SKILL BASED SUBJECT-II MUSHROOM CULTIVATION

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UNIT-I

Classification and Identification of Edible and Poisonous Mushrooms

Introduction: A mushroom, or toadstool, is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source.The word “mushroom” is most often applied to those fungi (Basidiomycota, Agaricomycetes) that have a stem (stipe), a cap (pileus), and gills (lamellae, sing. lamella) on the underside of the cap. “Mushroom” also describes a variety of other gilled fungi, with or without stems, therefore the term is used to describe the fleshy fruiting bodies of some Ascomycota. These gills produce microscopic spores that help the fungus spread across the ground. Mushrooms that deviate from the standard morphology usually have more specific names, such as “bolete”, “puffball”, “stinkhorn”, and “morel”, and gilled mushrooms themselves are often called “agaricus” in reference to their similarity to Agaricus or their order Agaricales. By extension, the term “mushroom” can also designate the entire fungus when in culture; the thallus (called a mycelium) of species forming the fruiting bodies called mushrooms; or the species itself.

Identifying mushrooms requires a basic understanding of their macroscopic structure. Most are Basidiomycetes and gilled. Their spores, called basidiospores, are produced on the gills and fall in a fine rain of powder from under the caps as a result. At the microscopic level the basidiospores are shot off basidia and then fall between the gills in the dead air space. As a result, for most mushrooms, if the cap is cut off and placed gill-side-down overnight, a powdery impression reflecting the shape of the gills or pores, or spines, etc. is formed (when the fruit body is sporulating). The color of the powdery print called a spore print is used to help classify mushrooms and can help to identify them. Spore print colors include white (most common), brown, black, purple-brown, pink, yellow, and creamy, but almost never blue, green, or red.

Mushrooms are used extensively in cooking, in many cuisines notably Chinese, Korean, European, and Japanese. Separating edible from poisonous species requires is very difficult .There is no single trait by which all toxic mushrooms can be identified, nor one by which all edible mushrooms can be identified. Many mushroom species produce secondary metabolites that can be toxic, mind-altering, antibiotic, antiviral, or bioluminescent. Although there are only a small number of deadly species, several others can cause particularly severe and unpleasant symptoms. Toxicity likely plays a role in protecting the function of the basidiocarp: the mycelium has expended considerable energy and protoplasmic material to develop a structure to efficiently distribute its spores.

Mushroom Features

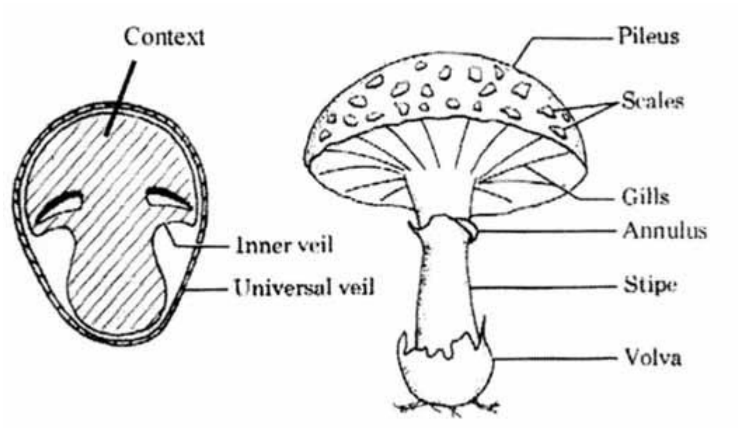
- Cap (Pileus): the expanded, upper part of the mushroom; whose surface is the pileus
- Cup (Volva): a cup-shaped structure at the base of the mushroom. The basal cup is the remnant of the button (the rounded, undeveloped mushroom before the fruiting body appears). Not all mushrooms have a cup.
- Gills (Lamellae): a series of radially arranged (from the center) flat surfaces located on the underside of the cap. Spores are made in the gills.
- Mycelial threads: root-like filaments that anchor the mushroom in the soil.
- Ring (Annulus): a skirt-like ring of tissue circling the stem of mature mushrooms. The ring is the remnant of the veil (the veil is the tissue that connects the stem and the cap before the gills are exposed and the fruiting body develops). Not all mushrooms have a ring.
- Scale: rough patches of tissue on the surface of the cap (scales are remnants of the veil).
- Stalk (or Stem, or Stape): the main support of the mushroom; it is topped by the cap. Not all mushrooms have a stalk (stem) . Another feature to consider when identifying mushrooms is whether they bruise or bleed a specific color. Certain mushrooms will change colors when damaged or injured. Color changes is very important in identifying the mushrooms.

