Chapter IV – Classification
CLASSIFICATION

Classification is the placing of a plant in groups or categories according to a particular plan or sequence and in conformity with a nomenclature system. The term taxonomy means identification, nomenclature and classification of the object of biological origin. Taxonomy is also defined as a science, based fundamentally on morphology with the support of other disciplines. Identification is the determination of a taxon identical to another and already known element, while nomenclature is concerned with the determination of the correct name of the known plant as per the nomenclature system. Latter on the plant is classified as a member of a particular genus, genus to a family, family to the order. So, classification deals with the placing of a plant in its proper place within a selected scheme. Theory of evolution postulates that, plants now living are the descendents of ancestral types and thus, there exists genetic relationship amongst the plants. The principles of modern classification recognize this relationship and these principles have been formulated in an attempt to bring related plant groups together. This relationship can be established with the help of sciences as morphology, anatomy cytology, genetics, paleobotany, phytogeography, ecology, biochemistry etc. Lower elements as species are easily affiliated to a particular species but higher the category, greater is the difficulty of determining the relationship. The another term phylogeny is also used to indicate interrelationship. Thus, the phylogenetical classification is of vital importance in taxonomy.

1. Two kingdom system: (Linnaeus, 1725)

This is the oldest type of the system of classification and has been concentrated upon the two different groups of organisms, which have been adapted for nutrition i.e. rooting, photosynthetic plants and the motile, food ingesting animals. Here, the concept of distinct dichotomy arrived in the direction of body organization, way of life and direction of evolution. However, this system failed to consider the position of those unicellular organisms, showing the characters of both plants and animals.
2. Three Kingdom system:
Considering the difficulty of classification of lower unicellular organisms showing either characters of plants and animals, Hogg (1860) proposed a third kingdom and the lower organisms were grouped into Primigenum or Protoctista. Hackel (1866), further proposed the name Protista for the lower organisms along with sponges and treated as a third Kingdom. Thus, Protista is defined as a Kingdom of unicellular organisms, as algae and fungi, lacking tissue differentiation.

Fungi are questionable even to day, whether, they are plants or not. It seems that, some have derived from algae while, the lower fungi (Chytrids) including the number of other groups had phylogenetically derived from colourless flagellate ancestors and the higher fungi, had derived from one of the groups of lower fungi. They are different from the green plants by their mycelial structure having dikaryotic condition while, the chytrid-like, non-mycelial fungi have globular spore (zoospores) with rhizoids, extending into the food source and the protoplasm form spores (zoospores) which are released. Thus, they are related to algae in one hand and mycelial bacteria on other hand. So, fungi are the plants and hence must be placed in Plant Kingdom. The evolution of fungi, on the basis of mode of nutrition can also be traced as: plants are photosynthetic and partially absorptive, where as animals ingest the food. So plants are producers, animals are consumers while, the third community can be grouped as reducers, which is purely absorptive one and include both fungi and bacteria. They have been evolved by adapting for absorptive mode as, by embedding the non-motile habit in food source with mycelial organization with maximum contact with food and only reproductive organs emerge to release the spores. This leads to consider the separate existence of fungi.

3. Four Kingdom system:
Copeland (1956) has given a scheme of classification, which includes four kingdoms and has been widely accepted. These are as follows:
a) Kingdom Mycota or Monera: Organisms without well organized nuclei e.g. Bacteria, Blue-Green Algae.
b) **Kingdom Protoctista**: Nucleated organisms but without having either characters of plants and animals e.g. Protozoans, Red and Brown Algae and Fungi.

c) **Kingdom Plantae**: Organisms having cells containing pigments like Chlorophyll a, b, Carotene and Xanthopylls in their chloroplasts and produce glucose and sucrose.

d) **Kingdom Animalia**: Multicellular organisms, which have passed blastula and gastrula type of development.

In this system, the evolutionary lines, on the basis of nutrition and organisation from Monera to higher plants and also of higher fungi can be traced. Till, this system has a drawback of placing the fungi far below on the basis of tissue differentiation and organisation, and this was due to their limited tissue differentiation. Dillon (1963) further stated that, there is only one kingdom exists in plants, within which number of lines evolved and fungi are one of them.

4. **Five kingdom system**:

Attempts were made to solve the delimitations of Copeland’s system. Simpson (1965) placed the fungi as well as the unicellular and higher algae in the kingdom Plantae. Pimental (1963) reported Monera, as a sub-kingdom of Protista with eukaryotic algae and land plants. In five kingdom system, Whittakar (1969) treated Monera and Protista as separate kingdoms. This system was supported by Grants and others.

This system is more advanced from the previous one by (i) separation of Monera from Protista at kingdom level, (ii) recognition of five phyla in Monera, (iii) segregation of branches as groupings between the major sub-kingdoms and phyla and (iv) treatment of fungi and their evolutionary lines were proposed on the basis of flagellation and biochemical evidences.

The lower true fungi (Phycomycetes) include five evolutionary lines of separation from the unicellular flagellated one viz. True-chytrid line, Hypochytridiales, Bi-flagellated line, Zygomycota and Plasmodiophorales line. The biochemical pathway states that, the Chytridiomycota has been derived from the flagellate and related to the other groups as Euglenophyta and Zygomycotina.
With the loss of flagellate swimmers, the forms having mycelial organization such as Chytridiomycota were formed and latter on from them, the higher fungi as Ascomycota and Basidiomycota have been derived, and this represents the main axis of evolution in higher fungi.

