

Introductory mycology

Introduction and History

Three and half millennia ago, the Greek hero Perseus in fulfillment of Oracle, accidentally killed his grand father. Acrisius was the person to whom Perseus wanted to make the king (give throne of Kingdom Argos). When he returned back after fulfilling the Oracle, he was upset for killing his grand father, therefore he contacted with Megapenthes the father of Proetus to change his kingdom with Argos. He accepted his request and give the kingdom of Proetus to the Perseus. When Perseus reached and he found ~~new plants~~ like that the cap of his scabbard fallen, he perceived it as a good omen to build a new city. The new city was named as Mycense. Secondly, he also drank the water flowing from mushroom (mykes) and full-fill his thirst. After doing these two things i.e. topping off of the cap (mykes) of his scabbard and drinking water from the mushroom (mykes), he gave the new founded city as Mycense.

This is possible. Let from mycense city name the word myc-nanesh has been taken. If greek words are considered, then mycology (mykes = mushroom, + logos = discourse),

thus the study of mushroom is called mycology.

mycology is not correct word, it must be mycetology (due to its origin from the city name mycence), but because by default it has been ~~renowned~~ renowned, therefore is being used. firstly the mushrooms were studied with open eye (due to their macro structure), afterword lenses were used for their study but, after the discovery of microscope by the great scientist Leeuwenhoek, its biology and systematic studies began. Pier Antonio, the founder

Pier Antonio

of mycology, contributed significantly in the field of mycology. This scientist in 1729 published Novae Plantarum Genera, in which his researches on fungi are present.

Traditionally biologists have defined fungi as "Eukaryotic, spore-producing, achlorophyllous organisms with absorptive nutrition, that generally reproduce both sexually and asexually whose structure is usually filamentous and branched (technically called as hyphae) typically surrounded by the cell walls. This is good definition but has some limitations. For example many fungi are not closely inter-related. Due to this reason now two terms are used.

These two terms are:-

- fungi - some molds
- Fungi

"f" fungi, which have first letter small i.e. are not true fungi, but they have some character of Kingdom fungi. While "Fungi" having capital letter "F" are considered to be true fungi. These include:- (i) Chytridiomycota (ii) Zygomycota (iii) Ascomycota (iv) Basidiomycota.

Presently in the world is 1.5 million species, while in record is only 69,000 species of fungi. This huge gap between recorded and total i.e. 1.5 million shows that there is much need of fungi sampling and research. Further, it has been also observed that research on fungi sampling in tropical and sub-tropical region is less, hence by increasing research on fungi on these areas will be helpful to further record of fungi species.

Importance of fungi:-

Systematic study of fungi is 250 years old. But the manifestation of fungi are million years old. In ancient peoples were well-aware of the role of fungi in fermentation process.

We know that fermentation is done by ^④ single celled fungi i.e. yeasts. But the old people of Egypt considered this as gift of Great God. Ancient Romans celebrated two festivals i.e. Dionysia and ~~Bacchus~~ Bacchanalia to please two gods (Dionysius and Bacchus) in which wine flowed freely. As wine is manufactured through fermentation process, therefore old Greek people know about the fungi. Still in Mexico and Guatemala, peoples considered a fungus (Amanita muscaria) the cause of thunder and lightning. In these same countries, and northwest coast of United States, spirit figures are carved on the sporophores of fungus (Fomitopsis officinalis). These sporophores are then put on the graves as Guardians. Especially shaman graves are guarded with former mentioned. The same fungus is also being used for medicine purpose in North America. Similarly in France a fungus was discovered from the melting glacier. The fungus name was Piptoporus betulinus. This fungus has been using as tinder (firewood).

On regard to fungal folklore and general ~~mystique~~ mystique (magic) of fungi, we should mention the topic of BIO LUMINE SCIENCE in these organisms. In some fungi, the reproductive structure give off visible light causing them to glow in light. Sometime the fungi permeated in the wood logs also produce light. This phosphorescent light has been frightening people in old civilisations. Even, in the age of Aristotle, peoples used pieces of bioluminescent wood pieces in which fungus was grown to mark their path. Soldiers use these pieces on their helmet in order to be visible to one another at night. In United state bioluminescent fungi are called fox fire. The example of bioluminescent fungi is jack-o-lantern mushroom whose orange gills glow in light.