A universal veil is a temporary membranous tissue that fully envelops immature fruiting bodies of certain gilled mushrooms. The mushroom -Amanita caesarea, which resemble a small white sphere is protected by this structure. The veil will eventually rupture and disintegrate by the force of the expanding and maturing mushroom, but will usually leave evidence of its former shape with remnants. These remnants include the volva, or cup-like structure at the base of the stipe, and patches or “warts” on top of the cap .

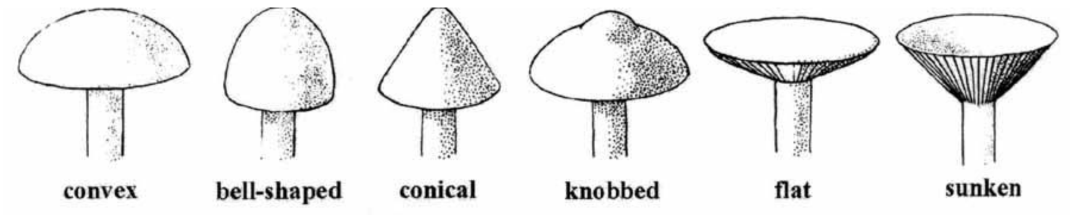
A partial veil (also called an inner veil, to differentiate it from the “outer” veil, or velum) is a temporary structure of tissue found on the fruiting bodies of some basidiomycete fungi, typically agaricus. Its role is to isolate and protect the developing spore-producing surface, represented by gills or tubes, found on the lower surface of the cap. A partial veil, in contrast to a universal veil, extends from the stem surface to the cap edge. The partial veil later disintegrates, once the fruiting body has matured and the spores are ready for dispersal. It might then give rise to a stem ring, or fragments attached to the stem or cap edge. In some mushrooms, both a partial veil and a universal veil may be present.

Mushroom Identifying Features

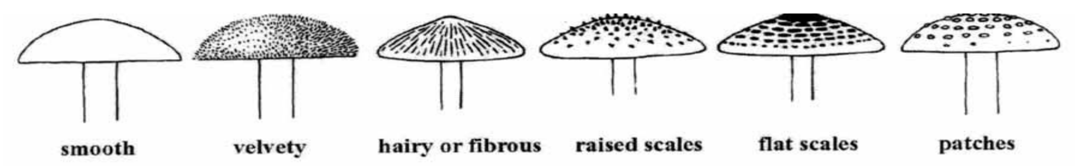
Mushroom structure:



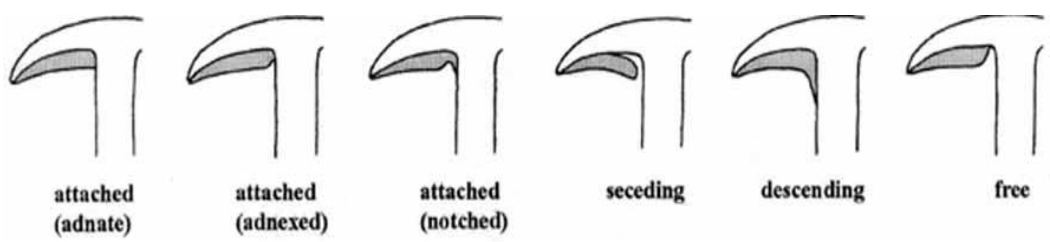
Mushroom cap shape:



