VIRUS

- A Virus is neither a cell, nor alive nor able to reproduce independently.
- Virus is an extreme micro, parasitic non-cellular **nucleoprotein particle** which persists inside any living organism. So all viruses are parasites.
- A virus can reproduce ONLY inside a living organism.

Virus is a Latin word whose literal meaning is poison. Viruses were discovered by the Russian scientist **Dimitri Ivanovsky** in 1892 during the investigation of plant disease called **tobacco mosaic**. So, the TMV or **Tobacco Mosaic Virus** was the first Virus that was discovered.

Viruses naturally grow and reproduce in the living cells of more complex organisms, where they may cause diseases. The study of the viruses is called virology. Viruses undergo reproductive activities through multiplication.

- In plants, the viruses transmit generally through phloem, while in the animals through the blood / fluid of the body.
- Viruses have **DNA and RNA but not both** and these are composed from **nucleoproteins**.

Virus affects only a certain species and exhibits the properties of living and non-living both, as shown in the following table:

Living properties	Non-living properties
The presence of DNA or RNA (but never both)	The absence of cell.
Structural diversity	The lack of protoplasm.
Geneticity and parasitic properties	No any reproduction and growth outside the living cell.
Sensitivity and evolution	Stored in the form of crystal outside the living cell.
Capable of spreading the disease	The lack of metabolic activities like nutrition, digestion etc.

Structure and types of Viruses

There are three main constituents or components of the structure of the virus-protein capsid, nucleic acid and a thick outer layer. Around a virus there is a closed frame of protein and which acts as genetic carries.

- Generally, nucleic acid RNA is present in the plant virus, while in the animal virus nucleic acid DNA is present.

On the basis of parasitic nature there are three types of virus-

1. **Plant virus:** This is nucleic acid of RNA. Examples are Tobacco Mosaic Virus and YMV (yellow mosaic virus.
2. **Animal virus :** The animal Viruses contain either RNA or DNA and are **usually spherical** in shape. Examples are influenza, mumps etc.
3. Bacteriophage: The viruses that are parasites on a bacterial cell are called Bacteriophage. Please note that in Bacteriophage ONLY DNA is present and they can destroy NOT ONLY Bacteria BUT also other viruses.

Virus as Boon

- ✓ Since Viruses contain the characteristics of both living and non-living organisms, they are utilized in the field of Biotechnology research.
- ✓ Bacteriophage can be used in water preservation as it can destroy the bacteria and keep water fresh.

How Viruses are beneficial for Aquatic Ecosystems?

A teaspoon of seawater contains about one million of Viruses, making them the most abundant biological entity in aquatic environments. They are useful in the regulation of saltwater and freshwater ecosystems. The Bacteriophage, which **is harmless to plants and animals,** play the most important role here. They infect and destroy the bacteria in aquatic microbial communities, comprising the most important mechanism of recycling carbon in the marine environment. However, the organic molecules released from the bacterial cells by the viruses stimulate fresh bacterial and algal growth. Viruses are useful for the rapid destruction of harmful algal blooms that arises generally from the Blue Green algae and often kills other marine life. Viruses INCREASE the amount of Photosynthesis in Oceans and are responsible for reducing the amount of carbon dioxide in the atmosphere by approximately 3 gigatonnes of carbon per year.

What is Horizontal gene transfer?

It is now accepted that viruses played a central role in the early evolution, before the diversification of bacteria, Achaea and eukaryotes and at the time of the last universal common ancestor of life on Earth.

They play very important role in the Horizontal gene Transfer. Horizontal gene transfer (HGT) or lateral gene transfer (LGT), is the process in which an organism incorporates genetic material from another organism **without being the offspring of that organism**. What is generally discuss in genetics is Vertical Gene Transfer.

- ✓ Viruses are an important natural means of transferring genes between different species, which increases genetic diversity and drives evolution.

Horizontal gene transfer is a highly significant phenomenon and amongst single-celled organisms perhaps the dominant form of genetic transfer. Artificial horizontal gene transfer is a form of genetic engineering.

Other applications of Viruses

- ✓ Molecular Biology, Cellular Biology, Molecular genetics, such as DNA replication, transcription, RNA processing, translation, protein transport, and immunology.
- ✓ Virotherapy uses viruses as vectors to treat various diseases, as they can specifically target cells and DNA. It shows promising use in the treatment of cancer and in gene therapy.
- ✓ The viruses represent largest reservoirs of unexplored genetic diversity on Earth. They can be used as alternative to the antibiotics because of the high level of antibiotic resistance now found in some pathogenic bacteria.
- ✓ Viruses contain protein and this property can be used in production of various proteins such as vaccine antigens and antibodies.
- ✓ In nanotechnology, viruses can be regarded as organic nanoparticles. Because of their size, shape, and well-defined chemical structures, viruses have been used as templates for organizing materials on the nanoscale.
- ✓ It's relatively easy to synthesize a new Virus. First synthetic virus was created in 2002, which is actually a DNA genome (in case of a DNA virus), or a cDNA copy of its genome (in case of RNA viruses). Ability to synthesize viruses has far-reaching consequences, since viruses can no longer be regarded as extinct; as long as the information of their genome sequence is known and permissive cells are available. Currently, the full-length genome sequences of 2408 different viruses (including smallpox) are publicly available at an online database.
- ✓ Viruses can cause devastating epidemics in human societies. They can be weaponised for biological warfare.

Viruses as Curse

Usually viruses spread various diseases in plants, animals nad human beings indetails profile can eb tabulated as below:

Viral diseases in plants

Plants	Diseases
Tomato	Twisted leaf disease
Lemon	Yellowing of veins
Almond	Streak pattern
Mustard	Phyllody
Beet root	Twisted apex
Lady finger	Yellow vein mosaic

Sugarcane	Grass shoot disease
Papaya	Mosaic
Banana	Mosaic

Viral diseases in animals :

Diseases	Animals	Viruses
Herpes	Cow	Herpes virus
Blue tongue Disease	Cow	Blue tongue virus
Small pox	Cow	Variola vaccinia
Small pox	Buffalo	Poxverdi orthopox
Rabies	Domestic animals dog	Rabdovergi vasculo virus stereit virus
Mouth and gland infection	Cow and buffalo	Picornaverdi aphtho virus
Renderpest disease.	Cow and buffalo	Paramixoverdi morbeli virus

- ✓ **Foot-and-mouth disease virus** (FMDV) causes acute systemic vesicular disease that affects cattle worldwide, foot-and-mouth disease. FMDV is a highly variable and transmissible virus. Its an RNI Virus.
- ✓ **Pestiviruses** causes diseases in animals such as Classical swine fever (CSF) and Bovine viral diarrhea / Mucosal disease (BVD/MD).
- ✓ **Arteriviruses** are small, enveloped, animal viruses that infect animals such as Horses, Rabbits, Mice etc.
- ✓ **Influenza is caused by RNA viruses** and affects birds and mammals. Wild aquatic birds are the natural hosts for a large variety of influenza A viruses. Occasionally viruses are transmitted from this reservoir to other species and may then cause devastating outbreaks in domestic poultry or give rise to human influenza pandemics.
- ✓ **Bluetongue virus (BTV)** causes serious disease in livestock (sheep, goat, cattle). BTV is a complex non-enveloped virus with seven structural proteins and a RNA genome consisting of 10 double-stranded (ds) RNA segments of different sizes.
- ✓ **Porcine Circoviruses (PCV)** are the smallest viruses replicating autonomously in eukaryotic cells. They cause Postweaning Multisystemic Wasting Syndrome (PMWS), a new emerging and multifactorial disease in swine.
- ✓ **Herpesviruses** are highly successful pathogens infecting animals and man.

Viral diseases in human beings:

Type	Most Common Disease	Other Diseases	Transmission
adenovirus	**Pharyngitis** **Gastroenteritis in infants**	pharyngoconjunctival fever epidemic keratoconjunctivitis	droplet contact (mainly) faecal-oral venereal direct contact (ocular infections)
Epstein-Barr virus		infectious mononucleosis Burkitt lymphoma	Saliva
Hepatitis A virus	**Hepatitis**	acute hepatitis	faecal-oral
Hepatitis B virus	**Hepatitis** **Cirrhosis** **Live Cancer**	acute hepatitis chronic hepatitis hepatic cirrhosis hepatocellular carcinoma	All body fluids (blood, semen, saliva, mother's milk etc.)
Hepatitis C virus	**Hepatitis** **Cirrhosis** **Live Cancer**	acute hepatitis chronic hepatitis hepatic cirrhosis hepatocellular carcinoma	blood (sexual)
Herpes simplex virus, type 1	**gingivostomatitis in children, tonsillitis & pharyngitis in adults, keratoconjunctivitis)**		direct contact with saliva and lesions
Herpes simplex virus, type 2	**Meningitis**	aseptic meningitis	sexually birth
Human herpesvirus, type 8	**Cancer**	Kaposi sarcoma multicentric Castleman disease	

		primary effusion lymphoma	
HIV	**AIDS**		• sexual • blood • mother's milk
Influenza virus	**Influenza**	influenza (Reye syndrome)	droplet contact
measles virus	**Measles**	measles postinfectious encephalomyelitis	droplet contact
Mumps virus	**Mumps**	Mumps	droplet contact
Human papillomavirus		Warts in genital and anal parts, Cancer	direct contact
Parainfluenza virus	**Common Cold**	croup pneumonia bronchiolitis common cold	droplet contact
Poliovirus	**Polio**	Poliomyelitis	faecal-oral
Rabies virus	**Rabies**	Rabies	Animal bite droplet contact
Respiratory syncytial virus	**Pneumonia**	bronchiolitis pneumonia influenza-like syndrome severe bronchiolitis with pneumonia	droplet contact, hand-to-mouth
Rubella virus	**German Measles**	German measles congenital rubella	droplet contact

What is a Pandemic?

A widespread endemic disease is a pandemic (Pan =all). It spreads through human populations across a large region such as multiple continents, or even worldwide.

An endemic that is stable in terms of how many people are getting sick from it is not a pandemic. More recent pandemics include the HIV pandemic and the H1N1 pandemic.

