

Microbiology of Water

Importance of water

- Water is the medium of life.
- All organisms are composed primarily of water.
- Liquid water is the medium in which all cellular chemical reactions occur.
- Essential for survival and growth of organism.



Types of Water

- Natural Water
 - Atmospheric Water—water in clouds, air,
 - Surface Water--lakes, streams, rivers oceans
 - Ground Water---beneath the surface of earth
- Fresh water habitat..lakes, ponds, river
- Marine habitat: oceans
- **Estuarine habitat**: The region between fresh water and oceans (coastal body of water)
- Microorganism and chemicals are present in all types of water
- **Aquatic Microbiology**

Drinking Water

- Mostly from surface water, also underground water
- Chances of pollution
- Recycling of used water
- Not safe if contains pathogenic microorganism
- Potable and non-potable water
- Purification methods-(sedimentation, filtration and chlorination)
- Treatment for waste water
- Assessment of microbiological activity

Water Microbiology

- Study of microorganisms and their communities in water environment is called **Aquatic microbiology**.
- The scope of Aquatic Microbiology is wide and includes the habitats like planktons, benthos, microbial mats and biofilm which may be found in lakes, rivers, streams, seas, groundwater, rain, snow and hail.



Water born diseases

- H₂O can act as a vector for the transmission of bacterial, viral and protozoan agents which cause a variety of diseases (mainly intestinal)
- It can also be linked to worm invasions and viral/protozoan diseases transmitted by insects (aquatic hosts or insect breeding in H₂O - indirect)
- Water is responsible for, by some estimates, approximately **80%** of all infectious disease not just waterborne diseases, but any disease where water plays a role.

- **Water contains a variety of microbes including:**

Viruses

Bacteria

Protozoa

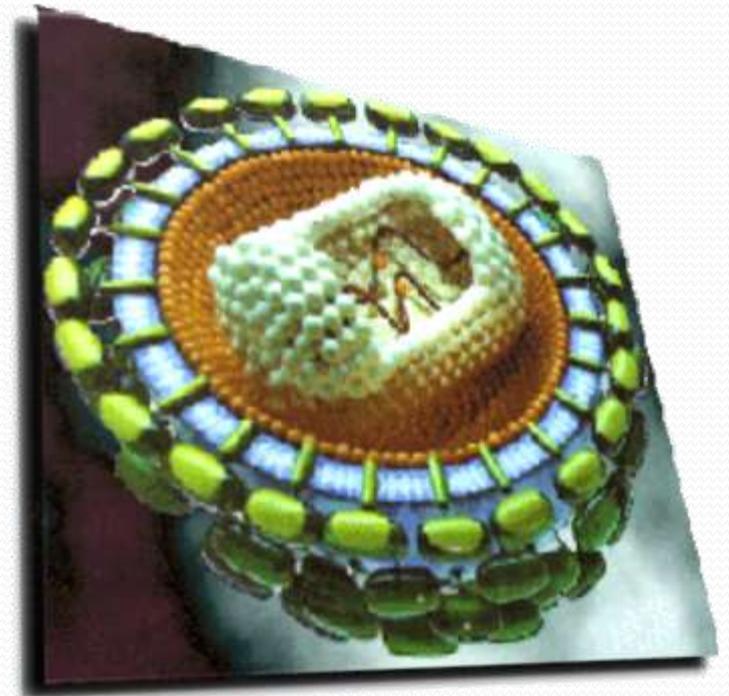
Helminth

Fungi



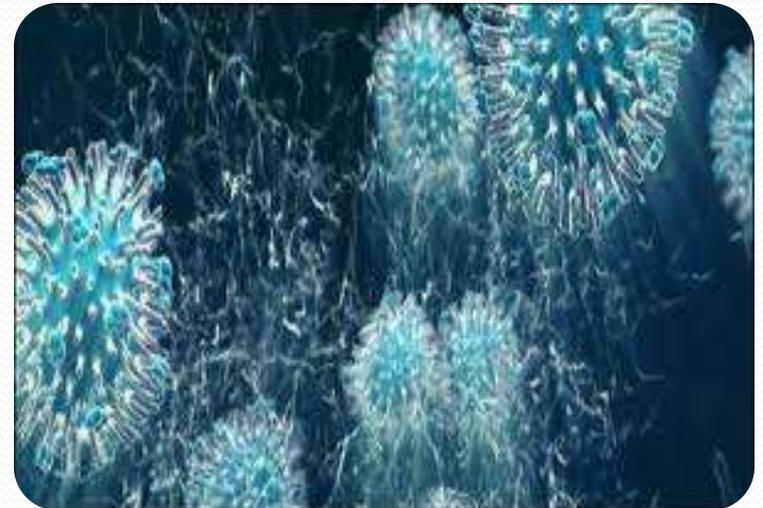
VIRUS

- Sub microscopic entity consisting of a single nucleic acid surrounded by a protein coat and capable of replication only within the living cells of bacteria, animals or plants.
- Viruses particles are unable to make copies of themselves they must infect living host to make multiple copies.
- Viruses that infect bacteria is called **Bacteriophage**.
- Viruses cause disease in animals as rabies, and different foot mouth diseases.
- Cause serious disease in humans like HIV, hepatitis, common cold, influenza & polio.



VIRUSES PATHOGENS

- Enteritis, diarrhea, and dysentery
 - Rotavirus
 - Norwalk
- Liver damaging
 - Hepatitis A
 - Hepatitis E
- Paralysis
 - Polio virus



BACTERIA

- The most abundant organism on earth ,it live everywhere in soil, water plants and animal .
- Bacteria vary in their shapes like bacteria have spherical(cocci), rod (bacillus) and spiral (spirillum) shaped arrangement and are organized in specific cellular shape.
- Bacteria reproduce asexually, and divide rapidly.
- Bacteria damaged human tissue by producing toxin and cause disease e.g food poisoning.



- They are responsible for many diseases transmitted by means of water and other sources.
- Enteritis, diarrhea, and dysentery
 - Campylobacter
 - Cholera
 - *E. coli*
 - Salmonella
 - Shigella
- Enteric fever
 - Typhoid
 - Paratyphoid
- Eye, ear, and skin infections
 - Miscellaneous bacteria

Protozoa

- These are unicellular organisms with protoplasm differentiated into nucleus and cytoplasm.
- Diameters in the range of 2-100 μm .

The most important groups of medical protozoa are:

A-Amoeba:

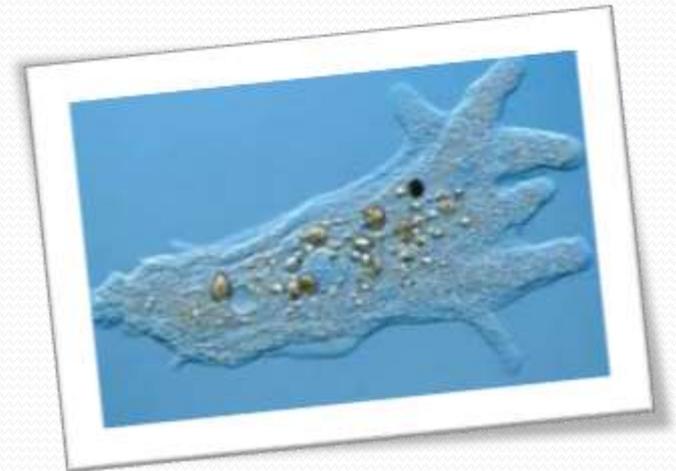
Entamoeba species.

