Myke® Pro Mycorise®		www.premiertech.com
PLantmate®	*Trichoderma* spp.	Agrimms Technologies Ltd, www.vinevax.com
Promote®	Ectomycorrhizal fungi *(Pisolithus tinctorius)*	JHBiotech Inc. California, USA www.jhbiotech.com
Rhizanova	Mycorrhizal fungi	Becker-Underwood Inc., USA www.beckerunderwood.com
Rootgrow, Rootgrow Professional	Mycorrhizal fungi	PlantWorks Ltd., United Kingdom www.plantworksuk.co.uk
Soil Moist™	Ectomycorrhizal fungi Endomycorrhizal fungi	JRM chemical, Inc. Ohio, USA www.soilmoist.com
Superzyme	*Trichoderma* spp.	JH Biotech. Inc., Ventura. CA. USA www.jhbiotech.com
Tricho*	*Trichoderma* spp.	Agrimms Technologies Ltd, www. vinevax.com

10.9. MEDICAL MYCOLOGY

Medical mycology is the study of fungi as human and animal pathogens. Fungi are mostly the pathogens of plants. There are comparatively few species that are pathogenic to humans. However fungi affect human beings also. The fungal diseases of animals including human beings are called as **mycosis.** The diseases are relatively few but the fungi that cause the diseases have a wide host as well as geographical range. Most of the diseases are not fatal but once contracted, they may be the source of constant irritation leading to permanent scaring.

The fungal human fungal pathogens can be classified according to the type of infection :

1. **Superficial infection**—which are caused by fungi that attack the skin or its appendages like nails, feathers, hairs, etc. These fungi are called as **dermatophytes.**
2. **Systemic infection**—which occur deep within the tissues involving vital organs and even nervous systems. This infection may be fatal or may be chronic. The fungi are transmitted through blood circulation or respiratory system.
3. **Intermediate infections**—where the infection occurs below the skin but remains localized.

The fungal diseases however can be clinically grouped as :

(a) Superficial Mycoses

These are superficial infections of the skin or hair shaft. No living tissue is invaded and here is no cellular response from the host. These infections are often so insignificant that the patients are unaware of their condition.

Disease	Causative Fungal Pathogen	Incidence
(*i*) Pityriosis versicolour, Seborrhoeic dermatitis including dandruff and follicular pity riasis	*Melassezia furfur* (a liprophilic yeast)	Common
(*ii*) Tinea nigra	*Exophiala wernecki*	Rare
(*iii*) White priedra	*Trichosporon bigelii*	Common
(*iv*) Black piedra	*Piedraia hortae*	Rare

(*b*) Cutaneous Mycoses

These are superficial fungal infections of skin, nails or hair. No living tissues are affected however a varieties of pathological changes may be observed in the host due to the presence of the infectious fungi and their metabolic products.

Disease	Causative fungi	Incidence
(*i*) Dermatophytosis, Ringworm of scalp, Glabrous skin and nails	*Microsporum* spp. *Trichophyton* spp. *Epidermophyton* spp.	Common
(*ii*) Candidiasis of skin Mucous membrane and nails	*Candida albicans* and related species	Common
(*iii*) Dermatomycosis	Non-dermatophytic moulds— *Hendersonulla toruloidae, Scytalidium hayalium, Scopulariopsis brevicaulis*	Rare

(*c*) The Subcutaneous Mycoses

These are chronic, localized infections of skin and subcutaneous tissue. The causative fungi are all soil saprophytes. They adapt to the tissue environment and elicit the disease.

Disease	Causative fungi	Incidence
(*i*) Sporotrichosis	*Sporothrix* spp.	Rare
(*ii*) Chromoblastomycosis	*Fonsecacea, Phialophora, Cladophialophora* spp.	Rare
(*iii*) Phaeohyphomycosis	*Cladophialophora* sp., *Exophiala, Bipolaris, Exserohilum, Curvularia,* spp.	Rare
(*iv*) Mycoticmycetoma	*Pseudallescheria, Madurella, Trematosphaeria, Acremonium,*. *Exophiala* spp.	Rare
(*v*) Subcutaneous zygomycosis (Entomophthoromycosis)	*Basidiabolus ranarum Conidiobolus coronatus*	Rare
(*vi*) Subcutaneous zygomycosis (Mucormycosis)	*Rhizopus, Mucor, Rhizomucor, Lichtheimia, Saksenaea* spp.	Rare
(*vii*) Rhinosporidiosis	*Rhinosporidium seeberi*	Rare
(*viii*) Labomycosis	*Loboa loboi*	

(*d*) Dimorphic Systemic Mycosis

These are the fungal infections of the body due to dimorphic fungal pathogens. The pathogens over come the physiological and cellular defences of the body by changing their morphological form. Their primary sites of infections are usually the pulmonary track due to inhalation of the conidia.

Disease	Fungal Pathogen	Incidence
Histoplasmosis	*Histoplasma capsulatum*	Rare
Coccidioidomycosis	*Coccidioides immitis*	Rare
Blastomycosis	*Blastomyces dermatitidis*	Rare
Paracoccidioidomycosis	*Paracoccidioides-brasillensis*	Rare

These are common in endemic areas.

