CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

892

COURSE 1

BIOLOGY OF MUSHROOMS

Block - 1 : Plant Kingdom and Fungi

Block - 2 : Introduction to Mushroom Science

BRAOU

DR. B.R AMBEDKAR OPEN UNIVERSITY
UNIVERSITY - LIBRARY
CM0066

DR. B.R. AMBEDKAR OPEN UNIVERSITY
HYDERABAD

1996

COURSE TEAM

Editor
Dr. M. Ramachandraiah

Writers
Prof. A. Janaki Bai
Dr. I. Kunwar
Ms. K. Prasunamma
Dr. M. Ramachandraiah
Dr. R.P. Tewari

Programme Coordinator
Dr. M. Ramachandraiah

Programme Associate
Ms. K. Prasunamma

Cover Design
Chandra

Graphics
M. Ramesh

CM-0066
31-3-97

Dr. B.R.A.O.U. LIBRARY
Acc. No. CM-0066
Date 31-3-97
Call No

BRAOU

Dr. B.R. Ambedkar Open University, Hyderabad

First Edition : 1996

Copyright © 1996, Dr B.R. Ambedkar Open University. All rights reserved. No part of this book may be reproduced without written permission from the University.

This Text forms a part of Open University course.

Further information may be obtained from the Director (Academic), Dr. B.R. Ambedkar Open University, Road No. 46, Jubilee Hills, Hyderabad - 500 033

Printed at M/s Planographers, Abids, Hyderabad - 500 001. Ph. : 203390, 202717

PREFACE

This book deals with the Biology of Mushrooms included in the syllabus of 6 months duration Certificate Programme in Mushroom Cultivation offered by Dr. B.R. Ambedkar Open University. The topics generally cover the core area of the subject. The syllabus for the sake of convenience, is divided into Blocks, each of which comprises a number of units. Each Block generally covers a specific area of the subject. The units are prepared by the specialists in accordance with a format so designed as to enable the student to read and understand them without much difficulty. Each unit begins with a statement of its contents followed by objectives. In order to check the students understanding ability some questions are introduced here and there in the unit. The students can write the answers in the space given below every question and compare their answers with those given at the end of the unit. At the end of each unit summary and model examination questions are given for quick reading and to acquaint the student with the type of questions that appear in the examinations.

This paper on Biology of Mushrooms is included mainly to acquaint the students with various aspects such as classification of plant kingdom, general characters, morphology, cell structure, nutrition, reproduction, life cycles, classification, growth requirements and economic importance of Fungi. An introduction to Mushrooms is also given in which the history, distribution, occurrence, description of various edible and poisonous mushrooms are included. Nutritional, medicinal and industrial importance of Mushrooms and export potential of various cultivated mushrooms are also given.

The University hopes that this material will help the students to understand the Biology of mushrooms before they study the Cultivation aspects of important edible mushrooms in the second course viz., Cultivation of Mushrooms. Critical suggestions for improving the text are most welcome and they will be incorporated in the future edition.

BRAOU

CONTENTS

BRAOU

BLOCK - 1
PLANT KINGDOM AND FUNGI

BRAOU

BRAOU

UNIT - I : INTRODUCTION AND CLASSIFICATION OF PLANT KINGDOM

Contents

1.1. OBJECTIVES

After going through this unit you will be able to :

* explain the general characters of plants,
* list out the differences between plants and animals and
* describe the various classifications of plant kingdom

BRAOU

1.2. INTRODUCTION

The word **"Taxonomy"** was first proposed by A.P. de Candolle in 1813. This study reflects the differences and similarities among the organisms. Some of the important objectives of plant classification are : 1. Identification, 2. Nomenclature on the basis of similarities and differences, 3. Arrangement and grouping of plants into various taxonomic ranks in a natural way, 4. To build up the evolutionary history of a taxon and 5. To follow the International Code of Nomenclature (set of rules for naming plants) for naming a taxon.

The living world comprises of four main groups : 1. Primitive life forms (Viruses), 2. Monera (Bacteria and blue green algae), 3. Protista (Protozoa, Algae and Fungi) and 4. Modern Plants and Animals. But, many biologists recognise only two kingdoms, namely plant and animal kingdoms. Haeckel (1894) felt the necessity of a third Kingdom, Protista. Plants at the cellular level possess cellulose cell wall in addition to the plasma membrane, while animals have only the plasma membrane limiting the cells. Nutritionally, the plants in general can prepare their own food due to the presence of chlorophyll (autotrophs) while the animals are heterotrophs.

Of late, modern biologists have recognised the following four kingdoms of the living world: Monera, Protista, Metaphyta (Plants) and Metazoa (animals). Bacteria and blue green algae are included in Monera. The protista includes algae, fungi, slime molds and the protozoans. From these two primitive kingdoms, the modern plants and animals are said to have been evolved. However, we are still following the 2 kingdom (Plants and Animals) concept.

Check Your Progress - 1

What are the four kingdoms recognised by the modern biologists in the living world? And what are the organisms that are included under each one of them ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

1.3. GENERAL CHARACTERS OF PLANTS

BRAOU

Plants synthesize their own food materials by photosynthesis. A typical plant body is differentiated into stem, roots and leaves. However, lower plants (Algae, Fungi and Bryophytes) do not have such a typical structure and their plant body is called thallus. Root system is usually underground and helps in absorption of water and mineral salts. The stem is the aerial part of the plant body which bears the entire foliage. Stem performs the function of conduction of water and food materials to various parts of the plant body. Leaves are the green, photosynthetic structures which synthesize food materials. Plants, also bear flowers which are the sexual reproductive structures. Gynoecium and androecium are the female and male reproductive parts of the flower respectively, while calyx and corolla help in protection and pollination. In lower plants, the reproductive structures do not resemble a flower of higher plants. Plants bear fruits and seeds. Seeds are the main propagating units of plants. The lower plants propagate by means of spores.

Plants in general reproduce by three methods. They are vegetative, asexual and sexual methods. Vegetative propagation in higher plants takes place by means of stem and root-tubers, runners, suckers, bulbils etc., where as in lower plants it occurs by means of fragmentation, accidental breaking etc. Asexual reproduction takes place by means of spores. Sexual reproduction in lower plants takes place by means of gametes produced in special structures called antheridia and archegonia.

1.4. DIFFERENCES BETWEEN PLANTS AND ANIMALS

The question arises as to what is the fundamental difference between plants and animals. To a casual observer plants donot move while animals do. But there are plants like algae which move and animals like sponges which do not. At the cellular level plant cells have

an external covering called the 'cell wall' while in animal cells 'plasma membrane' is the outer-most covering of the cells. A clear-cut distinction between the plants and animals lies in the way they nourish or feed themselves i.e., the mode of nutrition. Plants do not eat, but animals eat. Usually plants synthesize their own food by photosynthesis. On the other hand animals depend for their food upon plants and other animals.

Check Your Progress - 2

State the main differences between animals and plants.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

BRAOU

1.5. CLASSIFICATION OF PLANT KINGDOM

Karl Linnaeus (1707-1778) was the first to devise the taxonomic classification. He is also known as the father of taxonomy. Linnaeus developed the binomial nomenclature as a system for naming the plants and animals. In this system an organism is given two latin names, the *"generic"* and the *"specific"* names.

In *Cycas revoluta* the first name is of the genus and the second name is of the species. Capital letter is used for the first letter of the genus as it is normally a noun. The specific name has a small first letter as it is usually an adjective. The generic and the specific names are printed in italics. Therefore when they are written with hand or typed they are underlined.

Family is a group of genera with close resemblance. Genera in a family have some common characteristics; e.g., those in cruciferae have cruciferous flowers, tetradynamous stamens etc., Families showing affinities and similar evolutionary trends are included in an **order.**

Similarly, orders with closer affinities are included in a **sub-class** and the sub-classes in a still higher unit, **class,** the classes into a **Division** and all the divisions collectively form the Plant Kingdom.

Methods of classifying plants and animals evolved by Linnaeus is followed even now. More than four lakhs of plants have been described till to-day.

The Fifth International Botanical congress at Combridge in 1930 was held to formulate rules and regulations regarding nomenclature throughout the world. Thus, the International Code of Botanical Nomenclature came into being. Some of the important rules of the International Code are :

1. All species should have a latin name. Author's name should be given in abbreviated form at the end.
2. Herbarium sheet, a diagram, slides etc., of the author's original collection should be preserved as the type specimen.
3. Date and place of collection, a reference name should precede author's name.
4. Use of specific names as generic names (e.g., *Sassafras sassafras*) i.e., tautonyms are not allowed. Homonym is also discarded. Earlier name is valid. Other names or duplicate names are called synonyms.
5. Ambiguous names are rejected.
6. If a species is transferred from one genus to the other, the species name should be retained if that name is not there in that genus. The name of the original author is kept within brackets and the name of the author who is suggesting the change should come after the bracket.
7. The plants should have description. It should be published validly through scientific journals.
8. A variety of a species should be indicated by var. and form as formal These should come after the name of the species and the author's name follows.
9. For the original type material the term holotype is used. Neotype is the term sugested for the specimen which is used for substituting the original material which is missing. Isotype is the specimen which is exactly like the holotype. Terms such as Paratype, Co-type and syntype are also used.

BRAOU

Check Your Progress - 3

What is binomial nomenclature ? Who has developed it ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

History of classification dates back to pre-historic man. Man in the ancient past distinguished the palatable, non-palatable and poisonous plants. This was the beginning of plant classification.

Theophrastus (372-287 B.C.) wrote a book entitled *"Causes of Plants"* in six volumes.

Earlier he wrote nine volumes on *"History of Plants"* in Greek. Dioscores (50 B.C.) described 600 medicinal plants in his *"Materia Medica"* . Pliny (32-75 A.D.) also described more than thousand plants, most of which were medicinal.

William Turner (1557), *"Father of English Botany"*, and *John Gerard* (1597) wrote *'Herbals'* and described many plants. They attempted the classification of plants based on their utility to man. Plants were classified based on the characters of seeds and the embryo by *Caesalpin* (1519-1603) and an Italian Botanist *Kespar Bauhin* (1620) made the first attempt to use binomial system of nomenclature, though, it was fully developed later by *Linnaeus*.

John Ray (1627-1705) gave his classification of plants in his book *"Historia Plantarum"* (1686-1704). He divided the plants into two major groups Herbae (Herbs) and Arborae (trees and shrubs). Herbae is subdivided into 1. Imperfectae (the cryptogams) and 2. Perfectae (the following plants) with monocotyledons and dicotyledons. The arborae was also sub-divided into monocotyledons and dicotyledons.

Rudolf Camerarias (1665-1721) recognised sexuality in flowering plants. He established the stamens as male, ovary as female parts and the importance of pollen transfer in seed production.

Linnaeus (1735) published *"Systema Naturae"* and proposed sexual system of classification. On the basis of sexual characters (stamens and carpels), Linnaeus formed 24 classes of which 1 to 23 belong to flowering plants and the 24th class includes non-flowering plants, i.e., *Cryptogamia*.

Jussieu (1789) in his work entitled *"Genera Plantarum secundum ordines naturales disposita"* recognised 15 classes of which the class 1. Acotyledons included the Thallophyta, Bryophyta, Cryptogams and some flowering plants. Classes 2-15 included the flowering plants.

A.P. de Candolle (1778-1841) in his book entitled *"Theorie elementaire de la botanique"* proposed two major groups-1. Vasculares (Cotyledonous plants with vascular bundles) and 2. Cellulares (plants without cotyledons and vascular bundles). *Robert Brown* (1773-1858) showed that Gymnosperms have naked ovules. *Endlicher* (1805-1849) recognised two important groups in the plant kingdom. They are 1. Thallophyta with algae, lichens and fungi and 2. Cormophyta with mosses, ferns and seed plants. *Lindley's* system (1846) recognised Phanerogamia and Cryptogamia.

Bentham (1800-1884) and *Hooker* (1817-1911) in their famous work *"Genera Plantarum"* divided plant kingdom into cryptogamia and phanerogamia as two subkingdoms. *Eichler* (1839-1887), *Engler* (1844-1930) and *Prantl* (1849-1893), *Bessey* (1845-1915), *A.B. Rendle* (1865-1938), *Hutchinson* (1926-1934), *Oswald Tippo* (1942), *Benson* (1957) etc. classified plants variously. In general Plant kingdom is divided into three major groups. Thallophyta, Bryophyta and Trachaeophyta. In view of the recent study employing Electron Microscope, Scanning Electron Microscope, newer strains, bio-chemical and genetic studies, changes are often brought specially in the classification of lower plants. Some important broad systems of classification are summarized in table-1.

BRAOU

Table-1.1 Comparative survey of the classification systems (Adapted from Bold, 1960)

Eichler, 1883 (and modifications)	*Tippo, 1942*	*Bold, 1956*	*Common name*
PLANT KINGDOM →	PLANT KINGDOM →	PLANT KINGDOM	
A. CRYPTOGAMAE →	Abandoned		
DIVISION 1. THALLOPHYTA →	SUBKINGDOM THALLOPHYTA →	Abandoned	
Class 1. Algae →	Abandoned		
Cyanophyceae →	PHYLUM 1. CYANOPHYTA →	DIVISION 1. CYANOPHYTA	
Chlorophyceae →	PHYLUM 2. CHLOROPHYTA →	DIVISION 2. CHLOROPHYTA	
	PHYLUM 3. EUGLENOPHYTA →	DIVISION 3. EUGLENOPHYTA	
		DIVISION 4. CHAROPHYTA	ALGAE
Phaeophyceae →	PHYLUM 4. PHAEOPHYTA →	DIVISION 5. PHAEOPHYTA	
Rhodophyceae →	PHYLUM 5. RHODOPHYTA →	DIVISION 6. RHODOPHYTA	
Diatomeae →	PHYLUM 6. CHRYSOPHYTA →	DIVISION 7. CHRYSOPHYTA	
	PHYLUM 7. PYRROPHYTA →	DIVISION 8. PYRROPHYTA	
CLASS 2. FUNGI →	Abandoned		
Schizomycetes →	PHYLUM 8. SCHIZOMYCOPHYTA →	DIVISION 9. SCHIZOMYCOTA	BACTERIA
	PHYLUM 9. MYXOMYCOPHYTA →	DIVISION 10. MYXOMYCOTA	SLIME MOULDS
Eumycetes →	PHYLUM 10. EUMYCOPHYTA →	Abandoned	
	Class 1. Phycomycetes →	DIVISION 11. PHYCOMYCOTA	
Lichens →	Class 2. Ascomycetes →	DIVISION 12. ASCOMYCOTA	FUNGI
→	Class 3. Basidiomycetes →	DIVISION 13. BASIDIOMYCOTA	
DIVISION 2. BRYOPHYTA →	PHYLUM 11. BRYOPHYTA		
Class 1. Hepaticae →	Class 1. Hepaticae →	DIVISION 14. HEPATOPHYTA	LIVERWORTS
Class 2. Musci →	Class 2. Musci →	DIVISION 15. BRYOPHYTA	MOSSES
DIVISION 3. PTERIDOPHYTA →	Abandoned		
	PHYLUM 12. TRACHEOPHYTA →	Abandoned	
	Sub-phylum 1. Psilopsida →	DIVISION 16. PSILOPHYTA	PSILOPHYTES
Class 1. Lycopodinae →	Sub-phylum 2. Lycopsida →	DIVISION 17. MICROPHYLLOPHYTA	CLUB MOSSES
Class 2. Equisetinae →	Sub-phylum 3. Sphenopsida →	DIVISION 18. ARTHROPHYTA	HORSETAILS AND SPHENOPSIDS
	Sub-phylum 4. Pteropsida	Abandoned	
Class 3. Filicinae →	Class 1. Filicinae →	DIVISION 19. PTEROPHYTA	FERNS
B. PHANEROGAMAE →	Abandoned		
DIVISION 4. SPERMATOPHYTA →	Abandoned		
Class 1. Gymnospermae →	Class 2. Gymnospermae →	Abandoned	
	Subclass 1. Cycadophytae →	DIVISION 20. CYCADOPHYTA	CYCADS
	Subcalss 2. Coniferophyta →	DIVISION 21. GINKGOPHYTA	MAIDEN HAIR TREE
	→	DIVISION 22. CONIFEROPHYTA	CONIFERS
	→	DIVISION 23. GNETOPHYTA	NO COMMON NAME
Class 2. Angiospermae	Class 3. Angiospermae →	DIVISION 24. ANTHOPHYTA	FLOWERING PLANTS

The arrows indicate the fate of taxa in sucessively more modern system of classification. When the name of a group is used later at a higher rank. as, for example, in the change from chlorophyceae to chlorophyta, the name of the lower group is usually retained as a subsidiary under the higher.

BRAOU

Plant Kingdom is divided into two major groups, they are : Cryptogams and Phanerogams. Cryptogams are the plants bearing concealed reproductive organs (Cryptos : hidden; Gamos : reproductive organs). Hence they are called flowerless or non-flowering plants. Cryptogams are divided into three divisions by Eichler 1886). They are Thallophyta, Bryophyta and Pteridophyta. Thallophyta includes all the plants having simple plant body known as "thallus" (a plant body not differentiated into root, stem and leaves). Division : Thallophyta is divided into two subdivisios, Algae and Fungi.

Green, autotrophic (synthesizing their own food materials) thallophytes are called algae. The study of algae is called phycology (phykos : seaweeds; logos : study).

Non-green, heterotrophic (not syhthesizing their own food and depending for food on other sources) thallophytes are called Fungi. The thallus of fungi is called mycelium. Study of fungi is called Mycology or Mycetology (mykes : mushrooms, logos : study).

Division Bryophyta includes all thalloid or foliose plants that live in damp and shady areas. Vascular tissues are absent in them. Study of bryophyta is called bryology and in the life cycle of bryophytes gametophyte is the dominant stage..

Division Pteridophyta consists of primitive vascular land plants. The plant body is

differentiated into root, stem and leaves.

Phanerogams are the flowering plants which produce seeds. Phanerogams are again divided into two divisions based on whether the seeds are naked or enclosed within the fruit and they are Gymnosperms and Angiosperms respectively.

Gymnosperms (Gymnos : naked; sperma : seed) include the plants bearing naked seeds (ovules not produced within the ovary). The dominant stage of the plant body is sporophyte.

Angiosperms (angios : covered or enclosed; sperma : seed) are the plants bearing enclosed seeds. Sporophyte is the dominant stage and is divided into root, stem and leaves. Angiosperms are again divided into two classes - dicotyledonae and monocotyledonae based upon the number of cotyledons present in the embryo.

1.6 . SUMMARY

The term taxonomy means the science of classification. *Carl Linnaeus* introduced the binomial nomenclature i.e., giving two names to any living organism, one generic and the second specific. The plant kingdom with modern plants is said to have evolved from protista which comprises of protozoans, algae and fungi. Plants and animals show distinct differences.

The fifth International Botanical Congress held in Cambridge in 1930 formulated rules and regulations regarding nomenclature throughout the world. Vaious taxonomists classified plant kingdom in different ways. But in general it is divided into three major groups. They are Thallophyta, Bryophyta and Trachaeophyta.

BRAOU

1.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Monera, Protista, Metaphyta and Metazoa are the four different kingdoms recognised by the modern biologists in the living world. Bacteria and blue green algae are included under Monera; algae, fungi, slime moulds and protozoans under protista; all plants under Metaphyta and all the animals under Metazoa.
2. The main differences between plants and animals are : i) Plants do not move while animals do. However there are plants like algae which move and animals like sponges which do not move. (ii) Plant cells have an external covering called the cell wall while in animal cells plasma membrane is the outer-most covering of the cells. (iii) Plants do not eat, but animals eat. (iv) Plants synthesize their food by photosynthesis and on the other hand, animals depend for their food upon plants.
3. The naming of plants and animals with two different names i.e., generic and specific names is called binomial nomenclature. *Linnaeus* was the first man to develop this system.

1.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What are the important rules and regulations of International Code of Botanical Nomenclature?
2. Describe briefly about the classification of plant Kingdom.

II. Answer the following questions in about 10 lines each.

1. What are the contributions of *Linnaeus* to plant classification.
2. Write briefly about the binomial system of nomenclature.
3. State the general characters of plants.
4. Write a note on the differences between plants and animals.

Dr. M. Ramachandraiah

BRAOU

UNIT - 2 : GENERAL CHARACTERS OF FUNGI

Contents

2.1. OBJECTIVES

After going through this unit you will be able to :

* explain the habitat and habit of fungi,
* describe the vegetative and reproductive characters of fungi and
* recognise the status of fungi in living world.

BRAOU

2.2. INTRODUCTION

Fungi are achlorophyllous (chlorophyll absent) organisms and are commonly known as moulds. They depend upon other sources for their food materials (heterotrophic). They consist of the true nucleus in their cells (eukaryotic) and may be unicellular or multicellular. The plant body is called mycelium which is made up of branched or unbranched, septate thread like structures called hyphae (sing : hypha). Fungi reproduce asexually by means of zoospores and conidia. Sexual reproduction occurs by means of planogametic (motile gametes) union, gametangial contact, gametangial union, spermatisation and somatogamy (fusion of vegetative hyphae).

2.3. HABITAT AND HABIT

Habitat is a place where a particular organism lives. The fungi grow in a variety of habitats. Many of them occur in soil and water. Some live in tissues of animals and plants, while others grow on dead and decaying organic materials. They prefer to grow in moist shady places. Fungi living in water are called 'water moulds' and are the primitive forms. Examples of watermouldsare *Saprolegnia* and *Achlya*. The fungi found in soil are *Pythium*, *Trichoderma* etc. Fungi like *Mucor*, *Penicillium* grow on decaying materials like fruits and vegetables. Examples for fungi growing on plant tissues are *Phytophthora*, *Plasmopara*, *Puccinia*, *Ustilago* etc., Species of *Aspergillus* like *A. flavus*, *A. fumigatus*, *A. niger* and also *Monilia* occur as human pathogens.

Fungi can not prepare their own food materials and hence consist of varied modes of nutrition. They live as saprophytes, parasites or symbionts. Organisms growing on dead organic matter are called saprophytes *(Penicillium, Mucor)*. The fungi that live in the living bodies of plants, animals and other organisms are called parasites. The organism in which the parasite lives is called the host. The parasitic fungi include *Phytophthora, Ustilago, Puccinia, Cercospora* etc., The parasite in due course destroys the host partially or totally. Symbionts are those which live in association with other organisms for mutual benefit. Lichens, where algae and fungi live together forms a typical example for symbiosis. Mycorrhiza, where fungi establish relationship with the roots of forest trees like *Pinus* is another example for symbiosis. The Fungi in mycorrhiza absorb water and minerals and perform the function of root hairs which are lacking in that region. In turn, fungi derive food from the trees.

Check Your Progress - 1

What are symbionts ? Furnish two examples for symbiotic fungi ?

Note : a) Write the answer in the space given below.

b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

2.4. VEGETATIVE CHARACTERS

BRAOU

Fungus consists of vegetative and reproductive phases in its life-cycle. The vegetative phase may be unicellular or multicellular. Some of the lower fungi such as *Synchytrium* and yeasts (Fig. 2.1) consist of single celled thallus. During reproduction, the entire cell functions as a reproductive unit. Such fungi are called holocarpic fungi.

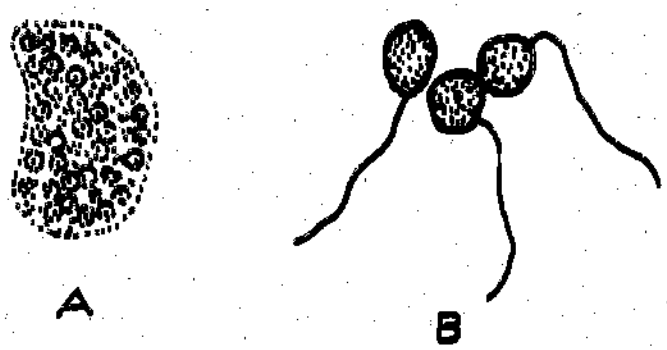


Fig. 2.1. ***Synchytrium endobioticum*** **. A. Thallus (Zoosporangium). B. Zoospores.**

Many fungi possess multicellular thallus in the form of filaments and such fungi are called filamentous fungi. Fungal spore germinates and produces a germ tube. The germ

tube grows into a thread-like structure called hypha. The hyphae branch repeatedly to form a mesh-like structure called mycelium. The mycelium may be colourless or coloured due to the presence of pigments. The hyphae may have cross walls or septa and called septate mycelium. Mycelium without septa is called aseptate or coenocytic (Fig. 2.2 A&B). The septum consists of a central pore. This may be single without any thickenings and called simple pore septum.

In some higher fungi septate mycelium may have barrel-shaped thickenings (parenthosomes) covering the pore of a septum and this type of septum is called dolipore septum.

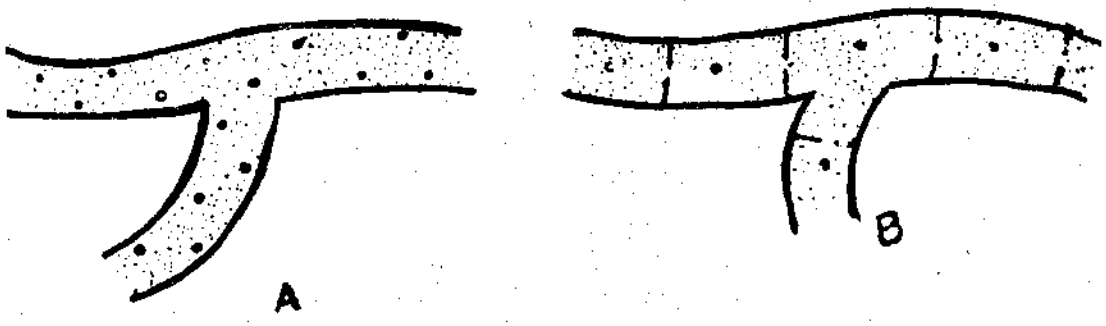


Fig. 2.2 Fungal hyphae. A. Coenocytic hyphae. B. Septate hyphae.

BRAOU

Check Your Progress - 2

Write the important vegetative characters of fungi.

Note : a) Write the answer in the space given below.

b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

Septate hyphae may have multinucleate cells (with many nuclei), binucleate cells or uninucleate cells. The mycelium having binucleate cells is called dikaryotic mycelium while the mycelium with uninucleate cells is called monokaryotic mycelium.

2.5. REPRODUCTIVE CHARACTERS

The fungi mainly reproduces by spores. These spores may be produced by either sexual or asexual methods. Sexual reproduction involves the union of protoplasm and union of

nuclei resulting in a diploid zygote followed by meiosis to restore the haploid phase. Asexual reproduction does not involve such union. Asexual reproduction takes place by means of (i) arthrospores or oidia which are the broken bits of mycelium into thin walled cells with flat ends. (ii) budding, which is a multiplication process in yeast. Here a new cell is formed from a small outgrowth on the parent cells. e.g., *Saccharomyces* (iii) fission, a process in which unicellular organism splits into two by constriction of the nucleus and the cells. e.g. *Schizosaccharomyces.*

Asexual reproduction also takes place by means of aplanospores (non-motile spores produced within a sporangium) or zoospores (motile spores produced inside the zoosporangium) or conidia (borne externally at the hyphal tips). Zoospores are the motile spores produced within the zoosporangium. Each zoospore is a naked protoplasmic unit having flagella. Electron microscopy revealed the fine structure of flagella. There are two types of flagella in fungi whiplash type and tinsel type. Tinsel type of flagellum has many hairy outgrowths (cilia) all around its surface and whiplash type of a flagellum is long thread like structure which is rigid at the base with eleven fibrils and thinner towards the apex as the 2 central fibrils project out. The latter portion is flexible.

Flagella are attached to a basal granule called blepharoplast. It is connected to the nucleus by a strand called rhizoplast. Flagellum consists of eleven fibrils. Two are present in the central region and these are covered by nine separate fibrils forming a sheath. Flagellum is made up of a protein called flagellin (Fig. 2.3).

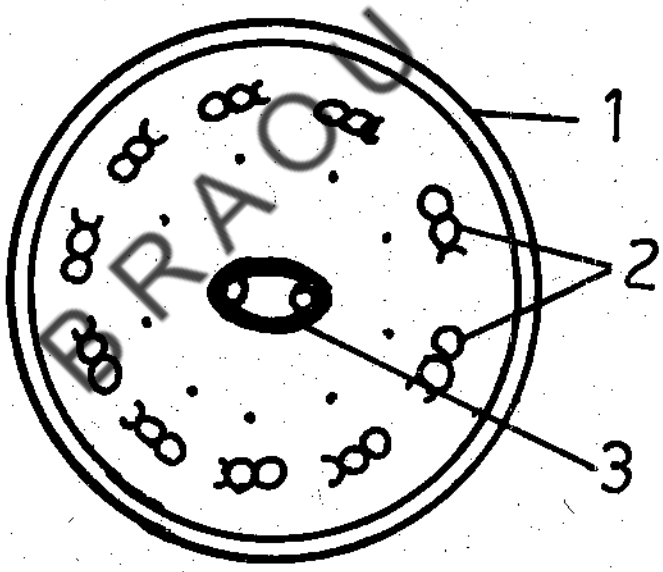


Fig. 2.3. The 9+2 structure of flagellum. 1. Membrane. 2. Outer fibrils (9). 3. Central fibrils (2).

The sporangiospores are formed within a sac-like structure called sporangium. Conidia, the non-motile spores are produced either directly from the mycelium or on specialized structures, the conidiophores.

Sexual reproduction takes place by fusion of motile gametes (planogametic copulation), gametangial contact, gamentangial copulation, spermatisation (non-motile cells called spermatia come in contact with female gametangium) and somatogamy (fusion between undifferentiated vegetative cells).

Check Your Progress - 3

What is the main difference between tinsel type and whiplash type of flagella ?

Note : a) Write your answer in the space given below.

b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

The spores produced either sexually or asexually are disseminated by means of air currents, insects, water and animals. Then they germinate and the germinated spores develop into new fungi.

2.6. STATUS OF FUNGI IN LIVING WORLD

The living organisms are divided into plant kingdom and Animal Kingdom. There are some microscopic organisms (Bacteria, algae, fungi and protozoa) bearing the characters of plants and animals. Haeckel (1894) included all such organisms under a separate kingdom called protista. Modern biologists include the prokaryotic organisms like bacteria and blue-green algae in yet another kingdom : Monera.

Linnaeus classified the fungi as a sub-division under Thallophyta. Eichler (1886) classified bacteria, fungi and slime moulds under Thallophyta only. Gaumann (1952) proposed three classes namely Schizomycetes (bacteria), Myxomycetes (slime moulds) and Eumycetes (fungi).

Tippo (1942), Alexopoulos (1962) and Bold (1957) have proposed a separate division for fungi, the Mycota. Mycota was further divided into Schizomycophyta (bacteria), Eumycophyta (true fungi) and Myxomycophyta (slime moulds). Ingold treated fungi as a separate kingdom. Many taxonomists still consider fungi as a separate division under the plant kingdom itself (Ainsworth, 1973).

BRAOU

2.7. SUMMARY

Fungi are achlorophyllous, heterotrohic, eukaryotic, unicellular or multicellular organisms with absorptive nutrition. Mycelium is non-septate or septate. Asexual reproduction takes place by the production of arthrospores, budding, fission, zoospores and conidia. Sexual reporduction is by planogametic copulation, gametangial contact, gametangial copulation, spermatisation and somatogamy. Many taxonomists consider fungi as a separate division under the plant kingdom itself.

2.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Symbionts are the organisms that live in association with other organisms for mutual

Dr. BRAOU LIBRARY
Acc. No: CM-0066
Class No: 589.2 CER

benefit. Lichens (a symbiotic association between algae and fungi) and mycorrhiza, (between fungi and roots of some forest trees) are the two examples for symbionts.

2. Important vegetative characters of fungi are : (a) Fungi are either unicellular or multicellular. (b) The unicellular fungi are holocarpic in nature. (c) The multicellular thallus is filamentous. (d) Hyphae may be branched or unbranched, septate or aseptate. (e) Septate hyphae may be multinucleate, binucleate or uninucleate.

3. The tinsel type of flagellum bear a large number of hair like projections all around its surface where as in whiplash type these hair like projections are absent.

2.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the vegetative and reproductive characters of fungi.
2. Describe in detail the habitat and habit of fungi.

II. Answer the following questions in about 10 lines each.

1. Write a short note on the status of fungi in living world.
2. Write a brief account on reproductive characters of fungi.
3. Write briefly about the vegetative characters of fungi.

Ms. K. Prasunamma

BRAOU

UNIT - 3 : MORPHOLOGY, CELL STRUCTURE, NUTRITION AND GROWTH OF FUNGI

Contents

3.1. OBJECTIVES

After going through this unit you will be able to :

* describe the morphology and cell structure of fungi,
* list out different somatic structures of fungi,
* explain the nutritional aspects of fungi and
* describe the growth of fungi.

BRAOU

3.2. INTRODUCTION

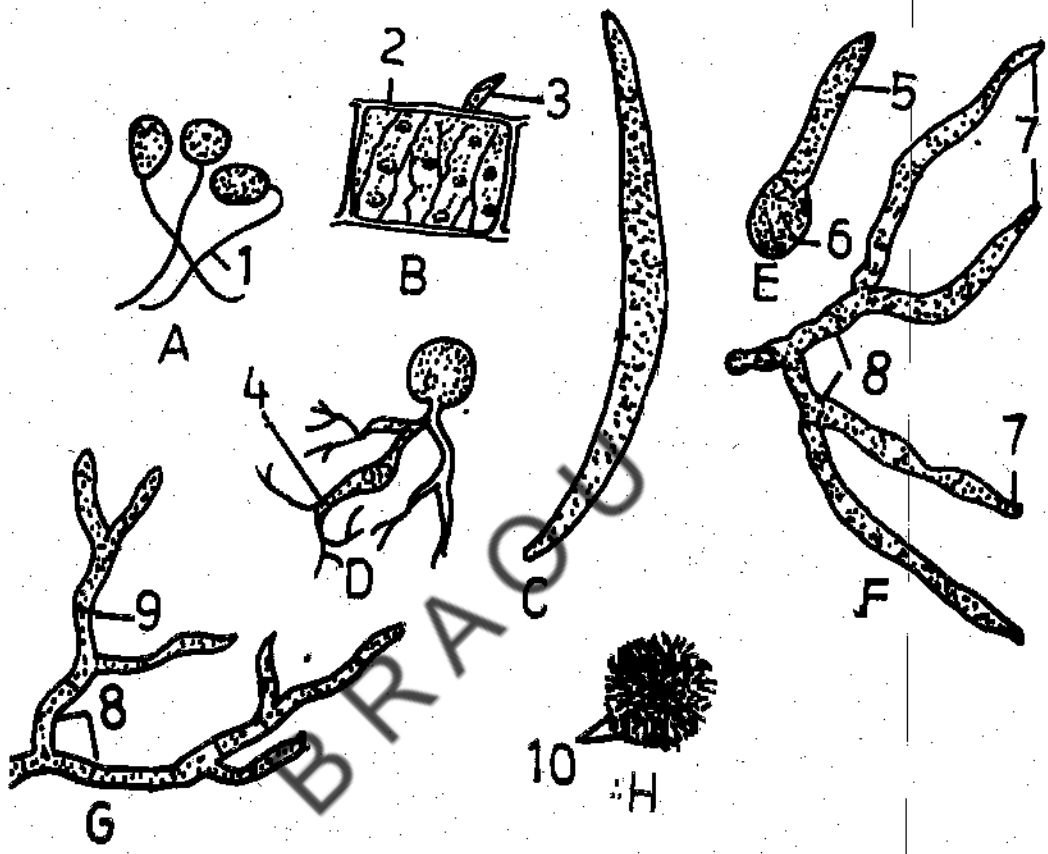
Fungi are achlorophyllous, heterotrophic organisms having a typical cell structure. The vegetative hyphae of fungi are modified into specialized structures performing different functions. They grow in any type of environment having suitable food, temperature and moisture. The optimum temperature range for their growth is 20-30°C.