B- Flagellates:

Gastrointestinal flagellates: *Giardia intestinalis*

Urogenital flagellates: *Trichomonas vaginalis*

Tissue and blood flagellates: *Trypanosoma*



C- Ciliophora: motile by cilia.

Example: *Balantidium coli*.

D- Sporozoa: intracellular infection.

Example: *Plasmodium* that cause Malaria



FUNGI

- Fungi are a diverse group of eukaryotes that are plant-like but that cannot carry on photosynthesis.
- They serve as decomposers, absorbing nutrients from dead leaves or other organic matter in soil and water.
- Fungi are found in very less quantity/numbers in water. This is due to their **competition with other heterotrophic** organisms like some bacteria and archae for food intake. their low abundance is an indicator for their loss during competition.
- Fungi produce spores during the reproductive process.

Algae

- Algae may produce toxins in sea food which can cause illness to human beings by using contaminated seafood.

Most important are;

- Amnesic Shellfish Poisoning (ASP)
- Ciguatera Fish Poisoning (CFP)
- Diarrhetic Shellfish Poisoning (DSP)
- Neurotoxic Shellfish Poisoning (NSP)
- Paralytic Shellfish Poisoning (PSP)

Amnesic Shellfish Poisoning (ASP):

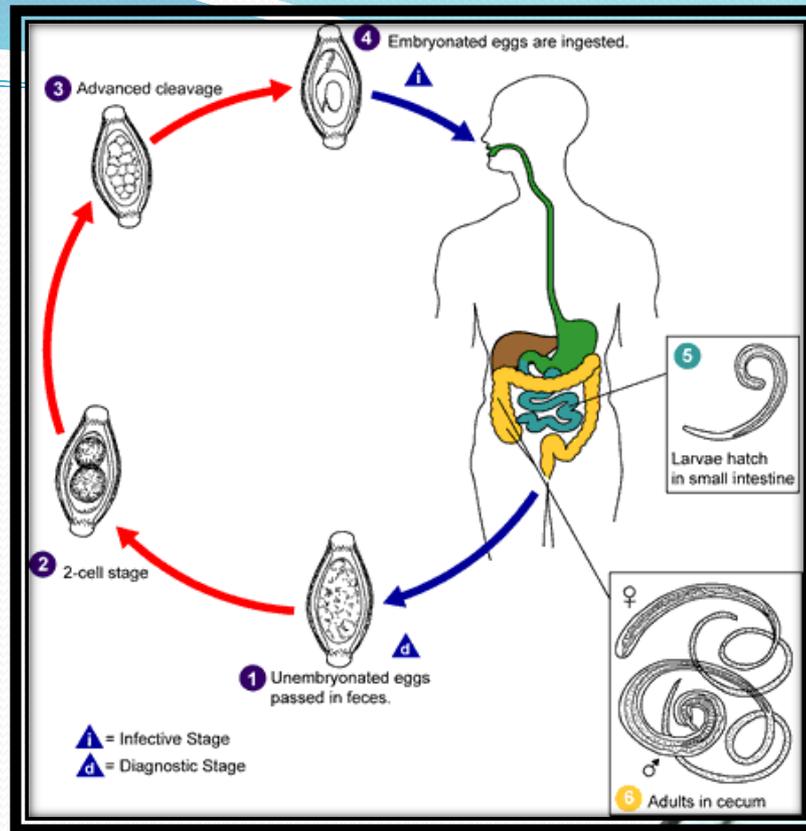
Causative organisms: *Pseudo-nitzschia* sp.

ASP can be a life-threatening syndrome. It is characterized by both gastrointestinal and neurological disorders. Gastroenteritis usually develops within 24 hours of the consumption of toxic shellfish; symptoms include nausea, vomiting, abdominal cramps & diarrhea.

- In severe cases, neurological symptoms also appear, usually within 48 hours of toxic shellfish consumption.
- The symptoms include dizziness, headache, seizures, disorientation, short-term memory loss, respiratory difficulty, and coma.
- Shellfish beds are closed to harvesting when the domoic acid (toxin) concentration reaches 20 $\mu\text{g/g}$ shellfish meat.
- Fish and crab viscera can also contain domoic acid, so the risk to human consumers and animals in the marine food chain is more significant than previously believed.

HELMINTHES

- Round worm
- Tape worm
- Hook worm
- Whip worm



SPREAD AND SYMPTOMS OF DISEASE

- A person may be infected by direct drinking contaminated water.
- By coming in contact with contaminated water.

Common symptoms

- Abdominal pain
- Fever
- Diarrhea
- Condition are more severe in peoples with weakened immune system.

Water-associated diseases can be classified under 4 different categories: -

1. Water-borne diseases
2. Water-washed diseases
3. Water-based diseases
4. Water-related diseases

A. Water-borne diseases

- ❑ They are produced by ingestion of contaminated water.
- ❑ They are mainly enteric diseases.
- ❑ Classical H₂O -borne diseases are mostly:
 - ❑ **Protozoal infection;** Amoebiasis, Giardia and Cryptosporidium etc.
 - ❑ **Bacterial infection;** cholera and typhoid fever (rare), Campylobacteriosis, bacillary dysentery, leptospirosis (rare), dysentery, E.coli infections.
 - ❑ **Viral infections;** infectious hepatitis, poliomyelitis, **SARS** (Severe Acute Respiratory Syndrome).

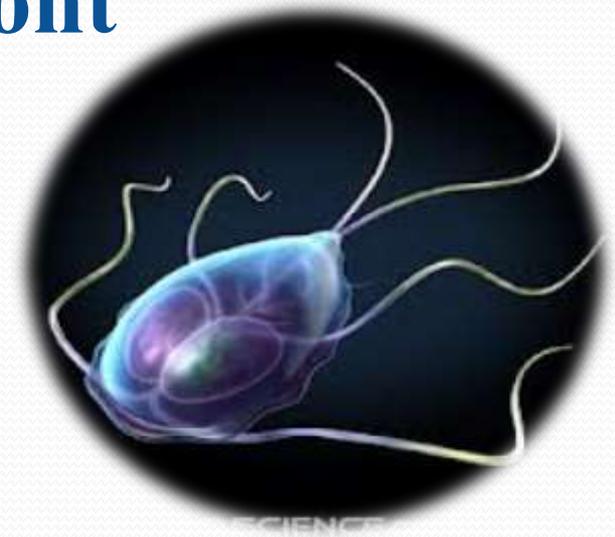
Protozoal infection



- **Amoebiasis:-**
- Microbial Agent: *Entamoeba histolytica*
- Sources of Agent in Water Supply
- Sewage, non-treated drinking water, flies in water supply

General Symptoms : Abdominal discomfort, fatigue,, weight loss, fever, diarrhea, bloating.

Protozoal infection...cont



- **Giardiasis:-**
- Microbial Agent: *Giardia lamblia*
- Sources of Agent in Water Supply
- Untreated water, pipe breaks, groundwater contamination. Rodents create ponds that act as reservoirs for Giardia.
- General Symptoms
- Diarrhea, abdominal discomfort, bloating (swelling or increased diameter of abdominal area) and flatulence.

