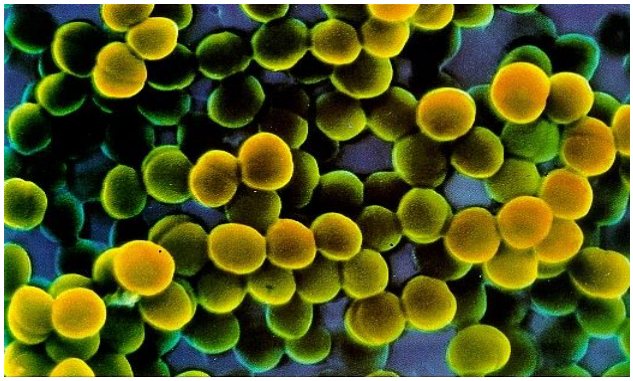
SOIL MICROBIOLOGY: MICROBIAL GROUPS IN SOIL

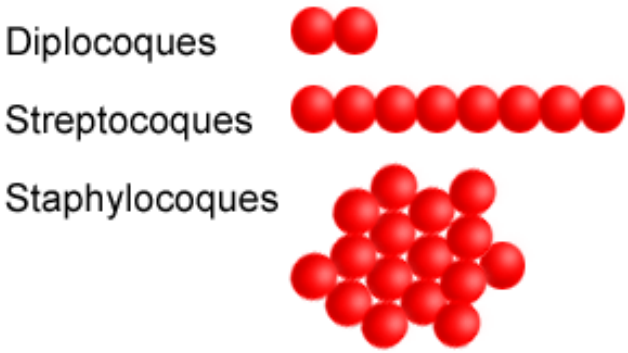
The field of soil microbiology was explored during the very last part of 19th century. The establishment of the principal roles that microorganisms play in the biologically important cycles of matter on earth: the cycles of nitrogen, sulphur and carbon was largely the work of two men, S. Winogradsky (1856-1953) and M.W. Beijerinck (1851–1931). S. Winogradsky, Russian and regarded by many as the founder of soil microbiology, discovered nitryfiying bacteria (1890-91); described the microbial oxidation of H2S and sulphur (1887); developed the contributed to the studies of reduction of nitrate and symbiotic nitrogen fixation; and, originated the nutritional classification of soil microorganisms into autochtonous (humus utilizers) and zymogenous (opportunistic) groups.

Almost equally important was the work of M.W. Beijerinck, a Hollander, who isolated the agents of symbiotic (1888) and non-symbiotic aerobic (1901) nitrogen fixation. However, the greatest contribution of Beijerinck was a new and profoundly important technique: enrichment culture technique: to isolate and study various physiological types of various microorganisms from natural samples through the use of specific culture media and incubation conditions.

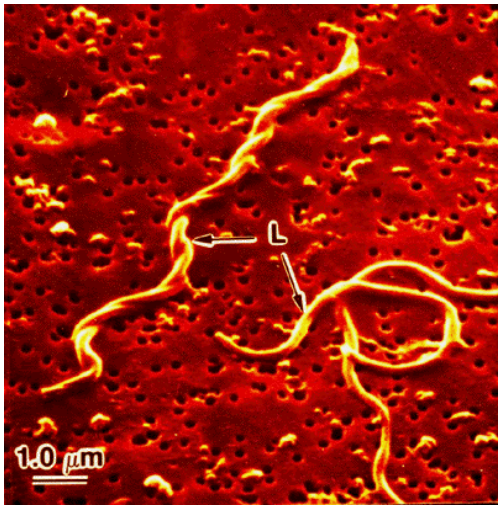
Bacteria- more dominant group of microorganisms in the soil and equal to one half of the microbial biomass in soil. Majority are Heterotrophs. (Common soil bacteria - *Arthrobacter, Bacillus, Clostridium, Micrococcus*).

ROD SHAPED BACTERIA





SPHERICAL BACTERIA



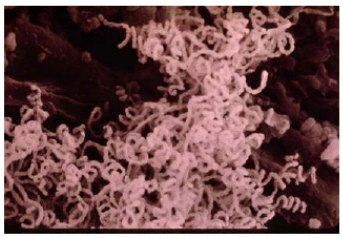
SPIRILLUM

- **Most common soil bacteria:**
  - ***Pseudomonas, Arthrobacter, Clostridium, Bacillus, Micrococcus, Flavobacterium, Chromobacter, Sarcina, Enterobacter***
  - **Myxobacteria: *Myxococcus, Polyangium, Cytophaga* are common in soil**
- **Source of energy:**
  - **Autotrophic**
    - **Energy from:**
      - **Photoautotrophs - *Rhodopsuedomonas***
      - **chemoautotrophs (N, S, Fe) – *Nitrosomonas, Nitrobacter***
    - **C from:**
      - **CO_2 or dissolved carbonates**
  - **Heterotrophic**

- **Most soil bacteria are heterotrophic**
  - **Chemoorganotrophs – N_2 fixers**
  - **Obtain energy and C from OM - general breakdown of OM in soils**
- **Requirements**
  - **Oxygen – aerobe; anaerobe; facultative anaerobe**
  - **pH**
  - **Nutritional**
    - **Oligotrophy: 1-15 mg sol. C/ lit.**
    - **Copiotrophy: 1000 mg sol. C/ lit.**

Actinomycetes - intermediate group between bacteria and fungi. Numerous and widely distributed in soil. Abundance is next to bacteria. 10^4 - 10^8/g soil. 70% of soil actinomycetes are *Streptomyces*. Many of them are known to produce antibiotics. Population increases with depth of soil.