Oomycota and Chytridiomycota, both include the progressions from Chytridas to mycelial forms. Whittaker (1969), placed the transitional phyla in the fungi parallel with Chlorophyta. The main line from Chytridiomycota – Basidiomycota is treated in sub-kingdom of Eumycota and others in the Oomycota. The Hypochytridiomycota and Plasmodiophoromycota became the phyla of Protista, adjacent to absorptive and spore forming organization forms as protozoans etc.

The slime molds were developed from the unicellular taxa into three separate lines as true slime molds (Myxomycetes), Cellular slime molds (Acrasiales) and cell-net slime molds (Labyrinthulales) and were assigned to Gymnomycota.

This system has number of merits and is advantageous one. It proposes considerable evolution of sex. The groups as orders and classes are treated as phyla, while in some cases, are separated into sub-kingdoms. The Chytrids were classified into 7 orders and Slime molds into three orders. Large number of fungi are considered in this system. It shows the evolution and the independent origin of different groups. This system represents the broad relationship in regards the organization and nutrition.

Ainsworth et al (1973) have divided Myxomycota into 4 classes viz. Acrasiomycetes, Hydromyxomycetes, Myxomycetes and Plasmodiophoromycetes. On the basis on number, position and type (whiplash or tinsel) of flagella of zoosporces. The class Acrasiomycetes divided into three orders viz. Protosteleales (2 families), Acrasiales (3 families) and Dictyosteliales (2 families). The class Hydromyxomycetes divided into 2-orders viz. Hydromycales and Labyrinthulales (2 families). The class Myxomycetes divided into 6 orders viz. Ceratiomycales (1 family), Physarales (2 families), Liceales (3-families), Echinosteliales
(2-families), Trichiales (2 families), Stemonitales (1 family). The class Plasmodiophoromycetes is divided into a single order viz. Plasmodiophorales (1-family).

Hawksworth, D. L. and et al. (1998) have placed Myxomycetous fungi in three kingdom system, viz. Kingdom Protozoa. The kingdom Protozoa is divided into 4-divisions viz. Acrasiomycota, Dictyosteliomycota, Myxomycota and Plasmodiophoromycota, and Myxomycota is further divided into two classes viz. Myxomycetes and Protosteliomycetes.

The system also seems to be disadvantageous as far as fungi are concerned as the convergent groups which have been placed in one group, the treatment of slime molds and the line of unicells- multicellular and multi-nucleated forms has been crossed with the number of independent lines.

The circumscription (limit) of fungi is not always well defined. The best known example of a group of uncertain affinity is that of slime molds, which has been claimed by both mycologists (as the Myxomycetes) and zoologists (as the Mycetozoa). Other groups, if less familiar, are of equally uncertain status: the cellular slime molds (Acrasiomycetes), e.g. are claimed as Protozoa, a taxon to which the Hydromyxomycetes (including the Labyrinthulales) have been referred.

At the turn of the century, it was a widely held belief that fungi of the class Phycomycetes were derived from algae, a belief reflected in the nomenclature adopted by Clements and Shear (1931) in their "Genera of fungi" for the orders of Phycomycetes. This hypothesis, which failed-into disrepute, has recently been revived in modified form as seen by the classification of the Oomycetes with the algae by both Copeland (1956) and Barkely (1968) and by the German mycologist Kreisel (1969), while the Hyphochytridiales (or Hyphochytridiomycetes) are also associated with biflagellated algal groups by Barkely, Copeland, and Kreisel.

The most taxonomic arrangements of the fungi have differentiated, the plasmodial (Myxomycota) from the mycelial (Eumycota) forms, which shows the bulk of fungi. Three classes of the latter have been universally recognised viz. Phycomycetes, Ascomycetes and Basidiomycetes, based on the types of sexually
produced spores. These are grouped with the Deuteromycetes, or fungi Imperfecti, which are characterised by the possession of asexual spores only. Because the class Phycomycetes was patently a miscellagenous assemblage, following the lead of Sparrow (1959), its constituents are with increasing frequency being accommodated in a series of classes viz. Chytridiomycetes, Hyphochytridiomycetes, Oomycetes, Zygomycetes and Trichomycetes. Although it shows that the Ascomycetes are monophyletic, there have been major adjustments within the group, particularly as a result of the significance now given to uni-and bitunicate asci as taxonomic criteria. For many years, treatment of the basidiomycetes, which include so many of the larger and higher fungi, has been dominated by the Friesian approach which had-and still has-the attraction of differentiating fungi into groups mainly on field characters. More critical microscopic studies of basidiocarp structure and morphogenesis and the recognition that there has been much evolutionary convergence are leading to an abandonment of the Friesian system and the development of more natural openings. For many basidiomycetes, as for many ascomycetes, the older literature is inadequate and new literatures have yet to be prepared, so that, in many areas the current classification of these fungi is in a state of transition. Some of the other classes recognized in the present account, e.g. Pyrenomycetes and Gasteromycetes are also clearly heterogenous but they are still useful pigeonholes for ordering many common fungi. Even this proposal and status of fungi as a separate, independent kingdom does not solve the problem of the too many fungi and thus, many specialists- taxonomical mycologists proposed/ modified the schemes of taxonomy/ and classification using many modern techniques and methods to investigate the characters upto molecular one and used to classify and to establish their inter-relationships e.g. Rust and Smuts- (Bawer, R. et al. 1999) and Vanky, K. (1999) as well as Oberwinkler (1984) who does not recognize two separate classes viz. Basidiomycetes and Gasteromycetes but all the fungi of these classes were merged and divided into two sub-classes and 39 orders – including even rusts and smuts together- realizing only significance of their mode of spore discharge:
ballistospores and statismospores with various mode of adaptations during their course of evolution and parasitism. Thus, taxonomy is a dynamic branch and ever changing. A seven kingdom system has been proposed very recently by Myers.