The World Health Organization (WHO) classifies the spread of influenza through a system of incremental alerts, from Phase-1 to Phase-6.

1. When a new virus is found among **animals without infecting humans** then a Phase-1 alert is issued.
2. If the same virus is found to cause infection in humans also then the alert is raised to Phase-2.
3. In Phase-3, the virus starts causing a disease in groups or clusters of humans but there is no clear vulnerability pattern, and no human-to-human transmission.
4. The alert is raised to Phase-4 if the virus shows human-to-human transmission and the ability to sustain community-level outbreak of the disease or infection. However the virus is yet confined to the geographical boundaries where that particular community is living.
5. If the same virus starts spreading across neighboring countries and the illness caused by the virus is reported in at least two countries of the same geographical region then a Phase-5 alert is released.
6. If community-level outbreak is reported from at least one country from a different geographical zone then the alert is raised to Phase-6.

Criteria for Declaration of Pandemic:

WHO's criteria for declaring a pandemic is when the infection spreads locally in at least two distinct regions of the world.

- It **does not relate to the severity of the infection** and hence pandemic declaration doesn't mean that the flu has become more dangerous than it was before.

It only means that the virus has spread over a wide region across the world and that all countries should prepare to deal with it.

Please note that most pandemics end when enough people become immune to the disease. This can happen in the natural course or through vaccination. Compared to the past, medical science today is considerably more advanced — there are some anti-viral drugs available, the genetic structure of flu viruses is known, and responses to outbreaks are very rapid due to advanced communications.

AIDS spread

Human disease AIDS (acquired immune deficiency syndrome) was invented in 1981 which is viral disease In 1986 the virus of AIDS was called HIV (human immune deficiency virus). At present the disease AIDS has various curable modes and medicines like HILV-III, combination therapy, AZT-3 etc are frequently used. AIDS spreads via Unprotected sexual activity, Blood and Mother's milk.

- ✓ Saliva does contain HIV, but the virus is only present in very small quantities and as such cannot cause HIV infection. Unless both partners have large open sores in their mouths, or severely bleeding gums, there is no transmission risk from mouth-to-mouth kissing. There has been only one documented case of someone becoming infected with HIV through kissing; a result of exposure to infected blood during open-mouthed kissing. **(So as an option you should mark Yes)**
- ✓ AIDS also does not spread via sneezing, coughing, sharing glasses/cups, etc.
- ✓ HIV is unable to reproduce outside its living host, except under strictly controlled laboratory conditions.
- ✓ HIV does not survive well in the open air, and this makes the possibility of this type of environmental transmission remote. In practice no environmental transmission has been recorded.
- ✓ HIV also does not spread from use of swimming pools, showers or by sharing washing facilities or toilet seats.
- ✓ There is no evidence of HIV transmission through insect bites, even in areas where there are many cases of HIV and AIDS and large populations of insects such as mosquitoes. Lack of such outbreaks, despite considerable efforts to detect them, supports the conclusion that insects do not transmit HIV. This is because HIV only lives for a short time and cannot reproduce inside an insect. So, even if the virus enters a mosquito or another sucking or biting insect, the insect does not become infected and cannot transmit HIV to the next human it feeds on or bites

Dengue

- ✓ Dengue is a mosquito-borne seasonal viral infection caused by any of four closely related viruses (DENV 1-4).
- ✓ The virus is transmitted by a bite of female mosquito of any of two species of mosquitoes of the genus Aedes. The mosquito, which **typically bites humans in the daylight hours**, can be easily recognized because of its peculiar **white spotted body and legs**.
- ✓ Outbreak of the disease **typically occurs in summer season** when the mosquito population reaches its peak. It occurs **widely in tropical and subtropical areas** in Asia, Africa, Central and South America.
- ✓ Unlike *malaria, which is a major health concern in rural areas, dengue is equally prevalent in the urban areas too*. In fact, it is predominantly reported in urban and semi-urban areas.
- ✓ WHO estimates that there may be 50 million dengue infections worldwide every year. A severe form of the infection is known as dengue hemorrhagic fever (DHF). DHF **can be fatal if not detected**.

Symptoms of Dengue

- ✓ After its entry into patient's body, the virus multiplies to reach sufficient numbers to cause the symptoms. This process might take 4-6 days after which the symptoms become visible. The main symptoms of dengue are high fever (103-105 degrees Fahrenheit), severe headache (mostly in the forehead), severe pain behind the eyes, joint pain, muscle and bone pain, rashes, and mild bleeding from nose or gums.
- ✓ Because of the severe joint pain, dengue is also known as **break-bone fever**.
- ✓ Typically, younger children and those with their first dengue infection have **a milder illness than older children and adults**.
- ✓ DHF is characterized by a fever that lasts for 2 to 7 days, with general signs and symptoms consistent with dengue fever. In addition to these symptoms, if a patient suspected with dengue experiences decrease in platelets or an increase in blood haematocrit, it becomes more certain that the patient is suffering from the infection.
- ✓ Platelets are cells in blood that help to stop bleeding, while haematocrit indicates thickness of blood. The smallest blood vessels become excessively permeable allowing fluid component to escape from blood vessels to organs of the body.
- ✓ This may lead to failure of circulatory system, which might also cause death.

Treatment:

- ✓ Like in most viral diseases, there is **no specific cure** for dengue. Antibiotics do not help and paracetamol is the drug of choice to bring down fever and joint pain.
- ✓ Other medicines such as Aspirin and Brufen or any medicine that can decrease platelet count should be avoided since they can increase the risk of bleeding.
- ✓ As it has no specific medication, most dengue patients can be treated at home.

Polio

Poliomyelitis, often called polio or infantile paralysis, is an acute viral infectious disease. Polio virus is an enterovirus which means that the route of entry of this virus is through the gastrointestinal system.

- ✓ It is an RNA virus.

Polio is usually spread via the fecal-oral route (i.e., the virus is transmitted from the stool of an infected person to the mouth of another person from contaminated hands or such objects as eating utensils). Some cases may be spread directly via an oral to oral route.

Symptoms

The virus makes its way into the body of humans through the fecal oral route and divides within gastrointestinal cells for about a week, from where it spreads to the tonsils and then widely distributed throughout the body. It affects the CNS (Central Nervous System) reflected as inflammation (of Spine) and this is called the non-paralytic Polio.

- ✓ The incubation period for polio is commonly 6–20 days, with a range of 3–35 days. Surprisingly, 95% of all individuals infected with polio have no apparent symptoms.
- ✓ Another 4%–8% of infected individuals have symptoms of a minor, non-specific nature, such as sore throat and fever, nausea, vomiting, and other common symptoms of any viral illness. About 1%–2%

of infected individuals develop nonparalytic aseptic (viral) meningitis, with temporary stiffness of the neck, back, and/or legs.

- ✓ Less than 1% of all polio infections result in the classic "flaccid paralysis," where the patient is left with permanent weakness or paralysis of legs, arms, or both.
- ✓ In this case, the Virus spreads along certain nerve fiber pathways, preferentially replicating in and destroying motor neurons within the spinal cord, brain stem, or motor cortex resulting in flaccid paralysis. This has made polio a feared disease for hundreds of years. Of people with paralytic polio, about 2%–5% of children die and up to 15%–30% of adults die.

Cure

- ✓ There is no "cure" for polio. People infected with polio need supportive therapy, such as bed rest and fluids. Standard precautions should be taken to avoid passing on the virus through any contamination from the patient's stool.
- ✓ Since, there is no cure known for the disease, and so the best strategy is prevention. Immunization is the only way to prevent Polio and it is done at prescribed intervals and en-masse vaccinations.

Polio Eradication

- ✓ In 1988, the World Health Organization (WHO) adopted the goal of global polio eradication. Although the initial target date of 2000 was not met, substantial progress has been made. In 1988, there were estimated to be 350,000 reported cases of polio in the world; in 2001, just 483 cases were reported.
- ✓ Unfortunately, rumors about the safety of polio vaccine in 2003, and subsequent refusal of vaccine by many parents in Nigeria, led to an increase in cases and spread of the virus to nearby countries that had previously been polio free.
- ✓ Many organizations have been working hard toward eradicating polio including WHO, the United Nations Children's Fund (UNICEF), the Centers for Disease Control and Prevention (CDC), Rotary International, the Bill and Melinda Gates Foundation, and many other international and national groups. Strategies include house-to-house vaccination and National Immunization Days, where even warring factions have called temporary cease fires to allow children to be vaccinated

Polio Vaccines

- ✓ The first polio vaccine was an **inactivated, or killed, vaccine (IPV)** developed by Dr. Jonas Salk and licensed in 1955.
- ✓ In 1961, a live attenuated (e.g., weakened) vaccine was developed by Dr. Albert Sabin. This vaccine was given as an oral preparation instead of as a shot.
- ✓ By 1963, this oral vaccine had been improved to include protection against three strains of polio and was licensed as "**trivalent oral poliovirus vaccine**" (OPV).
- ✓ OPV was the vaccine of choice for the most countries of the world from 1963. However In some developed countries including US, there was a policy change later on.
- ✓ In 1988, an enhanced-potency IPV formulation became available and by 1997 had become part of the routine schedule for infants and children, given in a sequential combination with OPV. IPV is also available in combination with other vaccines (e.g., DTaP-HepB-IPV, DTaP-IPV/Hib, or DTaPIPV).

Thus, two types of Vaccines are employed today: -

- ✓ **Inactivated Polio Vaccine or IPV** used since 1955 contains the inactivated polio virus. The vaccine is administered as a shot in the leg or the arm. Common in United States.
- ✓ The **Oral Polio Vaccine or OPV**, employed since 1961, contains a mild form of the live polio virus and is administered as 'drops' orally. Common in India.

Why United States discontinued giving OPV?

OPV became controversial in medical circles due to a rare but serious side effect associated with the use of the vaccine - **vaccine derived paralytic poliomyelitis and Vaccine associated paralytic poliomyelitis**. This culminated in the ban on OPV in United States.