Bacterial Infection

Cholera

- Microbial Agent: *Vibrio cholera*
- Sources of Agent

Drinking water contaminated with the bacterium

- General Symptoms

In severe forms it is known to be one of the most rapidly fatal illnesses known. Symptoms include very watery diarrhea, nausea, cramps, nosebleed, increased pulse rate, vomiting and in severe cases hypovolemia (decreased blood volume) at which point death can occur in 12–18 hours



Bacterial Infectioncont

Typhoid fever

- **Microbial Agent** : Salmonella typhi
- **Sources of Agent** in Water Supply

Ingestion of water contaminated with feces of an infected person

- **General Symptoms**

Characterized by sustained fever up to 40°C (104°F), profuse sweating, diarrhea, less commonly a rash may occur. Symptoms progress to delirium (acute confusion & disorientation) & splenomegaly and hepatomegaly if untreated. In this case it can last up to four weeks and cause death.



Viral Infection

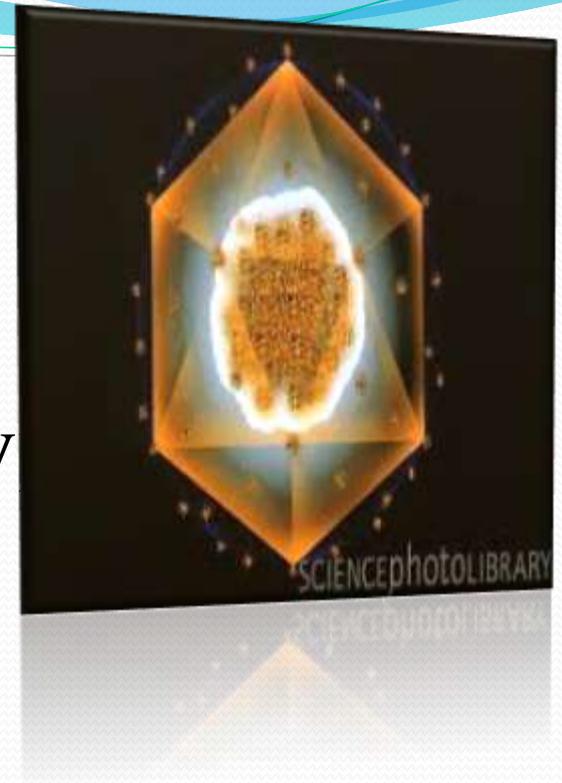
Infectious hepatitis

- Microbial Agent: Hepatitis A virus (HAV)
- Sources of Agent

Can manifest itself in water (and food)

- General Symptoms

Symptoms are only acute & include Fatigue, fever, abdominal pain, nausea, diarrhea, weight loss, itching, jaundice & depression.



Viral Infectioncont

- **Poliomyelitis**
- **Microbial Agent:** Poliovirus
- **Sources of Agent**

Enters water through the feces of infected individuals

- **General Symptoms**

Cause of gastrointestinal illness and poliomyelitis

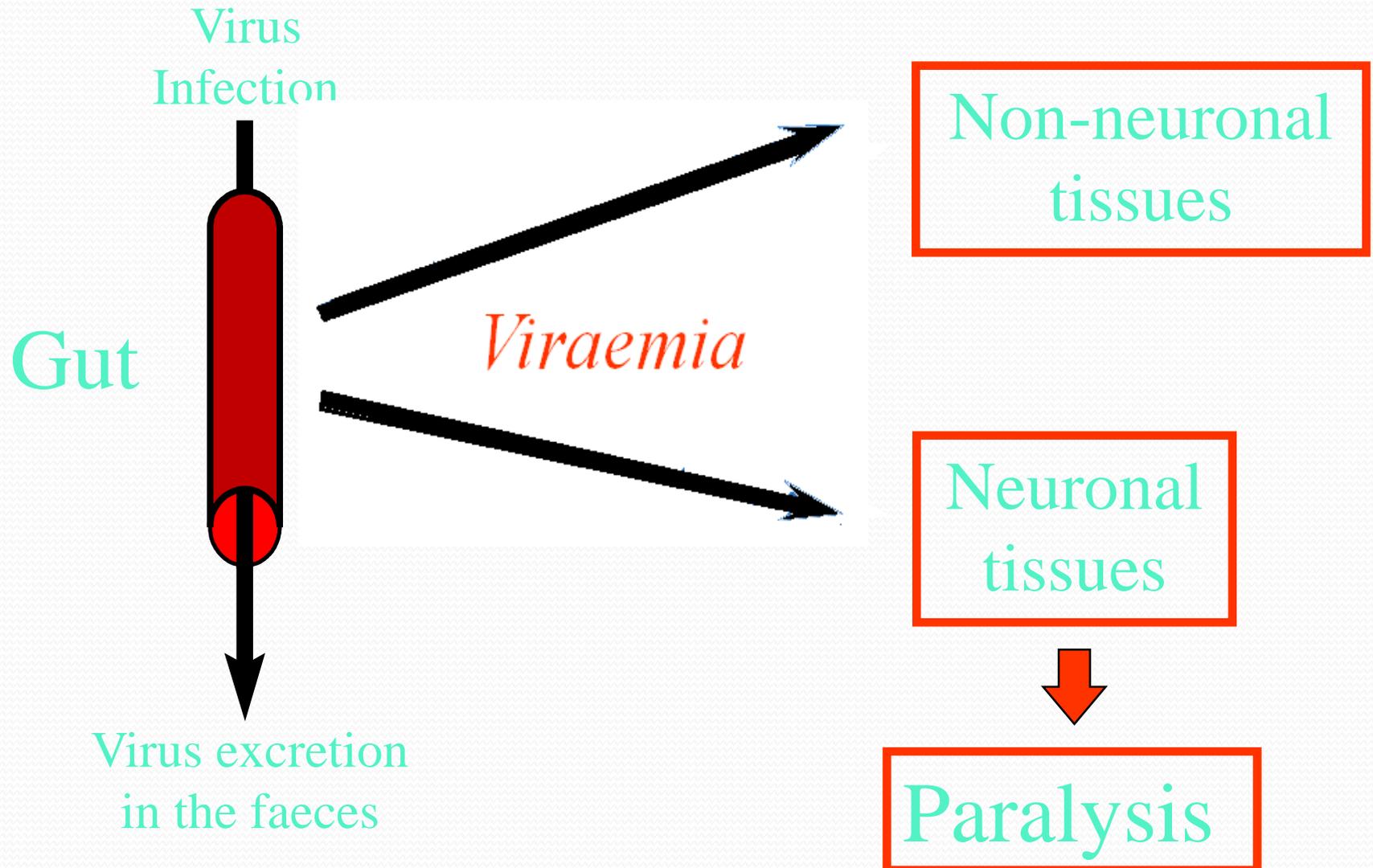
90-95% of patients show no symptoms, 4-8% have minor symptoms (comparatively) with delirium, headache, fever & occasional seizures spastic (unusual stiffness) paralysis, have symptoms of non-paralytic aseptic meningitis. The rest (1-5 in 1000) have serious symptoms resulting in Paralysis or death

- Two basic patterns of polio infection are:
 - A) A minor illness which does not involve the CNS, sometimes called abortive poliomyelitis,
 - B) Major illness involving the CNS, which may be paralytic or non-paralytic.

