

COURSE SYNOPSIS

MCB 201: GENERAL MICROBIOLOGY I (3 UNITS)

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1. Biology of microorganisms: Nutrition, metabolism, growth and reproduction in microorganisms

❖ Nutritional Requirements

All forms of life, from microorganisms to human beings, share certain nutritional requirements, in terms of the chemicals necessary for their growth and normal functioning.

- a. Source of Energy: microorganisms can be classified as
 - Phototrophs: utilising radiant energy (sunlight) as sole source of energy
 - Chemotrophs: depend on oxidation of chemical compounds for their energy.
- b. Source of Carbon
 - Autotrophs: Carbondioxide is their sole carbon source
 - Heterotrophs: organic form of carbon as the sole source of carbon
- c. Other nutrients: Water, Vitamins
- d. Other elements: Nitrogen, Sulphur, Phosphorus, Sodium, Potassium, Calcium, Magnesium, Manganese, iron, Zinc, Copper, Cobalt.

❖ Conditions for Growth

- a. Temperature: Microorganisms could be classified as:
 - i. Psychrophiles: they are able to grow at 0°C or lower, though they grow at higher temperatures (15°-20°C).
 - ii. Mesophiles: they grow within temperature range of approximately 25°-40°C.
 - iii. Thermophiles: they grow at temperatures between 45° – 60°C. There are some extreme thermophiles that can withstand temperatures about 100°C e.g *Thermus aquaticus*.

Optimum temperature is the temperature of incubation which allows for most rapid growth during a short period of time (12 to 24 h).

- b. pH:
 - i. Acidophiles: they grow at acidic pH
 - ii. Neutrophiles: they grow at neutral pH
 - iii. Alkalophiles: they grow at basic/alkaline pH

For most bacteria, the optimum pH for growth ranges from 6.5 – 7.5.

- c. Oxygen Requirement:
 - i. Aerobes: grow in the presence of free oxygen
 - ii. Anaerobes: grow in the absence of free oxygen
 - iii. Facultative anaerobes: grow either in the presence or absence of free oxygen.
 - iv. Microaerophiles: grow in the presence of minute quantities of free oxygen.

d. Additional requirements:

- i. Halophiles: grow only in medium with unusually high concentration of salt (10-15%) found in brines, salt packs, ocean water and certain foods.

2. Role of microorganisms in nature

❖ How they affect people, property and the environment

Microorganisms are widely distributed in the different habitats available in nature. They are carried by air currents from the earth's surface to the atmosphere. They are found in seas and oceans and they can be transported to high altitudes. They are carried by streams and rivers and found at ocean depths and sea beds. Microorganisms are found abundantly in the soil too.

Microorganisms occur abundantly where they find nutrients, moisture and conditions conducive for their growth and reproduction. These conditions are prevalent everywhere around places humans inhabit and that's why microorganisms are found in the air we breathe, food we eat, on body surfaces, alimentary canal, mouth, nose etc.

Microorganisms can be found in very harsh environments where other life forms could not be found such as salt lakes which have high concentrations of salt and thermal vents which are characterised by exceptionally high temperature.

Microorganisms play several roles in nature that has a wide range of effects on man and the environment, which could be advantageous or detrimental.

Some of the beneficial roles microorganisms play are as follows:

- a. In the production of antibiotics
- b. Production of fermented foods: improved flavours and texture in foods
- c. Bioremediation of metal from ores
- d. Production of alcoholic beverages
- e. Production of milk-based products
- f. Production of organic acids
- g. Production of amino acids and enzymes
- h. Remediation of oil spills
- i. Biodegradation of sewage
- j. Biogas production
- k. Production of bio-fertiliser
- l. Production of microbial pesticides
- m. Production of vaccines

Detrimental roles of microorganisms

- a. Deterioration of food/Food spoilage
- b. Food borne diseases

- c. Degradation of food materials
- d. Cause animal diseases
- e. Cause plant diseases
- f. Degradation of industrial materials

❖ **Broad aspects of Host-Parasite relationships**

3. Public Health

❖ **Bacterial Diseases**

- Tuberculosis: caused by *Mycobacterium tuberculosis* which spreads through droplets. *M. bovis* cause tuberculosis in cow and cattle. Diagnosis is by isolation of the bacterium, chest X-ray, DNA probe, HPLC test and Mantoux (Tuberculin) test. Treatment is by administering isoniazid plus rifampicin, ethambutol, and pyrazinamide.
- Diphtheria: caused by *Corynebacterium diphtheriae* and this is inhaled through droplets. The organism produces exotoxin which inflames the respiratory mucosa. Diagnosis is by culturing the organism on pseudomembrane in throat. Treatment is by Penicillin and Erythromycin.
- Pertussis: caused by *Bordetella pertussis* and is characterised by whooping cough. Diagnosis is by culturing the bacterium, fluorescent antibody and serological test. Treatment is by chloramphenicol, tetracycline or erythromycin. Vaccination with DPT vaccine is also done to prevent the disease.
- Tetanus: caused by *Clostridium tetani*, and characterised by a muscle spasm called “lock jaw”. It is prevented by using tetanus toxoid and antitoxin and penicillin are used as prophylaxis.
- Cholera: caused by *Vibrio cholerae*. It is characterised by loss of water and electrolyte from the body and results in vomiting, abdominal cramps, fever and watery diarrhoea. Diagnosis is by culturing faeces and agglutination reactions. For treatment, patients are rehydrated with ORT (salt and sugar solution) and antibiotics such as tetracycline, trimethoprim, sulfamethoxazole or ciprofloxacin.
- Syphilis: Venereal syphilis is a sexually transmitted disease while congenital syphilis is acquired by newborns from the mother in uterus. It is caused by *Treponema pallidum* Diagnosis is by clinical history, physical examination and immunofluorescence examination of fluids from lesions. Several serological tests can be used to detect the antigen including the Wassermann test. Prevention is by public education, prompt treatment of new cases and prophylaxis.

