DC-I
Semester-II
Paper III : Mycology and Phytopathology

Unit-I
Lesson: The World of Fungi and Their Significance
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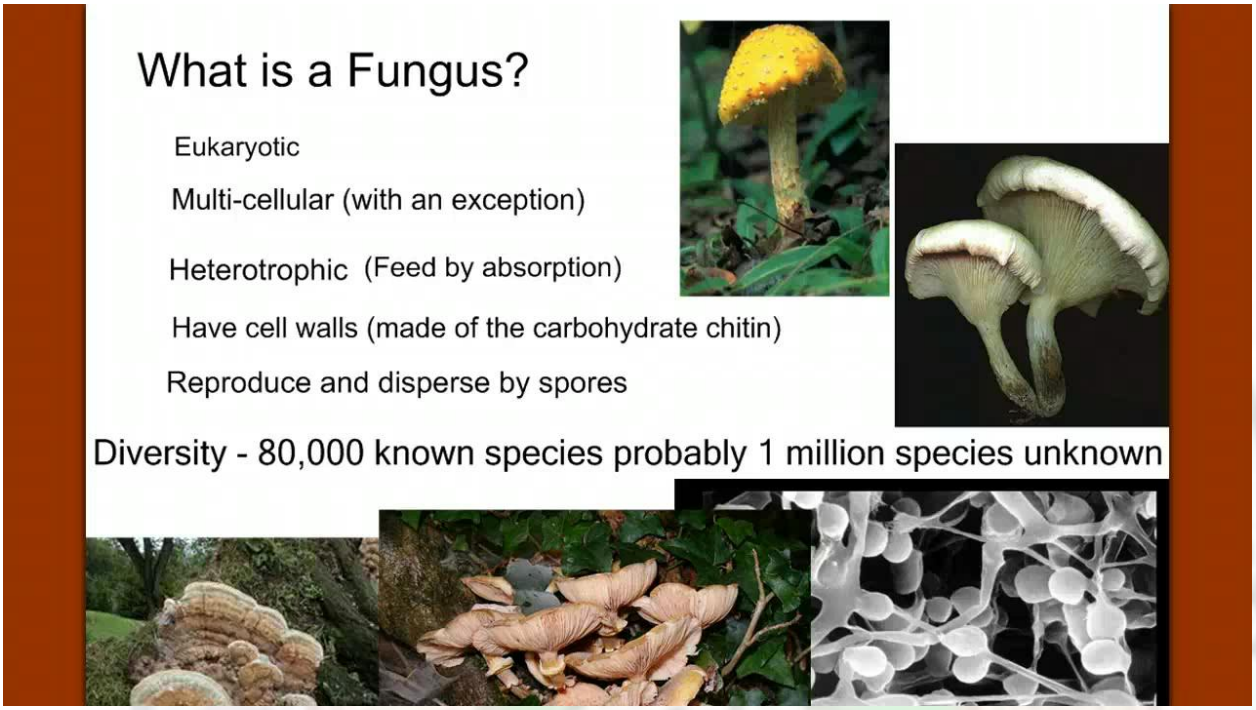
Introduction



Source: http://www.youtube.com/watch?v=p-kQ_I6aSAA

Fungi are a large group of eukaryotic organisms, with distinctive behaviour. Study of fungi is termed **mycology** (Gr. *mykes* = mushroom; *logos* = discourse). Etymologically, mycology is the study of mushrooms, as these gained attention in the past from naturalists because of their large size and eye-catching appearance, before the microscopes or even simple lenses had been thought of. It was only after the discovery and systematic use of microscopes by **Robert Hooke,** an English natural philosopher and **Antonie van Leeuwenhoek,** a Dutch tradesman and scientist, that existence of microorganisms came into the light in 17th century. Teliospores of *Puccinia mucronatum* were among the first fungal spores illustrated by Robert Hooke in 1667 soon after the invention of the microscope and **van Leeuwenhoek** first observed bacteria and protozoa in 1674.

Fungi, together with bacteria and protists are the prominent decomposers of dead and decaying organic matter on earth. This kingdom has a wide range of morphologies, ranging from small amoeba-like protists and single-celled aquatic chytridiomycetes to large basidiomycete mushrooms, variable ecologies and life histories.

Definition of Fungi

Biologically fungi can be defined as "**eukaryotic, achlorophyllous, characteristically mycelial, exhibiting heterotrophic absorptive nutrition and reproducing by both asexual and sexual spores.**" This definition explains the majority of the characters of fungi, but in recent years, it has become increasingly apparent that the organisms traditionally referred to as fungi are not closely related.

Fungi and its similar groups e.g., water moulds, belonging to Kingdom Straminipila, slime moulds and related species of Kingdom Protista constitute a very large group of organisms prevalent in every nook and corner of the world. In a nut shell, a mycologist includes small unicellular yeasts, moulds, filamentous fungi, mushrooms, lichen fungi, slime moulds, and members of Oomycota in his study of fungi.

Types of fungi

Five major groups of fungi are recognized on the basis of their sexual reproductive characters:

Chytridiomycota (chytrids) - Reproduce by producing flagellated zoospores

Chytridiomycota- Sexual and asexual spores motile with posterior flagella.

Zygomycota- Sexual spores are thick walled. Resting spores are called **zygospores.**

Ascomycota – Spores borne internally in a sac called ascus and are known as ascospores.

Basidiomycota- Spores borne externally on a club-shaped structure called a basidium known as basidiospores.

Table: An example of how the fungi are classified

Taxon	Termination	Example
Kingdom		Fungi
Division	-mycota	Basidiomycota
Subdivision	-mycotina	Basidiomycotina
Class	-mycetes	Basidiomycetes
SubClass	-mycetidae	Basidiomycetidae
Order	-ales	Boletales

SubOrder	-inae	Boletinae
Family	-aceae	Boletaceae
SubFamily	-oideae	Boletoideae
Tribe	-eae	Boleteae
SubTribe	-ineae	Boletineae
Genus	Genus have no standard endings	*Durianella*
Species	-Do-	*Echinulata*

Value addition: Did you Know?