Ainsworth, G. C. and et al. (1973) treated fungi as a separate kingdom or sub-kingdom of plant kingdom with two divisions, the Myxomycota-for plasmodial forms and the Eumycota-for non-plasmodial forms, which are frequently mycelial. The Eumycota divided into five subdivisions viz. Ascomycotina, Basidiomycotina, Deuteromycotina, Mastigomycotina and Zygomycotina based on their perfect state spores.

Keys to the higher taxa: Fungi:

Key to divisions of fungi:
1. Plasmodium or pseudoplasmodium present ———————— Myxomycota I
   1'. Plasmodium or pseudoplasmodium absent, assimilative phase typically filamentous (mycelial) ———————— Eumycota II

I. Myxomycota:

Key to classes of Myxomycota:
1. Assimilative phase a plasmodium ———————————————————— 2
   1'. Assimilative phase free-living amoebae which unite as a pseudoplasmodium before reproduction ———————————————————— Acrasiomycetes
   2(1) Plasmodium forming a network ("netplasmodium") ——— Labyrinthulales
   2'(1) Plasmodium not forming a network ———————————————————— 3
   3(2) Plasmodium saprobic, free-living ———————————————————— Myxomycetes
   3'(2) Plasmodium parasitic within cells of the host plant ———— ———— ——— Plasmodiophoromycetes

II. Eumycota

Key to subdivisions of Eumycota:
1. Motile cells (zoospores) present; perfect state spores typically oospores ———— ———— ——— Mastigomycotina-III
   1'. Motile cells absent ———————————————————— 2
   2 (1) Perfect state present ———————————————————— 3
21 (1) Perfect state absent -------------------------------Deuteromycotina -VII
3(2) Perfect state spores zygospores----------------------Zygomycotina -IV
31 (2) Zygospores absent ----------------------------------4
4 (3) Perfect-state spores ascospores----------------------Ascomycotina -V
41 (3) Perfect-state spores basidiospores ----------------Basidiomycotina -VI

III. Mastigomycotina

Key to classes of Mastigomycotina:
1. Zoospores posteriorly uniflagellate (flagella whiplash-type)------------------
   -----------------------------------------------Chytridiomycetes
1. Zoospores not posteriorly uniflagellate ----------------------------------2
2(1) Zoospores anteriorly uniflagellate (flagella tinsel-type)----------------
   -----------------------------------------------Hyphochytridiomycetes
21 (1) Zoospores biflagellate (posterior flagellum whiplash-type; anterior tinsel-
   type); cell wall cellulosic -----------------------------------------------Oomycetes

IV. Zygomycotina

Key to classes of Zygomycotina:
1. Saprobic or, if parasitic or predacious, having mycelium immersed in host
   tissue---------------------------------------------------------------Zygomycetes
1. Associated with arthropods and attached to the cuticle or digestive tract by a
   holdfast and not immersed in the host tissue--------------------------Trichomycetes

V. Ascomycotina

Key to classes of Ascomycotina:
1. Ascocarps and ascogenous hyphae lacking; thallus mycelial or yeast like-------
   ---------------------------------------------------------------Hemiascomycetes
1. Ascocarps and ascogenous hyphae present; thallus mycelial-------------------2
2(1) Asci bitunicate; ascocarp an ascostroma------------------Loculoascomycetes
21 (1) Asci typically unitunicate; if bitunicate, ascocarp which is apothecium----
3(2') Asci evanescent, scattered within the astomous ascocarp which is typically a cleistothecium; ascospores aseptate—Plectomycetes

3' (2') Asci regularly arranged within the ascocarp as a basal or peripheral layer —

4(3') Exoparasites of arthropods; thallus reduced; ascocarp a peritheciun; asci inoperculate—Laboulbeniomyctes

4' (3') Not exoparasites of arthropods —

5(4') Ascocarp typically a perithecium which is usually ostiolate (if astomous, asci not evanescent); asci inoperculate with an apical pore or slit—Pyrenomycetes

5' (4') Ascocarp an apothecium or a modified apothecium, frequently macrocarpic, epigean or hypogeun; asci inoperculate or operculate—Discomycetes

VI. Basidiomycotina

Key to classes of Basidiomycotina:

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

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

2(1') Basidiocarp typically gymnocarpous or semiangiocarpous; basidia phragmobasidia (Phragmobasidiomycetidae) or holobasidia (Holobasidiomycetidae); basidiospores ballistospores(forcibly- discharge)—Hymenomycetes

2' (1') Basidiocarp typically angiocarpous; basidia holobasidia; basidiospores not ballistospores (but statismospores not forcibly discharge)—Gasteromycetes
VII. Deuteromycotina