(*e*) Opportunistic System Mycoses

Such type of infections occur in the human beings whose immune system is weak. The organisms involved are cosmopolitan in occurrence. The incidence of the disease is more common in AIDS patients, patients having aggressive cancers, post transplantation, chemotherapy, excess use of antibiotics etc. which have reduced the immunity.

Disease	Fungal Pathogen	Incidence
(*i*) Candidiasis	*Candida albicons*	Common
(*ii*) Cryptococcosis	*Cryptococcus neoformans*	Rare/Common
(*iii*) Aspergillosis	*Aspergillus fumigatus*	Rare
(*iv*) Pseudallescheriasis	*Scedosporium, Pseudallescheria*	Rare
(*v*) Zygomycosis (Mucormycosis)	*Rhizopus, Mucor, Rhizomucor, Lichtheimia*)	Rare
(*vi*) Hyalohyphomycosis	*Penicillium, Paecilomyces, Beauveria, Fusarium, Scropulariopsis*	Rare
(*vii*) Phaeohyphomycosis	*Cladophialophora, Exophiala, Pripolaris, Exserohillum, Curvularia*	Rare

Successful treatment of fungal diseases is difficult than the bacterial diseases. It is because the bacteria are prokaryotic and their cell make ups are different from the human cells. But fungi are eukaryotic like our cells. So it is difficult to find a suitable chemical that kills the fungi without affecting our eukaryotic cells. Compared to other pathogens fungi are evolutionarily close to humans which limits the scope of drug discovery and development.

The introduction of echinocandins and the third generation triazoles (voriconazole and posaconazole) has improved the therapeutic choices for fungal diseases. But there are many other problems and the successful cure is yet to be achieved. It is therefore suggested to take precautionary measures to avoid fungal infections.

10.10. GENETIC ENGINEERING ON FUNGI

The recombinant DNA technologies in fungi has led to over production of limiting enzymes of important biosynthetic pathways thereby increasing the production of final products.

(*i*) Brewing yeasts have been engineered in order to overcome several problems. A gene for endoglucanase from *Trichoderma reesi* has been cloned and introduced to yeast cell. This hydrolyzes the barley β-glucans which reduce the filterability of beer and helps in quality improvement.

(*ii*) A new strain of *S. cerevisiae* is developed to utilize starch producing lower acidity and enhancing flavour.

(*iii*) Brewing yeasts have also been engineered to produce acetolactate decarboxylase from *Enterobacter aerogenes* and *Acetobacter aceti* which has reduced the fermentation period and maintains the quality and flavour of beer.

(*iv*) Lower acidity and enhanced flavour in wine has been achieved by transformation of wine yeast with the genes encoding the malolactic conversion enzyme from *Lactobacillus delbrueckii*.

(*v*) Similar technologies have been used to improve the enhanced production of antibiotics. Replacement of a native promoter ACVS-encoding gene in *A. nidulans* increased penicillin production 30 fold. Transfer of gene from *Streptomyces clavuligerus* and from *A. chrysogenum* to *Penicillium chrysogenum* has developed recombinant strains for production of cephalosporins.

(*vi*) Thaumatin is a protein with intense sweetness (3000 times that of sucrose) and is obtained from plant *Thaumaticoccus danielli*. Expression of thaumatin has been done in *Penicillium roqueforti* and *Aspergillus niger* var *awamori* for its production.

Now there are progresses in modifying the biosynthetic pathways in fungi so that non-fungal production can be expressed in filamentous fungi for industrial production. Fungi are now screened and designed to degrade the toxic chemicals, pesticides, petroleum products in the environment. Peroxidase enzymes of *Penicillium crysosporium* and *Streptomyces* species have potential biodegradable activities. Fungi can also be used for recovery of metals, bioremediation, biomineralization processes in industrial areas.

The future of fungi in biotechnology is prominent and encouraging. Only 5% of the total fungal species have been used now for different uses. There are many species in soil and marine environment not yet explored. The hidden potentials of fungal population if explored and designed can solve many global challenges. As more functions are revealed by functional genomics and bioinformatics new targets will become available for screening fungal products.

A. LONG ANSWER QUESTIONS

1. Give an account of role of fungi in alcohol and food industries.
2. Discuss the role of fungi in production of medicine and proteins.
3. Write briefly about fungal biofertilizers.
4. Give an account of mycofungicides and mycoinsecticides.
5. Write an essay on fungi as biocontrol agents.
6. Discuss the role of fungi in biotechnology.
7. Give an account of fungi in industrial production of organic acids and enzymes.
8. Briefly write on fungi and human diseases.

B. SHORT ANSWER QUESTIONS

Write notes on :

1. Mycofungicides
2. Myconemeticides
3. Mycoinsecticides
4. Fungal biofertilizers
5. Fungi in cheese production
6. Organic acid production by fungi
7. Fungi in beer, wine production
8. Medical mycology.