- *One of the greatest civilizations, the Mycenaean, may have been named for a legendary mushroom.*
- ***R. Hooke** published a book Micrographia, in 1665. He devised the compound microscope and illumination system.*
- ***Antonie van Leeuwenhoek** is considered the father of microscopy because of the advances he made in microscope design and use. He is commonly known as "the Father of Microbiology", and considered to be the first microbiologist.*
- ***Pier' Antonio Micheli** a noted Italian botanist in 1679, deserves the honour to be called as the **founder of the science of mycology***
- At present, nearly **80,000** species of fungi have been named. However, recent estimates suggest that total number of species worldwide may be **1.5million** that means only approximately 5% of the fungi have been defined so far.
- **This discrepancy between the numbers of known verses estimated species is due to** inadequate studies of fungi in many parts of the world, specially from tropical and subtropical regions.
- **Apart from ethical reasons, necessity of reporting all fungi from tropical and subtropical parts of the world rests in** their importance in **bioprospecting**, i.e. survey of natural ecosystems for economically valuable biotic products. Such products might include certain novel edible fungi, significant enzymes for biotechnology industries, metabolites for pharmaceuticals, or potential biological agents etc.

Author

Who is a mycologist?

*You are a **mycologist** if you study various biological features of fungi, including their physiology, genetic constitution, ecology, systematics, taxonomy, pathology, evolution and molecular biology.*

In Which Fields a Mycologist can play a role?

He can be a:

- ***Plant Pathologist -** one who study diseases caused by fungi, bacteria, viruses and other microorganisms.*
- ***Mushroom Scientist –** one who cultivate edible mushrooms and seek to improve the strains and methods used to cultivate them.*
- ***Timber Technologist –** one who study decay of timber.*
- ***Food Microbiologist or Food Engineer –** one who studies spoilage of food, all aspects of the microbiology of food, i.e. science that deals with microorganisms involved in spoilage, contamination and preservation of food.*
- ***Food Technologist –** one who study various aspects of fermentation and baking including production of a variety of foods and also is involved in research in brewing science.*
- ***Veterinary mycologist –** one who study diseases in man and domestic animals.*

Besides these, a mycologist can venture into some other disciplines, such as Microbial Ecology, Molecular Mycology, Environmental Mycology, Lichenology, Human Pathology, and Pharmacology.

Economic Importance of Fungi

Fungi are known to have a variety of enzymes involved in decomposition of organic products, so may cause destruction, thus creating nuisance. They may target clothes, waxes containers, leather, insulating material of cables and wires, paint, jet fuel, photographic film, and also the layer of the lenses of photosensitive equipment - in fact, almost any possible substance. The two most important requirements of the fungal growth are temperature and humidity. Thus, they can grow on dough preparations, meats, fruits, vegetables etc. rendering them tasteless and **decreasing their nutritional value.**

Fungal activities can be both useful as well as harmful.

Useful Activities of Fungi

Decomposition and Nutrient cycling

The fungi and heterotrophic bacteria along with some other organisms are considered as the **decomposers** of the biosphere. They are equally important as primary producers in sustainable functioning of the biosphere. Thus they act as a significant links in the food webs existing in any ecosystems. Being heterotrophic, they are totally dependent on organic material (living or dead) for their energy requirement. Since fungi are able to decompose dead and decaying material into simpler compounds, they are excellent scavengers in nature. These simpler compounds can be easily assimilated by other members of the ecosystem. So, in the absence of fungi, complex organic materials like wood would not be broken down, making it harder for some insects and animals to digest it.

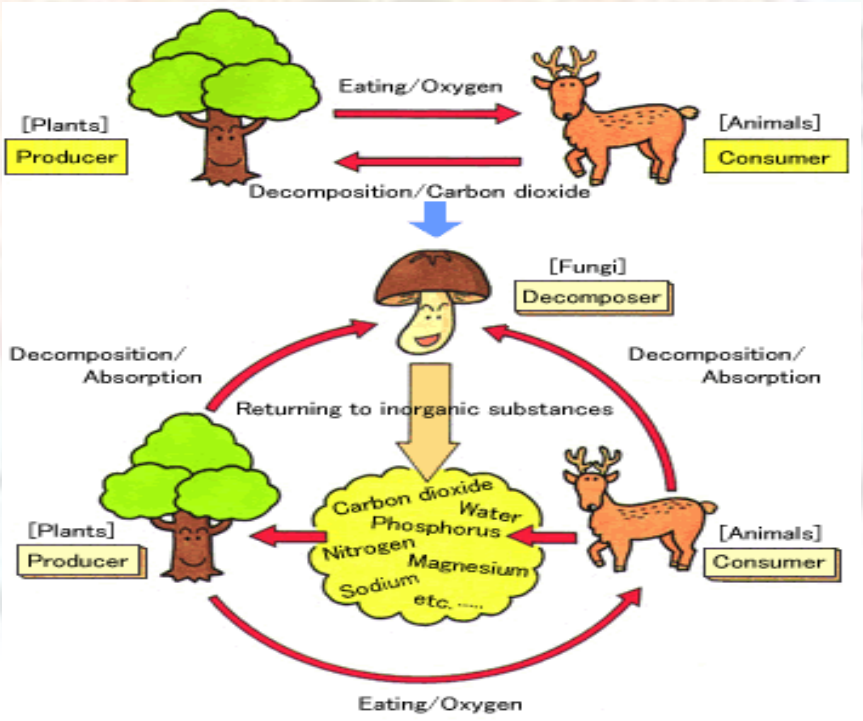


Figure: Role of fungi as a decomposer in nutrient cycling

Source: http://fungi-cys04.wikispaces.com/file/view/fungi.gif/284066556/fungi.gif

Decomposition not only gives carbon dioxide back into the atmosphere but also returns nitrogen and some other components to the soil where they can be used again by the green plants and ultimately by the animals. Plants growing in soils where decomposition activity is not taking place will show deficiency symptoms for the major nutrients which are being provided to them free by the activities of fungi. For example species of *Alternaria, Aspergillus, Cladosporium,Mucor, Penicillium,Rhizopus*etc. are indispensable for achieving sustainable development as they play pivotal role in the process of **biodegradation.**

A B

Figure: Fungi growing on bark (A) and plant debris.

