SEM-I: DSC-C-MIC-111T, Introduction to Microbiology

3.2 Agricultural Microbiology

- Soil Microbiology: Contribution of Sergei N. Winogradsky and Martinus W. Beijerinck and development of enrichment culture technique
- Plant Pathology: 'Fire Blight' of pears, 'Peach Yellow' transmission of the viral diseases of plants by insects, discovery of TMV

- Microorganisms play critical roles in nature and in maintaining ecological balance. Understanding the essential roles of microorganisms in environmental processes began in the late nineteenth century with the independent studies of **Martinus Beijerinck** in Netherland and **Sergei Winogradsky**, a Russian who worked mainly in France and Switzerland.
- Their studies linked microbial physiology (activities of microbes, including their metabolism) and microbial ecology (interrelationships of microorganisms with their surrounding environment).
- Martinus and Winogradsky made significant discoveries concerning microbial transformations of inorganic compounds.
- They were primarily concerned with soil processes, but the microbial transformations that they discovered formed the basis for understanding biogeochemical cycling reactions and the critical role of microorganisms in transforming elements on a global scale.
- These microbially mediated cycling reactions are essential for maintaining environmental quality and are necessary for supporting life on Earth.
- Sergei Winogradsky (1856-1953) discovered that certain soil bacteria could take nitrogen from the air and convert this nitrogen into a form that can be used as nutrient for plants.
- He isolated and described the nitrifying bacteria, which are bacteria that covert ammonium ions (NH_4^+) to nitrite ions (NO_2^-) and nitrite ions to nitrate ions (NO_3^-)
- He showed that the nitrifying bacteria are responsible for transforming ammonium ions to nitrate ions in soil, an important process because the change from the positively charged ammonium ion to the negatively charged nitrate ion leads to leaching of nitrate from soil and its loss as nutrient for plants.
- He demonstrated that microorganisms can derive energy from inorganic chemical oxidation reactions such as these, while obtaining their carbon from carbon dioxide.

- Winogradsky also described the microbial oxidation of sulfur, hydrogen sulfide, and ferrous iron and anaerobic nitrogen-fixing bacteria.
- Beijerinck reported on symbiotic and nonsymbiotic aerobic nitrogen fixation by bacteria, the process by which atmospheric nitrogen is combined with other elements to make this essential nutrient available to plants, animals and other microorganisms.
- He also isolated sulfate-reducing bacteria, which are important in they cycling of sulfur compounds in soil and sediments.
- All of these reactions form the basis of important transformations and movements of elements in soil ecosystems and determine the fertility of soil.

Enrichment Culture Technique

- Beijerinck developed the technique of enrichment culture, which permits the isolation of a bacterium with a particular metabolic activity by adjusting incubation conditions.
- Enrichment culture technique – a procedure that greatly 'improves the possibility of isolating special kinds of microorganisms from sources such as soil and water.'
- For example,
- Isolation of **cellulose degrading microbe** from soil, which is the major carbon-containing substance in plants.
- Liquid medium with cellulose added as the only carbon source and dispensed it into a flasks or test tubes.
- Then medium is inoculated with soil, incubated for several days, transferred to fresh medium. This process is repeated several times.
- The microbes which have the ability to use cellulose will increase in numbers (the medium is enriched with this population)
- This procedure is similar to the process of natural selection – the composition of the medium favors the growth of a particular kind of microbe.

Plant Pathology: 'Fire Blight' of pears, 'Peach Yellow' transmission of the viral diseases of plants by insects, discovery of TMV

- Late in the nineteenth century, T. J. Burrill, working in Illinois, found that in pears a disease known as **fire blight** was caused by bacterium *Erwinia amylovora*.
- This discovery opened a new area for microbiology named plant pathology – the study of plant diseases.

- Additional discoveries followed in 1886 **A.E. Mayer** described a mottling disease of the tobacco plant and transmitted it to a healthy plant by transferring sap from an infected plant.
- About the same time, **Erwin F. Smith** of U.S Department of Agriculture transmitted the disease peach yellows from diseased to healthy plant by the process of budding.
- **Dmitri Iwanowski** demonstrated the viral nature of the infective agents of these plant diseases.
- Transmission of virus diseases of plants by insect was suggested by an observant Japanese farmed named Hashimoto in 1894 and independently in 1907 by the American workers **A.B. Ball**, **A. Adams** and **J.C. Shaw** proof that insects could harbor viruses and transmit them from diseased to healthy plants was not provided until 1915 by **E. Smith** and **P.A. Bonquet**.
- The tobacco mosaic virus was isolated in crystalline form in 1935 by **Wendell M. Stanley** and **John H. Northrup.**
- For their valuable contributions to knowledge of the nature of viruses and the crystallization of virus protein, they were awarded the Nobel Prize in chemistry in 1946.

Fire blight of pears

Peach yellow disease