energy sources the organisms are classified as
- Phototrophs (“light”):- These organisms get their energy for electron transfer from light.
- Chemotrophs (“chemical”):- These obtain energy for electron transfer by breaking chemical bonds.

Classifications		Energy Source	Carbon Source	Examples
Chemotrophs	Chemoautotrophs	Chemical	Inorganic	Hydrogen-, sulfur-, iron-, nitrogen-, and carbon monoxide-oxidizing bacteria
	Chemoheterotrophs	Chemical	Organic compounds	All animals, most fungi, protozoa, and bacteria
Phototrophs	Photoautotrophs	Light	Inorganic	All plants, algae, cyanobacteria, and green and purple sulfur bacteria
	Photoheterotrophs	Light	Organic compounds	Green and purple nonsulfur bacteria, heliobacteria

IMPORTANT QUESTIONS

- Define Biology.
- What are the different branches of biology?
- Engineering systems are key to understand the cellular behavior- Discuss.
- Compare the biological system “Eye” with man made system “Camera”.
- How man satisfied his ego to fly as bird in designing an aircraft.
- Classify living organisms based on Ultra structure.
- Differentiate Prokaryotic and Eukaryotic cells.
- Explain the difference between unicellular and multicellular organisms?
- How organisms are classified based on carbon sources.
- What are Autotrophs?
- What are saprophytes / saprophytic nutrients?
- Name some parasitic organisms.
- Explain different types of holozoic nutrients?
- How organisms are classified based on energy sources?
- Define phototrophs.
- What are chemotrophs.

SHORT VIDEOS

- https://ed.ted.com/lessons/eye-vs-camera-michael-mauser
- https://www.youtube.com/watch?v=4jKokxPRtck
- https://www.youtube.com/watch?v=pckKjaBjRe8
- https://www.youtube.com/watch?v=zZtcMBTQaS4