Source:A-http://static.newworldencyclopedia.org/d/d4/Fungi_in_Borneo.jpg,B http://cnx.org/content/m44632/latest/Figure_24_03_01.jpg

Chemical Changes During Decomposition At A Glance

(i) Cellulose $\xrightarrow[\text{Cellulase}]{\text{enzyme}}$ Cellobiose

(ii) Cellobiose $\xrightarrow[\beta\text{-glucosidase}]{\text{enzyme}}$ Glucose

(iii) Glucose $\xrightarrow[\text{Of many microbes}]{\text{Enzyme system}}$ $CO_2 + H_2O$ + and/or other end products

Wood Decay Fungi

A fungus digesting moist wood, causing it to decay is referred to as **wood-decay fungus**. Some act on dead wood (brown rot), and some, like *Armillaria* (Honey fungus), parasitize and colonize living trees. Fungi that decay the wood on which they are growing are called **lignicolous** fungi.

On the basis of type of rot, wood-decay fungi cause they are of following types:

Brown rot Fungi

These break down hemicellulose to release hydrogen peroxide (H_2O_2) which futher breaks down cellulose. Because H_2O_2 is a small molecule and diffuse rapidly through the wood decomposing it, which now appears shrunken with a brown discoloration, and roughly cubical cracks, hence the name brown rot or cubical brown rot.

Examples of brown-rot-causing fungi are *Serpulalacrymans* (true dry rot) and *Fibroporiavaillantii* (mine fungus), which attack timber in buildings and are economically important.

Figure: Brown Rot (True Dry Rot) caused by *Serpula lacrymans*

Source:http://upload.wikimedia.org/wikipedia/commons/1/14/Braunfaeule_Holz_FI20070208.jpg

Soft Rot Fungi

This fungi breaks down cellulose of wood by secreting cellulase from their hyphae and results in the formation of minute cavities with sometimes a little discoloration and cracking pattern as found in brown rot.

Examples of soft-rot-causing fungi are *Chaetomium, Ceratocystis* etc.

White Rot Fungi

It mainly decays lignin (sometimes both lignin and cellulose) in wood by producing enzyme laccase. Light-colored cellulose can be seen left behind. Because of their direct attack on lignin and complex organic compounds, they are being investigated for various mycoremedial applications.

Most common example of white rot fungus is Honey mushroom (*Armillaria sp.*)- a notorious fungus usually attacking living trees. Other examples include the turkey tail, tinder fungus etc.

Figure: White rot on birch

Source:http://upload.wikimedia.org/wikipedia/commons/thumb/e/e7/Hvidmuld.JPG/220px-Hvidmuld.JPG

Value addition: Did You Know?
➢ Eighty-five billion tons of carbon is returned annually to the atmosphere as

carbon dioxide by decay of cellulose and liquefied cellulose and most of this is by fungi. ➢ Fungi, along with plants are the major participants in the carbon cycle. ➢ In the detritus ecosystems operating in streams and rivers, aquatic fungi colonize plant debris and lower the C:N ratio, making them more digestible to detritus feeding arthropods (e.g. Gammarus).
Source: Author

Source of industrial chemicals, antibiotics, medicines and vitamins

The importance of fungi in both elemental and contemporary biotechnological processes is noteworthy. Fungi are commonly employed in baking, brewing, and the production of antibiotics, alcohols, enzymes, organic acids, and several pharmaceuticals and biotechnological industries.

Fermentation and Flavoring: They are used in the industrial fermentation and processing and flavoring of dairy foods:

- ✓ in cheese-making (*Penicillium* spp.),
- ✓ alcoholic drinks(*Saccharomyces cerevisiae*)

Pharmaceuticals: - Some of the secondary metabolites produced by fungi are extremely important, e.g.

- ✓ **penicillins** from *Penicilliumchrysogenum*,
- ✓ **griseofulvin** from *P. griseofulvum*,
- ✓ **fusidin** from *Fusidiumcoccineum*.
- ✓ **Cyclosporine (**immunosuppressive anti-rejection transplant drug) from *Trichodermapolysporum*and *Tolypocladiuminflatum* and *Cylindriocarponlucidum.*
- ✓ **cephalosporins**from *Cephalosporiumacremonium*.

Agriculture

- ✓ **gibberellins,** a plant hormone is obtained from*Gibberellafujikuroi*
- ✓ **zearalenone,** a growth promoter for cattle, from *Gibberellazeae.*

Biotechnological Industries

- ✓ **Production of various enzymes** and **organic acids** from species of *Aspergillus*, *Mucor, Penicillium*, and*Rhizopus* etc.
- ✓ Many organic acids like **citric acid** used in **cola drinks and other soda** pop products are commercially produced from *Aspergillus* species.
- ✓ Amylase, used to **convert starch to maltose** during bread making is obtained from *Aspergillusniger* and *A. oryzae*.
- ✓ *Mucor* spp. yield rennet, which is used to coagulate milk for cheese making.

Medicines

- ✓ **Ergot**, the sclerotia of *Clavicepspurpurea*, is used since sixteenth century to hasten childbirth, to stop bleeding during childbirth and in the treatment of migraine.
- ✓ Yeast is a part of some patent medicines and takadiastase has medical uses.
- ✓ Earlier *Fomesofficinalis* was used as a universal remedy.
- ✓ *Lycoperdon* spores and capillitium were used for stopping blood from wounds.
- ✓ Various mushrooms also have been reported to have medicinal properties ranging from anti-tumour to lowering cholesterol levels.
- ✓ Various fungi produce birth control pills and different **hormones and steroids at** commercial level.
- ✓ Similarly various lichens are used for medicinal purposes.
- ✓ Statins used to reduce low density lipoproteins from blood vessels in humans. Examples include Lovastatin from *Aspergillus terreus*and Squalestatin from *Phoma* sp.

