Mosul University

Mycology

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Alexopoulos, C.J., Mimis, C.W., Blackwell, M. 91996): Introductory Mycology, 4th.edition, New York, Wiley-Liss,

Mycology:

Deals with the study of fungi from the lower to the upper ones on the scale of evolution starting from the simple-structure and reproduction fungi to the most complicated ones in terms of their structure or their fruitage bodies. This discipline studies all types of fungi thoroughly including:

1- Studying the external appearance of fungi.

2-Reproduction.

3-living styles.

4-The vegetative structure of their bodies.

5-Propagation structures.

6-Sexual and nonsexual reproduction.

7-Life cycles.

8-Classification.

9-Their harmful and useful effects.

History of Mycology:

The term "mycology" is derived from Greek word "mykes" meaning mushroom. Therefore mycology is the study of fungi.

The ability of fungi to invade plant and animal tissue was observed in early 19th century but the first documented animal infection by any fungus was made by Bassi, who in 1835 studied the muscardine disease

of silkworm and proved the that the infection was caused by a fungus *Beauveria bassiana*.

In 1910 Raymond Sabouraud published his book *Les Teignes*, which was a comprehensive study of dermatophytic fungi. He is also regarded as father of Medical Mycology.

The knowledge of man about fungi is as old as using bread, but this knowledge hasn't found its way into scientific study only after the invention of the microscope by **Livinhook** more than 400 years ago and that the study of fungi had begun to develop by **Antoni Michele** who is considered the founder of fungi science (**the father of fungi science**) as well as Carolus Linnaeus (1707–1778) (The father of Botany).

Then in 1837 came the scientist **Person** who was able to improve the microscope and had much more fungi followed by the scientist **Anton de Bary** who achieved many deeds particularly the discovery of many life cycles of fungi among which are **rust fungi**.

Mycology has made use from other sciences such as **Cell scienc**e, **Biochemistry** , **Molecular biology** and other sciences that helped in the development of Mycology through studying their division, their life cycles and the possibility of using them in solving human's problems and his wellbeing. The story of the discovery of **Penicillin** and other antibiotics are not far from our minds, and time might come when feasts contribute in solving one of the greatest problems of humanity: the lack of nutrition via making use of industrial and agricultural residues in producing **Single Cell Protein (SCP).**

Humanity has witnessed so many disasters caused by fungi. Examples for this is when the Russian army was infected in the 18th

century, poisoned with the Ergotism disease because of feeding on flour containing stony bodies of ***Claviceps purpurea***.

Fungi has also caused a disaster in Ireland, t**he Irish Famine 1945-1946** which resulted in the death of more than million people who starved to death because they were infected by potato plants which were died because of blight disease caused by *Phytophythora infestans* and forced more than other million to immigrate to north America.

Fungi also caused another disaster in Bangladesh in 1941 when the rice crop was infected with blight disease caused by *Pyricularia oryzae* resulted in the death of about half million people.

What are fungi ?

It is too hard to give a constant definition of fungi due to the great number of this group, their diversified and overlapped characteristics. Still, the term fungi is referred to the group of the organisms that are characterized by having Eukaryote and Spores-bearing (Spores = germs), non-chlorophyll, sexual and asexual reproduction and their bodies are usually formed of varied linear structures and their cells are surrounded with a cellular wall .These walls contain Chitin.

Beneficial Effects of Fungi:

1. **Decomposition** - nutrient and carbon recycling.
2. Biosynthetic factories. The fermentation property is used for the **industrial production** of alcohols, fats, citric, oxalic and gluconic acids.
3. Important sources of **antibiotics**, such as Penicillin and Cephalosporin.

4. Model organisms for biochemical and **genetic studies**. Eg: *Neurospora crassa*

5. *Saccharomyces cerviciae* is extensively used in recombinant DNA technology, which includes the Hepatitis B Vaccine.

6. Some fungi are **edible** (mushrooms).

7. Yeasts provide nutritional supplements such as **vitamins and cofactors**.

8. *Penicillium* is used to flavor Roquefort and Camembert cheeses.

9. Ergot produced by *Claviceps purpurea* contains medically **important alkaloids** that help in inducing uterine contractions, controlling bleeding and treating migraine.

10. Fungi *(Leptolegnia caudate* and *Aphanomyces laevis*) are used to trap mosquito larvae in paddy fields and thus help in **malaria control**.

Mycology divided into :

1-Medical Mycology

2-Plant Pathology (Phytopathology).

3-Fungal Genetic.

4-Industerial Mycology.

Harmful Effects of Fungi:

1. Destruction of food, lumber, paper, and cloth.

2. Animal and human diseases, including allergies.

3. Toxins produced by poisonous mushrooms and within food (Mycetism and Mycotoxicosis).

4. Plant diseases.
5. Spoilage of agriculture produce such as vegetables and cereals in the go down.
6. Damage the products such as magnetic tapes and disks, glass lenses, marble statues, bones and wax.

General properties of fungi:

1. They are **eukaryotic**; cells contain membrane bound cell organelles including nuclei, mitochondria, golgi apparatus, endoplasmic reticulum, lysosomes etc. They also exhibit mitosis.
2. Have **ergosterols** in their membranes and possesses 80S ribosomes.
3. Have a rigid cell wall and are therefore non-motile, a feature that separates them from animals. All fungi possess cell wall made of **chitin.**
4. Are **chemoheterotrophs** (Heterotrophs) (require organic compounds for both carbon and energy sources) and fungi lack chlorophyll and are therefore not autotrophic.
5. Fungi are osmiotrophic; they obtain their nutrients by **absorption**.
6. They obtain nutrients as **saprophytes** (live off of decaying matter) or as **parasites** (live off of living matter).
7. All fungi require water and oxygen and there are no obligate anaerobes.
8. Typically reproduce **asexually** and/or **sexually** by producing spores.
9. They grow either reproductively by budding or non-reproductively by hyphal tip elongation.

10.7. Fungi contain a large quantity of proteins, which is a direct nutrition source such as *Fusarium venanatum and Agaricus bisporus*.

11. **8.** Many kinds of them produce toxic materials for man and animal, they are called Mycotoxins such as Aflatoxins.

12. They are considered the base for many industries such as fermentation, an example for that is Saccharomyces (*Saccharomyces: cerevisiae*) .

13. Some kinds of fungi create symbiotic relationships with high class plants and help them to grow better , an example for that is the Mycorrhiza or with Lichens.

At the academic level (the study and the research), fungi are no longer confined to fungi scientists only, rather they have become favored research tools used by scientists of cytology, genetics, biochemistry and molecular biology due to the **following characteristics**:

1. Fast growth rate.
2. Short period of generation for most fungi.
3. Produce (n) Haploid spores, which make their genetic study easy.
4. Grown in small places, may be in a test tube and on simple environments.
5. Give huge number of strains (individuals).

Nutrition and Growth of fungi:

Fungi cannot get food by themselves; rather they depend on the biomaterials they deteriorate or by invading the living cells. They also get

their food by degrading materials into simple compounds easy to be absorbed, heterotrophy.

Fungi are divided-according to nutrition- into two main groups:

1. Parasitic Fungi

2. Saprophytic Fungi (Saprotrophic)

The fungi of the first group get their food by parasite on other organisms, while the second group's fungi get their food by degrading organic matter dead (plant and animal residues).

In addition to the previously mentioned groups, there are other ones derived from them as follows:

1. **Obligate parasite fungi**: this type of fungi can't live and grow unless parasite on living cells,
2. **Facultative Parasitic Fungi**: Saprophytic fungi but can parasite on organisms under certain circumstances.
1. **Obligate Saprophytic Fungi**: they are only saprophytic on organic materials and never have the ability to parasite.
2. **Facultative Saprophytic Fungi**: parasite fungi but could be saprophytic under certain circumstances in the absence of the host or the sustainer they parasite on.

Fungi could be **symbiotic** with other organisms such as plants particularly with the roots of higher-class plants. These structures are called **Mycorihiza**. The fungus absorbs nutrition materials and deliver them to the plant, and then the plant ensures a suitable environment for the fungus. There are also symbiotic relations between fungi and algae called **Lichens.**

Fungi differ from most plants for their need to readymade and complicated food materials, (they are heterotrophic organisms, i.e. could not make food by themselves rather they degrade organic materials into simple compounds to get elements and energy out of them). Yet, if they were provided with a carbon source such as (Sugar, Maltose, Glucose), they will be able to use these sugars to make proteins and make use of Nitrogen that could be supplied from a nonorganic source such as Nitrates or from an organic source such as (Amino acids) including the (Arginine) plus making use of mineral salts. The following elements are required by all fungi: (C, O, H, N, P, K, Mg, Mn , S, B, Mo ,Cu, Fe, Zn) and some fungi need Ca but its role has not been identified.

In general, Glucose is considered the best source for Carbon and organic, Nitrogen is the best source for Nitrogen followed by Ammonium compounds and Nitrates.

Most of the fungi are able to make the necessary vitamins required for their growth. Yet, a few number of them need certain vitamins such as Biotin, Thiamine or the origins of these vitamins (Precursor's) which are added to the nutrition environment or medium.

Fungi vary in their nutrition needs as some of them can coexist with an organic medium like the *Penicillium* and *Aspergillus* fungi which have

the ability to grow on fruits, skins and seeds provided that an amount of moisture, while other fungi have limited growth such as the fungi that parasite on a certain group or a specified type or a single descent of the sustainer. Generally, the enzymes that the fungi have bound their ability to make use of the nutrition sources upon which most of the fungi exist.

Fungi grow in temperatures range between 0-35°C, but the optimum degree ranges between 20- 30°C. There are fungi that could live under 0° or above 50°C. Organisms are generally divided-per temperatures suitable for growth- into groups with no boundaries separate between them as follows:

1. **Psychrophilic**: (cold-living fungi): grow between 0° and 10°C and the **maximum is 25°C.**
2. **Mesophyllic :** optimum temperature for growth is 5°C or more and could reach 50°C or **more and the minimum is 25°C**.
3. **Thermophiles**: (Heat loving): grow in a middle range of temperatures from 25 to 45°C or more .
4. **Hyper thermophiles** : this type prefer growing in 75°C and can grow in higher temperatures as in the *Pyrodictium* species and the optimum temperature for this type is 82°C and could endure up to 110°C.

Fungi prefer to grow in the acidic nutrition (agricultural) medium and pH-6 is considered the best conditions for most fungi.

Though fungi do not need light during growth, however light is important in Sporulation and Spore dispersal. Some of spores-carrying fungi are of positive phototropic where they throw their spores in the direction of the light.

Structure of fungal body

Fungi's bodies greatly vary in size and shape starting from the uni-cell (yeast) which can be seen by microscope only to the big mushrooms' bodies, which represent only the fruit bodies of fungi. The body of fungus may be apparent over the medium it lives in or concealed or sunken into the sustainer's tissues it parasite on.