3.3. MORPHOLOGY AND CELL STRUCTURE

Fungi may be unicellular or filamentous in their structure. The unicellular thalli may produce chain of cells in succession and may look like a filament. Such a structure is called Pseudomycelium (e.g., Yeast). The multicellular thallus may be poorly developed, rhizoid-like and called rhizomycelium (Fig. 3.1). The higher fungi consist of a well developed, branched structures called mycelium. Fungi like *Taphrina* (a pathogenic fungus) consist of mycelial thallus in the host and a yeast-like thallus in culture. Such thalli are called dimorphic thalli.

Each filament of mycelium is called hypha. It is a tube-like structure enclosing protoplasm and reserve food. The diameter of hyphae range from 0.5μ to 1mm. The hyphae

branch repeatedly and the type of branching is either dichotomous or lateral. The hyphae may be septate or aseptate. The septa are of two types : primary and adventitious. Primary septa are formed during cell division while adventitious septa are formed due to the local concentration of cytoplasm and not associated with the cell division. Aseptate hyphae produce septa at the region of formation of reproductive structures.



BRAOU

Fig. 3.1. Morphology of vegetative structures of Fungi. A. Unicellular uninucleate rounded thallus of *Synchytrium*,. B&C. Unicellular uninucleate elongated in *Harpochytrium sp.* D. Rhizomycelium in *Nowakowskiella* sp. E. Spore germination. F. Aseptate hyphae. G. Septate hyphae. H. Spherical hyphal colony with radiating hyphae. 1. Flagellum. 2. Host cell. 3. Fungal thallus 4. Rhizomycelium, 5. Germ tube. 6. Spore wall 7. Hyphal tips, 8. Hyphal branches. 9. Septa. 10. Radiating hyphae.

Many fungi possess a central pore in the septum. Such septa are called porous or perforated septa while the septa without pores are called non-porous septa. The septal pore is of two types, simple and complex. A simple pore is not surrounded by a swollen rim made up of amorphous material. A complex pore is surrounded by a swollen rim and is called a dollpore septum (Fig. 3.2). The swollen rim consists of barrel-shaped thickenings called parenthosomes.

The structure of a fungal cell in both unicellular and filamentous fungi is almost similar. Fungal cells are surrounded by a three layered cell wall and the plasma membrane delimits

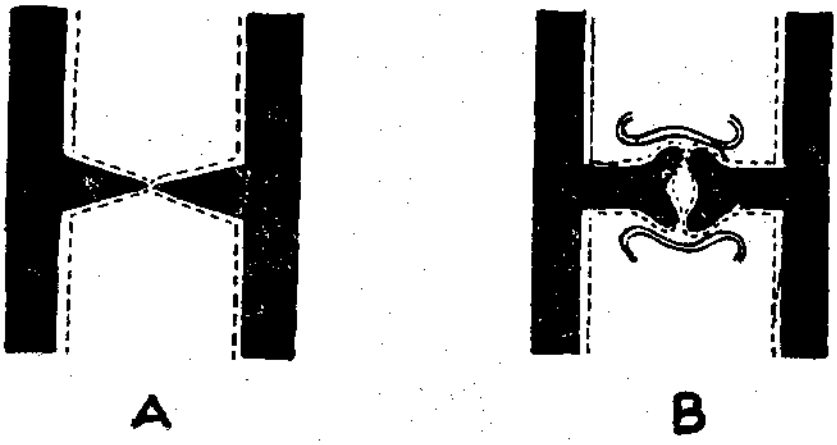


Fig. 3.2. Types of Septa. A. Simple pore septum. B. Dolipore septum.

the cytoplasm. Fungi are eukaryotic (having true nuclei) in nature. The reserve food is in the form of glycogen. A remarkable feature of a fungal cell is the occurrence of lomasomes. Lomasomes are the vesicles formed in between the cell wall and plasma membrane due to the invagination of plasma membrane (Fig. 3.3). The function of lomasomes is unknown. Main cell inclusions are mitochondria, vacuoles, ribosomes, endoplasmic reticulum, nucleus, dictyosomes and centrioles. Mitochondria may be spherical or elongated and similar to that of higher plants. Ribosomes are also similar to those found in higher plants and animals. The vacuoles are surrounded by a distinct membrane called tonoplast. They consist of crystalline and amorphous inclusions and also pigments. The nuclei of fungi are very small ranging from 2-25μ in diameter. A living fungal nucleus consists of a central dense area surrounded by a clear area and is surrounded by a nuclear membrane. The nuclear membrane is continuous with endoplasmic reticulum. Endoplasmic reticulum of fungi is not closely packed as in higher plants and animals. Centrioles are observed only during nuclear division, one in each pole of the nuclear spindle. Dictyosomes consist of a pile of membrance bound sacs.

Cell walls contain 80-90% carbohydrates and the remaining being proteins and lipids. An important feature of cell wall is the presence of chitin. Glucans, mannans and cellulose are also reported.

BRAOU

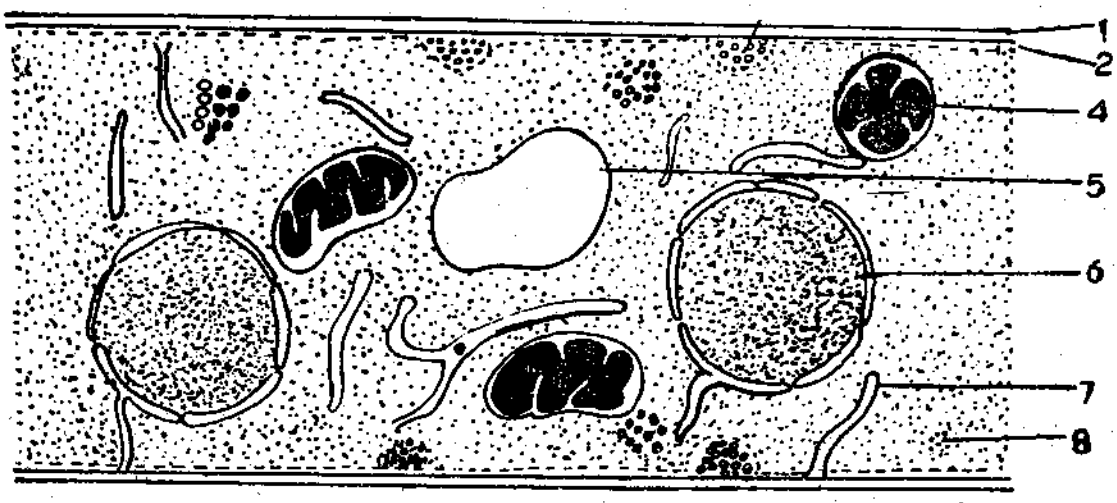


Fig. 3.3. Ultrastructure of hypha. 1. Cell wall. 2. Plasma membrane. 3. Lomasome. 4. Mitochondrion. 5. Vacuole. 6. Nucleus. 7. Endoplasmic reticulum. 8. Ribosomes.

Check Your Progress - 1 & 2

1. What is a dolipore septum ?
2. What are lomasomes ?

Note : a) Write the answers in the space given below.

b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

3.4. DIFFERENT SOMATIC STRUCTURES

BRAOU

Special forms of mycelium are formed to perform special functions. They are (a) Rhizoids (b) Haustoria (c) Rhizomorphs (d) Stroma and (e) Sclerotium. Rhizoids are root-like structures used as holdfasts and are feeding organs e.g., *Rhizopus nigricans*. Haustoria (singular: Haustorium) are the specialized hyphal branches which are sent inside the living

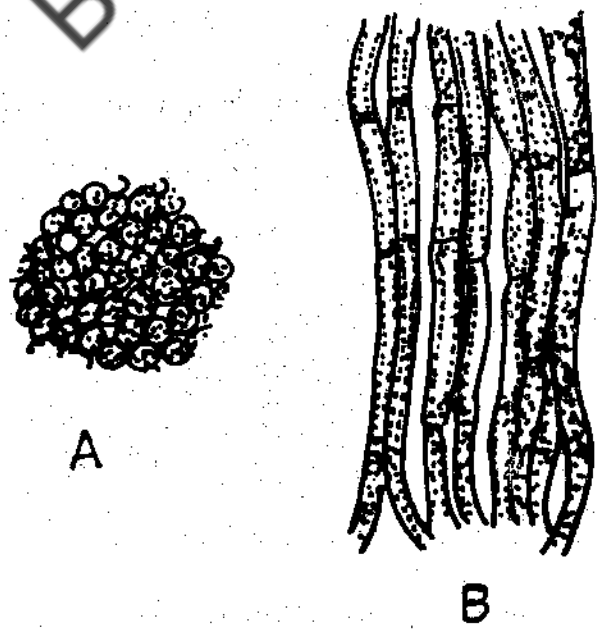


Fig. 3.4. Fungal tissues (plectenchyma). A. Pseudoparenchyma B. Prosenchyma.

cells of the host for absorption of food. They are knob-like, elongated or lobed. Rhizomorphs are thread like structures made up of loosely aggregated hyphae. A stroma is a compact mass of vegetative hyphae produced in fungi and a sclerotium is hard and firm with a rind and consists of a mass of hyphae. It serves as a resting body resistant to unfavourable conditions. Due to aggregation of vegetative hyphae fungal tissues are also formed and such fungal tissues are called Plectenchyma. e.g., prosenchyma and pseudoparenchyma (Fig. 3.4).

3.5. NUTRITION IN FUNGI

Fungi require carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, magnesium, sulphur and also minor elements like iron, zinc, copper, manganese and molybdenum. Some fungi require vitamins also especially thiamine or biotin.

In nature, fungi obtain the above food materials from living or dead plants. These food materials exist in complex form. So fungi breakdown these materials and assimilate them. These processes are carried on by enzymes secreted by fungi. Enzymes are organic catalysts produced by living cell.

Fungi lack chlorophyll and hence depend upon other sources. Parasites and saprophytes feed on dead organic matter. The parasites and saprophytes are further divided as obligate parasites, facultative parasites and facultative saprophytes. Obligate parasites require a living host for the completion of their life cycle. e.g., rust fungi. These are also known as 'biotrophs'. Facultative parasites are those fungi that lead a saprophytic life but when they come in contact with a host, they are capable of parasitizing. e.g., *Pythium*. Facultative saprophytes are basically parasites but can live as saprophytes also. e.g., smut fungi.

Two living organisms may live in association with one another and are called symbionts. However, they are helpful to each other. e.g., lichens, mycorrhizae. A lichen is an association of an alga and a fungus. Mycorrhizae means fungus roots.

BRAOU

Check Your Progress - 3

Distinguish between obligate parasites and facultative parasites.

Note : a) Write the answer in the space given below.

b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

3.6. GROWTH OF FUNGI

Many fungi grow between 0 and 35° C. The optimum temperature required for the

growth of fungi being 20-30°C. Some fungi can withstand low temperature even up to -195° C for at least few hours.

Fungi prefer an acid medium for growth, i.e., a pH of 6. Light is not essential for the growth of fungi but to some extent it is necessary for sporulation and spore dispersal. Many fungi are facultative anaerobes and some are strict aerobes. During respiration free oxygen is used by the fungi. Facultative anaerobes perform anaerobic respiration which does not involve free oxygen. The amount of growth in fungi is affected by the oxygen supply.

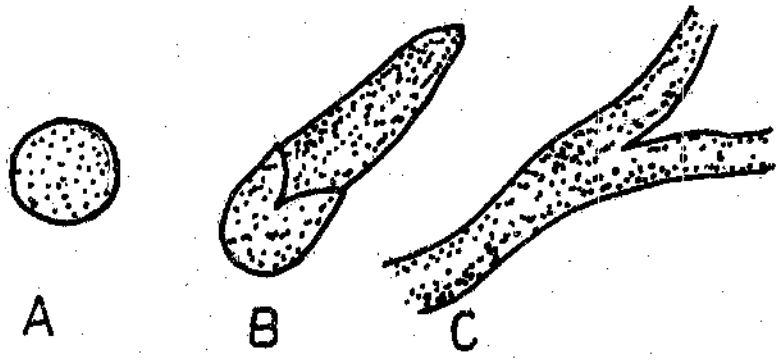


Fig. 3.5. Germination of spore and hypha formation. A. Spore. B. Germinating spore. C. Hypha.

BRAOU

The growth of fungus starts from a fungal spore which is a very simple structure, about one thousandth of an inch in size. The contents of a fungal spore are colourless and contain oil as reserve food. Such a spore settles upon a suitable substratum and germinates under the proper conditions of temperature and humidity. At the first instance, the fungal spore sends out a pale thread like structure called germ tube which grows in size and called hypha. The hypha branches repeatedly to form a dense mass of mycelium resembling a cotton wool (Fig. 3.5).

3.7. SUMMARY

Fungi are either unicellular or multicellular organisms. The filamentous structures of multicellular fungi are called hyphae and the entire thallus is called mycelium. The hyphae may be aseptate or septate. The septate hyphae consist of a central pore which may be either simple or complex. Septum having complex pore is called dolipore septum.

The structure of a fungal cell is similar both in unicellular and multicellular fungi. The reserve food of fungi is glycogen. A special feature of fungal cell is the occurrence of lomasomes.

Fungal cell also consists of other inclusions like mitochondria, ribosomes, endoplasmic reticulum, vacuoles, nucleus, dictyosomes and centrioles. 80-90% of cell wall is made up of carbohydrates and the remaining are proteins, lipids and chitin.

Fungal mycelium is modified into various forms to perform certain special functions. They are rhizoids, haustoria, rhizomorphs, stroma and sclerotium. The fungal hyphae

aggregate to form tissues like prosenchyma and pseudoparenchyma.

Fungi live as saprophytes, parasites or symbionts. They require many elements like carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, magnesium, sulphur and molybdenum for their growth.

The optimum temperature required for the growth of many fungi is 20- 30° C. They prefer an acid medium for growth (pH 6). Though light is not essential for growth of the fungi, certain amount of light is necessary for sporulation and spore dispersal. Growth of fungi starts from the germination of spore which give rise to germ tube, hypha and mycelium respectively.

3.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The fungal hyphae are divided into cells with the help of cross walls with a small pore in the centre. These cross walls are called septa. The septum without any thickenings is called simple pore septum and the septum with barrel shaped thickenings around the pore is called dolipore septum.
2. In the fungal mycelium some small particles or vesicles are present in between the cell wall and plasma membrane. These are called lomasomes.
3. Obligate parasites are fungi requiring a living host for the completion of their life cycle. e.g., rusts. Facultative parasites are those fungi that lead a saprophytic life but when come in contact with a host they are capable of parasitizing. e.g., *Pythium*.

3.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the morphology and cell structure of fungi.
2. Write an essay on growth and nutrition of fungi.

II. Answer the following questions in about 10 lines each.

1. Write briefly about different somatic structures that you come across in fungi.
2. Write a brief note on the structure of a fungal cell.
3. Write a short note on nutrition of fungi.

Dr. M. Ramachandraiah

BRAOU

UNIT - 4 : REPRODUCTION AND LIFE CYCLES IN FUNGI

Contents

BRAOU

4.1. OBJECTIVES

After going through this unit you will be able to :

* list out the types of reproduction in fungi,
* describe different types of reproduction in fungi,
* explain the term parasexuality and describe different stages in it and
* describe the life-cycles of major groups of fungi.

4.2. INTRODUCTION

Most of the fungi reproduce by spores. These spores are produced either by asexual or sexual means. The asexual reproduction is sometimes called vegetative or somatic reproduction. Except Deuteromycetous fungi, all other fungi possess both asexual and sexual stages in their life-cycle. Deuteromycetous fungi reproduce only asexualy and sexual reproduction is absent in their life-cycle.

4.3. REPRODUCTION

Formation of new individuals from old ones having all the characters typical to that of a species is called reproduction. Two types of reproduction commonly occur in fungi. They are asexual and sexual reproduction. Every individual consists of vegetative phase

and reproductive phase in its life cycle. During reproduction either the whole thallus or a part of it is converted into reproductive organs. The fungi wherein the whole thallus is converted into reproductive structure are called holocarpic (Gr. holo : whole; Karpos: fruit), e.g., unicellular fungi such as *Olpidium, Synchytrium* etc. In majority of fungi, a part of the thallus functions as reproductive structure and such fungi are called eucarpic (Gr. Eu : good; Karpos : fruit). e.g., *Albugo, Rhizopus* etc., The holocarpic forms are regarded as primitive members.

Check Your Progress - 1

Differentiate between holocarpic and eucarpic fungi.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

4.3.1. Asexual Reproduction

Non-sexual production (not accompanied by the fusion of reproductive units) of special reproductive cells is called asexual reproduction. In fungi, asexual reproduction takes place by means of fragmentation, budding, fission and spores.

Fragmentation is the division of fungal hyphae into one or more fragments, each of which develop into a new individual. Fragmentation may be accidental or a normal mode of reproduction.

Budding is a multiplication process in yeasts. A new cell is formed from a small outgrowth on the parent cells. e.g., *Saccharomyces* (Fig. 4.1)

Fission is a process by which an unicellular organism splits into two by constriction of the nucleus and the Cytoplasm. e.g., *Schizosaccharomyces* (Fig. 4.1).

BRAOU

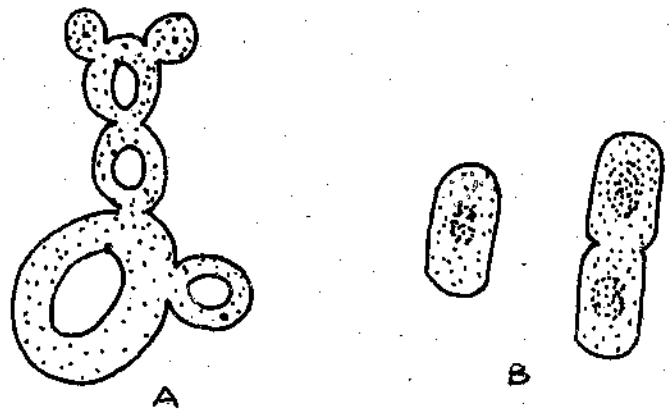
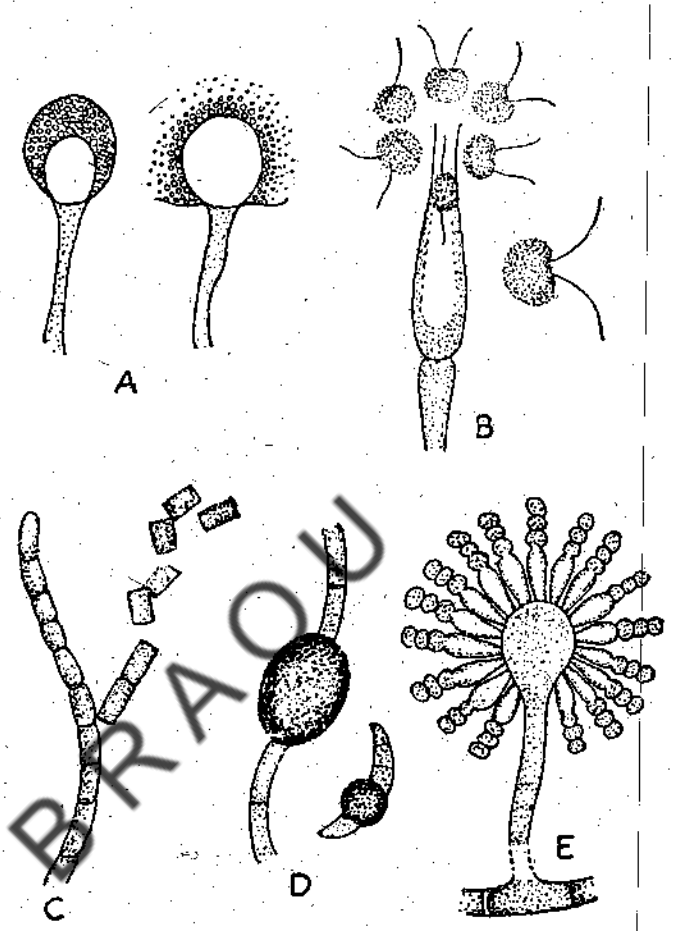


Fig. 4.1. Asexual Reproduction. A. Budding. B. Fission.

Asexual reproduction also takes place by the production of aplanospores (non-motile sporangiospores borne inside a sporangium) or zoospores (motile spores produced inside the zoosporangium) or conidia (borne externally at the hyphal tips).

Sporangiospores are formed within a sac-like structure called sporangium. Sporangia are present on erect stalks, sporangiophores (Fig. 4.2).



BRAOU

Fig. 4.2. Asexual reproduction through spores. A. Sporangiospores. B. Zoospores. C. Arthrospores. D. Chlamydospores. E. Conidia

Lower fungi produces three types of zoospores. They are uniflagellate zoospore with a posterior whiplash flagellum, uniflagellate zoospore with an anterior tinsel type of flagellum and biflagellate zoospore with whiplash and tinsel type of flagella attached apically or laterally (Fig. 4.3).

Conidia are produced by mitosis either directly from mycelium or on specialized structures, the conidiophores (Fig. 4.2). The apical cell of the conidiophore is the conidiogenous cell. Conidiogenous cell enlarges and blasts out a ball like structure, the conidium. This development is called blastic. When both the wall layers of the conidiogenous cell contributes for the formation of conidium, the development is called holoblastic and when only the inner wall contributes for the formation of conidium, the

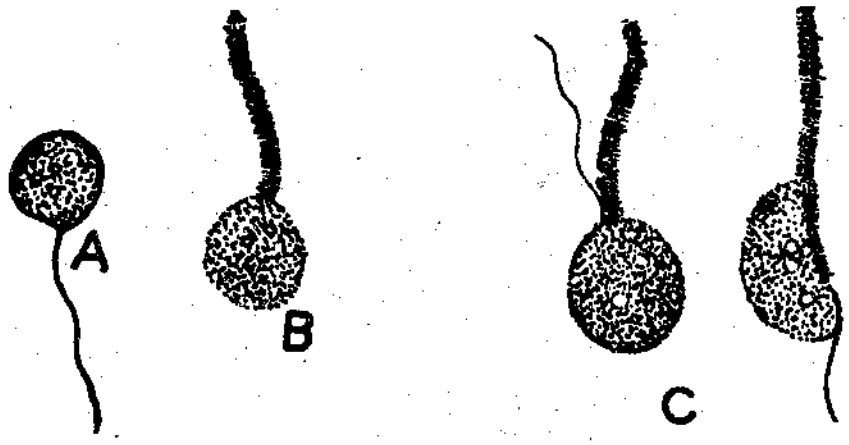


Fig. 4.3. Three types of Zoospores. A. Posteriorly uniflagellate (whiplash type). B. Anteriorly uniflagellate (tinsel type). C. Biflagellate zoospores (Whiplash & tinsel type).

development is called enteroblastic. Conidia are also produced on a bottle shaped structure called Phialide. Conidial chains are formed when conidium after conidium are produced on the conidiophore at different points. As the conidium falls down, a scar is left on the conidiophore. These conidia some times arise in special structures like pycnidium (flask like), sporodochium (disc-like), acervulus (saucer like) and synnema (broom stick - like). Conidia may be one or many celled. They may be colourless or coloured. They may be longitudinally septate or transversely septate or both.

In some fungi the hyphae break up into short thin walled cells with flat ends and are called oidia.

BRAOU

Check Your Progress - 2

What is a conidium ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

4.3.2. Sexual Reproduction

Fusion of two nuclei of different parents to form a diploid zygote is called sexual reproduction. Sexual reproduction involves the following three events.

Plasmogamy : The coming together and union of protoplasts of two sex cells.

Karyogamy : Fusion of two nuclei brought together leading to the formation of diploid nucleus.

Meiosis : Reduction division of the diploid nucleus by which the haploid number is restored.

In some higher fungi karyogamy is delayed. In such cases the two nuclei of different parentage lie in the same cell. This phase is called dikaryotic (di : two; Karyon : nuclei).

The sex organs involved are gametangia *viz.*, antheridium (male gametangium) and oogonium or ascogonium (female gametangium). The following are the different methods

of sexual reproduction in fungi.

1. Planogametic Copulation : Union of two motile gametes is called planogametic copulation. When the two fusing gametes are similar the process is called isogamy. The fusion between two dissimilar gametes is called anisogamy. Heterogamy is the union of a motile gamete and a non-motile female egg present in oogonium. e.g., *Allomyces, Chytrids, Monoblepharis.*

2. Gametangial Contact : Male and female gametangia come closer and male gametangial protoplast migrates into oogonium through a pore or tube. e.g., *Albugo.*

3. Gametangial Copulation : The entire contents of dissimilar or similar gametangia fuse and form a diploid zygote. e.g., *Rhizopus, Saccharomyces.*

4. Spermatisation : Minute, non-motile cells (spermatia) come in contact with female gametangium resulting in fertilization. e.g., *Neurospora.*

5. Somatogamy : Fusion takes place between two undifferentiated vegetative cells, and all cells are compatible. e.g., *Peziza.* Different methods of sexual reproduction are shown in Fig. 4.4.

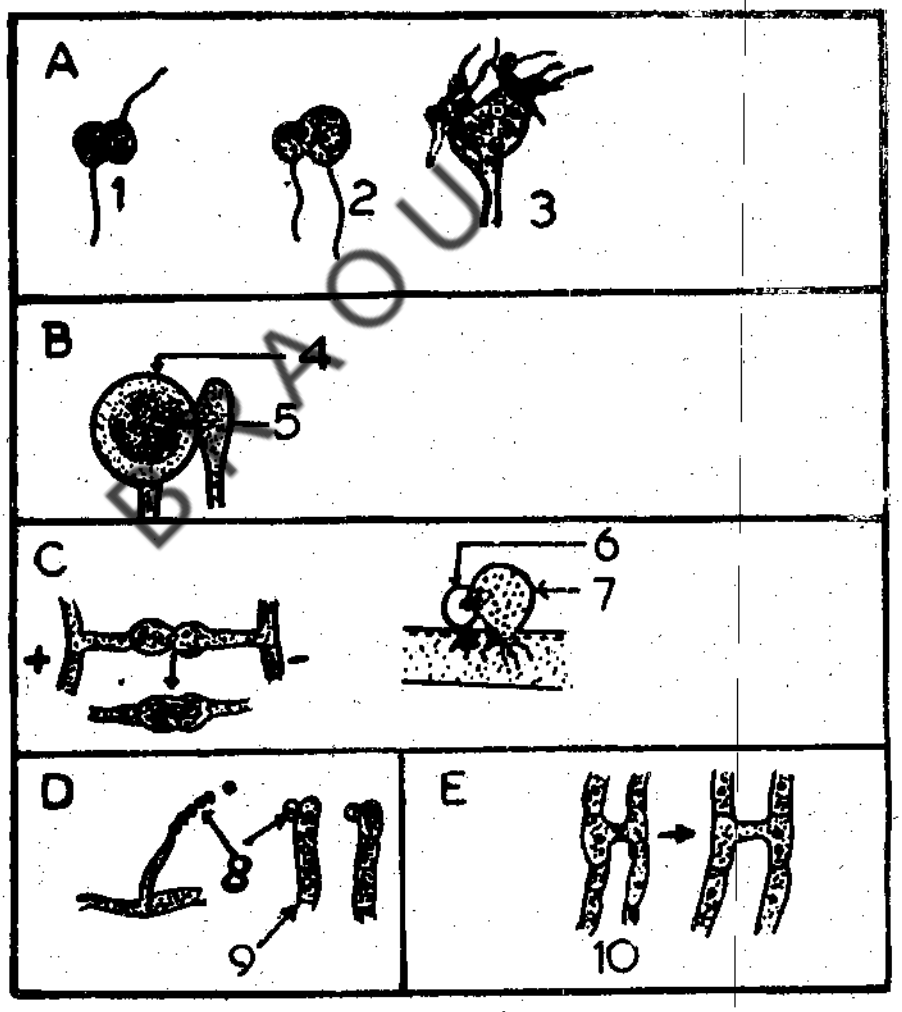


Fig. 4.4. Various types of sexual reproduction. A. Planogametic Copulation. B. Gametangial Contact. C. Gametangial Copulation. D. Spermatisation. E. Somatogamy. 1. Isogamy. 2. Anisogamy. 3. Heterogamy. 4. Oogonium. 5. Antheridium. 6. Male gametangium. 7. Female gametangium. 8. Spermatia. 9. Receptive hyphae. 10. Hyphae of opposite mating types.

BRAOU

4.3.3. Parasexuality

Parasexuality is a process in which plasmogamy, karyogamy and haploidization take place in sequence, but not at specified points in the life cycle of an individual. It was discovered in *Aspergillus nidulans* by Pontecorvo (1952). After this, the parasexual phenomenon has been identified in several other Imperfect fungi (Deuteromycetes). The sequence of events in parasexuality are given below :

i) Formation of Heterokaryotic Mycelium : The presence of genetically different nuclei in the same protoplast is called heterokaryosis. Most commonly, the heterokaryotic mycelium is formed by anastomosis of somatic hyphae or spores of different genetic constitutions. Mutation is also reported to be the cause of heterokaryosis.

ii) Nuclear Fusion and Multiplication of Diploid Nuclei : In the heterokaryotic mycelium, fusion takes place between the haploid nuclei of different types and this results in the formation of heterozygous diploid nuclei. All these diploid nuclei multiply mitotically along with other haploid nuclei.

iii) Mitotic Crossing Over : This is the most important phase in the parasexual cycle. During the multiplication of the diploid nuclei, mitotic crossing over takes place. This results in the formation of new genetic combinations.

iv) Sorting out of Diploid Strains : The segregation of diploid strains occurs during the conidial formation. The diploid nuclei are incorporated into some conidia. These diploid conidia germinate and produce diploid mycelia.

v) Haploidization : Some diploid nuclei undergo haploidization in the mycelium during growth and are sorted out. Some of them are genetically different from both the original parents because of mitotic recombinations. The haploidization is not by reduction division (meiosis) but by aneuploidy. Aneuploidy is a phenomenon in which chromosomes are lost during mitotic division. Thus the parasexual cycle involves plasmogamy and karyogamy (haploidization without meiosis).

BRAOU

Check Your Progress - 3

Define parasexuality ?

Note : a) Write the answer in the the space given below.

b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

4.4. LIFE-CYCLES

In the life history of fungi, haploid and diploid nuclear phases alternate with each other. Haploid phase begin with the completion of meiosis and diploid stage starts with the nuclear fusion. Usually, fungi consist of both asexual and sexual modes of reproduction in their life cycle. The following are the various life-cycles of major groups of fungi.

4.4.1. Asexual Life - Cycle

Some fungi multiply only by asexual reproduction. They do not reproduce by sexual methods. e.g., members of Deuteromycotina.

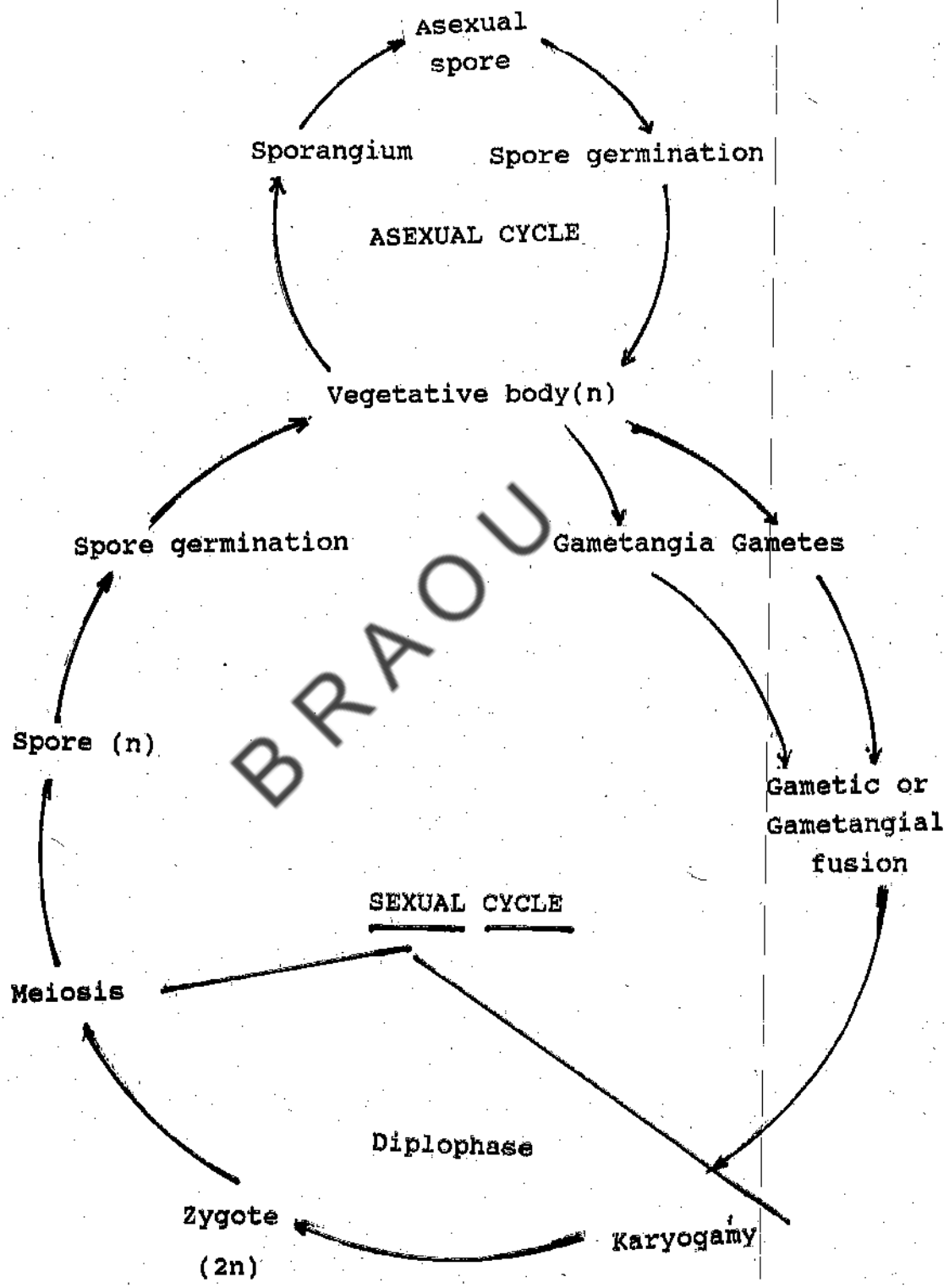
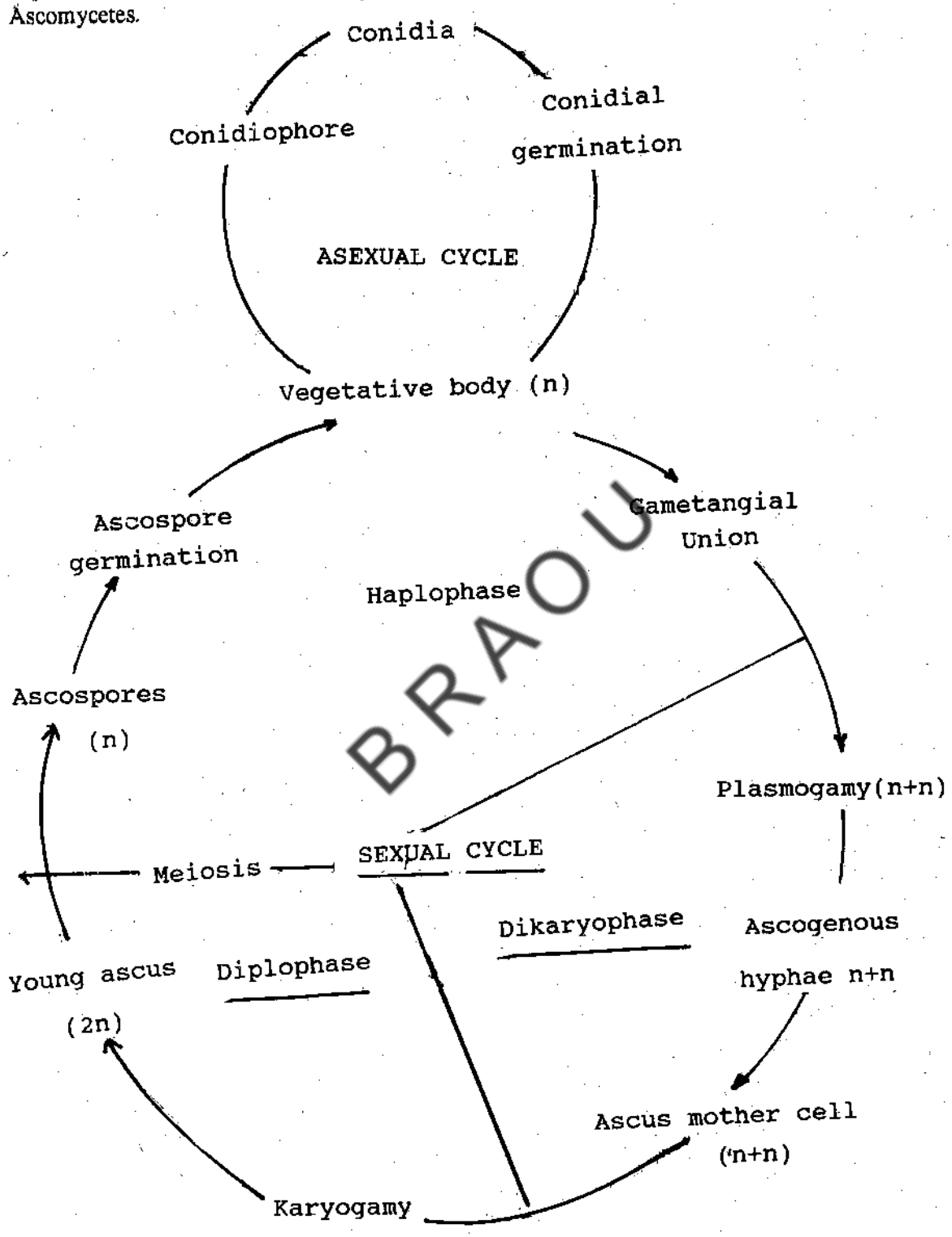


Fig. 4.5. Haplontic Life-Cycle.