In most people with a normal immune system, a poliovirus infection is asymptomatic.



POLIOVIRUS INFECTION



Fungal Infections:

- **Ringworm or Tinea** is a typically mild disease of the skin, scalp or nails caused by a fungus.
- It's link with water is via poor personal domestic hygiene and shortage of water for cleaning and washing.

2. Water-washed diseases

- Diseases caused by poor personal hygiene.
- Obviously more common in tropical, 3rd world countries where maybe water scarcity is present.
- Intestinal and non-intestinal infections (Eye & skin diseases)
- Intestinal: *Shigella* (dysentery); typhoid; cholera; scabies, Yaws (Yaws is caused by *T. Pallidum* subspecies *pertenue*, affects skin, bone and cartilage), leprosy, conjunctivitis, other skin infections and ulcers. *Campylobacter*; *Giardia*; *Cryptosporidium*; viruses.

3. Water-based diseases

- Diseases caused by pathogens that have a complex life-cycle which involves an intermediate aquatic host.
- All of these diseases are caused by worms, e.g.
 - ✓ Schistosomiasis caused by the Schistosoma worm which uses aquatic snails as an intermediate host,
 - ✓ Dracunculiasis cause by Guinea worm which uses a small crustacean as an intermediate host

Schistosomiasis

- Also known as **Bilharzia/bilharziosis** or **snail fever** is a parasitic disease caused by several species of platyhelminthes.
- **Snails** serve as the **intermediary agent** between mammalian hosts.
- **Microbial Agent:** Parasitic worm of the genus *Schistosoma*
- **Sources of Agent**
Fresh water contaminated with certain types of snails that carry Schistosomes.
- **General Symptoms**
Blood in urine (depending on the type of infection), rash or itchy skin. Fever, chills, cough and muscle aches.

4. Water-related diseases

- Diseases caused by pathogens carried by insects that live near H₂O and act as mechanical vectors.
- Difficult to control and diseases are severe.

Examples:

- **Yellow fever** (viral disease) is transmitted by the mosquito *Aedes* spp.
- **Dengue** (viral) transmitted by the mosquito *Aedes aegypti* (breeds in water);
- **Malaria** is caused by a protozoan (*Plasmodium* spp.) and is transmitted by a mosquito (*Anopheles* spp.)
- **Trypanosomiasis** (Gambian sleeping sickness) is also caused by a protozoan transmitted by the riverine Tsetse fly (*Glossina* spp.)

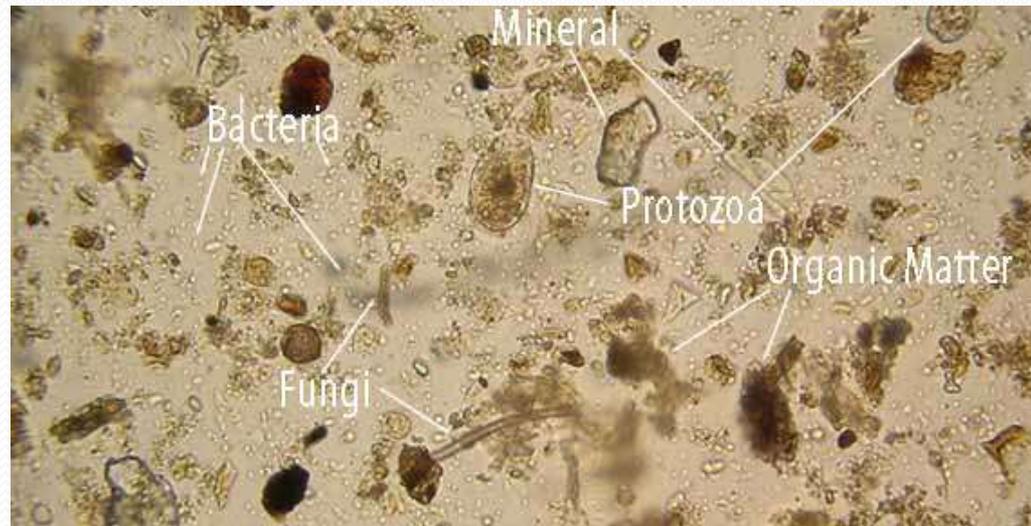
HOW TO PREVENT....?

- Always wash your hand before handling food especially and after using toilet
- Wash your fruits and vegetable before use as it contain harmful chemicals and microbes.
- Don't drink water from river, lakes and ponds.
- Try to adopt healthy and good hygiene as possible

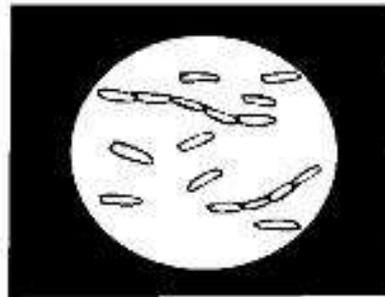
SOIL MICROBIOLOGY

Soil Microbiology:

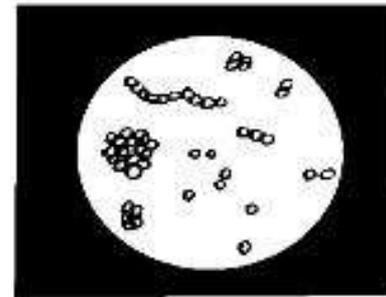
- A study of the microorganisms in soil, their functions, and the effect of their activities on the character of the soil and the growth and health of plant life.
- It is believed that between two and four billion years ago, the first ancient bacteria and microorganisms came about in Earth's primitive seas. These bacteria could fix nitrogen, in time multiplied and as a result released oxygen into the atmosphere.



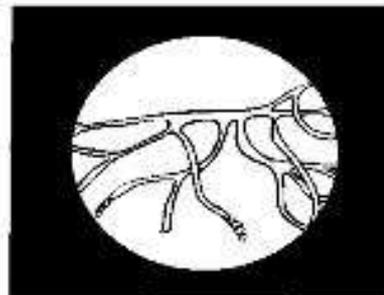
- This release of oxygen led to more advanced microorganisms.
- Microorganisms in soil are important because they affect the structure and fertility of different soils by showing phenomenon of mutualism and symbiosis.