Value addition: Important Facts
Ergot or **ergot fungi** refers to a group of fungi of the genus *Claviceps* with *Claviceps pupurea*, one of the most important members. It grows on rye and its relatives. The alkaloids produced by it remain active even after complete processing

of food. These alkaloids are toxic causing ergotism in humans and animals consuming its contaminated grains containing ergot sclerotia (fruiting body).

Economically significant species include:

C. purpurea (growing on grasses and cereals), *C. fusiformis* (on pearl millet), and *C. africana* (on sorghum). *C. purpurea* mostly attacks rye followed bytriticale, wheat and barley. However, it affects oats very rarely.

Figure: Sclerotium of *Claviceps purpurea* on wheat

Source:http://upload.wikimedia.org/wikipedia/commons/c/ca/Claviceps_purpurea.JPG

Ergot poisoning from eating contaminated rye flour resulted in a number of deaths in the Middle Ages. Its major symptom, referred to as **St. Anthony's Fire** include reduced blood circulation with burning and freezing sensations, followed by extreme

infection.

Ergotism is common in livestock feeding on contaminated grain at the farm level. Major symptoms are lameness, abortions in pregnant animals, convulsions, and finally death. It may also lead to decrease milk production in lactating animals.

Sources:www.wikipedia.org;The importance of ergot by Penny Pearse, Plant Disease Specialist,Saskatchewan Food and Agriculture,September 7, 1999, revised June 2006

Food and Food products

- ✓ Both cultivated and wild varieties many mushrooms, e.g. *Agaricus, Lentinula, Morchella, Tuber* etc. are **edible**.
- ✓ A few edible varieties exhibit **antibacterial** and **antifungal** properties, while some of the species show **antitumour**(anticancer) and **anticholesterolemic** (reducing cholesterol levels in the blood) activity.
- ✓ Slugs, insects and some mammals like pigs and deer are particularly fond of fungi.
- ✓ Fungal structures like galls of *Ustilagomaydis* and fruiting bodies of *Cyttaria* on living branches of beech (*Nothofagus*) are being eaten from quite a long time.
- ✓ Some fungi have been used for making traditional fermented foods like **miso** (a fungus fermented rice food of japan)**,tempeh** and**sufu** (made in Indonesia and China from soybeans).

Value addition: Did you Know?

Quorn

"Quorn", a high quality **mycoprotein**is produced from *Fusariumvenenatum,* which is now available in British and European supermarkets. The fungus is grown in large vessels, the mycelium harvested and processed into meat-like chunks, various other oven-ready meals and as a cooking ingredient. It is considered as a nutritious supplement of meat for vegetarians.

Figure: Products of Quorn (mycoprotein)

Source: Author

Biological control agents

Fungi are being used commercially to control various plant pathogenic fungi, weeds, nematodes and insect pests, thus serving as an effective component of sustainable development.

- ✓ *Trichodermaharzianum*is a potential biocontrol agent against a wide variety of soil fungi such as, *Rhizoctoniasolani* causing damping off disease of cotton and *Pythiumultimum,* pathogen of cucumber and others plants.
- ✓ Spores of *Colletotrichumgloeosporioides*, marketed under the trade name **Collego**, is a mycoherbicide

Mutualistic symbionts

Some fungi form specific relationships with other organisms.

- ✓ The fungi develop a mutualistic association with the roots of most plants forming **mycorrhizae**. In this beneficial relationship nutrient absorbing capacity of the root is enhanced as fungus absorbs minerals from the soil and in return get food (organic nutrients) synthesized by the plant.

- ✓ Mycorrhizae is well known in improving the status of phosphate and other nutrients in afforestation programmes for reclamation of damaged or nutrient deficient soils or wastelands. Mycorrhizal associations are prevalent in more than 90% of the plants in nature**.**
- ✓ Another type of mutualistic association of fungi is in the form of **lichens** where it associates with the algae and cyanobacteria.
- ✓ Besides these associations with plants, fungi are also known to exist in mutualistic associations with different animals. As **leaf-cutting ants** serve fungi (primarily living in ant nests) with food in the form of cut pieces of leaves in their underground nests and the ants themselves eat nothing but the fungi.
- ✓ Some **termites** and **wood-boring beetles** break down the cellulose in wood with the help of fungi.

Value addition: Important fact
Endophytes
➢ Several fungi exist as **endophytes** in the leaves and stems of healthy plants and protects their hosts from pathogenic fungi, insects and grazing mammals. ➢ Seed producers market endophyte-infested seeds for use in lawns which are better than endophyte-free strains with respect to insect resistance and drought resistance.
Source: Author

Experimental Organisms

Fungi are preferred choice of scientists to be used as model organism for experimental works, because

- ✓ these are quite simple to handle
- ✓ have a short life cycle and
- ✓ easier to grow many species in pure culture,
- ✓ needs little space,
- ✓ grow and multiply rapidly,

- ✓ if necessary, can be produced in large amounts.

Being eukaryotes these could be easily and more closely related to animals, so their study is more useful than bacteria in solving human problems. These are often employed to study

- ✓ metabolic pathways,
- ✓ many fundamental cell-biological processes,
- ✓ growth, development, and differentiation relevant to biomedical research,
- ✓ microbial assays of vitamins and amino acids and
- ✓ the mechanisms of inheritance.

Value addition: Did you Know?
Pioneers of Fungal World
• At the end of the nineteenth century **Hans and Eduard Buchner**, demonstrated the role of yeast extracts in conversion of sugar into alcohol, which was earlier known to be a simple activity of the intact cell. • In 1940s **Beadle and Tatum** established the concept of "one gene one enzyme" by experimentation on nutritional mutants of the mould *Neurospora crassa*. They are known as founder of **biochemical genetics**. • In the 1950s **Pontecorvo** on *Aspergillus nidulans*, sexual process is not required for genetic analysis. • The completion of **sequencing of the genome** of the yeast *Saccharomyces cerevisiae*, 1996, highlighted the fact that not only many genes, but also their functions in a cell, were similar to humans.
Source: Author

Bioremediation

(i) Due to increase in pesticides and other related chemicals in the environment existence of many animal and plant specie is at risk.