- Oral polio vaccine (OPV) is its known ability to revert to a form that can achieve neurological infection and cause paralysis. This is known as Vaccine Derived Polio Virus or VDPV.
- Though VDPV is rare event, but outbreaks of vaccine-associated paralytic poliomyelitis (VAPP) have been reported, and tend to occur in areas of low coverage by OPV, presumably because the OPV is itself protective against the related outbreak strain.
- In simple words, for a few people (about one in 2.4 million), **OPV actually causes polio.** Since the risk of getting polio in the United States is now extremely low, experts believe that using oral polio vaccine is no longer viable. It has been proved that the polio shot (IPV) does not cause polio.

OPV and India

- In India, OPV is the backbone of Polio Vaccination Programme. The children need to be administered **four doses of Polio vaccine** during the period from infancy **till 5 years of age**.
- In India, the initiative against polio began in 1978 under the project called, the Expanded Programme on Vaccination (EPV) .
- This programme brought more than 40% of the infants under its cover to avail 3 doses of Oral Polio Vaccine. Upon success of the first en-masse initiative, this programme was expanded to include many districts in the country. The Pulse Polio Immunization (PPI) Programme commenced in 1995-96 to include all children below age of 3. Please note that 'PULSE' stands for Post-Resuscitation and Initial Utility in Life Saving Efforts.
- In order to accelerate the pace of polio eradication, the target age group was increased from 1996-97 to all children under the age of **5 years**. (Please note **this** age)

Emplying poliovirus vaccines in many parts of the world have significantly reduced the worldwide occurrence of polio by 99%. The western countries are today complete polio free. Only 613 cases were reported worldwide in 2007. The most affected area today is Afghanistan, Pakistan, some areas in India and Africa. In 2010, India has reported only 40 cases of Polio, which indicates that India is near its aim to achieve 100% Polio Free Status.

Why does orally taken polio vaccine not get destroyed in the stomach's digestive system?

Some viruses are enveloped in a lipid layer that can be destroyed by the lipolytic agents present in the digestive system. The lipid layer cannot withstand the stomach's digestive system as it is sensitive to alcohol, acid and other enzymes in the digestive system. Examples are influenza and HIV viruses. However, there are other types of viruses, which are non enveloped, called naked viruses, like the polio virus, which cannot be destroyed by acid, bile or other proteolytic enzymes present in the digestive tract. Therefore the polio vaccine that contains attenuated strains of live polio virus, when given orally, cannot be destroyed by the digestive acids and enzymes and survives in the intestinal tract and induces local immunity in the intestinal tract.

What are Interferons?

Interferons (IFNs) are proteins made and released by host cells in response to the presence of pathogens—such as viruses, bacteria, or parasites—or tumor cells.

They allow communication between cells to trigger the protective defenses of the immune system that eradicate pathogens or tumors. Interferons (IFNs) play pivotal roles in shaping the immune responses in mammals and are particularly important for the control of viral infections and cell growth, and immune regulation. These proteins rapidly induce an "anti-viral state" in cells that surround infected cells. In order to survive, viruses have evolved multiple strategies to evade the anti-viral effects of IFNs. Elucidating the molecular and cellular biology of the virus-interferon interaction is key to understanding issues such as viral pathogenesis, latency, and the development of novel antivirals.

Why is the virus H5N1 called so?

The influenza A (H5N1) virus — also called the H5N1 virus — is a subtype that occurs largely in birds. It is very contagious and can be deadly. There are many different subtypes of type A viruses. These differ because of certain proteins on the virus surface — hemagglutinin (HA) and neuraminidase (NA) proteins. All known subtypes of flu A viruses can be found in birds. However, influenza A subtypes are chiefly found in birds. They do not usually infect humans, though they can. When we talk about human flu viruses, we refer to those subtypes that occur widely in humans. There are only three known A subtypes of human flu viruses (H1N1, H1N2, and H3N2); it is likely that some genetic parts of current human influenza A viruses came from birds originally.

BACTERIA

The living beings (organisms) of all the prokaryotic cells which are extremely microscopic and simplified found everywhere come under kingdom Monera. Monera is a prokaryotic cell which has an incipient nucleus and under it. Bacteria and blue green algae have been kept in Monera.

Bacteria are the most important member of Kingdom Monera.

Bacteria are simplified microbes having **prokaryotic cells lacking of chlorophyll**.

- ✓ The bacteria are unicellular microorganisms which were first observed and reported by **Anton Von Leeuwenhoeck** in 1676 and he described them as animalcules.
- ✓ The term "bacterium" was introduced **Christian Gottfried Ehrenberg** in 1838 and in 1859, Louis Pasteur demonstrated that the fermentation process is caused by the growth of microorganisms, and that this growth is not due to spontaneous generation.
- ✓ This gave rise to the germ theory of disease and **Robert Koch** pioneered the medical microbiology and worked on cholera, anthrax and tuberculosis. For his germ theory, Koch was awarded a Nobel Prize in 1905

  All bacteria are unicellular and prokaryotic. Their size and shape varies as per the species. Majority of Bacteria are in the size range of 0.5 to 50 μ, the smallest bacterium is “pasteurella” which is 0.7μ and largest bacteria Beggiota is 15-22 μ in size.

Later on the basis of fermentation research activities a germ theory of disease was propounded by **Louis Pasteur**. Also in 1881 Robert Coach detected and separated bacteria, of anthrax and tuberculosis on the basis of artificial culturing.

- Bacterial cells have no chlorophyll, no mitochondria
- Respiratory activities are performed by the misosomes.
- All spores producing bacteria are **gram positive** and on colouration they become purple, while the **cellular walls of such bacteria are made of murine**.
- Louis Pasteur had invented the inoculation of the rabies and the pasteurization of the milk.

Pasteurization

Pasteurization is one of the methods of preservation of products such as milk, alcoholic beverages etc. at higher temperatures. Pasteurization is defined as the process of heating products to a particular temperature and holding it at that temperature for a particular time till the pathogenic (disease causing) micro-organisms are destroyed causing minimum change in composition, flavor and nutritive value of products such as milk.

- ✓ There are two methods of pasteurization (of milk) in general use. One is **low temperature holding (LTH)** method in which milk is heated to 62.8°C (145F) for 30 minutes in commercial pasteurizers (or) large closed vats which are heated by steam coils, hot water jackets etc.
- ✓ The other method (i.e.) **high temperature short time (HTST)** method in which the milk is heated to 71.7°C (161F) for 15 seconds.
- ✓ The heating is accomplished by electricity (or) hot water and requires a heat exchange system, which preheats raw, cold milk and cools the hot pasteurized milk.

Please note that Pasteurization conditions are not sufficient to destroy thermo-resistant spores (reproductive part of microorganisms). Thus, Pasteurization does not sterilize the products but kills only those organisms that grow most readily at low temperatures. The surviving organisms must be kept from multiplying by constant refrigeration.

General features, shape and structure

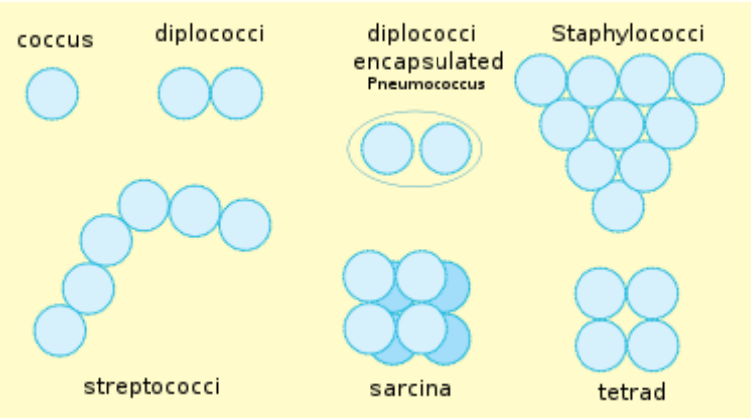
Bacteria are the monocellular microorganisms which are found in almost places in singleton form or in group. The cellular wall of the bacteria is thick and it is made from chitin, Murine etc.

Shapes

Coccus

These are spherical bacteria. They can be

- ✓ Monococcus: single spherical bacterium
- ✓ Diplococcus: Occurs always in pairs
- ✓ Streptococcus : chains of bacteria arranged in a single row
- ✓ Sarcina: Cocci which are arranged in cubes of 8.
- ✓ Staphylococcus: irregular shapes.

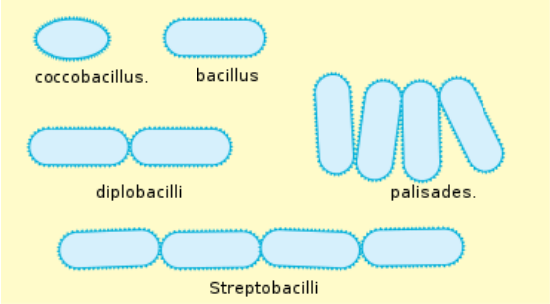


Bacillus:

These are rod shaped bacterium. They can be

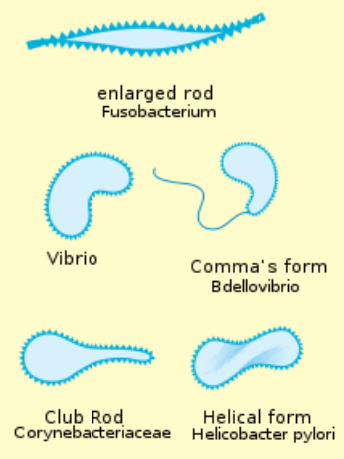
- ✓ Monobacillus: Single rod shaped bacterium

- ✓ Diplobacillus : Rod shaped bacteria arranged in pairs.
- ✓ Streptococcus: Chain of rod shaped bacteria



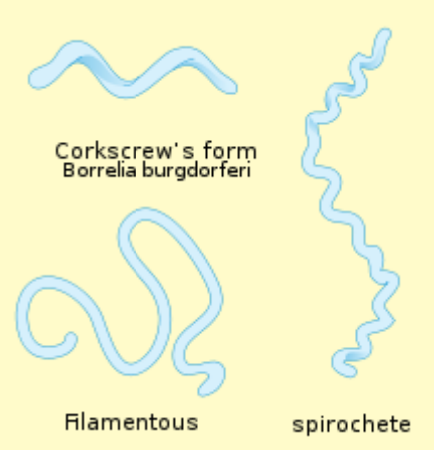
Vibrio:

These are coma shaped bacteria.



