

SUB- DIVISION: BASIDIOMYCOTINA

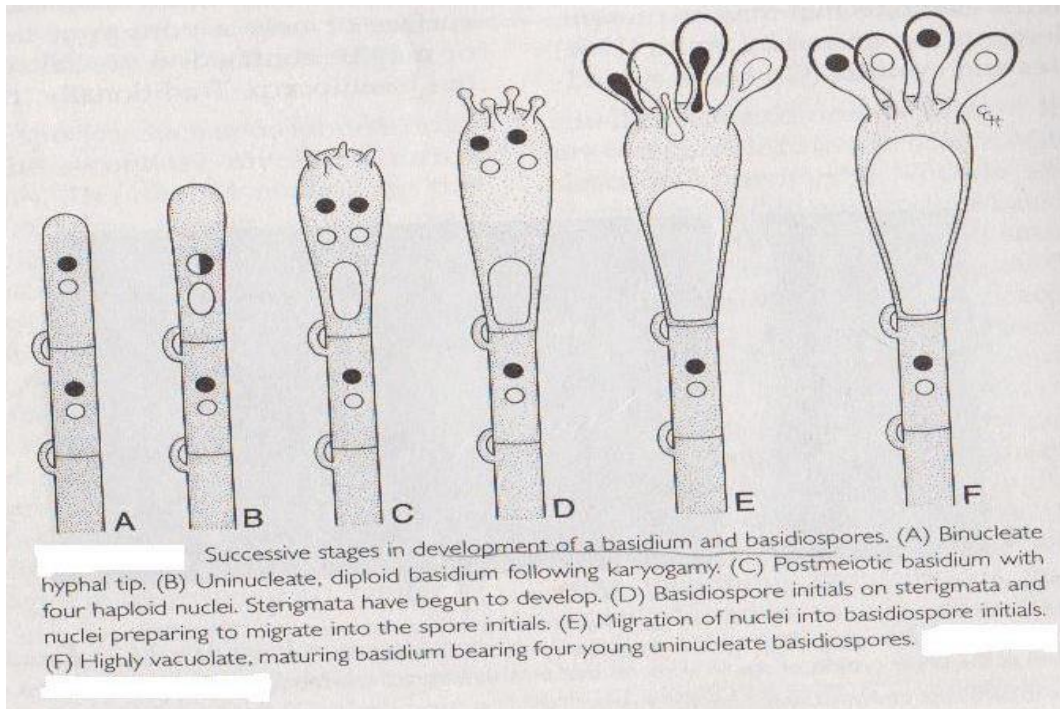
1. The name Basidiomycotina is given because the fungi produce sexual spores on a special club shaped fruiting body called **basidium**.
2. A definite number of sexual spores called basidiospores (usually **four** in number) are produced on pointed projections called sterigmata in each basidium .
3. Fungi belonging to this sub division are referred as **club fungi**.
4. The group includes mushrooms, toadstools, shelf fungi, jelly fungi, puff balls, coral fungi, bracket fungi, birds nest fungi, stink horns, rusts and smuts.

General characteristics:

- Basidiospores are haploid, uninucleate and are the result of plasmogamy, karyogamy and meiosis.
- Presence of clamp connections on the mycelium .
- Presence of dolipore septum, except in rusts and smuts.
- Absence of motile spores.

Clamp connections: It is a hook like structure formed laterally in between the dividing nuclei in a dikaryotic hypha. It acts as a by-pass for the nuclei, as they can not pass through septal pore ie., dolipore septum. It is meant for multiplication of dikaryotic cells.

Dolipore septum: Both primary and secondary mycelium consists of dolipore septum. The septum around the central pore swells at the center forming a barrel shaped structure with open ends, thus forming a septal pore. The septal pore is surrounded by a cup like or dome shaped membrane called parenthosome or septal pore cap or nuclear pore cap. It is made up of a double membrane and its function is to shut the pore. The dolipore septum will not allow the movement of nuclei in hyphae but maintains continuity of cytoplasm.