BRAOU

4.4.2. Haploid Life - Cycle (Haplontic)

Fungi reproduce both asexually and sexually. Dominant phase is the haploid phase. Nuclear fusion is immediately followed by meiosis and the resultant cells are haploid. Diploid stage is only a temporary phase, e.g., some members of Mucorales and Ascomycetes.



BRAOU

Fig. 4.6. Haploid - Dikaryotic Life-Cycle.

4.4.3. Haploid - Dikaryotic Life - Cycle

In some fungi haploid phase is followed by prolonged dikaryotic phase. Dissimilar but compatible haploid nuclei come closer in a cell, making the cell to become dikaryotic. Karyogamy is delayed in these fungi. Karyogamy is immediately followed by meiosis e.g., members of Ascomycetes and Basidiomycetes.

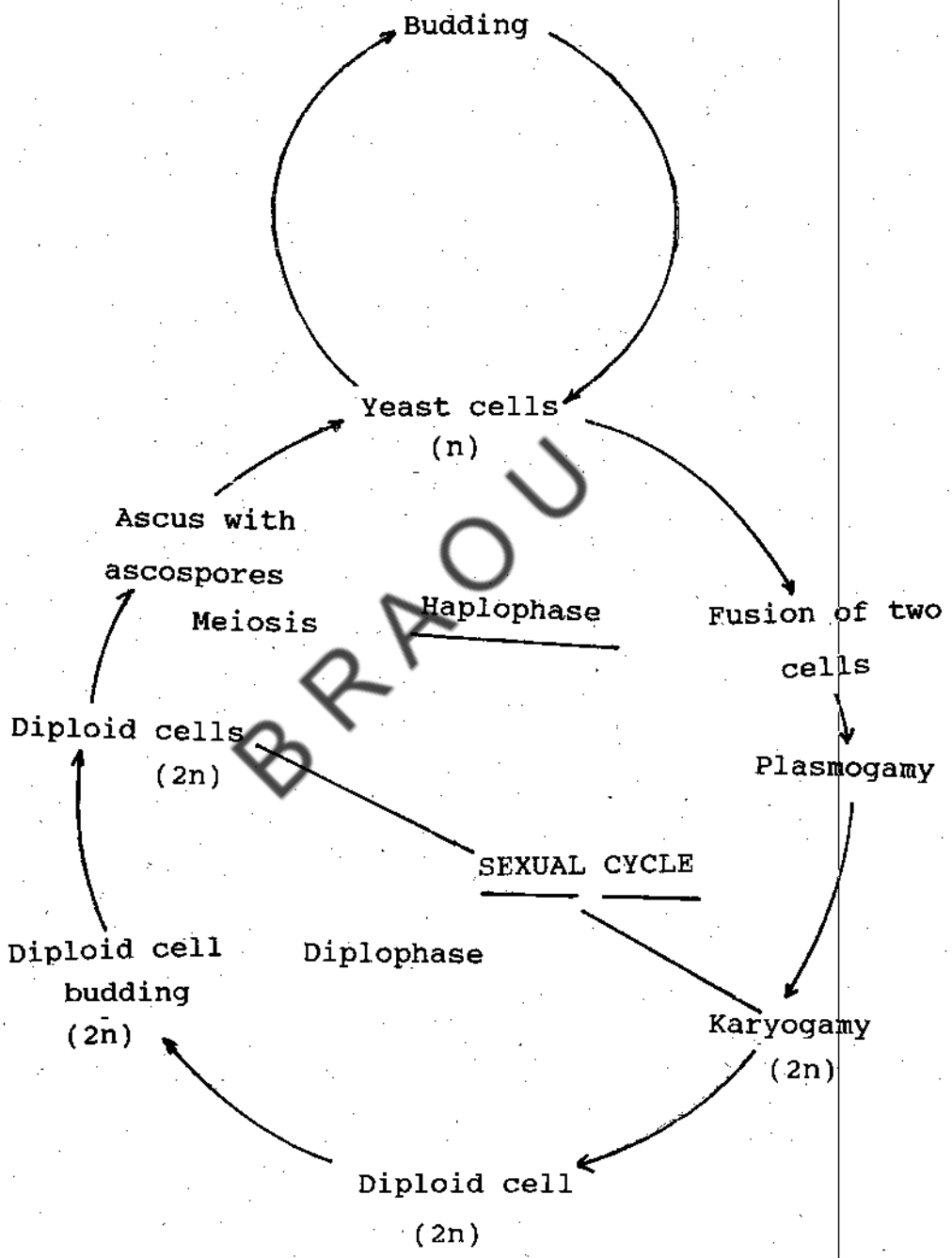


Fig. 4.7. Haploid and Diploid Life-Cycle.

BRAOU

4.4.4. Haploid and Diploid Life Cycle

Haploid phase of the fungus alternates with the diploid stage of the fungus and both phases share the life cycle equally. e.g., *Saccharomyces cerevisiae* (yeast).

4.4.5. Diploid Life-Cycle (Diplontic)

Haploid stage is confined to gametangium or gametes only. The thallus is diploid and undergoes meiosis just before gamete formation. Thus, haploid phase is for a short period and diploid phase forms the major part. e.g., *Saccharomyces ludwigii* (yeast).

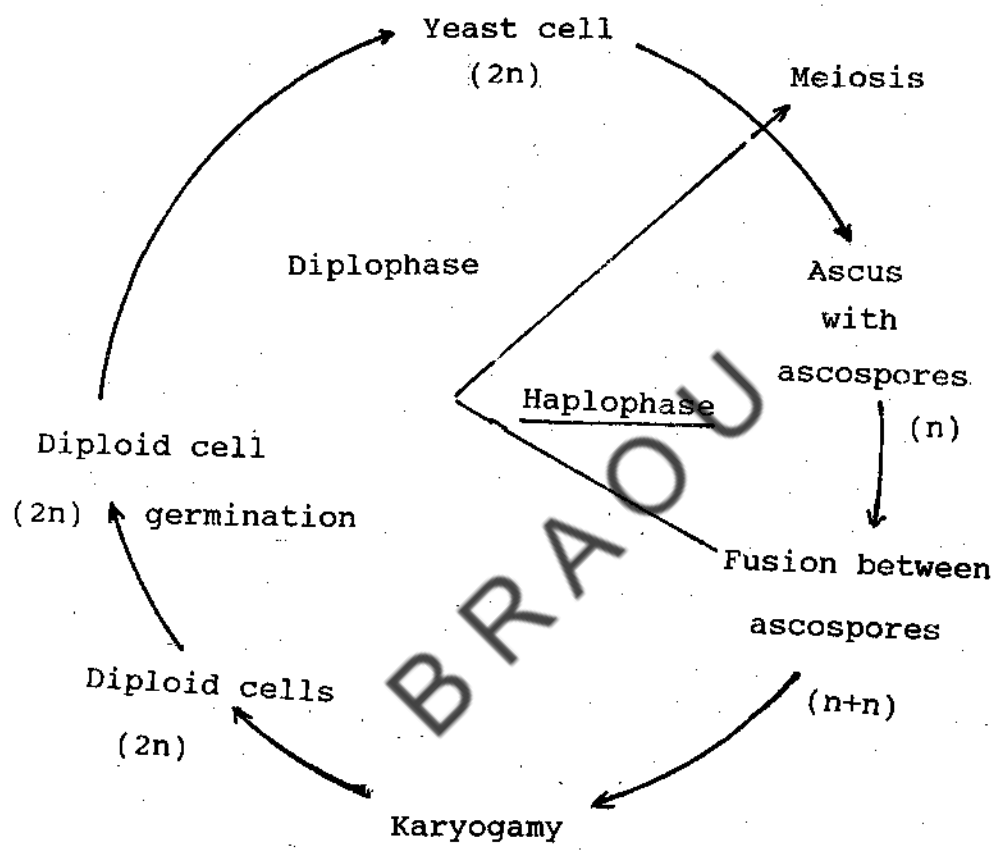


Fig. 4.8. Diploid Life Cycle.

4.5. SUMMARY

Fungi reproduce by asexual and sexual means. Asexual reproduction takes place by fragmentation, budding, fission, zoospores, aplanospores, conidia etc. Sexual reproduction involves plasmogamy, karyogamy and meiosis. Various types of sexual reproduction in fungi are planogametic copulation, gametangial contact, gametangial copulation, spermatisation and somatogamy. Parasexuality, a phenomenon where plasmogamy, karyogamy and meiosis do not occur at specified points is seen in members of deuteromycetes.

Different groups of fungi show different life-cycles and they are asexual life-cycle,

haploid life cycle, haploid dikaryotic life-cycle, haploid and diploid life cycle and diploid life-cycle.

4.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The holocarpic fungi are those fungi in which the whole thallus is converted into reproductive structure. In eucarpic fungi, a part of the thallus is converted into a reproductive structure.
2. Conidium is an asexual, non-motile spore produced exogenously over the conidiophore.
3. Parasexuality is a process in which plasmogamy, karyogamy and haploidization takes place, but not at specified points in the life-cycle of the fungus.

4.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain briefly different types of reproduction in fungi.
2. Write an essay on various types of sexual reproduction in fungi.
3. Describe different types of life cycles in fungi.

II. Answer the following questions in about 10 lines each.

1. What is heterokaryosis and sexual compatibility ?
2. Write a note on asexual reproduction in fungi.
3. Write a brief note on vegetative reproduction in fungi.

BRAOU

Ms. K. Prasunamma

UNIT - 5 : CLASSIFICATION OF FUNGI

Contents :

5.1. OBJECTIVES

BRAOU

After going through this unit, you will be able to :

* describe the system of classification proposed by Ainsworth (1971),
* give the key to Sub-divisions of Eumycota,
* give the key to classes of Myxomycota, Mastigomycotina, Deuteromycotina, Zygomycotina, Ascomycotina and Basidiomycotina,
* describe the outline classification of Myxomycota, Mastigomycotina, Deuteromycotina, Zygomycotina, Ascomycotina and Basidiomycotina and
* explain the important changes brought about by Hawksworth, Sutton and Ainsworth (1983) in the classification of fungi.

5.2. INTRODUCTION

Although fungi are plant-like in having a cell wall and reproduction by spores, mycologists now believe that most fungi have originated from some ancestral protozoans like flagellates and are therefore, unrelated to plants. There is an increasing tendency among taxonomists to separate the fungi from the plant kingdom. Edwards (1976) and Whittaker and Margulis (1978) segregated fungi into a kingdom of their own; kingdom Myceteae (Fungi).

Though several systems of classification have been proposed from time to time, the classification of fungi is still in a state of flux. Saccardo as early as 1884 classified fungi into six classes; (1) Schizomycetes (bacteria), (2) Myxomycetes (slime molds), (3)

Phycomycetes, (4) Ascomycetes, (5) Basidiomycetes and (6) Deuteromycetes. de Bary (1887) and Bessey (1950) placed slime molds (Myxomycetes) in animal kingdom, but today many botanists consider them related to fungi. Ainsworth (1966, 1971) kept Myxomycetes in a separate division Myxomycota and included plasmodial forms. Alexopoulos (1962) included all fungi under division Mycota. He subdivided the division Mycota into two sub-divisions, Myxomycotina (slime moulds) and Eumycotina (true fungi). Eumycotina is further divided into eight classes (Chytridiomycetes, Hyphochytridiomycetes, Plasmodiophoromycetes, Oomycetes, Trichomycetes, Zygomycetes, Ascomycetes, Basidiomycetes) and one form-class Deuteromycetes. Ainsworth (1966) treated fungi either as a separate kingdom or as a sub-kingdom with two divisions, the Myxomycota for Plasmodial forms and the Eumycota for mycelial forms. The scheme proposed by Ainsworth (1971) is mostly in use and an outline of scheme of classification of fungi by Ainsworth (1973) is given in this unit.

Check Your Progress 1 & 2

1. State the rank given to the fungi in living world by Edwards.
2. Which is the most widely used classification system for fungi ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

BRAOU

5.3. KEY TO DIVISIONS OF FUNGI

Plasmodium or Pseudoplasmodium present..... *Myxomycota.*

Plasmodium or Pseudoplasmodium absent, assimilative phase typically filamentous.... *Eumycota.*

5.3.1. Key to Classes of Myxomycota

1. Assimilative phase free-living amoebae which unite as a psuedoplasmodium before reproduction..... *Acrasiomycetes.*
   Assimilative phase a plasmodium ..... 2.
2. Plasmodium forming a net work ("net plasmodium")..... *Hydromyxomycetes.*
   Plasmodium not forming a network ..... 3.
3. Plasmodium saprobic, free-living & plasmodium parasitic within the cells of the host plant..... *Plasmodiophoromycetes.*

5.3.2. Key to Sub-divisions of Eumycota

Eumycota has been sub divided into five sub-divisions on the basis of motility of spores, perfect stage (sexual stage) and type of sexual spores.

1. Motile cells (Zoospores) present, perfect state spores typically Oospores..... *Mastigomycotina.*
   Motile cells absent ..... 2.

2. Perfect state absent ..... *Deuteromycotina.*
   Perfect state present ..... 3.

3. Perfect state spores Zygospores ..... Zygomycotina
   Zygospores absent ..... 4.

4. Perfect state spores ascospores ..... *Ascomycotina.*
   Perfect state spores basidiospores ..... *Basidiomycotina.*

Check Your Progress - 3 & 4

3. Name the divisions assigned to plasmodial and mycelial forms of fungi.

4. On what basis the division Eumycota was further subdivided ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

BRAOU

Mastigomycotina has been divided into three classes based on number and position of flagella of the zoospores.

Key to Classes of Mastigomycotina

1. Zoospores posteriorly uniflagellate (flagella whiplash type) ..... *Chytridiomycetes.*

   Zoospores not posteriorly uniflagellate..... 2

2. Zoospores anteriorly uniflagellate (flagella tinsel type)..... *Hyphochytridiomycetes.*

   Zoospores biflagellate (posterior flagellum whiplash type; anterior tinsel type); cell wall cellulosic..... *Oomycetes.*

Zygomycotina has been subdivided into two classes based on either saprobic, parasitic or predacious nature of the organisms and also whether they are endoparasites or ectoparasites.

Key to Classes of Zygomycotina

Saprobic or, if parasitic or predacious, having mycelium immersed in host tissue ..... *Zygomycetes.*

Associated with arthropods and attached to the cuticle or digestive tract by a holdfast and not immersed in the host tissue ..... *Trichomycetes.*

Key to Classes of Ascomycotina

1. Ascocarps and ascogenous hyphae absent; thallus mycelial or yeast like..... *Hemiascomycetes.*

   Ascocarps and ascogenous hyphae present; thallus mycelial ..... 2.

2. Asci bitunicate; ascocarp an ascostroma ..... *Loculoascomycetes.*

   Asci typically unitunicate; if binuticate ascocarp an apothecium :..... 3.

3. Asci evanescent, scattered within the astomous ascocarp, aseptate ..... *Plectomycetes.*

   Asci regularly arranged within the ascocarps as a basal or peripheral layer ..... 4.

4. Exoparasites of arthropods; thallus reduced; ascocarp a perithecium; asci inoperculate ..... *Laboulbeniomycetes.*

   Not exoparasites of arthropods ..... 5.

5. Ascocarp typically a perithecium which is usually ostiolate (if astomous, asci not evanescent); asci inoperculate with an apical pore or slit ..... *Pyrenomycetes.*

   Ascocarp an apothecium or a modified apothecium, frequently macrocarpic, epigean or hypogean; asci inoperculate or operculate ..... *Discomycetes.*

Key to Classes of Basidiomycotina

Basidiomycotina has been subdivided into three classes based on presence or absence of basidiocarp and type of basidiocarp.

1. Basidiocarp lacking and replaced by teliospores or chlamydospores (encysted probasidia) grouped in sori or scattered within the host tissue; parasitic on vascular plants ..... *Teliomycetes.*

   Basidiocarp usually well-developed; basidia typically organised as a hymenium; saprobic or rarely parasitic ..... 2.

2. Basidiocarp typically gymnocarpous or semi-angiocarpous; basidia phragmobasidia *(Phragmobasidiomycetidae)* or Holobasidia *(Holobasidiomycetidae)*, basidiospores ballistospores ..... *Hymenomycetes.*

   Basidiocarp typically angiocarpous; basidia holobasidia; basidiospores not ballistospores ..... *Gasteromycetes.*

Key to Classes of Deuteromycotina

Deuteromycotina has been sub divided into three classes based on presence or absence of true mycelium and type of asexual spores.

1. Budding (Yeast or yeast like) cells with or without pseudomycelium; characteristic true mycelium lacking or not well developed ..... *Blastomycetes.*

   Mycelium well-developed, assimilative budding cells absent ..... 2.

2. Mycelium sterile or bearing spores directly or on special branches (sporophores) which may be variously aggregated but not in pycnidia or acervuli ..... *Hyphomycetes.*

   Spores in pycnidia or acervuli ..... *Coelomycetes.*

5.3.3. Outline Classification of Division Myxomycota

The Division : Myxomycota is divided into four classes. They are :

BRAOU

Class I Acrasiomycetes

Class II Hydromyxomycetes

Class III Myxomycetes

Class IV Plasmodiophoromycetes.

Class I : *Acrasiomycetes* is divided into three sub-classes. They are : Sub-Class : 1) *Protostelidae* which includes a single order : *Protosteliales; Sub-Class 2 :* Acrasidae includes a single order: *Acrasiales;* Sub-Class 3 : *Dictyostelidae* consists of an order : *Dictyosteliales.*

Class II : *Hydromyxomycetes* consists of two orders. They are 1. *Hydromyxales* and 2. *Labyrinthulales.*

Class III : *Myxomycetes* includes three sub-classes. The sub-classes and the orders in each sub-class are as follows.

Class III *Myxomycetes*

Sub-Class : A. Ceratiomycetidae

Order : Ceratiomyxales

Sub-Class : B. Myxogastromycetidae

Order : 1. Physarales.

" 2. Liceales.

" 3. Echinosteliales

" 4. Trichiales

Sub-Class : C. Stemonitomycetidae

Order : Stemonitales.

Class IV : *Plasmodiophoromycetes* includes a single order : *Plasmodiophorales.*

5.3.4. Outline Classification of Sub-Division Mastigomycotina

The Sub-Division : *Mastigomycotina* is divided into three classes. The classes and their respective orders are as follows :

Class I *Chytridiomycetes*

Orders 1. Chytridiales.

2. Harpochytriales

3. Blastocladiales

4. Monoblepharidales.

Class II *Hyphochytridiomycetes*

Orders : 1. Hyphochytridiales.

Class III *Oomycetes*

Orders 1. Saprolegniales

2. Leptomitales

3. Lagenidiales

4. Peronosporales.

BRAOU

5.3.5. Outline Classification of Zygomycotina

Further classification of Zygomycotina into repsective classes and orders is as follows :

Class I *Zygomycetes*

Orders 1. Mucorales
2. Entomophthorales
3. Zoopagales.

Class III *Trichomycetes*

Orders 1. Harpellales
2. Asellariales
3. Eccrinales
4. Amoebidiales.

5.3.6. Outline Classification of Ascomycotina

The classification of *Ascomycotina* into classes and their respective orders is as follows :

Class I : *1. Hemiascomycetes 2. Plectomycetes 3. Laboulbeniomycetes 4. Pyrenomycetes 5. Discomycetes 6. Loculoascomycetes.*

Class I *Hemiascomycetes*

Orders 1. Protomycetales
2. Endomycetales
3. Taphrinales

Class II *Plectomycetes*

Orders 1. Gymnoascales
2. Eurotiales
3. Ascosphaerales
4. Elaphomycetales
5. Microascales
6. Ophiostomatales

Class III *Laboulbeniomycetes*

Orders : Laboulbeniales

Class IV *Pyrenomycetes*

Orders 1. Meliolales
2. Erysiphales
3. Coronophorales
4. Sphaeriales

Class V : *Discomycetes*

BRAOU

Orders : 1. Medeolariales
2. Cyttariales
3. Tuberales
4. Pezizales
5. Phacidiales
6. Ostropales
7. Helotiales

Class VI : *Loculoascomycetes*

Orders 1. Microthyriales
2. Myriangiales
3. Dothideales
4. Pleosporales
5. Hysteriales

5.3.7. Outline Classification of Basidiomycotina

The classification of *Basidiomycotina* into respective classes, sub-classes and orders is given below:

Class I : *Teliomycetes*

Orders : 1. Uredinales
2. Ustilaginales

Class II : *Hymenomycetes*

Sub-class 1. Phragmobasidiomycetidae

Orders : 1. Tremellales
2. Auriculariales
3. Septobasidiales

Sub-class 2. Holobasidiomycetidae

Orders : 1. Exobasidiales
2. Brachybasidiales
3. Dacrymycetales
4. Tulasnellales
5. Aphyllophorales
6. Agaricales.

Class III : *Gasteromycetes*

Orders : 1. Podaxales
2. Phallales
3. Hymenogasterales
4. Lycoperdales
5. Gautieriales

BRAOU

6. Tulostomatales
7. Nidulariales
8. Melanogasterales
9. Sclerodermatales.

5.3.8. Outline Classification of Deuteromycotina

The classification of *Deuteromycotina* into respective classes and orders is as follows.

Class I : *Blastomycetes* (This class is directly divided into families but not orders).

Families 1. Sporobolomycetaceae
2. Cryptococcaceae

Class II : *Hyphomycetes*

Order : Moniliales

Class III : *Coelomycetes*

Orders : 1. Melanconiales
2. Sphaeropsidales

Check Your Progress - 5 & 6

5. What is the basis of classification of the sub-division Mastigomycotina into respective classes ?
6. What is the basis of classification of Ascomycotina into classes ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

BRAOU

The older discriptions are inadequate for most of the ascomycetous and basidiomycetous fungi. Critical understanding of the microscopic structure and morphogenesis of basidiocarp is necessory for the development of more natural groups in basidiomycetes. Hawksworth, Suttan and Ainsworth (1983) in their classification system of fungi brought out some important changes. The most important change is the complete integration of lichen forming fungi. Secondly the ranks above the order within Ascomycotina are not recognised. In place of Teliomycetes of Basidiomycotina two classes Uredinomycetes and Ustilaginomycetes have been recognised and the class Blastomycetes is not recognised.

5.4. POSITION OF MUSHROOMS IN FUNGI

Mushrooms are the fruit bodies of some higher fungi. They fall into two groups *Ascomycotina* and *Basidiomycotina*. The edible fungi belonging to *Ascomycotina* are commonly called morels and truffles.

Most of the edible fungi belong to the order : Agaricales of sub division : *Basidiomycotina*. The following table shows the list of some common mushrooms and their place in the classification (Table - 5.1).

Table - 5.1. List of common mushrooms and their taxonomic position (Chang & Miles, 1993).

Genus	Family	Order	Sub-class	Class
1. *Agaricus*	Agaricaceae	Agaricales	Holobasidiomycetidae	Basidiomycotina
2. *Psalliota*	"	"	"	"
3. *Amanita*	Amanitaceae	"	"	"
4. *Termitomyces*	"	"	"	"
5. *Boletus*	Boletaceae	"	"	"
6. *Coprinus*	Coprinaceae	"	"	"
7. *Clitopilus*	Entomolataceae	Agaricales	"	"
8. *Flammulina*	Tricholomataceae	Agaricales	"	"
9. *Lentinus*	"	"	"	"
10. *Pleurotus*	"	"	"	"
11. *Tricholoma*	"	"	"	"
12. *Armillarifella*	"	"	"	"
13. *Marasmius*	"	"	"	"
14. *Stropharia*	Strophariaceae	"	"	"
15. *Volvariella*	Pluteaceae	"	"	"
16. *Hypholoma*	Hypholomataceae	"	"	"
17. *Lepiota*	Lepiotaceae	"	"	"
18. *Cantharellus*	Cantharellaceae	Aphyllophorales	"	"
19. *Hericium*	Hericiaceae	"	"	"
20. *Dictyophora*	Phallaceae	Phallales	Phragmobasidiomycetidae	"
21. *Auricularia*	Auriculariaceae	Auriculariales	"	"
22. *Tremella*	Tremellaceae	Tremellales	Hymenoascomycetidae	Ascomycotina
23. *Tuber*	Tuberaceae	Tuberales	"	"
24. *Peziza*	Pezizaceae	Pezizales	"	"
25. *Morchella*	Morchellaceae	"		

BRAOU

5.5. SUMMARY

Grouping of individuals based on the characters of similarity and difference is called classification. Due to their complexity in approach and data presentation a perfect classification could not be proposed. The commonly followed systems of classification are of Alexopoulos and Ainsworth. Alexopoulos included all fungi under the division Mycota and divided it into 2 sub divisions, Myxomycotina and Eumycotina. Myxomycotina includes only one class, Myxomycetes and Eumycotina was divided into 8 classes viz., Chytridiomycetes, Hyphochytridiomycetes, Plasmodiophoromycetes, Oomycetes, Trichomycetes, Zygomycetes, Ascomycetes & Basidiomycetes and one form class, Deuteromycetes.

Ainsworth included all fungi under Fungi and divided it into 2 divisions viz.,

Myxomycota and Eumycota. The division Myxomycota is divided into four classes and Eumycota is divided into 5 sub divisions viz., Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Mushrooms are included in two sub divisions of fungi, viz., Ascomycotina and Basidiomycotina. Ascomycotina includes few mushrooms and are called truffles and morels. Most of the mushrooms belong to the sub-division Basidiomycotina.

5.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Fungi have been elevated to the rank of a kingdom along with plants and animals.
2. The classification system of fungi proposed by Ainsworth (1971) is widely in use.
3. The Plasmodial and mycelial forms of fungi have been kept in two divisions Myxomycota and Eumycota respectively.
4. Eumycota has been divided into five sub-divisions based on motility of spores, production and non-production and type of sexual spores.
5. Mastigomycotina has been divided into 3 classes based on number and position of flagella of the zoospores.
6. Ascomycotina has been divided into 6 classes based on production and non-production and type of ascocarp.

5.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write the outline classification of Myxomycota.
2. Describe the outline classification of sub-division Ascomycotina.
3. Write the outline classification of Basidiomycotina.

II. Answer the following questions in about 10 lines each.

1. Write the key to classes of Myxomycota.
2. Write the key to orders of Oomycetes.
3. Write the key to sub-divisions of Eumycota.
4. Write the key to classes of Deuteromycotina.

Prof. A. Janaki Bai
Ms. K. Prasunamma

BRAOU

UNIT - 6 : REQUIREMENTS FOR GROWTH OF FUNGI

Contents

6.1. OBJECTIVES

BRAOU

By the end of this unit you will be able to :

* list out the essential elements required for the growth of fungi,
* list out the non-metallic elements and metallic elements required for the composition of fungus mycelium,
* describe the role of nutrients like carbon, nitrogen, minerals and vitamins in the growth of fungi,
* list out the physical factors necessary for growth of fungi and
* describe the range of temperature, light, moisture, aeration, and pH for the growth of fungi.

6.2. INTRODUCTION

Fungi are heterotrophic (depend upon other sources for food) in nutrition and are in direct contact with their nutrients in the environment. Smaller molecules such as simple sugars and amino acids which are in solution in the watery film surrounding the hyphae can be directly absorbed by the hyphae. Larger insoluble polymers such as cellulose, starch and proteins must undergo a preliminary digestion before they are utilised. Fungi have a large number of digestive enzymes and these control hydrolysis reactions which cleave the large molecules into simpler substances. These substances after absorption into the cell are further acted upon by intracellular enzymes. Growth of the fungus occurs equally well on substratum containing either complex or simple nutrients if the necessary enzymes are

present. In addition the physical requirements such as temperature, light, moisture, aeration and pH determine the rate and amount of growth.

Check Your Progress - 1

1. What is the mode of nutrition in fungi ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

6.3. NUTRITIONAL REQUIREMENTS FOR GROWTH

Fungi require some essential elements for their growth. These are of two types, macro-elements and micro-elements. The fungal mycelium is composed of non-metallic elements (macro-elements) such as carbon, nitrogen, hydrogen, oxygen, sulphur and phosphorus and the metalic elements like potassium and magnesium. These elements are required in comparatively larger quantities by fungi.

6.3.1. Carbon

About half of the dry weight of the fungal cells consists of carbon. Protoplasm, enzymes, cell wall and reserve food materials stored within the cells are composed of carbon. Fungi use a large number of organic compounds as a source of carbon including carbohydrates, organic acids, and carbon dioxide.

Carbohydrates : Carbohydrates are divided into monosaccharides, disaccharides and polysaccharides. Monosaccharides are simple sugars and each molecule has either an aldehyde group (-CHO) called aldoses or a ketone group (=CO) called ketoses. The number of carbon atoms in a chain may be five (pentoses) or six (hexoses). Glucose is used by many fungi and is nearly a universal carbon source. Many fungi can make equally good growth on three naturally occurring hexoses d- glucose, d- fructose and d- mannose. Of the naturally occurring pentoses, d- xylose and l-arabinose are the most easily available and more extensively used than other pentoses. Many sugar alcohols such as sorbitol, glycerol and mannitol are widely distributed in nature and many fungi appear to utilize the corresponding sugars with greater facility than the sugar alcohols. Acids derived from sugars and glycosides may serve as a carbon source.

Check Your Progress - 2

2. What are monosaccharides ? Name the commonly used monosaccharide as carbon source by most of the fungi.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

BRAOU

.....

.....

Disaccharides and Polysaccharides are also important sources of carbon for fungi in nature. Simple sugars or their derivatives may combine to form complex, chain-like polymers. If the polymer consists of only two monomers (monosaccharides), it is a disaccharide and longer polymers are polysaccharides. The extra-cellular digestive enzymes of a fungus can cleave the sugars and their derivatives from di-and polysaccharies and utilize them in the same fashion as it would utilize a freely occurring sugar. The most commonly occurring disaccharides are maltose, cellobiose, lactose and sucrose. These are digested to their component molecules by the enzymes maltase, cellobiase, lactase and sucrase respectively. Maltose and cellobiose are widely available to fungi. Sucrose is utilised by few fungi and even fewer use lactose.

Polysaccharides such as glycogen, starch, cellulose, pectins, hemicelluloses, lignins and gums are widely available in nature and are utilized by at least some fungi. Starch, cellulose and glycogen are widely utilised as carbon sources by fungi. The utilization of these substances by fungi is dependent upon the secretion of hydrolytic enzymes. They yield glucose on hydrolysis. Organic acids include monocarboxylic and dicarboxylic acids and may serve as a sole source of carbon for some fungi.

Check Your Progress - 3

Name the widely used polysaccharides as carbon sources by fungi.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

BRAOU

6.3.2. Nitrogen

Nitrogen is used by fungi for functional as well as structural purposes. Not all fungi use nitrogen sources with equal facility, and a fungus may have a requirement for nitrogen in a specific form. Fungi may use inorganic nitrogen in the form of nitrates, nitrites or ammonia or organic nitrogen in the form of aminoacids. A few fungi are able to fix nitrogen. Species of *Phoma* isolated from roots of Ericaceae fixed significant amounts of nitrogen. Numerous fungi utilize nitrates as a form of nitrogen. Nitrates occur in the soil and thus are a natural source of nitrogen. A fungus which utilizes nitrate nitrogen (NO_3) must be able to reduce the nitrogen to the oxidation level of ammonia. Any fungus which can reduce and assimilate the nitrate ion can utilize any form of nitrogen with an oxidation level equivalent to that of ammonia. Nitrites (NO^-_2) may serve as the sole source of nitrogen for some fungi. Some nitrate utilising fungi may be able to utilize nitrites also. Nitrites tend to be toxic to most species of fungi. Those fungi which are unable to utilize nitrates as a source of nitrogen may use nitrogen in the form of ammonium ion or in the form of organic nitrogen, which has the same oxidation level as the ammonium ion. In the soil both nitrates and ammonia usually occur together but the preferential use of ammonia over nitrate is due to less energy requirement by the fungus to use the reduced form of nitrogen. All fungi utilize nitrogen supplied to them in the organic form, though small

number must obtain their nitrogen in this form. Fungi decompose proteins in nature to their component amino-acids, which can be assimilated.