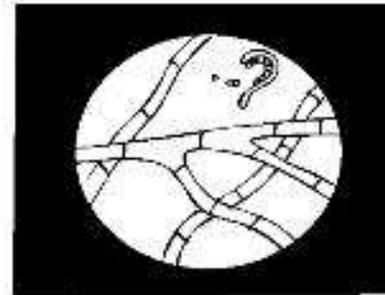
Bacilli



Cocci



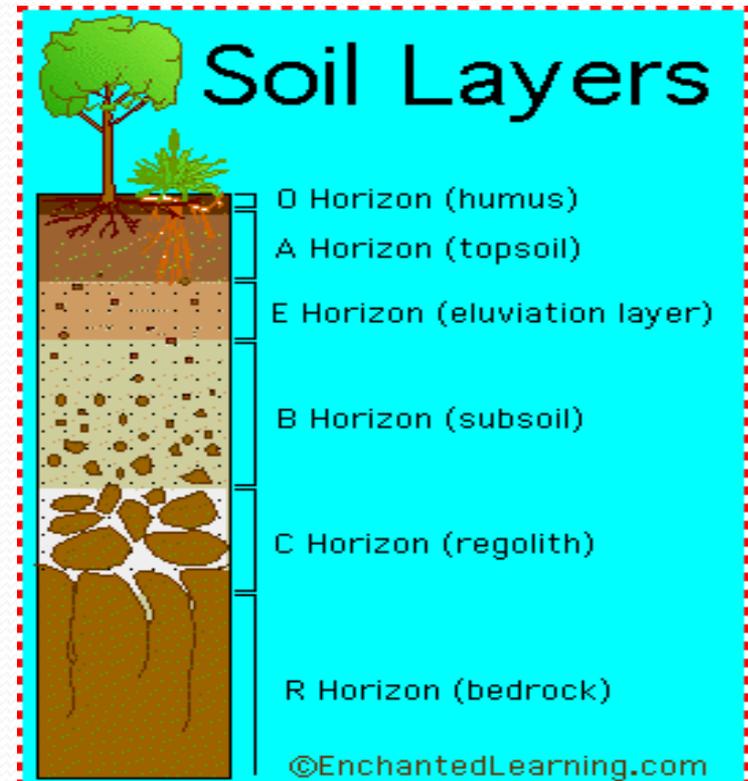
Actinomycetes



Fungi

Soil:

- It is the outer, loose material of earth's surface which is distinctly different from the underlying bedrock and the region which support plant life.
- Soil is the region which supports the plant life by providing mechanical support and nutrients required for growth.



Layers of Soil:

- **Organic matter:** Litter layer of plant residues in relatively undecomposed form.
- **Surface soil:** Layer of mineral soil with most organic matter accumulation and soil life.
- **Subsoil:** This layer accumulates iron, clay.
- **Parent rock:** Layer of large unbroken rocks. This layer may accumulate the more soluble compounds.
- **Bedrock:** It denotes the layer of partially weathered bedrock at the base of the soil profile.

Components of Soil:

- Organic matter.
- Mineral matter.
- Soil air.
- Soil water.
- Soil microorganisms.

Classification of Soil Microorganism

Soil microorganisms can be classified as:

- Bacteria.
- Actinomycetes.
- Fungi.
- Algae.
- Protozoa.

Bacteria

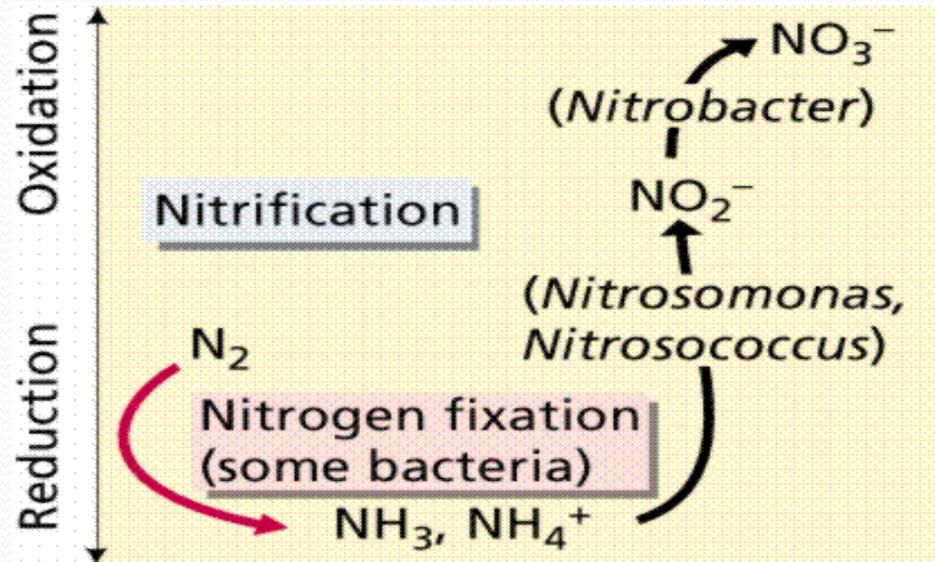
- Bacteria are the smallest organisms in the soil and are the only soil microorganisms that are prokaryotic.
- Bacteria are the most abundant microorganisms in the soil, and serve many important purposes, one of those being *nitrogen fixation* among other biochemical processes.



Bacteria dot the surface of strands of fungal hyphae.

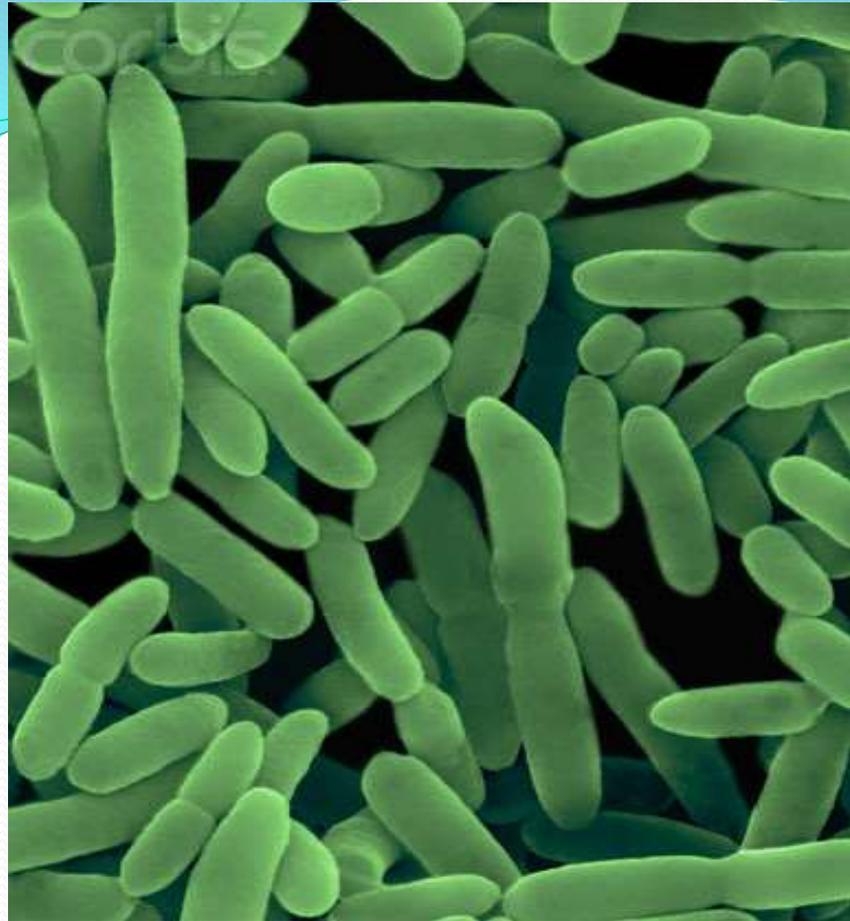
Biochemical processes

- One of the most distinguished features of bacteria as a whole is their biochemical versatility.
- Bacterial genera, **Pseudomonas** can metabolize a wide range of chemicals and fertilizers.
- Another genera known as Nitrobacter can only derive its energy by turning nitrite into nitrate, which results in a gain of oxygen and is known also as oxidation.