- **Intermediary between bacteria and fungi - have some characteristics similar to bacteria; others similar to fungi**
  - **Are filamentous, but mycelial threads are much smaller than those of fungi (rarely >1µ)**
  - **Are unicellular like bacteria & similar in size; are prokaryotic; often break up into spores – segmentation**
  - **Cell wall composition – no chitin or celluose**



- **Occurrence:**
  - **2nd to bacteria – 10^4 to 10^8 per gram of soil**
- **Generally are aerobic heterotrophs**
- **Requirements**
  - **pH – intolerant to acidity (pH: 6.5 to 8.0)**
  - **Temperature: Optimum: 25-30 °C although Thermophiles at 55-65°C**
  - **Compost heaps: *Thermoactinomyces, Streptomyces***
  - **Order of abundance: *Streptomyces* (70%) > *Nocardia* > *Micromonospora***
  - **Water logging - unfavourable**
- **More drought tolerant than bacteria or fungi – in deserts of arid and semi-arid zones (spores?)**
- **Population percentage – increase with depth – even at Horizon C**

Fungi: More numerous in surface layers of well-aerated and cultivated soils- dominant in acid soils. Common genera in soil are *Aspergillus, Mucor, Penicillium Trichoderma, Alternaria, Rhizopus*.

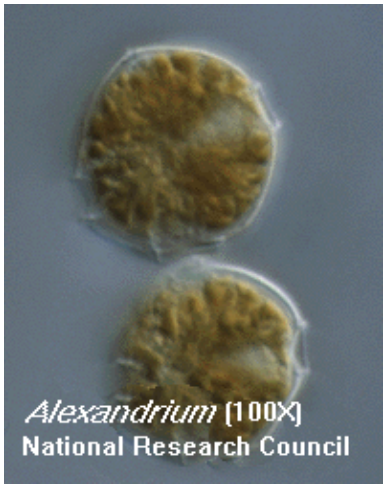
- **Distinctly filamentous, microscopic or submicroscopic**
- **Play an extremely important role in soil OM breakdown**
- **Grow vigorously in acid, neutral and alkaline soils;**
- **may dominate the microflora in acid surface soils**
- **Are especially important decomposers in acid forest soils**
- **Four common genera are: *Penicillium, Mucor, Fusarium & Aspergillus***
- **Complexity of OM seems to determine the particular molds which are prevalent**

- **More or less normal range: 100,000 - 1 million per gram**
- **Mushroom fungi:**
  - **Grow in grass and forested areas with ample moisture & OM**
  - **The above ground fruiting body for most mushrooms is only a small part of the total organism**
  - **An extensive network of hyphae permeates the underlying soil or organic residue**
  - **Largest living organism known is thought to be a fungus growing in the soil in the Pacific northwest**

- **Extremely diverse group of microorganisms**
- **present in soil as mycelial bits, spores, rhizomorphs**
- **Population: few 100s to few million per gram of soil**
- **Tens of thousands of species identified (most do not sporulate on agar media); as many as 2500 at a single location**
- **May dominate the biomass & metabolic activity in many soils**
- **Heterotrophs - depend upon living or dead OM for C & energy**
- **Are aerobic organisms, many can tolerate very low O_2**
  - **Numerous in surface layers of well aerated & cultivated soils**
- **Dominant in acidic soils – also neutral; tolerate pH 9.0**
- **Most common genera:**
  - ***Aspergillus, Mucor, Penicillium, Trichoderma, Cladosporium, Alternaria, Rhizopus, Fusarium, Verticillium, Cephalosporium, Botrytis, Pullularia, Gliocladium, Chaetomium, Pythium***
- **Groups: yeasts, molds & mushrooms**

Algae – found in most of the soils in number ranges from 100 to 10,000 per g.

- **Found in most soils – moisture and sunlight**
- **Most grow best under moist to wet conditions; some are found in hot or cold deserts**
- **Population: 100-10,000 per gram soil**
- **Form scum on soil surface**
- **Unicellular, filamentous or colonial; photoautotrophs**
- **are eukaryotes (nuclei inside cell membrane)**
  - **(1) green algae – dominant in acid soil – also in neutral & alkaline soil –**
    - ***Chlorella, Chlamydomonas, Chlorococcum***
  - **(2) diatoms – highly silicified outer layer – neutral & slightly alkaline soil**
    - ***Achnanthes, Frangilaria, Navicula, Pinnularia***
  - **(3) yellow-green**
- **group formerly called blue-green algae are prokaryotes & are considered with bacteria**
  - **Chlorophyll and phycocyanin – no flagella – no sexual reproduction**
  - **In neutral to alkaline soils**
  - ***Chrococcus, Lyngbya, Oscillatoria, Cylindrospermum, Anabaena, Scytonema, Tolypthrix***



Protozoa: Unicellular – population ranges from 10,000 to 100,000 per g of soil. Most of the soil forms are flagellates, amoebae or ciliates. Derive their nutrition by devouring soil bacteria. Abundant in upper larger of the soil. They are regulating the biological equilibrium in soil.

Importance

- Involved in nutrient transformation process
- Decomposition of resistant components of plant and animal tissue
- Role in microbial antagonism
- Participate in humus formation
- Predator of nematodes
- Surface blooming reduces erosion losses
- Improve soil structure
- Involved soil structure
- Maintenance of biological equilibrium

Factors influencing activities of soil microorganisms

Soil microorganisms are influenced by various factors. Chief factors are,

- fertility level
- Soil moisture
- Soil air
- soil temperature
- Organic matter
- H ion concentration
- Cultural factors