6.3.3. Minerals

Metallic elements required in trace quantities by fungi are iron, zinc, copper, manganese and molybdenum. These micro-elements are usually required in concentration ranging from 0.001 to 0.5 ppm. Molybdenum is needed in such small quantities and c[illegible] range between 0.1 to 10 ppb. The micro-elements are required for activation of various enzymes, for synthesis of vitamins and other metabolites and for normal growth and sporulation. Excess of micro-elements than the required amount are generally toxic.

6.3.4. Vitamins

Vitamins are organic compounds that function as coenzymes or constituent parts of coenzymes, which catalyze specific reactions. They are effective in very small quantities and are not used in the manufacture of structural parts of the cell. Some fungi are able to synthesize all the vitamins they require if supplied with a sugar, nitrogen source and minerals. Other fungi may have a partial vitamin deficiency. Fungi do not have a need for vitamins A, D and E and require the water-soluble B vitamins and vitamin H(biotin). Vitamins manufactured by fungi are thiamine (Vitamin B_1), biotin (Vitamin H), pyridoxine (Vitamin B_6), nicotinic acid (Vitamin B_7) pantothenic acid (Vitamin B_3), riboflavin (Vitamin B_2), inositol (component of vitamin B-Complex) and p-aminobenzoic acid (part of Vitamin M). Fungi are most deficient for thiamine. It has a role in the regulation of carbohydrate metabolism. Numerous fungi are deficient for biotin and its role is only vaguely understood. It is apparently involved in the synthesis of aspartic acid and fatty acids as oleic acid. Pyridoxine (Vitamin B_6) is required by fewer fungi than either thiamine or biotin. The coenzyme form of pyridoxine serves as a coenzyme for vairous enzymes involved in amino acid metabolism.

BRAOU

Check Your Progress - 4, 5 & 6

4. Natural source of nitrogen for fungi are _____

5. Metallic elements required by fungi in trace amounts are _____

6. Name the vitamins manufactured by many fungi.

Note : (a) write the answers in the space given above and below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

6.4. PHYSICAL REQUIREMENTS FOR GROWTH

Fungi must be exposed to favourable physical environmental factors such as temperature, light, moisture, aeration and pH. For each factor, there is a range in which growth will occur delimited by a minimum point and a maximum point below or above which no

growth will occur. Thus all reactions of a cell tend to have their own minimum, optimum and maximum of the physical factors.

6.4.1. Temperature

Temperature is extremely important in determining the amount and rate of growth of an organism. Beginning with the minimum temperature permitting growth, the amount of growth of the fungus increases with the increase in temperature until the optimum is reached. The growth rate becomes more or less steady at the optimum range. Above the optimum temperature, the growth rate declines. In general most fungi have similar temperature requirements. The optimum temperature is between 15 and 30° C with a minimum temperature of 0 to 5° C. However, some fungi can grow at temperatures as low as -5 to -8° C and some fungi above the maximum tempeartures of 35-40° C. The minimum, optimum and maximum temperatures differ for growth, reproduction and spore germination.

Increasing temperature has the general effect of increasing enzyme and chemical activity. Temperature directly affect the synthesis of vitamins, amino acids or other metabolites.

6.4.2. Light

Light may affect the growth rate and synthetic capacity of some fungi, but growth of most fungi is apparently not sensitive to light. The most wide-spread effect of light on fungal growth is that of inhibition in strong light. The effects of light on reproduction in fungi are complex and the intensity, duration and quality of light play a role. It may affect the formation of reproductive structures and their oriented phototrophic movements. Light may be either stimulatory or inhibitory to the formation of reproductive structures and spores.

On the basis of response of fungi to light they may be divided into five groups : (1) Those which are apparently indifferent to light; (2) those in which sporulation is decreased or prevented; (3) those which require alternating light and darkness to sporlulate; (4) those which are able to produce less number of viable spores in complete darkness but sporulate more abundantly with exposure to light; (5) those which require light in order to produce reproductive structures and spores.

The wave lengths of light which induce or inhibit reproductive structures are in the violet, blue, blue-green, near ultra-violet, or ultraviolet regions. The photo-receptors are present in the hyphae of light-sensitive fungi.

6.4.3. Moisture

The ability of a fungus to grow in nature on a substrate is partially determined by the moisture content of the substrate. Fungi require relatively high moisture levels and high relative humidity. Most fungi grow to their maximum at 95 to 100% relative humidity and the growth will decline or stop in humidity of 80 to 85%. Few fungi will grow at a relative humidity as low as 65%. Soil fungi grow better in moderate than in high moistures. Many of the higher fungi are able to grow in the absence of free water.

6.4.4. Aeration

All fungi require some aerobic oxygen for growth. Effective utilization of carbon and nitrogen compounds as sources of nutrients may be affected by the amount of oxygen available in the atmosphere. Oxygen is vital to cellular respiration in which an energy

BRAOU

source is oxidised to carbon dioxide and water, and energy is made available to the cell. High concentration of carbon dioxide inhibits the growth of majority of the fungi. Some lower fungi which occur in stagnant waters can tolerate a higher carbon dioxide concentration. *Aqualinderella fermentous* can tolerate a concentration up to 99% and it actually requires carbon dioxide for optimum growth.

6.4.5. Hydrogen Ion Concentration

All fungi are in contact with aqueous solutions in nature and the hydrogen ion concentration (pH) of these solutions extends control over fungal growth. Fungi have broad pH range over which they can grow. Most fungi have optimum pH on the acidic side of the scale, under pH7. Growth at low pH may be the result of greater iron availability and at higher pH due to the increased activity of enzymes with high pH optima.

The availability of certain metallic ions is effected by pH. Metallic ions form complexes which become insoluble at certain pH ranges. At higher pH magnesium and phosphate form insoluble complexes and thus the availability of these ions to the fungus is reduced. The effect is similar with Iron, Calcium and Zinc ions. The cell permeability is altered with different degrees of acidity or alkalinity. At a lower pH, the protoplasmic membrane becomes saturated with hydrogen ions so that passage of essential cations is limited, while at a higher pH membrane becomes saturated with hydroxyl ions and thereby limits the entrance of essential anions. External hydrogen ion concentration also effects pH within the cell which in turn affects enzyme activity. Enzymes are inactivated at either pH extreme, but they have different optimum pH levels for activity. Optimum pH for most enzymes lie between pH 4 and 8.

BRAOU

6.5. SUMMARY

Fungi obtain their nutrients either from living or non-living organic materials. With the help of digestive enzymes they cleave larger molecules into simpler substances before utilization. The fungi require non-metallic elements such as carbon, nitrogen, hydrogen, oxygen, sulphur and phosphorus in large quantities and metallic elements such as iron, zinc, copper, manganese and molybdenum in trace quantities. The fungi must be exposed to favourable physical environmental factors such as temperature, light, moisture, aeration and pH. Each factor has a range in which growth will occur.

6.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Fungi are heterotrophic in their mode of nutrition.
2. Monosaccharides are simple sugars with either an aldehyde group (aldoses) or a ketone group (ketoses). Glucose is the commonly used carbon source by fungi among monosaccharides.
3. The widely used polysaccharides by fungi are starch, cellulose and glycogen.
4. Nitrates.
5. Iron, zinc, copper, manganese and molybdenum.

6. The vitamins manufactured by many fungi are thiamine, biotin, pyridoxine, nicotinic acid, pantothenic acid, riboflavin, inositol and p-aminobenzoic acid.

6.7. MODEL EXAMINATION QUESTIONS

I. Write the following questions in about 30 lines each.

1. Write a detailed account on the physical requirements for growth of fungi.
2. Write in detail the different nutritional requirements for growth of fungi.

II. Answer the following questions in about 10 lines each.

1. Write the importance of temperature on the growth of fungi.
2. Describe the effect of hydrogen ion concentration on the growth of fungi.
3. Write how fungi utilise nitrogen for functional and structural purposes.
4. Write the importance of vitamins in the growth of fungi.

Prof. A. Janaki Bai

BRAOU

UNIT - 7 : ECONOMIC IMPORTANCE OF FUNGI

Contents

7.1. OBJECTIVES

By the end of this unit you will be able to :

* describe and differentiate the helpful activities of fungi from harmful activities,
* describe the role of fungi in medicine,
* list out various fungal species that are useful in the production of alcohol, bread, enzymes, organic acids, gibberellins, cheese, vitamins etc. and
* list out the fungi that are edible and also useful in the preparation of some food items.

BRAOU

7.2. INTRODUCTION

Several species of fungi are economically important to human beings. Man is being benefited by these organisms both directly and indirectly. Fungi play an important role in agriculture, medicine and industry. Fungi also spoil our day to day goods such as food stuffs, clothes, rubber, leather, paper, wood etc. The fungi are known to cause diseases to human beings also. Some species of *Aspergillus* cause human diseases which are collectively called Aspergilloses (e.g., Aspergilloses of lungs, external ear etc.). Many fungi belonging to Deuteromycetes live in the mucous membrane of throat, bronchii and lungs. Some of the well known skin diseases such as ring worm, barbers itch are also caused by some fungi.

Some chemcials produced by fungi are toxic to human beings, plants and poultry.

These toxic chemicals are called mycotoxins, which are usually produced on stored grains and other food products. Aflatoxins are most important substances produced by *Aspergillus flavus* and *Aspergillus parasiticus*. Groundnuts and their products, cotton seeds and copra are the most favourable substrates for Aflatoxin production. Aflatoxins are assumed to be one of the causes of cancer. Other important mycotoxins are produced by the species of *Penicillium*, *Pithomyces* and *Fusarium*. The role of fungi in different areas is dealt with clearly below.

7.3. ROLE OF FUNGI IN AGRICULTURE

Our country is mostly agriculture dependent. Fungi play both positive and negative roles in agriculture. The harmful activities are more than the helpful activities.

7.3.1. Helpful Activities

Some of the saprophytic fungi in the soil decompose the dead material of animals and plants. The enzymes secreted by these fungi convert the fats, carbohydrates and nitrogen compounds of the dead animals and plants into simpler compounds such as carbon dioxide, ammonia, hydrogen sulphide, water and some other nutrients in a form available to green plants. Some of them will be in the soil to form humus and the remaining go into air where they can be used up as raw material for food synthesis. By liberating carbondioxide these fungi participate in maintaining the never ending cycle of carbon in nature. The carbon dioxide is very important for green plants in the preparation of food materials by photosynthesis.

Some fungi are in symbiotic association with the roots of certain plants. Satisfactory growth of the plant can be observed only when the specific fungal partner is present inside the roots of the plants. This type of association of a fungus and plant is called mycorrhiza.

Some nematodes are known to cause severe losses to agricultural crops directly and some transmit certain disease causing viruses also. A few fungi (e.g. *Dactylaria*) are known to destroy the nematodes. These predatory fungi produce mycelial loops. When the nematodes pass through, these loops get tightened up to catch the nematodes. Then the fungus sends special hyphae into the nematodes to absorb the nutrients from them (Fig. 15.1).

Pythium is known to cause damping off disease in the seedlings of certain crops. Certain fungi such as *Trichoderma* and *Gliocladium* are known to inhibit the gtowth of *Pythium* in soil. In this way certain fungi serve to suppress the growth of disease causing fungi.

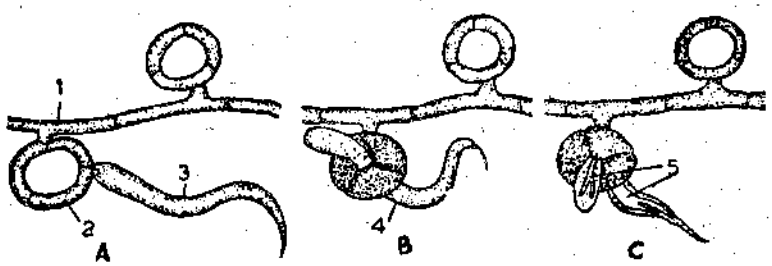


Fig. 7.1. Predacious fungus. A-C. Different stages in catching the nematodes by the fungus. 1. Mycellal hypha. 2. Hyphal loop. 3. Nematode. 4. Strangulated nematode. 5. Haustorial hyphae.

BRAOU

7.3.2. Harmful Activities

Several fungi are known to cause severe crop losses by causing diseases. About 20,000 diseases of crop plants are known to be caused by fungi. The fungal diseases of crop plants have become a major problem for the agricultural farmers. The scientists are seriously trying to develop special techniques and chemicals to control these diseases. Some of the economically important diseases of crop plants are given below.

Damping off of Seedlings : Damping off has been recognised as a definite disease responsible for poor germination of seeds and the death of seedings in nursery beds. The young seedlings may be killed before they reach the surface of the soil or after they emerge from the soil. Many kinds of plants are attacked by damping-off. They are tobacco, mustard, beans, peas, tomatoes, cotton etc. Most common fungi responsible for the damping-off are *Pythium, Phytophthora, Fusarium, Rhizoctonia, Sclerotium* and a few others.

Downy Mildews : These diseases are characterised by leaf spots of various sizes and shapes. On the lower side of these spots downy growth appear on the petioles and stems in some cases. The affected plants are generally weak and show stunted growth. The downy mildews are generally caused by the species of *Sclerospora, Peronospora, Plasmopara* and some other genera. The plants generally affected by this disease are bajra, jowar, maize, peas, crucifers, cucumbers, grapevines etc.

Wilts : Wilting of plants can occur in all stages of plant growth. When the plants are atacked by wilt pathogens the growth of the plant ceases. the lower leaves shrivel and wither away. This is followed by the death of the plant. The important wilts are wilts of cotton, flax, banana, cicer, pigeonpea, pea, tomato etc. The causal organisms of wilts are species of *Fusarium* and *Verticillium*.

Powdery Mildews : The disease first appears on the leaves and spreads to other green areas. This disease is characterised by the formation of white floury patches on the upper side or both sides of the leaves, pods, and stems. The loss of crop depends on the disease intensity. The powdery mildews are generally caused by species of *Erysiphe, Uncinula, Podospheria* and *Phyllactinia* are also known to cause powdery mildews. These fungi attack different crops such as barley, beans, coriander, turnip, cabbage, pumpkins, potato, sunflower, mango, castor, grapewine, apple, dalbergia, teak etc.

Ergot of Graminaceous Plants : Ergot disease has been recorded on rye, oats, barley, jowar, bajra, wheat, sugarcane and some other grasses. This disease is of worldwide occurrence and it is caused by *Claviceps*. The infected kernels are transformed into thick horny structures. The consumption of these diseased kernels causes ergotism in man and cattle. This disease results in nervous breakdown. Pregnant animals suffer from abortion when they are fed with diseased crops.

Smuts : The smut diseases are caused by *Ustilago*. The crops which are generally affected are wheat, barley, sugarcane, oats, maize, sorghum, bajra etc. Every head of the affected plant may be converted into black mass of spores with no grains. In some cases the ears may remain shorter. They may be usually retained within the sheath for a long time or some times fail to emerge at all.

Rusts : The rust diseases cause severe losses to wheat, barley, oats, rye etc. The rust diseases are caused by several species of *Puccinia*. The disease first appears as elongated brown pustules on the leaves, leaf sheaths and stalks of the plants. The pustules turn to black colour in the later stages. The rust fungus has a marked effect on the physiology of the plant. Transpiration and respiration are increased and translocation of carbohydrates is retarded.

BRAOU

Wood Rotting : The members of Polyporaceae such as *Polyporus, Coriolus, Poria, Polystictus, Fomes, Daedaka* and *Lenzites* destroy wood and timber of *Dalbergia*, mulberry, oak and other trees. There are two types of wood rotting - brown rot and white rot. In brown rot only cellulose destruction takes place and in white rot only lignin destruction takes place. Wood rotting fungi produce several enzymes which help in the degradation of wood.

Check Your Progress - 1 & 2

1. What are predacious fungi ?
2. What is the characteristic feature of powdery mildews ? Give some examples.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

BRAOU

7.4. ROLE OF FUNGI IN MEDICINE

Some fungi are known to produce organic substances which inhibit the growth of certain other microorganisms. These are called antibiotics. These antibiotics have gained a high popularity because of their extensive use in disease treatment. The production of antibiotics by fungi was first discovered by Alexander Flemming in 1929. He discovered Penicillin, the wonder antibiotic, which is produced by *Penicillium notatum*. Penicillin kills several bacteria and it has no harmful effects on the human cells. Penicillin is now produced commercially all over the world from improved strains of *P. notatum* and *P. chrysogenum*. India is also producing penicillin commercially in a factory at Pimpri near Poona in Maharashtra.

The limited use of penicillin against the vast number of diseases made the researchers to search for other antibiotics. This search resulted in the discovery of several other antibiotics. Fumigallin from *Aspegillus fumigatus* inhibits certain phages and amoebae. Griseofulvin, another antibiotic from *Penicillium griseofulvum*, is used against the skin diseases such as ring worm and athletes foot. This anitbiotic interferes with the wall

formation of the disease causing fungi. Consequnetly the pathogens cease to grow. The compound accumulates in skin and hair when taken orally and so it is effective against skin diseases. A mixture of alkaloids from *claviceps purpurea* (causal organism of ergot of rye) is highly poisonous. This is used to control bleeding during child birth.. Calvacin, a substance extracted from *Calvatia*, prevents stomach tumours.

Check Your Progress - 3

What are the important antibiotics that are produced by fungi ? Name the source organisms.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

BRAOU

7.5. ROLE OF FUNGI IN INDUSTRY

Fungi are used in industries for several purposes. The biochemical activities of several fungi are used for the production of various industrial products. Most important among them are given below.

7.5.1. Brewing and Baking Industries

Yeasts are used in both the brewing and baking industries to convert sugar into carbondioxide and ethyl alcohol. Alcohol is the main product in brewing and wine making industry, where as carbondioxide is a valuable product in baking industry. An enzyme complex called zymase is secreted by yeast. *Saccharomyces cerevisiae* is the yeast commonly employed. This enzyme complex converts sugars into alcohol and carbondioxide. Instead of sugars, starch is used as a substrate in the production of industrial alcohol. In this case other fungi such as *Mucor* and *Rhizopus* are used initially for the conversion of starch into sugars. In the second stage, i.e., in the conversion of sugars to alcohol and carbondioxide, yeasts are used.

7.5.2. Enzymes

The enzymes such as digestin, taka diastase, polyzime, which are used for dextrinisation of starch and desizing of textiles, are produced by *Aspergillus* only. The enzymes, amylase and invertase, are extracted from *Aspergillus* and *Saccharomyces*, respectively.

7.5.3. Organic Acids

Several organic acids such as Oxalic acid, Citric acid, Gluconic acid, Gallic acid and Fumaric acid are produced commercially as fermentation products of *Aspergillus* and *Penicillium.*

7.5.4. Gibberellins

Gibberellin is used to accelerate the growth of several horticultural and some commercial fruit crops. This is produced by a fungus called *Gibberella fujikuroi.*

7.5.5. Cheese

Certain species of *Penicillium (P. camemberti* and *P. roqueforti)* are used in the ripening of cheese in cheese industries. This is a big industry in foreign countries.

7.5.6. Vitamins

The dried yeast extract which is rich in vitamin B_2-Complex is being sold in the market. Some moulds and yeasts are also used in the synthesis of ergosterol. This is a precusor to vitamin D.

Check Your Progress - 4

What are the fungi that are used in the conversion of starch to alcohol in the brewing & wine industries?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

BRAOU

7.6. EDIBLE FUNGI

Several mushrooms *(Agaricus bisporus, Pleurotus sp., Calocybe* sp., *Auricularia* sp., *Lentinus* sp., *Volvariella* sp. etc.), puffballs, morels *(Morchella* sp.) and truffles are edible and they are grown commercially in several western countries; in north India they are becoming popular now and slowly expanding to south. These fungi are used in the preparation of different types of food stuffs. e.g., Mushroom Pizza. These are rich in proteins and vitamins.

In addition, in countries like Indonesia, China and Japan, many foods are fermented with the help of fungi and these are extremely popular. For instance, 'Tempeh', which

is an important food for millions in Indonesia, is prepared by fermenting soyabeans with *Rhizopus oligosporus*. In Japan, 'Miso' is prepared by fermenting soyabeans with *Aspergillus oryzae*. 'Shoyu' is another preparation made from soyabeans fermented with *A. oryzae or A. soyea*. In China, rice is fermented with the help of *Monoascus purpureus* and the pigment produced by the fungus give a typical red colour to the rice. This preparation is known as red rice or 'Ang-kak'.

7.7. SUMMARY

Fungi are active decomposers of organic waste products in soil. As symbionts they help in the growth and health of plants. They also cause enormous damage to many of our crop plants by inciting diseases like wilts, damping off of seedlings, downy mildews, powdery mildews, ergot, smuts and rusts. They also cause wood rotting of timber yileding plants. Fungi also produce mycotoxins which are harmful to humans and certain animals. Antibiotics such as penicillin are produced by fungi and these are helpful in medicine. Many fungi are employed in the industrial production of some enzymes, alcohols, organic acids and gibberellins. They are also useful in cheese ripening, brewing and baking industries. Some fungi are edible and some are employed in the fermentation of certain food products.

BRAOU

7.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The fungi which feed on animals are called predacious fungi.
2. The formation of white floury patches on the upper side or on both sides of the leaves, pods and stems is the characteristic feature of powdery midlews. The examples for powdery midlews are the species of *Erysiphe, Uncinula, Podospheria* and *Phyllactinia*.
3. Penicillin, Fumigallin, Griseofulvin are the important antibiotics produced by fungi. Penicillin is produced by *Penicillium notatum* and *P. chrysogenum* where as *P. griseofulvum* produces griseofulvin. *Aspergillus fumigatus* produces fumigallin.
4. In brewing and wine making industries *Mucor* and *Rhizopus* are used for the conversion of starch to sugars and *Saccharomyces cerevisiae* the commonly employed yeast for the conversion of sugars to alcohol.

7.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Comment on the harmful activities of fungi.
2. Discuss in detail the role of fungi in Industry and Medicine.

II. Answer the following questions in about 10 lines each.

1. Write briefly about harmful activities of fungi in Agriculture.

2. Write briefly about the role of fungi in medicine.

3. Discuss briefly about the role of fungi in Industry.

4. Write briefly about the helpful activities of fungi in Agriculture.

Dr. M. Ramachandraiah

BRAOU

BRAOU

BLOCK - 2
INTRODUCTION TO MUSHROOM SCIENCE

BRAOU

BRAOU

UNIT - 8 : AN ACCOUNT OF BASIDIOMYCOTINA

Contents

8.1. OBJECTIVES

By the end of this unit you will be able to :

* describe the somatic structure of the members of Basidiomycotina.
* describe the different types of asexual reproduction in Basidiomycotina,
* explain the sexual reproduction in Basidiomycotina and
* describe the basidium, basidiospores and basidiocarp.

BRAOU

8.2. INTRODUCTION

The members of this group are the most advanced of all fungi and includes mushrooms, toad stools, puff balls, geasters, bracket fungi, stink horns and bird's nest fungi. This group also includes the rusts, the smuts and the jelly fungi which are primitive than the higher basidiomycetes. The name of the group is derived from a special structure, the basidium, within which nuclear fusion and meiosis occur resulting in the production of four basidiospores exogenously. In many of the Basidiomycotina these basidia are produced in a basidiocarp which may differ in size and shape in different species.

Basidiomycotina includes about 1100 genera and over 16,000 species. Of these the rusts, smuts, agarics and polypores are important fungi. Rusts and smuts cause many diseases of cereals and destroy several million dollars worth of crops annually. The polypores cause enormous damage to the forest trees as parasites and timber as saprobes. The cultivation of mushrooms for food and flavour has developed into an industry in several countries including India. However, some mushrooms like *Amanita* spp. are deadly poisonous and species of *Psilocybe* produce hallucinogenic substances.

The basidiomycetous mycelium plays an important role in the decomposition and

recycling of nutrients as it can produce various extracellular enzymes that act on the lignin and cellulose.

8.3. SOMATIC STRUCTURE

The basidiomycetes are typically mycelial but some have a yeast like state. In the members producing basidiocarps, the mycelium passes through three distinct stages of development, the primary, the secondary and the tertiary. The primary mycelium usually develops from the germination of the basidiospores. This is usually of short duration and limited extent. Where well developed, the mycelium is branched, septate with uninucleate (haploid), sometimes multinucleate cells. It is usually monokaryotic. The secondary mycelium originates from primary mycelium. The primary mycelium undergoes dikaryotization either by spermatization or somatogamy resulting in the production of a secondary or dikaryotic mycelium. In all the basidiomycotina, except the rusts, a specialized structure known as clamp connection (Fig. 8.1) is formed in the secondary mycelium. When a binucleate cell, usually the terminal cell of a hypha is ready to divide, a short branch, the clamp, arises between the two nuclei and forms a hook. The two nuclei now divide. One nucleus divides in such a fashion that the daughter nucleus forms in the clamp connection and the other forms in the dividing cell. The division of second nucleus orients itself along the long axis of the dividing cell so that one daughter nucleus forms near one end of the cell and the other near the other end of the cell. Two transverse walls are now laid down, one along the base of the outgrowth and the other across the cell just below the level of the out growth. The outgrowth is now a uninucleate clamp cell, the terminal cell is binucleate and the subterminal cell is uninucleate. The clamp cell fuses with the subterminal cell and transfers its nucleus into it by the dissolution of the wall between the two. The remains of the clamp connections are evident on the mycelium. Thus almost all fungi which possess clamp connections in their mycelia belong to the Basidiomycetes. The secondary mycelium occurs commonly in nature and is often perennial, growing centrifugally year after year and producing basidiocarps during each season. The mycelium of *Marasmius oreades* may live up to the age of 400 years and form basidiocarps each year. The secondary mycelium undergoes certain morphogenetic changes to give rise to a tertiary mycelium which actually takes part in the construction of basidiocarps.

The septal pore region in certain Basidiomycotina is more complex. In the members of Teliomycetes the septa are either perforate with an open central pore, or the pore is blocked by a plug, seems to block the cytoplasmic continuity between adjacent cells. In other basidiomycetes the septal pore of primary and secondary mycelia is surrounded by a doughnut-like, or barrel shaped thickening and this type of pore is called a *dolipore septum*. The pore provides cytoplasmic continuity between adjacent cells. The dolipore septum is enclosed on either side by a dome-shaped double membranous structure called *parenthosome* or the septal pore cap. This cap functions as a sieve allowing movements of some organelles from one cell to the next and simultaneously, withholding the movement of others. Under certain circumstances, nuclei may migrate between cells with small pored caps.

Check Your Progress - 1 & 2

1. What are the important characters of the mycelium of basidiomycetes ?

2. What are parenthosomes ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

8.4. ASEXUAL REPRODUCTION

Asexual reproduction is much less frequent in this group in comparison to the lower fungi and Ascomycotina. It occurs by budding similar to that in yeasts, by fragmentation of the mycelium and by the production of conidia, arthrospores and oidia. Conidia occur rarely and the urediniospores produced in rusts are conidial in origin and function. Very often the hyphae of many Basidiomycetes get fragmented into uninucleate sections called the arthroconidia or arthrospores without forming thick walls. These may be uninucleate or binucleate depending upon whether the mycelium is primary or secondary. Oidia are produced on specialized, erect hyphal branches known as oidiophores. The oidiophores cut off oidia successively from their tips and coalesce in a sticky globule. These are

BRAOU

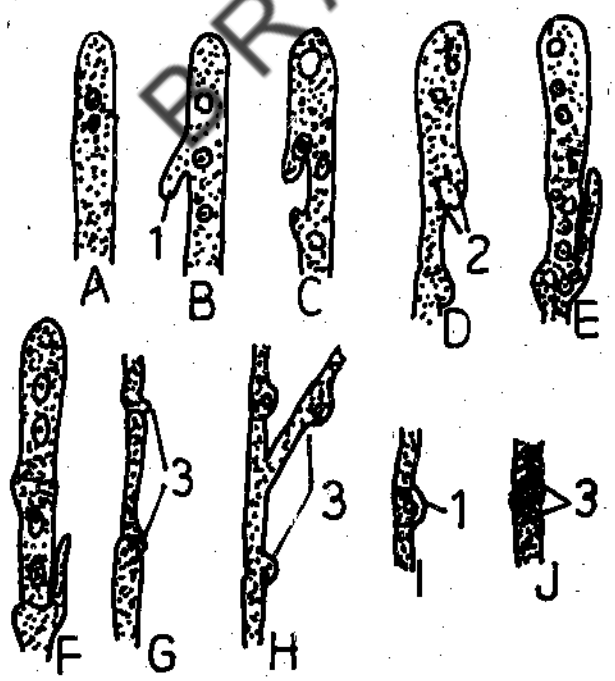


Fig. 8.1. Formation of clamp connections. A-F. Successive stages in the development of a clamp connection in the hypha. G-J. Different types of clamp connections. 1&3. Clamps. 2. Nuclear division.

uninucleate, cylindrical and smooth walled. Oidia produced from the primary mycelium either germinate and produce primary mycelia or may function as spermatizing agents, thus behaving like the microconidia.

8.5. SEXUAL REPRODUCTION

Sex organs are not found in the Basidiomycotina except in the rusts. However, plasmogamy, karyogamy and meiosis takes place in all Basidiomycotina. The sexuality in Basidiomycotina gets progressively suppressed and the whole process is reduced to copulation between vegetative mycelia (somatogamy). Spermatization of a receptive hypha in Uredinales, and Oidization or Somatogamy in Hymenomycetes is seen.

In general, the life cycle is characterised by a short diploid phase (basidium) and a long haploid phase. The monokaryotic phase is typically very short and dikaryotic phase predominates during the greater part of the life cycle. It ends with the occurrence of karyogamy and meiosis in the basidium. The resulting four recombinant haploid nuclei are incorporated in the four basidiospores.

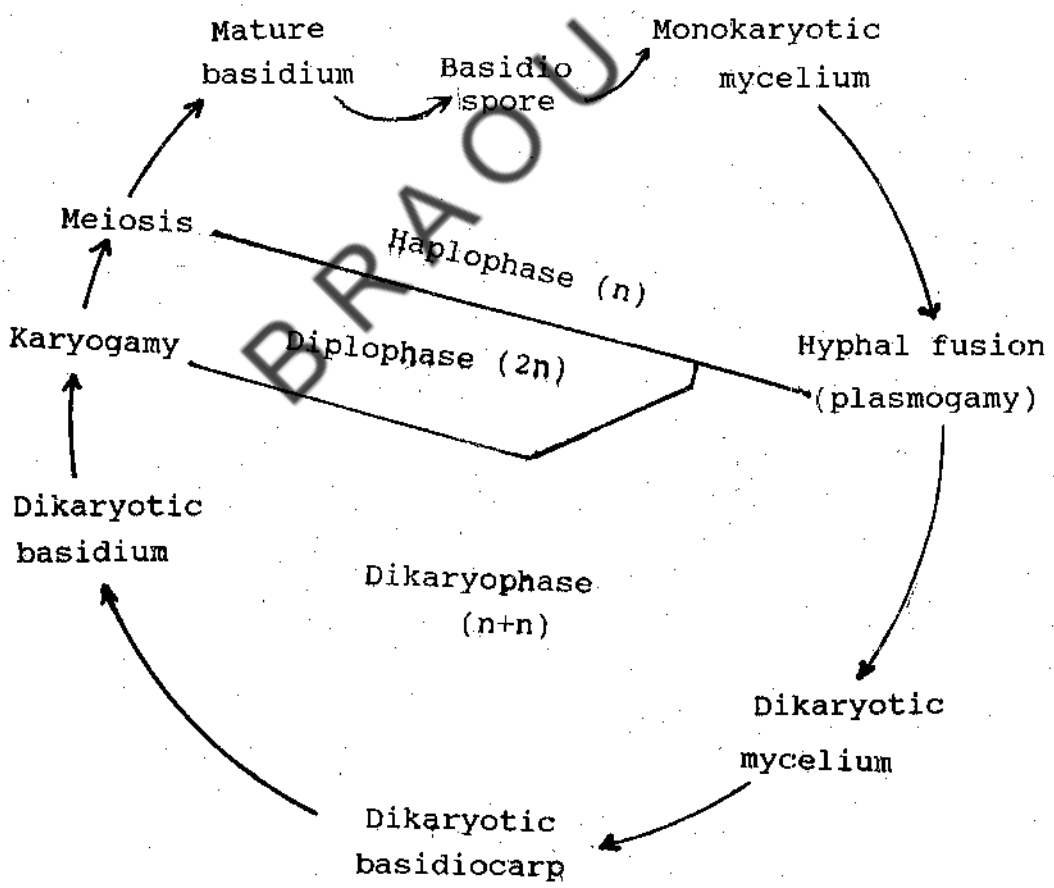


Fig. 8.2. A generalized life cyle of a basidiomycete.

BRAOU

The majority of the Basidiomycetes are reported to be heterothallic and about 10% are homothallic.

8.5.1. Basidium

The basidium (fig. 8.3) is the organ in which karyogamy and meiosis takes place resulting in the formation of four meiospores termed basidiospores. Basidia vary considerably in structure, and the form of basidium is an important criterion in the classification of basidiomycotina. A typical basidium is a club shaped, unicellular structure. Like the other cells in the basidiocarp those cells which represent the young basidia are dikaryotic and possess two haploid nuclei. These nuclei fuse to form a diploid nucleus, which then undergoes meiosis to produce 4 nuclei. Usually, the enlarging basidium forms four elongate projections, the sterigmata, from the apex. The tip of each sterigma swells to form the basidiospore initial. A single haploid nucleus and cytoplasm migrate through the sterigma into the basidiospore initial which becomes the basidiospore. Typically, four uninucleate basidiospores are produced on each basidium. Some times, a nucleus in a uninucleate basidiospore may divide mitotically to form a binucleate basidiospore. If some of the nuclei degenerate after meiosis fewer than four basidiospores may be formed. The mature basidium includes the probasidium, the metabasidium and the sterigmata. The probasidium is the portion of the basidium in which karyogamy takes place. The metabasidium is that developmental stage of the basidium in which meiosis occurs. The sterigma are the extensions of the metabasidum wall through which nuclei migrate from the metabasidium to the developing basidispore. There are three main types of basidia : the *holobasidium,*

BRAOU

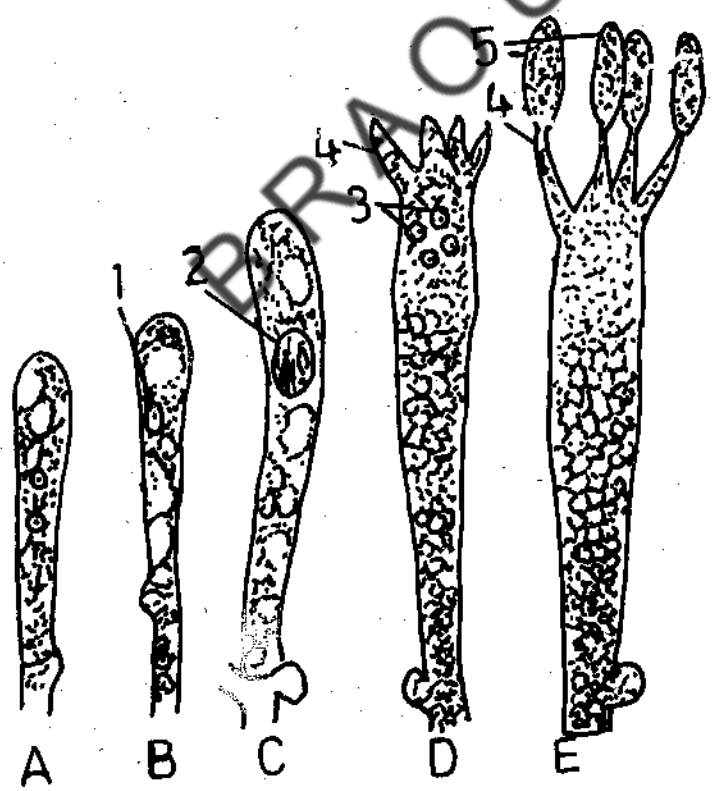


Fig. 8.3. Structure and development of a basidium with basidiospores. A. dikaryotic terminal cell. B-C. Karyogamy, .D. Young basidium. E. Mature basidium. 1&2. Diploid Nucleus. 3. Haploid nuclei. 4. Sterigma. 5. Basidiospores.

phragmobasidium and *teliobasidium*. Holobasidium is that basidium in which metabasidium is not divided by primary septa; the phragombasidia are those in which the metabasidum is divided by primary septa, usually vertical or transverse; the teliobasasidia are those which consist of generally thickwalled resting spores and finite germ tube, produced by its germination which bears the basidiospores.

