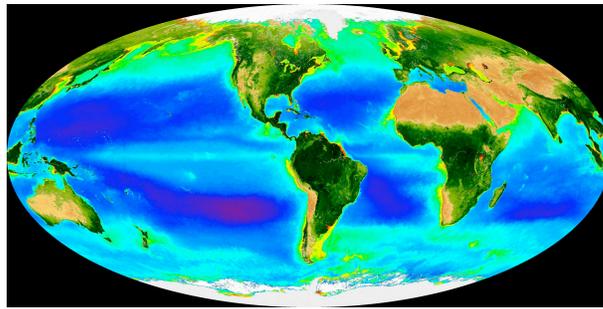


## MICROBES IN ECOLOGY

**INTRODUCTION** - Microbes usually live in communities and rarely as individuals

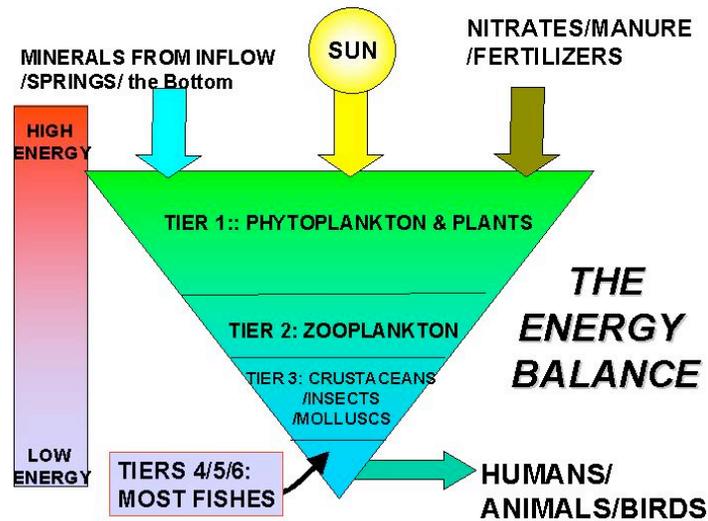
They are

- Present in every known ecosystem
- Over 99% of microbes contribute to the quality of human life
- In terms of numbers, microbes represent most of the diversity of life on Earth and are found in every environment
- Play a vital part of the ecosystem
- Major producers in aquatic environments
- Decomposers – bacteria and fungi – in many ecosystems
- Key role in Biogeochemical cycles to recycle carbon, nitrogen, carbon, water
- Natural pest killers in gardens and on crops
- Serving as natural water treatment
- Causing some ecological problems as red tide and algal blooms
- Involved in many symbiotic relations as lichens, human digestion, rumens of cows



**MICROBES IN ECOSYSTEMS** - Microbes interact with other microorganisms, higher organisms and the inorganic world (abiotic world)

- Microorganisms can form biofilms called microbial mats and thereby create their own microenvironment and niche
- The roles of microorganisms in the larger ecosystem include
  - Primary producers – fix carbon dioxide
  - Decomposition of organic matter
  - Nutrient cycling
  - disease
- Movement of microorganisms
  - Soil can blow around
  - Rivers move microorganisms
  - Animals move microorganisms around
  - Human activities
- Extremophiles are microbes that live in places where they are the only organisms capable of surviving



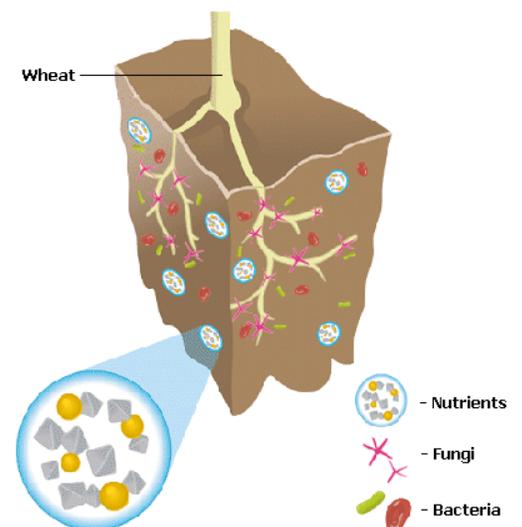
### Aquatic and Marine Ecosystems

- There is a wide variety of microorganisms in aquatic systems:
  - Viruses
  - Bacteria
  - Diatoms
  - Algae
  - Protozoa
  - Some limited fungi - more in freshwater
- Cyanobacteria, diatoms and algae serve as major producers and sources of oxygen
- Protozoa serve as consumers at the lower ends of the food web
- Bacteria and fungi serve as decomposers
- Viruses are parasites that can infect other cells