❖ **Mycotic Diseases**

Fungal diseases can either be mycoses (caused by infection) or toxicoses (caused by toxic fungal metabolites).

Examples of Mycotic diseases are as follow:

a. Candidiasis: This is an acute or chronic superficial infection caused by *Candida albicans*. Other species associated with one or more clinical types of candidiasis is *C. parapsilopsis*, *C. tropicalis*, *C. stellotoidea*, *C. krusei*, *C. guilliermondii* etc.

Candidiasis could be manifested as oral candidiasis, bronchocandidiasis, pulmonary candidiasis, endocarditis and meningitis.

Though the disease could subside with therapy, treatment could be by Nystatin in form of ointment or cream for topical application. Sodium carprylate, sodium or calcium propionate, gentian violet, amphotericin-B are also used for treatment of candidiasis.

b. Dermatophytosis: It is also called Dermatormycosis. It is a superficial infection on the keratinised parts of the body such as skin, nails and hairs. They are caused by species of *Epidermophyton*, *Tricophyton* and *Microsporum*.

The scaly annular skin lesions caused by dermatophytes are called Tinea. Tinea are classified according to the parts of the body they affect.

- i. Tinea pedis: ringworm of the foot (athletes foot) caused by *T. rubrum*, *T. mentagrophytes*, *E. floccosum*.
- ii. Tinea capitis: ringworm of the scalp (hair) caused by *T. tonsurans*, *T. mentagrophytes*, *M. Audouinii*, *M. canis*
- iii. Tinea corporis: ringworm of non-hairy skin of the body caused by *T. rubrum*, *T. mentagrophytes*, *M. canis*
- iv. Tinea unguium: ringworm of the nail caused by *T. rubrum*, *T. mentagrophytes*,
- v. Tinea barbae: ringworm of the beard caused by *T. verrucosum*, *T. mentagrophytes*,
- vi. Tinea cruris: ringworm of the groin caused by *T. schoenleinii*, *T. violaceum*, *M. Gypseum*

c. Aspergillosis: It is caused primarily by *Aspergillus fumigatus*. It is an occupational disease which occurs in the sinuses, bronchi, lungs and other parts of the body and is important among those who are immunocompromised.

It could be pulmonary aspergillosis, myocarditis, otomycosis or bronchopulmonary aspergillosis.

Treatment is with Sodium iodide intravenously, potassium iodide orally and amphotericin B.

Other fungal diseases are caused by *Cryptococcus neoformans*, *Coccidioides immitis*, *Blastomyces dermatidis*, *Histoplasma capsulatum*

❖ Viral Diseases

- Measles: caused by Morbillivirus of family *Paramyxoviridae*. Symptoms are nasal discharge, cough, fever, headache and conjunctivitis. Diagnosis can be by observing bright-red lesions called koplik's spots on the oral cavity. Vaccination with attenuated measles vaccine (Attenuvax) is used. There is no specific treatment for measles.

- Acquired Immune Deficiency Syndrome (AIDS): caused by Human Immunodeficiency Virus (HIV), which is a lentivirus in the family Retroviridae. Transmission is by sexual contact, sharing sharp objects with infected persons, blood transfusion, and by mother-to-child transmission. Preventing is by avoiding contact with infected objects, blood or sexual intercourse with infected person. Attempts are being made to develop a vaccine but antiretroviral drugs are being used to manage the condition.

❖ Epidemiology

Epidemiology is the science that deals with the occurrence, determination, distribution and control of disease. The study of infectious disease is very important to public health. Infectious diseases is any change in a state of normal health in which part or the whole body of the individual does not function properly due to the presence of an infectious agent or its products.

When a disease occurs occasionally and at irregular intervals in a human population, it is called a sporadic disease e.g. typhoid. A disease maintaining a steady, low level frequency at a regular interval is called endemic disease. An epidemic is a sudden increase in the occurrence of a disease beyond limit while Pandemic is if the occurrence of disease increase within a large population over a wide region.