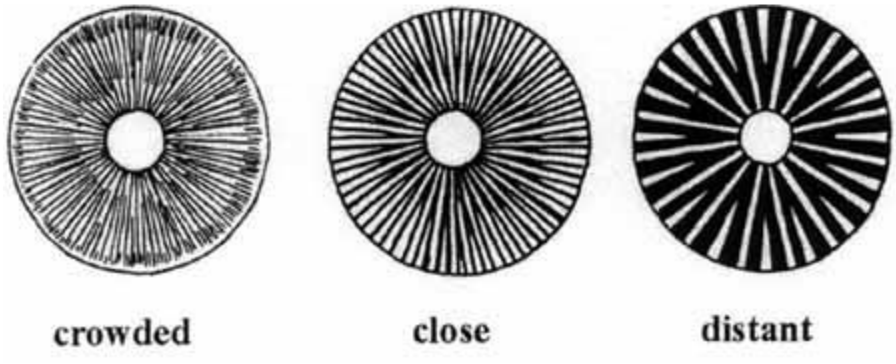
Mushroom cap surface:



Mushroom gill attachment:

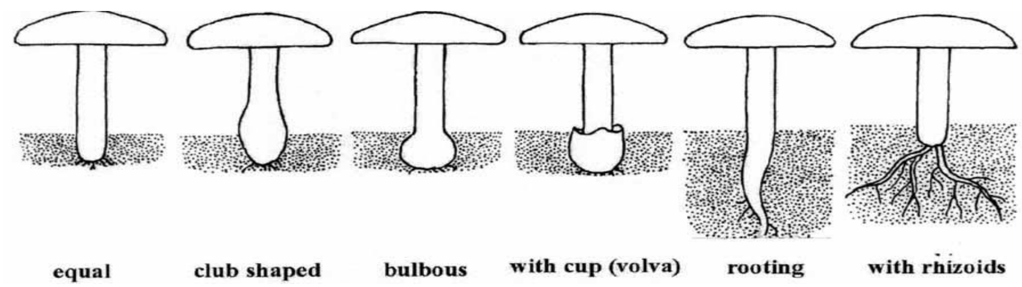


Mushroom gill spacing:

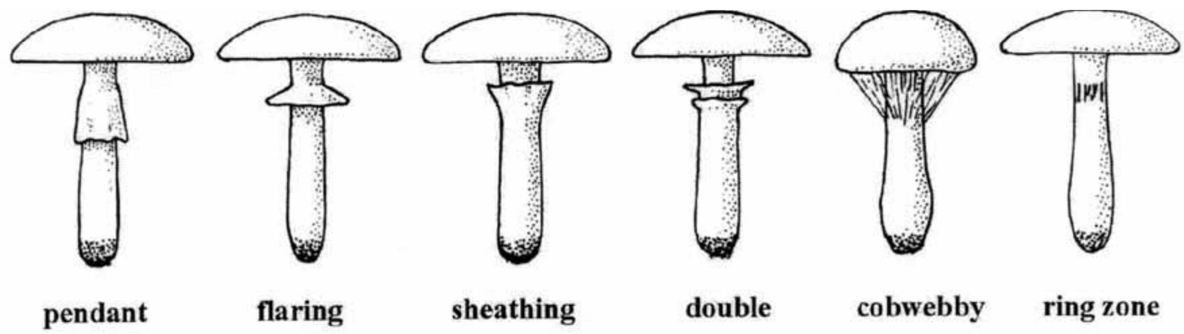


Mushroom gill tissue arrangement:

Mushroom stalk type:



Mushroom ring type:



Nutritional and Medicinal Values of Mushrooms

Nutritional values of Mushrooms

Indian diet is primarily based on cereals (wheat, rice and maize), which is deficient in protein. Supplementation of mushroom recipe in Indian diet will bridge protein gap and improve the general health of socio-economically backward communities. Earlier mushrooms were considered as an expensive vegetable and were preferred by affluent peoples for culinary purposes. Currently common populace also considers mushroom as a quality food due to its health benefits.