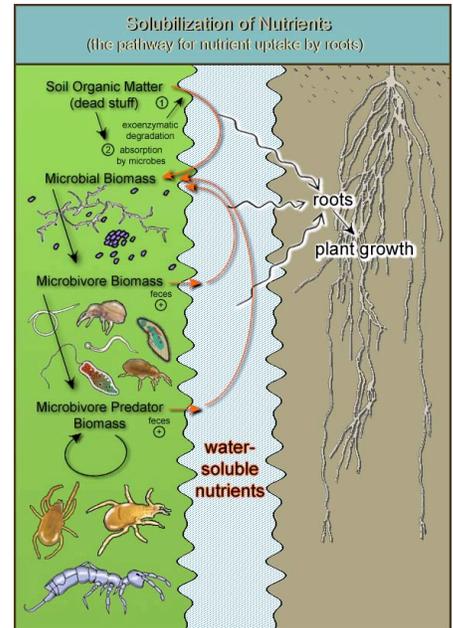
**Soil Ecosystems** - There are millions and millions of microbes naturally present in soil.

The types of microbes in soil

- Bacteria -
- Archaea
- Fungi – lots of fungi in the soil
- Protozoa
- There is a much more diverse microbial communities in soil than fresh and saltwater
- Soil Formation
  - Soil contains both abiotic and biotic components
  - Soil microbes play a major role in nutrient cycling
  - Soil animals – insects and worms break down larger organic components and increase availability for microbes
  - The microbes become food for the small animals



- Roles of microbes in soil include:
  - Breakdown rock particles and convert nutrients such as Phosphorous, Calcium, Manganese, Silica, Zinc, Copper etc. into plant soluble form using acid secretions and hold for later use by the plant
  - Fungal filaments called hyphae act as extensions to the roots. The surface area of the root system becomes much greater allowing for far better access to moisture and nutrients from the soil. This extended root system acts to aerate the soil
  - A number of microbes produce natural plant stimulants like enzymes, vitamins and acids which are necessary for growth and vigor. This reduces the need for Nitrogen.
  - Secretions from different microbes help to form soil aggregates which improves soil structure
- Human Pathogens in Soil- there are a number of human bacterial, fungal, and protozoan pathogens found in soil



### Dry Land Ecosystems

- Cyanobacteria or algae and fungi live in a mutualistic relationship to form lichens
- Lichens are the major producers in the tundra
- They are also play a key role in the taiga



### **SYMBIOTIC RELATIONS** - relationships between microbes and other organisms

**Mutualism** – both the microbes and the other organism benefit

**Commensalism** - microbes that benefit from the relationship but the other organism is not helped or harmed

**Parasitism** – the microbe benefits and the other organism is harmed. A successful parasite does not harm its host enough to kill it or it loses its source of benefit. Disease is an example of microbe parasitism.

**Predation** – the microbe attacks and kills the host. Sometimes there can be beneficial effects of predation

- Use to treat patients with antibiotic resistant bacteria
- Increased rates of nutrient cycling
- Develop a better understanding of pathogens inside the prey – *Legionella* inside of protozoa

## MICROBIAL COMMUNITIES WITHIN PLANTS

Samples of mutualism are

- Methanotrophic organisms and shagnum moss – the methanotrophic bacteria are associated with the moss – the bacteria oxidize methane and release carbon dioxide the moss uses
- **Mycorrhiza**- Fungal symbiotic association with plants which helps plants to absorb phosphorus from soil

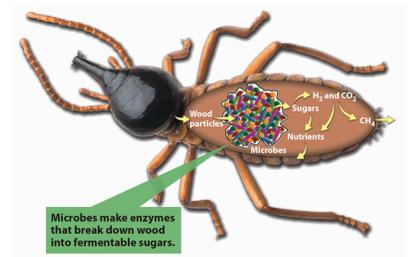
Some examples of commensalism are where the waste products of one organism is utilized by another

- *Nitrosomonas* oxidize ammonium to nitrite
- *Nitrobacter* oxidize nitrite to nitrate
- Bacteria alter their environment and allows other bacteria to grow – organisms in sauerkraut