Fungi - molds and yeasts

Molds - exhibit filamentous type of growth

Yeasts - pasty or mucoid form of fungal growth

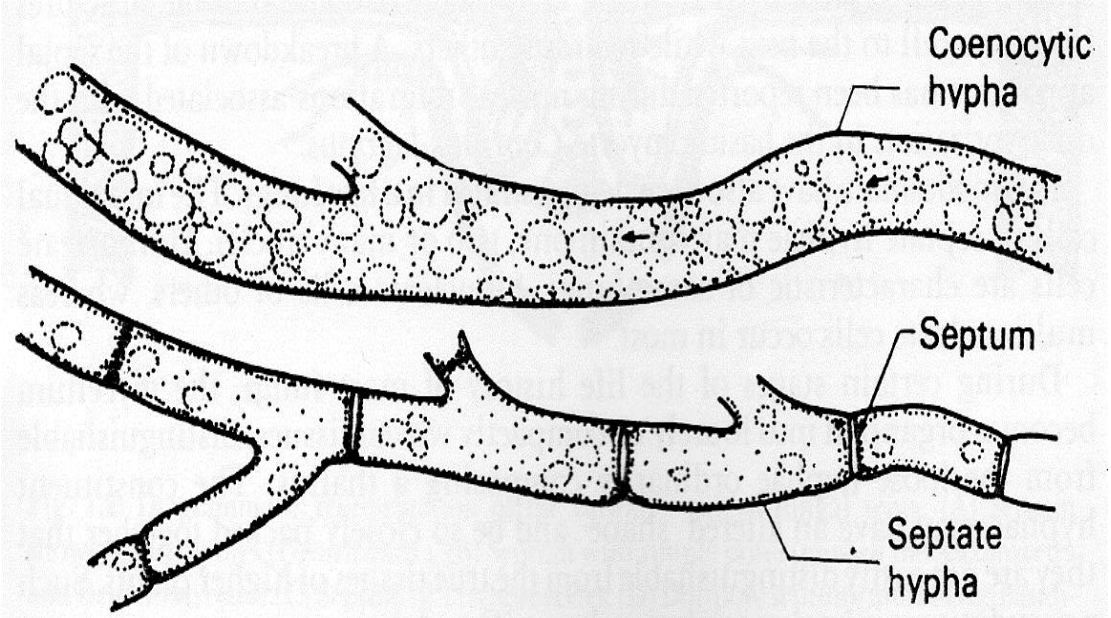


Fig. 1.1: Two types of somatic hyphae.

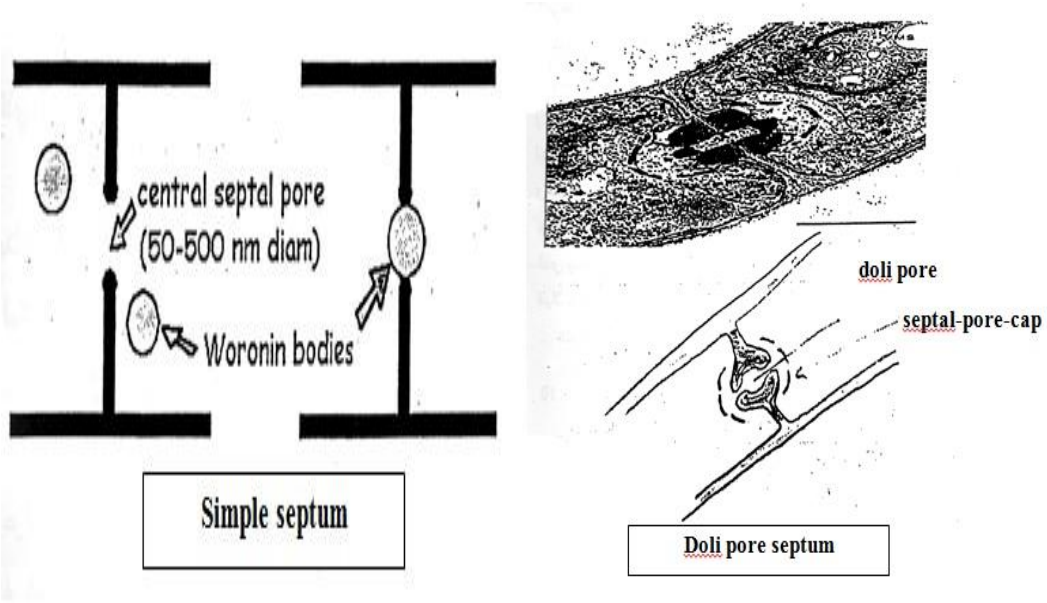
There are many fungi of unicell (Yeast) or might be in the form of (Plasmodium) looks more like animal's body than plant such as in jelly fungi. However, the body in most fungi consists of minute filaments with too many ramifications called the fungal filaments or the Hyphae (the singular form is Hypha). These Hyphae are usually have no color with white cottony appearance or might have different colors (red, orange, black). These filaments form fungal isolation called (Mycelium) and they

might be ramified or non-ramified, divided or undivided (Septate or No-Septate) and the latter is called (Coenocytic).

In this case, fungal isolation is tube filaments where Cytoplasm continues to go through without septa and most of them contain nucleus. In Septate fungal cells might be (Uninuclate) or (Binucleate) or (Multinucleate). Cells are separated from each other by means of Septa (the singular form is septum) and often contain central pores through which the cytoplasmic filaments pass representing the continuation of the living material among fungal cells. Crosswise septa are formed as an internal circle of a wall, then gradually widen towards the center, then the process ends.

The central pore which allows food pass through from one cell to another and sometimes the nucleus and the cavity is formed besides a little formation of septa at the back of the Hyphal tip. The septa is simple in all fungi except in some types of Basidiomycetes and it is a sort of a middle opening in the wall with few simple modifications. Round-shaped bodies might exist on both sides of the pore called **Woronin bodies** play a protection role for the fungus when exposed to inconvenient conditions. These bodies block the pore exposed to bad condition in order to prevent the fungus's content going out and to keep the fungus sound.

In Basidiomycetes, the septum is more complicated as the parts of the transverse wall surrounding the pore swallow up such that take a barrel shape. Moreover, the pore opening is surrounded with fragments of Endoplasmic Reticulum (ER) which take the shape of the arches surrounding the pore called Parenthosome or Septal pore cap , the pore is called Doli pore and the septum is called Dolipore Septum.



Septate Hyphae

Fungal Reproduction

There are two types of reproduction in the fungi :

First **: Sexual Reproduction**

Second**: Asexual or Vegetative reproduction**

1- Sexual reproduction and its structures in the main fungal groups

Names of the main groups of fungi were coined according to the structures developed during their sexual reproduction. Sexual reproduction of the main fungal groups differs significantly between each other and even within those groups.

Oomycota : produce **gametangia**. The Oogonium contains haploid Oocytes produced by meioses. Beside the **oogonium**, **antheridia** develop and produce haploid nuclei via meioses. These nuclei migrate to oogonia across a fertilization tube developed by the **Oogonium** to fertilize an oocyte. Their fusion produces **diploid Oospores** that germinate and produce coenocytic non-septate hyphae with many nuclei. This life cycle is diploid. Differences in life cycles occur within the group: different numbers of oocytes develop in the Oogonia, and the oospores can produce not only coenocytic hyphae but also sporangium-producing zoospores. Both the oogonia and the antheridia can produce hormones that reciprocally stimulate and regulate their development.

Chytridiomycota : have several different types of sexual reproduction. Some have gametes which fuse (gametogamy). They can be similar in size (izogamy) or different (anyzogamy). Moreover, a bigger, non-motile oocyte sometimes develops and is fertilized by a motile gamete (Oogamy). In some chytrids the gametangia fuse

(gametangiogamy) and in others gametes fertilize gametangia. Somatogamy can also happen when thalli of chitrids fuse.

Gametangia develop during the sexual reproduction of zygomycetes. Compatible coenocytic hyphae with **haploid nuclei** develop gametangia, generally opposite to each other, and these gametangia fuse (real gametangiogamy). Afterwards, the nuclei also fuse (karyogamy) and a thick walled, generally spherical zygospore develops. Homothallic **zygomycota** : do not need two gametangia for sexual reproduction and consequently could produce azygospores. Zygospores are held by suspensors which develop from the remaining parts of the two opposing hyphal outgrowths. The name of the Zygomycota originated from the Greek name of yoke ("zygos"), as the opposing gametangia and the zygospore held by two suspensors resemble this structure. The zygospore, strictly speaking, is not a spore but a resting zygote. After karyogamy the diploid nucleus undergoes meiosis, in some cases during spore development, in others during germination of the zygospores. This life cycle is haploid**.** When the zygospore germinates, a sporangium developed from the hypha produces endogenous **haploid mitospores**.

The name of the **Ascomycota** refers to the sac-like structure (ascus) in which the meiospores (ascospores) develop. The reproductive features discussed below refer to the hyphal taxa of the Pezizomycotina. An ascogonium develops with haploid nuclei and produces a trichogyn, a fertilization tube to the antheridium developed from a compatible monokaryotic hypha nearby. The **haploid nucleus** migrates from the antheridium to the ascogonium, from which **dikaryotic hyphae** with two nuclei of different origin will develop in each segment. The dikaryotic hyphae form crosiers

which enable proper segregation of the two different nuclei after mitotic cell division.

Halocarp fungi: all of body fungi change to reproduction structures.

Eucarpic fungi : developing reproduction structures on limited portions of the thallus residue nucleate protoplasm remaining and capable of further mitotic growth and regeneration.

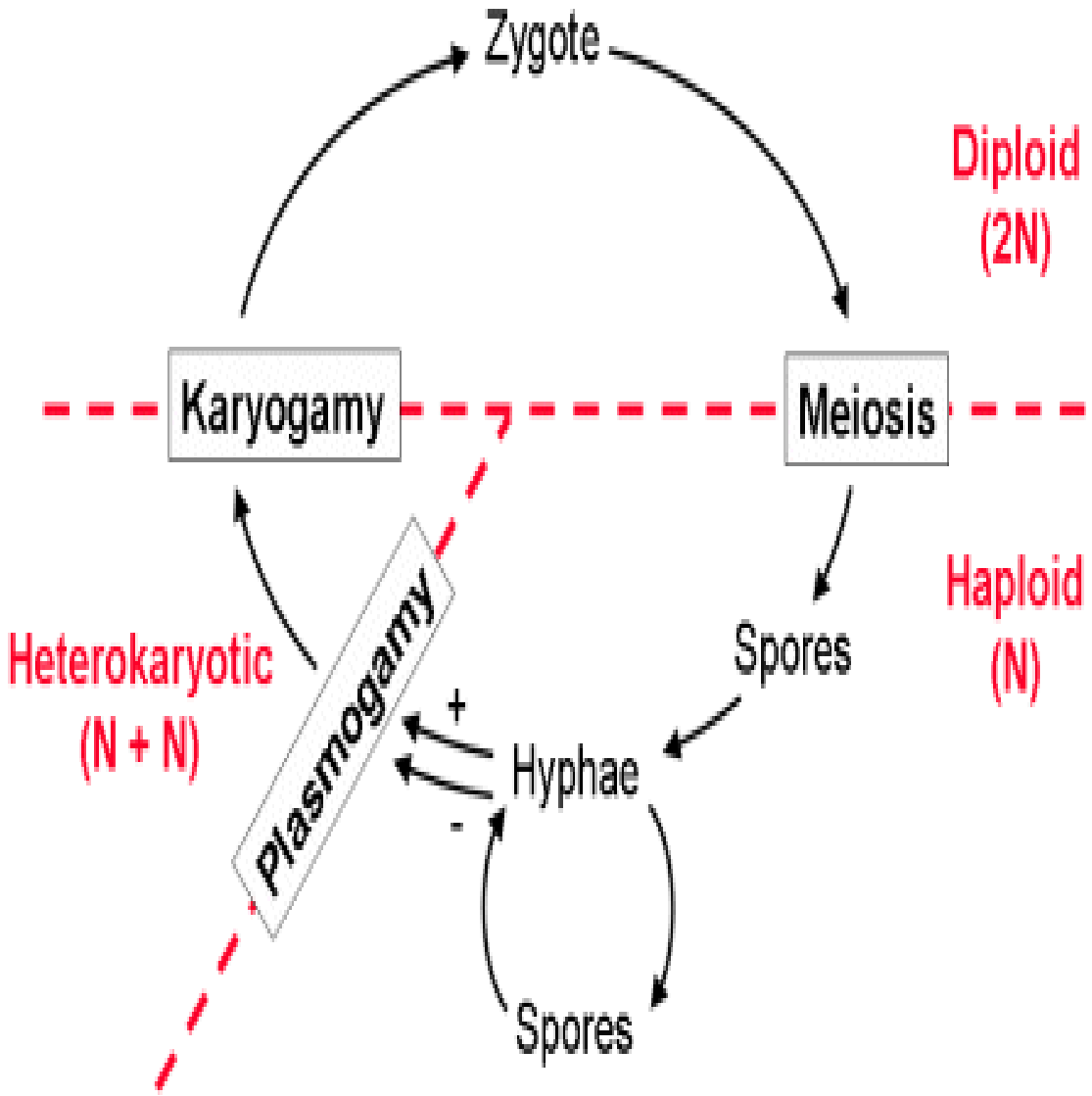
Sexual Reproduction

Sexual reproduction involved three stage:

