Subdivision: Ascomycotina, class: Hemiascomycetes (Taphrinales), class: Plectomycetes (Eurotiales), class: Pyrenomycetes (Erysiphales, Clavicepitales), class: Loculoascomycetes (Pleosporales)

General characters

Mycelium is well developed branched and septate. Yeast is single celled organism. Septum has a central pore. Cell wall is made up of chitin. Asexual spores are non-motile conidia. Sexual spores are ascospores. Ascospores are usually 8 in an ascus. They are produced endogenously inside the ascus.

Key to the classes of Ascomycotina

Ascocarps and ascogenous hyphae absent, thallus mycelial or yeast-like - **Hemiascomycetes**

Ascocarps and ascogenous hyphae present, Thallus mycelial: Asci bitunicate, ascocarp an ascostroma **- Loculoascomycetes**

Asci typically unitunicate, if bitunicate, ascocarp as apothecium: Ascocarp a cleistothecium, asci evanescent and scattered **- Plectomycetes**

Asci regularly arranged as basal or peripheral layer in the ascocarp

Insect parasites **- Laboulbeniomycetes**

Not insect parasites, Ascocarp perithecium **- Pyrenomycetes**

Ascocarp apothecium **– Discomycetes**

Class: Hemiascomycetes

The class is characterized by the lack of ascocarp, vegetative phase comprising of unicellular thallus or poorly developed mycelium. It is divided into three orders:

1. Asci developing parthenogenetically from a single cell or directly from a zygote formed by population of 2 cells **- *Endomycetales***
2. Asci developing from ascogenous cells, forming a palisade like layer **- Taphrinales**
3. Asci developing in a compound spore sac (synascus), produced singly from thick walled chlamydospores **- Protomycetales**

Order: Endomycetales

Family	Genus
Saccharomycetaceae	*Sacchromyces, Schizosaccharomyces, Saccharomycodes*

Order: Taphrinales

Family: Taphrinaceae **Genus*:*** *Taphrina*

Taphrina deformans - Leaf curl or leaf blister of peach

T. maculans -Leaf spot of turmeric and ginger

Order: Protomycetales

Family: Protomycetaceae **Genus:** *Protomyces Protomyces macrosporus*-

Stem gall of coriander

Class: Loculoascomycetes

It comprises the following 5 orders

Myriangiales, Dothideales, Pleosporales (Pseudosphaeriales), Hemisphaeriales (Microthyriales) and Hysteriales

Order: Myriangiales

Family: Myriangiaceae (Genera: *Elsinoe, Myriangium*)

Order: Dothideales

Family: 1. Capnodiaceae (Genera: *Capnodium, Limacinia*)

2. Dothideaceae (Genera: *Mycosphaerella, Guignardia*)

Order: Pleosporales

Family: Venturiaceae

Superficial mycelium lacking. Pseudothecial immersed or erumpent or developing superficially on immersed hypostroma or mycelium arising from it.Pseudothecial wall composed of distinct dark brown cells, ascospores smooth, and bicelled.

e.g., *Venturia inaequalis* -apple scab;

V. pirina -pear scab

Class: Pyrenomycetes

Order: Meliolales

Family: Meliolaceae (Genus*: Meliola*)

Order: Erysiphales

The fungal species in this order cause plant diseases commonly called as powdery mildews. The mycelium is usually ectophytic to partially endophytic. Asexual reproduction is by conidia borne on conidiophores either singly or in basipetal chains. Conidia of powdery mildews germinate at 0 to 100% RH. Their germination at very low RH has been explained due to their very high osmotic pressure, which makes them able to draw sufficient moisture for germination from dry air. The ascocarps are provided with characteristic appendages, which in addition to the number of asci are used in differentiating genera. Many of the powdery mildews are not known to produce ascocarps or these are produced rarely. In the absence of ascocarps, conidia have been utilized for classifying these fungi. It has only one family, Erysiphaceae and it has the following genera.