Spiriullum

These are cork screw shaped or helically coiled bacteria.



Bacteria are saprophytic or parasitic. There are three common bacterial bodies-spherical (coccus forms), rod-shaped or cylindrical (Spiriullum forms) and spiral or screw (Spiriullum). Some species of the bacteria are branched thread like bodies, live in liquids, and have long thread like shape called **flagella**. Cell

membrane is made from **protein and phospholipids**. Almost bacteria undergo the metabolic activities, like nutrition , reproduction etc.

Gram staining

Gram staining is the first stage in identification of the bacteria. It differentiates the bacteria on the basis of chemical properties of their Cell Wall. Hans Christian Gram was the inventor of Gram staining. Please note that NOT all bacteria can be classified by this technique and only those bacteria which can be classified by using this technique are called Gram variable. Otherwise they are called Gram indeterminate.

How does it work?

The staining distinct two types of bacteria viz. Gram positive and Gram negative denoted by G+ and G-. The primary stain used in the technique is crystal violet. Crystal violet is followed by use of a trapping agent (Gram Iodine) and after that alcohol is used to decolorize and finally Safranin / Basic fushcin is used to counter stain. The crystal violet gets dissociated in CV+ and Cl- ions in water and these ions penetrate the cell walls.

- ✓ The cell wall which is made up of Peptidoglycan as well as lipids gets violet due to the reaction of the CV+. After the decolorization with alcohol, the lipids gets dissolved and the bacteria with higher Peptidoglycan remain violet. These are called Gram Positive bacteria. The bacteria which lose the violet color are called Gram negative bacteria.

Properties of Gram negative bacteria:

- ✓ The cell wall is heterogeneous.
- ✓ Thickness of the wall is in the range of 10-15 nanometer
- ✓ The cell wall is 10-20% of the cell's dry weight
- ✓ Composition: Peptidoglycan (5-15%), Phospho –lipids 35% and proteins 15%. 50 % is lipopolysachharides.
- ✓ **Teichoic Acid , which provides the rigidity to the cell walls is absent** in gram negative bacteria.

Properties of Gram Positive Bacteria:

- ✓ Cell wall is homogenous.
- ✓ Thickness of the Cell wall is around 25-30 nanometer
- ✓ 20-40% of dry weight is made by Cell wall.
- ✓ 20 to 80% of the cell wall is made up of Peptidoglycan.
- ✓ The teichoic acid is present in the cell walls of Gram Positive bacteria.

Flagella of Bacteria:

The tail-like projection that protrudes from the cell body of certain prokaryotic and eukaryotic cells is Flagella. It helps in locomotion.

- ✓ If bacteria has no Flagella, then it is called atrichous
- ✓ If there is a single flagellum in the side of the cell wall, it is called Monotrichous.
- ✓ If a tuff of flagella is found attached to any side of the cell wall, it is Lophotrichous.
- ✓ If there wre two tuffs presents on either side of the cell, it is called Amphitrichous
- ✓ If many flagella are distributed on all sides of the bacteria cell wall, it is called Peritrichous.

Bacteria on the basis of Nutrition

- ✓ If the bacteria absorb the inorganic substances from the environment and convert them into organic substances there are called **autotrophic** bacteria. They are similar to the green plants.
- ✓ If they cannot use the CO_2 and meet their carbon requirements from the organic substances such as Glucose and amino acids, they are called **heterotrophic** bacteria.
- ✓ Some bacteria contain chlorophyll and obtain energy from the sunlight , they are called **Photoautotroph.** It includes the Purple sulphur and Green sulphur bacteria.

✓ Some of the bacteria such as Nonsulphur purple bacteria obtain energy from the sunlight but derive their Carbon requirement from the organic sources. So they are called **Photo-heterotrophs.**

✓ Some bacteria derive the carbon from the CO_2 but Energy from the oxidation of the inorganic substances. They are called **Chemo-autotrophs.**

✓ Some bacteria derive their carbon as well as Energy requirements form the organic substances such as Glucose and amino acids. They are called **Chemo heterotrophs**.

✓ Some bacteria grow on the dead and decaying material and they are called Saprophytes.

✓ The bacteria that grow on plants and animals are called parasitic bacteria.

✓ The bacteria which make mutually beneficial association are called symbioants.

Reproduction:

In bacteria reproduction takes place by two methods viz. Asexual and Sexual.

- ✓ **Asexual reproduction:** Reproduction in bacteria is largely asexual and the most of the bacteria reproduce by binary fission. This is a simple process of cell division, in which one bacterium splits into two new ones. Asexual reproduction in bacteria is done by **conidia and endospore**.
- ✓ **Sexual reproduction :** Some bacteria also exhibits the reproduction by sexual method and members of such bacterial species contain a **virus like agent called fertility or F factor**. Sexual reproduction is of three types-
  - o **Conjugation** : Two cells fuse and a transfer of DNA takes place called conjugation.
  - o **Transduction:** A virus replaces DNA of any bacterium and this replaced DNA is fused with DNA of another bacterium, called transduction.
  - o **Transformation:** Sexual reproduction through which genetic profile of the bacteria is changed by absorbing DNA from the external medium called transformation.

The Hydrogen bacteria and Sulfur bacteria

Hydrogen bacteria use Hydrogen and as source of energy. There are examples such as sulfate reducing and acetogenic bacteria which are commonly called **Hydrogen bacteria.** They have a membrane bound *Hydrogenase* which can oxidize the Hydrogen and convert it into various quinones and cytochromes.

Sulphur bacteria

Sulphur bacteria are capable of oxidation of the reduced Sulphur compounds such as Hydrogen Sulphide (H_2S), Inorganic Sulphur etc. They create Sulphuric Acid. Examples are *Beggiatoa* and *Paracoccus.*

Ferrous bacteria

Acidithiobacillus ferooxidans and *Leptospirrillum ferrooxidans* are example of such bacteria which use Ferrous Iron and oxidize them. Since Ferrous Iron is stable at a very low pH, these bacteria are essentially acidophilic.

Nitrification by Bacteria

This is the process in which the ammonia is converted into Nitrate. Nitrification is a two step process and based upon these two steps, the bacteria are divided into Nitrosifying and Nitrite-Oxidizing bacteria.

✓ Example of Nitrosifying bacteria is *Nitrosomonas,* which converts the Ammonia (NH_3) into Nitrite (NO_{2-}).

✓ Example of Nitrite-Oxidizing bacteria is Nitrobacter which are able to oxidize the Nitrite and crate Nitrate (N_{03}-).

Anammox

The above procedure simply uses Oxygen and thus they are aerobic nitrification. The phenomenon of Anammox was described in 1990s and it is **anaerobic nitrification of ammonia**.

✓ Anammox was not only demonstrated by the bacteria but also some fungi such as Planctomycetes (e.g. *Candidatus Brocadia anammoxidans*) are able to do so.

✓ The process is still under studies. It is said that the phenomena is widely present in the anaerobic aquatic systems. In 2006 a study was published titled "Global impact and application of the anaerobic ammonium-oxidizing (Anammox) bacteria" which says that this process could be source of production of 50% Nitrogen in the oceans. This process is being seen as a very handy tool in the **wastewater treatment**.

Biological Nitrogen Fixation

The Nitrogen Fixation is the procedure by which Nitrogen in the atmosphere is converted into ammonia. It can be biotic or abiotic. The examples of abiotic processes are lightening, Industrial processes such as Haber-Bosch Process, and combustion. The biotic nitrogen fixation was discovered by **Martinus Beijerinck.**

The Nitrogen fixation is one of the important components of the Nitrogen cycle

How does it work?

Two molecules of ammonia are produced from one molecule of nitrogen gas, at the expense of 16 units of ATP and a supply of electrons and protons (hydrogen ions):

$$N_2 + 8H+ + 8e- + 16\ ATP = 2NH_3 + H2 + 16ADP + 16\ Pi$$

Please note that **exclusively the prokaryotes do this reaction**. The enzyme used is called **nitrogenase**. The nitrogenase enzyme has two kinds of proteins viz. **Iron Protein, and Iron-Molybdenum protein.**

1. The N2 is is bound to the nitrogenase enzyme complex.
2. The Fe protein is first reduced by electrons donated by ferredoxin.
3. Then the reduced Fe protein binds ATP and reduces the molybdenum-iron protein, which donates electrons to N2, producing HN=NH.
4. There are two more cycles and each requires electrons donated by ferredoxin) HN=NH is reduced to H2N-NH2, and this in turn is reduced to 2**NH_3** .

Thus in summary:

✍ 16 ATP are used in BNF (Biological Nitrogen Fixation)
✍ Two minerals viz. **Iron and Molybdenum** play important role in BNF.
✍ End product is ammonia **+ Hydrogen**
✍ Enzyme used is Nitrogenase
✍ Please note that BNF can be done by both **anaerobic bacteria as well as the aerobic bacteria** but the process occurs **in absence of Oxygen** and **thus is anaerobic process**. The enzyme nitrogenase is susceptible to destruction by oxygen. Many bacteria cease production of the enzyme in the presence of oxygen that is why many nitrogen-fixing organisms exist only in anaerobic conditions.
✍ Some aerobic bacteria which carry out the Nitrogen Fixation use another protein called **Leghemoglobin** to bind the oxygen and bring its level down.
✍ Further, it is not necessary that ONLY symbiotic bacteria are able to fix nitrogen by BNF.

✍ It is also NOT necessary that only leguminous plants do this.

The examples of all kinds of bacteria that are able to fix nitrogen are shown below:

Examples of nitrogen-fixing bacteria			
Free living		**Symbiotic with plants**	
Aerobic	**Anaerobic**	**Legumes**	**Other plants**
Azotobacter *Beijerinckia*	*Clostridium* *Desulfovibrio* Purple sulphur bacteria Purple non-sulphur bacteria Green sulphur bacteria*	*Rhizobium*	*Frankia* *Azospirillum*

Legume Plants

Plants that contribute to nitrogen fixation include the legume family – Fabaceae – with taxa such as clover, soybeans, alfalfa, lupines, peanuts, and rooibos. They contain symbiotic bacteria called **Rhizobia** within nodules in their root systems, producing nitrogen compounds that help the plant to grow and compete with other plants.