Check Your Progress - 3

3. Differentiate between the probasidium and metabasidium.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

.....

8.5.2. Basidiocarp

In rusts and smuts there is no formation of basidiocarp. The basidiocarps (Fig. 8.4) in other Basidiomycetes are typically macroscopic and exist in a variety of forms. They may vary in diameter from a metre or more and may be crust like, gelatinuous, fleshy, cartilaginous, thin and papery, corky, spongy, hard and woody or of almost any texture. The basidiocarp may open from the beginning (gymnocarpic), open at a later stage (hemiangiocarpic) or typically angiocarpic and remain permanently closed, releasing basidiospores only after the disintegration of the peridium. The basidiocarps of Hymenomycetes generally comprise of 3 basic types of hyphae, these are generative, skeletal and binding hyphae. The generative hyphae are thin-walled branched, usually septate, with or without clamp connections. The skeletal hyphae are thick-walled, have many branches and are rarely septate. The combination of hyphae used in the construction of basidiocarp are of five principal constructional types : (i) Monomitic, which comprises of only the generative hyphae, (ii) Dimitic, comprising of two hyphal types, generative and either skeletal or binding hyphae, (iii) sarcodimitic, which comprises of generative hyphae and thick-walled

BRAOU

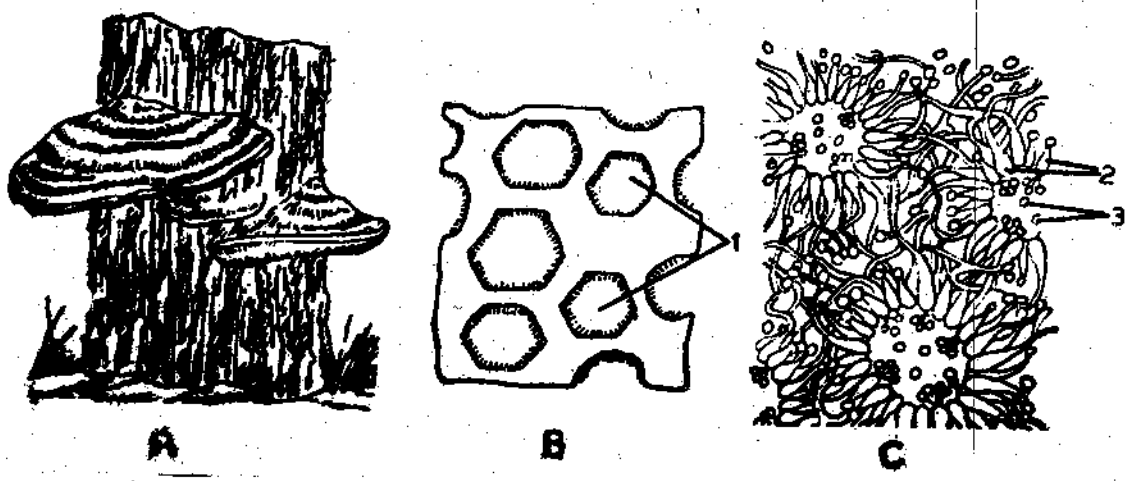


Fig. 8.4. Basidiocarp of *Polyporus* sp. A. Habit. B. Ventral surface of the pileus showing pores. C. Portion of the hymenium. 1. Pores. 2. Basidia. 3. Basidiospores.

very long fusiform, inflated cells whose ends taper to relatively narrow septa, (iv) Trimitic, with all the three types of hyphae and (v) Sarcotrimitic, where generative hyphae give rise not only to inflated fusiform skeletal cells but also to narrow, thick walled hyphae resembling binding hyphae in structure and function but differing from being septate. The generative hyphae in addition to participating in basidiocarp construction give rise to basidia and to structures such as cystidia, gloeocystidia, cystidioles, basidioles, setae etc. A special type of outer layer, the hymenium is characterized by the parallel arrangement of the basidia and sterile elements. This covers the gills, pores, spores or other surfaces. Both the basidia and sterile cells arise from a morphologically distinct tissue, the subhymenium and any sterile tissue that separates adjacent hymenia is known as the trama.

8.5.3. Basidiospore

A typical basidiospore is unicellular, haploid structure with one or two haploid nuclei. They may be globose, oval, fusoid, flattened with smooth or ornamented walls. The spores may be colourless or variously coloured ranging from white to black, (cream, green, yellow, orange, pink, brown, purple). The colour of the spores may be due to the substances in the cytoplasm or spore wall. The spore colour is used as an important criterion in the taxonomy of mushrooms. The basidiospore wall is made up of five wall layers or integuments; endosporium, episporium, exosporium, perisporium and ectosporium. The germ pore is located at the apex of the spore through which the germination of the spore takes place, giving rise to uninucleate mycelium. Some times the basidiospores may give rise to tiny conidia by budding. These conidia on germination give rise to mycelium. The basidiospores that are discharged violently occur in majority of the basidiomycetes (except in Gasteromycetes and Ustilaginales) and they are called Ballistospores and the basidiospores are passively discharged and are called statismospores.

BRAOU

Check Your Progress - 4

What are ballistospores ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

8.6. IMPORTANCE TO MAN

The division Basidiomycotina includes rusts, smuts which cause serious diseases in plants, mushrooms, toad stools, puff-balls, bracket fungi etc., which have much nutritive and medicinal values. Thus, this group is of much importance to man. Rusts and smuts which belong to the class Tellomycetes cause enormous losses to economically important crops by attacking them. Few examples are *Puccinia graminis tritici* (black stem rust of wheat), *Ustilago maydis* (corn smut), *Ustilago nuda var. tritici* (loose smut of wheat), *Ustilago scitaminea* (whip smut of sugarcane) etc. Mushrooms have been used as food since ancient times. Few common ones are *Agaricus bisporus* (White button mushroom), *Pleurotus* sp. (Oyster mushroom), *Volvariella* sp. (paddy straw mushroom), *Lentinus edodes*

(shiitake mushroom) etc. Fungi like *Lentinus edodes, Amanita muscaria* (fly agaric), *Grifola frondosa* (maitake mushroom), *Ganoderma lucidum* (Reishi mushroom) are medicinally important and are reported to increase immunity of the body system and also cure many body disorders.

8.7. CLASSIFICATION OF BASIDIOMYCOTINA

The Sub-division Basidiomycotina is divided into 3 classes and the important characters of each class are given below.

1. Teliomycetes : Basidiocarp lacking and replaced by teliospores or chlamydospores grouped in sori or scattered within the tissue; parasitic on vascular plants.

2. Hymenomycetes : Basidiocarp well developed and gymnocarpous (basidiocarp without covering, exposing the fertile layer, hymenium) or semiangiocarpous (hymenium, the fertile layer with basidia and basidiospores covered at the beginning and exposed later on before the spores mature); basidia either holobasidia (without septa) or phragmobasidia (with septa).

3. Gasteromycetes : Basidiocarp typically angiocarpous (the fertile part of the basidiocarp enclosed within the basidiocarp tissue till the spores mature); holobasidia.

Outline Classification of Basidiomycotina

The subdivision Basidiomycotina is divided into three classes. 1) Teliomycetes 2) Hymenomycetes and 3) Gasteromycetes. The classes are further divided into orders and the characters of each order are given below.

Class Teliomycetes : The class teliomycetes is subdivided into two orders. They are 1) Uredinales and 2) Ustilaginales.

Order Uredinales : The teliospores are terminal and germinate to give a promycelium bearing basidiospores on sterigmata from which they are forcibly discharged. The order uredinales includes three families. They are 1) Pucciniaceae, 2) Melampsoraceae, and 3) Coleosporiaceae.

Order Ustilaginales : The teliospores are usually intercalary and the basidiospores are produced either terminally or laterally but are sessile i.e., not borne on sterigmata and are not forcibly discharged. The order ustilaginales is subdivided into three families. They are 1) Ustilaginaceae 2) Tilletiaceae and 3) Graphiolaceae.

Class Hymenomycetes : This is divided into 2 sub-classes, *viz.*, 1) Phragmobasidiomycetidae and 2) Holobasidiomycetidae on the basis of presence of either phragmobasidia (septate) or holobasidia (aseptate).

Subclass Phragmobasidiomycetidae : The sub-class is divided into three orders. They are 1) Tremellales, 2) Auriculariales and 3) Septobasidiales.

Order Tremellales : Metabasidia are globose, pyriform, clavate or rarely spindle - shaped, longitudinally or obliquely cruciate, septate, or aseptate. The order consists of the family: Tremellaceae.

Order Auriculariales : In this order metabasidia are more or less cylindrical, transversely septate, saprobic or parasitic on phanerogams, cryptogams or other fungi. The order consists

BRAOU

of the family : Auriculariaceae.

Order Septobasidiales : The fungi are symbiotic or parasitic on scale insects and on living plants. The order includes one family i.e., Septobasidiaceae.

Sub-class Holobasidiomycetidae : The sub-class is divided into six orders. They are 1) Exobasidiales, 2) Brachybasidiales, 3) Dacrymycetales, 4) Tulasnellales, 5) Aphyllophorales and 6) Agaricales.

Order Exobasidiales : The fungi are internal leaf parasites of higher plants. Basidia emerge to form a hymenium. The order includes the family Exobasidiaceae.

Order Brachybasidiales : The fungi of this order are the internal leaf parasites of higher plants. Basidia emerge from the leaf in tufts. Family : Brachybasidiaceae is included in this order.

Order Dacrymycetales : The members are not the internal parasites of higher plants or if parasitic have a distinct external basidiocarp. Basidia furcate (sterigmata 2), spores are not repetitive. The order consists of the family Dacrymycetaceae.

Order Tulasnellales : The members are not internal parasites of higher plants or if parasitic have a distinct external basidiocarp. Basidia not furcate (sterigmata usually 4), subspherical to broad with stout finger like or inflated sterigmata, spores repetitive. Family Tulasnellaceae is included in this order.

Order Aphyllophorales : The members are not internal parasites of higher plants. Basidia not furcate, sterigmata relatively small, uninflated, spores not repetitive. Fruit body development is gymnocarpous (basidiocarp not covered by a covering and with exposed hymenium), hymenium unilateral or amphigeous (hymenium borne on all sides of basidiocarp), smooth or covered with dentate processes or lining tubes, if tubular tubes firmly united to the basidiocarp. The important families that are included under this order are 1) Thelephoraceae, 2) Clavariaceae, 3) Cantharellaceae, 4) Hydnaceae, 5) Meruliaceae, 6) Polyporaceae and 7) Hericiaceae.

Order Agaricales : The members are not internal parasites of higher plants. Fruit body development is hemiangiocarpous (the hymenium or fertile layer is enclosed by the basidiocarp tissue at first but later becomes exposed) or gymnocarpous. Hymenium covers lamellae on the lower surface of the pileus or lining tubes which are easily separable from the pileus. The important families that are included in the order are 1) Agaricaceae, 2) Amanitaceae, 3) Boletaceae, 4) Coprinaceae, 5) Entomolataceae, 6) Tricholomataceae, 7) Strophariaceae, 8) Pluteaceae, 9) Hypholomataceae, 10) Lepiotaceae, 11) Paxillaceae and 12) Russulaceae.

Class Gasteromycetes : The class is divided into nine orders. They are 1) Podaxales, 2) Phallales, 3) Hymenogastrales, 4) Lycoperdales, 5) Gautieriales, 6) Tulostomatales, 7) Nidulariales, 8) Melanogastrales and 9) Sclerodermatales.

Order Podaxales : Development of gleba (fertile tissue) is either unipileate (from a single tramal branch) or multipileate (from a number of tramal branches) and stipiate (with true stipe). Gleba powdery at maturity, spores dark in colour. Family podaxaceae is included in this order.

Order Phallales : Gleba fleshy or mucid at maturity, fruit body never with a true stipe. Spores hyaline and bacilloid or ovoid and pale brown. The order consists of the family phallaceae.

BRAOU

Order Hymenogastrales : Gleba fleshy to cartilaginous or gelatinous. Original glebal structure is maintained till maturity. Fruit bodies hypogeous or epigeous. Spores ellipsoid often ribbed. Family Hymenogastraceae is included in this order.

Order Lycoperdales : Gleba powdery, spores usually globose, never ribbed, peridium is present. The order consists of the family Lycoperdaceae

Order Gautieriales : Gleba cartilaginous, spores ellipsoid, longitudinally ribbed, peridium often absent. The order consists of the family Gauteriaceae.

Order Tulostomatales : Fruit body is truely stipitate. The family Tulostomataceae is included in this order.

Order Nidulariales : Fruit body sessile, 1 cm. in diameter. Gleba organised into peridioles (sometimes a single peridiole). Spores smooth, hyaline, often large. The order Nidulariales consists of the family Nidulariaceae.

Order Melanogastrales : Fruit body is usually more than 1 cm. in diameter. Gleba not so organized and fleshy at maturity. The family Melanogastraceae is included in this order.

Order Sclerodermatales : Fruit body is greater than 1 cm. in diameter. Gleba is not well organized and powdery at maturity. Family Sclerodermataceae is included in this order.

8.8. SUMMARY

In the Basidiomycotina sexual structures are lacking and plasmogamy occurs by the fusion of haploid hyphae produced from a basidiospore. The dikaryotic mycelium is the most predominant phase and comprises the vegetative mycelium and the tissues in the basidiocarp. Each cell is binucleate and this condition is maintained by the formation of clamp connections. Basidium is one of the most important characters of Basidiomycotina, presence of dolipore septa, typical mycelia (few yeast like), absence of flagellated cells are some other diagnostic characters of Basidiomycotina. The majority of Basidiomycetes form large, conspicuous basidiocarps.

The basidomycetous fungi are very much important to man, because they include pathogenic fungi that cause enormous losses to crop plants. A typical example, *Puccinia graminis tritici* belong to this group. Apart from these the group also include mushrooms, toad stools, bracket fungi, puff-balls etc., which are edible and also medicinally important. Thus the entire group is of great importance to mankind.

BRAOU

8.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The distinguishing characters of the somatic mycelium of Basidiomycetes are the occurrence of clamp connections and presence of dolipore septum.
2. Dome shaped double membranous structures present on either side of a dolipore septum are called parenthosomes.
3. A probasidium is the portion of basidium in which Karyogamy takes place where as a metabasidium is the developmental stage of the basidium in which meiosis occurs.
4. Ballistospores are the basidiospores that are discharged violently.

8.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an account of asexual and sexual reproduction in Basidiomycotina.
2. Write briefly about the somatic structures and economic importance of the members of Basidiomycotina.

II. Answer the following questions in about 10 lines each.

1. Write a brief account on basidium.
2. Describe the vegetative mycelium of Basidiomycetes.
3. Write about the different types of asexual reproduction in Basidiomycotina.
4. Describe the construction of hyphal system in basidiocarp.

Prof. A. Janaki Bai

BRAOU

UNIT - 9 : HISTORY, DISTRIBUTION AND OCCURRENCE OF MUSHROOMS

Contents

9.1. OBJECTIVES

By the end of this unit you will be able to :

* define mushrooms,
* give the historical account of mushrooms and explain about their distribution in nature.

9.2. INTRODUCTION

In general, the term 'Mushroom' is used to represent the fleshy edible fungus. The poisonous fleshy fungi are known as 'toadstools'. Scientifically, the mushrooms are epigeous (above the soil), or hypogeous (below the soil) macroscopic fruiting bodies of certain fungi. The mushrooms or the fruiting bodies represent a short stage in the life-cycle of fungi producing them. The fruiting bodies are the spore bearing organs of the fungi. The fungi producing mushrooms grow either saprophytically on a variety of substrates, symbiotically with the roots of other plants or parasitically on certain plants. The fleshy fungi belong to the subdivisions Ascomycotina and Basidiomycotina and majority of the mushrooms belong to Basidiomycotina. A typical mushroom is divided into pileus or cap, lamellae or gills, veil, the stipe or stalk and volva (Fig. 9.1). The uppermost part of the mushroom is called pileus or cap which is variously shaped in different fungi. Underneath the cap starting from the apex of the stalk and extending towards the margin of the cap are the plate like structures called gills. Gills bear spores. The gills are covered by a membrane called veil, at the young stage. The stipe is the stalk of the basidiocarp. Volva is a thin sheet of interwoven hyphae around the bulbous base of the stalk, found in certain mushrooms only.

In Latin 'Fungo' means to flourish. This term was used later on, to refer to mushroom. In Greek, this term (Mushroom) was derived from the word "sphonggos" or "sphoggos" which means sponge. The term sponge refered to the sponge-like structures (Mushrooms) of some fungi. The word mushroom is thought to be derived from the French words "Mousseron" (Muceron) "mousse" "Moss" "muscheron" or "Mouscheron". Consequently, the name "mushroom" is originated in due course of time from the above words.

BRAOU

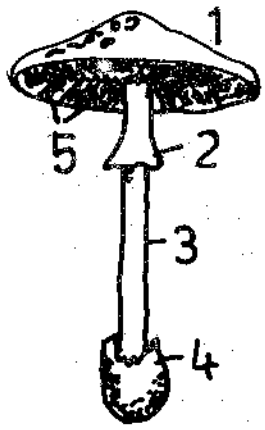


Fig. 9.1. A typical mushroom. 1. Pileus 2. Annulus. 3. Stipe. 4. Volva. 5. Gills.

Check Your Progress - 1

Define Mushrooms ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

BRAOU

9.3. HISTORY OF MUSHROOMS

Three and a half million years ago, the Greek hero Perseus, being thirsty, chanced to take up a mushroom (Mykes), drank the water flowing from it, pleased of it and gave the name Mycenae for that place. Thus, Mycenae one of the greatest civilisations of history, was named after a legendary mushroom. From the same Greek word Mycology (Mykes : Mushroom; Logos : discourse) has been derived (Alexopoulos, 1962).

In Sanskrit, the term 'ksumpa' refers to mushroom which has been evolved into Khumbi in Hindi. This mushroom 'ksumpa' was later on identified as *'Phellorina delestri'* by scientists. The fleshy capped fungi are later on called 'Chatra'. Other common Sanskrit words are Kukurmutta, Kavaka, Bhustrana and Bhoomi Kavak.

Around 1500 B.C. when Aryans migrated into the Indian subcontinent carried 'soma' an intoxicating drink. The drink soma was used in Aryan religious rites. Wasson (1969) reported that Soma in Rigveda refers to *Amanita muscaria*. There are many songs on soma in *Rigveda*. Mushrooms were worshipped and considered divine in primitive cultures. Records about the prehistoric people using fungi are very rare. Traces of puff balls and other fungi carved on stones were found by O' Heer (1886). Mushroom shaped stone carvings have been found in Central America and the highlands of Guatemala. These are

Dr. BRAOU LIBRARY
Acc. No: CM-0066
Class No: 589.2
CER

reported to belong to Mayan period and were used in ceremonies. Religious and astrological paintings in Mayancodices depict figures holding or offering mushroom-shaped objects which resemble the fruit body of fly agaric *(Amanita muscaria)*. Various names for fungi like *Agarikon, Amanita, Boletus* etc., have been given from classifical times. Minarets, temples and cupola columns were constructed by architects in the shape of mushrooms. In Roman times the most luxurious feasts were served with mushroom dishes. A Roman poet Horace (Born 65 B.C) praised in one of his satires "Pratanses" probably the field mushroom, as the best among all fungi. Pliny, the Roman naturalist (died in A.D. 79) described *Amanita caesaria* and *Boletus edulis* as the most delicious mushrooms and said that the mushroom preparations were served only to masters in special and costly utensils. The mushrooms have been collected for food throughout the world since ages. High prices were offered by the aristocrats as they are the favourites of princes. Dogs, bears and pigs were trained for searching truffles and a special code of law was also made for this purpose. Myths of ancient Indian, Greek and Roman believe that mushrooms grow from a stroke of lightning. Mushrooms occupied a special position at the Royal tables and have been praised for their delicacy till present. Later on, the man started cultivating the mushrooms according to his choice. One of which was *Auricularia* (black ear mushroom) which was cultivated in China about 1000 years ago. About 900 years ago *Lentinus edodes* (Shiitake mushroom) was cultivated in China. In 1650 *Agaricus bisporus* (White button mushroom) was grown in France. Around 300 years ago in Kwangtung Province in China *Volvariella volvacea* (paddy straw mushroom) was cultivated. Thus the mushrooms occupied a special place in international markets also.

9.4. DISTRIBUTION AND OCCURRENCE

The mushrooms are distributed over a wide geographical area. They occur frequently in places which are warm, moist and shady during spring, summer, rainy season and autumn. They do not occur in very high or very low temperatures. They are found growing in mountains, plains, valleys, near river banks etc., The vegetative part of the mushroom, which is the mycelium grows saprophytically in soil rich in organic matter, in or on dead wood, in or on rotten logs or stumps. The hyphae spread in every direction of the substratum and absorb food from it. The individual hyphae are usually not isolated, but woven together into strands which may develop into root-like structures often termed rhizomorphs. These fungi are mostly saprophytic growing commonly in lawns, pastures and gardens. e.g., *Agaricus campestris, Lepiota morgani*. But some are also facultative parasites on the roots of trees and elsewhere. Very common one is *Armillariella mellea* which is known as the 'honey agaric'. It causes root rot of Larch. Again some are involved in mycorrhizal associations. e.g., *Amanita muscaria* and *Lactarius rufus*. The vegetative mycelium buried in the substratum sends up basidiocarps or fruiting bodies at irregular intervals of months or years, usually after soaking rains. A mycelium established at a single point tends to ramify radially in all directions and die out at the centre with the depletion of the available food supply. Successive crops of basidiocarps may thus be produced in successively larger rings, often called *'fairy rings'* based on the ancient belief that these circular rings marked the path of dancing fairies. The fairy rings or fungus rings are very frequent in grass lands and not uncommon in woods (Fig. 9.2).

BRAOU

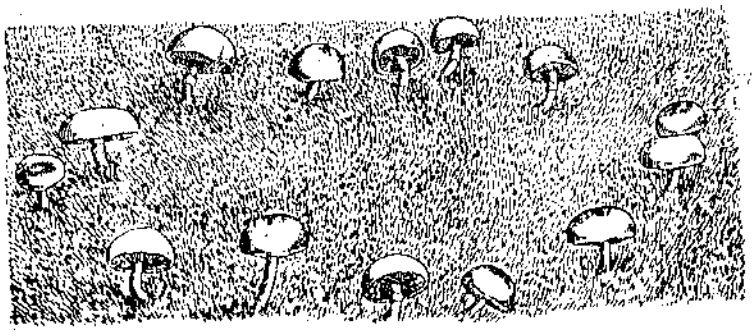


Fig. 9.2. Fairy ring of basidiocarps.

Mushrooms are divided into the following groups on the basis of their natural habitat.

Humicolous or foliicolous

These are humus (decomposed organic matter in the soil) inhabiting mushrooms, e.g., *Volvariella* species, *Calocybe* species, *Polyporus tubestar*, *Boletus* spp., *Amanita muscaria*, *Lactarius rufus*, *Tuber* and *Morchella* spp.

Lignicolous

These mushrooms inhabit the wood of plants either dead or living. These are divided into saprophytic and parasitic mushrooms.

(a) Saprophytic : *Pleurotus* spp., *Auricularia* spp., *Lentinus edodes* etc.

(b) Parasitic : *Armillariella mellea*, *Marasmius* spp. and *Cyttaria* spp.

Coprophilous

These mushrooms commonly inhabit the dung e.g., *Agaricus* spp., *Coprinus* spp.

BRAOU

Check Your Progress - 2 & 3

2. Name two mushrooms having mycorrhizal associations.
3. What are lignicolous mushrooms ? Give two examples for parasitic lignicolous mushrooms ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

9.8. SUMMARY

Mushrooms grow saprophytically on various substrates or parasitically and symbiotically on or with other organisms. Edible mushrooms belong to Ascomycetes and Basidiomycetes. Majority of the mushrooms belong to Basidiomycetes. The typical umbrella like fruiting body of mushroom has some or all the following parts - cap or pileus, gills or lamellae, veil, stipe or stalk and volva or universal veil. Mushrooms are worshipped and considered to be divine in primitive cultures. 'Soma' an intoxicating drink served in religious ceremonies of Aryans was extracted from *Amanita muscaria*, a mushroom. They have been also under cultivation since 1000 years.

Mushrooms are distributed world-wide. Basidiocarps of *Agaricus* appear in rings in grasslands and popularly called 'fairy rings or fungal rings'. On the basis of their natural habitat, they are divided into humicolous, lignicolous and coprophilous mushrooms.

9.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Mushrooms are the fleshy spore bearing structures that represent a short stage in the life-cycle of fungi producing them.
2. Mushrooms having mycorrhizal associations are *Amanita muscaria* and *Lactarius rufus*.
3. Mushrooms inhabiting the wood of dead and living plants are called lignicolous mushrooms. Examples for parasitic lignicolous mushrooms are *Arillariella mellea* and *Marasmius* spp.

BRAOU

9.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give an account of history of mushrooms.
2. Write a detailed account of the distribution and occurrence of mushrooms.

II. Answer the following questions in about 10 lines each.

1. Write an account on types of mushrooms which are divided on the basis of their natural habitat.
2. What are fairy rings ?

Ms. I. Kunwar
Ms. K. Prasunamma

UNIT - 10 : EDIBLE MUSHROOMS

Contents

BRAOU

10.1. OBJECTIVES

After going through this unit you will be able to :

* list out the important cultivated mushroom species,
* describe various edible mushrooms including morels, puffballs and truffles.

10.2. INTRODUCTION

The umbrella - like, fleshy, sometimes hard fruiting bodies of fungi are popularly called mushrooms. Generally the fruiting bodies of Basidiomycotina are referred by the term mushroom. The fruiting bodies of Ascomycotina which are large and fleshy may also be called mushrooms. Some species of mushrooms are edible and some are poisonous. The edible fungi, besides, mushrooms are known as morels, puff-balls and truffles also. Morels are species of *Morchella*. Truffles are the species of *Tuber*. Both morels and truffles belong to ascomycotina. Puff-balls are species of *Lycoperdon*. *Lycoperdon* and other mushrooms belong to Basidiomycotina. In most cases mushrooms are present above ground, but there are some mushrooms whose natural fruiting bodies are located beneath the ground. (e.g., *Truffles*).

Large number of mushrooms grow wildly in nature. They are being used as food since time immemorial. Some of them like *Morchella* and *Tuber* are highly prized for their taste and flavour. This resulted in the temptation to domesticate mushrooms. Though there are

about 2000 edible mushrooms and many have been successfully cultivated, but only a few are cultivated extensively. The important genera from the cultivation point of view in the world are *Agaricus*, *Lentinus*, *Volvariella*, *Pleurotus* and *Auricularia*. In India *Calocybe* is also promising. Other important edible mushrooms belong to the species of *Coprinus*, *Boletus*, *Flammulina* and *Termitomyces* etc.

10.3.1. Agaricus spp.

This is the most popular edible mushroom which is known as the white button mushroom, button mushroom, or simply the common cultivated mushroom. In western countries cultivation of *Agaricus* has developed over the past 30 to 40 years. It grows in lawns, pastures, by road sides, even in gardens and cultivated fields, conifer forests, under hardwoods etc. They are common in late summer and autumn.

The cap is white and some what silky, and expands to about 10 cm across, often with pieces of veil adhering to the edge. The short, rather stout stalk is not longer than the cap's diameter, and it tapers below.

It is an umbrella shaped mushroom. In the genus *Agaricus* the spores at maturity are either purple brown or blackish with a purple tinge. The annulus is present on the stalk, though disappearing soon in some species. Gills are dark purple - brown to black at maturity

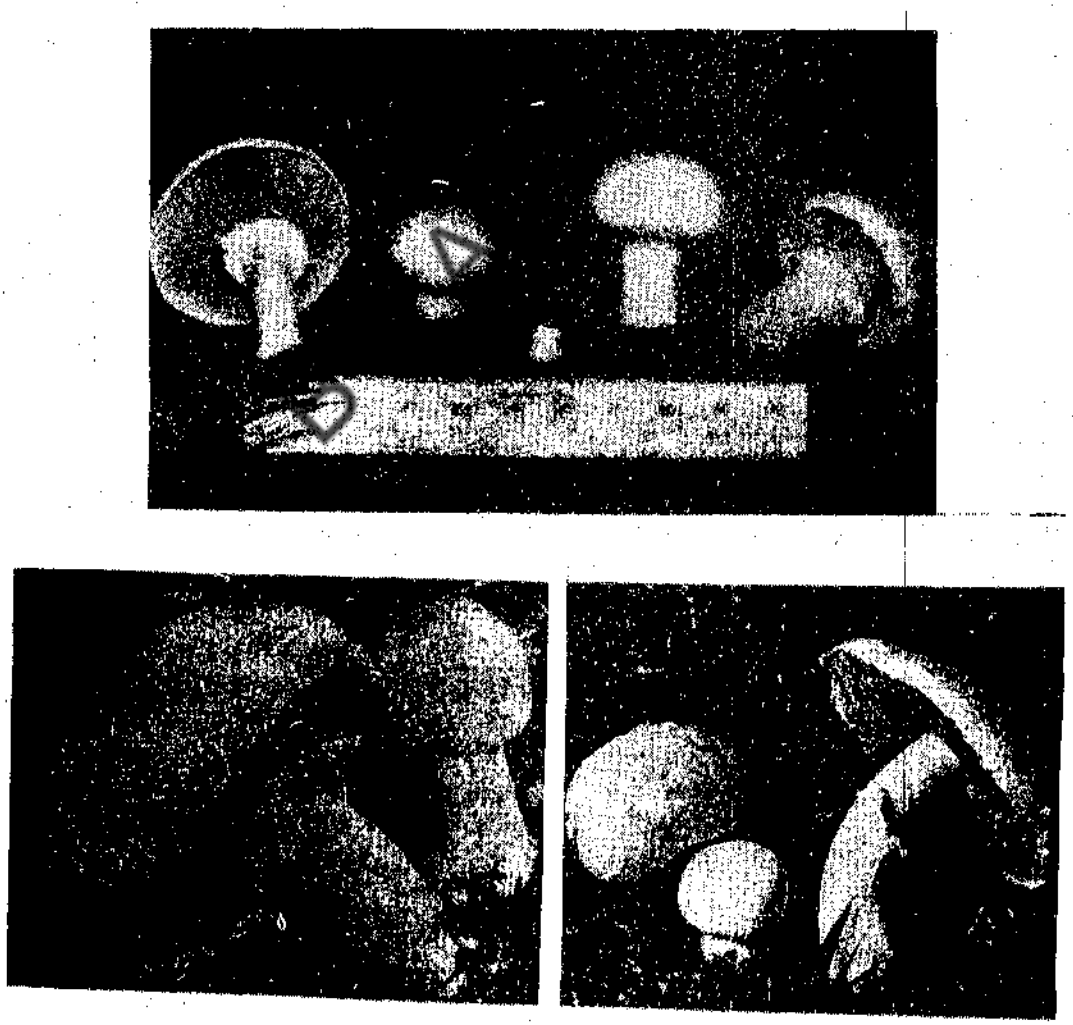


Fig. 10.1 *Agaricus* spp. (Button Mushrooms). A. *Agaricus bisporus*. B. *A. arvensis* C. *A. campestris*.

and are free from the stalk (though touching it in few species). The stalk separates easily and clearly from the cap. No volva is present. Various species of *Agaricus* are edible. The common ones being *A. bisporus, A. bitorquis, A. arvensis, A. compestris*. The first three species are commercially cultivated. *A. bisporus* is the most common. In case of *A. bisporus* the diameter of cap is about 11.25 cm and the length of the stipe is about 6.25 cm. *A. bitorquis* is very much similar to *A. bisoprus* in size. In *A. campestris* cap is about 12.5 cm. in diameter and length of the stipe is about 9.5 cm. In *A. arvensis* cap is about 20 cm in diameter and the stipe is about 10 cm in height. *A. bitorquis* can tolerate little higher temperature, so it is very promising for tropical countries like India.

10.3.2. Lentinus edodes

Lentinus edodes, the cultivated species is commonly known as black forest mushroom; the Chinese name is shiong-gu and Japanese name is shiitake. It is the second most important edible mushroom from the stand point of production.

Lentinus edodes grow naturally on dead wood of many hardwood tree species under different climatic conditions. Cultivation of the mushroom on natural wood logs is an important agricultural and industrial business in China, Japan and South Korea. It is Cultivated in polypropylene bags also ("bag log" cultivation) containing saw dust. For a long period of time, this mushroom has been valued for its unique taste and flavour and as a medicinal tonic.

Fruit bodies of this mushroom are tough and pliant (bend easily), become hard when old and dry. The genus differs from the other tough and pliant ones by the peculiarity of the gills, the gills being notched or serrate on the edges. The fruit bodies are typical mushroom like. Cap is brown in colour and covered with numerous scales. Stalk is central and has annulus, usually scales of veil tissue are present below the stalk. The cap measures about 11 cm in diameter and stipe 3-4 cm. in length.

AOU

Fig. 10.2. *Lentinus edodes* (Shiitake mushroom).

10.3.3. Volvariella spp.

Although more than one hundred species, subspecies, and varieties of *Volvariella* have been reported throughout the world, all the cultivated forms of *Volvariella* in South - East Asia are probably varieties of the species *Volvariella volvacea*. *Volvariella volvacea* is commonly known as the straw mushroom, paddy straw mushroom, or the Chinese mushroom. It is an edible mushroom of the tropics and subtropics and has been cultivated on paddy straw in China and other Asian countries for about 2000 years. *V. volvacea* is referred to as a "warm mushroom" because it can grow at relatively high temperatures, i.e., vegetative growth at about 32 to 34° C. It is a fast growing mushroom and the time required from spawning to harvesting is only about 8 to 10 days. No other mushroom can be served as a table dish within such a short time.