Key to classes of Deuteromycotina:
1. Budding (yeast or yeast like) cells with or without pseudomycelium characteristic; true mycelium lacking or not well-developed----------------------Blastomycetes

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

2(1') Mycelium sterile or bearing spores directly or on special branches (sporophores) which may be variously aggregated but not in pycnidia or acervuli---------------------------------------Hyphomycetes

2'(1') Spores (conidia) produced in pycnidia or acervuli ---------Coelomycetes

The process of classifying the different fungi was started and had gone over hand in hand with the identification of different taxa. Since from the last century, number of workers, carried out this work on the basis of different characters time to time and tried to classify the fungi with maximum convenience. Fries (1822-23) classified the fungi into Ascomycetes and Basidiomycetes on the basis of morphological characters as ascospores and basidiospores. While Boudier (1879) classified only Discomycetous fungi into operculate and inoperculate types on the basis of ascus tip character.

Saccardo (1822) formulated a standard system of classification and was accepted for about half a century or more. He classified both Ascomycetes and Basidiomycetes on the basis of the different morphological characters as spores-septation, colour, stroma and subiculum. His work was published in 26 volumes (1882-1926, and 1972) as a monument for mycologists.

In the first quarter of the twentieth century, with the exploration of the number of areas and with the establishment of a good number of taxa, it became indispensable to place the taxa or genera etc. systematically and phylogenetically in a scheme. As far as the bitunicate Ascomycetous fungi were concerned, number of workers as Hohnel (1909), Theissen and Sydow, H. (1918) classified them on the basis of morphological character. Thus, Honel (1909) placed all the bitunicate Ascomycetous fungi into a single group Dothidiales which was further divided
into three orders viz. Myriangiales, Pseudosphaeriales and Dothidiales. This was based on various characters as asci, ascomata and ascospore septation. Theissen and Sydow, H. (1918) followed the same scheme of Hohnel (1909) and placed all these fungi in a single group Dothideineae.

A still more broad treatment to the bitunicate Ascomycetous fungi was given by Nanfeldt (1932) who proposed the name ‘Ascoloculares’ for it. He classified all these fungi into five orders i.e. Myriangiales, Dothidiales, Pseudosphaeriales, Hemisphaeriales and Hysteriales, on the basis of ascus and ascomata characters. This system was followed for longer times and latter worker as Eriksson, Ove E. (1984) has modified it.

Clements and Shear (1931) classified the fungi and divided into five subclasses on the basis of various characters as habit, ascospores, conidial states, stroma, inserson of asci and pseudoparaphyses. They classified the Ascomycetous fungi into 10 orders and 51 families. Clements and Shear summerised all bitunicate Ascomycetes and placed them into four orders viz. Periosporales (7 fam.), Dothidiales (3 fam.), Microthyriales (3 fam.) and Phacidiales (5 fam.). They used here various characters as septation of ascospores, ostiole, pseudoparaphyses, ascomata more precisely in their scheme and number of genera were grouped likewise. They were the first to use the dichotomous keys in the classification. This system was more advantageous than the Nanfeldt’s but in most of the groups, there is an amalgamation of unitunicate and bitunicate Ascomycetous genera which led to its limited use.

As early as in 1950, von Arx and Muller studied a large number of genera of bitunicate Ascomycetous fungi and classified them into three orders viz. Pseudosphaeriales with cylindrical to saccate asci and ostiolate ascomata; Dothidiales with broad, spherical or ovate asci in non-ostiolate ascomata and those forms with their asci embedded in fungal tissue were grouped into the order Myriangiales. This system was followed by Munk (1957) and Gaumann (1964) and others in their work but in 1975, they accepted only one order viz. Dothideales for all bitunicate ascomycetes. Most basic and fundamental and important feature
in Ascomycetous fungi is ascospores (Rogers, 1970) a stable and most reliable character to be used.

Attempts were made to classify the Ascomycetous fungi by von Arx and Muller in 1954 and 1962. They considered the septation of ascospores as a fundamental criterion and classified all the one-celled ascospore producing genera of the Ascomycetous fungi into different orders. In 1962, they summarised all the 2-celled ascospore character was presumed as a fundamental one, the unitunicate and bitunicate Ascomycetous genera were intermixed in their scheme. Thus, all the one-celled ascospore producing genera having bitunicate asci were grouped in the order Dothidiales while, 2-celled ascospore producing genera were placed in three orders viz. Myriangiales, Dothiorales and Pseudosphaeriales of the sub-class Ascoloculares.

Luttrell (1946, 1951, 1955 and 1973) has made several efforts to classify the various bitunicate Ascomycetous fungi time to time. He (1946) accounted the different species of the genus *Stomiopeltis* Theiss. and stated that there occur two types of developmental patterns in non-radiate Hemisphaeriaceae and radiate Microthyriaceae. He classified the Hemisphaeriales into radiate and non-radiate one and further classification was made on the basis of the characters as insertion and arrangement of asci, ostiole and pseudoparaphyses.

Luttrell (1955) classified the Loeuloascomycetes into 6-orders viz. Myriangiales (6 fam.), Dothidiales (4 fam.), Trichothyriales (1 fam.), Pleosporales (7 fam.), Hysteriales (4 fam.) and Microthyriales (2 fam.).