Mushroom is considered to be a complete, health food and suitable for all age groups, child to aged people. The nutritional value of mushroom is affected by numerous factors such as species, stage of development and environmental conditions. Mushrooms are rich in protein, dietary fiber, vitamins and minerals. The digestible carbohydrate profile of mushroom includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols and sugar acids. The total carbohydrate content in mushroom varied from 26-82% on dry weight basis in different mushrooms. The crude fibre composition of the mushroom consists of partially digestible polysaccharides and chitin.

Edible mushrooms commonly have insignificant lipid level with higher proportion of polyunsaturated fatty acids. All these resulted in low calorific yield from mushroom foods. Mushrooms do not have cholesterol. Instead, they have ergosterol that acts as a precursor for Vit-D synthesis in human body. The protein content of edible mushrooms is usually high, but varies greatly. The crude protein content of mushrooms varied from 12 – 35% depending upon the species. The free amino acids composition differs widely but in general they are rich in theronine and valine but deficient in sulphur containing aminoacids (ethionine and cysteine). Nutritive values of different mushroom are given in Table 1.

Table 1: Nutritive values of different mushrooms (dry weight basis g/100g)

Mushroom	Carbohydrate	Fibre	Protein	Fat	Ash	Energy k cal
Agaricus bisporous	46.17	20.90	33.48	3.10	5.70	499
Pleurotus sajor-caju	63.40	48.60	19.23	2.70	6.32	412
Lentinula edodes	47.60	28.80	32.93	3.73	5.20	387

Pleurotus ostreatus	57.60	8.70	30.40	2.20	9.80	265
Vovarella volvaceae	54.80	5.50	37.50	2.60	1.10	305
Calocybe indica	64.26	3.40	17.69	4.10	7.43	391
Flammulina velutipes	73.10	3.70	17.60	1.90	7.40	378
Auricularia auricula	82.80	19.80	4.20	8.30	4.70	351

Courtesy: Stamets, 2005 *(A.bisporous, P. sajor-caju, Lentinula edodes)*, FAO, 1972 (*Pleurotus ostreatus , V. volvaceae*), Doshi and Sharma, 1995 (*Calocybe indica*), Crison and Sand, 1978 (*Flammulina velutipes* and *Auricularia spp*).

Mushrooms comprise about eighty to ninety per cent of water, and eight to ten per cent of fiber. In addition to these, mushroom is an excellent source of vitamins especially C and B (Folic acid, Thiamine, Riboflavine and Niacin). Minerals viz., potassium, sodium and phosphorous are higher in fruit bodies of the mushroom. It also contains other essential minerals (Cu, Zn, Mg) in traces but deficient in iron and calcium.

A. Medicinal values

Since thousands of years, edible fungi have been revered for their immense health benefits and extensively used in folk medicine. Specific biochemical compounds in mushrooms are responsible for improving human health in many ways. These bioactive compounds include polysaccharides, tri-terpenoids, low molecular weight proteins, glycoprotins and immunomodulating compounds. Hence mushrooms have been shown to promote immune function; boost health; lower the risk of cancer; inhibit tumor growth; help balancing blood sugar; ward off viruses, bacteria, and fungi; reduce inflammation; and support the body's detoxification mechanisms. Increasing recognition of mushrooms in complementing conventional medicines is also well known for fighting many diseases. Medicinal values of the some important mushroom are given in Table 2.