Fungi reduce pollution or potentially polluting materials from the environment. These detoxify pollutants by decompose the organic material in them, when added with suitable nutrient medium. The strains used may be naturally occurring or genetically manipulated.

- ✓ The preferred fungi for bioremediation are *Aspergillus, Penicillium*, *Rhizopus, Mucor,* and *Trichoderma* and *Fusarium*.
- ✓ *Beauveria bassiana*, an entomopathogenic fungus is used to control a number of insect pests.

Miscellaneous activities

Fungi produce **gallic acid**, which is used in photographic developers, dyes and indelible black ink, and in the production of **artificial flavourings and perfumes**, **chlorine, alcohols**, and **several acids**.

They are also used to make **plastics, soap** and **toothpaste**, and in the **mirror silvering process**. Stone washed jeans are softened by *Trichoderma* species.

The chitin, N- acetylglucosamine polymer and its deacetylated derivative, chitosan are the main structural components of fungal cell walls. Fungal mycelial waste, therefore, is the best source for their commercial production. The chitin, chitosan and their derivatives have applications in the removal of harmful metals, in paper and textile finishes. In medical field these polymers are useful in developing artificial kidney membranes, pharmaceutical carriers, blood anticoagulants and wound healing accelerators.

Harmful Activities of Fungi

Plant pathogens

(i) About 70% of the major crop diseases are caused by fungi with an economic loss of billions of dollars every year. These plant pathogens may infect seeds, seedlings or even mature and aged crop plants, followed by their reduced growth and reproduction.

- ✓ Some important pathogens are *Erysiphe, Puccinia, Ustilago* etc. *Ophiostomaulmi*, is known to have tens of millions of elm trees world wide by causing Dutch elm disease.
- ✓ Ergot caused byergot fungus, *Claviceps purpurea* produces many powerful alkaloids in the maturing grains which if consumed cause the disease ergotism in humans as well as in animals.
- ✓ Late blight disease in potatoes is caused by *Phytophthora infestans*. It caused epidemicsacross Europe in the mid19th century resulting in the Irish potato famine.

A B

Figure: *Phytopthora infestans* A.Symptoms on leaf and B. on potato tuber

Source:http://upload.wikimedia.org/wikipedia/commons/thumb/a/a6/Symptom_potato_late_blight.jpg/220px-Symptom_potato_late_blight.jpg

Pathogen of Vertebrates

Study of the pathogenic fungi of humans is known as medical mycology. Humans may succumb to diseases caused by:

- ✓ *Candida* sp. causes opportunistic infections in patients suffering from AIDS, cancer or transplant patients. Infections can be very serious and difficult to control, leading to death of 30-40% of patients suffering from systemic infections.

- ✓ *Aspergillus* cause diseases in following three ways: via production of mycotoxins; induction of sensitive responses; and local or systemic infections.

A. flavus and *A. fumigatus* produce aflatoxins, which are well known carcinogens contaminating food like nuts. *A. fumigatus* and *A. clavatus* can cause allergic reactions. Species of *Aspergillus* can cause diseases on graincrops (e.g., maize) and produce mycotoxins. Group of diseases caused by *Aspergillus*, showing symptoms like illness, cough, chest pain or breathlessness are referred to as *Aspergillosis*. This disease is caused if the immune system has collapsed.

- *Coccidioides immitis cause valley fever.*

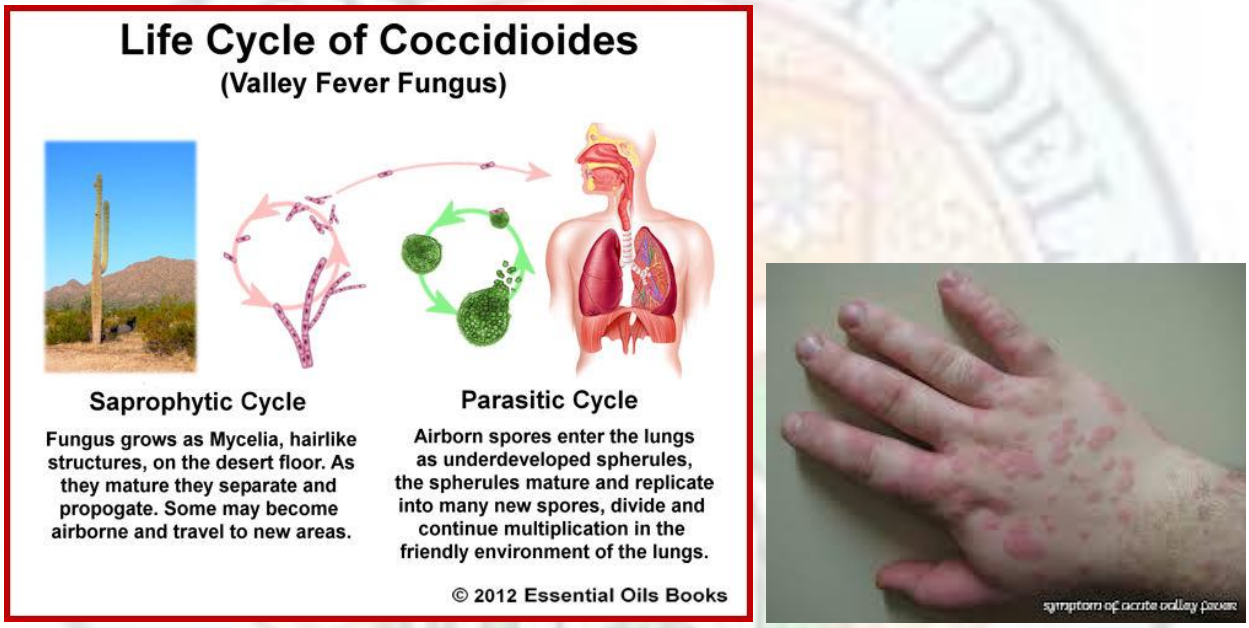


Figure: Life cycle and symptoms of valley fever that infects lungs and shows various symptoms including on hands

Source:http://www.everythingessential.me/mainimages/Valley%20fever.jpg, http://trialx.com/g/Acute_Valley_Fever-1.jpg

- ✓ *Ajellomyces* (**blastomycosis** and **histoplasmosis**),

Figure: Symptoms of blastomycosis on Nose

Source: http://botit.botany.wisc.edu/toms_fungi/jan2001.htm

- ✓ *Cryptococcus neoformans* is known to cause meningitis and meningo-encephalitis in patients suffering from AIDS.