Luttrell (1973) has given a broad treatment and proposed a new scheme of classification based on number of morphological, anatomical and developmental characters as: asci, ascoscarp, septate ascospores.

Developmental types: There are four developmental types observed in Loeuloascomycetes. viz. *Elsinoe* type, *Dothidea* type, *Pleospora* type and *Patellaria* type.

Luttrell (1973) classified the Loeuloascomycetes into 5 orders. In his previous system (1955) there, he kept a separate existence for the orders
Trichothyriales and Microthyriales but here, he merged them and a separate order Hemisphaeriales was proposed. Thus, he classified Loculoascomycetes into 5 orders viz. Myriangiales, Dothideales, Pleosporales, Hysteriales and Hemisphaeriales. This classification was the modification of von Arx and Muller’s original one (1954).

With a slight modification of Luttrell’s system of classification, Barr (1979) proposed a new type of classification. Luttrell (1955, 1973) accepted their main developmental types of locule, which was the basis of this classification. Barr (1979) also used this character as a basic one and the bitunicate Ascomycetous fungi were classified into following groups as:

i) Loculoplectomycetidae (1 or 6 fam.) with Elsinoe type of development.

ii) Loculoparenchymecetidae (2 or 14 fam.) with Dothidea type of development.

iii) Loculoedaphomycetidae (2 or 6 fam.) Pleospora type of development.

Recently in 1984, Ove E. Eriksson has proposed a scheme for bitunicate Ascomycetous and yet, it is far from its perfection. He (1982) studied the bitunicate nature of the Ascomycetous fungi, and divided them into two sub-classes viz. Euascomycetidae and Laboulbeniomycetidae. The former sub-class was again divided into four groups comprising 37 orders while later comprises only 2 orders. All the Pseudoprototunicate Ascomycetes were grouped into 7 orders and 70 families viz. Patellariales (3 fam.), Arthrouiales (3 fam.), Opegraphales (2 fam.), Pyrenulales (3 fam.), Dothideales (57 fam.) and Ophiostomatales (1 fam.).

This classification was also based on certain morphological characters as bitunicate ascus, ascospores, ascomata etc. it is a modification of Nanfeldt’s system. The group B and A corresponds to Ascohymeniales, group C to the Ascoloculaires and group D corresponds to Plectascales of Nanfeldt’s system. Accordingly approximately 50% genera in Ascomycetes are synonymous/invalid/or uncertain and remind us the statement or comment of one of the great Hyphomycetologist, Mason (1955) who said God has made species and man has
made (proposed) the genera too many. Eriksson followed, von Arx and Muller (1975) for the classification and proposed number of synonymy and established number of valid genera and he excluded large number of genera, which show uncertain affinities and were doubtful.

They considered that, such a sub-division of the bitunicate Ascomycetous fungi based on taxonomically reliable characters as structure of asci, deposition of asci within ascomata or formation of an ostiolum, is difficult to accept. In their re-evolutionary studies they found that, out of these 14 orders, some are overlapped while some have little phylogenetic value of ecological and biological features. Some could be even treated at the rank of a family. They thus, grouped all bitunicate Ascomycetous fungi in a single order Dothideales on the basis of bitunicate ascus as a primary character which were further classified into two sub-orders, viz. Dothideineae and Pseudosphaerineae. The suborder Dothideineae comprises 16 families while Pseudosphaerineae with 18 families.

The system is an artificial system of classification even though the biological and ecological characters have been used. Little importance has been given for the interrelation and evolution and it has been devised to classify the genera at a maximum convenience.

Classification of Imperfect fungi:

The classification of the fungi Imperfecti and keys to their identification are based principally on the system presented by Saccardo (1886) and later modifications of this system by Lindau (1900), Saccardo (1906) and others.

Saccardo (1886) divided the Fungi Imperfecti into three groups:

1. Conidiophores produced inside flask-shaped receptacle (Pycnidia)----------------------------------------------------------Sphaeropsidales
2. Conidiophores produced in a saucer-shaped receptacle, or forming a tuberculate mass, breaking through the surface of the substratum-------------------------------------------------------------Melanconiales
3. Conidiophores free, arising from the surface of the substrate, or from the aerial mycelium----------------------------------------------------------Hyphomycetales
The Hyphomycetales (= Hyphomycetes) were divided into four families viz. Mucedinaceae, Dematiaceae, Tuberculariaceae, and Stilbaceae. Saccardo again divided the families into a number of sections on the basis of the septation or shape of spores viz. spores 1-celled Amerosporae, Spores 2-celled-Didmosporae; spores with both transverse and oblique or longitudinal septa: Dictyosporae; spores forked or star-shaped: Staurosporae, spores spirally coiled, septate: Helicosporae.

The sections were further subdivided into two groups i.e. Micronemae and Macronemae. There is no doubt that Saccardo's system is the only classification yet available that has been nearly well worked out to include most of the genera of the Hyphomycetes. Most of the European workers of fungi adopted Saccardo's system viz. Lindau (1900), Migula (1913), Ferraris (1910-14), Clements (1909), Clements and Shear (1931), Ainsworth and Bisby (1943).