1. Good for heart

The edible mushrooms have little fat with higher proportion of unsaturated fatty acids and absence of cholesterol and consequently it is the relevant choice for heart patients and treating cardiovascular diseases. Minimal sodium with rich potassium in mushroom enhances salt balance and maintaining blood circulation in human. Hence, mushrooms are suitable for people suffering from high blood pressure. Regular consumption of mushrooms like *Lentinula, Pleurotus spp* were stern to decrease cholesterol levels.

Table 2: Medicinal values of some important mushrooms

Mushroom	Compounds	Medicinal properties	Courtesy
Ganoderma lucidum	Ganoderic acid Beta-glucan	Augments immune system Liver protection Antibiotic properties Inhibits cholesterol synthesis	Lin and Zhang, 2004 Wang et al., 2007 Moradali et al., 2006 Komoda et al., 1989
Lentinula edodes	Eritadenine Lentinan	Lower cholestrol Anti-cancer agent	Enman et al., 2007
A. bisporous	Lectins	Enhance insulin secretion	Ahmad, 1984
P. sajor-caju	Lovastatin	Lower cholesterol	Gunde and Cimerman, 1995
G. frondosa	Polysaccharide Lectins	Increases insulin secretion Decrease blood glucose	Horio and Ohtsuru, 2001
Auricularia auricula	Acidic polysaccharides	Decrease blood glucose	Yuan et al., 1998
Flammulina velutipes	Ergothioneine Proflamin	Antioxidant Anti cancer activity	Bao (2008) Ikekawa et al., 1985
Trametes versicolor	Polysaccharide-K (Kresin)	Decrease immune system depression	Coles and Toth, 2005
Cordyceps sinensis	Cordycepin	Cure lung infections Hypoglycemic activity Cellular health properties Anti-depressant activity	Li et al., 2006 Ko et al., 2009 Nishizawa et al., 2007

2. Low calorie food

The diabetic patients choose mushroom as an ideal food due to its low calorific value, no starch, and little fat and sugars. The lean proteins present in mushrooms help to burn cholesterol in the body. Thus it is most preferable food for people striving to shed their extra weight.

3. Prevents cancer

Compounds restricting tumor activity are found in some mushrooms but only a limited number have undergone clinical trials. All forms of edible mushrooms, and white button mushrooms in particular, can prevent prostate and breast cancer. Fresh mushrooms are capable of arresting the action of 5-alpha-reductase and aromatase, chemicals responsible for growth of cancerous tumors. The drug known as Polysaccharide-K (Kresin), is isolated from *Trametes versicolor* (*Coriolus versicolor*), which is used as a leading cancer drug. Some mushroom-derived polysaccharides have ability to reduce the side effects of radiotherapy and chemotherapy too. Such effects have been clinically validated in mushrooms like *Lentinula edodes, Tramtes versicolor, Agaricus bisporous* and others.

4. Anti-aging property

The polysaccharides from mushrooms are potent scavengers of super oxide free radicals. These antioxidants prevent the action of free radicals in the body, consequently reducing the aging process. Ergothioneine is a specific antioxidant found in *Flammulina velutipes* and *Agaricus bisporus* which is necessary for healthy eyes, kidney, bone marrow, liver and skin.

5. Regulates digestive system

The fermentable fiber as well as oligosaccharide from mushrooms acts as a prebiotics in intestine and therefore they anchor useful bacteria in the colon. This dietary fibre assists the digestion process and healthy functioning of bowel system.

6. Strengthens immunity

Mushrooms are capable of strengthening the immune system. A diverse collection of polysaccharides (beta-glucans) and minerals, isolated from mushroom is responsible for up-regulating the immune system. These compounds potentiate the host's innate (non-specific) and acquired (specific) immune responses and activate all kinds of immune cells.

Mushrooms, akin to plants, have a great potential for the production quality food. These are the source of bioactive metabolites and are a prolific resource for drugs. Knowledge advancement in biochemistry, biotechnology and molecular biology boosts application of mushrooms in medical sciences. From a holistic consideration, the edible mushrooms and its by-products may offer highly palatable, nutritious and healthy food besides its pharmacological benefits.