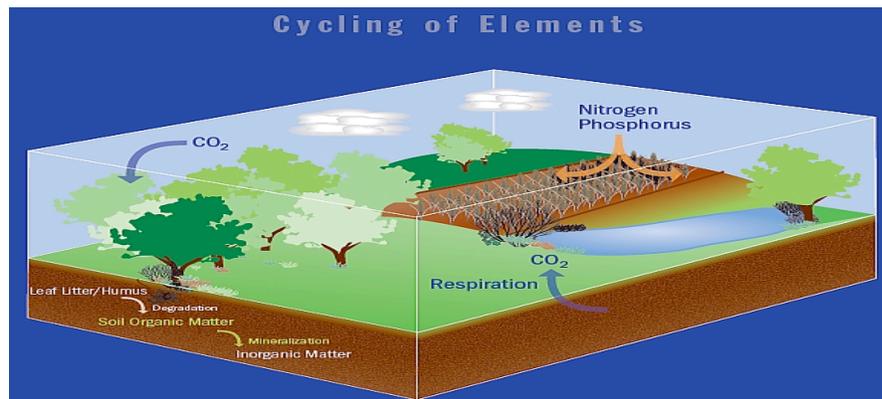
## MICROBIAL COMMUNITIES WITHIN ANIMALS

Samples of mutualism are

- Aphids and *Buchnera aphidicola* live in the cytoplasm of the aphid cells and provide 10 amino acids to the aphid – neither will grow apart - coevolution
- Protozoan – termite relationship – the protozoa breakdown cellulose and release acetate which can be absorbed and used by the termite
- Many marine invertebrates have endosymbiotic dinoflagellates
- Endosymbionts in tube worms fix carbon dioxide by the Calvin cycle and provide fixed carbon for the worms
- Methanotrophic organisms and shagnum moss – the methanotrophic bacteria are associated with the moss – the bacteria oxidize methane and release carbon dioxide the moss uses
- The rumen of ruminants are filled with microorganisms and they help breakdown the plant material the animals eat



- **BIOGEOCHEMICAL CYCLES** - Microbes are key in maintaining ecological balance on Earth



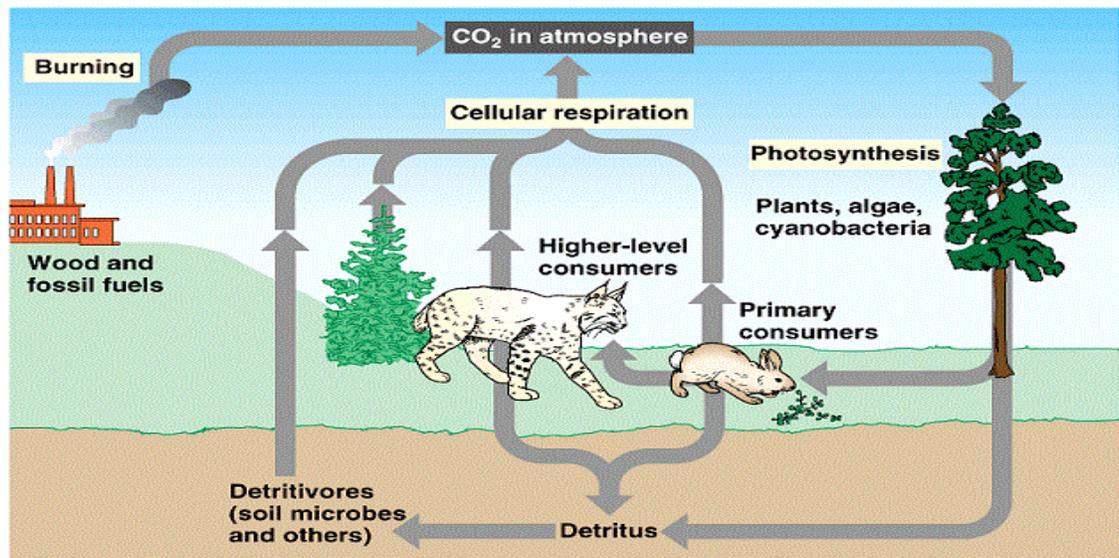
## Oxygen Cycle

- Oxygen is a key element for chemical reactions of aerobic respiration
- Photosynthesis releases oxygen as a product
- Algae and Cyanobacteria along with plants are the key organisms to carry out photosynthesis