1- **Plasmogamy: fusion of cells or plasmodil cytoplasms without karyogamy (Nuclear fusion) or precursor**
2- **Karyogamy: the fusion of two sex nuclear after cells fusion (after plasmogamy).**
3- **Meiosis : arranged the genetic formation**

Sexual reproduction is known to occur in all groups of fungi except the Fungi imperfecti or Dueteromycetes. It may involve fusion of gametes, gametangia or hyphae. The process may involve only fusion of cytoplasm (plasmogamy) or fusion of nuclei (karyogamy) or production of meiotic spores (meiospores)

In most of the lower fungi plasmogamy is immediately followed by karyogamy and meiosis. In higher fungi karyogamy is often delayed so that the hyphae remain dikaryotic. This phase of fungal life cycle is called dikaryophase. Such fungi complete their life cycle in three phases a haplophase, a dikaryophase and a diplophase.

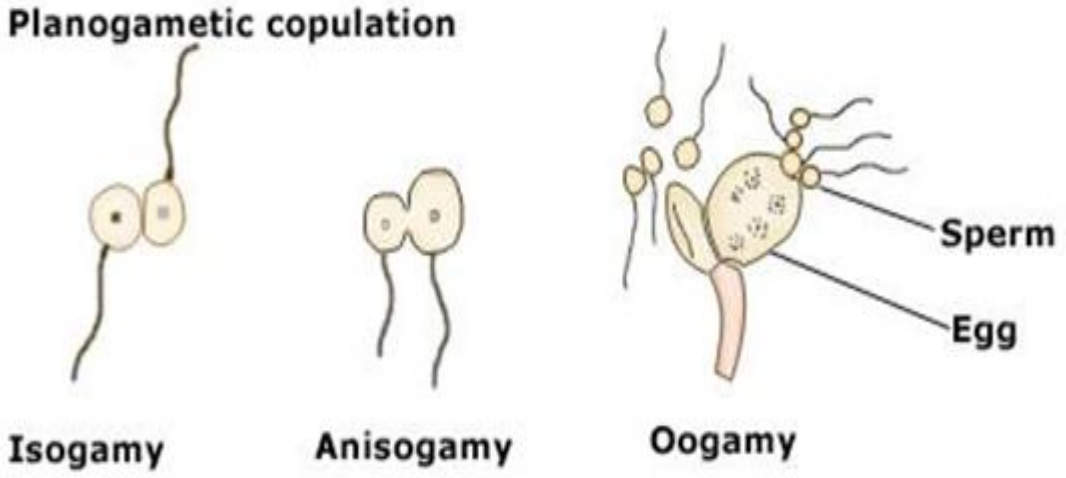


Methods of sexual reproduction:(Methods of plasmogamy)

1- Planogametic Copulation : Here motile gametes called planogametes undergo fusion. When both the gametes are motile and morphologically similar, the fusion process is called isogamy.

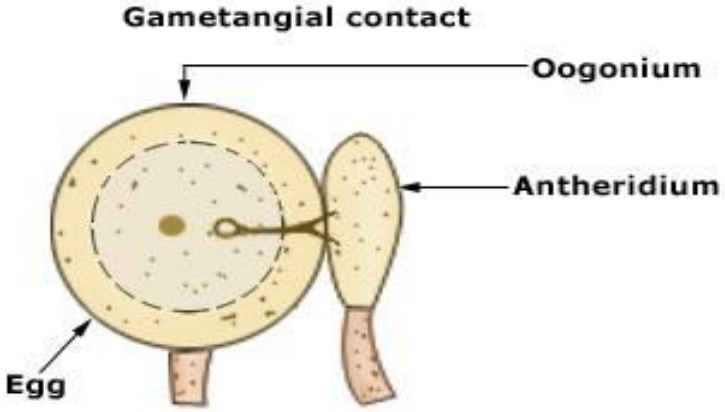
Eg.: Synchytrium When both the gametes are motile but differ in their size, the fusion process is called anisogamy.

Eg.: Allomyces. When one gamete (male) is smaller and motile and the other (female) gamete is larger and non motile, the fusion process is called heterogamy.



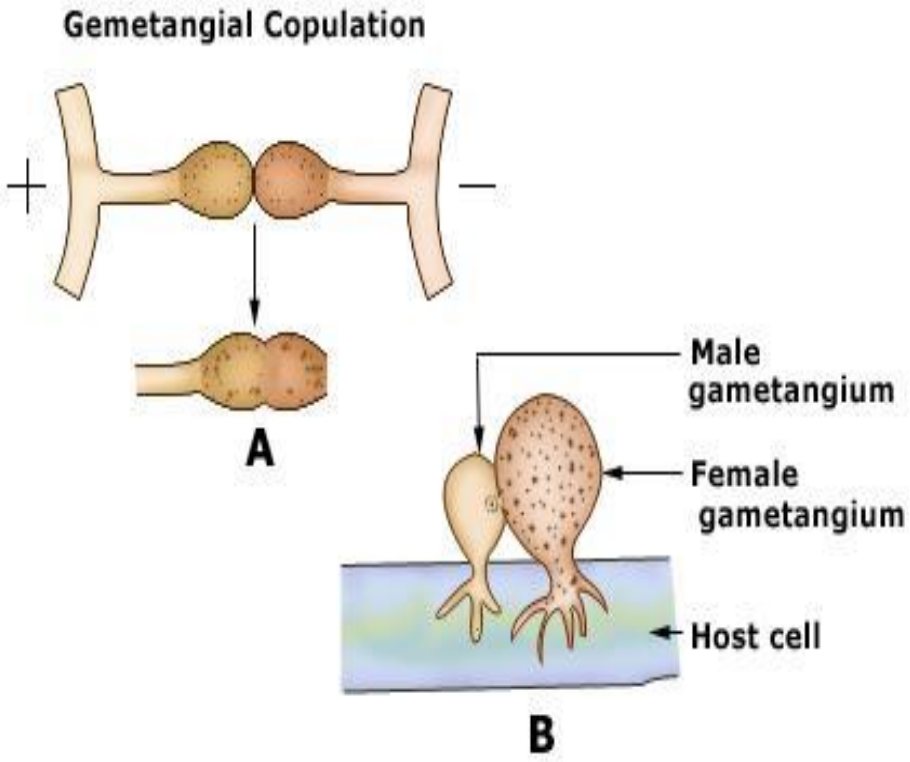
2- Gametangial Contact : Here, gamete bearing structures called gametangia come closer to each other and develop a fertilisation tube through which the male gamete migrates into the female gametangium.

Eg. : *Phytophthora, Albugo.*

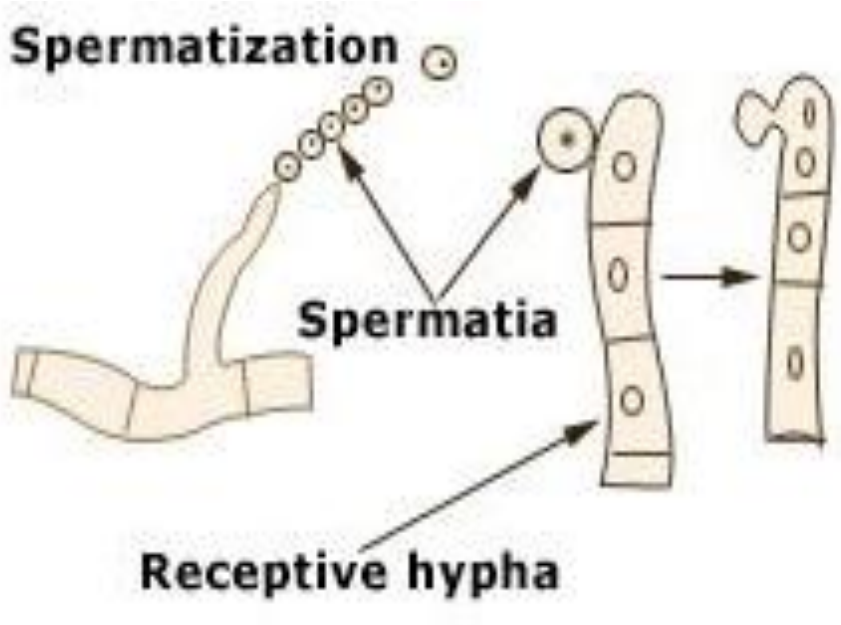


3- Gametangial Copulation : Here, the gametangia fuse with each other, lose their identity and develop into a zygospore

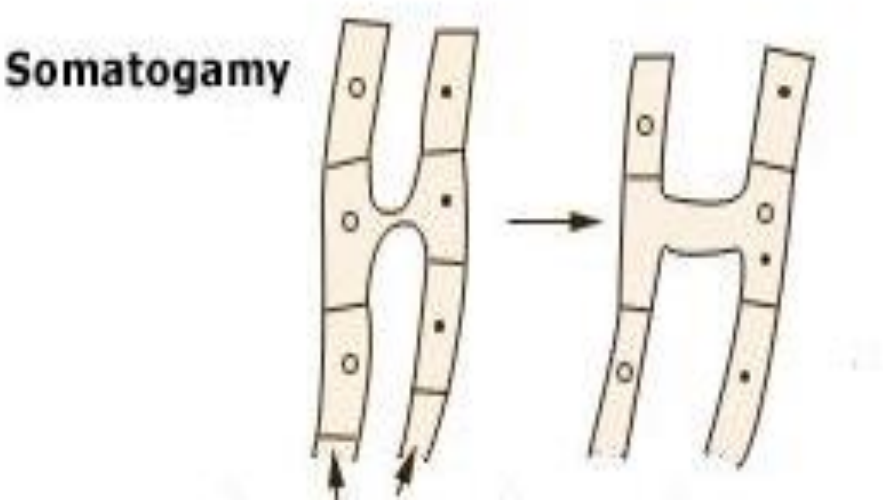
Eg.: Mucor, Rhizopus



4-Spermatisation : In some fungi like Puccinia, tiny unicellular spore like structures called spermatia are formed. They get transferred to female gametangia through various agencies. *Podosphaera or Puccinia graminis*.