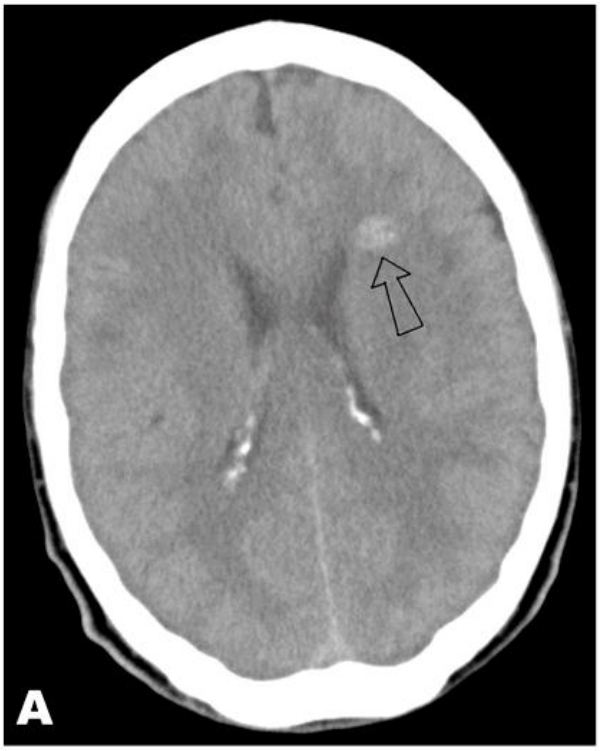


Figure: Cryptococcal meningitis showing diffuse cerebral edema with nodular lesions
Source: http://www.scielo.br/img/revistas/rsbmt/v43n4/a29fig1a.gif

- ✓ *Pneumocystis jiroveci* cause a type of **pneumonia** that affects individuals having improper functioning of immune system, as in premature children, elderly people and AIDS patients.
- ✓ *Stachy botryschartarum* or 'black mold' damages respiratory system and cause severe headaches. It is more frequent in indoor places in regions that are persistently damp.
- ✓ *Microsporum*and *Trichophyton* cause (**ringworm, athelete's foot, unsightly toe nails**).

Figure: Symptoms of Ringworm disease on toe

Source:http://upload.wikimedia.org/wikipedia/commons/5/57/Onychomycosis.JPG

- ✓ Histoplasmosis is caused by *Histoplasma capsulatum humans, dogs and cats. Infection is usually due to inhaling of* contaminated air.

Pathogen of Animals

- ✓ *Cordyceps, Entomophthora* attack insects.
- ✓ *Arthrobotrys, Dactylaria* etc. grow on nematodes and are used for the biocontrol of these organisms.

Biodeterioration

- ✓ All kinds of possible manufactured goods are vulnerable to be attacked by fungi except some plastics and pesticides.

- ✓ *Serpula lacrymans* is a major cause of timber decay in building (Fig. 1.10).

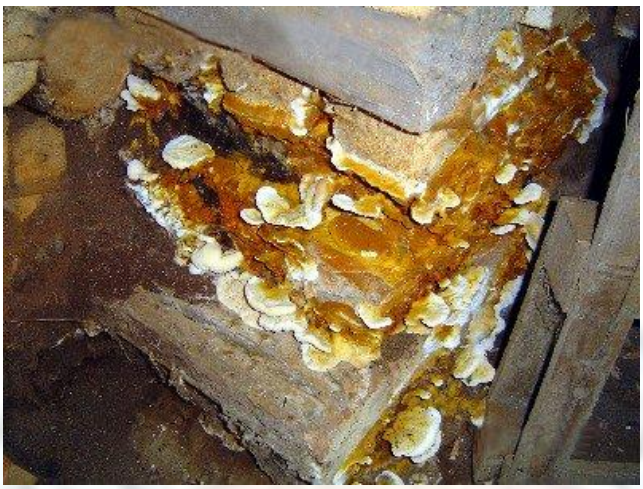


Figure: *Serpula lacrymans* causing timber decay

Source: http://upload.wikimedia.org/wikipedia/commons/4/4f/Serpula_lacrimans.jpg

- ✓ the kerosene fungus *Amorphothecaresinae* causes significant problems by growing in the long chain hydrocarbons in aviation fuel, machine lubricants etc.

Mycotoxins

Mycotoxins are those toxins which are produced by more than 100 sp. of fungi in cereals, fruits, vegetables and nuts.

- ✓ *Aspergillus flavus* and *Aspergillus parasiticus* growing on peanuts, tree nuts and corn are known to produce most common mycotoxin i.e. **aflatoxin**. It can be also be transmitted to humans through the milk, meat, or eggs of animals fed on contaminated grains.
- ✓ Other examples of mycotoxins are **trichothecenes** and **zearalenone** produced by species of *Fusarium* growing on stored grain, straw, or hay. These are known to cause severe infection of intestine, bone marrow, lymph nodes, spleen, and thymus. Mostly prevalent on grains whose harvesting has been delayed and grains lying dormant in the damp fields until they are harvested in the spring.

Affinities of Fungi

To know more about the affinities of fungi with the other organisms let us look at the relationships of these organisms with plants and animals.