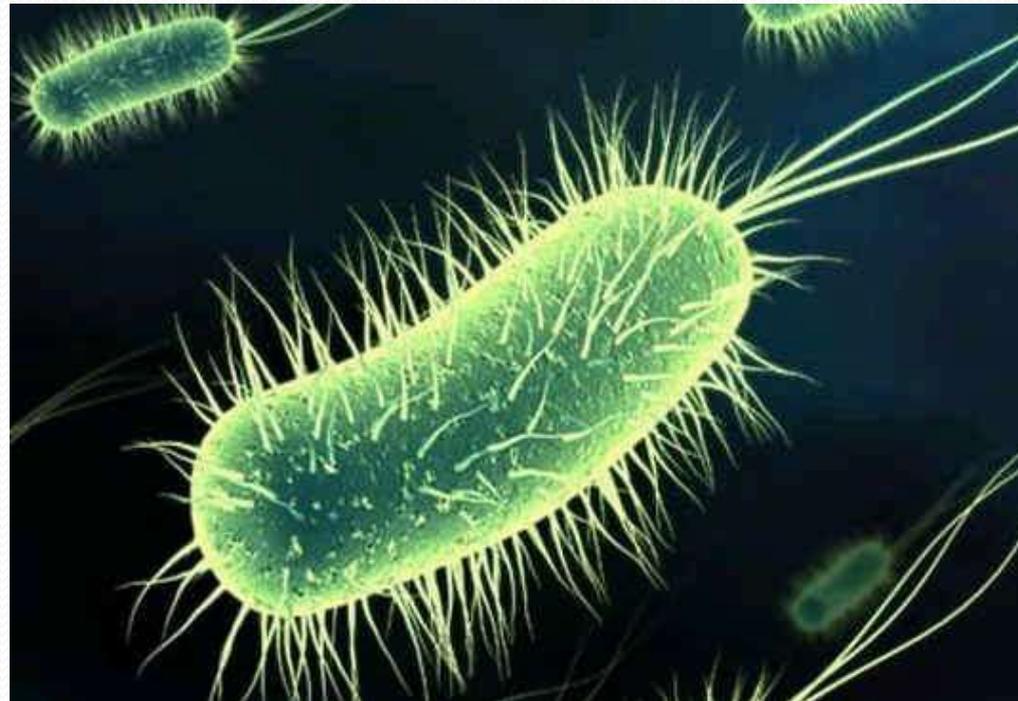




- *Pseudomonas* (SOIL BACTERIA)



•NITROBACTER(SOIL BACTERIA)



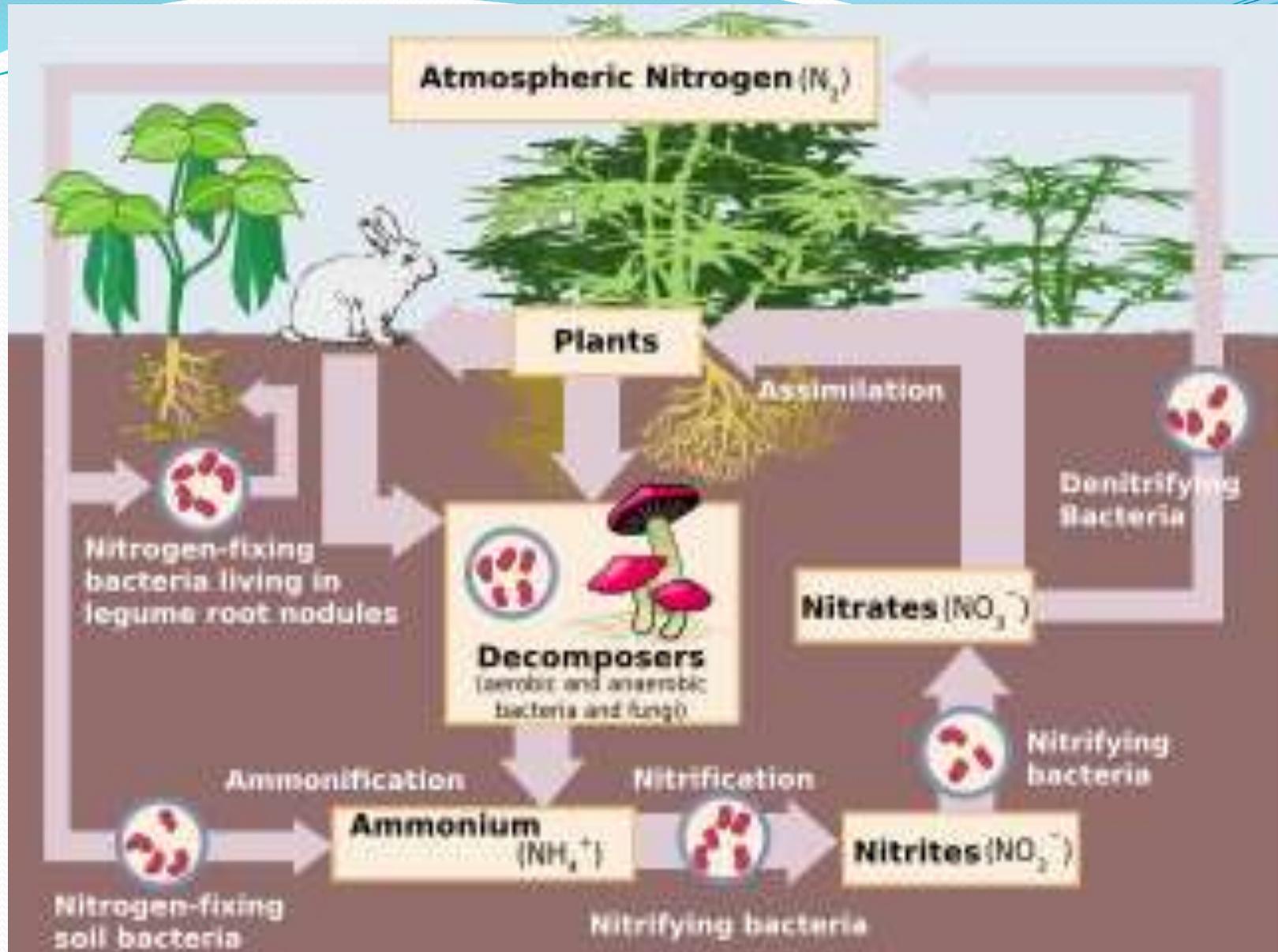
•First exploration of **Nitrobacter** diversity in **soils** by a PCR

Nitrogen fixation

- Bacteria are responsible for the process of nitrogen fixation, which is the conversion of atmospheric nitrogen into nitrogen-containing compounds (like ammonia) which can be used by plants to uptake.
- Autotrophic bacteria, or bacteria that derives its energy making its own food by oxidation, like the Nitrobacters species are responsible for nitrogen fixation.
- These bacteria are very important because almost every plant and organism require nitrogen in some way, and would have no way of obtaining it if not for nitrogen-fixing bacteria.