In United States, in 1992 fungus Armillaria bulbosa was discovered having 10 tons weight. This fungus was reported to be 1500 years old

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The most important aspect of fungi in the ecosystem is as "decaying agent". Fungi decompose cellulose and lignin, the primary component of the wood. In fact, biomass production in the forest is largely due to fungi. If there would be no biomass production, it means there would be loss of forests. Although fungi is playing important role in the decay process, but they are also notoriously damaging the wood poles, lumber, railway ties and other wood products. Even, fungi are great threat to the wood warships and other items present in the ships. Losses caused by fungi to wood items are comparable to termites. There is special place of mycologist in Royal Army of U.K for protecting warships from decaying process. The fungus causes decay in warships and other products of wood is Serpula lacrymans.

- Fungi are also big threat to:-
- (i) Fabrics
 - (ii) Leather goods
 - (iii) Various petroleum products including certain fuels and lubricants.
 - (iv) Almost all food stuffs. Due to this threat we employ various techniques to protect from fungi. These techniques

include; salting, drying, freezing, heating, canning, irradiation and the use of chemical additives. ⑦

Besides, simply spoiling food, fungi also produce very toxic substances known as MYCOTOXINS on certain plant material either we consume or feed to our animals. For example, ochratoxins produced on cereal grains by Aspergillus ochraceus and Penicillium viridicatum, the aflatoxin produced by Aspergillus flavus grows on various nuts and grains (Peanuts, Pecans, corn and millet) and fumonisins produced on corn by Fusarium moniliforme.

These toxins are lethal to human beings, e.g. ochratoxins causes renal failure, aflatoxins have been found to cause cancer, in humans possibly causing liver cancer. Recently aflatoxins have also been found on meat, dairy products and eggs, from this it can be envisaged that in near future these toxins will be big threat to human beings and animals. Fumonisin recently discovered mycotoxin, these have been reported to cause esophageal cancer, a fatal neurological disease of horses, and fatal respiratory condition in pigs. It has been said that these potent toxins have been used in ~~the~~ Vietnam and Afghanistan as war biological warfare.

agents.

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Ancient toxins were claviceps purpurea. This fungus causes ergot of rye disease. The symptoms produced due to these toxins in human beings are technically called Ergotism. During ergotism, the alkaloids which are toxic and present in sclerotia - A structure which is small, dark and resistant produced by c. purpurea in the grains of the rye instead of its original seeds, infect causes blockage of veins and affects central nervous system. These alkaloids not only disturb the human beings but also the animals which uses infected rye. When these alkaloids (sclerotia) are eaten by the human beings, they feel like fire on their body. This fiery condition is known as St. Anthony fire or Holy fire (Holy fire). This condition was so named because the afflicted persons felt that parts of their bodies were on fire due to inadequate blood flow. Many died because of this problem in past. Why this disease is called St. Anthony fire, because first time St. Anthony screened out rye plants/varieties and determined the resistance against ergotism in the rye plants. He then used to give these resistant varieties to ~~plant~~ people and people become healthy against these toxins, so in history due to the contribution of St. Anthony, the fire condition was renowned as St. Anthony fire.

Sclerotia of ε-purpures also contains many ⁽⁹⁾ other toxins which may induce different problems;

- can induce abortions
- cause brain hemorrhage.

Interestingly, some of these same chemicals are extracted from sclerotia and used medicinally to induce labor, prevent hemorrhage associated with childbirth, and ease the pain of migraine. For this purpose, men to produce sclerotia on large scale for medicinal point of view, the rice plants are intentionally inoculated with ε-purpures in different parts of the world.

The other important substances which are also produced by different fungi are highly beneficial for human beings. The examples of which are

(i) Penicillins produced from Penicillium chrysogenum, discovered by British microbiologist Alexander Fleming in 1928. Penicillin is used as antibacterial agent (antibiotic).

(ii) Another important group of substances is cephalosporins produced by Cephalosporium acremonium. These like penicillin kills the bacteria by inhibiting the enzymes involved in wall biosynthesis.

(iii) An additional substance is cyclosporin, marketed with the name of Sandimmune and Sandimmune, this is extremely

effective immunosuppressant agent. (10)
Due to this substance transplantation of
different organs in human beings has
become easy. This compound was
discovered in 1970 in fungi i.e.
Cyathocarpa lucidum, and Tolypos-
cladium inflatum.

Fruiting bodies of many
fungi are now a days being used
as medicinal ways. The wood rot-
ting fungus Ganoderma lucidum
is the best example being used
as medicinally. Spores of Psalli-
otia are used as styptic in
Europe.