A different approach to the classification of the Hyphomycetes notably work by Costantin and Vuillemin. Costantin (1888) proposed a classification and he recognised the following four categories:
1. Spores or spore chain inserted on special cells,
2. Spores or spore chain inserted directly on filaments,
3. Spores produced endogenously in a tube and emerging in chains through the open mouth,
4. Fungi without spores

Within these four above categories, Costantin (1888) recognized fourteen groups which are as follows:

I. Spores or spore chains inserted on special cells — sporogenous cell.
   - Sporogenous cells rounded or spherical ———— Group 1
   - Sporogenous cells boat-shaped ———— Group 2
   - Sporogenous cells on conidiophore, different from ordinary cells — Group 3

II. Spores or spore chains inserted directly on filaments
   - Filaments simple
      - Terminating in a single spore or a single chain of spores ———— Group 4
Bearing several terminal and lateral spores or chains of spores — Group 5

Filaments branched
Branches short, fertile only towards the upper part — Group 6
Branches in verticels — Group 7
Branches not in verticels — Group 8
Filaments erect, of two kinds: sterile and fertile — Group 9
Fertile filaments in a layer or short

Filaments forming a layer — Group 10
Filaments short — Group 11
Spores enveloped in mucilage — Group 12

III. Spores produced endogenously in a tube and emerging in chains through the open mouth — Group 13

IV. Fungi without spores — Group 14

Costantin gave little importance to spore colour; and 'mucinous' and 'dematiaceous' genera were distributed by him into the groups listed above. Thus, the mucinuous Gonatobotrys Corda and the dematiaceous Gonatobotryum Sacc. were placed near each other. Costantin was aware of the importance of production of conidia in slime, and he placed the genera in which the spores were enveloped in mucilage in a distinct group (Group 12); Nine genera were included in this group. On the basis of the insertion of the conidia on the conidiophores, these genera were keyed out by him in the other groups i.e. Group 5, 6, 7, 8, 11 etc.

Costantin's work naturally foreshadowed further extension of his concepts by French mycologists, viz. Vuillemin (1990, 1911, 1912) who has made a significant contribution leading to a better understanding of methods of spore formation and proposed a system of classification based primarily on methods of formation (ontogeny) of spores. He recognised two main types of spores i.e. Thallospores and Conidiospores. The Thallospores may be formed in different ways and, depending on the way in which they are formed (5 types):
1) Arthorospores  2) Blastospores  3) Dictyospores  4) Chlamydospores.
5) Aleuriospores.

The fungi producing conidiospores were placed in the conidiosporae, which was divided into three groups by Vuillemin:

1) Conidia arising from any point on the fertile hypae,
2) Conidia produced on distinct conidiophores
3) Conidia produced from the tips of phialides.

A good account of Vuillemin's concepts is given by Langeron and Vanbreuseghem (1952) and by Moreau (1953). His ideas have also been discussed by Mason (1933, 1937, 1941) in a series of papers. Mason (1941) proposed three more terms i.e. Meristemspores, Terminus spores and Radula spores. Mason (1937) concluded that conidial dispersal, 'which displays itself so obviously when the conidial mass is exposed for dispersal by the external forces of nature, is a character that can claim a high degree of objective validity' for classification. Mason (1937) classified the two biological spore types viz. i) slime/wet type ii) dry type. Mason's idea was accepted by Wakefield and Bisby (1941), who classified the British Hyphomycetes on this basis.

Smith (1960), in treating Hyphomycetes of industrial importance, has applied Mason's idea and presented keys to some of the most common genera, species of which are considered important in industry. Ingold (1942) published an important paper on aquatic hyphomycetes in which he described several interesting fungi observed by him on submerged decaying leaves in England. Many interesting species were listed, briefly described and illustrated elegantly by Arnaud (1952-53). He classified into spore groups on the lines of Saccardo.

In an outstanding contribution to the mycological literature, Hughes (1953) presented an experimental classification of the Hyphomycetes based on the different types of conidium development. The mononematous, synematous or tuberculariaceous nature of the conidiophores, the form of the mature conidia, their dematiaceous or mucedinaceous nature, their septation and the presence or
absence of slime around them were treated as subsidiary characters. Hughes (1953) divided the Hyphomycetes into eight sections and two subsections viz. Section I A- Blastosporae, section I B- Botryoblastosporae, Section II – Sympodulosporae, Section III – Annellosporae, Section IV – Phialosporae, Section V – Meristem Arthrosporae, Section VI – Porosporae, Section VII – Arthrosporae, Section VIII – Meristem Blastosporae.

Subramanian (1962) recognised eight different types of spores on the basis of their origin and development (ontogeny). These are as follows:

1. The blastospore: formed as a blownout end from any cell on a fertile hypha or, where spores develop in acropetal chains, from the previously formed spore as well.
2. The gangliospore: developed by the transformation of the swollen tip of a hypha into a spore.
3. The phialospore: abstricted from the tip of a phialide in succession, endogenous or exogenous.
4. The porosporae: formed through minute terminal or lateral pores on the wall of the conidiophores.
5. The arthrospore: formed as a result of septation and breaking up of simple or branched hyphae.
6. The meristem arthrospore: formed at the tip of a conidiophore, which remain meristematic, and differentiated in basipetal succession, such spores may or may not form chains.
7. The spiculosporae: formed at the tip of elongate pointed structures resembling a 'spike', as in some entomogenous fungi (*Beauveria, Spicaria* etc.).
8. The chlamydocospore: formed by transformation of existing elements of vegetative hyphae becoming thick-walled and endowed with dense cell contents.