The basiodiocarp of the straw mushroom is roughly divided into six different stages in development, *viz.*, "pinhead", "button", "egg", "elongation" and "mature" stages. The egg and "button" stages are sold in market at bargain prices.

1. Mature stage : At the "mature" stage, the whole structure is divided into three regions, (1) the pileus or cap, (2) the stipe or stalk, and (3) the volva. The volva is fleshy white and cup-shaped with irregular margin around the bulbous base of the stalk. The stipe is white, fleshy and without annulus. It is attached to the centre of the lower surface of the pileus and connects it to the volva. The length of the stipe varies according to the size of the pileus. It is usually about 3 to 8 cm long and 0.5 to 1.5 cm in diameter. The fully expanded pileus is circular, with an entire margin and a smooth surface which is dark grey in colour at the centre, but light grey near the margin. The diameter is about 5 to 12 cm. Gills do not touch the stipe but are separated from it by about 1 mm.

2. Elongation stage : Previous to the "mature" stage is the "elongation" stage. It is similar in shape to the mature stage, except that the pileus is not opened and the size is smaller. The stipe is extended to almost full length at this stage; hence, the name "elongation" stage.

Fig. 10.3. *Volvariella volvacea* (Paddy straw mushroom).

3. Button and Egg stages : The "button" stage and the "egg" stage are sold in market at a premium price. Both stages are ovoid in this stage. In the "button" stage, the whole structure is wrapped by a coat which is called the universal veil. Inside the universal veil is the closed pileus. The stipe can only be seen in a longitudinal section of the whole structure. In the "egg" stage the pileus is pushed out of the veil, which remains to form the volva. Here again the stipe is hidden. The pileus in these two stages is similar to that in the above two stages except that it is smaller in size.

4. Pinhead stage : In the "pinhead" stage and the "tiny-button" stage the universal veil is much thicker. On its removal, the tiny pileus can be seen with a dark grey centre and white margin. The basal portion of the entire structure is quite big compared to the pileus. For the younger tiny buttons only the top of the universal veil is brown, the rest is white. The tiny buttons are round in shape. If a vertical cut is made through a very young tiny button, the lamellae are seen as a narrow band on the lower surface of the comparatively thick pileus. The "pinhead" stage, by its name, is of the size of a pinhead. The universal veil is spotlessly white. With a vertical section, the pileus and the stipe cannot be seen. The whole structure is a tiny knot of hyphal cells.

10.3.4 . Pleurotus spp.

This mushroom is generally called the oyster mushroom, because the pileus or cap is shell-like, spatulate and tongue-shaped and the stipe eccentric or lateral. *Pleurotus ostreatus* is one of the best known among the oyster mushrooms. Other commonly cultivated species are *P. sajorcaju* (grey oyster mushroom or phoenix tail mushroom); *P. cystidiosus* (abalone mushroom), *P. ostreatus* var. *florida* (white oyster mushroom); *P. flabellatus* (pink oyster mushroom) and *P. sapidus* (black oyster mushroom). Oyster mushrooms fruit during spring and fall, and all summer if the weather is cool and wet. *Pleurotus* species are wood-destroying, saprophytic fungi and are spread over all parts of the world. They have a fragrant and delicious flavour. The size of the cap reaches 5 to 15 cm on wood and 30 cm and more on straw substrates. The gills are whitish or grey. The stipe is short (1 to 5 cm). The pileus is usually shell or tongue shaped or, in case of older stages, depressed. The cap has a smooth surface without scales, and the whole fruiting body is soft and fleshy. The colour of the cap could be white, greyish or greyish pink or dark blue.

BRAOU

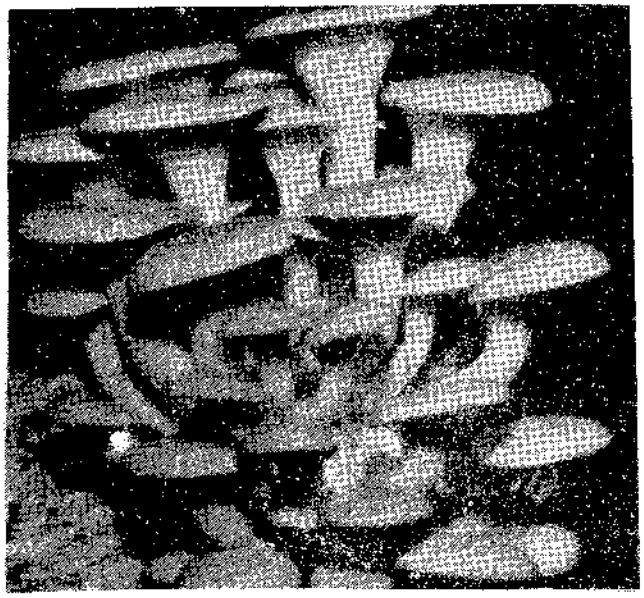


Fig. 10.4. *Pleurotus florida* (white oyster mushroom).

Pleurotus species are comparatively easy to grow and of broad adaptability. They are cultivated worldwide and their production has increased rapidly in recent years. However, *Pleurotus* mushrooms discharge spores in tremendous numbers during the process of cultivation, and this frequently causes allergies and respiratory problems to workers in the mushroom house. To overcome this drawback breeding for sporeless mutant varieties is needed. Sporeless mutants of *P. ostreatus, P. pulmonarius* and *P. florida* are available. *Pleurotus florida* was earlier called *P. ostreatus* var. *florida*.

10.3.5. Auricularia spp.

The name *Auricularia* is derived from the Greek word "Auricula", meaning ear. Therefore, this mushroom is commonly called wood ear, Jew's ear or simply ear fungus, because of the shape of their fruiting bodies. The fruiting bodies are not only shaped like a human ear, but also feel like ears, due to their rubbery, gelatinuous state when fresh. The fruiting bodies when dry are waxy and cartilaginuous and the colour ranges from purplish-brown to black. Fruit bodies are 2-8 cm across. The brownish outer surface is velvety with fine grey hairs. This fungus is edible and it is said to be especially good for soups. The *Auricularia* mushroom has been reported to be the first mushroom cultivated.

Auricularia auricula and *A. polytricha* are the two most popular edible species. The former is usually collected from its natural habitat and the latter is commonly cultivated on logs of various trees or on sawdust with different supplements. They are saprophytic fungi.

Fig. 10.5. ***Auricularia polytricha*** **(Black ear mushroom)**

10.3.6. Calocybe indica

It is commonly known as milky white mushroom. *Calocybe indica* (Fig. 10.6) was reported from West Bengal during 1974. It grows in nature on humus soil in the forest. It is collected from the forest and sold in the market. It has very attractive fruit body and long shelf life. The fruit bodies are milky white in colour. The diameter of cap is about 8 cm. The stalk is central, thick upto 8 cm long. It can be easily cultivated on

Fig. 10.6. *Calocybe indica* (Milky white mushroom).

paddy straw based substrate.

10.3.7. Flammulina velutipes

It is commonly called winter mushroom or velvet stem and in Japan it is known as enokitake. This wood-destroying mushroom occurs all over the world, living as a saprophyte on trunks and stumps of some broad leaved trees. Fruiting is from beginning of winter to early spring. In Japan it has been appreciated as food for many centuries and nowadays it belongs to artificially cultivated mushroom in Japan and Taiwan, the species being *Flammulina velutipes*.

BRAOU

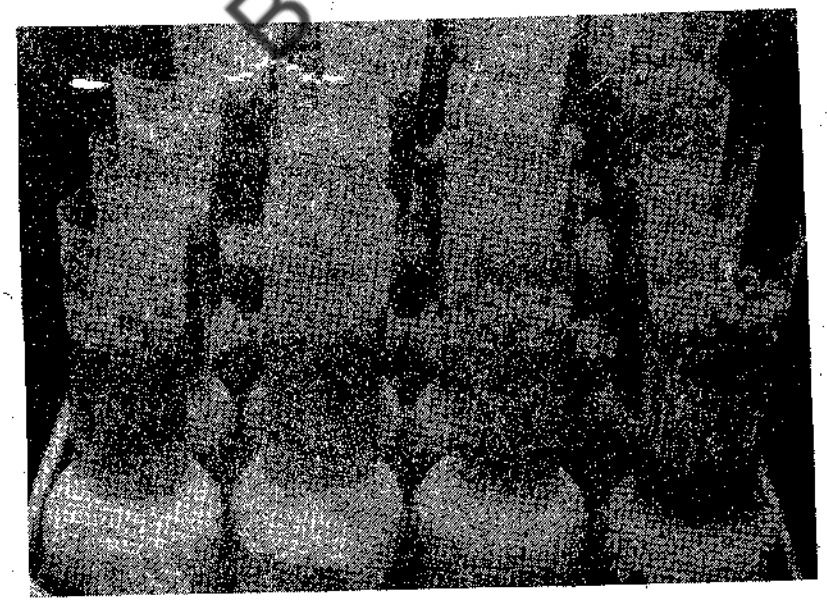


Fig. 10.7. *Flammulina velutipes.*

Pileus is yellow to brown coloured, usually with a light brown margin. The flesh is almost white, the gills are white or light cream coloured and decurrent to the stipe. The pileus has a diameter of 2-3 cm. The dark brown stipe is 2-9 cm in length and 2-8 mm in diameter.

10.3.8. Boletus spp.

This mushroom is truly fleshy, rapidly decaying, and often worm riddled. The entire mushroom is soft and fleshy and decays soon after maturity. The layer of tubes on the under side of the cap can be easily peeled off and separated. Large number of species grow on the humus in the ground, under hardwoods or in mixed woods. Some species change colour when bruised or cut. It is important to note this character when the mushroom is fresh. Species are usually collected in warm, wet weather from July to September.

Although on first glance the fruit body of a bolete may resemble a "typical" mushroom, there is one significant difference. Instead of bearing gills on the underside of the pileus, a bolete possesses vertically arranged tubes. The pores visible on the undersurface of the cap are actually the open ends or mouths of these tubes. Fruit bodies are often large and brightly coloured. Pileus is convex to expanded, smooth, firm and colour varies according to the species. Stalk is stout. Usually there is reticulate pattern or dots on the stalk. Annulus, volva are absent. *Boletus edulis, B. mirabilis* and *B. aurantiacus* are some of the edible sepcies. *Boletus edulis* consists of cap ranging from 20-40 cm in diameter and length of the stipe is up to 30 cm.

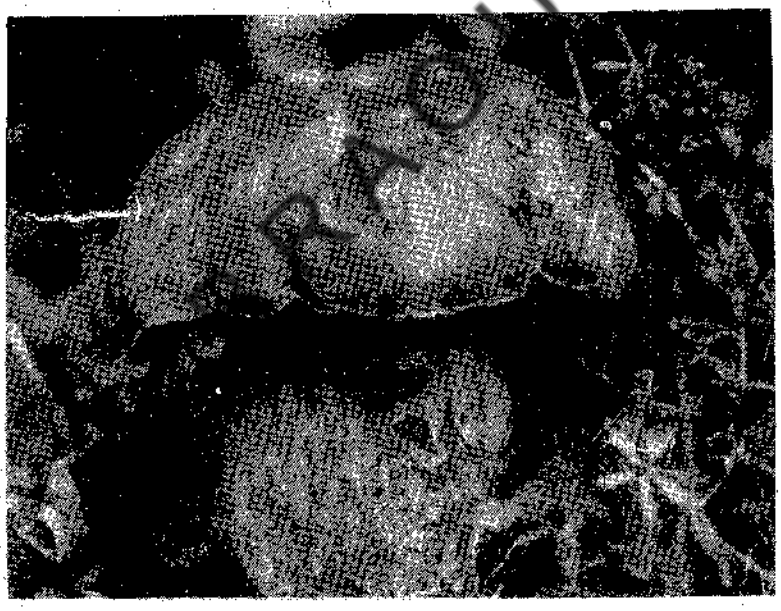


Fig. 10.8. *Boletus edulis.*

10.3.9. Coprinus spp.

This is a group of gill fungi in which the gills blacken at maturity and then dissolve into a dark ink like liquid, thus completely destroying themselves. This "melting" of the gills is simply a process of autodigestion, and the kinds of mushrooms which have this character are placed in the genus *Coprinus*. These are commonly called Inky caps. Among the *Coprinus* species, *C. comatus*, the shaggy mane, has been successfully cultivated. However, the poor keeping quality of the *Coprinus* fruit bodies do not make them very attractive commercially. Some species have large rather fleshy fruiting bodies, and some

are extremely small and delicate. Most of the larger ones are edible if young stages are obtained. Some grow on manure piles or in richly fertilized soil, some live on humus in the forest, and a large number characteristically grow on wood.

Pileus is cylindrical or barrel shaped. Veil forms a loose ring around the stem. The total height of the mushroom is 20-30 cm. The cap is rather thick at centre, i.e., where it joins the stem, becomes comparatively thin where it spreads out over the gills. When spores ripen and become black the colour of the gills changes. At the same time the cap and the gills begin to dissolve into an inky fluid. As this accumulates it forms into drops which dangle from the cap until they fall away. The cap now begins to expand outward more, so that it becomes somewhat umbrella shaped. The extreme outer surface does not dissolve so freely and the thin remnant curls upwards and becomes enrolled on the upper side as the cap with gills becomes nearly flat.

Fig. 10.9: *Coprinus comatus* (Inky cap mushroom).

10.3.10. Termitomyces microcarpus

It is a highly valued mushroom gathered in plenty each season in Asia as well as in Africa. It is comonly found growing on termite nests. Man has not been able to match the skill of termites in cultivation of this mushroom, Fruit body is umbrella shaped with the stipe being long and with a veil or doubly veiled. In *Termitomyces microcarpus* the diameter of the cap ranges from 0.5-1.5 cm. and length of the stipe is about 2-4 cm.

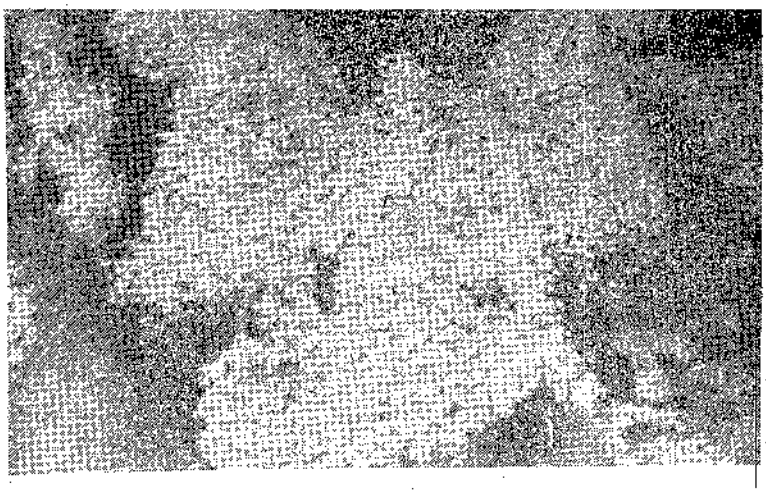


Fig. 10.10. *Termitomyces microcarpus.*

10.3.11. Morchella spp.

These are commonly known as morels or sponge mushrooms. All morels are edible and delicious. Indeed, with possible exception of the European truffles, they are the most delicious of all the mushrooms. *Morchella* is sold as "Guchhi" in India, the major produce comes from Jammu and Kashmir and fetches a great deal of foreign exchange. Among the most prized wild edible fungi are *M. crassipes, M. esculenta, M. conica* and *M. semilibera.* Among these *M. crassipes* has the best flavour. It occurs mainly in the coniferous forests or soils rich in humus.

Morels season is short and does not exceed one month in the spring. That is why they are occasionally found in the market during the early spring. Morels are dried and stored for future use. The fruit body of *Morchella* has two distinct, prominent parts, the cap or pileus and the stem or stipe. The cap could be ovate, conical or cylindrical in

BRAOU

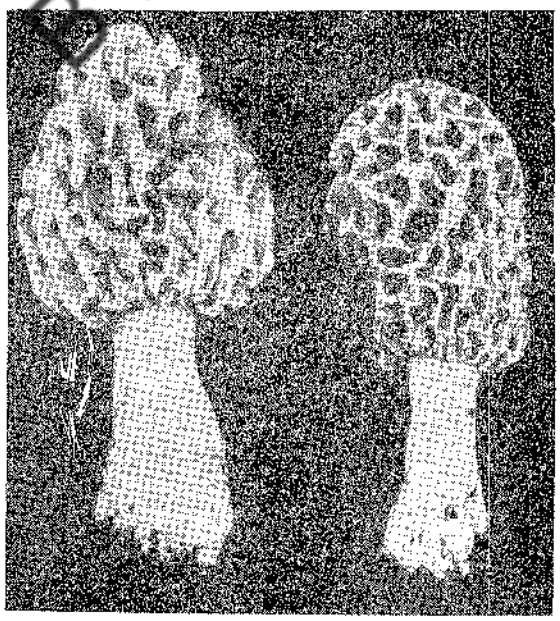


Fig. 10.11. *Morchella esculenta* (Morel).

shape and is always marked by broad pits, covering the entire outer surface, which are separated from each other by the ridges forming a network, resembling a sponge. The colour varies from dirty greyish white to a dark-brown, depending on the species and age of the specimen. The size varies from 2-5 cm or less to 10-14 cm in height. The stem is usually quite stout. The cap and the stem are hollow from inside.

10.3.12. Tuber spp.

Truffles are the species of the genus *Tuber*. Besides just being edible, they have already earned a fame of special importance for their delicacy of flavour. When mature, their fruiting bodies emit a powerful odour. The subterranean fruiting bodies are gathered usually with the assistance of trained dogs or pigs. When looking for truffles without the aid of trained animals some sort of rake is required. The truffles are most likely to be found on well-drained calcareous soils, often amongst the roots of oak trees. They can sometimes be detected by cracks in the soil and by a scorched look of plants growing over them. The dogs and pigs locate them by their odour. In Italy and France they are canned for export. The mycelium of *Tuber* grows in close association with the roots of some trees (ectotrophic mycorrhiza). For the last 100 years truffles are produced by half-or semi-culture technique. Although they have not yet been induced to fruit in culture, it is now possible to obtain fruiting bodies of *Tuber* on a regular basis in fair quantity. In semi-culture technique, suitable host trees are planted along with the mycorrhizal fungus, *Tuber*. Various edible species of *Tuber* are *T. melanosporum, T. aestivum,* and *T.magnatum*. The fruit bodies of *Tuber* are hypogeous, closed, globose, ovoid or irregular in shape, 10 cm. in diameter and covered with a rind. The fruit bodies are usually dark coloured and may be either hollow or solid.

10.3.13. Lycoperdon spp.

Members of this genus are commonly known as *"Puffballs"*. They grow on tree stumps,

DRAOU

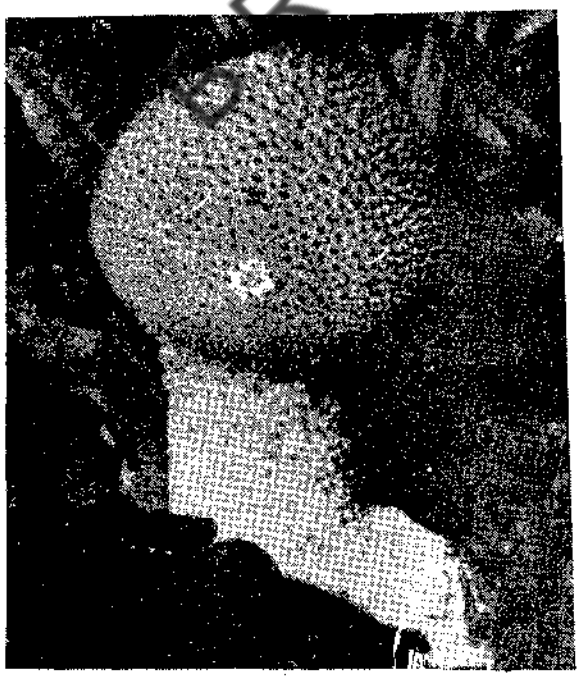


Fig. 10.12. ***Lycoperdon perlatum*** **(Puff ball).**

on decaying logs, or on the ground in the woods. Some species, notably the giant puff-balls can be found growing in city lawns, golf greens, and grassy open fields. All species of puff-balls are edible, although some have been known when consumed to cause intestinal difficulties in some people. They are best when pure white inside. As the spores form, the centre of the puff ball begins to turn yellow and the flavour is spoiled by this time; even then, the puff-ball is generally not poisonous although it no longer tastes good. It is always a good idea to section vertically any puff-ball collected for consumption since some mushrooms produce a so-called "button stage" that resembles a puff-ball. In particular, the young stage of *Amanita* resembles some puff-balls.

The fruit body of *Lycoperdon* is enclosed by two peridial (wall) layers. The outer *exoperidium* may be warty, spiny or granular. It withers away leaving the inner thin, membranous *endoperidium*. In fact, the endoperidium is provided with a small central opening from which the spores are puffed out when wind or an object strikes the surface of the fruit body, sugggesting the name puff-ball. *L. perlatum*, *L. giganteum* and *L. cyathiforme* are common edible species. When young fruit bodies range from 5 - 6.5 cm. height and 3.5 - 5 cm. diameter.

Check Your Progress - 1 to 5

1. Which are the other edible fungi besides umbrella like mushrooms ?
2. Name the commonly cultivated genera of mushrooms.
3. Which species of button mushroom is commonly cultivated ?
4. Why is *Auricularia* so named ?
5. What are puff-balls ?

Note : a) Write the answers in the space given below.

b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

BRAOU

10.4. SUMMARY

The edible fungi besides umbrella-like mushrooms are known as morels, puff-balls and truffles. The morels are the species of *Morchella*, Puff-balls are the species of *Lycoperdon* whereas truffles which are located beneath the ground are the species of *Tuber*. The important fungi from the point of view of cultivation are *Agaricus*, *Lentinus*, *Volvariella*, *Pleurotus* and *Auricularia*. Other important edible mushrooms belong to the species of *Calocybe*, *Coprinus*, *Boletus*, *Flammulina* and *Termitomyces* etc. Edible mushrooms can be identified with the help of their morphological characters such as shape, size, colour, texture, presence or absence of annulus, volva and veil

10.5. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The other edible fungi besides umbrella-like mushrooms are morels, puff-balls and truffles.
2. The important genera from the cultivation point of view are *Agaricus*, *Lentinus*, *Volvariella*, *Pleurotus*, *Auricularia* and *Calocybe*.
3. *Agaricus bisporus* is the commonly cultivated species of button mushroom.
4. The genus name *Auricularia* is derived from the Greek word "Auricula", meaning ear. Therefore, this mushroom is commonly called as wood ear, Jew's ear or ear fungus.
5. Fruit bodies of *Lycoperdon* are commonly called puff-balls.

BRAOU

10.6. MODEL EXAMINATION QUESTIONS

I. Answer the following question in about 30 lines each.

1. Write in detail about *Volvariella* especially its various stages of development.
2. Describe any four of the edible mushrooms which can be cultivated.

II. Answer the following questions in about 10 lines each.

1. Give a brief account of *Agaricus* spp.
2. Write a detailed account of Pleurotus spp.
3. Write briefly about *Boletus* spp.
4. Give a detailed account of *Coprinus* spp.
5. Write about *Morchella* spp.
6. *Give an account of truffles.*

Dr. I. Kunwar

Ms. K. Prasunamma

UNIT - 11 : POISONOUS MUSHROOMS

Contents

BRAOU

11.1. OBJECTIVES

By the end of this unit you will be able to :

* explain the nature of poisonous mushrooms,
* distinguish and differentiate some important poisonous mushrooms on the basis of morphologcal characters,
* list out rules for safe mushroom hunting.

11.2. INTRODUCTION

There is no visible sign on any mushroom nor is there any thumb rule which indicates whether it is toxic or not. However, there are some visible features which certain groups of poisonous mushrooms share, but no generalisation is possible. The rules of edibility of wild mushrooms have emerged over centuries of experience. The belief by many that those wild mushrooms which have been nibbled by slugs, insects, squirrels or rabbits are edible, does not hold good. Earlier the term "mushroom" was used for umbrella shaped edible species and "toadstool" was used to refer to non edible or poisonous mushrooms.

11.3. MORPHOLOGICAL CHARACTERS OF SOME IMPORTANT POISONUS MUSHROOMS

The different kinds of mushrooms vary in form. Some are quite strikingly different from others, so that no one would have difficulty in recognising the difference in shape, texture and colour. For example a typical umbrella shaped mushroom can be easily distinguished from a puff ball or earth ball. Different species of a genus could be edible or poisonous and in many cases the species vary only slightly in form, so that it becomes more or less difficult to distinguish them. As a result of mistake in correctly identifying the mushroom, poisoning occcurs. Mushrooms could be poisonous/non poisonous depending upon how they are eaten and with what, or their reaction may vary from person to person. Therefore correct knowledge regarding the identification of poisonous mushrooms is essential. While identifying, attention is to be paid to the cap, gills, stem or stipe and volva.

11.3.1. Amanita spp.

The most important species of *Amanita* which are highly poisonous are *A. muscaria, A. phalloides, A. verna* and *A. virosa. Amanita muscaria* in some places is popularly known as the fly agaric, since infusions of it are used as a fly poison. It is handsome and striking because of the usually brilliant colouring of the cap in contrast with the white stipes and gills. It usually ranges from 10-15 cm high, and the cap from 8-12 cm in diameter, while the stem is 1-1.5 cm in thickness, or the mushroom may be considerably larger. This species (Fig. 11.1) is quite variable. Cap is white through yellow and orange to scarlet

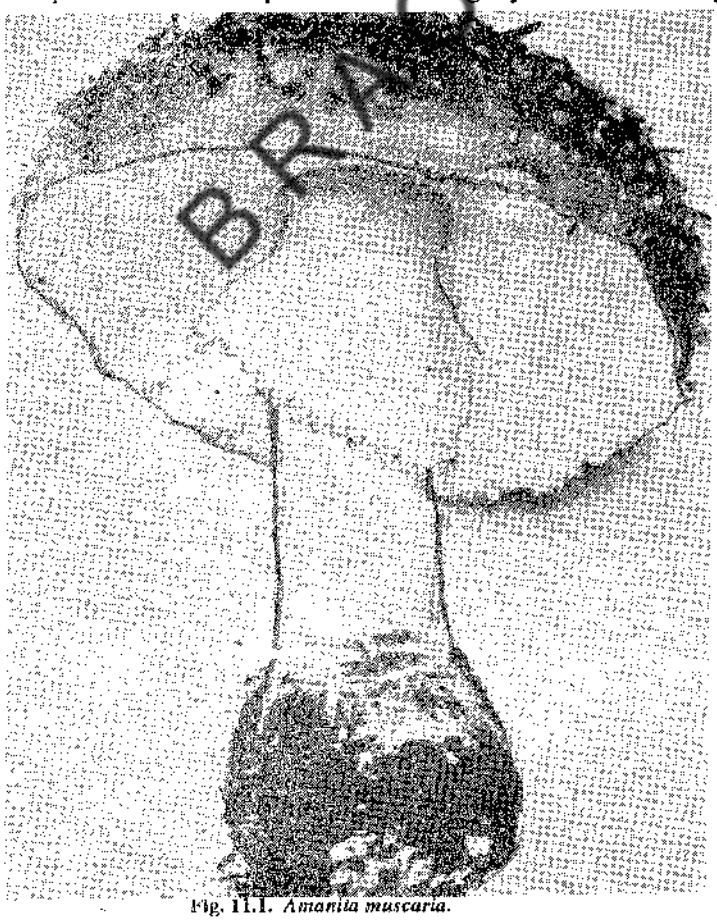


Fig. 11.1. *Amanita muscaria.*

BRAOU

or blood-red depending on the variety of the species. On the surface of the cap are a number of scales or warts, formed from the fragments of the upper part of the volva or outer veil. Gills usually white, the stipe is cylindrical, hollow or stuffed when young and enlarged below into a prominent bulb. Upper part of the bulb is marked usually by prominent concentric scale forming interrupted rings. These are formed by the splitting of the outer veil or volva and form the remnants of the volva present on the base of the stipe. Farther up on the stalk, main ring or annulus is present.

Amanita phalloides and its various forms, or closely related species are the most dangerous of the poisonous mushrooms. For this reason *Amanita phalloides* is known as the deadly agaric or deadly amanita or death cap. The mushroom is very variable in colour from pure white, or yellowish, green, or olive to brown. Variations also occur in the way in which the volva ruptures, as well as in the surface characters of the stipe. The mushroom usually occurs in woods or along the borders of the woods. It does, however sometimes occur in lawns. It varies from 6-20 cm height, the cap from 3-10 cm diameter and the stem 6-10 mm in thickness. Pileus is fleshy, slimy when moist, smooth, round to bell shaped, convex and finally expanded and in old specimens more or less depressed by the elevation of the margin. The cap is often free from any remnants of the volva, while in other cases portions of the volva or outer veil appear on the surface of the cap in rather broad patches, or it may be broken up into a number of smaller ones quite evenly distributed over the surface of the cap. The gills are white and free from the stipe or only joined by a narrow line. Stipe stuffed when young, but in age nearly or quite hollow. It is cylindrical, 6-20 cm long, 6-12 mm in thickness. In the longer specimens the bulb is quite prominent. Stipe smooth, usually white except in dark forms. Volva variable, when quite thick it splits at the apex and a prominent free limb remains at the base. But when volva is thinner it splits transversely about the middle in circumcissile manner. There are gradations in between when volva tears up irregularly.

BRAOU

Fig. 11.2. *Amanita phalloides.*

Amanita verna is the most deadly poisonous mushroom known. It is particularly deceptive because the symptoms of poisoning are so late in appearing that first-aid attempts are practically useless. *A. verna* (Fig. 11.3) is of a pure white colour and commonly known as Fool's mushroom. The mushroom is often large (caps upto 7.5 cm in diameter and stipe upto 12.5 cm. height). The death cup or volva encloses the base of the stalk and there are no universal-veil remnants on the cap. The annulus or ring hangs like a skirt from near the apex of the stalk, and gills are free from the stalk and white in colour.

Fig. 11.3. *Amanita verna*.

BRAOU

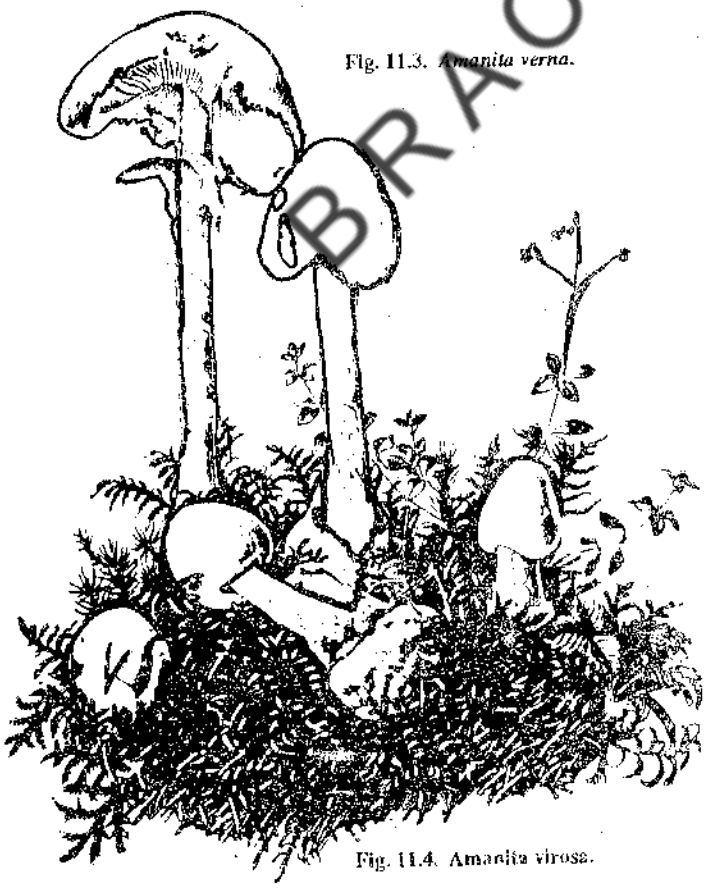


Fig. 11.4. Amanita virosa.

Amanita virosa is commonly known as destroying angel (Fig. 11.4). It is deadly poisonous when young, the pileus or cap is white, sticky, 10 cm in diameter and egg-shaped with a slender stalk (15 cm. length). The cap later turns yellowish, breaks through the sheath and carries the pieces of skin. The swollen base is half-buried and surrounded by volva. The gills are pure white and free from the stipe. The flesh has an offensive smell.

11.3.2 Clitocybe spp.

The two important species of *Clitocybe* are *C. aurantiaca* and *C. illudens*. *C. aurantiaca* occurs on humus, around burned over areas, and around and on rotting logs of conifers and sometimes hardwoods (Fig. 11.5). It is abundant at times during rather dry seasons in late summer and fall. Gills vary close to crowded, noticeably forked, brilliant orange to orange-yellow. Variability is found in the colour of the cap. It is almost black in some forms to dark brown, toned with orange in other, and paler forms occur which in their extremes are almost white. The species produces different reactions in different people. The cap is about 10 cm. in diameter and stipe about 3 cm. height.

Fig. 11.5. *Clitocybe aurantiaca.*

C. illudens fruits during the late summer and early fall or around old hardwood stumps and logs. The species in a few hours causes nausea and vomiting, but recovery is usually complete. Clustered habit of growth, all parts of the fruiting body yellow-orange in colour, 7-9 cm. in diameter and 12-15 cm. height, gills crowded, narrow, stalks tapered to the base. When in fresh growing condition the fruiting bodies, if taken into a dark room, give off a ghostly sight. This is why the name jack-o-lantern is often applied to this mushroom.

11.3.3. Gyromitra esculenta

The most poisonous species of *Gyromitra* is *G.esculenta*. It resembles a morel in shape has a shorter, thicker stem and a mop-like cap. The cap is marked by prominent folds and convolutions, resembling some what that of brain convolutions. It ranges from 5-10 cm high and the cap from 5-7 cm diameter. In spite of its name it is wiser to avoid eating this species as it contains a poisonous substance which may not be destroyed completely during cooking.