5- Somatogamy : In examples like Agaricus, fusion occurs between two somatic cells and involves only plasmogamy. This results in the formation of dikaryotic hyphae. Hence, the process is called dikaryotization. Ex. Mushroom



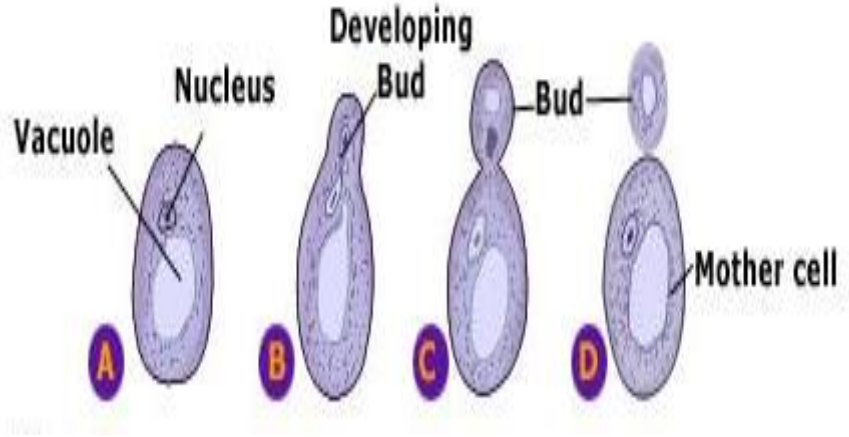
2- Asexual or Vegetative Reproduction

1. Fragmentation
2. Budding
3. Fission
4. Spores formation

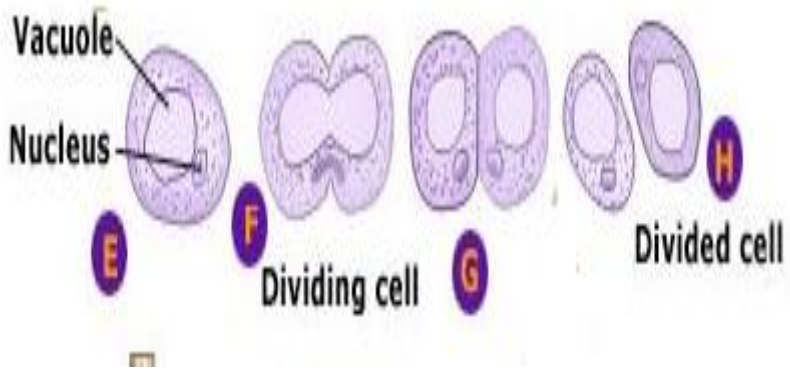
It is the type of reproduction which involves the somatic portion of the fungal thallus. It occurs by the following methods (Methods of asexual Reproduction:(

1- **Fragmentation** : In this process, the mycelium breaks into two or more similar fragments either accidentally or due to some external force. Each fragment grows into a new mycelium.

2-Budding : The parent cell produces one or more projections called buds, which later develop necessary structures and detach to grow into new individuals. Budding is common in unicellular forms like yeast.



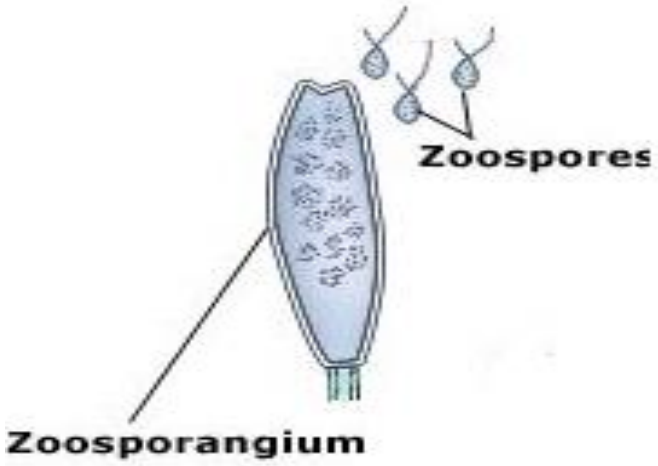
3- Fission : In this process, the parent cell splits into two equal halves, each of which develop into a new individual. Fission is also common in yeast.



4-Spores formation: (Asexual spores)

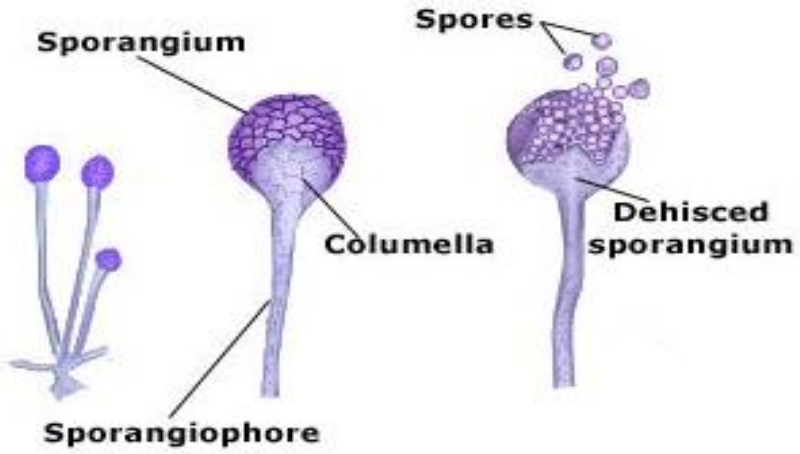
It is the type of reproduction in which special reproductive structures called spores or propagates are formed. The fungal spores always result from mitosis and hence are described as mitospores. Following are the types of spores produced in different groups of fungi:

a-Zoospores : They are flagellated, motile spores produced inside structures called zoosporangia. These spores do not have a cell wall. Such spores are produced in lower fungi such as Achyla and Saprolegnia.

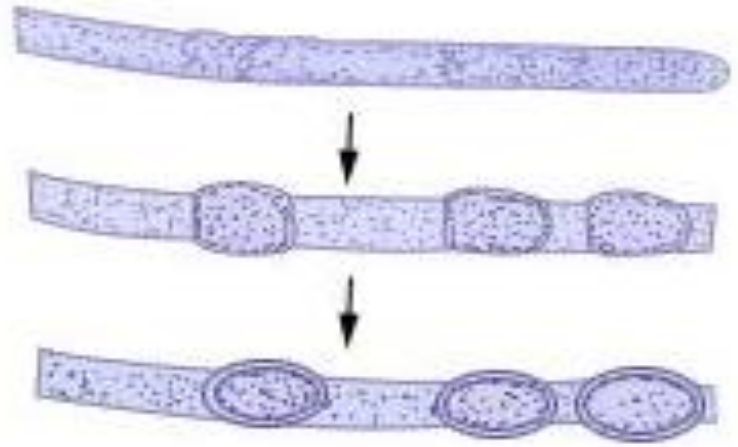


b-Sporagiospores

These are non-motile spores produced inside structures called sporangia in fungi such as Rhizopus and Mucor. These spores are dispersed by wind.



c-Chlamydospores : These are thick walled resting spores which arise directly from hyphal cells. They store reserve food

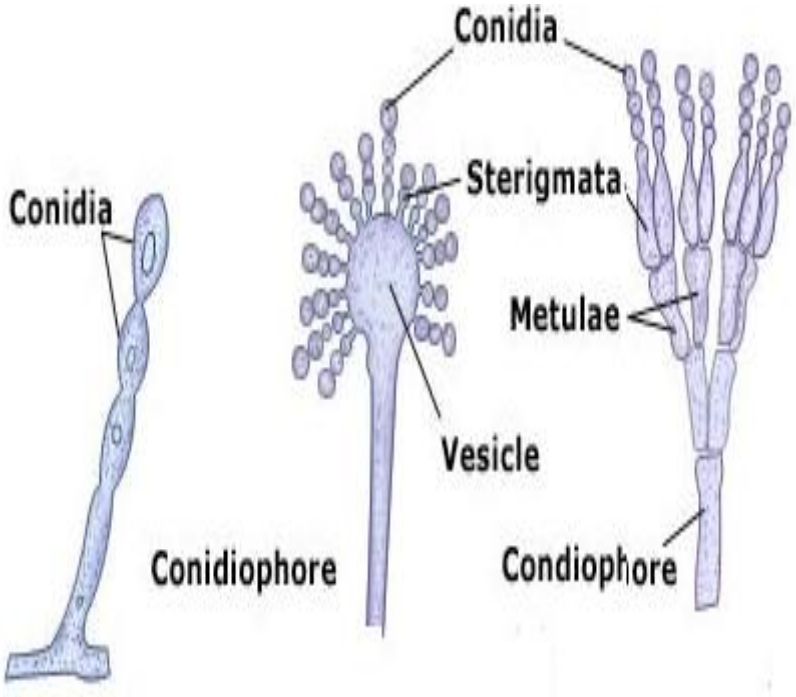


d-Oidia

These are spore like structures formed by the breaking up of hypha cells. They do not store reserve food and hence cannot survive under unfavourable conditions. Such spores are produced in Rhizopus.

e-Conidia

These are non-motile spores produced singly or in chains at the tip of the hypha branches that are called conidiophores. Such spores are produced in fungi like Aspergillus and Penicillium.



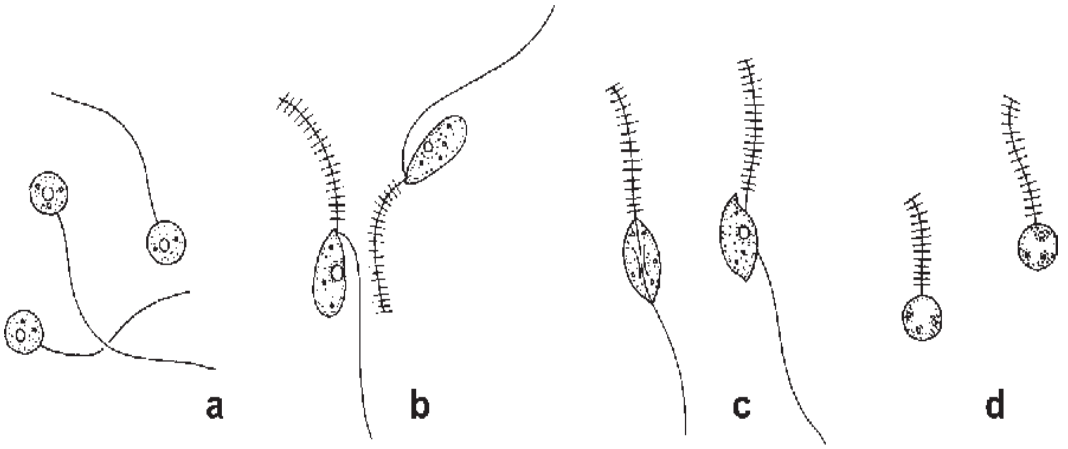
Spores formation:

1-One whip a filament type, back site (Whiplash). E.g. Chytridiomycetes.

2-One whip tensile type front site. E.g. Hypochytridiomycetes.

3-The spore has two whips one is filament whiplash and the other is tensile. E.g. Oomycetes.

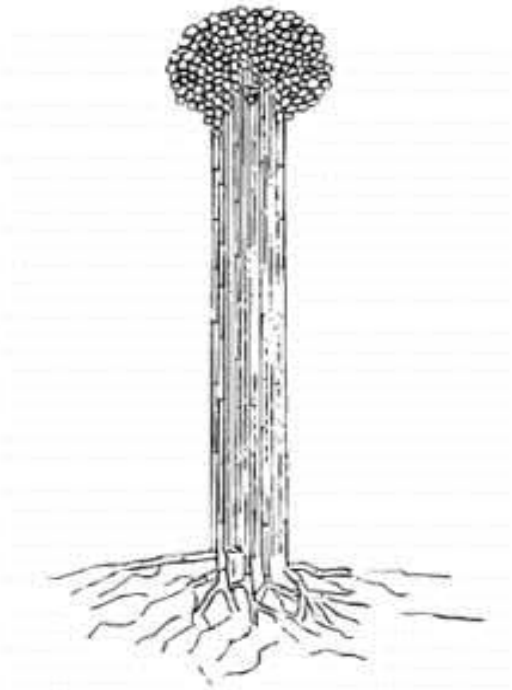
4. The last type of moving spores has two whips of filament type whiplash. E.g. Plasmodiophoromycetes.