Nitrogen Cycle:

- This cycle consists of four steps.
- Ammonification. e.g. *Azobacter*
- Assimilation.
- Nitrification e.g. *Nitrosomonas*
- Denitrification



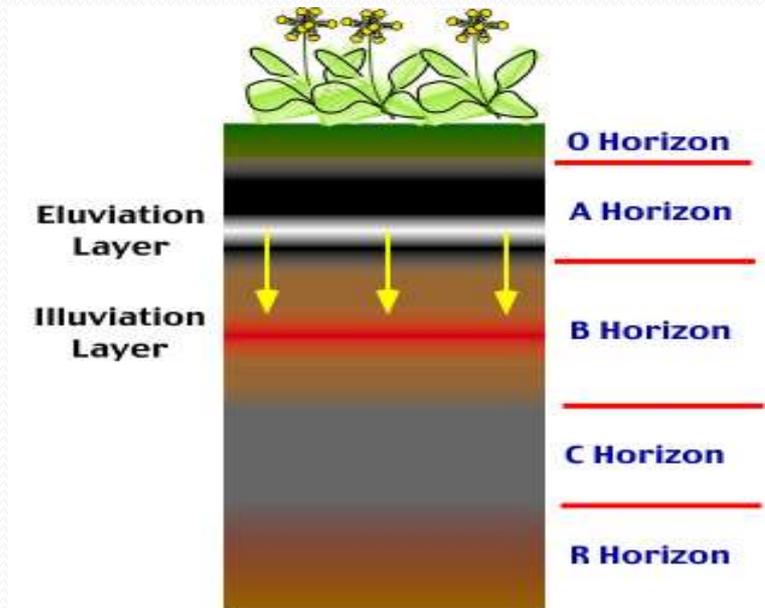
ACTINOMYCETES

- Actinomycetes (actinobacteria) are soil μ -organisms. Actinobacteria are a group of Gram-positive bacteria.
- Actinobacteria include some of the most common soil life, playing an important role in decomposition of organic materials, such as cellulose and chitin, and thereby playing a vital part in organic matter turnover.
- This replenishes the supply of nutrients in the soil and is imp. part of humus formation.



• Scanning electron micrograph of *Actinomyces israelii*.

- Some types of Actinobacteria are responsible for the peculiar odor emanating from the soil after rain (Petrichor).
- They are sensitive to acidity / low PH (optimum PH range 6.5 to 8.0) and waterlogged soil conditions.
- The population of actinomycetes increases with depth of soil even up to horizon 'C' of a soil profiler.



Soil-related bacterial infections:

- Tetanus (caused by the toxin-producing, anaerobic, spore-bearing, Gram-positive bacteria *Clostridium tetani*).
- Botulism (caused by the toxin-producing, anaerobic, spore-bearing, Gram-positive bacteria *Clostridium botulinum*).
- Wound infections
- **Gastroenteritis** (*Clostridium perfringens* is ubiquitous in soil, from which it is ingested into GIT. It is associated with a variety of human diseases including classic food poisoning. Evidence suggests that most cases of gastrointestinal disease caused by *C. perfringens* have their source from food contaminated by other humans or by animal feces rather than directly from the soil).

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- Other Organisms involved in Gastroenteritis include:

Bacillus cereus, Campylobacter jejuni, E. coli & Listeria monocytogenes

- **Anthrax** (caused by the Gram-positive, spore-forming rod *Bacillus anthracis*)

Fungi

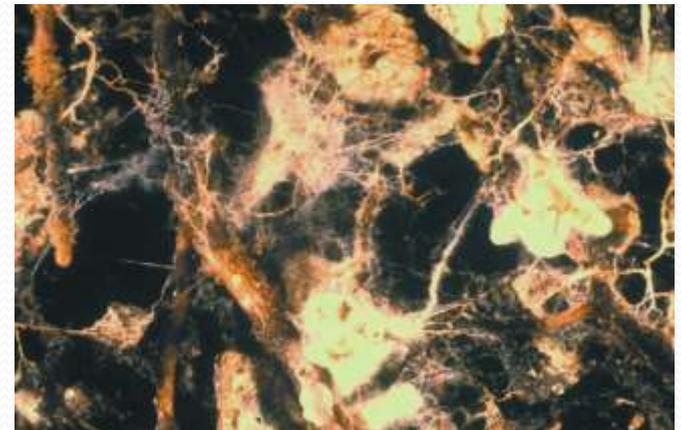
- Next to bacteria, fungi are abundant in soil population compared to other microorganisms.

Fungi are important in the soil as:

- Food sources for other, larger organisms.
- Pathogens.
- Beneficial symbiotic relationships with plants or other organisms.
- Help to reduce crop residues.
- Biochemically process nutrients to improve the soil they inhabit.

Pathogenic fungi:

- The growth and distribution of **bacteria and actinomycetes** also influence fungi.
- The **quality as well as quantity of organic matter** in the soil has a direct correlation to the growth of fungi, because most fungi consume the organic matter for nutrition.
- Fungi also grows well in dry, arid soils because fungi are aerobic, or dependent on oxygen, and the **higher the moisture content in the soil, the less oxygen is present for fungi.**



- *Coccidioides*, a dimorphic (mycelium/spherule) fungus has been associated with alkaline, highly salinic, sandy soils and extremes of temperature. The ability to survive such harsh conditions may allow successful competition with other soil microorganisms.
- Progressive *Coccidioidomycosis* respiratory failure, chronic pneumonia, and dissemination to other organs, including skin, bones/joints, and the central nervous system. Many infections are inapparent.
- *Blastomyces dermatitidis* occurs in soil and near-soil environments.
- Pulmonary blastomycosis has a wide differential diagnosis and may be asymptomatic or present as mild, moderate, or severe acute pneumonia. The latter may be complicated by acute respiratory distress syndrome. Subacute to chronic infiltrates, cavitary lung disease, or both may occur instead. In addition, acute or chronic dissemination of *B. dermatitidis* to the skin, brain, genitourinary system, bone, or any other organ system may result.

Other infections due to fungi residing in soil related environment include;

- *Penicillium marneffeii*, may cause a fatal systemic mycosis in patients infected with HIV.
- Sporotrichosis is a rare, subacute to chronic mycosis caused by the dimorphic fungus *Sporothrix schenckii*.
- Infections caused by *Aspergillus* species (excludes allergic bronchopulmonary aspergillosis) are usually in immunocompromised patients and include invasive pulmonary aspergillosis (cough, dyspnea, possible fever, chest pain, hemoptysis, wheezing); pulmonary or sinus fungus balls; chronic pulmonary aspergillosis (cavitary, fibrosing, subacute).

Algae

- Algae are present in most of the soils where moisture and sunlight are available. Their number in soil usually ranges from **100 to 10,000 per gram of soil**.
- Blue-green algae and grass-green algae are more abundant in soil.
- The **green-grass algae and diatoms** are dominant in the soils of temperate region while blue-green algae predominate in tropical soils.