1. Ascocarps present

A. Mycelium superficial

1. Ascocarp containing one ascus only

a. Perithecial appendages simple, myceloid -*Sphaerotheca*

b. Perithecial appendages dichotomously branched -*Podosphaera*

2. Ascocarp containing many asci

a. Perithecial appendages simples, myceloid -*Erysiphe*

b. Perithecial appendages dichotomously branched -*Microsphaera*

c. Perithecial appendages coiled at the top -*Uncinula*

B. Mycelium partially endophytic

Perithecial appendages simple, imperfect state -Oidiopsis, *Leveillula*

Perithecial appendages coiled at the tip, imperfect state -Oidiopsis –*Pleochaeta* 1 Perithecial appendages with basal swellings, imperfect state -*Ovulariopsis*

II. Ascocarp absent

A. Mycelium superficial

Basal cell of the conidiophore swollen

2. Basal cell of the conidiophore not swollen

a. Conidia borne in chains -*Euoidium*

b. Conidia borne singly -*Pseudoidium*

B. Mycelium partly endophytic

Conidia ovoid, obclavate -*Oidiopsis*

Conidia pyriform -*Ovulariopsis*

Order: Clavicipitales

Family: *Clavicipitaceae* Genus C*laviceps*

Claviceps

The stromatic structures are quite prominent. The perithecia are deeply immersed in stroma which develops as an apical head on an erect stalk (stipe) arising from a dark coloured sclerotium, Perithecia are produced towards the periphery of the stroma. Ascospores are thread like.

Claviceps microcephala (C. fusiformis) -ergot of pearl millet

C. oryzae -sativae -false smut of rice/

Claviceps purpurea -ergot of rye

C. sorghi (Sphacelia sorghi) -ergot of sorghum

Classification, symptoms and life cycle of powdery mildew – *Erysiphe* and *claviceps*

I. Powdery Mildews

Powdery mildew is the appearance of white powdery growth mostly on upper leaf surfaces on stems, floral parts and fruits leading to premature defoliation. Powdery mildews arc caused by members in the order Erysiphales in the subdivision Ascomycotina. There are three types of powdery mildew pathogens have been recognized based on the mycelium and type of conidia the differences are given below.

S. No.	**Description**	***Oidium***	***Oidiopsis***	***Ovulariopsis***
1.	Symptoms	Mostly on upper surface of leaves	Mostly on lower surface of leaves	Lower or upper surface of leaves
2.	Mycelium	Hyaline, septate ectophytic	Hyaline, septate, endophytic	Hyaline, septate, ecto and endophytic
3.	Haustoria	Present in epidermis only	Present in Epidermis	Epidermal haustoria

			and spongy cells	absent, haustoria in inner cells
4.	Conidiophores	Short, single, club shaped, non septate,	Long, branched, Septate	Long, single, septate
5.	Conidia	Cylindrical or barrel shaped, in chains	Club shaped single celled,	Club shaped, single celled
6.	Examples	Grapes - *Uncinula Necator* Blackgram- *Erysiphe po/ygoni* Bhendi - *Erysiphe cichoracearum* Apple - *Podosphaera Eucotricha* Rose - *Sphae rotheca pannosa var.rosae* Oak - *Microsphaera alphitoides*	Chillies and Pigeonpea - *Leveillula taurica* (syn. *Oidiopsis taurica)*	Muberry *Phyllactillia guttata* (syn. *P. corylea)*

The powdery mildew fungi produces closed ascocarp called cleistothecium. The genera are differentiated based on the number of asci in the cleistothecium and type of appendages on it. They are classified as follows.