Fungi is also being used
as food. Cultivation of mushroom
first started in early 600 A.D in
China. In Europe, firstly mushrooms
were cultivated in France in 1650s.
From France it is spread to whole
Europe. Now, mushroom industry has
become largest industry both in Europe
and America. Mushrooms are cultured
on inexpensive substrates like waste
material of manure, tobacco, stems,
rice, and wheat straw, also sawdust
is being used for the same purpose.

In United States meadow mushrooms, are mostly cultivated. Meadow mushrooms (Agaricus brunnescens), the sporophores of A. brunnescens are used in pigs.

Other mushrooms like; Shiitake, oyster and straw mushrooms are also being used for the same purposes and are commercially grown. Mushroom has higher amino acids content than all fungi except spinach and soybeans - mushroom has also medicinal value are being used to cure tumor and cholesterol. Two naturally grown fungi are morels and Truffles, they are highly renowned for their taste and other nutritional values. Truffles are associated with the roots of many trees especially oak tree. Truffles are hunted by pigs and dogs. Truffles are highly expensive because these are found in Europe. European people sell them at very high cost that is one pound for hundreds of dollars. Morels are also known as sponge mushrooms - morels appears only for few weeks in spring in certain geographical regions of the world, therefore people love to hunt them. This is really a great leisure activity in many parts of the world, specially in U.S.A.

many mushrooms are highly poisonous - most renowned poisonous mushroom is Amanita spp.

the symptoms which may appear due to poisonous mushroom may be; (12)

- Gastrointestinal distress.
- Severe liver and kidney damage

Some years ago, American Ambassador to Italy is said to have become ill because one voracious fungus attacked the green pigment in the wall paper of her bedroom producing arsin, a poisonous gas.

A smut fungus i.e. Ustilago maydis that attacks on the ears of corn, produces galls these galls are called "Maire mushrooms"; these maire mushrooms have different food additives which are used in Mexican dishes and are very popular in Mexico. These mushrooms are also being used as gourmet cooks in U.S.A.

Many other fungi, for example are being used for many purposes. eg

- ↳ penicillium are used to give flavour to cheese
- ↳ many fungi are used in the production of various types of sausages, soy sauce from wheat and soybeans.
- ↳ Rhizopus, mucor and actino-mucor are used in increasing the digestibility of vegetable material.
- ↳ many fungi are involved in fermentation
- ↳ Fusarium graminearum are used as high quality mycoprotein instead of meat in U.S.A and U.K.

These mycoprotein are highly nutritious but these have two constraints i, - Having high level of nucleic acid that can cause health problem ② low in number of amino acids. (13)

Yeasts like Sacchromyces cerevisiae convert glucose sugar to ethyle alcohol and CO₂ (fermentation process), thus fungi in this way are important in brewing and bakery industry. During fermentation, the small bubbles of CO₂ raise the bread, while in brewery alcohol is the important product. Virtually any plant that contains either sugar or starch can be used to produce alcohol. Fungi like Botrytis cinerea plays role in making dessert wine by grapes. Therefore, European farmer inoculate the grapes vines with B. cinerea that rot the vines and make them sweeter. For this reason, B. cinerea is also called "Noble rot".

Different types alcohol are formed from different plant sources; VODKA from wheat, rye, potato and CORNS, BEER from barley, RYE from corn, MEAD from honey and BOURBON from corn. As the grains of wheat, barley, rice etc have starches which can not directly be converted into alcohol. Therefore, first must be converted into simple glucose molecules, and then to alcohol. Fungi in this regard help for example, Mucor, Rhizopus and

Yeast convert starches to glucose, which then after fermentation are converted to alcohol. Hence, it is proven, fungi are pivotal in brewing industry. (14)

In addition to ethyle alcohol, fungi also produce variety of chemical compounds, e.g. ergosterol, cortisone, various enzymes, α -amylase, rennin, cellulase, catalase, lactase, and lipase; acids such as fumaric acid, lactic, citric, succinic acid; and plant growth regulator known as gibberellins. B-vitamins can also be obtained from yeasts.

Fungi are of course very important in terms of plant diseases and are causing billion dollars loss in the world. Examples of these diseases may be;

- Downy mildew
- Powdery mildew
- Late Blight of potato and tomato.
- Early Blight of potato and tomato.
- Corn smut
- Rust diseases
- Foolish seedling disease of rice
- Ergot of rye
- club root of crucifers
- Golf disease i.e. grass disease caused by Pythium and Phytophthora spp.