Until now, wild mushrooms are not explored. The utility of mycelia is paid little attention but it has tremendous potential, as it can be produced year around with defined standard. Knowledge on dose requirement, route and timing of administration, mechanism of action and site of activity is also lacking. Work is under progress in various laboratories across the world to validate these medicinal properties and isolation of new compounds. If these challenges are meet out in the coming days, mushroom industries will play a lead role in neutraceutical and pharmaceutical industries. The increasing awareness about high nutritional value accompanied by medicinal properties means that mushrooms are going to be important food item in coming days and at places may emerge as an alternate to non-vegetarian foods. Growing mushroom is economically and ecologically beneficial. Consuming mushroom is beneficial in every respect.

Economic Importance of Mushroom

Mushrooms are popular for their delicacy and flavor rather than food. They are excellent sources of vitamins and minerals. The medicinal properties of mushrooms can help in solving the problems of malnutrition and diseases. Besides being an important food, mushroom are variously exploited by man. They are at the same time, also beneficial to forest.

1. Decomposition of Dead Organic Matter/Forest Importance:

There are few species of mushrooms which attack living trees where as large number of them grows on fallen timber, bark, sap wood etc. The mycelium of mushroom grows in few years and completes disintegration of wood take place. It gradually mixes with forest soil and provides food for living trees. Thus mushrooms are one of the important agents in providing available food for virgin forest.

The role of mushroom in deposing of fallen timber in forest and converting dead trees and fallen leaves into available food is most important in managing an ecological balance in the forest. One of the key roles that mushrooms play in natural systems is the decomposition of dead organic matter. Decomposition is accomplished by a succession of saprophytic fungi.

The primary decomposers such as Shiitake, Oyster, and Wine Cap mushroom (Stropharia rugoso-annulata), start the process by breaking down the lignin and cellulose in wood, straw and other plant matter. Secondary decomposers typically grow on compost and include the White Button mushrooms and Portobello (Agaricus spp.).Tertiary decomposers are typically soil dwellers existing in reduced substrates.These include some Agaricus species, the Peel mushroom, Conocybe, Agrocybe, and Pleuroteus. Primary and secondary decomposers are the most suitable for cultivation since the mycelium of these species is usually quite vigorous and with proper techniques there is a high rate of success. In addition, substrates are readily available. Mushrooms are than to be given a very high rank among the natural agencies, which have contributed to the good of the world.

Snuff:

Polyporus nigricans when dried and pounded is an ingredient in snuff.

Dyeing:

Polyporus bispidus which gives a brown dye is used for coloring silk, cotton, and wool. This is used by leather dresser's to give fawn chestnut colour and by carpenters to give a brown colour to furniture. P. sulphurous gives yellow colour and Fomes ignitarius gives a brown black colour. Many other mushrooms are also used for giving different colours.

Writing Materials:

Inky cap mushroom Coprinus comatus is very deliquescent and soon become black liquid which can be used for writing purposes.

Mushroom Used for Flower Pots:

Shaped fruit bodies of Polyporus fomentarius and P. ignitarius are used for flower pots.

Luminosity:

The ability of organism to produce light in the dark is well known in bacteria, plants and animals. Many fungi are also luminescent and either fruit body or mycelium or both may be luminous, depending on the species. Luminous is well known to woodmen, foresters, timber men and others who have occasion to pass through a wood in darkness.

The decayed wood itself permitted with the mycelium of Armillaria mellea, glow strongly as long growth continues and remains damp. Fome anosus is also aluminous fungus. This fungus grows in mines and both the mycelium and fruit bodies are luminous.

Pleurotus japonicus also emit light. Light is emitted from the gills of P. japonicus. A single body can give so much luminosity that one can see Roman letters four-tenth of an inch wide. Other species are Boletus edulis, Collybia longipes, etc. Luminosity is often so bright that when brought near a printed page in dark, words can be read.