CLASSIFICATION OF BASIDIOMYCOTINA

CLASSES

1. TELIOMYCETES

ORDER: UREDINALES

FAMILY: PUCCINIACEAE

Eg. *Puccinia*, *Uromyces*, *Hemileia*

FAMILY: MELAMPSORACEAE

Eg. *Melampsora*

ORDER: USTILAGINALES

FAMILY: USTILAGINACEAE

Eg. *Ustilago*, *Sphaecelotheca*, *Tolyposporium*

FAMILY: TILLETIACEAE

Eg. *Tilletia*, *Neovossia*, *Urocystis*

FAMILY: GRAPHIOLACEAE

Eg. *Graphiola*

2. HYMENOMYCETES

SUB CLASS: HOLOBASIDIOMYCETIDAE

ORDER: AGARICALES

FAMILY: AGARICACEAE

Eg. *Agaricus*, *Volvariella*, *Pleurotus*

ORDER: APHYLLOPHORALES

FAMILY: POLYPORACEAE

Eg. *Polyporus*, *Fomes*, *Peria*

FAMILY: GANODERMACEAE

Eg. *Ganoderma*

CLASS

1.TELIOMYCETES

In class Teliomycetes there are two orders.1.Uredinales 2.Ustilaginales

IMPORTANT CHARACTERISTICS OF ORDER UREDINALES:

The popular name for the Uredinales is the rust fungi, spores are reddish brown in colour.

Clamp connections are rare or absent.

The rusts have **polymorphic life cycle**. Production of many spore forms in the life cycle is called polymorphism. Generally 5 types of spores are seen during the life cycle viz., **spermatia** (uninucleate) in spermogonium, **aeciospores** (binucleate) in aecium, **uredospores** (binucleate) in uredium, **teleospores** (binucleate) in telium and **basidiospores** (uninucleate) on promycelium or metabasidium.

The spermogonium represents gametic stage (male gamete- spermatium, female sex organ- receptive hypha)

Autoecious rust: If all the spore stages are produced on the same host then the fungus is called autoecious and the phenomenon is called **autoecism**.

Eg. *Melampsora lini*- linseed rust, *Uromyces appendiculatus* - bean rust.

Heteroecious rust: If spore stages are formed on two unrelated hosts ie., pycnia and aecia on one host and the uredia and telia on the other host, such rusts are called heteroecious rusts and phenomenon is called **heteroecism**.

Eg. *Puccinia graminis f. sp. tritici*- black stem rust of wheat. **Primary host:** The host in which heteroecious rust produce the telial stage is called primary host (Eg. wheat).

Based on life cycle pattern, rusts are divided into macrocyclic, demicyclic and microcyclic rusts.

Macrocyclic rust: (long cycled rust): Rusts in which all 5 spore forms are produced or produce at least one type of binucleate spore in addition to teleospores are called macrocyclic rusts.

(Eg. *Puccinia helianthi*- sun flower rust) or heteroecious , macrocyclic rust
(Eg. *Puccinia graminis f.sp. tritici* - black stem rust of wheat).

Demicyclic rust: The rust in which uredial stage is absent. eg. *Gymnosporangium juniperi – virginianae*- cedar apple rust.

Microcyclic rust (short cycled rust): Rusts which produce no binucleate spore other than teleospore. i.e., teleospore is the binucleate spore produced and both aecia and uredia are lacking. Eg. *Puccinia malvacearum*- hollyhock rust.

FAMILY: PUCCINIACEAE:

Genus Puccinia:

Obligate parasites. Teleutospores are two celled and stalked.

Disease: *Puccinia graminis f.sp. tritici*- black stem rust of wheat



Genus Uromyces:

Teleutospores are single celled with a thick apex (papillum) and stalked. The stalks are fragile and short.