I. One ascus in a cleistothecium

i. Myceloid appendages - e.g., *Sphaerotheca*

ii. Dichotomously branched appendages - e.g., *Podosphaera*

II. Many asci in a cleistothecium

i. Myceloid appendages - e.g., *Erysiphe Leveillula.*

ii. Appendage coiled at the tip (circinoid type) - e.g., *Uncinu/a.*

iii. Dichotomously branched appendages - e.g., *Microsphaera*

iv. Appendage with bulbouse base and spear like tip - e.g., *Phyllactinia.*

Powdery mildew of grapevine - *Uncinula necator.*

Systematic position

Sub-kingdom : Mycota

Division : Eumycota

Subdivision Class : Ascomycotina

Order : Pyrenomycetes

Family : Erysiphales

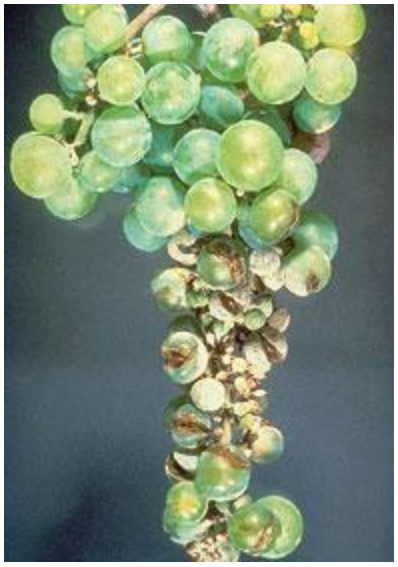
Genus : Erysiphaceae

Species : *Uncinula*

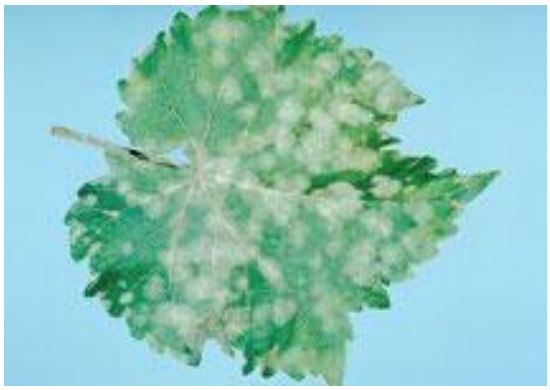
Mycota : *U .necator*

Symptoms

Whitish powdery growth on the upper surface of the leaves and in several cases leaves dry and fall off. On berries also it produce white coloured fungal growth which leads to deformation and cracking of berries.



Powdery mildew symptoms on grape berries (L) and Rachis (cluster stem) (R)



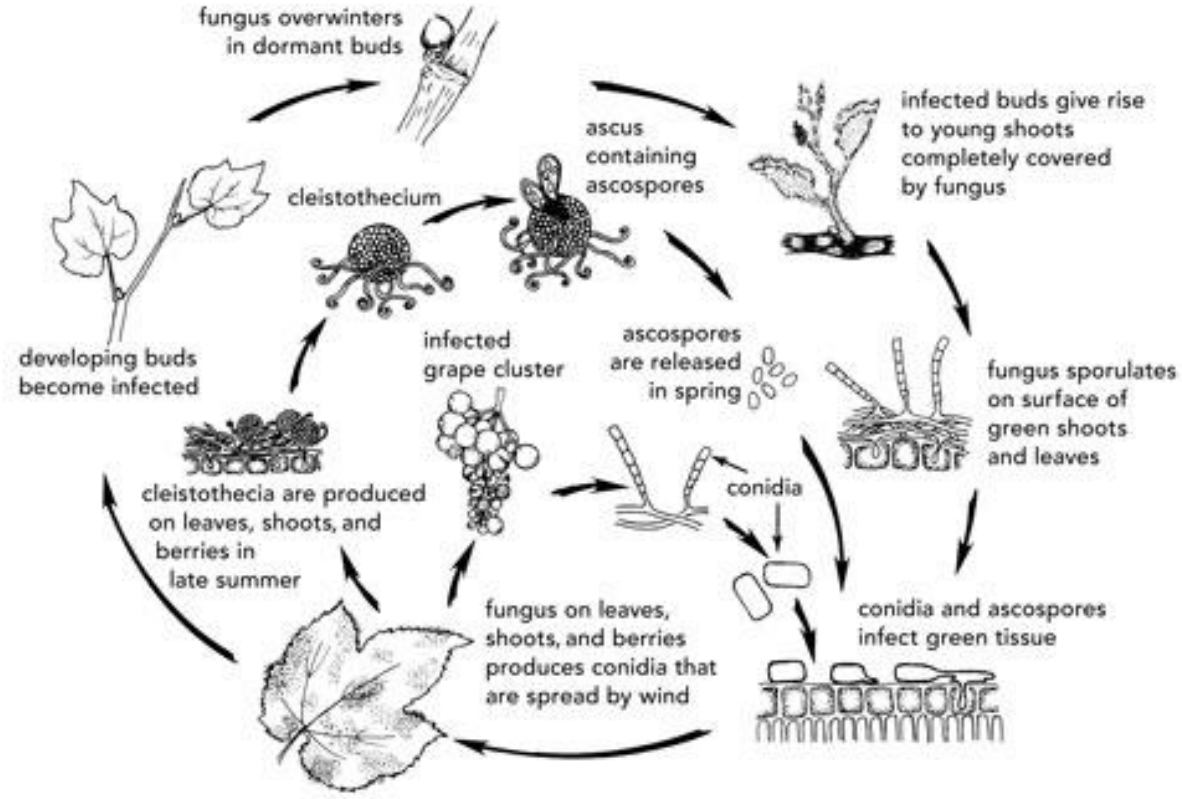

Primary infections of powdery mildew on grape leaf (Left) and powdery mildew covering grape leaf surface (Right)

Pathogen

Mycelium is hyaline, septate, branched and ectophytic. Haustoeia are saclike. Conidiophore is erect, long, hyaline, single celled, simples, club-shaped are barrel shaped, hyaline, thin walled and are produced in chain. 'Cleistothecium is of circinate type, globose and brown or black in colour. Asci are ovate and 4 to 8 asci per cleistothecium .Ascospores are 4 to 6 per ascus, single celled, hyaline and oval.