2. Medicinal Uses:

Ganoderma lucidum and Cordyceps sinense are common medicinal mushrooms cultivated in China and Japan. Shiitakemushrooms is said to be rich in vitamin D2 and has antitumor activity polysaccharides, antiviral glycoproteins, platelet agglutination inhibitive substances, and anti- cholesterol active substances. Ganoderma lucidum is known for its medicinal properties. It is associated with health and recuperation, longevity, wisdom, and happiness. It is believed that certain triterpenes and polysaccharides may account for the multiple activities of Ganoderma.

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About 100 triterpenes have been isolated from either the fruit bodies or mycelium but only a few have been tested for their bio-activity Maitake, Grifila frondosa, has been shown to have both antitumor and anti-viral and immunity enhancement properties.

Powdered fruit bodies are used in the production of many health foods such as Maitake tea, whole powder, granules, drinks, and tablets. Polysaccharides in Hericium spp. are believed to inhibit a variety of cancers by enhancing the hosts' immune functions. It has also been suggested that the phenol-analogous compounds hericenone-C, -D, -E, and Y-A- 8-c, which induces the synthesis of nerve growth factor, might be effective in treating patients suffering from Alzheimer's disease.

The antitumor polysaccharide, β -(1-3)-D- glucan, isolated from Hypsizygus marmoreus showed very high activity. Dried mushroom powder from this mushroom is believed to stimulate the radical-trapping activity of blood. Excessive free radicals in the blood stream are believed to hasten the aging process.

Tremellafuciformis is said to cure tuberculosis, high blood pressure and common cold Psilocybin, an extract of certain psychodelic mushrooms is being studied for its ability to help people suffering from certain mental diseases such obsessive compulsive disorders. Minute amounts have been reported to stop cluster and migraine headaches.

Polyporus officinalis was used in homes as a drastic purge and applied externally stop bleeding. It was also used for chronic catarrh diseases of the breast and lungs, as remedy for night sweating in tuberculosis, for rheumatism, gout, jaundice, dropsy and intestinal worms. It is used in homeopathic doses as Boletus laricis.

Jew's ear (Auricularia auriculata) was frequently used as a poultice for inflamed eyes and as gargle for inflammation of the throat.

Fomes ignitarius and F. fomentarius and surgeon agarics is used for rapid coagulation of blood.

Lycoperdon giganteum is used as soft and comfortable surgical dressing.

Clavatia gigantia is still used in anesthesia.

Amanita muscaria has been used therapeutically from the earliest times as powder or tincture for swollen glands, epilepsy and various diseases. It is still used today in homeopathic doses under the name of Agaricus muscarius. It is used in highly diluted preparations of heart ailment and rheumatoid arthritis.

Volvariella volvcea and Flammulina velutipes cardio toxic proteins have been isolated. They lower the blood pressure and also active against turner cells. Anti-cancerous extract of Shitake causes recession of some kinds of cancer and inhibits the growth of some viruses like influenza.

Hallucination:

The hallucinogenic mushrooms are Amentia muscorina, several species of Stropharia and Psilocybin. Amentia muscorina, the drug like stimulant is not decomposed in the stomach but apparently is excreted unchanged in the urine. Many writers have commented on the common practice of renewing the stimulation by drinking the urine of someone who has already eaten the mushroom. The hallucinogenic principle of Psilocybin is due to the derivatives Psilocybin and Psilocin.

Tinder Mushroom:

Polyporus fomentarius or tinder mushroom sometimes called German tinder was used in the manufacture of tinder.

3. General Uses:

Daedalea quercina is sometimes used to clean down horses, particularly those whose skin is too tender for an ordinary curry-comb. It is also used by men for cleaning hair.
The fruit bodies of Fomes fomentarius and Ganoderma applanatum are stilled used to produce a suede-like material from which hats, various articles of dress, handbags and picture frames are made.