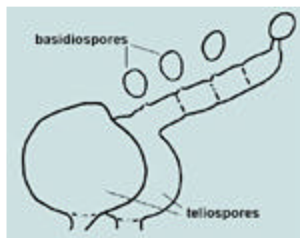
Eg. *U. appendiculatus* - bean rust

Genus Hemileia:

Uredospores are reniform, bifacially ovate resembling orange segments, concave side smooth, convex side echinulate.

Teleutospores are turnip shaped. 1 celled, stalked, smooth walled and produced on erumpent, club shaped stalks which arise through stomata.

Eg. *H. vastatrix* - coffee rust



LIFE CYCLE OF PUCCINIA GRAMINIS F. SP. TRITICI

The pathogen is an obligate parasite and causes black stem rust of wheat. It is a heterocious rust that requires 2 hosts for completion of its life cycle. The primary host

(wheat) and the secondary host (barberry). On barberry it produces pycnia and aecia while uredial telial stages are produced on wheat.

Stage	Spore	Nucleus status
O	spermagonia with spermatia (pycnia with pycniospores)	uninucleate
I	aecia with aeciospores	binucleate
II	uredia with uredospores	binucleate
III	telia with teleospores	binucleate
IV	basidia with basidiospores	uninucleate

It produces the first 2 stages in barberry and other 3 stages on wheat or other graminaceous hosts.

Significance of each stage :

Stage “ O “: The spermatia produced in spermagonia were thought to be functionless asexual spores. In 1927, Cragie found that spermatia are male gametes and are essential for spermatization of receptive hyphae (female organ) and consequent formation of aeciospores. This stage “ O” represents the sexual stage of rust fungi but the nomenclature stage “ O “ retained even today to avoid confusion.

Stage I: Aeciospores are the first binucleate spores formed in the life cycle.

Stage II: Uredospores are also called as repeating asexual spores as they function as conidia for the propagation of the rust fungus.

Stage III: Teleutospores represents the perfect stage because karyogamy and meiosis occur in them.

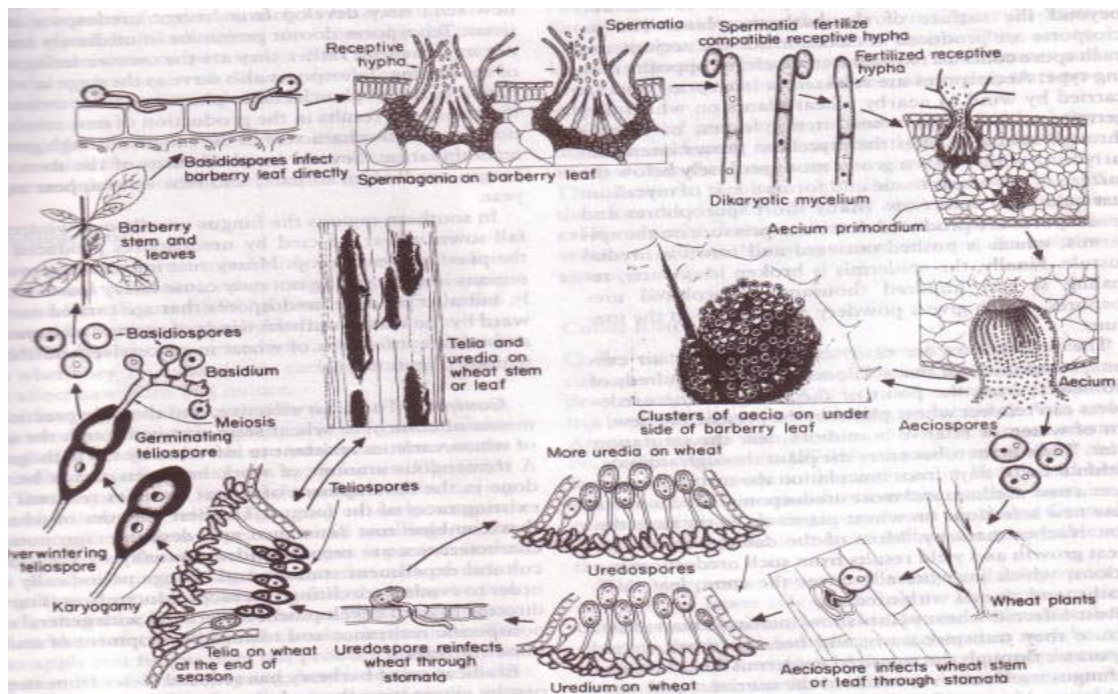
Stage IV: Basidiospores represent the sexual spores.