Disease cycle

The fungus survives through hyphae inside the dormant vegetative buds and through c1eistothecia. The ascospores or the hibernating mycelium in the host buds cause infection and produce enormous conidia. They spread through wind, germinate on the leaf surface and produce germ tubes and appresorium and cause infection. Cleistothecia are formed late in the season on leaves and stem. They are also formed on the fallen leaves. The ascospores in the cleistothecium are released in the spring by the swelling and rupturing of perithecial wall. Ascospores which fall on any green surface of the developing vine cause primary infection.



Powdery mildew of pulses - *Erysiphe polygoni*

Symptoms

Greyish white powdery growth appears on the upper surface of the leaves, stems, petioles and pods. Later the growth becomes brown and the leaves turn yellow and drop.

Pathogen

Mycelium is ectophytic, hyaline, septate and branched. Haustoria are bulbous and sac-like. Conidiophore is simple, erect, hyaline and bear chain of conidia. Conidia are hyaline, thin walled, single celled and ovate or barrel or cylindrical in shape. Cleistothecia are black, round with myceloid appendages and each cleistothecium bears 2 to 8 asci. Asci are ovate and contain 3 to 8 ascospores. Ascospores are hyaline, elliptical and single celled.

Powdery mildew of chillies and pigeonpea - *Leveillula taurica*

Symptoms

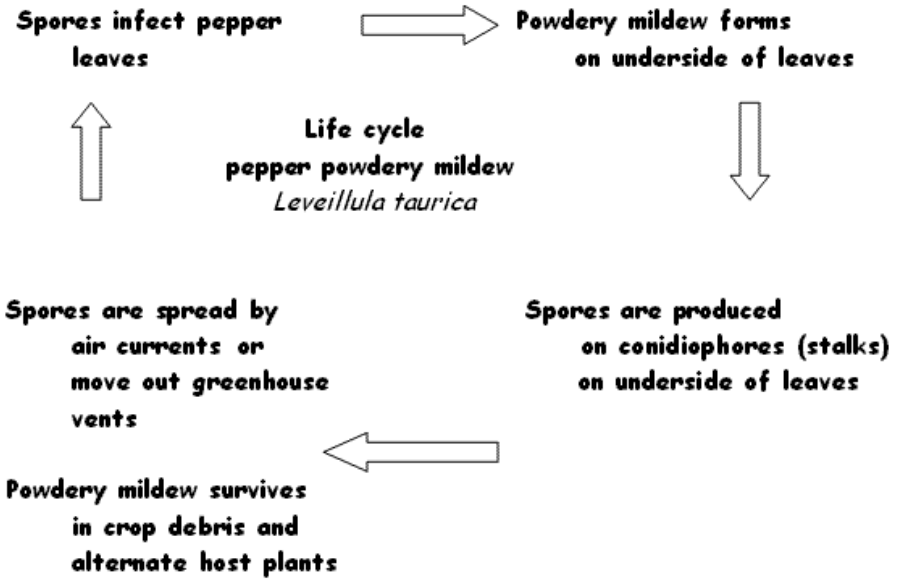
Whitish fungal growth on the under surface of the leaf and the corresponding upper surface show yellow discolouration. Later the disease spreads to entire leaf surface cause yellowing and defoliation of leaves.

Pathogen

Mycelium is endophytic, hyaline, septate and branched. Conidiophores emerge through stomata, single or in groups, branched, septate and bear single conidium at its tip. Conidia are hyaline, single celled and clavate. Cleistothecia are with myceloid appendages. Asci are cylindrical and 9 – 20 / cleistothecium. Each ascus contains two ascospores.

Disease cycle

Ascospores from the perennating cleistothecia infect the lower most leaves near the soil level. The fungus penetrates through stomata. Mycelium sends globular haustoria in to the mesophyll cells and epidermis. C**onidiophores** with a conidium at the tip arise vertically from the plane of mycelial growth. Conidia are wind borne and helps in secondary spread.Later in the season, black, globose **cleistothecia** are produced. Asci are cylindrical and 9 – 20 / ascocarp. **Ascospores** are hyaline, 8 / ascus and are elliptical.



iv. Powdery mildew of mulberry - ***Phyllactinia guttata (***syn***. P.corylea).***

Symptoms

White fungal growth on lower surface of leaves and corresponding upper surface shows yellow discolouration; leaves dry and defoliate.