## Phosphorus Cycle

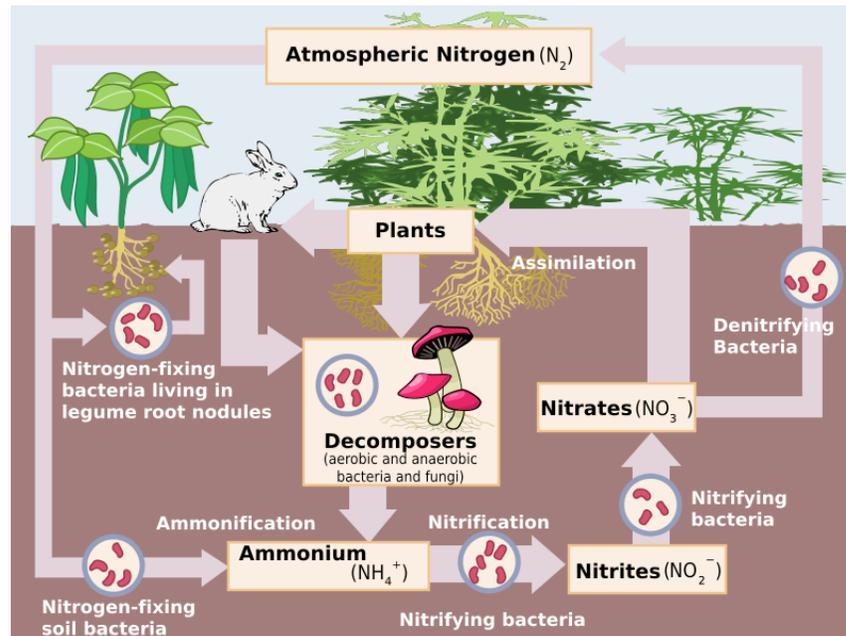
- Microbes use phosphorus in the form of calcium phosphate, magnesium phosphate and iron phosphate
- Phosphorous from these forms are assimilated as phosphate into DNA, RNA, and other organic compounds
- When the organisms are used as food by other organisms, it is released into the food chain
- Decomposers release the phosphates into the soil so it can be absorbed by the plants
- Phosphate is often used in fertilizer and if excess phosphate from fertilizer or industry is drained into water supplies, it can cause algal blooms

## Carbon Cycle



- Cyanobacteria and algae along with plants do the photosynthesis
- The breakdown of organic matter is a major part of the carbon cycle
- Bacteria and fungi are the major decomposers

**Nitrogen Cycle** is primarily a prokaryotic activity



- Bacteria use their metabolic activities during numerous parts of the cycle
- Bacteria and fungi act as **decomposers** of plant and animal matter to form ammonia.
- **Nitrogen fixation** – converting nitrogen gas from atmosphere into ammonia and bacteria fix atmospheric nitrogen in legume root nodules.
- Many bacteria and Cyanobacteria can live apart from legumes and can fix nitrogen in the soil.
- **Nitrification** – Conversion of ammonia to nitrate – Nitrification occurs in soils, water and marine environments where the nitrifying bacteria live.
- **Denitrification** – nitrate is converted into gaseous nitrogen. Numerous types of denitrifying bacteria are involved in reducing nitrates to nitrites to nitrous oxide and then to gaseous nitrogen

### Iron Cycle

- The iron cycle revolves around the conversion of ferrous iron to ferric iron and back again
- Ferric iron reduction is part of the respiratory pathway of some bacteria
- Some bacteria can produce magnetite
- Some bacteria can use ferrous iron as an electron donor

## Sulfur Cycle

- Many bacteria play important roles in the sulfur cycle
- Sulfur compounds are a key part of proteins
- Sulfur-reducing bacteria during decomposition reduce sulfate compounds to hydrogen sulfide
- Photosynthetic sulfur bacteria grow anaerobically and oxidize hydrogen sulfide releasing elemental sulfur
- Species of colorless sulfur bacteria grow in hydrogen sulfide converting the sulfide to sulfate where it is available to plants and then to the rest of the food chain

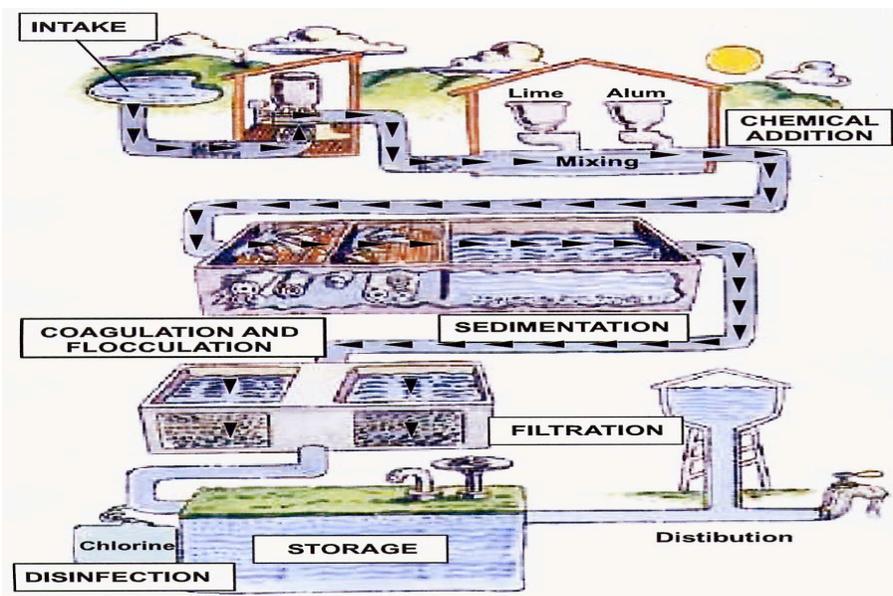
**Metal toxicity** – The toxicity of metals such as mercury or zinc can be enhanced by microbes and end up in the food chain and poison humans