Asexual spores borne with Conidiophores in different ways. They are different spores as there is no membrane or a fragment that surrounds it. Conidiophores could be separate or gathered with each other and are borne either separately or in chains. Conidiophores could gather with each other in different ways and form different asexual fruity bodies as follows:

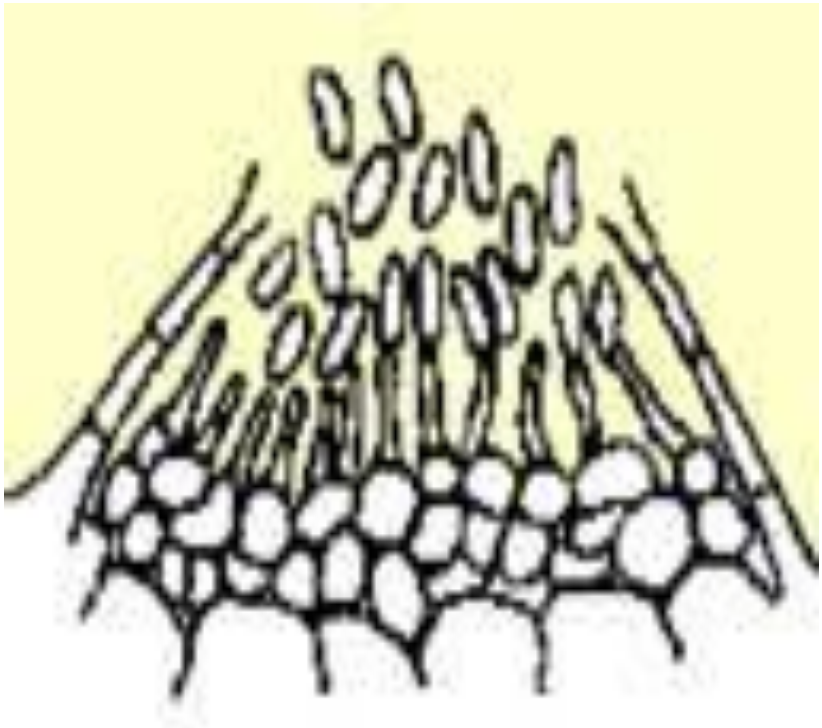
1. Synnemata (synnema) or Coremium:

Conidiophores here take together the shape of a standing unlimited growth column in some cases and Conidia are produced laterally whereas the apex still able to grow such as *Arthrobotryum*.



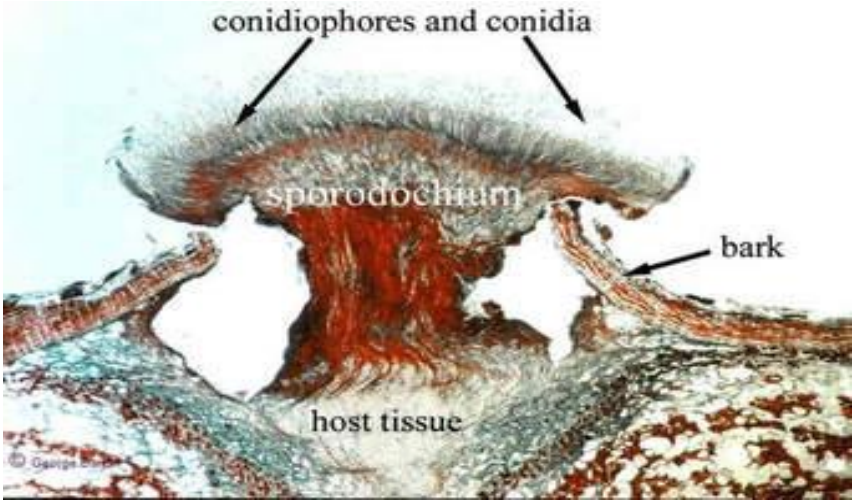
1. **Acervulus:**

This body is made up of Stroma from which the Conidia is stemmed from vertically. Conidiophores are outside the sustainer's body and the Conidiophores are not arranged. E.g. *Fusarium*.



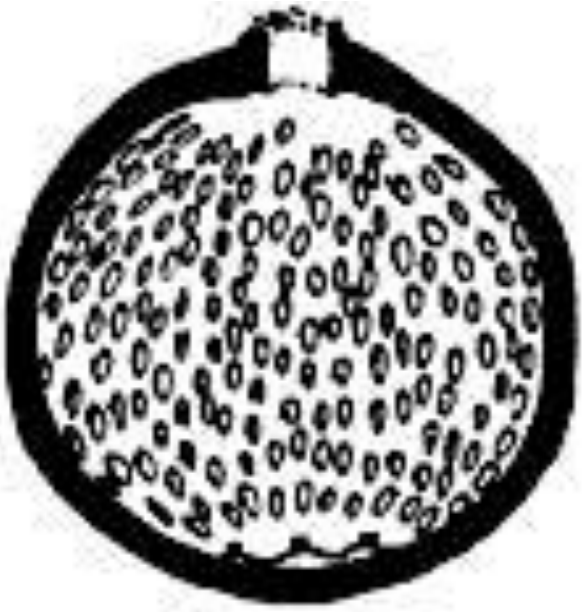
3. Sporodochium:

The Conidiophores are vertically arranged, short and perpendicular on the Synnemata. The sporodochium might contain sterile capillaries called (Setae) or might not. E.g. *Colletotrrichum*.



4. Pycnidium:

Short simple Sporespholes surrounded with Pseudoparanchyma wall taking a ball or flask shape. E.g. *Septoria*.



Life cycle of fungi

In the life cycle of a sexually reproducing fungus, **a haploid phase** (n) alternates with a **diploid phase**(2n) .The haploid phase ends with nuclear fusion, and the diploid phase begins with the formation of the **zygote** (the diploid cell resulting from fusion of two haploid sex cells). **Meiosis** (**reduction division**) restores the haploid number of chromosomes and initiates the haploid phase, which produces the gametes. In the majority of fungi, all structures are haploid except the zygote. Nuclear fusion takes place at the time of zygote formation, and meiosis follows immediately. Only in *Allomyces* and a few related genera and in some yeasts is alternation of a haploid thallus with a diploid thallus definitely known.

1- **Asexual cycle** (Imperfect fungi – *Penicillium* + *Aspergillus*): Commonly found in imperfict fungi where the fungi spend the life cycle the (n) phase because these fungi lose sexual reproduction like the *Penicillium* and the (2n) phase doesn't appear in these fungi.

2- **Haploid cycle** (Zycomycetes and Ascomycetes): This cycle is common in Zygomycetes and some Ascomycetes. These fungi are characterized with spending the whole life cycle roughly in the (n) form except for the stage of (2n) zygote formation.

2- **Haploid cycle with restricted dikaryon** (*Neurospora*): This cycle occurs in some types of Ascomycetes as in the life circle of *Neurospora* .

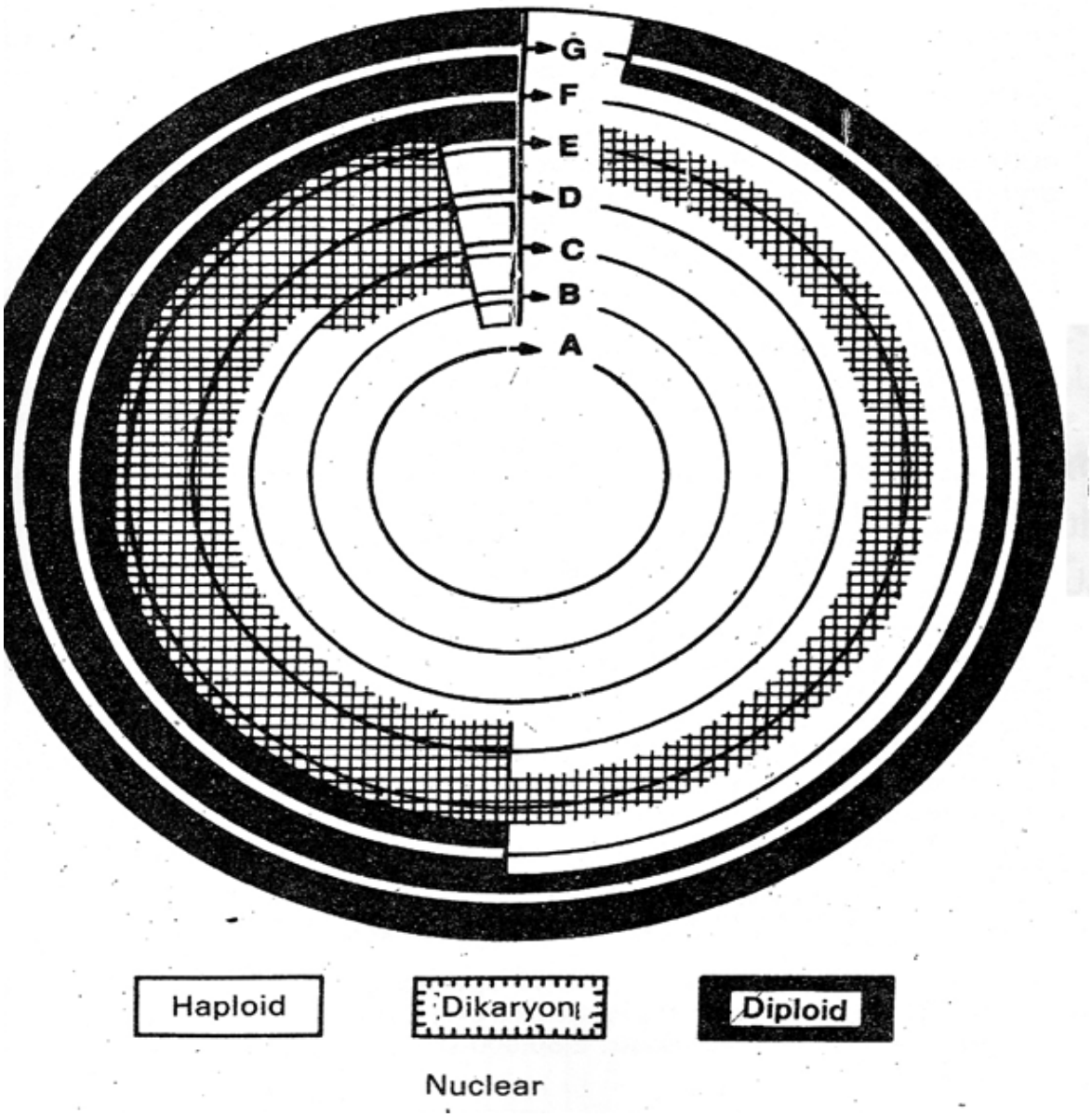
3- **Haploid Dikaryon cycle** (Basidiomycetes): where the two nucleus undiffused directly after the (p) diffusion rather continue for a short time and such the cells be in (n+n) Dikaryon stage and the Hyphae

are dependent on uni-nucleus Hyphae (n) and usually each phase needs different physiological conditions as in *Coprinus.*

5- **Dikaryotic cycle** (Smuts and Yeasts):In this cycle both phases (n) and (2n) meioses each phase to a short period whereas the fungus spends most of its life in a form of (n+n) as in the life cycle of *Ustilago* and *Puccini* .