The eight types of spores defined above and as delimited here are easily understood and may be applied without difficulty for taxonomic purposes i.e., in
the delimitation of taxa and also in the identification of taxa. The seven types of 'dispersal spores' thus delimited and defined, six families have been recognised (Subramanian, 1962) as follows:

1) Torulaceae - characterised by blastospores; 
2) Bactridiaceae - characterised by gangliospores; 
3) Tuberculariaceae - characterised by phialospores; 
4) Helminthosporiaceae - characterised by porospores; 
5) Coniosporiaceae - characterised by meristem arthrospores; 
6) Geotrichaceae - characterised by ordinary arthrospores.

Subramanian divided the Hyphomycetes further into 24 sections on the basis of secondary criteria i.e. initiation and development among in his six families. Thirteen sections were in the Torulaceae, four in the Bactridiaceae, two in the Tuberculariaceae, two in the Helminthosporiaceae, two in the Geotrichaceae and one in the Coniosporiaceae.

Barron, George. L. (1972), "Hyphomycetes of soil Fungi" divided them into 10 groups viz. Blastosporae, Botryoblastosporae, Sympodulosporae, Aleuriosporae Annellosporae, Phialosporae, Meristem Arthrosporae, Porosporae, Arthrosporae and meristem Blastosporae, mycelia sterile i.e. conidia lacking, the units of reproduction or perennation consisting of irregular groups of cells or sclerotia. Of course, we know not much about these fungi taxonomically and thus their further study will add much and will be utilize in their taxonomy and classification. Therefore, we considered them fungi-imperfect in which no perfect state is known or absent or lost or so far not discovered.

Classification of Coelomycetes:

In order to separate hundreds of imperfect fungi into convenient groups of form orders and form families, Saccardo (1886) has proposed five groups viz. Amerosporae, Didymosporae, Phragmosporae, Staurosparae and Helicosporae, belonged to four orders viz. Agonorygates, Moniliales, Sphaeropsidales and Melanconiales on the basis of development and formation of conidia / propagules.
Klebahn (1918) classified the imperfect fungi and divided into four orders on the basis of conidia produced within pycnidia and acervuli singly or in chains viz. Sphaeropsidales and Melanconiales. In the order Sphaeropsidales there are 4-families viz. Sphaeropsidaceae, Zythiaceae (Nectrioidaceae), Leptostromataceae, and Excipulaceae. In Melanconiales, only one family—Melanconiaceae.

Grove (1919) accommodated these fungi in a single category the extremes of pycnidial and acervular forms and adopted the term “Coelomycetes” for the assemblage of fungi with conidia borne within a cavity of the substrate in which the fungus grows as opposed to Hyphomycetes where conidia are borne on the exterior of the substrate bearing the fungi. Grove (1935, 1937) adopted the Saccardoan system to delimit genera and species on the basis of morphological criteria such as stroma, colour and texture of pycnidia and pycnidiohrophores and size, shape, colour and septation of conidia. These characters are often variable.

Bessey, E. A. (1950) accepted Klebahn’s (1918) system of classification of imperfect fungi and followed his system.

In 1953, Hughes proposed that conidiogenesis should be the primary basis for the classification of the Hyphomycetes and conjectured that this scheme should be equally good for Coelomycetes. He introduced the following 8-sections showing major types of conidial production:

Section IA –Blastosporae, Section B – Botryoblastosporae,
Section II – Sympodulosporae, Section III – Annellosporae,
Section IV – Phialosporae, Section V – Meristem Arthrosporae,
Section VI – Porosporae, Section VII – Arthrosporae, Section VIII – Meristem Blastosporae.

Spore types in the Fungi Imperfecti were described and illustrated by Subramanian (1962), Tubaki (1963) and Barron (1968). Subramanian (1972) studied well relationships in conidium ontogeny and published schematic diagrams of true and false chains of conidia that are products of different modes of ontogeny. Morgan-Jones, Nagraj and Kendrik (1972) studied the percurrently
proliferating phialides in the conidium ontogny of the Coelomycetes. Merezhko (1976) discussed generic affinities between many Sphaeropsidales and Ascomycetes the well accepted fact i.e. anamorphs and teleomorphs-relation and confirmed by cultural studies. Sutton, B. C. (1980) whose most valuable contribution to the class Coelomycetes.

Classification of Basidiomycetes:

Bessey (1950, 1968) classified the fungi of the class Basidiomycetes into three sub-classes viz. Heterobasidiae, Teliosporeae and Eubasidiae. Subclass Teliosporae has been divided into two orders i.e. Uredinales and Ustilaginales. The subclass Heterobasidiae is characterised by:

1. The basidium may be elongated and transversely divided by three septa into four cells from each of which a sterigma arises and produces a single basidiospore.
2. It may be rounded and divided into four cells by vertical septa.

On this basis Bessey (1950) recognises four orders based upon the four types of basidia viz. Auriculariales, Dacrymycetales, Tremellales and Tulasnellales.

In these four orders there is marked parallelism of evolution of spore fruit structure from effused, film-like, cushions, shelves, stipitate pilei etc. On the contrary the groups have been produced by a more or less parallel evolution from primitive forms that have been lost. Gilbert (1921) has studied the nuclear behavior in the Heterobasidiae and found that in their essentials, they are identical with those occurring in the Eubasidiae. In the order Auriculariales, Bessey (1950) included three families i.e. Auriculariaceae, Phleogenaceae and Septobasidiaceae; in the order Dacrymycetales included single family i.e. Dacrymycetaceae; in the order Tremellales includes three families viz. Tremellaceae, Sirobasidiaceae and Hyaloriaceae; in order Tulasnellales included single family viz. Tulasnellaceae.