Dried Coriolus versicolor brackets have been used for making hats for costume decoration, while bottle corks are made from Polyporus squamosus.
Polyporus applantus is used as a curio and also for the purpose of etching. Some species of polyporus have been used for making major strop. Polyporus squamosus, P. betulinus are suitable for this purpose.

4. Other Uses:

Mushrooms can be used for dying wool and other natural fibers. Before the invention of synthetic dyes the mushrooms were the primary sources of dying textiles.

Some mushrooms have been used as fire starters and are known as tinder fungi. They also play a role in mycoremediation and microfiltration. Shitake, Portabellas. Criminic and Oysters are being used for cleaning up of the environment. The technique called mycoremediation uses mycelium to breakdown the contaminants like petroleum, fertilizers, pesticides, explosives and agricultural, medical and industrial wastes.

I. Antibiotic Activities:

Antibacterial effect: Antibacterial properties compounds are poly acetylene was mostly found in genera Aleurodiscus, Clitocybe, Marasminus, Polyporus, Tricholoma etc. Antibacterial activity in the genera which parasites on tree, such as Fomes, Ployporus and Trametes reported antibacterial property in Agaricus bisporus and found quinoid and phenolic derivatives. Bose (1953) reported antibacterial activity in Agaricus campestris, Flemmulina mellea against Staphylococcus aureus, Salmonella typhi and E. coli.

Anti-Fungal Effect:

Sparossol from Sparassis ramosus was reported by Falck in 1923. Examples of anti-fungal activity among edible fungi include Lentinus edodes, cortenellin, Coprinus comatus and Oudemansiella mucida.

Anti-Protozoal Effect:

Omphalotus olearius is toxic mushroom with terpenoid illudin M and S, reported to be active against Plasmodium gallinaceum. Gregory et al., (1966) reported Irpex flavous active against protozoan.

Antiviral Effect:

Ganoderma nutriceuticals have exhibited promising antiviral effects like anti-HIV, anti-hepatitis B and Epstein Barr vims. In L. edodes a polysaccharide fraction has been found to be active in-vivo and in-vitro against influenza.

Anti-Tumor Effect:

Calvacin from giant puffball Calvatia gigantea has anti-tumour activity. Chemical nature of calvacin shows that it is a non-diffusible basic micro protein. Lucas et al., (1957) reported anti-tumor activity in Boletus edulis. Ikekawa et al., (1969) reported the anti-tumour effect of edible mushroom.

Mushroom derived chemical compounds associated with anti-tumour activities and their source includes polysaccharide Lentinan from Lentinus edodes, Pleurotus ostreatus. Flammulin from Flammulina velutipes, the acid protein from Poria corticola protein and quinoid from Agaricus bisporus, Ganoderma lucidum has been reported to certain many immuno regulating compounds/and called as longevity mushroom in Korea. Nanba (1993) have shown that Maitake (Grifola frondosa) had stronger anti-cancer and anti-tumor effect. Maitake has been shown to be highly effective in controlling blood pressure, diabetes, constipation and has been shown to kill AID-virus and increase the activity of helper T-cells. Low molecular weight of G. lucidum showed significant anti-HIV activity without affecting host T-cells. Weaver et al., (1970) reported that quinoids from Agaricus bisporus may bind sulfhydral group and inhibit deoxyribonucleic synthesis.

Use of Mushroom as Brain Drugs:

Psilocybin and psilocin isolated from Psillocybe mexicana has been found to affect mind. From Amnita muscaria a drug has been prepared that may treat diseases such as epilepsy and schizophrenia, which are characterized by malfunctioning of gamma amino butyric acid (GABA).This compound has been reported to have inhibitory effect on human central nervous system. Krogsgaard (1981) found that muscinol and ibotenic acid two compounds isolated from Amnita muscaria interact with GABA. These compounds are highly toxic and are of specific action in nature.