✍ The fixed nitrogen is released only when the plant dies. This helps to fertilize the soil.

Economic utilities of the bacteria

Based on economic utilities, bacteria can be divided into two categories viz. Useful and Harmful.

Useful bacteria

Bacteria in Dairy

Lactobacillus are found in the milk which through the process of fermentation (anaerobic respiration) with lactose of the milk form lactic acid and that's why milk becomes sour. In the milk a protein namely casein is found and with these protein bacteria of lactic acid transforms the milk into the curd (dahi). The bacteria used in dairy industry are *Streptococcus lactis, Leuconostoc cremoris, Megatherium* etc.

The bacteria such as *Streptococcus lactis, Leuconostoc cremoris, Lactobacillus bulgaricus* are useful in the Dairy Industry.

Some as *Lactobacillus, Acetobacter,* etc are bacteria which work as **Fermentation starter** in making of Cheese. The other Fermentation starters are fungi (yeasts and molds) such as Rhizopus, Aspergillus, Mucor, Amylomyces, Endomycopsis, Saccharomyces, Hansenula anomala. These bacteria (and the enzymes they produce) also play a large role in the eventual **flavor of aged cheeses**. Most cheeses are made with starter bacteria from the *Lactococci, Lactobacilli, or Streptococci* families.

Why there are holes in Emmental cheese?

Emmental cheese is also known as **Swiss Cheese**, and is a cheese from Switzerland. It is unique because of the characteristic large holes in it as shown in this pic. These holes are due to a bacteria called *Propionibacterium freudenreichii*, which consumes the lactic acid excreted by the other bacteria, and **releases carbon dioxide gas**. The Gas is trapped and is not able to get released thus forming the bubbles that make holes.

Bacteria in Industries

- The *Bacillus megatherium* bacterium is used in the Flavoring of Tea and Tobacco.
- *Acetobacter aceti* is used in preparation of vinegar from Alcohol
- Clostridium acetobutylicum is able to produce acetone from acetic acid as well as butanol from butyric acid.
- In Biogas plants, the bacterium called *Methanobecterium* is used for production of Methane.
- Bacteria work as natural scavangers as they are able to decay huge amount of plan, animal and human waste.
- Bacteria are useful in the Fibre ratting in which the fibres of Jute, hemp and Flax are prepared. Clostridium butyricum is used in the process and these bacteria hydrolyze the middle lamella of these plant fibres.

Antibiotics

Many antibiotics are used from bacteria. Some of them are Bacitracin, Polymyxin B, Streptomycine, Erythromycine, neomycin-B, Chloramophenicol etc.

Soil formation & Fertility

As soon as a fresh rock is exposed to a biological environment certain organisms, notably the bacteria take possession of it. There is an instance of increased production of organic matter and it results in the aumumention of formation of soil contents.

There are many bacteria which decompose the rotten substances like dung, dead residues of animals etc. Some bacteria enhance the fertility of the soil by means of denitrification specially of plants *Rhizobium* bacteria are found in the roots of the plants which nitrified (transformed) atmospheric nitrogen into the nitrates. Such nitrates act like fertilizers and along with the growth of the plants fertility of the soil is also enhanced.

Other Applications

1. Similarly vinegar is prepared by the decomposition of sugar solution through *Acetobacter aceti* bacteria.
2. Bacteria, often *Lactobacillus* in combination with yeasts and molds, have been used for thousands of years in the preparation of fermented foods such as cheese, pickles, soy sauce, sauerkraut, vinegar, wine, and yogurt.
3. Microbial mining, which is the bacteria and other microorganisms are cultured in container and then used to bring these processes e.g., copper extraction, iron extraction; which involves bacteria called Ferro-oxidans.
4. Using biotechnology techniques, bacteria can also be bioengineered for the production of therapeutic proteins, such as insulin, growth factors or antibodies.
5. Some bacteria living in the gut of cattle, horses and other herbivores secrete ***cellulase***, an enzyme that helps in the digestion of the cellulose contents of plant cell walls. Cellulose is the major source of energy for these animals. generally plant cells contain cellulose.the bacteria present in the stomach of cattle will help in the digestion of cellulose.

6. *Escherichia coli* that lives in the human large intestine synthesize vitamin B and release it for human use. Similarly, *Clostridium butyclicum* is used for commercial preparation of riboflavin, and vitamin B.
7. *Bacillus thuringiensis* (also called BT), a Gram-positive, soil dwelling bacterium is used for Pest Control. This bacterium is used as a Lepidopteran-specific insecticide under trade names such as Dipel and **Thuricide**. Because of their specificity, these pesticides are regarded as environmentally friendly, with little or no effect on humans, wildlife, pollinators, and most other beneficial insects.
8. **Bioremediation techniques such as Oil zapper use bacteria.**
9. *Bacillus megatherium* is used in flavoring of tea and tobacco.
10. *Clostridium acetobutylicum* can produce acetone from acetic acid and butanol from butyric acid.
11. In Biogas plants, the Methanobacterium produces methane.
12. Bacteria are used in retting of Flax, Jute and Hemp.
13. Bacteria work as natural scavengers.
14. Some antibiotics (medicines) are also prepared by the various bacteria as below :

Antibiotics (medicines)	Bacteria
Streptomycin	*Streptococcus groseis*
Chloromycetin	*S.Venzualae*
Teramcyin	*S.Rimosus*
Nystatin	*S.Noursei*
Erythromycin	*S.Erythreus*
Tyrothrycin-A	*Bacillus brevis*
Polymyxin-B	*Bacillus polymixa*
Bacitracin	*B.Subtilis, Bacillus Licheniformis*

Harmful Bacteria

Some bacteria decompose (denitrify) the chemical compounds like nitrate, nitrite and some others ammonium compounds into the free nitrogen. The bacteria like bacillus, thiobacillus, micrococcus etc are the examples of such bacteria. Also some bacteria like *Clostridium botutinium* etc are directly respondent for the food poisoning.

Plant disease

Diseases	Pathogens bacteria
Potato wilt	*Pseudomonas solanacearum*
Blight of rice	*Xanthomonas orzae*
Citrus canker	*Xanthomonas citri*
Bean blight	*Xanthomonas phaseoli*
Potato scab	*Streptomyces scabies*
Black arm of cotton	*Xanthomonas malvacearum*
Fire flight of apple	*Agrobacterium tumefacines*

Human disease

Disease	Pathogens bacteria
Leprosy	*Mycobacterium leprae, Corynobacterium diphtheriae*
Pneumonia	*Diplococcus pneumonia*
Cholera	*Vibrio cholera*
Typhoid	*Eberthalla typhosa*
Dysentery	*Shiquella dysenteriae*
Tetanus	*Clostridium tetani*
Tuberculosis	*Mycobacterium tuberculosis*
Whooping	*Hemophilous*
Cough	*Pertusis*
Plague	*Pasteurella pestis*

Gonorrhea	*Gonoccus*
Syphilis	*Treponema pallidium*

Animal diseases

Diseases	Pathogens bacteria
Black leg of animals anthrax of sheep	*Clostridium chauvei, Bacillus anthracis*

Human Diseases and bacteria:

Diarrhoea

- Diarrhea can be caused by all sorts of parasites such as viruses, Bacteria, protozoa and others.
- Most common virus causing Diarrhoea in adults is **Norovirus.**
- Most common virus causing Diarrhoea in children below 5 years **is rotavirus.** A *rotavirus vaccine* has the potential to decrease rates of diarrhea, and is under studies.
- Most common bacteria causing Diarrhoea is *campylobacter*, others are *salmonellae, shigellae and some strains of Escherichia coli (E.coli)*.

Dysentery

Dysentery is usually caused by a **bacterial or protozoan** infection or infestation of parasitic worms, but can also be caused by a chemical irritant or **viral infection**. The most common cause of the disease in developed countries is infection with a bacillus of the *Shigella* group (causing bacillary dysentery). Infection with the amoeba *Entamoeba histolytica* can cause amoebic dysentery

Typhoid

Typhoid is transmitted by the ingestion of food or water contaminated with the feces of an infected person, which contain the bacterium *Salmonella enterica enterica*. The bacteria perforates through the intestinal wall and are phagocytosed by macrophages. It ia a G- short bacillus that is motile due to its peritrichous flagella.

Whooping Cough

Pertussis or Whooping cough is a highly contagious bacterial disease caused by Bordetella Pertussis.

Tuberculosis

Tuberculosis is caused by various strains of **mycobacterium**, usually *Mycobacterium tuberculosis*. It usually attacks the lungs but can also affect other parts of the body. It is spread through the air when people who have active MTB infection cough, sneeze, or spit In most cases the disease is asymptomatic, latent infection, and about 10% latent infections eventually progresses to active disease. If untreated, it killed 50% of its victims.

- One third of the world's population is thought to be infected with M. tuberculosis, and every second a new infection occurs.
- About 80% of the population in many Asian and African countries test positive in tuberculin tests.
- An estimated 1.7 million people died from TB in 2009. The highest number of deaths was in the Africa Region.

HIV and TB

HIV and TB form a lethal combination, each speeding the other's progress. TB is a leading cause of death among people who are HIV-positive. In Africa, HIV is the single most important factor contributing to the increase in the incidence of TB since 1990.

Drug resistant TB

Until 50 years ago, there were no medicines to cure TB. Now, strains that are resistant to a single drug have been documented in every country surveyed; what is more, strains of TB resistant to all major anti-TB drugs have emerged. Drug-resistant TB is caused by inconsistent or partial treatment, when patients do not take all their medicines regularly for the required period because they start to feel better, because doctors and health workers prescribe the wrong treatment regimens, or because the drug supply is unreliable. A particularly dangerous form of drug-resistant TB is multidrug-resistant TB (MDR-TB), which is defined as the disease caused by TB bacilli resistant to at least isoniazid and rifampicin, the two most powerful anti-TB drugs. Rates of MDR-TB are high in some countries, especially in the former Soviet Union, and threaten TB control efforts. (WHO website).