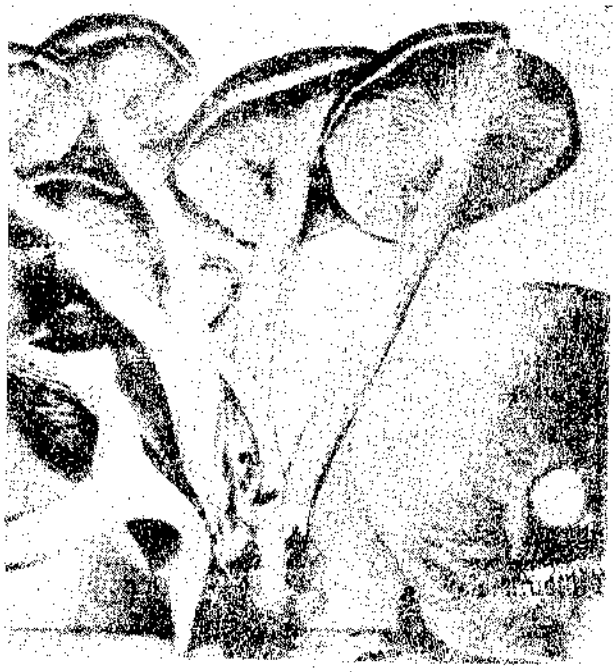


Fig. 11.6. *Clitocybe illudens.*

11.3.4. Coprinus spp.

The species of *Coprinus* are commonly known as inky cap mushrooms. Common species of *Coprinus* are *C. atramentarius* (Fig. 11.7), *C.micaceus* and *C. plicatilis*. It occurs in lawns and other grassy places. It is poisonous when consumed with alcoholic beverages. The mushroom sometimes occur singly, or a few together, but often quite large numbers of them (upto 20 or more) appear in a small area. The cap is egg-shaped or oval. It varies in colour from silvery grey to dark ashes, grey or smoky brown colour. The cap may have a pallid overtone from a thin layer of pale fibrils and in some forms rather distinct

BRAOU

Fig. 11.7. *Coprinus atramentarius.*

scales are present around the centre. A layer of dark fibrils covers the base of the stalk. This represents the remains of a veil. The veil breaks as the cap expands and a zone is left at the breaking point which varies from regular to irregular in its boundaries. Above this zone the stalk is white and silky. The gills blacken first near the cap margin and the process continues upward. As a result of deliquescence of gills at maturity into a black inky fluid it has got the name inky cap. The diameter of the cap is about 4 cm. and length of the stipe is about 9 cm.

11.3.5. Verpa bohemica

The most poisonous species of the genus *Verpa* is *Verpa bohemica.* It is commonly known as bell morel. It is the first to appear in spring and is generally found near the trees and shrubs in the area that has been leafed out. It usually grows in rich wet soil along the edges of swamps or along streams. It is poisonous when eaten in large quantities. Lack of muscular coordination is noticed four to five hours later. The fungus produces long, thick, white to buff stalks (10 cm. height) bearing brown, bell-shaped caps (6 cm. diameter). Because of their relatively small sized caps, appear disproportionate to the stalk. The cap is attached only to the top of the stalk, the sides hanging down like a skirt. The outer surface of the cap has longitudinal ridges. The cap varies from grey-brown to yellow brown.

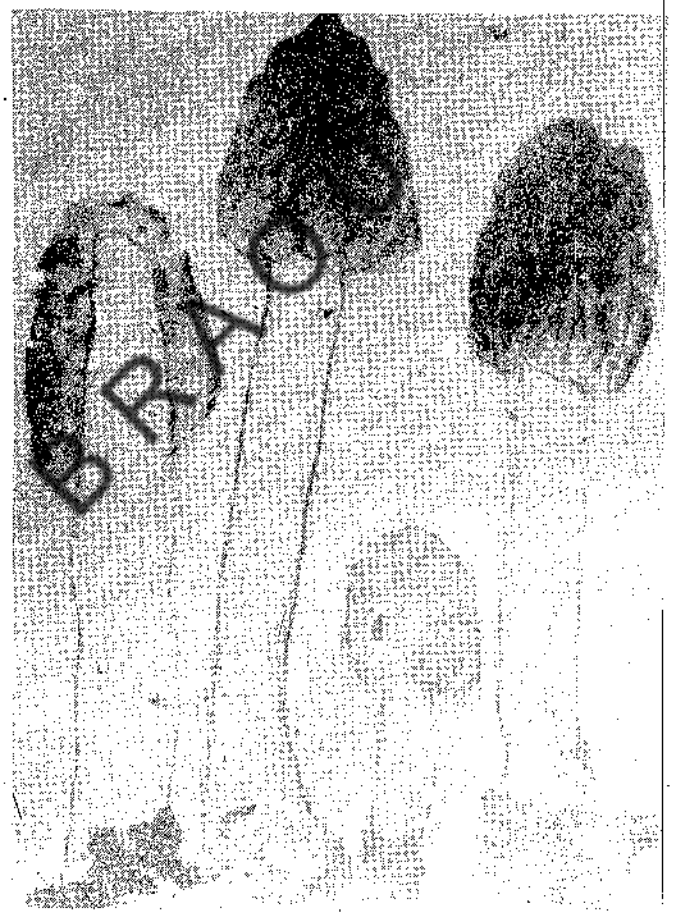


Fig. 11.3. *Verpa bohemica.*

11.3.6. Psilocybe semilanceolata

The important species of *Psilocybe* which is poisonous is *P. semilanceolata.* This mushroom is hallucinogenic and is eaten to achieve this ecstatic effect. It grows in mud, in swamps, among *Sphagnum*, on peat, on sticks and decayed trunks, also on the earth

in low clearings, margins of woods and in open coniferous woods but not on dung. It is a small mushroom with companulate cap (1.5 cm. diameter and stipe 1 cm. height), dull yellow ochraceous or with olive tinge, slightly viscid. Gills attached, long thin stalk that may or may not have an annulus.

11.3.7. Paxillus involutus

Paxillus involutus is the most poisonous species of *Paxillus*. This mushroom for some unknown reason is deadly poisonous in some geographical areas but edible in others. *P. involutus* is the "babye ookhy" of the Russian farmer who considers it second rate but sells it in large numbers in years when other mushrooms are not available in sufficient quantity. In Poland and Germany this species has caused poisonings, and it is now thought necessary to boil it well and discard the liquid before using it for the table. This mushroom is quite common in some places and is widely distributed. It occurs on the ground in grassy places, in the open, or in woods and on decaying logs or stumps. The stem is central, or nearly so, when growing on the ground, or eccentric when growing on wood, especially if growing from the side of a log or stump the mushrooms are 5-7 cm. height, the cap 3-7 cm broad, and the stem 1-2 cm in thickness.

The pileus is convex to expanded and depressed in the centre. The colour of the pileus varies greatly. The young mushroom when fresh is often olive umber, becoming reddish or tawny when older. The margin with a higher shade. The flesh is yellowish and changes to reddish or brownish when bruised. Gills greyish, then greenish yellow changing to brown where bruised. Veil present or more often absent. The stem is short and of the same colour as the cap.

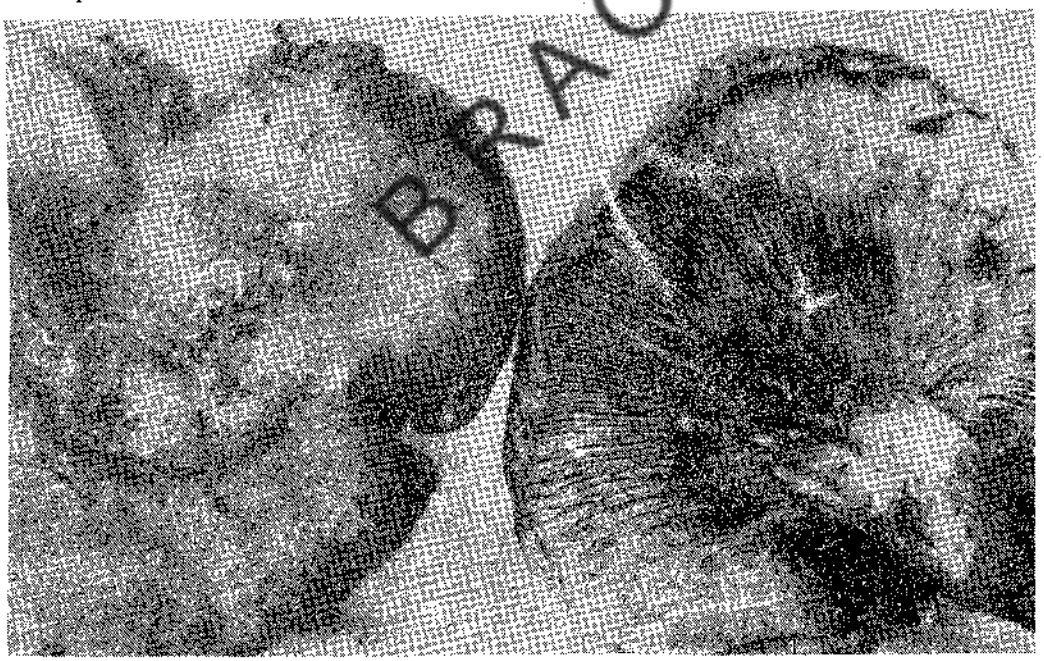


Fig. 11.9. *Paxillus involutus.*

11.3.8. Armillariella mellea

Armillariella mellea is the well known poisonous species. Earlier this species was known as *Armillaria mellea*. It is poisonous when old and decayed. It is one of the most common of late summer and autumn fungi, and is widely distributed over the world. It is a parasite on trees and other woody plants. The entire mushroom is often more or less honey coloured, from which the mushroom gets its specific name and is commonly known

as honey mushroom. The mushrooms occur in tufts or clusters, several to many individuals growing together, the bases of their stems connected with a black rope-like strand (rhizomorphy from which they arise). Its clustered habit, the usually prominent ring on the stems, and the sharp, blackish, erect scales which usually adorn the centre of the cap, mark it as an easy mushroom to determine in most cases. The mushroom varies in height from 10-15 cm, the cap from 5-10 cm broad, and the stem 4-10 mm in thickness.

The colour of the cap is exceedingly variable but yellow may be present on the margin while the centre is some shade of pale to dark brown. Gills are attached to the stalk, whitish, and with age they become more or less dingy or stained. Stalk whitish near the upper end, but dull brown or reddish brown below the annulus. Veil could be membranous and thin or quite thick, or in other cases may be absent entirely.

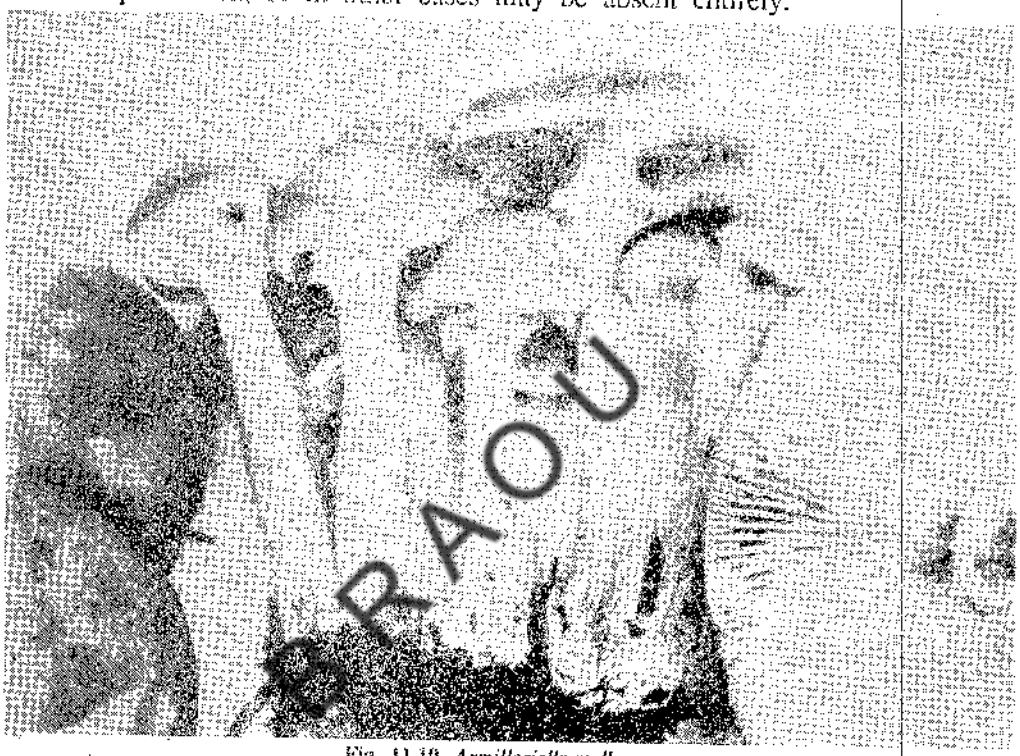


Fig. 11.10. *Armillariella mellea.*

11.3.9. Galerina autumnalis

The important species of *Galerina* is *G.autumnalis*. It occurs from spring to fall and may be found during warm winters. It inhabits the wood of hardwoods, but also grows on conifers. The distiguishing features of this mushroom are dingy yellow-brown, slightly sticky cap (2.5 cm. in diam) pale tawny gills, the narrow band like ring on atleast most of the stalks in any cluster, and the darkening of the stalk from the base upwards as the specimen ages. The stipe grows upto 5 cm. height. Clusters are typical, but solitary specimens are not uncommon. The habit on wood is very important, but clusters may arise from buried wood and hence appear terrestrial.

11.3.10. Helvella underwoodii

Helvella underwoodii is the most poisonous species. It is false morel closely related to true morels. False morels have a wrinkled head whereas true morels *(Morchella)* have a pitted head.

H. underwoodii is characteristic of hardwood forests. The fruiting bodies are more

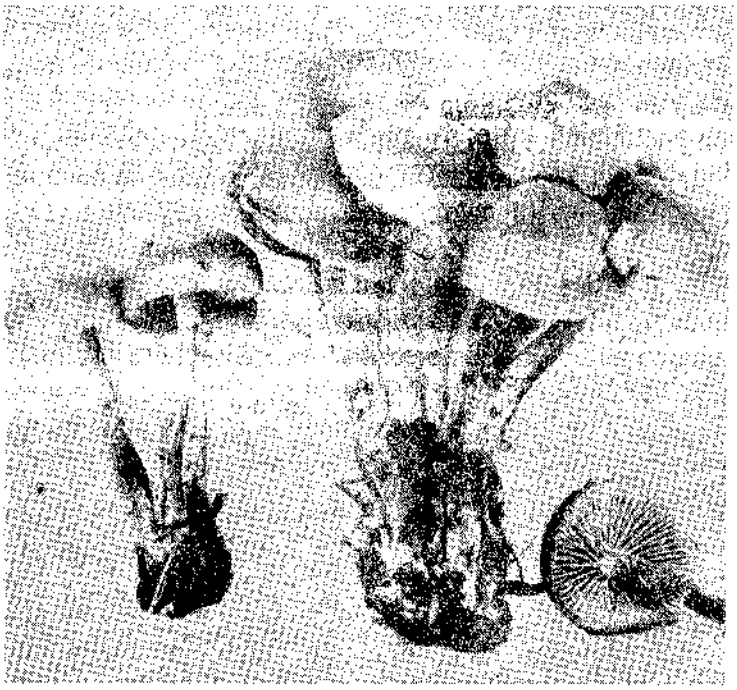


Fig. 11.11. *Galerina autumnalis.*

or less scattered. Its important character is the manner in which the edge of the cap curls away from the stalk. The stalk is very massive and grows upto 5 cm. height. The cap's diameter is about 7 cm.

11.3.11. Scleroderma aurantium

Scleroderma aurantium is the well known poisonous species. This is the commonest of the hard skinned earth balls. It occurs during summer and grows on humus and on

BRAOU

Fig. 11.12. *Helvella underwoodii.*

very rotten logs in conifer and hardwood forests. The pattern of warts and the dingy ochraceous to brownish yellow colour are the best external distinguishing characters; the colour of the interior, which very soon (before the specimens are two-thirds grown) becomes purplish, is the best glebal character. Sometimes a stalk like base consisting of a mass of debris held together by threads of the spawn is present. The bun-shaped fruit body is 5-8 cm across. This fungus is poisonous if eaten in quantity. Nevertheless, it has been used as a substitute for truffles, but it entirely lacks the true truffle flavour.

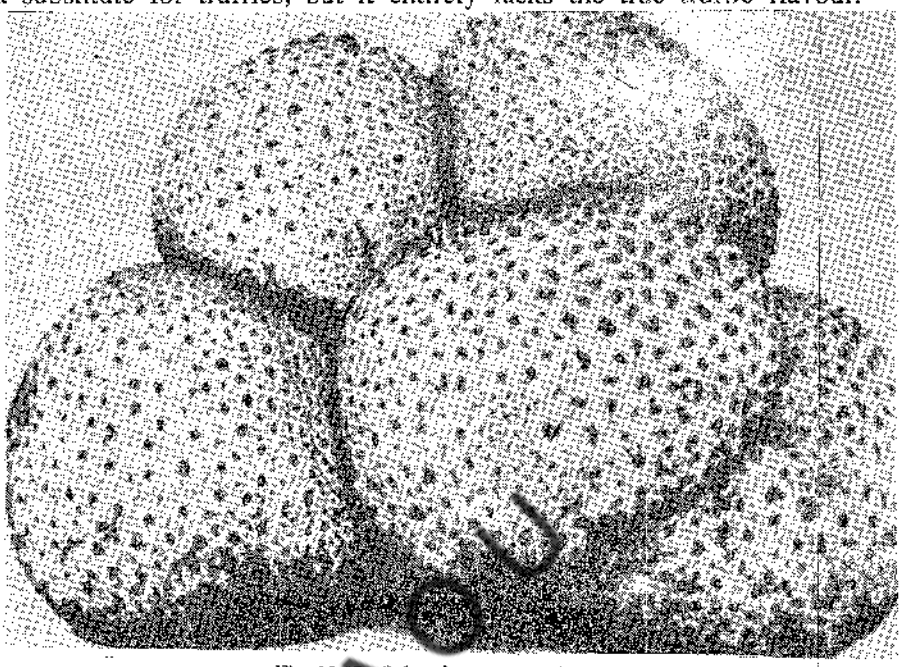


Fig. 11.13. *Scleroderma aurantium.*

BRAOU

11.3.12. Boletus eastwoodiae

The important poisonous species of *Boletus* is *B. eastwoodiae*. It grows in the ground of woods, sometimes on rotten logs also. This beautiful bolete is at once recognised by

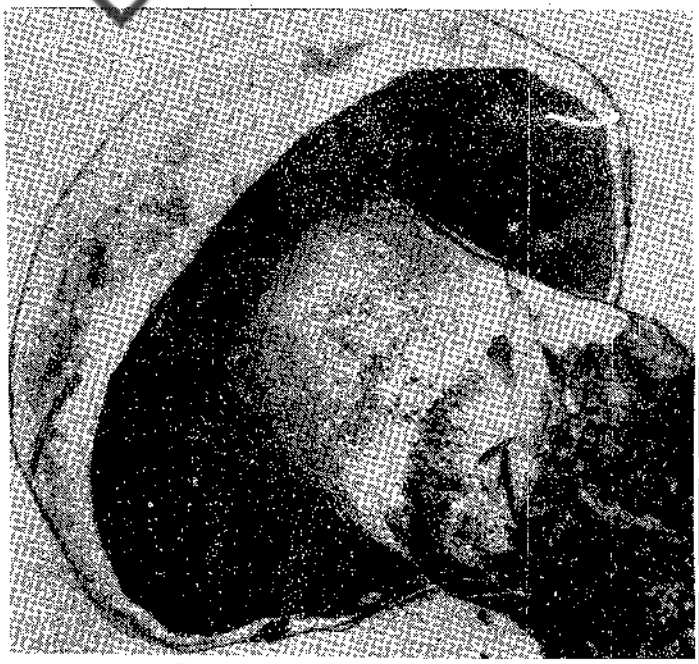


Fig. 11.14. *Boletus eastwoodiae*

the brilliant scarlet tube mouths, the olivaceous brown cap, 16 cm. in diameter and reticulate stalk of about 8 cm height with a varied colouration of red and yellow, and by the broken flesh staining blue. *Boletus satanus* (satan's boletus) has a paler whitish cap. The rule to avoid boletes with dry caps that turn blue when bruised, is a good thing.

Check Your Progress - 1, 2, 3 & 4

1. Which *Amanita* is known as the deadly *Amanita* ?
2. What is the main difference between *Helvella underwoodii* and other poisonous mushrooms?
3. Which is the most deadly poisonous mushroom ?
4. Which mushroom is eaten to enjoy the ecstatic effect ?

Note : (a) Write your answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

BRAOU

11.4. NATURE OF POISONOUS MUSHROOMS

1. Certain mushrooms are poisonous when raw and harmless when cooked, e.g., *Clitocybe nuda*.
2. Some mushrooms are poisonous unless they are parboiled and then thoroughly cooked, e.g., *Gyromitra esculenta*.
3. Certain mushrooms are poisonous irrespective of the manner of preparation. e.g., *Amanita phalloides*.
4. Some mushrooms are poisonous only under certain conditions i.e., when consumed with alcoholic beverages e.g., *Coprinus atramentarius*.
5. Some mushrooms are poisonous only when they are eaten in large quantities, e.g., *Verpa bohemica*.
6. Some mushrooms although classified, as poisonous are in fact only hallucinogenic even then they are eaten to achieve this effect. They are not poisonous except in cases of overdoses or unexpected adverse reactions. e.g., *Psilocybe semilanceata*.
7. Some mushrooms for reasons unknown are deadly poisonous in some geographical areas but edible in other areas e.g., *Paxillus involutus*.

8. Some mushrooms are poisonous when they are old, decayed or hit by frost but they are edible when fresh and young e.g., *Armillariella mellea.*

11.5. GUIDELINES FOR SAFE MUSHROOM HUNTING

1. Avoid "LBMs" (little Brown Mushrooms) whose species can rarely be determined by amateurs. There are many poisonous species among these little mushrooms that defy identification.

2. Do not eat any white capped mushroom which is not identified; some are deadly poisonous.

3. Beware of mushrooms with a ring on its stalk. The delicious Meadow Mushroom, *Agaricus campestris*, has a ring on its stalk, but so does the Destroying Angel, *Amanita virosa.*

4. Beware of mushrooms with a sack or cup at about the base of its stalk. The edible *Amanita fulva* has such a sack at about its base, but so does the Death Cap, *Amanita phalloides.*

5. Beware of mushrooms with swollen stalk base. Many edible species have a pronounced swelling at the base of their stalks. e.g., *Armillariella mellea*, but many poisonous species of *Amanita*, e.g., *Amanita muscaria*, do as well; and in cases where the cup or boot like covering has disintegrated, all that is left is a swollen stalk base.

6. Beware of mushrooms with warts, scales, or raised projections on its cap. The edible Parasol Mushroom, *Lepiota procera*, has prominent scales on its cap, but so do many poisonous species, such as the Green-spored *Lepiota*, *Chlorophyllum molybdites*, and the Fly Agaric, *Amanita muscaria.*

7. Avoid all species of *Boletus*, fleshy mushrooms with pores instead of gills on the undersides of their caps, which have red pore mouths or which stain blue on bruising. Some of these species are edible, but some are poisonous, and their differentiation is particularly difficult.

8. Avoid all brain like *(Gyromitra)*, saddle-shaped *(Helvella)* fungi, or deformed "morels". In these genera some species are known to be edible when parboiled and then thoroughly cooked, but other species are known to be highly poisonous.

9. Always cut all puffballs in half to examine the contents of each specimen. Whose inside is not pure white and undifferentiated should be avoided. Those with interior structures resembling the outline of a mushroom, can be deadly *Amanita* buttons. One that is firm but discolored or black within can be an over ripe puffball or a poisonous earthball, e.g., *Scleroderma aurantium.*

10. Do not eat mushrooms found growing on or near dung that you have not positively identified. Certain edible species of *Coprinus* and some mildly hallucinogenic psilocybes grow on dung, but so do some poisonous species.

BRAOU

11.6. SUMMARY

There is no thumb rule to distinguish an edible mushroom from poisonous one. It is learnt by experience. Nature of poisonous mushrooms varies. They could be poisonous when raw, when consumed with alcohol, eaten in large quantities of hallucinogenic mushrooms. They could be poisonous in one region and non-opoisonous in another. Some are poisonous regardless of the manner of preparation. Mushrooms can be safely collected if some ruels are followed while looking for them. Illness or death from wild mushrooms can be aovided by following some precautions. Some of the important poisonous mushrooms are *Amanita muscaria, A. phalloides, A. verna, A. virosa, Clitocybe illudens, C. aurantiaca, Gyromitra esculenta, Coprinus atramentarius, Verpa bohemica, Psilocybe semilanceolata, Paxillus involutus, Armillariella mellea, Galerina autumnalis, Helvella underwoodii, Scleroderma aurantium, Boletus eastwoodiae etc.*

11.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. *Amanita phalloides* is known as the deadly amanita.
2. *Helvella underwoodii* is a false morel. It has a wrinkled head whereas none of the other poisonous mushrooms has wrinkled head.
3. *Amanita verna* is the most deadly poisonous mushroom.
4. *Psilocybe semilanceolata* is hallucinogenic and is eaten to achieve this ecstatic effect.

BRAOU

11.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write briefly about poisonous species of *Amanita & Clitocybe.*
2. Write a brief account on any other five poisonous mushrooms.
3. What are the guideliens for safe mushroom hunting.

II. Answer the following questions in about 10 lines each.

1. Write about *Amanita muscaria.*
2. Write about *Coprinus atramentarius.* Why is it called ink cap mushroom ?
3. Give a brief account of the nature of poisonus mushrooms.

Dr. I. Kunwar

UNIT - 12 : NUTRITIONAL VALUE OF EDIBLE MUSHROOMS

Contents

12.1. OBJECTIVES

After going through this unit you will be able to :

* explain the nutritional importance of edible mushrooms,
* list out the nutrients present in mushrooms,
* compare the nutritive value of mushrooms with other vegetarian and non-vegetarian diet.

BRAOU

12.2. INTRODUCTION

Mushrooms have been a part of our dietary habits and regarded as a special food since ages. Romans treated mushrooms as the "Food of the Gods" while Chinese considered them as a health food. These were used as hallucinogens by Mexican Indians during religious ceremonies.

Mushrooms due to their high productivity per unit area and time, less dependence on land, ability to grow on varied agricultural wastes, high nutritive and medicinal values form a good source to reduce malnutrition in developing countries. Lintzel (1941, 1943) observed that 100 to 200 g of dry mushrooms per day are necessary to maintain nutritional balance in a normal human being weighing 70 kg.

Mushrooms form a low caloried food with high quality proteins, little fat and sugars, high fibre content, vitamins and minerals. They consist of about 90 per cent moisture.

The edible mushrooms lack cholesterol thus forms a good item in the diet of heart patients. Due to low sodium and high potassium ratio, low fat (rich in linoleic acid), fibre rich, high alkaline ash, mushrooms form the choice of the deitician for people with hypertension, obesity, constipation and hyperacidity. Starch is entirely lacking, hence suitable for diabetic patients.

12.3. NUTRITIONAL ASPECTS

Mushrooms contain 90 per cent moisture. They consist of 35 to 40 per cent protein, 4 per cent protein, 4 per cent fat, 45 per cent carbohydrates, 25 per cent fibre on dry weight basis. The stored carbohydrates are glycogen, hemicellulose, mannitol and reducing sugars instead of starch. Less amount of sugars (9% on dry weight basis) are present. Though the fat content is less it is rich in an essential fatty acid, linoleic acid (70% of the total fat). Mushrooms lack a dreaded sterol viz., cholesterol, instead ergosterol is present which can be converted to Vitamin-D by human body. Vitamins C and B complex (thiamine, riboflavin, niacin, biotin and pantothenic acid) are present in mushrooms. Folic acid and B-12, which are absent in other vegetables are present in mushrooms. The minerals like potassium, phosporus, sodium, calcium and magnesium are in comparatively larger amounts while copper, zinc, iron, manganese, molybdenum and cadmium are in very less amounts.

Check Your Progress - 1

1. Name the fatty acid available in major amounts in mushrooms ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

BRAOU

12.3.1. Composition of Mushrooms

Mushrooms are a good source of proteins, carbohydrates, vitamins and minerals. The following table shows the composition of three edible mushrooms.

Table : 12.1. Composition of three edible mushrooms (Percentage on fresh weight basis).

Sl. No.	Mush-rooms	Mois-ture	Ash	Pro-tein	Fat	Crude-fibre	Carbo-hydrate	Mine-rals	Energy value K.Cal. 100 g. dry weight basis
1.	*Agaricus bisporus*	89.5	1.25	3.94	0.19	1.09	2.45	0.90	328
2.	*Pleurotus spp.*	90.0	0.97	2.78	0.65	1.08	2.6	0.46	265
3.	*Volvariella spp.*	88.4	1.46	4.98	0.74	1.38	5.1	0.42	276

Proteins : On an average mushrooms consist of 3.5 to 4 percent proteins on fresh weight basis. Mushroom protein consists of all the essential aminoacids required by a human body. The following table shows the aminoacid composition of *Agaricus bisporus* (White button mushroom).

Table : 12.2. Amino acid composition of *Agaricus bisporus* (Hayes and Haddad, 1976).

Sl.No.	Amino Acid	per 100 g dry matter
1.	Alanine	2.40
2.	Arginine	1.90
3.	Aspartic acid	3.14
4.	Cysteine	0.18
5.	Glutamic acid	7.06
6.	Glycine	1.20
7.	Histidine	0.64
8.	Isoleucine	1.28
9.	Leucine	2.16
10.	Lysine	1.62
11.	Methionine	0.39
12.	Phenylalanine	1.55
13.	Proline	2.50
14.	Serine	1.89
15.	Threonine	1.48
16.	Tryptophan	3.94
17.	Tyrosine	0.78
18.	Valine	1.63

Compared to cysteine and methionine, tryptophan and lysine are present in high concentrations. These are absent in cereals, the staple food of Indian diet. Thus, these can supplement the cereals in our diet. Methionine and cysteine present in low amounts in mushrooms can be compensated by cereals. The digestability of mushroom protein is72 to83 percent (Lintzel, 1941). The quality of mushroom protein is intermediate between vegetable and animal protein. Being a protein food, consumption of mushrooms prevent protein malnutrition and reduce the rate of diseases like Kwashiorkor, Marasmus, Anaemia etc., in human beings.

BRAOU

Also many crops of mushrooms can be produced per year, thus compensating for the protein production. Mushrooms give an annual yield of 2 million Kg/hectare. Beef, cattle, conventional agriculture yield 78 Kg/hectare, fish rearing upto 675 Kg/hectare while *Agaricus bisporus* yields 65000 Kg/hectare dry protein (Nita Bahl, 1982).

Check Your Progress - 2

2. Name the two amino acids that are present in mushrooms and absent in cereals ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

Fat : Mushrooms contain on an average 0.4 percent fat on fresh weight basis. The crude fat of mushrooms consists of all classes of liquid compounds including free fatty acids, monoglycerides, diglycerides, triglycerides, sterols, sterol esters and phospholipids. About 72% of the fatty acids are unsaturated fatty acids especially linoleic acid (70% of the total fatty acids). A dreaded sterol, cholesterol, responsible for heart attacks is absent. Instead, ergosterol, which can be converted to Vitamin D by the human body is present. Some reports reveal that cream coloured varieties of mushrooms contain more fat than white ones.

Carbohydrates : Mushrooms consists of 2-5 percent carbohydrates on fresh weight basis. Fresh mushrooms consist of 0.95 percent mannitol, 0.28 percent reducing sugars, 0.59 percent glycogen and 0.91 percent hemicellulose (Mc Connell and Esselen, 1947). Starch is completely absent which is a boon to diabetic patients.

Check Your Progress - 3

3. Name the Carbohydrates present in Mushrooms ?

Note : (a) Write the answer in the space given below ?

(b) Compare your answer with the one given at the end of this unit.

.....

.....

.....

BRAOU

Fibre : Fibre helps in excretion of waste and prevents constipation. Mushrooms are rich in fibre. The fibre content in *Pleurotus spp.* ranges from 7.4 to 27.6 percent compared to 4 to 20 percent in *Volvariella* spp and 10.4 percent in *Agaricus bisporus* on dry weight basis.

Vitamins : Mushrooms consist of Vitamin C (ascorbic acid) and B-complex group of vitamins like biotin, niacin, pantathonic acid, riboflavin, thiamine, folic acid and B-12. Folic acid and B-12 are essential for pregnant and lactating women. Many vegetables lack these two vitamins. Vitamins A, D, E and K are lacking in mushrooms. Ergosterol, which can be converted to Vit-D by the human body is present in mushrooms. The following table (Table-12.3) shows the vitamin content of some edible mushrooms.

Table : 12.3. Vitamin content of some edible mushrooms (Chang and Miles, 1993) (In mg. per 100 g. dry wt).

S.No.	Mushroom	Ascorbic acid	Niacin	Riboflavin	Thiamine
1.	*Agaricus bisporus*	81.9	55.7	5.0	1.1
2.	*Lentinus edodes*	0.0	54.9	4.9	7.8
3.	*Pleurotus* spp.	0.0	108.7	4.7	4.8
4.	*Volvariella volvacea*	20.2	91.9	3.3	1.2

Minerals : Mushrooms consist of good amount of minerals (Table 12.4). Potassium is present in high amounts followed by phosphorus, sodium, calcium and magnesium. Other minerals like copper, zinc, iron, manganese, molybdenum and cadmium are present in minor

amounts. Minerals like K, P, Na, Ca and Mg comprises about 56 to 70 percent of the total ash content. Potassium alone accounts for about 45 percent of total ash content. Sodium and calcium are in equal amounts in all other edible mushrooms except in *Lentinus edodes* where calcium is in large amounts. Though straw consists of low zinc, *Pleurotus spp.* consists of high zinc content than all other heavy metals. This mushroom consists of copper in compartatively higher amounts (12.2-21.9 ppm) while cadmium and lead contents range from 0.3 to 0.5 ppm and 1.5 to 3.2 ppm respectively. However, the concentration of these heavy metals are under the prescribed limit of the Fruit Product Order and Prevention of Food Adulteration Act, 1954.

Table : 12.4. Mineral content of some edible mushrooms (In mg per 100 g dry wt) (Chang and Hayes, 1978).

Sl.No.	Mushroom	Ca	P	Fe	Na	K
1.	*Agaricus bisporus*	23	1429	0.2	nd	4762
2.	*Lentinus edodes*	33	1348	15.2	837	3793
3.	*Pleurotus ostreatus*	98	476	8.5	61	nd
4.	*Volvariella volvacea*	71	677	17.1	374	3455

* nd : not determined.

* Due to high potassium and low sodium ratio mushrooms became the choice of patients suffering from hypertension.

BRAOU

Check Your Progress - 4

4. Name the mineral present in higher amounts in mushrooms ?

Note : (a) Write the answer in the space given below ?

(b) Compare your answer with the one given at the end of this unit.

.....

.....

Nucleic acid content : Usually microorganisms consist of high content of nucleic acid. The suggested maximum intake of nucleic acids per day by the Protein Advisory Group of United Nations System is 4g, half of which only should come from microbial source. Urate oxidase, essential enzyme for the oxidation of uric acid is lacking in man. Uric acid is sparingly soluble in purine bases, guanine and adenine. Accumulation of uric acid in plasma result in precipitation of urate in tissues, joints, stone formation in kidneys and bladders. Of the four edible mushrooms studied, the highest amount of nucleic acid is present in *Pleurotus sajorcaju* (4.06 percent on dry wt. basis) and one can consume 392.5g of fresh *P. sajorcaju* per day. While the other mushrooms being low in nucleic acid content can be consumed in higher quantities. Hence, mushrooms can be used as a safe vegetable with low nucleic acid content (Table 12.5).

Table : 12.5. Nucleic acid content of edible mushrooms and other foods (percent on dry wt. basis) (Chang and Miles, 1993).