Stages “ O” and “ I” occur on barberry while stages “ II” and “ III “ occur on wheat.

Stage “ O”: Spermagonia with spermatia:

The spermagonia or pycnia are the structures which bear the sex organs of the pathogen. It contains spermatia which are the male sex organs and the receptive hyphae which are the female sex organs. In nature it generally happens that several basidiospores at random will reach and infect the same barberry leaf so that both + and – mycelium develop side by side and intermingle in the barberry tissue. Each spermagonium contains numerous spermatia. These are exuded (ooze out) in small droplets of nectar present in the spermagonium. Each spermatium carries + or – nucleus depending on the strain of mycelium which produced the

spermogonium. Spermatization i.e., fusion between receptive hyphae and spermatia of opposite sex takes place through agency of insects which are attracted by the honey fluid. The spermatial contents pass into the receptive hyphae. Meanwhile the mycelium penetrates the entire leaf and the hyphae near the lower epidermis develop number of aecial primordia. It is presumed that spermatial nuclei which pass from the spermatia into the receptive hyphae reach the cells of the aecial primordia rendering them binucleate. It has been demonstrated that aecial primordia fail to develop into aecia until and unless spermatization takes place.



Life cycle of *Puccinia graminis f. sp. tritici*

Stage "I" : Aecia and aeciospores are formed in the lower epidermis soon after dikaryotisation. These are the first binucleate spores produced in the life history of the fungus. An aecium is a group of binucleate hyphal cells (aeciospore mother cell) which give rise to aeciospores in chains. The aeciospores finally disseminated by the wind and under favourable conditions germinate on graminaceous host . These can not infect barberry.

Stage " II": Soon after infection by aeciospores on graminaceous host , binucleate mycelium begins to form masses of cells. These are called uredia from which binucleate

uredospores are borne on long stalks. The uredospores are one celled, oval, yellowish and spiny. They germinate readily in water and produce one or more germ tubes. The uredospores are those spores which perpetuate the fungus throughout the growing season and they are capable of re-infecting the graminaceous host on which they produce. Hence, they are also known as repeating asexual spores. They spread from plant to plant and from field to field and the disease soon becomes an epiphytotic. The uredospores upon germination produce binucleate mycelium which grows between the cells of the host and in a few days produce new uredia and uredospores.

Stage “ III” : Late in summer, at the time of ripening of grain another kind of spores known as teleospores or teleutospores are developed in the same mycelium when the uredia begin to cease. The pustules which produce teleospores are known as telia and constitute the black stage of rust. The teleospores are ellipsoidal, oblong or obclavate, typically two celled, and thick walled with slight constriction at the septum. The young teleospore is binucleate. Karyogamy eventually takes place and renders the teleospores diploid and uninucleate. The teleospores are not capable of germinating immediately and should have a resting period of several months and thus remain dormant until the following spring.