Stop TB Strategy of WHO

In 2006, WHO had launched the new Stop TB Strategy. The heart of this strategy is **DOTS**, the TB control approach launched by WHO in 1995. Since its launch, 41 million patients have been treated under DOTS-based services. The new six-point strategy builds on this success, while recognizing the key challenges of TB/HIV and MDR-TB. It also responds to access, equity and quality constraints, and adopts evidence-based innovations in engaging with private health-care providers, empowering affected people and communities, to help strengthen health systems and promote research.

The six components of the Stop TB Strategy are:

1. High quality DOTS expansion to even the remotest areas.
2. Addressing TB/HIV, MDR-TB and the needs of poor and vulnerable populations.
3. National TB control programmes must contribute to overall strategies to advance financing, planning, management, information and supply systems and innovative service delivery scale-up.
4. Engage all care providers. TB patients seek care from a wide array of public, private, corporate and voluntary health-care providers. To be able to reach all patients and ensure that they receive high-quality care, all types of health-care providers need to be engaged.
5. Empower people with TB, and communities through partnership via Community TB care projects.
6. Enable and promote research. While current tools can control TB, improved practices and elimination will depend on new diagnostics, drugs and vaccines.

BCG Vaccine

Tuberculosis was declared a global emergency by the WHO in 1993. Control of this disease relies upon prevention through **Bacillus Calmette-Guérin** (BCG) vaccination or "preventive therapy" (chemoprophylaxis), and the ascertainment and treatment of cases, in particular employing the "**directly observed therapy - short course**" (DOTS) approach.

BCG, or Bacille Calmette-Guérin, used for vaccination of infants in 192 countries. But not widely used in the United States, because TB is uncommon in US. BCG was the first vaccine for TB that was discovered after 1905, when Albert Calmette and Camille Guérin worked at the Institut Pasteur de Lille and the Pasteur Institute in France developing BCG, administering the first human trials in 1921.

- Original BCG vaccine was derived from an isolate of *M. bovis* at the Institut Pasteur in Lille.
- *M bovis* ,that has lost its virulence in humans by being specially cultured in an artificial medium for years is still used for producing BCG Vaccine. However, please note that BCG does not always protect against people from getting TB. At best, the BCG vaccine is 80% effective in preventing tuberculosis for a duration of 15 years.

Why BCG shows variable efficacy?

This is the most controversial issue of the BCG administration. It has been shown that the BCG shows variable efficacy, which depends upon geography. The studies have almost concluded that the efficacy of BCG appears to fall the closer one gets to the equator.

Many hypothesis have been postulated so far. One such theory says that in areas where there is high levels of background exposure to tuberculosis, every susceptible individual is already exposed to TB prior to BCG, that is why the natural immunizing effect of background tuberculosis duplicates any benefit of BCG. This means that BCG is less effective in the area where the Mycobacteria is less prevalent. One document of WHO says that in South Africa, the country with the highest prevalence of TB, BCG is given to all children under age three,. but since BCG is less effective in areas where mycobacterium are less prevalent; it is not given to the entire population in these countries. In United States, BCG vaccine is not recommended except for people who meet specific criteria.

Another theory says that Variable efficacy is because of the Genetic variation in BCG strains . In this context, a WHO document says that a so-called RD-2 region, which encodes the **mpt-64 gene**, is present in the "primitive" BCG strains but is absent from those sub-strains derived from the original BCG Pasteur strain after 1925. However, full details are unavailable.

World Tuberculosis Day

World Tuberculosis Day is observed on 24th March every year.

TB and India

Tuberculosis in India takes a toll of 1,000 per day or one every minute. It is estimated that there are 14 million TB cases in our country out of which 3.5 million are sputum positive. About 1 million sputum cases are added every year. (the data are bit old, but nothing seems to have changed in last few years).

National Tuberculosis Control Programme

National Tuberculosis Control Programme was started in 1962 on a 50:50 sharing basis between Centre and State. The objectives of the Programme were to reduce the morbidity and mortality; to reduce disease transmission and to diagnose as many cases of tuberculosis as possible and to provide free treatment. The programme was a flop show mainly due to incomplete treatment as treatment completion rate was less than 40 per cent along with some other causes such as inadequate budget; shortage of drugs; emphasis on x-ray diagnosis; poor quality sputum microscopy and multiplicity of treatment regimens.

Revised National TB Control Programme

The National TB Control Programme was later expanded to cover additional 100 million population in 100 districts/reporting units. For the first time in India, a web-based resource centre was developed for preparing TB communication materials. The heart of this programme is DOTS and that is why DOTS is known as the Revised National TB control programme (RNTCP) in India.

DOTS

DOTS, is an acronym for Directly Observed Treatment, Short course. The DOTS strategy represents the most important public health breakthrough of the decade, in terms of lives which will be saved. It is based largely on research done in India in the field of TB over the past 35 years. As it is the only strategy effective in controlling TB on a mass basis, nearly 100 countries are following it.

DOTS has five components:

1. Government commitment (including both political will at all levels, and establishing a centralized and prioritized system of TB monitoring, recording and training)
2. Case detection by sputum smear microscopy
3. Standardized treatment regimen directly observed by a healthcare worker or community health worker for at least the first two months
4. A regular drug supply
5. A standardized recording and reporting system that allows assessment of treatment results

- ✓ The technical strategy for DOTS was developed by Dr. Karel Styblo in the 1980s primarily in Tanzania.
- ✓ In 1989, the World Health Organization and the World Bank began investigating the potential expansion of this strategy. In July 1990, the World Bank, under Richard Bumgarner's direction, invited Dr. Styblo and WHO to design a TB control project for China. By the end of 1991, this pilot project was achieving phenomenal results, more than doubling cure rates among TB patients. China soon extended this project to cover half the country.
- ✓ In India, Government had adopted the revised strategy for TB in the form of DOTS.
- ✓ Since 1993, DOTS has been pilot tested in 20 sites in India as RNTCP.
- ✓ In RNTCP the proportion of TB cases confirmed in the laboratory is double that of the previous programme, and the cure rate is nearly triple that of the previous programme. The operational feasibility of DOTS in the Indian context has been demonstrated, with 8 out of 10 patients treated in the programme being cured as compared to three out of 10 under the previous regime.

DOTS has also been shown to prevent the emergence of multi-drug resistant tuberculosis (MDRTB) and to reverse the trend of MDRTB in communities in which it has emerged. Also DOTS can cure TB even in HIV-positive patients. Entire country has been covered under DOTS Strategy by March 2006. The international Joint Monitoring Mission (JMM) in October 2006, has hailed it as the fastest expansion of DOTS in the world.

Isoniazid

Isoniazid / Laniazid or Nydrazid) is the classic antituberculosis medication, first discovered in 1912. It was found to be effective against tuberculosis in 1950s. However, Isoniazid is never used on its own to treat active tuberculosis because resistance quickly develops.

Rifampicin

Rifampicin is a bacteriocidal antibiotic drug. It has been used for TB along with isoniazid, ethambutol, pyrazinamide and streptomycin etc.

MDR-TB

TB that is resistant at least to isoniazid and rifampicin the two most powerful first-line anti-TB drugs is called the Multi-drug-resistant tuberculosis (MDR-TB). It develops because the when the course of

antibiotics is interrupted and the levels of drug in the body are insufficient to kill 100% of bacteria. This means that even if the patient forgets to take medicine, there are chances of developing MDR-TB.

MDR-TB is treated with secondline of antituberculosis drugs such as a combination of several medicines called **SHREZ** (Streptomycin+isonicotinyl Hydrazine+Rifampicin+Ethambutol+pyraZinamide)+MXF+cycloserine.

XDR-TB

When the rate of multidrug resistance in a particular area becomes very high, the control of tuberculosis becomes very difficult. This gives rise to a more serious problem of extensively drug-resistant tuberculosis (XDR-TB). XDR-TB is caused by strains of the disease resistant to both first- and second-line antibiotics. This confirms the urgent need to strengthen TB control.

Thus, Extensively-drug resistant TB (XDR-TB) is a sub-set of MDR-TB which is further resistant to at least two more drugs which are second line drugs and is thus virtually incurable. XDR TB was first described in March 2006 following a joint survey of laboratories by the WHO, IUATLD, and CDC, Atlanta.

Leprosy

Leprosy or Hansen's disease is caused by the bacteria Mycobacterium leprae and Mycobacterium lepromatosis. Leprosy has affected humanity for over 4,000 years and was well-recognized in the ancient China, Egypt, and India. The primary symptom is skin lesions and if left uncured , it can be progressive, causing permanent damage to the skin, nerves, limbs and eyes.

✓ BCG helps against Leprosy also.

Leprosy has a high degree of stigma attached to it because of the fact that there was no cure for the disease till the eighties and also due to disfigurement caused by the disease. Human Rights Council had adopted the Resolution 8/13 – "Elimination of discrimination against persons affected by leprosy and their family members", as proposed by the Japanese Government.

Treatment of Leprosy

Some drugs such as rifampicin, clofazimine, and dapsone are used to treat Leprosy. In 1993, the WHO had recommended two types of standard MDT regimen be adopted. One was a 24-month treatment for multibacillary (MB or lepromatous) cases using rifampicin, clofazimine, and dapsone. Another was a six-month treatment for paucibacillary (PB or tuberculoid) cases, using rifampicin and dapsone.

India and leprosy

In 2007, India was contributing to about 54% of new cases detected globally during the year 2007, and this trend was supposed to continue for some more years. The National Leprosy Control Programme was launched by the Government of India in 1955. Multi Drug Therapy came into wide use from 1982 and the National Leprosy Eradication Programme was launched in 1983. Since then, remarkable progress has been achieved in reducing the disease burden. India achieved the goal of elimination of leprosy as a public health problem, defined as less than 1 case per 10,000 population, at the National level in the month of December 2005 as set by the National Health Policy, 2002. Here is the current position : (*Source Ministry of Health, data is of January 2009)*

- ✓ 29 states/UTs have achieved leprosy elimination status
- ✓ 6 States/UTs viz. Bihar, Chhattisgarh, West Bengal, Jharkhand, Chandigarh and D&N Haveli are yet to achieve elimination.