6- **Haploid –Diploid Cycle** (Chytridiomycetes) :In this cycle the two phases succeed clearly as in *Allomyces*.

7- **Diploid cycle (Myxomycetes)** :In this cycle, the dominant phase in the fungus's life is the (2n). This common circle in the vulnerable organisms such as top plants and animals and be only (n) after meiosis directly. Example of fungi of this life cycle is the Myxomycetes.



Life cycles of fungi

Heterokaryosis

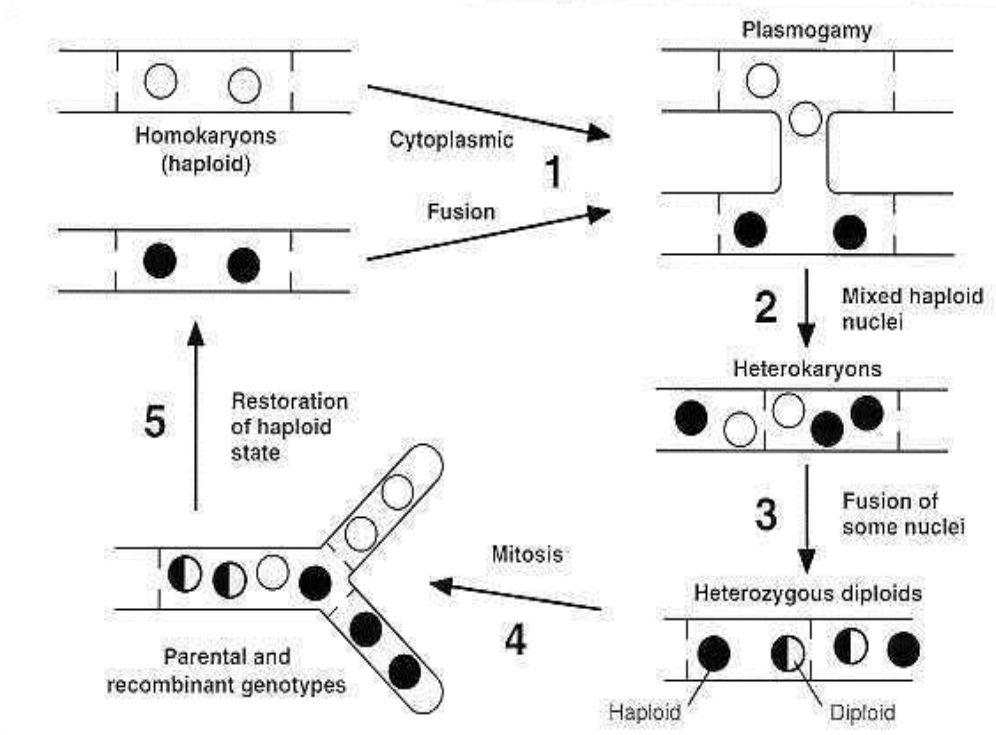
Refers to the presence of **two or more genetically distinct nuclei within the same cell**. While uncommon throughout most of life's kingdoms, heterokaryosis is a hallmark of kingdom Fungi. The fungal subkingdom, Dikarya, which contains two phyla (Ascomycota and Basidiomycota) and 95 % of all known fungal species, is named for its characteristic heterokaryons with exactly two genetically distinct nuclei., the nuclei in these dikaryotic cells fuse and undergo meiosis, resulting in genetically recombined haploid basidiospores or ascospores.

1-Germination of heterokaryotic spores produced heterokaryon hyphae.

2-Introduced different nucleus in monokaryon.

3-Mutation in one nucleus of hypha contain many nucleus.

4- Somatogamy between two hyphae(**genetically distinct nuclei**) or between hypha contain nucleus (haploid = n) and hypha contain (diploid=2n).



Compatibility and Sterility

Introduction

Variation in a population may arise following sexual reproduction. Two compatible isolates of the same fungus may initiate reproduction, and the basic process is remarkably similar in all fungi. The isolates first recognise each other and potentially conjugant regions are induced, probably because of the release and recognition of specific hormones. Growth of one or both towards the other, and contact between the two isolates is followed by fusion of the cells (**plasmogamy**). Nuclei from one pass to the other thallus. Nuclei fuse (**karyogamy**), perhaps multiply and spread, within the second, before the reproductive units are formed. The details of sexual structures, and process and location of **plasmogamy**,

Acording the sexuality fungi divided into 3 types:

1- Monoecious (Hermaphroditic) fungi

2- Dioceous fungi

3- Sexually undifferentiated **(**Un-differentiated fungi**).**

Sexual Compatibility:

How do fungi recognise one another, and once aware, get together? Sexual compatibility is determined by mating systems. Various patterns are found. A few fungi are **homothallic**, and are thus capable of forming sexual structures within a single thallus. Most fungi appear to be **heterothallic**, requiring compatible mating types on different thalli for sexual reproduction to be initiated.

Acording the **Compatibility fungi divided into**

A- Homothallic Fungi:

Homothallism enables isolated fungi to go through the sexual process where no compatible mycelia are present. Homothallic isolates are particularly common in isolates of fungi maintained in the laboratory. Particularly successful genotypes may be sustained by homothallism in a sexually reproducing population.

B-Heterothalic fungi

1- Bipolar Mating Types:

The fungi have a variety of compatibility genes involved in outcrossing. The simplest system is where a single locus has two alleles, leading to a sexual interaction where both alleles are involved. Where only **one type of allele** is present, the interaction is incompatible.

Mating types	A	B
A	-	+
B	+	-

(+) 50 % Self-fertile and (-) 50% Self-sterile

2-Tetrapolar Mating Types:

In the remaining Basidiomycota, mating is more complex. Compatibility is determined by **two loci or linked regions**, each of which may have many different alleles. The mating system is called tetrapolar if **two loci** determine compatibility. Here, a compatible interaction requires different **alleles** at each of the two loci Tetrapolar interactions are more complicated. This is because the interaction may be staged: one locus determines whether the hyphae combine, the second determines whether the organism produces a sexual structure. For a dikaryon to be fertile, the alleles at each locus must be different.

Mating types	A1B1	A1B2	A2B1	A2B2
A1B1	-	-	-	+
A1B2	-	-	+	-
A2B1	-	+	-	-
A2B2	+	-	-	-
25% Self-fertile and 75% Self-sterile				

3-Secondarily homothallic fungi:

Some of these fungi form secondarily homothallic mycelia in apparently heterothallic mycelia. Each spore may contain a pair of compatible nuclei. Indeed, some mating type alleles are "silent" in the genome of some fungi, resulting in successful mating because the mating type has switched.

Mycotoxin:

From the Greek *mykes*, "fungus" and *toxini*, "toxin" is a toxic secondary metabolite produced by organisms of the fungi kingdom and is capable of causing disease and death in both humans and other animals. The term 'mycotoxin' is usually reserved for the toxic chemical products produced by fungi that readily colonize crops.

Examples of mycotoxins causing human and animal illness include **Aflatoxin , Citrinin , Fumonisins , Ochratoxin A** , Patulin , Trichothecenes , Zearalenone , and Ergot alkaloids such as ergotamine. One mold species may produce many different mycotoxins, and several species may produce the same mycotoxin.

Major groups of Mycotoxin

1-Aflatoxin

Aflatoxins are a type of mycotoxin produced by *Aspergillus* species of fungi, such as ***A. flavus*** **and** ***A. parasiticus***.

Aflatoxin Symptoms:

Liver damage, Liver cancer, Pulmonary Edema, Hemorrhage and death

Aflatoxin Types

There are three main types of aflatoxin mycotoxins:

a-**Aflatoxins B**: This group includes aflatoxin B1 and B2. Aflatoxin B1 is the most common aflatoxin, as well as the most toxic and carcinogenic

b-**Aflatoxins G**: This group includes aflatoxin G1 and aflatoxin G2

c-**Aflatoxins M**: This group includes aflatoxins M1 and M2. These aflatoxins are metabolic products which are found in the urine and milk produced by animals which have been given the feed with aflatoxins in it.

2-Ochratoxin

Ochratoxin is a mycotoxin that comes in three secondary metabolite forms, A, B, and C. All are produced by ***Penicillium*** **and** ***Aspergillus*** species. The three forms differ in that Ochratoxin A (OTA) , Ochratoxin B (OTB) and that Ochratoxin C (OTC).

Symptoms

Symptoms may be acute, subacute or chronic depending on the severity of the exposure. OTA has been labeled as a carcinogen and a nephrotoxin and has been linked to tumors in the human urinary tract, although research in humans is limited by confounding factors.

3-Trichothecenes

Trichothecenes comprise a group of toxins that share a common chemical structure, though produced by a variety of fungi particularly ***Fusarium*** and related genera. Purple-red molds, occasionally detected in corn, wheat, and soybeans, signal the presence of trichothecenes.

The trichothecenes include

1-Deoxynivalenol (DON), also known as vomitoxin because of its strong vomiting effect. At levels over 1 ppm, severe weight loss and vomiting occur. Effects on reproduction are unknown, but it is best to avoid feeding breeding animals infected grain.

2-T-2 is a very potent tricothecen, barley, and wheat, which can seriously impair fertility in swine.

Symptoms

Initial symptoms include nausea, vomiting, and burned skin. Dermal exposure results in significant blistering and formation of vesicles, bullae, petechiae, and ecchymoses. Ocular exposure may cause burns and corneal opacification. Respiratory exposure induces a cough, pleuritic chest pain, dyspnea, and hemoptysis. Severe gastrointestinal symptoms such as hematemesis and abdominal pain may occur after inadvertently

swallowing small amounts of aerosolized dispersed trichothecene mycotoxin. Bloody diarrhea and severe dehydration have also been described following mycotoxin exposures in Southeast Asia.

4-Zearalenone

Zearalenone is produced by several ***Fusarium*** molds under cool, wet conditions. It grows on grain before harvest but can worsen in storage. Insect damage increases the susceptibility of crops. Infected corn may be identified by dark purple discoloration and affected wheat by pink tips.

Zearalenone is probably the mycotoxin most detrimental to swine with serious effects on the breeding stock.

Symptoms

Toxicity results in the reddening and swelling of the vulva, increased the size of the mammary tissue, straining with subsequent rectal and vaginal prolapsed, as well as pseudopregnancy and false heat. Fertility problems surface at 100 to 200 ug/l.

Other Selected Mycotoxins

Other Mycotoxins Produced by ***Aspergillus***:

Sterigmatocystin (ST) is a naturally occurring hepatotoxic and carcinogenic mycotoxin produced by fungi in the genera *Aspergillus*, *Bipolaris,* and *Chaetomium* as well as *P. luteum*.

Alternaria **Toxins**

Infects the plant in the field, such as wheat, sorghum, and barley. Also, fruits and vegetables that can cause spoilage in refrigeration. Toxins include alternariol, alternariol monomethyl ether, attenunate, tenuazonic acid, and alter toxins.

Little is know of these toxins; but, toxic effects are seen in rats, chicks, ducklings, and turkeys.

Mycetism: a toxicosis status produced by digesting smut spores, toxic fruiting bodies or fungal sclerotia.

Mycotoxicosis: a toxicosis produced by digesting food containing toxic secondary metabolites (mycotoxins) of fungi.

Mycotoxins: are secondary metabolites of fungi that are recognized as toxic to other life forms.

secondary metabolite: A compound that is not necessary for growth or maintenance of cellular functions but is synthesized, generally, for the protection of a cell or micro-organism, during the stationary phase of the growth cycle. Many are used in foods, pharmaceuticals, and other industrial applications.