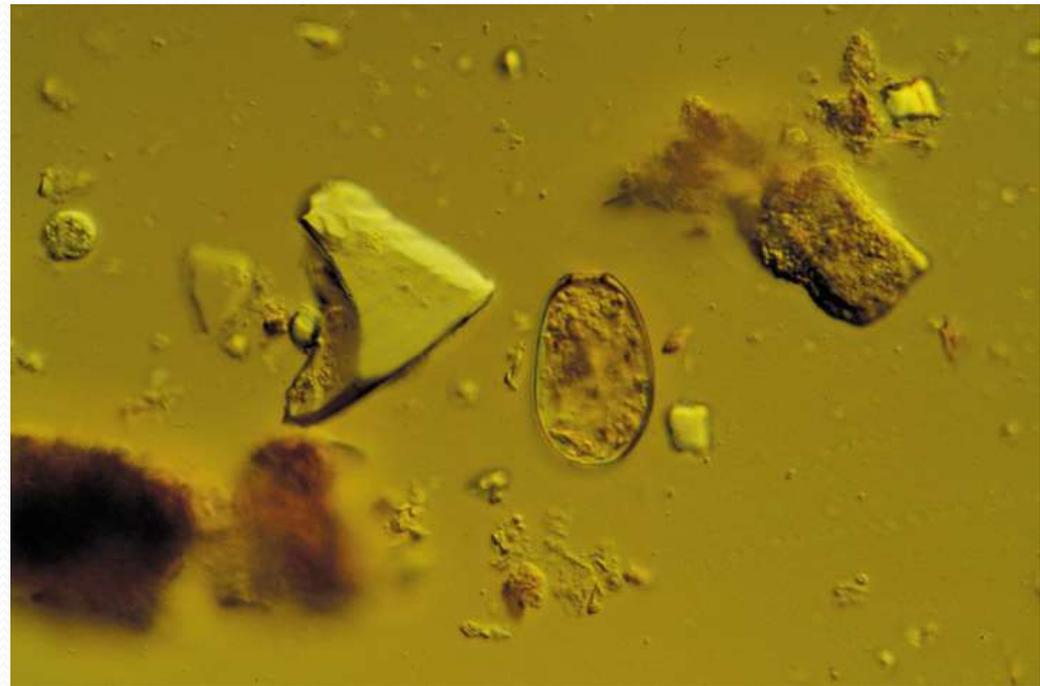
- Blue green algae are unicellular, photoautotrophic prokaryotes. They are common in neutral to alkaline soils.
- Some blue green algae possess specialized cells known as "**Heterocyst**" which is the site of nitrogen fixation.



Protozoa

- Their population in arable soil ranges from 10,000 to 1,00,000 per gram of soil and are abundant in surface soil.
- They can withstand adverse soil conditions as they are characterized by "**cyst stage**" in their life cycle.
- The soil protozoa belonging to the class ciliate / ciliophora are characterized by the presence of cilia around their body, which helps in locomotion.

- Protozoa are abundant in the **upper layer (15 cm) of soil**. Organic manures protozoa. Soil moisture, aeration, temperature and PH are the important factors affecting soil protozoa.



THE LIVING SOIL: PROTOZOA

Scope and Importance of Soil Microbiology

- Living organisms both plant and animal types constitute an important component of soil.
- Though these organisms form only a fraction (less than one percent) of the total soil mass, but they play important role in supporting plant communities on the earth surface.
- While studying the scope and importance of soil microbiology, soil-plant-animal ecosystem as such must be taken into account.

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- The **scope and importance** of soil microbiology, can be understood in better way by studying aspects like:

1. Soil as a living system
2. Soil microbes and plant growth
3. Soil microorganisms and soil structure
4. Organic matter decomposition
5. Humus formation

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6. Biogeochemical cycling of elements
 7. Soil microorganisms as bio-control agents
 8. Soil microbes and seed germination
 9. Biological Nitrogen fixation
 10. Degradation of pesticides in soil

Microbiology of Air

Airborne microorganisms:

Airborne particles are a major cause of respiratory ailments of humans, causing allergies, asthma, and pathogenic infections of the respiratory tract. Airborne fungal spores are also important agents of plant disease, and the means for dissemination of many common saprotrophic (saprophytic) fungi.

During a sneeze, millions of tiny droplets of water and mucus are expelled at about 200 miles per hour (100 metres per second). The droplets initially are about 10-100 micrometres diameter, but they dry rapidly to **droplet nuclei** of 1-4 micrometres, containing virus particles or bacteria. This is a major means of transmission of several diseases of humans as shown in the following slides.

Some important diseases of humans transmitted from person to person by inhaled airborne particles

Virus diseases (virus type in brackets)

Chickenpox (Varicella)

Flu (Influenza)

Measles (Rubeola)

German measles (Rubella)

Mumps (Mumps)

Smallpox (Variola)

Bacterial diseases (bacterial name in brackets)

Whooping cough (*Bordetella pertussis*)

Meningitis (*Neisseria* species)

Diphtheria (*Corynebacterium diphtheriae*)

Pneumonia (*Mycoplasma pneumoniae*,
Streptococcus species)

Tuberculosis (*Mycobacterium tuberculosis*)

Several other diseases, below, are acquired by inhaling particles from environmental sources, not directly from an infected person.

Disease	Source
Psittacosis (<i>Chlamydia psittaci</i>)	Dried, powdery droppings from infected birds (parrots, pigeons, etc.)
Legionnaire's disease (<i>Legionella pneumophila</i>)	Droplets from air-conditioning systems, water storage tanks, etc., where the bacterium grows.
Acute allergic alveolitis (various fungal & actinomycete spores)	Fungal or actinomycete spores from decomposing organic matter (composts, grain stores, hay, etc.)
Aspergillosis (<i>Aspergillus fumigatus</i> , <i>A. flavus</i> , <i>A. niger</i>)	Fungal spores inhaled from decomposing organic matter
Histoplasmosis (<i>Histoplasma capsulatum</i>)	Spores of the fungus, in old, weathered bat or bird droppings
Coccidioidomycosis (<i>Coccidioides immitis</i>)	Spores in air-blown dust in desert regions (Central, South and North America) where the fungus grows in the soil

Psittacosis is a serious disease acquired by handling birds or by inhaling dust from bird faeces. It is caused by the bacterium *Chlamydia psittaci*, an obligate intracellular parasite. After entering the respiratory tract, the cells are transported to the liver and spleen, multiply there and then invade the lungs, causing inflammation, haemorrhage and pneumonia.

Legionnaire's disease is a fairly common form of pneumonia in older or immunocompromised people. It is seldom transmitted directly from person to person. The bacterium is an aquatic rod-shaped species with a temperature optimum of about 36°C & is a common inhabitant of warm-water systems in buildings. Infection occurs when people inhale aerosol droplets containing the bacteria.

Extrinsic allergic alveolitis is a serious hypersensitive response, usually associated with repeated exposure to airborne spores in the work environment. An example is the condition termed **farmer's lung**, caused by exposure to spores of thermophilic actinomycetes.

Aspergillosis, Histoplasmosis and Coccidioidomycosis are examples of serious fungal infections of humans, initiated by spores deposited in the alveoli. They can be life-threatening diseases of immunocompromised people, when the fungi disseminate from the lungs to major organs of the body. However, in all cases the infection of humans is incidental to the fungus, playing no part in its normal biology. These are fungi that grow naturally as decomposer organisms in soil, bird faeces or other organic substrates.



Goodluck for terminals