Sl.No.	Sample	Nucleic acid content
1.	Algae	3.0-8.0% dry wt.
2.	Bacteria	8.0-16.0% -do-
3.	Cereals	1.1-4.0g/100g protein
4.	Meat and fish	2.2-5.7g/100g protein
5.	Microrganisms	8.0-25.0g/100g protein
6.	Mushrooms	2.7-4.1% dry wt.
7.	Yeast	6.0-12.0% dry wt.

12.3.2. Comparative nutritive value of Mushrooms and other diets

The edible mushrooms being rich in protein, moderate in fibre and ash, low in fat, carbohydrate content and energy value provide rich addition to the diet. The nutritive value of mushroom protein lie in between vegetables and non-vegetarian diet. Mushrooms lack waste matter while all other vegetables and non-vegetarian diet comprise moderate to higher amounts of waste matter. Vitamins are in appreciable amounts in mushrooms than in other vegetables. The following table (Table 12.6) shows the nutritive value of common foods and mushrooms.

Table : 12.6. Nutritive value of mushrooms and other foods (All values are per 100 g. of edible portion)

Sl. No.	Name of the article	Edible portion (%)	Moisture (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	Carbohy-drate (g)	Energy (K.cals)
	Cereals								
1.	Rice	100	13.7	6.8	0.5	0.6	0.2	78.2	345
2.	Wheat	100	12.8	11.8	1.5	1.5	1.2	77.2	356
	Pulses								
3.	Blackgram Dal	100	10.9	24.0	1.4	3.2	0.9	59.6	347
4.	Greengram Dal	100	10.1	24.5	1.2	3.5	0.8	59.9	348
	Vegetables								
5.	Amaranth Leaves	39	85.7	4.0	0.5	2.7	1.0	6.1	45
6.	Brinjal	91	92.7	1.4	0.3	0.3	1.3	4.0	24
7.	Cabbage	88	91.9	1.8	0.1	0.6	1.0	4.6	27
8.	Cauliflower	70	90.8	2.6	0.4	1.0	1.2	4.0	30
9.	Tomato (green)	98	93.1	1.9	0.1	0.6	0.7	3.6	23
10.	Carrot	95	86.0	0.9	0.2	1.1	1.2	10.6	48
	Fruits								
11.	Apple	90	84.6	0.2	0.5	0.3	1.0	13.4	59
12.	Banana (ripe)	71	70.1	1.2	0.3	0.8	0.4	27.2	116
13.	Guava	100	81.7	0.9	0.3	0.7	5.2	11.2	51

BRAOU

14.	Mango (ripe)	74	81.0	0.6	0.4	0.4	0.7	16.9	71
15.	Orange	67	87.6	0.7	0.2	0.3	0.3	10.9	48
16.	Sweetlime (musambi)	71	88.4	0.8	0.3	0.7	0.5	9.3	43
	Mushrooms								
17.	White button	100	90.1%	3.5	0.4	0.9	0.9	5.0	36
18.	Paddy straw	100	90.1%	3.8	0.7	0.42	1.1	4.7	36
19.	Oyster	100	90.2%	4.7	0.2	0.46	1.3	5.2	35
20.	Milk (Buffalos)	100	81.0	4.3	8.8	0.8	-	5.0	117
21.	Yeast (dried)	-	7.8	35.7	1.8	8.4	-	46.3	344
	Non-vegetarian diet								
22.	Egg (hen)	-	73.7	13.3	13.3	1.0	-	-	173
23.	Fish (Pomfret)	68	78.4	17.0	1.3	1.5	-	1.8	87
24.	Goat Meat	-	74.	21.4	3.6	1.1	-	-	118
25.	Prawn	45	77.4	19.1	1.0	1.7	-	0.8	89

(Source : Gopalan et al, Nutritive Value of Indian Foods, NIN, 1987).

Check Your Progress - 5

5. Mention the percentage of waste matter present in mushrooms ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

BRAOU

12.4. SUMMARY

As the Indian diet is cereal based, there is wide spread occurrence of protein malnutrition like Kwashiorkor, Marasmus and Anaemia. Mushroom protein is intermediate between vegetable and non-vegetarian protein in quality. Hence mushrooms are boon to the vegetarian population of our country in filling the 'protein gap'. Mushrooms consist of vitamins like folic acid and B-12 needed by the pregnant and lactating women. These are absent in vegetables. Low fat content, absence of cholesterol and rich in linoleic acid makes them suitable to heart patients. High fibre content and alkaline ash helps in excretion of waste materials and thus reduces constipation and hyperacidity. Low sodium and high potassium ratio, few calories, low fat content controls hypertension and obesity. Mushrooms lack starch and thus become the choice of a diabetic patient.

12.5. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The fatty acid available in major quantity in mushrooms is linoleic acid.
2. The aminoacids present in mushrooms and absent in cereals are tryptophan and lysine.

3. The carbohydrates present in mushrooms are mannitol, glycogen, hemicellulose and reducing sugars.
4. Potassium is the mineral present in higher amounts in mushrooms.
5. The percentage of waste matter present in mushrooms is zero.

12.6. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give a brief account of nutritive value of mushrooms ?
2. Explain briefly the nutritive value of mushrooms and compare with that of other common Indian foods.

II. Answer the following questions in about 10 lines each.

1. Write a note on protein content of edible mushrooms and their significance in our Indian diet.
2. Write briefly on mineral content of edible mushrooms.
3. Write a brief account on vitamin content of edible mushrooms.

Ms. K. Prasunamma

BRAOU

UNIT - 13 : MEDICINAL AND INDUSTRIAL IMPORTANCE OF MUSHROOMS

Contents

BRAOU

13.1. OBJECTIVES

After going through this unit you will be able to :

* describe the medicinal value of mushrooms,
* explain the hematological, antiviral and antitumour effects of mushrooms,
* describe the renal, cardiovascular and carcinogenic effects of mushrooms,
* explain the hallucinogenic and allergic reactions of mushrooms and
* describe the industrial importance of mushsrooms.

13.2. INTRODUCTION

Mushrooms, the fruit bodies of some Basidiomycetous fungi are noteworthy for their medicinal and Industrial uses. They have been used in medicine since ages. They consist of an enzyme, polyphenol oxidase responsible for proper metabolism and good health. Some mushrooms have been used as universal remedies (e.g., *Polyporus officinalis*) for all the disorders, while others for specific ailments like jaundice, intestinal worms, blood coagulation, anaesthesia, heart ailments, tumors etc. *Polyporus nigricans* is used in making snuff while from *Coprinus comatus* ink is being prepared.

13.3. MEDICINAL VALUE OF MUSHROOMS

Medicinal value of mushrooms were mentioned even in "Vedas". Greeks considered that the mushrooms give "Strength to soldiers in war". FAO (Food and Agriculture Organisation) has recommended the mushrooms as food especially where the protein malnutrition is prevalent i.e., in under developed and developing countries.

Mushrooms consist of varied medicinal properties. They are antiviral, antitumourous and antibacterial. The renal and cardiovascular effects of mushrooms are worth mentioning. Various medicinal properties of mushrooms are described below.

13.3.1. Haematological Effects

Haematological effect is nothing but an interaction between the fungal protein, the lectin and the surface glycoproteins of red blood cells. Lectins are the protein substances that have special affinity towards glycosylated material. These have been isolated from few edible mushrooms.

Such lectins were purified from *Agaricus campestris* and also *Flammulina velutipes*. Volvatoxin - A, isolated from *Volvariella volvacea* reduces haemolytic effect towards 'O' group red blood cells.

Fomes ignarius and *F. fomentarius* are used for blood coagulations. *Polyporus officinalis* when appleid externally stops bleeding.

Check Your Progress - 1

1. What is the lectin isolated from *Volvariella volvacea* ?

Note :(a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit ?

.....

.....

BRAOU

13.3.2. Antiviral Effects

Antiviral properties of mushrooms were reported by Cochran (1960) for the first time. Liquid extracts of Shiitake mushroom *(Lentinus edodes)* reacted against influenza A/SW 15 virus infection in mice (Tsunoda et al, 1969). *Lentinus edodes*, *Boletus edulis* and *Calvatia gigantea* are reported to produce viruses and inhibit both influenza and polio viruses. Ajinomoto company, Japan in International Conference in Immunopharmacology, 1988 suggested that Lentinan sulphate is inhibitory to AIDs. Food and Drugs Administration of USA also approved this and suggested that the extract of this mushroom can be used against AIDS in clinical trials.

Reishi mushroom *(Ganoderma lucidum)* is comonly termed as "Mushroom of Immortality" in Japan and marketed in the form of pills. This mushroom consists of immuno-regulating compounds and thus help in controlling AIDS. In view of the immuno-regulating property, this has been called "Longevity Mushroom" in Korea. Water extracts of maitake mushroom *(Grifola frondosa)* has been reported to kill AIDs causing HIV virus in human beings. This was found to be equally effective to that of widely used AZT drug for AIDS.

Check Your Progress - 2

2. Name the two mushrooms proved to be effective against AIDS ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

13.3.3. Antitumour Effects

Antitumour compounds like 'Lentinan' (a polysaccharide) from *Lentinus edodes*, 'Calvacin' from *Calvatia gigantea* (giant puff ball). 'Flamulin' and 'Flammutoxin from *Flammulina velutipes* and 'Volvatoxin' from *Volvariella volvacea* have been reported. The antitumourous activity has also been reported in maitake mushroom *(Grifola frondosa)*. Mushrooms like *Pleurotus, Agaricus bisporus, A. blazei* are also reported to be antitumourous. They inhibit the respiration of tumour cells.

Lentinan (antitumourous), rentinan (anticancerous) are being produced by Ajinomoto Co., Japan.

Check Your Progress - 3 & 4

3. Lentinan is isolated from _____.

4. Calvacin is isolated from _____.

Note : (a) Write the answers in the space given above.

(b) Compare your answers with those given at the end of this unit.

BRAOU

13.3.4. Renal and Cardiovascular Effects

Liquid extracts of *Pleurotus sajor-caju* is reported to reduce the Glomerular Filtration Rate (GFR) in rats. GFR reduction reduces the rate of nephron deterioration and increases the life span of chronic renal failure patients.

Coprinus comatus reduced the blood glucose in mice (Bailey etal).

Wu Shu (Ming dynasty, 1368-1644), a famous chinese doctor revealed that *Lentinus* cures colds, generates stamina, improves blood circulation and also lowers blood pressure. Cardiotoxic proteins have been isolated from *Flammulina velutipes* and *Volvariella volvacea*. *Auricularia polytricha, Agaricus bisporus* and *Lentinus edodes* have been reported to show hypolipidemic effect, a property of reducing cholesterol level in the blood.

Check Your Progress - 5 & 6

5. Mention two mushrooms that show hypolipidemic effect ?

6. What is meant by hypolipidemic effect ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

13.3.5. Carcinogenic Effects

Edible mushrooms having toxic effects are very rare. However *Agaricus bisporus* consists of agaritine (chemical having a nitrogen-nitrogen bond) which when breaks down 4 hydroxymethyl benzene diazonium tetraflouroborate is formed. This is reproted to be gastric tumourigenic in swiss albino mice at an oral dose of 400 μg/g of body weight (Toth et al, 1982). The negative effects of agaritine were seen only in large doses in mice but its health hazard in man is negligible.

13.3.6. Hallucinogenicity

Hallucination is a sort of imagination by forgetting individual's present existence and it resembles alcohol intoxication. Some hallucinogenic mushrooms are *Amanita muscaria*, *Stropharia* spp. and *Psilocybe* spp. They contain psilocybin, a substance responsible for hallucination and is used in the treatment of mental disorders.

Check Your Progress - 7

7. Mention two hallucinogenic mushrooms.
8. What is meant by hallucination ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

BRAOU

13.3.7. Allergic Reactions

Inhalation of spores of *Pleurotus* spp. develop allergy in some people. The symptoms are fatigue, fever, sinus pressure, joint pains, cough and nausea. The basidiospores are deposited in smaller bronchii and induce asthmatic symptoms. The symptoms last from 1 to 2 days upto one week and disappear without treatment. The persons prone to allergy are recommended to use respiratory masks inside the growing rooms.

13.3.8. Other Medicinal Values

Polyporus officinalis is used for all disorders and used under the name 'agerick'. This is used to stop night sweating in tuberculosis, to cure chronic diseases of lungs and breast, gout, jaundice, rheumatism, instestinal worms, etc. This is also used as homeopathic dose under the name *Boletus laricis* or *Agaricus albus*. *Lycoperdon giganteum* is used for surgical dressing. *Calvatia gigantea* is used for anaesthesia. *Auricularia auricula* is used as a gargle for throat inflammation and also for inflammed eyes. *Amanita muscaria* is used for epilepsy, swollen glands, rheumatoid arthritis, heart ailments and in homeopathic doses under the names 'agar', 'agarus' and 'agaric'.

From *A. muscaria* two chemical compounds muscinol and ibotenic acid are extracted. These two compounds cure the brain disease "Schizophorenia" which causes the malfunctioning of "GABA system" of brain. GABA is nothing but Gama Amino Butyric Acid, a main inhibitory compound of central nervous system causing 'brain break'.

Flammulina mellae, F. odilpis, A. campestris are antibacterial and are active against *Staphylococcus aureus, Salmonella typhii* and *Escherichia coli. Lentinus edodes. Cortinellus shiitake* and *Coprinus comatus* are antifungal in nature. *Clitocybe illudens* yields terpinoids like Illudin-M and Illudin-S which are active against *Plasmodium gallinaceum. Armillaria mellea* is a good purgative.

Satit Thaithatgoon (1995) at Arunyik Mushroom Centre, Bangkok, Thailand conducted a pretest of *Ganoderma lucidum* (Reishi mushroom) in about 200 patients. The pretest showed that the consumption of this mushroom not only cured allergies, tumours, rheumatism, diabetes, high/low blood pressure, heart diseases, cancers etc., but also prevented the diseases.

In China, a mushroom by name Yun Zhi *(Coriolus versicolor)* is used for curing chronic and acute hepatitis, cancer and for strengthening one's physique.

Phanasomba, an ayurvedic medicine is derived from *Phellinus merrillii* and *P. robinae.* This is applied in gums to check excessive salivation. Mushrooms boiled with milk and sugar is recommended for tuberculosis patients in Ayurveda. "Nilamanga' which looks like a mango is a rare, underground mushroom associated with old termite nests of the soil. This mushroom is reported to cure a number of disorders of the body. Internal application of its extract in sesamum oil cures ear pain in children. The extract of mushroom with butter cures body obscissions on external application. Body dehydration is prevented by consuming the boiled water extract of Nilamanga in boiled milk and is a good remedy for jaundice.

BRAOU

Check Your Progress - 9

9. What is the source of Agerick ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

In 15th century, Wu Shui, a physician from Singapore reviewed the beneficial effects of shiitake. This has been reported to enhance vigour, sexuality, energy and diminished ageing. Study on medicinal mushrooms gained much attention in china. They have listed nearly 107 medicinal mushrooms and are manufacturing nearly 20 types of commercial medicinal mushrooms. Some of the prominent ones are liver protective agent (Polysaccharide of shiitake), anticancer (Polysaccharie-peptide of *Coriolus versicolor*), for dizziness and head ache (*Armillariea mellea,* honey mushroom), as sedatives *(Ganoderma lucidum)* and antiradiation drug *(Tremella fuciformis).* All of them are available in tablet form in chinese markets.

13.4. INDUSTRIAL IMPORTANCE OF MUSHROOMS

Mushrooms are also used in dyeing industry, as an ingredient in snuff, in making flower pots, hats, picture frames, as luminiscents and writing material.

The dried and powdered fruit bodies of *Polyporus nigricans* are used as an ingredient in snuff. A brown dye used for colouring silk, wool, cotton, shoes, furniture is extracted from *Polyporus bisporus*. *Fomes ignitarius* yields brownish black dye and *Polyporus sulphureus* yields an yellow dye. The fruit bodies of inky cap mushroom *(Coprinus comatus)* are deliquescent and turn into black liquid which used for writing purposes. *Daedalea quercina* is used for cleaning horses and also hair of men.

Polyporus squamosus and *P. betulinus* are used for making rajor strop. Bottle corks are made from *Polyporus squamosus*, *Armellariella mellea*, *Fomes anosus*, *Pleurotus japonicus*, *Boletus edulis*, *Collybia longipes* etc., emit light. The emitted light (luminescence) is often so bright that a printed page can be read in dark. Articles like handbags, picture frames are made from the fruit bodies of *Fomes fomentarius* and *Ganoderma applanatum*.

Check Your Progress - 10

10. Give three examples for luminescent mushrooms ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

.....

.....

BRAOU

13.5. SUMMARY

Mushrooms have immense medicinal and industrial values. *Polyporus officinalis*, *Fomes ignarius* and *F. fomentarius* are used as blood coagulants. The antiviral properties of mushrooms are noteworthy. Few examples are *Lentinus edodes*, *Calvatia gigantea*, *Ganoderma lucidum* and *Grifola frondosa*. Mushrooms like *Lentinus*, *Auricularia*, *Agaricus bisporus* are reported to reduce blood cholesterol level. The hallucinogenic property of some mushrooms *(Amantia muscaria Stropharia* and *Psilocybe)* is being exploited in the treatment of mental disorders. Agerick which is prepared from *Polyporus officinalis* is used to cure many disorders.

Mushrooms have also been used in making decorating articles, dyes, snuffs and also as luminiscents.

13.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Volvatoxin-A is the lectin isolated from *Volvariella volvacea*.

2. *Ganoderma lucidum* (Reishi mushroom) and *Grifola frondosa* (Maitake mushroom) are the two mushrooms proved to be effective against AIDS.
3. *Lentinus edodes.*
4. *Calvatia gigantea.*
5. *Agaricus bisporus* and *Lentinus edodes* show hypolipidemic effect.
6. The property of reducing cholesterol in the blood is called hypolipidemic effect.
7. *Amantia muscaria* and *Stropharia* are the two examples for hallucinogenic mushrooms.
8. Hallucination is a sort of imagination by forgetting individual's present existence.
9. Agerick is extracted from *Polyporus officinalis.*
10. *Polyporus squamosus, Armillariella mellea* and *Fomes anosus* are the three examples for luminiscent mushrooms.

13.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an account on medicinal values of mushrooms.
2. Write briefly about the Industrial importance of mushrooms.

II. Answer the following questions in about 10 lines each.

1. Write briefly about antiviral effects of mushrooms.
2. Write a short note on antitumour and allergic reactions of mushrooms.

BRAOU

Ms. K. Prasunamma

UNIT - 14 : MUSHROOM EXPORT

Contents

14.1. OBJECTIVES

By the end of this unit you will be able to :

* explain the status of mushroom production in India and other countries,
* assess the potential of mushroom production in India,
* find out the export potential of the country in the field of mushrooms.

BRAOU

14.2. INTRODUCTION

The commercial production of mushrooms is being done in U.S.A., France, the Netherlands, U.K., Germany, Italy, China, Taiwan, South Korea, India, Indonesia etc. At present the world production (Tables : 14.1 and 14.2) is estimated to be around 4 million tons per annum. There has been steady increase in production in recent years. The total production which was 2.1 million tons in 1986 has increased to 3.76 millions during 1988-89 (Table 14.1).

The most astonishing progress in this field has been in China. The major mushroom producing countries are U.S.A., China and France. In India mushroom production is estimated to be around 25,000 tonnes per annum.

Table : 14.1. World Production of Cultivated Mushrooms 1986 and 1989/90 (From Chang & Miles, 1991).

Cultivated species	1986 Fresh Weight 1000 tonnes	%	1989/90 Fresh Weight 1000 tonnes	%
Agaricus bisporus	1,227	56.2	1,424	37.8
Lentinus edodes	314	14.4	393	10.4
Volvariella volvacea	178	9.2	207	5.5

Pleurotus Spp.	169	7.7	909	24.2
Auricularia Spp.	119	5.5	400	10.6
Others	175	8.0	430	11.5
Total	2,182	100	3,763	100

Table : 14.2. World Production of *Agaricus bisporus* (From Chang & Miles, 1991).

Country	1986 Fresh Weight 1000 tonnes	1989/90 Fresh Weight 1000 tonnes
U.S.A.	285	302
China	185	170
France	115	200
Netherlands	115	140
U.K.	95	118
Italy	75	100
Canada	51	51
Spain	45	50
W. Germany	38	43
Taiwan	35	30
S. Korea	18	12
Belgium	16	20
Ireland	16	23
Australia	14	20
S. Africa	11	11
Poland	04	08
Others	58	125
Total	1177	1424

BRAOU

14.3. MUSHROOM PRODUCTION IN INDIA

In India mushroom production started during 1965 in Himachal Pradesh and for some time this activity was centered in this state. The state Govt. and I.C.A.R. started research and developmental activities to promote mushroom cultivation during same time. This resulted in awareness about mushrooms particularly button mushroom *(Agaricus bisporus)* and their cultivation in this region. Later on its cultivation was taken up in Jammu & Kashmir, Punjab, Haryana and U.P. Hills., The most distinguished contribution was made by the Maharaja of Patiala and the Mushroom Research Laboratory, Solon. During 1983 I.C.A.R. established National Centre for Mushroom Research and Training at Solon to carry out research and training activities.

In South India mushroom production started when Mr. Nigel Steward started button mushroom cultivation in Ooty during 1970-71 and Indian Institute of Horticultural Research, Bangalore established Mushroom Culture Laboratory during 1972 in temporary structures and recently, full fledged Mushroom Culture Laboratory with fully air conditioned cropping rooms and spawn production facilities (cap. 1,00,000 spawn bottles/pp bags p.a.) became functional. Initially only button mushroom was being grown. Later on during 1976-77 oyster mushroom *(Pleurotus sajor-caju)* cultivation was introduced. These two varieties have become most popular for comercial production in the country. For a long time the progress was very slow. However, in recent years there has been a lot of awareness about mushrooms and their cultivation in the country. Some of the projects are producing sizable quantity of mushrooms for export (Table-14.3). At present mushroom production is being done in Himachal Pradesh, Haryana, U.P. Hills, Karnataka, Maharashtra, Kerala, Tamilnadu, Orissa, West Bengal, Madhya Pradesh and Goa.

Table : 14.3. Export of Mushrooms from India (1980-81 to 1990-91).

Year	Qty. (Mt)	Value (Rs. in Lakhs)
1980-81	47	235
1981-82	47	211
1982-83	45	235
1983-84	52	247
1984-85	30	143
1985-86	39	174
1986-87	68	1013
1987-88	70	1187
1988-89	43	658
1989-90	470	673
1990-91	700	2768
1991-92	*	4030

* Quantity not properly recorded.

BRAOU

The most important export oriented units in India are given in Table 14.4.

Table : 14.4. Export Oriented Firms and the Quantity Produced by them.

Name of the Firm	Quantity in M. Tonnes
Pond's India (Ooty)	3500
Saptarishi Agro Industries (Madras)	3500
Agro Dutch (Punjab)	4000
Flex Foods (Dehradun)	1500
Tegs Mushrooms (H.P.)	1500

Beside these, there are a few more projects in progress in A.P., Maharashtra and other parts of the country which will give further boost to mushroom production in the country. Some of the Indian Companies collaborating with foreign firms for Mushroom Cultivation are given below (Table : 14.5).

Table : 14.5 List of Indian Companies Collaborated with Foreign Firms for Mushroom Cultivation

S.No.	Indian Company	Foreign Firm	Place of Project/ Unit established
1.	Tegs Masrado Agro Farms Ltd.	Dalsem Veciap bc. Agro Industries, Holland	Chail, Himachal Pradesh
2.	Agro-Dutch Foods Ltd.	"	Tofapur Village, Patiala Dist., Punjab
3.	Indo-Britain Agro Farms Ltd.	Macon Agri Ltd., (Tyrone), U.K.	Jyotipur, Hissar
4.	Jain Group of Industries	Eldar Electronics Israel	Jalgaon, Maharashtra
5.	South Asian Mushrooms Ltd.	Macon Agri Ltd., Northern Ireland	Umari Village, Raison Dist. Madhya Pradesh
6.	Sugam Agrotech Ltd.	Avi of Israel, Israel	Kakinada, Andhra Pradesh
Projects Being Established			
7.	ASR Agro Ltd.	M/s. Agriconsulting, England, a division of Tray Master Ltd.,	Vemulavalasa Village Bheemili, Visakhapatnam Andhra Pradesh
8.	Moneshi Agro Foods Ltd.	South Star, Singapore	Guntur, Andhra Pradesh
9.	Agaricus Agro Exports Ltd.	Asia Ventures International Ltd. & Galil Engineering, Israel	Rawalkole Village, Medchal, Near Hyderabad Andhra Pradesh
10.	M/s. Premier Explosives Ltd.	Tray Master Ltd. England	Medchal, Near Hyderabad Andhra Pradesh

BRAOU

There are several tiny, small and medium farms of button and oyster mushrooms producing mushrooms for local market. The most important is seasonal button mushroom production (during winter) in the villages of Haryana where 2000-3000 tonnes of mushrooms are produced every year particularly for Delhi market.

The paddy straw mushroom *(Volvariella volvacea)* though very much suitable for tropical region is being produced mostly in Orissa. This variety is not much popular due to its low yield and poor keeping quality. Recently another tropical mushroom has been introduced by Purkayastha and Chandra of West Bengal known as milky mushroom *(Calocybe indica)*. This variety can be grown in temp. range of 25-37° C.

Check Your Progress - 1 & 2

1. Name two tropical mushrooms best suited to Indian conditions.
2. What are the important mushroom projects that are export oriented in India ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

.....

.....

.....

.....

.....

.....

.....

.....

14.4. MUSHROOM PRODUCTION IN OHTER COUNTRIES

The main mushroom producing countries are U.S.A., France, China, The Netherlands, U.K., Italy etc. Button mushroom is the major variety being produced. This variety contributed 1.227 million tonnes (56.2%) during 1986 and 1.424 (37.8%) during 1989-90. The major share is from U.S.A. (302000 tonnes) followed by France (2000000 tonnes), China (170000 tonnes), The Netherlands (140000 tonnes) U.K. (118000 tonnes) and Italy (100000 tonnes). However, the major increase in production has been due to the oyster mushroom. The production of this variety which was 169000 tonnes (7.7%) during 1986, increased to 909000 tonnes (24.2%) during 1989-90. The major contribution was from China. The next important variety has been Jew's ear mushroom (*Auricularia* spp.) which contributed 119000 tonnes (5.5%) during 1986 showed further increase to 400000 tonnes (10.6%) during 1989-90. This is also being grown in South Asian and far east countries. There has been negligible increase in production in case of paddy straw mushroom i.e., 178000 tonnes (9.2%) in 1986 to 207 tonnes (5.5%) during 1989-90. Shiitake mushroom is most popular among Japanese people. Its production has also increased marginally from 314000 tonnes (14.4%) to 393000 tonnes (10.4%) during 1986 and 1989-90. In recent years Indonesia, Thailand and Vietnam are also showing good progress in this field.

BRAOU

14.5. PROSPECT OF MUSHROOM PRODUCTION IN INDIA

India is a country of diversified agroclimate. There are temperate, subtropical and tropical regions and seasons suitable for the cultivation of different mushrooms. Besides agricultural/horticultural wastes are available in abundance which can be utilised to grow mushrooms. In recent years there has been a lot of awareness about mushrooms. This has resulted in more consumption of mushrooms. With increasing demand for mushrooms both in domestic and international market mushroom production is bound to increase in the country. Here are the positive points indicating the prospect of mushroom production in India as suggested by APEDA.

1. The consumption of mushrooms is increasing worldwide due to its high nutritive value and other health benefits.
2. The world trade has been declining for some years due to fall of production in

developed countries.

3. Due to high cost of labour there is decline in mushroom production in Taiwan and South Korea, once major producers.

4. China is also facing quality problem, faces U.S. ban on canns.

Opportunity for India : There are excellent opportunities for India on account of the following reasons.

(a) The growing gap between demand and supply due to the increasing demand in the domestic as well as International market.

(b) Reduction of the production by Taiwan and South Korea due to high labour cost.

(c) Decline in export from China due to quality problem in canns.

(d) Mushroom cultivation and processing being labour intensive, India enjoys advantage.

(e) Growing domestic market will also provide a wider base.

(f) Number of Integrated growing and processing plants are coming up and existing ones are likely to increase their production capacity.

State wise production of mushrooms in India during 1992-93 is given below (Table: 14.6).

Table : 14.6 State Wise Production of Mushrooms in India
(Source : Sharma and Rai, 1994)

State	1992-93 (tonnes)
Uttar Pradesh	2500
Himachal Pradesh	2000
Haryana	1650
Punjab	1200
Tamil Nadu	500
Karnataka	500
Jammu & Kashmir	300
Kerala	300
Andhra Pradesh	300
Maharashtra	250
Madhya Pradesh	200
Orissa	50
West Bengal	50
Gujarat	10
Rajasthan	5
Bihar	5
Others	500
Total Production	11520

BRAOU

14.6. PROSPECT OF EXPORT FROM INDIA

There is increasing demand for mushrooms in International market which is estimated to be 24.5% per annum. The consumption pattern is as follows.

(a)	Canned	50%
(b)	Fresh	45%
(c)	Dehydrated	5%

The button mushroom covers 85% of the market demand. The major importers are U.S.A. and Germany. The imports of preserved mushrooms in U.S.A. is shown in table 14.7. China is the major country which is supplying mushrooms to these countries. India's export has been very little in comparison to these. However, in recent years it has shown steady increase *viz.*, 673 lakhs in 1989-90 to 4030- lakhs in 1991-92. The Netherland is another country which is doing export (Table 14.8). The world canned mushrooms trends shown in chart shows that U.S.A., Germany, Canada and Japan are major importers of this and demand is increasing.

Table : 14.7. Imports of Preserved Mushrooms in U.S.A. (In Millio Litres).

Origin	1980	1982	1984	1985	1986
Taiwan	43.3	28.9	47.3	34.4	37.1
China	11.2	27.7	36.9	37.8	38.7
Hong Kong	14.8	12.3	18.4	25.6	34.0
Other Far East	16.6	6.8	12.1	10.9	10.4
Spain	0.1	-	12.7	8.7	3.7
The Netherlands	-	-	4.2	2.4	0.7

BRAOU

Table : 14.8 World Exporters of Processed Mushrooms (MT). (Chang & Miles 1993)

Source	1980	1985	1985 increase over 1980 (%)
Netherlands	48,900	96,969	98
France	49,400	61,183	24
Benelux	2,600	1,780	-15
Spain	1,300	15,000 (est.)	-
China	84,100	1,10,200	32
Taiwan	77,100	58,900	-24
South Korea	22,000	8,400	-62
Hongkong	22,700	Not available	-
Total world	3,10,000	3,80,000	

There is going to be more and more export of mushrooms from India as more and more projects particularly with buy back arrangements are coming up in different parts of the country. Besides there is good scope to export dried oyster mushrooms which is at present dominated by China. It is expected that in coming few years India is going to be one of the major mushroom producing countries in the world.

14.7. SUMMARY

Mushroom production is being done commercially in U.S.A., France, The Netherlands, U.K., Germany, Italy, China, Taiwan, South Korea, India, Indonesia etc., In India mushroom production started in the year 1965 in Himachal Pradesh. In South India Mushroom production was started in Ooty during 1970-71, by Mr. Nigel Steward. The most important mushroom projects in India are Ponds India (Ooty), Saptarishi Agro Industries (Madras), Agro Dutch (Punjab), Flex Foods (Dehradun) and Tegs Mushrooms (H.P.). Prospect of mushroom production in India is excellent due to the large gap between demand and supply, reduction of mushroom production in Taiwan and Korea, due to high labour cost and demand in both domestic and international markets.

14.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Tropical mushrooms well suited to Indian conditions are *Volvariella volvacea* (paddy straw mushroom) and *Calocybe indica* (Milky mushroom).
2. The most important mushroom projects that are export oriented are : Pond's India (Ooty), Saptarishi Agro Industries (Madras). Agro Dutch (Punjab), Flex Foods (Dehradun), and Tegs Mushroom (H.P.)

BRAOU

14.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on mushroom export.
2. Give an account of prospect of mushroom production and export in India.

II. Answer the following questions in about 10 lines each.

1. Write a note on mushroom production in other countries.
2. Write a note on the prospects of mushroom production in India.

Dr. R.P. Tewari
Ms. K. Prasunamma

DR. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - I : BIOLOGY OF MUSHROOMS

MODEL EXAMINATION PAPER

Time 3 Hours] [Max. Marks 100
Min. Marks 35

SECTION A (MARKS 4 x 15 = 60)

Answer any Four questions.
Each Question Carries 15 marks.
Answer the following in about 30 lines each.

1. Give a brief account of vegetative and reproductive characters of fungi ?
2. Discuss in detail about various types of life cycles in fungi..
3. Give a brief account on the role of fungi in industry and medicine.
4. Write an essay on distribution and occurrence of mushrooms.
5. Give an account of any four edible mushrooms which are cultivated.
6. Write an account of nutritional value of mushrooms.
7. Write briefly about the medicinal values of mushrooms.
8. Write an essay on mushroom export.

BRAOU

SECTION A (MARKS 5 x 4 = 40)

Answer any Five questions.
Each Question Carries 8 marks.
Answer the following in about 10 lines each.

9. Write a note on the structure of a fungal cell.
10. What is the position of mushrooms in fungi ?
11. Write a note on the nutritional requirements of fungi.
12. Give an outline classification of Basidiomycotina.
13. Write a note on asexual reproduction in Basidiomycotina.
14. Give a brief account of white button mushroom *(Agaricus)*.
15. Write a note on different species of *Amanita*.
16. What are the guidelines for safe mushroom hunting ?
17. Write a short note on industrial importance of mushrooms?
18. Write a note on *Coprinus*.

BRAOU

DR. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - I : BIOLOGY OF MUSHROOMS

ASSIGNMENT - 1

Time : 2 hours

Note :

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source, give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

I. Answer the following questions in about 30 lines each.

1. Write briefly about the general characters of fungi.
2. Give an account of sexual reproduction in fungi.
3. Discuss in detail about the various types of life cycles in fungi.

II. Answer the following questions in about 10 lines each.

1. Write a note on morphology of a fungal cell.
2. Give briefly about growth of fungi.
3. What is parasexuality ?

BRAOU

BRAOU

DR. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - I : BIOLOGY OF MUSHROOMS

ASSIGNMENT - 2

Time : 2 hours

Note :

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source, give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

I. Answer the following questions in about 30 lines each.

1. Write an essay on the physical requirements for growth of fungi.
2. Write briefly on the economic importance of fungi.
3. Write an essay on the distribution and occurrence of mushrooms.

II. Answer the following questions in about 10 lines each.

1. Write a note on nitrogen requirements of fungi.
2. Give an outline classification of basidiomycotina.
3. Write a note on asexual reproduction in Basidiomycotina ?

BRAOU

BRAOU

DR. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - I : BIOLOGY OF MUSHROOMS

ASSIGNMENT - 3

Time : 2 hours

Note :

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source, give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

BRAOU

I. Answer the following questions in about 30 lines each.

1. Enumerate the edible mushrooms that are cultivated and write their characteristic features ?
2. Write an essay on poisonous mushrooms.
3. Give an account of nutritional value of mushrooms.

II. Answer the following questions in about 10 lines each.

1. Write a note on carbohydrate and fat composition of mushrooms.
2. What are hallucinogenic mushrooms ?
3. Write a short note on prospect of export of mushrooms from India.

BRAOU

BRAOU

BRAOU