Historical

Modern mycotoxicology was not developed until the discovery of aflatoxins in the early .The 1960s as the causative agent in the peanut meal causing the "Turkey X" disease that killed more than 10,000 turkeys fed with the contaminated meal. Because aflatoxins are a series of highly potent carcinogens produced by commonly occurring *Aspergillus flavus* and *A. parasiticus*, research has focused new attention on mycotoxins. In the last 60 years, many new mycotoxins have been identified and characterized

Mycoses:

Most fungi are saprophytic or parasitic to plants and are adapted to their natural environment. Infection in humans is a chance event, occurring only when conditions are favorable. Except for few fungi such as the dimorphic fungi that cause systemic mycoses and dermatophytes, which are primary pathogens, the rest are only opportunistic pathogens. The human body is a hostile environment and offers great resistance to fungal invasion. Most fungi are saprophytic and their enzymatic pathways function more efficiently at the redox potential of non-living substrates than at the relatively more reduced state of living metabolizing tissue. Some fungi such as ***Candida*** and ***Malasezzia*** have adapted to the human environment and exist as commensals.

The complex interplay between fungal virulence factors and host defense factors will determine if a fungal infection will cause a disease. Generally, infection depends on inoculum size and the general immunity of the host.

Factors predisposing to fungal infections:

• Prolonged antibiotic therapy, • Underlying disease (HIV infection, cancer, diabetes, etc.) , • Age ,• Surgical procedures,• Immunosuppressive drugs

• Irradiation therapy, • Indwelling catheters,• Obesity ,• Drug addiction

• Transplants, • Occupation

Classification mycoses:

1-Superficial Mycoses

2. Cutaneous mycoses

3-Subcutaneous Mycoses

4-Systemic mycosis

5-Opportunistic Systemic Mycoses

1-Superficial Mycoses

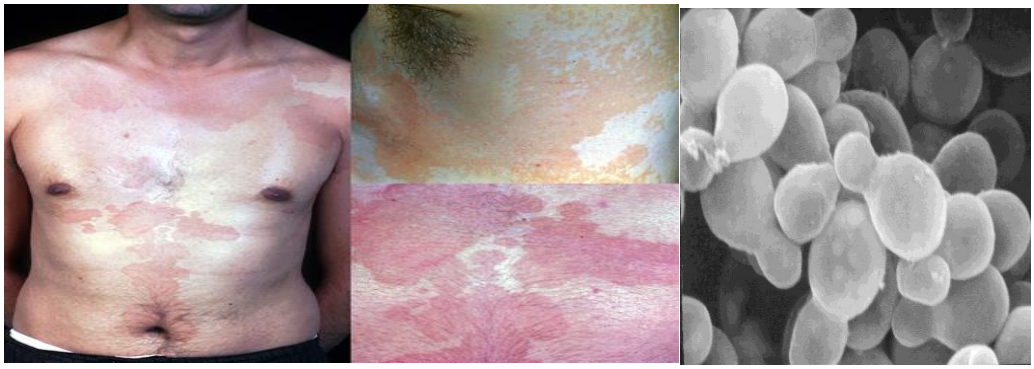
These are superficial cosmetic fungal infections of the skin or hair shaft. **No living tissue is invaded** and there is **no cellular response** from the host. Essentially no pathological changes are elicited. These infections are often so innocuous that patients are often unaware of their condition.

Disease	Causative organisms	Incidence
Pityriasis versicolor(a lipophilic yeast)	*Malassezia furfur*	common
Tinea nigra	*Hortaea werneckii*	rare
White piedra	*Trichosporon* spp	comman
Black piedra	*Piedraia hortae*	rare

A-Tinea Versicolor (pityriasis versicolor):

Malassezia species are basidiomycetous yeasts and form part of the normal skin flora of humans and animals. The genus now includes 14 species of which 13 are lipid dependent.

Pityriasis versicolor : This is a chronic, superficial fungal disease of the skin characterised by well-demarcated white, pink, fawn, or brownish lesions, often coalescing, and covered with thin furfuraceous scales. The colour varies according to the normal pigmentation of the patient, exposure of the area to sunlight, and the severity of the disease. Lesions occur on the trunk, shoulders and arms, rarely on the neck and face, and fluoresce a pale greenish colour under Wood's ultra-violet light. Young adults are affected most often, but the disease may occur in childhood and old age.

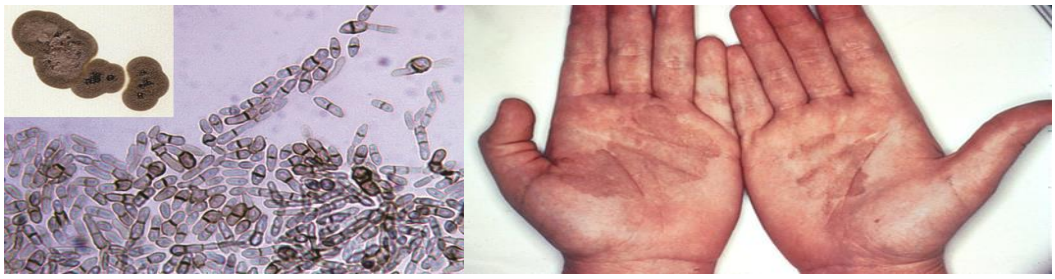


B-Tinea nigra

A superficial fungal infection of skin characterized by brown to black macules which usually occur on the palmar aspects of hands and occasionally the plantar and other surfaces of the skin. World-wide distribution. The aetiological agent is ***Hortaea werneckii*** a common saprophytic fungus believed to occur in soil, compost, humus and on wood in humid tropical and sub-tropical regions.

Skin lesions are characterised by brown to black macules which usually occur on the palmar aspects of hands and occasionally the plantar and other surfaces of the skin. Lesions are non-inflammatory and non-scaling. Familial spread of infection has also been reported.

Note: There is no inflammatoy reaction.

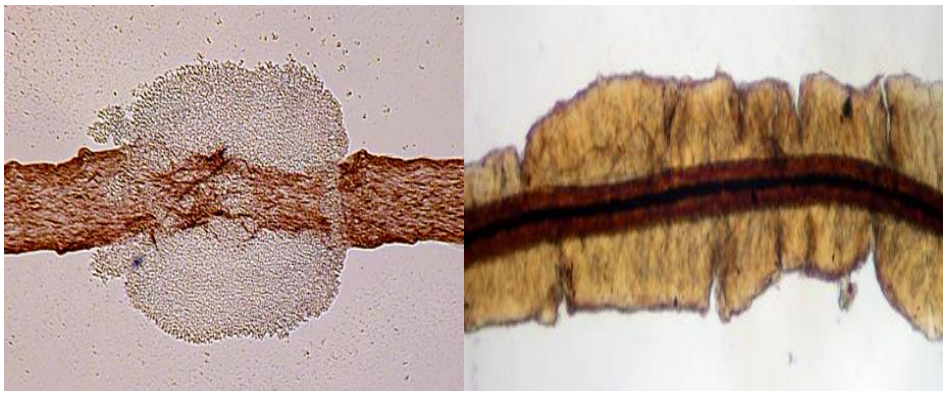
- 

C-White piedra,

White piedra is a superficial cosmetic fungal infection of the hair shaft caused by ***Trichosporon***. Infected hairs develop soft greyish-white nodules along the shaft. Essentially no pathological changes are elicited.

White piedra is found worldwide, but is most common in tropical or subtropical regions.

Trichosporon species are a minor component of normal skin flora, and are widely distributed in nature. They are regularly associated with the soft nodules of white piedra, and have been involved in a variety of opportunistic infections in the immunosuppressed patient. Disseminated infections are often fulminate and widespread, with lesions occurring in the liver, spleen, lungs and gastrointestinal tract. Infections in non-immunosuppressed patients include endophthalmitis after surgical extraction of cataracts, endocarditis usually following insertion of prosthetic cardiac valves, peritonitis in patients on continuous ambulatory peritoneal dialysis (CAPD), and intravenous drug abuse.



D-Black piedra : is a superficial fungal infection of the hair shaft caused by ***Piedra hortae***, an ascomycetous fungus forming hard black nodules on the shafts of the scalp, beard, moustache and pubic hair. It is common in Central and South America and South-East Asia.

Infections are usually localised to the scalp but may also be seen on hairs of the beard, moustache and pubic hair. Black piedra mostly affects young adults and epidemics in families have been reported following the sharing of combs and hairbrushes. Infected hairs generally have a number of hard black nodules on the shaft.

2. Cutaneous mycoses

Cutaneous mycoses extend deeper into the epidermis and also include invasive hair and nail diseases. These diseases are restricted to the keratinized the skin, hair, and nails. Unlike the superficial mycoses, host immune responses may be evoked resulting in pathologic changes expressed in the deeper layers of the skin.

Treatment: azoles, inhibits cytochrome 450 dependent enzyme systems at the demethylation step from lanosterol to ergosterol. Hair-Griseofulvin, oral, affects the microtubular system.

Dermatophytosis (Tinea or ringworm)

Dermatophytosis (tinea or ringworm) of the scalp, glabrous skin, and nails is caused by a closely related group of fungi known as dermatophytes, which have the ability to utilize keratin as a nutrient source, i.e. they have a unique enzymatic capacity [keratinase].

The disease process in dermatophytosis is unique for two reasons:

Firstly, no living tissue is invaded the keratinised stratum corneum is simply colonised. However, the presence of the fungus and its metabolic products usually induces an allergic and inflammatory eczematous response in the host.The type and severity of the host response is often related to the species and strain of dermatophyte causing the infection.

Secondly, the dermatophytes are the only fungi that have evolved a dependency on human or animal infection for the survival and dissemination of their species.

Clinical Manifestations:

Dermatophytes are **fungi** that require keratin for growth. These **fungi** can cause superficial infections of the **skin, hair, and**

nails. **Dermatophytes** are spread by direct contact from other people (Anthropophilic fungi), animals (Zoophilic fungi), and soil (Geophilic fungi).

The common **anthropophagic** species are primarily parasitic on man. They are unable to colonies other animals and they have no other environmental sources. On the other hand, **geophilic** species normally inhabit the soil where they are believed to decompose keratinaceous debris.

Some species may cause infections in animals and man following contact with soil. **Zoophilic** species are primarily parasitic on animals and infections may be transmitted to humans following contact with the animal host .

Zoophilic infections usually elicit a strong host response and on the skin where contact with the infective animal has occurred ie arms, legs, body or face.