- ✓ With 87,206 leprosy cases on record at end of March 2008, the prevalence rate was 0.74/10,000 population.
- ✓ During 2007-08, a total of 1.38 lakhs new leprosy cases were detected giving Annual New Case Detection Rate of 11.70 per lakh population. All the newly detected cases were put under treatment.
- ✓ During 2008-09 (upto November 2008), 94,794 new leprosy cases were detected and put under treatment.
- ✓ 1353 reconstructive operations were performed for correction of disability among leprosy affected persons during April to November 2008.
- ✓ Out of 85,176 cases discharged during April to November 2008, 78808 cases (92.5%) were released as cured after completing treatment.

Diphtheria

Diphtheria is caused by *Corynebacterium diphtheriae,* an anaerobic Gram-positive bacterium. It is an acute respiratory disease caused by bacteria , which leads to a thick coating in the nose, throat or airway. Diphtheria takes its name from Greek word 'dipthera' referring to the leathery membrane or coating that grows on the tonsils, throat and in the nose.

As per the WHO records from the World Health Statistics 2010 from 193 Member States India 's reported cases at of 2009 at 6081 are the highest in the world. I have retreieved the table from the WHO book which shows the number of reported cases in 2008 & 9.

Member State	Number of reported cases							
	Cholera[a]	Diphtheria[b]	H5N1 influenza[c]	Japanese encephalitis[b]	Leprosy[d]	Malaria[e]	Measles[b]	Meningitis[f]
	2008		2009	2008				2009
India	2 680	6 081	…	294	134 184	95 734 579	48 181	…

The total number of cases reported in the country steeply rising from 2834 in 2006, to 3354 in 2007, and almost doubling to 6081 (with 2139 cases from Karnataka) in 2008.

This is not a case of India only. Actually, Diphtheria which was controlled earlier has been now entered by the **Guinness Book of World Records as most resurgent disease.**

Diphtheria and vaccination

Diphtheria is a purely vaccine-preventable disease and effective vaccine is available. But national immunization coverage of triple antigen DPT (Diphtheria, Pertussis, Tetanus) is only 50 to 60 per cent (as published in Hindustan Times, May 22, 2009). It should be 100 per cent otherwise there are chances of the disease eradication being less. In India, the DPT vaccine comes under the Universal Immunization Programme (UIP). Under UIP, following six vaccines are provided free to all children including new borne:-

1. DPT (Diphtheria-Pertusis-Tetanus)
2. OPV/Oral Polio Vaccine
3. Measles
4. BCG (Bacillus Calmette-Guerin)
5. Hepatitis B (In selected States and selected cities)
6. Japanese Encephalitis (In selected areas

So, the mortality can be prevented by hundred percent immunization and early diagnosis and treatment.

Meningitis

Meningitis is a bacterial disease caused by *Neisseria* species.

Cholera

Cholera is an infection of the small intestine that is caused by the bacterium Vibrio cholerae. The main symptoms are profuse watery diarrhea and vomiting. In later half of 2010, 41 deaths in Rayagada district and 8 deaths in Kalahandi district occured due to acute diarrhoeal diseases in Orissa.It was concluded a cholera outbreak. Similarly, After the 2010 Earthquake in Haiti, Cholera had again spread recently in Haiti. The pandemic probably spread from the water of the Artibonite river, Haiti. More than 2000 people have killed in Haiti in the latest Outbreak of Cholera as per the reports published in newspapers. A new kind of strain of the Cholera bacteria Vibrio Cholerae known as El Tor was making news in this context. El Tor is known as V. cholera biotype eltor. It is differentiated from the classic strain on the genetic level and known to produce the Hemolysins. It was first found in 1905 in El Tor in Egypt. In early 1900s 6 major Cholera pandemics had spread the word. The 7th outbreak was caused by this new strain in 1961 in Indonesia. It spread rapidly elsewhere.

Questions and 2-Markers on Bacteria

Why Curd is easy to digest than Milk?

Curd is made by mixing a few spoonfuls of commercial yoghurt made with live cultures of bacteria into pasteurised milk. A mixed culture of *Lactobacilus bulgaricus* and *Streptococcus thermophilus* consumes the milk sugar or lactose for energy and excretes lactic acid which curdles the milk. Curds retain the fat, mineral and vitamin content of milk, but have only one-third to two-thirds the amount of lactose. Curds are, therefore, more digestible than milk for lactose intolerant people.

Gene Chip

Gene Chip is a diagnostic tool that can immediately identify the exact type of infectious disease a person is afflicted with, such as malaria, influenza, ebola or any other type of bacterial infection. It does so using tissue, blood, urine and stool samples. The gene chip is essentially a *glass slide with several rows of DNA and RNA samples from about 30,000 types of viruses, bacteria, fungi and parasites*. When the tissue or fluid sample is applied on the side, it would stick to the genetic material that is closely related to it.

Gnotobiology

Gnotobiology is the science of study of animals or other organisms raised in environments free of germs or those which contain only specifically known germs. Scientists compare gnotobiotic animals with ordinary animals whose bodies carry many germs, like bacteria, viruses and parasites. In this way, scientists can determine more precisely how specific germs affect a body.

Probiotic

A microbe that **protects its host and prevents disease is called Probiotic.** The best-known Probiotic is *Lactobacillus acidophilus*, found in yogurt, and other dairy supplements. Probiotic counter the destruction of helpful intestinal bacteria by antibiotics. They are useful in preventing antibiotic-associated diarrhea. Billions of bacteria inhabit the digestive system. These bacteria, also referred to as **'gut flora'**, are required to break down food remains that have not been digested and to discourage harmful bacteria and yeasts from invading the body. The gut flora consists of as many as 400

species of bacteria. Many produce vitamins and fatty acids and provide nutrients to the body. They maintain low pH level in the large intestine. Ayurveda has been using this concept for centuries.

QWERTY tummy & Delhi Belly

Qwerty tummy and Delhi Belly are alike. It is Enterotoxigenic ***Escherichia coli*** which causes a Traveler's diarrhea known as **Delhi Belly**.

Similarly, a bad tummy brought on by the use of a filthy computer keyboard is called QWERTY tummy. Some studies say that a keyboard has five times more bacteria than a toilet seat. The keyboard user could inadvertently put a finger in the mouth and suffer acute food poisoning. It all starts when people eat while working, leaving crumbs on the keyboard, which attract mice. Then there are others who don't wash their hands after using the restroom.

Pleasant smell of the earth after the first shower

Pleasant smell of the earth after the first shower (earthy odour) is caused by the production of a series of streptomycete metabolites called geosmins.

These substances are sesquiterpenoid compounds and unsaturated compound of carbon, oxygen and hydrogen. The geosmins first discovered has the chemical name trans-1, 10-dimethyl-trans-9-decalol; however, other volatile products produced by certain species of Streptomyces may also be responsible for the characteristic smell.

Oil Zapper

'Oilzapper' technology has been developed by ONGC-Teri Biotech Ltd (OTBL), a joint venture between Oil and Natural Gas Corporation Ltd and The Energy and Resources Institute. In OTBL, Teri has 47 per cent equity, while ONGC has 49 per cent. The remaining 2 per cent is with financial institutions.

Oilzapper is a microbial product wherein microbes that feed on oil are created. This technology was first used by OTBL in Mehsana in Gujarat to eliminate an oil spill and manage the sludge created from the first oil well in the region. The water became clean and subsequently a home to a variety of birds. The company has bid in past (2009) for cleaning the huge oil spill left over from the Gulf War in 1991 in Kuwait. Same technology made news again as TERI carried out the bioremediation process by using the 'oilzapper' technology at the Awas beach at Alibaug, in 2010, in the wake of oil contamination by MS Chitra Oil Spill in Mumbai.

AMR

AMR (Antimicrobial Resistance) is the ability of micro-organisms (mostly bacteria) to find ways to evade the action of the drugs used to cure the infections they cause. It has become a global public health concern in recent years. The bacteria develop the mechanism which makes them resistant to the antibiotics which are normally used for their treatment.

New Delhi metallo-beta-lactamase (NDM)

On August 11, 2010, an article "Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study" was published in by Kumarasamy et. al. (2010) in the "The Lancet", a medical journal. This article reported about "New Delhi metallo-beta-lactamase" a new kind of enzyme that makes bacteria resistant to broad range of beta-lactam antibiotics. The Bacteria which carry genes related to this NDM are often referred to in the news media as "superbugs", since infections with these bacteria are hard to treat successfully.

The report said :

"Gram-negative Enterobacteriaceae with resistance to carbapenem conferred by New Delhi metallo-β-lactamase 1 (NDM-1) are potentially a major global health problem. We investigated the prevalence of NDM-1, in multidrug-resistant Enterobacteriaceae in India, Pakistan, and the UK"

This publication reports the presence of a plasmid associated with drug resistance to several antibiotics including third generation cephalosporins in gram-negative bacteria. While the title and the contents broadly describe the antibiotics resistance profile of gram negative bacteria and its mechanism due to New Delhi metallo-b lactamase (NDM-1) gene in the plasmid, the conclusions are based

upon the inference drawn that these resistance genes/organism possibly originated in India and it may not be safe for the UK patients to opt for surgery in India.

Fungi

The fungi are among the most primitive members of the plant kingdom. Study of the fungi is called **mycology**.

- The fungi are non-chlorophylous, nucleated, non-vascular, thallophytic micro organism and due to lack of chlorophyll they do not prepare their own food.
- The fungi are among the thallophytes or plants with a thallus, which are simple plants, have no roots, stems, flowers and seeds- structures we commonly associate with higher plants.
- The thallus of a fungus is usually made of branching threads called **hyphae.**

Nutrition in Fungi

Fungi lack chlorophyll and cannot prepare their own food and depend on other organism for nourishment. On the basis of nourishment the fungi are of three types –

1. **Saprophytes:** The fungi which obtain their food or do nutrition from decayed moist leaves, moist dead wood or by some other useless rotten residues or organic substances. The fungi like *Rhizopus*, *Penicillium* etc are saprophytes.
2. **Parasites :** The fungi which obtain their food by taking or sharing the food of any other organisms. The fungi like *Ustilago, Puccinia* etc that are harmful parasites.
3. **Symbiotic:** The fungi, which coexist with other plants and facilitate water and mineral salt and plants prepare food for them. The microbe lichen is the best example of symobiotic fungus.