- Characteristics of Infectious Disease
- Disease Cycle
- Transmission of Pathogens
- Control of Infectious Disease

4. Ecology of Soils and Water

❖ Soil is the outer region of the earth crust consisting of loose material formed by gradual weathering of rocks and gives plants both mechanical and nutritional support. Soil is a unique habitat which harbours a variety of microflora and fauna. Microorganisms which live in soil include

- Algae such as *Anabaena*, *Calothrix*, *Oscillatoria*, *Aulosira*, *Nostoc*, *Scytonema*, *Tolypothrix* etc. They serve as cyanobacterial biofertiliser and also in reclamation of sodic soils.
- Bacteria: they are the most abundant group in soil being as much as 10^{10} cells per gram of soil. They could be autochthonous or allochthonous. They help in organic matter decomposition, biotransformation, biogas formation, nitrogen fixation etc. Examples are *Agrobacterium*, *Arthrobacter*, *Bacillus*, *Alcaligenes*, *Clostridium*, *Corynebacterium*, *erwinia*, *Nitrosomonas*, *Nitrobacter*, *Pseudomonas*, *Rhizobium*, *Thiobacillus* etc.
- Actinomycetes: Gram positive bacteria that share some characteristics of fungi. They are known to impart the earthy odour of newly wetted soils by their volatile growth products. They also release antibiotics. Examples are *Actinomyces*, *Actinoplane*, *Micromonospora*, *Microbispora*, *Nocardia*, *Streptomyces*, *Thermoactinomyces*.
- Protozoans: they regulate the number of bacteria by preying on them and eating them.

- v. Nematodes: they derive nutrients for their growth and reproduction from the cell contents and cytoplasm of protozoa, bacteria, fungi, etc. Examples are *Colpoda*, *Cercomonas*.
- vi. Fungi: *Aspergillus*, *Alternaria*, *Metarrhizium*, *Cladosporium*, *Helminthosporum*.

❖ Water is important to life. It is an essential part of protoplasm and creates a state for metabolic activities to occur smoothly. About 75% of the earth surface is covered by water.

Water receives microorganisms from air, soil, sewage, organic wastes, dead plants and animal. Majority of bacteria found in water belong to

- Fluorescent e.g *Pseudomonas* and *Alginomonas*
- Chromogenic e.g *Xanthomonas*
- Coliform e.g *E.coli*, *Aerobacter*
- *Proteus*
- Spore formers e.g *Bacillus*
- Pigmented and non pigmented cocci e.g *Micrococcus*

Water borne pathogenic microbes include *Vibrio cholera*, *Yersinia enterocolitica*, *Pseudomonas aeruginosa*, *Aeromonas hydrophilia*

➤ Environmental Pollution

The environment is constantly polluted by heavy metals and petroleum products. Soil microorganisms function as biogeochemical agents for the mineralisation of organic carbon, nitrogen, sulphur, phosphorus and other compounds.

Many microorganisms have been used to produce improved quality and variety of products for improved livelihood of humans. They are involved in solving environmental problems by:

- i. Degrading solid wastes (Lignocellulosics) into compost
- ii. Degradation of pesticides: *Proteus vulgaris*, *Clostridium sporogenes*
- iii. Degradation of heavy metal wastes and industrial effluent: *Escherichia coli*, *Staphylococcus aureus*
- iv. Treatment and Degradation of sewage sludge e.g *Spirulina platensis*, *Chlorella pyrenoidosa*, *Beggiatoa alba*, *Achromobacter* spp
- v. Degradation of petrol and other petroleum pollutants: *Pseudomonas putida*
- vi. Bioremediation of ores e.g *Thiobacillus ferrooxidans*, *Desulfotomaculum*

5. Systematic classification of microorganisms

Classification of microorganisms are done based on several criteria

i. Morphological

- Shape and Arrangement

Spherical: They are ellipsoidal cells called cocci (singular: coccus). The particular pattern is characteristic of particular bacteria.

Diplococci is arranged in pairs. Streptococci are arranged in chains. Tetrads are arranged in two planes characteristic group of four cells. Staphylococci are

irregular pattern in bunches. Sarcinae in a regular pattern producing a cuboidal arrangement.

- Cylindrical cells; they are rodlike (singular: bacillus; plural: bacilli). Diplobacilli arranged in pairs and Streptobacilli arranged in chains, palisade arrangement grouped like matchsticks.
- Spiral-shaped bacteria (singular: spirillum, plural: spirilla) occur as unattached cells with characteristic spiral shape and rigid cell wall. Short incomplete spirals are called comma bacteria or vibrio.

ii. Genetic Relatedness

This classification is based on DNA and RNA relatedness between organisms. The % G+C determines whether the organisms are similar or differ. If two organisms have different %G+C, then they are likely to be different. Genetic relatedness could be achieved by:

- i. DNA-DNA Hybridization/DNA Homology. If DNA from two organisms are similar, pairing will occur in the DNA strands when mixed, if not they are not of the same species.
- ii. 16S rRNA Sequencing: Ribosomal RNA homology and ribosomal RNA cataloguing determine the molecular characteristics and can be used to demonstrate the degree of relatedness.

iii. Biochemical reactions

- Gram reaction: The response of bacteria cell wall to gram staining is able to classify the organism as either Gram positive or Gram negative.

- Assimilation of sugars