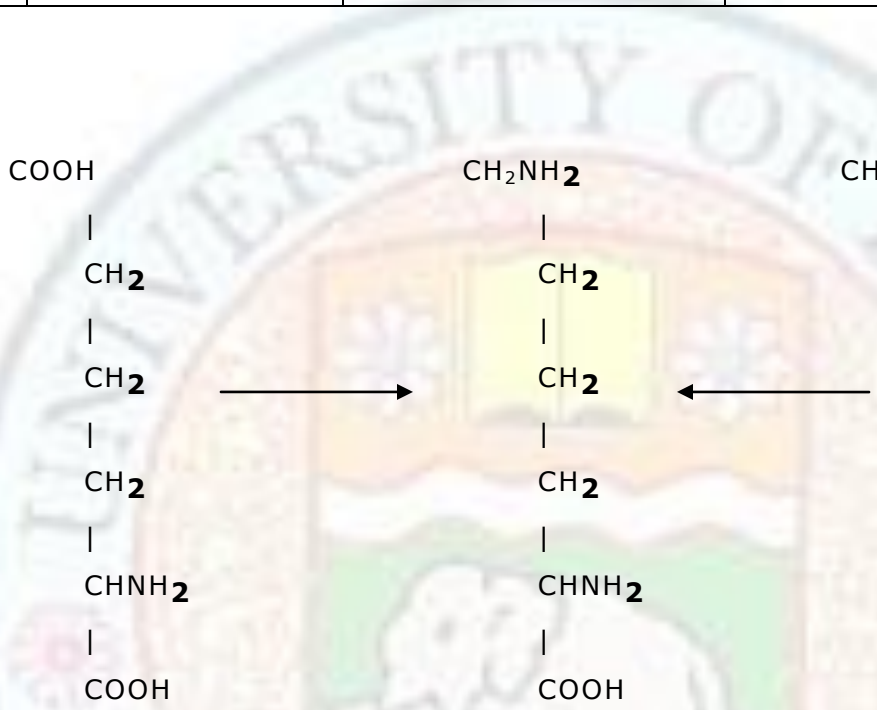
Similarities of Fungi with Plants and Animals

Characters similar to plants	Characters similar to Animals
• Presence of definite cell wall. • Multicellular or coenocytic thalli or filaments. • Non motile nature. • Reproduction by means of asexual and /or sexual spores. • Metabolic similarities - response to light, etc.	• Heterotrophic mode of nutrition. • Chitin present in cell wall (as also in the exoskeleton of insects, spiders and crustaceans). • Mitochondria have flattened plate-or disc-like or lamellate cristae (in some animals). • Storage compounds - glycogen, lipids or trehalose (in some animals only).

Dissimilarities of Fungi with Plants

S.No.	CHARACTERISTIC	FUNGI	PLANTS
1.	**Mode of nutrition**	Heterotrophic (absorptive)	Autotrophic
2.	**Chlorophyll**	Absent	Present
3.	**Differentiation into stem, roots or leaves**	No differentiation	Well differentiated, except algae
4.	**Vascular system**	No differentiation	Well differentiated
5.	**Cell wall composition**	Chitinous; except in Oomycetes	Mainly cellulosic
6.	**Stored food**	Glycogen, lipids and trehalose	Starch

7.	**Lysine (an essential dietary amino acid) synthesis pathway**	Amino-adipic acid (AAA) pathway in chitin containing fungi and some euglenids	Diamino-pimelic acid (DAPA) pathway (also in all other organisms, terrestrial plants, green algae, prokaryotes and **Oomycetes)**



☐-Amino-adipic acid (most fungi)

Lysine

☐-Diamino-pimelic acid (prokaryotes,Oomycetes, terrestrial plants and green algae)

8.	**Nuclei**	Usually haploid, without centrioles	Diploid with centrioles
9.	**Nuclear membrane during division**	Persists	Disintegrates
10.	**Golgi**	With single	With stacked

	bodies	cisterna	plate-like cisternae
11.	**Mitochondria**	Have flattened plate-like or lamellate cristae; except Oomycetes	Tubular cristae .
12.	**Products they can metabolize**	Wide variety of carbon sources - sugars, plastic and even jet fuel	Only sugars
13.	**Embryonic development**	Absent	Present

Such a major difference in fungi from other organisms clearly indicates an ancient, evolutionary divergence.

Dissimilarities of Fungi with Animals

S.No.	**CHARACTERISTIC**	**FUNGI**	**ANIMALS**
1.	**Mode of nutrition**	Absorptive	Ingestive
2.	**Growth habit**	Hyphal	Non hyphal
3.	**Cell wall**	Present	Absent
4.	**Nuclei**	Usually haploid, without centrioles	Diploid with centrioles
5.	**Nuclear membrane during division**	Persists	Disintegrates
6.	**Golgi bodies**	With single cisterna	With stacked plate-like cisternae
7.	**Mitochondria**	Have flattened plate-like or lamellate cristae; except Oomycetes	Tubular cristae in some
8.	**Lysine synthesis pathway**	AAA pathway	Not synthesized , so must be supplied as a dietary supplement
9.	**Cholesterol**	Absent	Present in cell membrane
10.	**Microtubules**	Not sensitive	Sensitive

	sensitivity to colcichine		
11.	**Embryonic development**	Absent	Present

Summary

Fungi are a large group of eukaryotic organisms, with distinctive behaviour. Study of fungi is termed **mycology** (Gr. *mykes* = mushroom; *logos* = discourse). Biologically fungi can be defined as "**eukaryotic, achlorophyllous, characteristically mycelial, exhibiting heterotrophic absorptive nutrition and reproducing by both asexual and sexual spores.**" Fungi are equipped with a variety of enzymes that break down organic products, so often create nuisance and sometimes may be highly destructive. They may target clothes, cartons, leather, waxes, insulation on cables and wires, paint, jet fuel, photographic film, and even the coating of the lenses of optical equipment - in fact, almost any conceivable substance. The two most important requirements of the fungal growth are temperature and humidity.