Fungi are also important to control weeds as weedicides. Colletotrichum & leosporioides is used as mycoherbicide.

Fungi producing phytoalexins are also being used against many ~~diseases~~ weeds as biological control.

Fungi as a "mycorrhizal phenomenon" are not only benefiting themselves but also assisting roots of higher plants. Mycorrhizal ~~fungi~~ relationship is basically beneficial relationship in which both fungi and higher plants ^{both} take benefits. Fungi which are associated with the roots of higher plants take their carbohydrates and vitamins from the plants, while plants takes benefits because their surface area become increased resulting in the absorption of more water and nutrients from the soil. Mycorrhizal fungi also benefit the plant by protecting it from many other pathogenic fungi.

Fungi in the form of endophytes also help the plants in protecting from pathogenic fungi and grazing mammals. Endophytes are basically fungi that live inside the leaves and stem of the plants. Endophytes protect their host by the highly active alkaloids.

but these alkaloids are highly toxic \therefore (6) to mammals, therefore negatively impact the mammals. They may cause different problems in mammals;

- (i), Lethargy
- (ii), Lowering of weight
- (iii), Lower milk production
- (iv), Lowering fertility
- (v), Spontaneous abortions
- (vi), Type of gangrene leads towards loss of limbs or tails and even foot

Other positive effect of endophytic grasses is, that when these grasses are sown in lawns, become protected from various types of threats like mammals, insect pests, and even such grasses are more tolerant to drought.

Fungi are also important in biological control of insect pest. There are many fungi of phylum Ascomycota and Basidiomycota, which are being used as a biological control of insect pests.

There is also beneficial relationship between fungi and insects, in which insects help the fungi to transport from one place to other place, while insect use them as food.

For example, wood wasps, fungi grow in the pouches of the wood wasps, and transferred from one place to other place, while wood wasp use these fungi as food. Fungus filled patches of woodwork are called mycangia (singular; mycangium). Similar relationship has also been seen in mites and beetles. Such beneficial fungi belong to phylum Ascomycota and yeasts. Still another beneficial relationship (symbiotic relationship) is, ~~between~~ in which fungi live intercellularly between spaces of the insects and protect them from toxic secondary products of their beetle hosts. In this relationship ascomycetous yeasts live in the intercellular spaces of insect body. Further, insect also feed on the fungi and take their food. Example of such mechanism is, Drosophila feed on mushrooms and take their food. It is said that when Drosophila feed on *Amnitis* spp. it become tolerant against its nematode parasites, which also another benefit.

Fungi also form association with blue green bacteria and green algae. These well known symbioses is called Lichens. In lichens, fungi involved are Ascomycetes and basidiomycetes. The benefit of this symbiotic relationship is; fungi provide protection cover to algae from adverse environmental factors while algae provide

carbohydrates to fungi.

A variety of fungi cause diseases of animals and human beings. Fungi infections are called mycoses, which during certain cases results in death of patients. It is important to mention that less treatment is available for mycoses.

Patients of AIDS ^{Acquired} Immunodeficiency Syndrome, cancer patients, burn victims and organ transplantations are more prone to fungal infections. Fungi may cause internal and external infections (mycoses); these include; external mycoses, example ringworm; internal mycoses, example skin, muscle, bone and internal organ. Common mycoses are;

- ① Blastomycosis.
- ② Coccidiomycosis.
- ③ Histoplasmosis.
- ④ Aspergillosis.
- ⑤ cryptococcosis
- ⑥ Histoplasmosis candidiasis

Cryptococcosis is the most fatal for AIDS patients, it is the most life threatening for AIDS patients. Fungi also cause mouth and vaginal mycoses, these infections are caused by yeast usually.

AIDS associated pneumonia is also caused by fungus Pneumocystis carinii

Fungi also cause allergies.

Fungi also cause sick-building syndrome

Fungi, have become popular experimental organisms for studies of fundamental biological processes, ~~fungi~~ are more because, these can be grown on simple media in test tubes and require less space, less care, and less expensive equipment than most plants and animals. one of the most famous fungus used in genetic studies is, of course, the red bread mold Neurospora spp. Fungi; Schizosaccharomyces ~~cerevisiae~~ ^{Pombi} and Saccharomyces cerevisiae are being used for molecular and cellular studies at the replacement of Escherichia coli.

Fungus Amanita phalloides is being used for biological and bio-medical research. Amanitin produced by this fungus, is being used as transcription Inhibitor.

The End