Pathogen

Mycelium is hyaline, septate and branched. Conidiophores are erect,septate, hyaline and simple. Conidia are hyaline, single celled, clavate or flame shaped and borne singly on

conidiophore. Cleistothecia are flat, spherical, black and with bulbous base and pointed spear-like tip appendages. Asci are clavate. Asci are 10-30 in each cleistothecium. Ascospores are two per ascus and oval in shape.

Disease cycle

Ascospores from the perennating cleistothecia infect leaves and penetrate through stomata.mycelium is endophytic and produces conidia which are spread through air. Cleistothecia help in the survival.

II. Sugary disease / Ergot

Exudation of honey-like sticky fluid from spikelets (conidial stage) and later with formation of black scletoria, (ergot) is known as **sugar disease or ergot.**

Sugary disease / ergot of pearlmillet- *Claviceps fusiformis* (syn**. *Claviceps microcephala)***

Systematic position

Sub-kingdom : Mycota

Division : Eumycota

Sub-division : Ascomycotina

Class : Pyrenomycetes

Order : Clavicepitales

Family : Clavicepitaceae

Genus : *Claviceps*

Species : C. *fusiformis*

Symptoms

Exudation of small droplets of light pinkish or brownish sticky fluid from the spikelets, trickling down of honey dew secretion; at later stage, black, dark sticky patch may be seen; transformation of ovary to a hard structure consisting of mycelial mat of fungus called **sclerotia**.

Pathogen

Mycelium is septate, hyaline and branched. It produces two types of conidia *viz.*, macroconidia and microconidia. Macroconidia are hyaline, fusiform, and unicellular and germinate by producing one to three germ tubes. Microconidia are hyaline, globular, unicellular and germinate by producing only one germ tube. Sclerotia are dark grey, long and club shaped. Perithecia are pyriform. The asci are long and hyaline. The ascospores are thread-like, hyaline and non-septate.

Disease cycle

The fungus spreads from plant to plant in the conidial stage. The honeydew mixed with the inoculum (conidia) attracts insects, which help in the dissemination of conidia and spread the disease in the field. The sclerotia form at the later stage in the diseased earheads. After harvest when the earheads are thrashed sclerotia are found mixed with seed and reach soil when they (seed and sclerotia) are sown help the fungus to perpetuate from season to season. They may fall and remain in the soil or plant debris and germinate during the next season and produce perithecia containing asci and ascospores. The ascospores, which spread through air, cause infection of the spike, producing the conidial stage.

Sugary disease / ergot of sorghum - ***Claviceps sorghi*** (syn.: ***Sphacelia sorghi)***

Sugary disease / ergot of rye-*Claviceps purpurea*

Symptoms

Droplets of light pinkish / brownish sticky fluid exudes from the spikelets and honeydew secretion trickling down from the earhead. Infected spikelets turn black and finally several sticky patches are seen on the ear. This stage is known as **honeydew / sphacelia stage**. It may continue for 20-25 days.Later, infected ovary is transformed into a hard, black structure called sclerotia, which are projecting out of the spikelet. This stage is called **ergot / sclerotial stage.**

Pathogen

Conidia are hyaline, single celled, oblong with a constriction in the middle. Sclerotia are hard, compact, black, cylindrical, straight or curved.

Disease cycle

Sclerotia germinate under favourable condition and produce vertical column of mass of hyphae called as stromatic stalk or stipe. Pyriform perithecia are arranged in the periphery of the head of the stipe. Perithecia contain hyaline asci. Ascospores are hyaline, aseptate and filiform. Ascospores are ejected with force, spread by wind and reach healthy flowers. These spores germinate on stigma and infection thread reaches the ovary through style. Honeydew stage / sphacelia stage develops as result of infection. Fungus produces dull brown, septate and branched mycelium on the ovary. Generative hyphae comprise of conidiophores and conidia are produced on the surface of the ovary.

Conidiophores are hyaline, short and simple. Conidia are are mixed with honeydew and ooze out. Insects attracted by honeydew carry conidia to healthy flowers and results in secondary infection of new ovaries. Later, ovary has been replaced by sclerotia, which forms horny structures between the glumes. Sclerotia spread along the seed as a contaminant or it falls on the ground and survives in the soil.