Reproduction in Fungi

Almost fungi are reproduced by two different ways- sexually and a sexually. The mycelium of many species produces both asexual spores and sexual structures.

Along with certain heterotrophic bacteria, the fungi are the major decomposers and their activities are essential for the recycling of inorganic resources in the biosphere. Some parasitic forms fungi cause diseases in plants and animals.

Economic utilities of Fungi

Useful Fungi

1. **Soil Fertility:** The fungi decompose moist residues of leaves, dead wood, animal along dung and other rotten organic substances into another, which act like manures, and thus soil becomes more fertile.
2. **Food:** There are various fungi which are used as food. ***Agaricus*** and *Morchella* are used in the forms of vegetables (mushrooms) fungi. *Aspergillus, penicillium* are used in cheese industry, yeast a (a type of fungi) like *Saccharomyces cervisiae* is used in making double roti (bread dough). Wines, beers are also prepared by the alcoholic fermentations of the yeasts.
3. **Nitrogen fixation :** The fungi like *Rodoturela* does the process of nitrogen fixation due to which the fertility of the soil is enhanced.
4. **Medicines :** In the fungi there are various types of antibiotics which are utilized in making medicines like *chloromycetin, neomycin, streptomycin, teramycin* etc.

5. **Chemical Industry:** Various types of acids and chemical substances are prepared. *Aspergillus gallomyces* and *Pencillium glaucum* are used in the Gallic acid. Similarly Gluconic acid and Fumeric acid are prepared by the fungi *Aspergillus niger* and *Rhizopus nigricans* respectively.
6. **Enzymes:** By the fungi and some yeast, various types of enzymes are prepared. The enzymes amylase is prepared from *Aspergillus orizae*. Similarly, invertase is prepared by yeasts.
7. **V**itamins : Various vitamins like vitamin B is prepared from *Streptomyces griseus*.
8. Bioremediation by means of Fungi is called **Mycoremediation**. Fungi have been shown to biomineralize uranium oxides, suggesting they may have application in the bioremediation of radioactively polluted sites. Some fungi are hyperaccumulators, capable of absorbing and concentrating heavy metals in the mushroom fruit bodies.
9. *Beauveria bassiana*, *Metarhizium spp, Hirsutella spp*, *Paecilomyces (Isaria) spp*, and *Lecanicillium lecanii* have been used in **Pest Control**
10. ***One gene-one enzyme hypothesis*** was formulated by scientists who used the bread mold Neurospora crassa to test their biochemical theories.
11. Aspergillus nidulans and the yeasts, Saccaromyces cerevisiae and Schizosaccharomyces pombe, have a long history of use to investigate issues in eukaryotic cell biology and genetics, such as cell cycle regulation, chromatin structure, and gene regulation.

Harmful fungi

The fungi act as disease causal organisms for the various plants animals and human beings.

Disease in plants

Disease (plants)	Causal organisms (fungals)
Wart disease of potato	*Synchytrium endobioticum*
Late blight of potato	*Phytophythora infestans*
Green ear disease of bajra	*Sclerospora gramicola*
Rust of wheat	*Puccinia graminis tritici*
Loose smut of wheat	*Ustilogo nuda tritici*
Tikka disease of groundnut	*Corcospora personata*
Red rot of sugarcane	*Collectotrichurn falcatum*
Brown leaf spot of rice	*Helmin thosporium oryzea*
Ergot disease of rye	*Cleviceps purpurea*
Powdery mildew of wheat	*Erysiphe graminis tritici*

Disease in human beings

Diseases	Casual organism (fungus
Athlete's foot scabies	*Taenia pedis*
Scabies	*Acarus scabies*
Ring worm	*Trichophyton*
Meningitis	*Cryptococcus neoformans*
Asthma	*Aspergillus fumigates*
Baldness	*Taenia capitis*
Aspergillosis	*Aspergillus fumigatus*

Lichens

Lichens are composite organisms consisting of a symbiotic association of a fungus (the mycobiont) with a photosynthetic partner (the photobiont or phycobiont), usually either a green alga (commonly Trebouxia) or cyanobacterium (commonly Nostoc).

Thus Lichens are associations of fungi and algae and the study of lichens is called Lichenology. The fungi facilitate water, minerals, vitamins, etc to the algae and algae prepare carbohydrate by the process of photosynthesis and supply the food to the fungi.

- Lichens coexist with fungi and algae as symbiotic and it is called **helotism**. Lichens are most commonly found on the trees.

Lichens are useful and by the help of these various economic activities can be observed. Lichens like Reindeer mosses, Iceland moss etc are utilized as food stuffs.

Reindeer moss

Reindeer mosses were originally named for their value as a food source for reindeer and caribou in the plant's northern range. Reindeer moss is really a lichen - a combination of a fungus and an alga, which share a symbiotic relationship and form a new plant. A short, stubby ground cover grows in pillow-like mats in sandy soil. There are about 40 species in the southeast, which range in color from gray-green to green-yellow to just gray. Because the common forms of reindeer moss are nitrogen fixers, they help form new soil, stabilize eroding sand, and create habitat for other plants and animals. The plant has the ability to absorb moisture and nutrients from the air through cells on its surface. However, this makes reindeer moss susceptible to pollutants in the environment. **It is sometimes used as an indicator of environmental health.**

Native Americans relied on the moss as a survival food in hard times. It is low in protein, but high in carbohydrates and vitamins A and B. It was also used in powder form to thicken soups, stews and desserts.

Reindeer moss is spongy and rubbery when moist, but becomes dry and brittle in times of little rain and will crunch if stepped on. It is slow to recover after a burn.

Lichens as Indications of Environment Change

Lichens are extremely vulnerable to habitat alteration, so habitats with the highest lichen species diversity are the remnants of ancient forests and other undisturbed ecosystems. The association between high diversity of lichens and pristine habitats is so clear that scientists use lichens as indicators of ecosystem continuity -- to help them identify areas that should be protected. Certain lichen species grow primarily (or even exclusively) in undisturbed habitats. Most lichens are extremely vulnerable to air pollution. When lichens disappear, they give early warning of harmful conditions. Scientists are using lichens to monitor air quality often compare current lichen inventories with past records.

PLANT KINGDOM

On the basis of modern concept and classification almost multicellular, photosynthetic, eukaryotic, reproductive and autotrophic organisms of the biosphere has been kept under this kingdom. Nearly 3,50,000 organisms have been kept inside this plant kingdom.

- Further this kingdom is divided into three categories-Thallophyta, Bryophyta and Tracheophyta.

Tracheophyta is further divided into three categories-Pteridophyta, Gymnosperm and Angiosperm. Angiosperm is divided into-Monocotyledonae and Dicotyledonae. A very brief description will follow here. Under **Thallophyta,** various types of microorganisms like algae, fungi have been kept.

ALGAE

Algae are chiefly water plants, dwelling in oceans, seas, lakes, ponds, rivers etc which have moist environment and which are not subjected to direct sunlight. Usually algae are chlorophylous, non-vascular,

autotrophic thalloid like microorganisms. Some species are found on rocks. The study of Algae is called Phycology. While father of Phycology is **F E Fritch,** father of **Indian Phycology is MO P Iyengar.**

Chief characteristics of algae:

- The cell walls of the cell of algae are made from cellulose.
- Usually sex organs of the algae are uniceller.
- Algae store their food in the form of starch.

Reproduction :

There exist three types of reproduction in the algae-

- **Vegetative reproduction**
- **Asexual reproduction**
- **Sexual reproduction:** There are three types of sexual reproduction -----Isogamous, Anisogamous and Oogamous.

Classes of Algae

There are several classes of Algae. Rather than studying the taxonomy, I am mentioning some of the important classes of algae.

Chlorophyceae:

They are Green algae, which have unicellular plant body, with chloroplast. *Chlamydomonas, Volvox, Spirogyra, Ulothrox, Oedogonium and Char*a are some example.

Phaeophyceae:

They are commonly called brown algae. **Kelps arepopular brown algae**. One important characteristic is that they store food in the form of **laminarin** and **mannitol.** *Ectocarpus, Laminaria, Sargassum* is common algae.

Rhodophyaceae:

They are Red algae. They are red because of the presence of a pigment called Phycoerythrin. Most of them are found in marines. They store food in Floridean starch. Common examples are Gracilaria, Porphyra etc.

Cyanophyceae

These include the Blue Green algae, and are most primitive algae which reproduce only asexually.

Some important Points related to Algae:

✓ Agar is obtained from the Red algae *Gracilaria* and *Gelidium.* Agar is used as a culture medium for growing of microbes in labs. Agar is also used in Food and Pharmaceuticals.

✓ The unicellular alga ***Chlorella*** is rich in proteins and vitamins and is considered a food for future. Chlorella is also source of an antibiotic *Chlorellin*.

✓ **Carragineen** which is used in the Dairy industry is obtained from a red alga called *Chondrus crispus.* It is also used in cosmetics and Pharma.

✓ **Alginic acid,** which is used as a stabilizer and thickening agent is obtained from Laminaria, the brown algae.

✓ **Dynamite is** prepared with the cell walls of Diatoms.

✓ Brown algae Laminaria is a good source of Iodine.

✓ *Cephaleuros virescens* is a pathogenic algae which causes **Red Rust in tea.**

✓ Some of the Blue green algae overgrow in the stagnant water and give rise to the water blooms. These include the Anabena, Microcystis, Ocilatoria etc.

✓ **Red Sea: Red** Sea is the part of the Mediterranean sea where a Blue green algae Trichodesmium grows profusely is called Red Sea. It is due to the presence of red Phycoerythrin in the cells of Trichodesmium.

✓ **Macrocystis** is an algae which is source of Potash. It's a brown algae (phaeophyceae) and is largest algae among all.

✓ Nicknames of some of the algae:

- Rockweed : Fucus
- Waternet : Hydrodictyon
- Kelp: Laminaria
- Irish Moss: Chondrus
- Sea Palm : Pstelsia
- Pond Silk : Spirogyra
- Sea Lettuce : Ulva