## SPECIAL BENEFITS FROM MICROBES

### Wastewater Management

- Microbes play a key role in drinking water and waste treatment facilities
- Are involved in natural waterways
- Involved in maintaining septic tanks

### Potable water (drinking water) – water purification systems

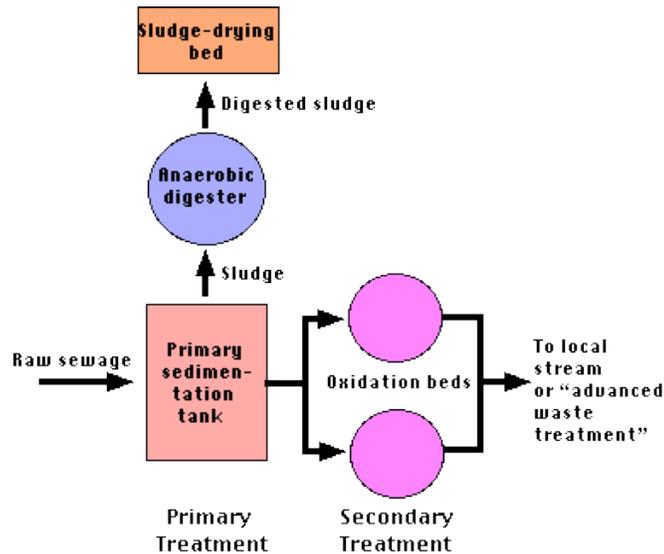


The water is sampled and tested throughout the treatment plant. Sampling is performed to make sure the processes are working and that the water is safe before it leaves the plant. In North America, governments have set standards for drinking water. When water leaves a treatment plant, it is as clean or cleaner than required by these standards.

## Sewage Treatment

Microbes are used in sewage treatment for

- nutrient recycling
- methane recovery
- disease control



**Primary treatment** : The treatment step of sewage for physical removal of particles – large and small – from the sewage through filtration and sedimentation

**Secondary treatment or Biological treatment**: After primary treatment .the primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped associated with fungal filaments to form mesh like structures). **BOD (biochemical oxygen demand)** -BOD refers to the amount of the oxygen that would be consumed if all the organic matter in one liter of water were oxidized by bacteria. **Activated sludge**- Once the BOD of sewage or waste water is reduced significantly, the effluent is then passed into a settling tank where the bacterial ‘flocs’ are allowed to sediment. This sediment is called activated sludge. **Anaerobic sludge digesters**- A small part of the activated sludge is pumped back into the aeration tank to serve as the inoculum. The remaining major part of the sludge is pumped into large tanks called anaerobic sludge digesters where anaerobic bacteria and the fungi digest the sludge. Methane is commonly produced in the sludge tank and it is often burned to fuel the treatment facility. The remaining sludge is burned or buried in a land fill and the fluid is recycled

**Tertiary treatment** – the fluid from the secondary treatment is cleansed of phosphate and nitrate products that could cause pollution before the water is returned to a natural water source.

### **Septic Tank System**

- Home septic tanks are miniature waste treatment facilities
- Household sewage is digested by anaerobic bacteria
- The solids settle to the bottom of the tank and is carried to the drain field
- Water seeps out through holes in the tiles of the drain field where bacteria in the soil complete the breakdown process

### **Oil Spill Cleanup**

- Microbes can breakdown oil from oil spills
- Algae can also be used to produce oil – a potential future solution to oil supply

**Animal Waste Treatment**—Microbes clean up waste from animals as farm animals

**Biofertilizers** – Microbes are used in agriculture to enrich the quality of soil.

**Yard composting** - Microbes function in yard compost piles to convert kitchen and yard waste into rich nutrients for soil

**Municipal composting** – Microbes are used to break down thousands of tons of leaves and grass clippings in municipal compost facilities

**Biocontrol** – Microbes are used to combat pests. A *Bacillus* bacterium produces a toxin that kills over 40 problem pests such as gypsy moths.

**Mining** – Microbes are used in mining of minerals

**Industrial waste** – Microbes are used to breakdown industrial and toxic waste