Stage “ IV” : Early in the spring each cell of teleospore germinates and produces a basidium (promycelium). The diploid nucleus in teleospore migrates into the promycelium and undergoes meiosis and four haploid nuclei are formed. Then septa are formed, separating the nuclei from one another into four cells. Each cell of promycelium produces a sterigmata on which basidiospore is formed. The nuclei now migrate into the basidiospore. Two of the basidiospores are of one strain (+) and two are of other strain (--). Soon after their formation, the basidiospores are ejected and are carried away by wind. They cannot infect graminaceous host, but can infect barberry and produce a well developed monokaryotic mycelium. Thus, the life cycle gets repeated on these two hosts viz., wheat and barberry.

IMPORTANT CHARACTERISTICS OF MELAMPSORACEAE :

1. Teleutospores are single celled and sessile (no stalk).

Genus Melampsora:

Teleutospores are single celled, sessile and laterally united to form layers and sub-epidermal.



Eg. *Melampsora ricini*- castor rust.

IMPORTANT CHARACTERISTICS OF ORDER USTILAGINALES:

The fungi included in this order are popularly called as smut fungi and the diseases they cause are called smut diseases.

No sex organs are produced . Plasmogamy takes place by fusion of any two basidiospores or two conidia. Somatic hyphae may also fuse resulting in dikaryotic condition.

IMPORTANT CHARACTERISTICS OF USTILAGINACEAE:

- 1.Known as smut fungi
- 2.Promycelium is septate
- 3.Basidiospores are produced laterally from each cell of the promycelium

Character	Rusts	smuts
Systematic position Order:	Uredinales	Ustilaginales
Plant parts affected	foliar parts (leaves, stem, petiole)	floral parts(flowers)
Symptoms	reddish brown coloured pustules	ovaries turn into black sooty masses
Parasitism	obligate parasites	facultative saprophytes
Polymorphism	polymorphic	not polymorphic
Teleutospores	terminal , 1 or 2 celled, stalked or sessile	intercalary, 1 celled, sessile
Basidiospores	produced on sterigmata, discharged, 4 in number	violently sessile,not violent 4 to many(indefinite in number
Sex organs	spermatia (male) receptive hyphae(female)	no sex organs
Dikaryotisation	spermatisation	fusion of 2 basidia or Basidiospores or conidia or promycelium

IMPORTANT CHARACTERISTICS OF FAMILY TILLETIACEAE:

1. Known as bunts
2. Promycelium is non-septate



3. Basidiospores arise terminally

DISTINGUISHED CHARACTERISTICS OF GENERA:

Tilletia:

1. Teleospores singles
2. Spores dusty and escaping at maturity
3. Sporidia are fused to form H shaped structures

Neovossia:

1. Teleospores singles
2. Spores dusty and escaping at maturity
3. Sporidia do not fuse, no H shaped structures

Urocystis :

1. Teleospores in balls
2. Sori dusty, spore balls surrounded by an adhering layer of hyaline sterile cells.
3. spore balls escape from sorus

DISEASES CAUSED BY THE GENERA:

Tilletia caries and *T. foetida*- bunt of wheat

Neovossia horrida- bunt of paddy

N. indica- Karnal bunt of wheat

Urocystis cepulae- onion smut

U. tritici- flag smut of wheat

DIFFERENCES BETWEEN SMUTS AND BUNTS :

S.No.	Smuts	Bunts
1	Belongs to family Ustilaginaceae	Belongs to family Tilliteaceae
2	Promycelium is Septate	Promycelium is non-Septate and hollow tube like
3	Basidiospores are formed laterally from each cell of the promycelium	Basidiospores are formed at the tip of the promycelium
4	Basidiospores are usually four	Basidiospores are more than four usually eight
5	H shaped structures are not formed	H shaped structures are present in which plasmogamy occurs.
6	Meiosis occurs in promycelium or teliospores	Meiosis always occurs in teliospores before germination
7	No fishy odour is observed	Characteristic stinking fishy odour is observed
8	Genera included are <i>Ustilago</i> , <i>Sphaecelotheca</i> , <i>Tolyposporium</i>	Genera included are <i>Tilletia</i> , <i>Neovossia</i> , <i>Urocystis</i>