Gaumann and Dodge (1928) recognised three families in the order Auriculariales which was accepted by Bessey.

Martin (1944) recognised three families of the order Tremellales i.e. Tremellaceae, Sirobasidiaceae and Hyaloriaceae, on the basis of basidial and
basidiospore morphology. This was accepted by Bessey and mentioned in his book (1968).

Bessey (1950, 1968) has classified the subclass-Eubasidiae, into two groups 1. Hymenomycetaceae and Gasteromycetaceae. Heim (1934) included in Hymenomycetes one order-Agaricales; two order i.e. Polyporales (or Aphyllophorales) and Agaricales; or several orders but Heim (1934) distinguished two orders; those in which the basidia are stichobasidial (Polyporales) and those in which the nuclear division chiastobasidium (Agaricales). But Bessey considered only one order i.e. Agaricales in Hymenomycetes.

Elias Fries (1821-1832) has made an extensive studies upon the Hymenomycetes. His original classification was based the studies of Persoon (1796-1818) whose later work in his earlier publications, were contemporaneous. He recognised five families within the Hymenomycetes of the order Agaricales viz. Agaricaceae, Polyporaceae, Hydnaceae, Thelephoraceae and Clavariaceae on the basis of hymenium character.

Several families have been segregated from those above. Bessey (1950), recognised the Exobasidiaceae, segregated from the Thelephoraceae and the Boletaceae and Fistulinaceae, separated from the Polyporaceae.

As more and more species and genera of the Hymenomycetes became known it was necessary to find other characters for their identification than the external morphological ones Patouillard (1900) recognised two main groups: Aphyllophorales, with the hymenium naked from the beginning and capable of continued to expansion, and Agaricales, with the hymenium more or less lamellar and hemiangiocarpic. Later, Bessey called these as Polyporales and Agaricales respectively. The order Polyporales which include 8-families viz. Exobasidiaceae, Thelephoraceae, Cantharellaceae, Clavariaceae, Hydnaceae, Polyporaceae, Fistulinaceae, Meruliaceae. Patouillard (1900) makes an entirely different arrangement of the Hymenomycetes families i.e. Boletaceae and Fistulinaceae were united with the Polyporaceae. Maire (1937) and Singer (1936) removed the
Cantharellaceae from the Agaricales but Heim (1934) retains this family in the Agaricales.

Gasteromycetes: The name Gasteromycetes is given to a group including those orders of Basidiomycetes, which have one-celled, two to four-spored basidia produced within closed spore fruits. Fischer (1933) arranged these fungi in several parallel series each ranging from simple to complex structures. In first series, the spore fruit is mainly fleshy, with well-developed hymenial chambers. It does not undergo partial autodigestion and depends upon decay for the distribution of its spores. This series contains forms of interesting complexity from Protagastraceae to Hymenogastaceae and on to Sclerodermataceae on the one hand and on the other, through the Hydnaniaceae and finally to the Secotiaceae, a family has closed connection with the Agaricales. In second series, leads from the partially gelatinous or cartilaginous Hysterangiaceae to the Clathraceae and Phallaceae, with increasing tendency to the autodigestion of the gleba to form a slimy, evil-odorred mass attractive to insects, which distribute the spores. A third series, arising again in the Hymenogastaceae leads to the Lycoperdaceae, Geastraceae and Tulostomataceae and possibly the Podaxaceae. A fourth series shows by the Sphaerobolaceae, Nidulariaceae and the Sclerodermataceae. These probably do not form a connected series but represent separate evolutionary changes from both the Hymenogastrales and the Sclerodermatales. Therefore, Fischer (1933) recognised seven orders viz. Protagastrales, Hymenogastales, Sclerodermatales, Lycoperdales, Nidulariales, Sphaerobolales, Phallales etc. Later on, Sanford M. Zeller (1948, 1949) recognised 9 orders and 32 families.

Ainsworth, G. C. et al. (1973) classified the Gasteromycetous fungi into 9 orders on the basis of the presence or absence of a hymenium is the most fundament criterion viz. Podaxales (1 family), Phallales (6 families), Hymenogastales (3 families i.e. Gastrosporiaceae, Protagastraceae and Hymenogastaceae), Lycoperdales (4 families–Arcachniaceae, Mesoprelliaceae, Geastraceae, Lycoperdaceae), Gautieriales (fam.–Gautieriaceae), Tulostomatales (2 fam.–Calostomataceae and Tulostomataceae) Nidulariales (2 fam.–
Sphaerobolaceae and Nidulariaceae), Melanogastrales (2 fam.- Melanogastraceae and Torrendiaceae), Sclerodermatales (3 fam. – Astraceae, Glischrodermataceae and Sclerodermataceae).

In general, it appears that there is splitting behaviours commonly observed in every group of fungi from the taxon-genus upwards using most modern methods- techniques based taxonomic – mycological research and using characters from morphology to molecular and biochemical studies and made our understanding deeper and deeper but far from perfection and reflected in the systems of classification which are not static but most dynamic – ever-changing.