Since, all fungi are heterotrophic, they rely on organic material, either living or dead, as a source of energy. Thus, many are excellent scavengers in nature, breaking down dead animal and vegetable material into simpler compounds that become available to other members of the ecosystem.The importance of fungi in both elemental and contemporary biotechnological processes is noteworthy. Fungi are commonly employed in baking, brewing, and the production of antibiotics, alcohols, enzymes, organic acids, and several pharmaceuticals and biotechnological industries**.** Some of the secondary metabolites produced by fungi are extremely important, e.g. **penicillins** from *Penicillium chrysogenum*, **griseofulvin** from *P. griseofulvum* etc. **Production of various enzymes** and **organic acids** from species of *Aspergillus*, *Mucor, Penicillium*, and*Rhizopus* etc. **Ergot**, the sclerotia of *Claviceps purpurea*, is used since sixteenth century to hasten childbirth, to stop bleeding during childbirth and in the treatment of migraine. Yeast is a part of some patent medicines and takadiastase has medical uses. Both cultivated and wild varieties many mushrooms, e.g. *Agaricus, Lentinula, Morchella, Tuber* etc. are **edible**. A few edible varieties exhibit **antibacterial** and **antifungal** properties, while some of the species show **antitumour**(anticancer) and **anticholesterolemic** (reducing cholesterol levels in the blood) activity. Fungi are being used commercially to control various plant pathogenic fungi, weeds, nematodes and insect pests, thus serving as an effective component of sustainable

development. *Trichoderma harzianum*is a potential biocontrol agent against a wide variety of soil fungi such as, *Rhizoctonia solani* causing damping off disease of cotton and *Pythium ultimum,* pathogen of cucumber and others plants.

Some fungi form highly specialized relationships with other organisms. The roots of most plants develop a mutually beneficial association with fungi to form **mycorrhizae**. Mycorrhizae greatly increase the nutrient-absorbing capacity of the plant root—the fungus absorbs minerals from the soil and exchanges them for organic nutrients synthesized by the plant.

Fungi are preferred choice of scientists to be used as model organism for experimental works, because: these are relatively simple eukaryotes, many species can be grown easily in pure culture, occupy little space, multiply rapidly, have a short life cycle and if necessary, can be produced in large amounts.

Fungi produce **gallic acid**, which is used in photographic developers, dyes and indelible black ink, and in the production of **artificial flavourings and perfumes**, **chlorine, alcohols**, and **several acids**.

Along with innumerous known useful activities fungi has several harmful actions also. Fungi cause about 100,000 diseases of plants including about 70% of the major crop diseases, resulting in an economic loss of billions of dollars each year. These plant pathogens cause extensive disease of seeds, seedlings, mature plants, and ageing plants, resulting in decreased growth and reproduction of crop plants. Some important pathogens are *Erysiphe, Puccinia, Ustilago* etc. Study of the pathogenic fungi of humans is known as medical mycology. Humans may succumb to diseases caused by certain fungi e.g. *Candida* sp. causes opportunistic infections in patients suffering from AIDS, cancer or transplant patients. Infections can be very serious and difficult to control, leading to death of 30-40% of patients suffering from systemic infections.

Mycotoxins are poisons produced by fungal growth in cereals, nuts, fruits, and vegetables. More than 100 species of fungi produce these toxins. The most common mycotoxin is **aflatoxin**, produced by *Aspergillus flavus* and *Aspergillus parasiticus*. Other mycotoxins include **trichothecenes** and **zearalenone**, compounds known to injure the intestines, bone marrow, lymph nodes, spleen, and thymus.

Excercises

Fill in the blanks:

1. The founder of the science of mycology is the Italian Botanist…….
2. The credit for discovering microorganisms in the 17th century goes to ……..and ……..
3. Mycology, the study of fungi is derived from a Greek word……which means …….
4. ……spp. are used in cheese making.
5. During Decomposition of wood enzyme *cellulase* secreted by fungi converts cellulose in to ……..
6. ……is used since sixteenth century to hasten childbirth and to stop bleeding during childbirth.
7. Scientific name of *the largest living thing on Earth* i.e. *Honey Fungus is……*
8. Cephalosporins are obtained from fungus……..
9. A fungus fermented rice food of japan is known as……..
10. Chitin is the major cell wall component of all fungi except……

True or False

1. *Saccharomyces cerevisiae* is unicellular fungus.
2. Lysine synthesis pathway- AAA stands for amino-acetic acid.
3. Teliospores of *Puccinia mucronatum* were among the first fungal spores illustrated by Robert Hooke.
4. Plant hormone gibberellin is obtained from *Gibberella fujikuroi.*
5. Some mushrooms produce anti-carcinogenic compounds.

Match the following:

1	Ergot	A	*Erysiphe sp.*
2	Late Blight of Potato	B	*Trichophyton*
3	Brown Rot Fungus	C	*Claviceps purpurea*
4	Dutch elm disease	D	*Serpula lacrymans*
5	Ring worm Disease	E	*Phytophthora infestans*

Answers

1. Fill in the blanks

(1)Pier' Antonio Micheli(2) *mykes* and *logos,* mushroom and discourse (3) Robert Hooke and Antonie van Leeuwenhoek (4) *Penicillium*(5)cellobiose (6) Ergot (7) *Armillaria mellea*(8)*Cephalosporium acremonium*(9) miso (10) Oomycetes

1.2 True or False

(1)True (2) False (3) True (4) True (5) True

1.3 Match the following

1-C, 2-D, 3-E, 4-A, 5-B

Glossary

Bioremediation: A method employed to clean up a hazardous waste site that uses microorganisms to break down toxic pollutants.

Endophyte: fungi that live inside the leaves and or stems of apparently healthy plant.

Heterotrophs: An organism that cannot derive energy from sunlight or from inorganic chemicals but must obtain energy by degrading organic molecules.

Lichen: A mutualistic association between a fungus and an alga or cyanobacterium, resulting in a new structural form

Mycorrhiza: Symbiotic association between the root of a plant and the mycelium of a fungus.

Mycotoxin: A general term for a toxin produced by a fungus.

Mycoprotein: is a generic term for protein-rich foodstuffs made from processed edible fungus.

Pathogen: A disease causing organism.

Symbiosis: A close association between two organisms.

Quorn: It is the leading brand of mycoprotein food product in the UK and a leading brand elsewhere produced by Marlow Foods Ltd.

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