The ringworm infections are called different names on basis of the location of infection sites:

a-**Tinea capitis** - ringworm infection of the head, scalp, eyebrows, eyelashes

bTinea favosa - ringworm infection of the scalp (crusty hair)

c-**Tinea corporis** - ringworm infection of the body (smooth skin)

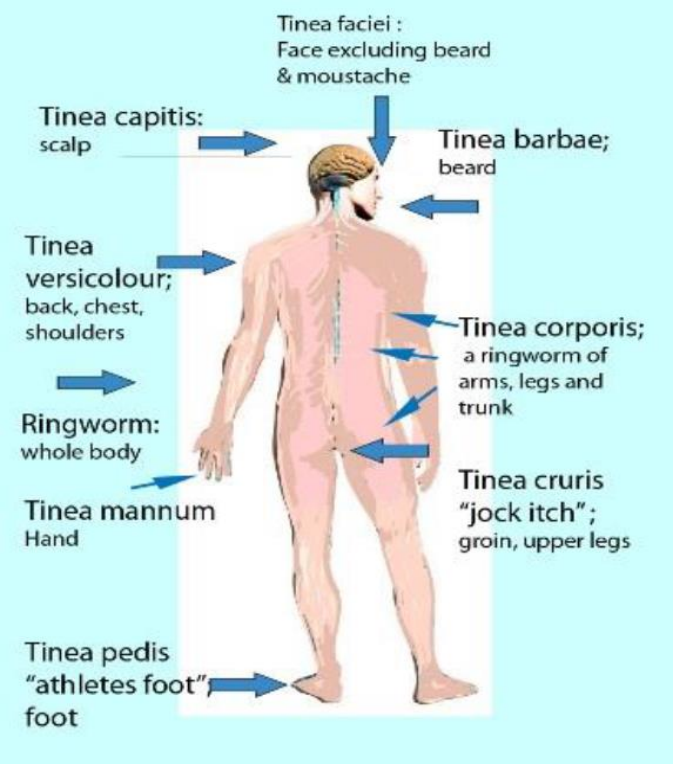
d-**Tinea cruris** - ringworm infection of the groin (jock itch)

e-**Tinea unguium** - ringworm infection of the nails

f-**Tinea barbae** - ringworm infection of the beard

g-**Tinea manuum** - ringworm infection of the hand

h-**Tinea pedis** - ringworm infection of the foot (athlete's foot)



Etiological agents are called dermatophytes - "skin plants". Three important **anamorphic** genera,

Anamorph	**Teleomorph**
Microsporum	*Arthroderma*
Trichophyton	*Arthroderma*
Epidermophyton	*Arthroderma*

A-Tinea pedis:

Infections by anthropophilic dermatophytes are usually caused by the shedding of skin scales containing viable infectious hyphal elements [arthroconidia] of the fungus. Desquamated skin scales may remain infectious in the environment for months or years. Therefore transmission

may take place by indirect contact long after the infective debris has been shed.

Substrates like carpet and matting that hold skin scales make excellent vectors. Thus, transmission of dermatophytes like *Trichophyton rubrum*, *T. interdigitale* and *Epidermophyton floccosum* is usually via the feet. In this site infections are often chronic and may remain subclinical for many years only to become apparent when spread to another site, usually the groin or skin.

B-Tinea cruris:

Tinea cruris refers to dermatophytosis of the proximal medial thighs, preum and buttocks. It occurs more commonly in males and is usually due to spread of the fungi from the feet. Thus, the usual causative agents are *T.rubrum* and *E. floccosum.*

C-Tinea unguium (dermatophyte onychomycosis):

Trichophyton rubrum and *T. interdigitale* are the dominant dermatophyte species involved. In countries like Australia, UK and USA the incidence

of dermatophyte onychomycosis has been estimated to be about 3% of the population, increasing up to 5% in the elderly, with some subgroups such as miners, servicemen and sportsmen etc having an incidence of up to 20% due to the use of communal showers and changing rooms.

It is important to stress that only 50% of dystrophic nails have a fungal a etiology, therefore it is essential to establish a correct laboratory diagnosis by microscopy and/or culture, before treating a patient with a systemic antifungal agent.

Dermatophyte onychomycosis may be classified into two main types;

(1) Superficial white onychomycosis in which invasion is restricted to patches or pits on the surface of the nail; and

(2) Invasive, subungual dermatophytosis in which the lateral, distal or proximal edges of the nail are first involved, followed by establishment of the infection beneath the nail plate. Distal subungual onychomycosis is the most common form of dermatophyte onychomycosis. The fungus invades the distal nail bed causing hyperkeratosis of the nail bed with eventual onycholysis, and thickening of the nail plate.

As the name suggests, lateral subungual onychomycosis begins at the lateral edge of the nail and often spreads to involve the entire nail bed and nail plate. In proximal subungual onychomycosis, the fungus invades under the cuticle and infects the proximal rather than the distal nail bed causing yellowish-white spots which slowly invade the lunula and then the nail plate.

D-Tinea corporis:

Tinea corporis refers to dermatophytosis of the glabrous skin and may be caused by anthrophophilic species such as *T. rubrum* usually by spread from another body site or by geophilic and zoophilic species such as *M. gypseum* and *M. canis* following contact with either contaminated soil or an animal host.

E-Tinea capitis:

Tinea capitis refers to dermatophytosis of the scalp. Three types of *in vivo* hair invasion are recognised:

1. **Ectothrix** invasion is characterised by the development of arthroconidia on the outside of the hair shaft. The cuticle of the hair is destroyed and infected hairs usually fluoresce a bright greenish yellow colour under Wood's ultraviolet light. Common agents include *Microsporum canis, Nannizzia.gypsea, Trichophyton equinum* and *T. verrucosum*.
2. **Endothrix** hair invasion is characterised by the development of arthroconidia within the hair shaft only. The cuticle of the hair remains intact and infected hairs do not fluoresce under Wood's ultraviolet light. All endothrix producing agents are anthropophilic eg *Trichophyton tonsurans* and *T. violaceum.*
3. **Favus** usually caused by *Trichophyton schoenleinii*, produces favus-like crusts or scutula and corresponding hair loss.

Favus of the Scalp

Candidiasis

is a primary or secondary mycotic infection caused by members of the genus *Candida* and other related genera. The clinical manifestations may be acute, subacute or chronic to episodic. Involvement may be localized to the mouth, throat, skin, scalp, vagina, fingers, nails, bronchi, lungs, or the gastrointestinal tract, or become systemic as in septicemia, endocarditis and meningitis. In healthy individuals, *Candida* infections are usually due to impaired epithelial barrier functions and occur in all age groups, but are most common in the newborn and the elderly. They usually remain superficial and respond readily to treatment. Systemic candidiasis is usually seen in patients with cell-mediated immune deficiency, and those receiving aggressive cancer treatment, immunosuppression, or transplantation therapy.

Clinical manifestations:

1. Oropharyngeal candidiasis: including thrush, glossitis, stomatitis and angular cheilitis.

- 

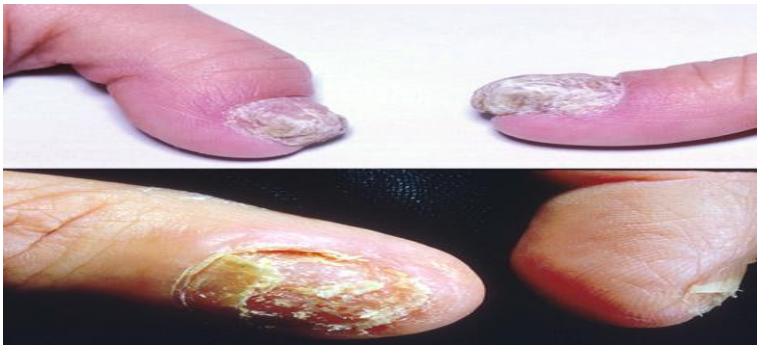
Acute oral candidiasis is rarely seen in healthy adults but may occur in up to 5% of newborn infants and 10% of the elderly. However, it is often associated with severe immunological impairment due to diabetes mellitus, leukemia, lymphoma, malignancy, neutropenia and HIV infection where it presents as a predictor of clinical progression to AIDS. The use of broad-spectrum antibiotics, corticosteroids, cytotoxic drugs, and radiation therapy are also predisposing factors. Clinically, white plaques that resemble milk curd form on the buccal mucosa and less commonly on the tongue, gums, the palate or the pharynx. Symptoms may be absent or include burning or dryness of the mouth, loss of taste, and pain on swallowing.

2. Cutaneous candidiasis: including intertrigo, diaper candidiasis, paronychia and onychomycosis.

Intertriginous candidiasis is most commonly seen in the axillae, groin, inter- and sub-mammary folds, intergluteal folds, interdigital spaces, and umbilicus. Moisture, heat, friction and maceration of the skin are the principle predisposing factors in the normal patient, however obesity, diabetes mellitus, warm water immersion or occlusion of the skin and the use of broad-spectrum antibiotics are additional factors. Lesions consist of a moist, macular erythematous rash with typical satellite lesions present on the surrounding healthy skin.

Diaper candidiasis is common in infants under unhygienic conditions of chronic moisture and local skin maceration associated with ammonitic irritation due to irregularly changed unclean diapers. Once again characteristic erythematous lesions with erosions and satellite pustules are produced, with prominent involvement of the skin folds and creases.

Paronychia of the finger nails may develop in persons whose hands are subject to continuous wetting, especially with sugar solutions or contact with flour, that macerates the nail folds and cuticle. Lesions are characterized by the development of a painful, erythematous swelling about the affected nails. In chronic cases the infection may progress to cause onychomycosis with total detachment of the cuticle from the nail plate.



Chronic *Candida* onychomycosis often causes complete destruction of nail tissue and is seen in patients with chronic mucocutaneous candidiasis or other underlying factors that affect either the hormonal or immunologic status of the host. These include diabetes mellitus, hypoparathyroidism, Addison's disease, dysfunction of the thyroid, malnutrition, malabsorption and various malignancies. The use of steroids, antibiotics and antimitotics may also be contributing factors.

3. Vulvovaginal candidiasis and balanitis:

Vulvovaginal candidiasis is a common condition in women, often associated with the use of broad-spectrum antibiotics, the third trimester of pregnancy, low vaginal pH and diabetes mellitus. Sexual activity and

oral contraception may also be contributing factors and infections may extend to include the perineum, the vulva and the entire inguinal area. Chronic refractory vaginal candidiasis, associated with oral candidiasis, may also be a presentation of HIV infection or AIDS. Symptoms include intense vulval pruritus, burning, erythema and dyspareunia associated with a creamy white, curd-like discharge.

In cases of balanitis, diabetes mellitus should be excluded and the sexual partner should be investigated for vulvovaginitis. The symptoms include erythema, pruritus and vesiculopustules on the glan penis or prepuce. Infections are more commonly seen in uncircumcised men and poor hygiene may also be a contributing factor.

4 Pulmonary candidiasis:

Pulmonary candidiasis can be acquired by either hematogenous dissemination causing a diffuse pneumonia or by bronchial extension in patients with oropharyngeal candidiasis.

5. Urinary tract candidiasis:

Transient asymptomatic candiduria may occur during antibiotic or corticosteroid treatment which promotes the growth of *Candida,* throughout the gastrointestinal and genital tracts, and most lower urinary tract infections result from local spread of yeasts from these sites.

6-Renal candidiasis .

7. Meningitis:

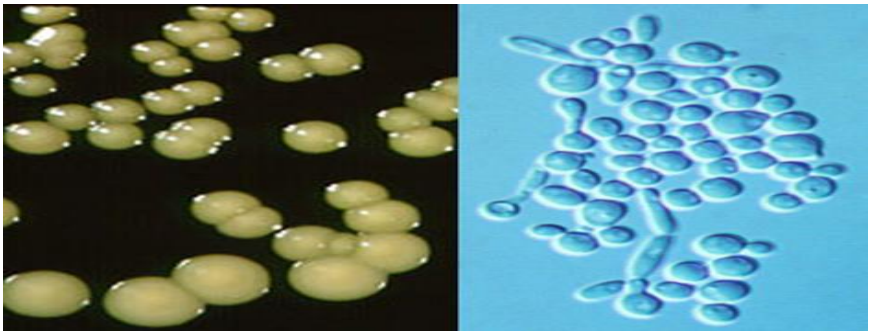
8. Endocarditis, myocarditis and pericarditis:

9. Candidemia (Candida septicemia) and disseminated candidiasis:

10. Ocular candidiasis:

and corneal infections have also been recorded following trauma.

11. Other forms of candidiasis.

- 

3-Subcutaneous Mycoses

These are chronic, localized infections of the skin and subcutaneous tissue following the traumatic implantation of the aetiologic agent. The causative fungi are all soil saprophytes of regional epidemiology whose ability to adapt to the tissue environment and elicit disease is extremely variable.

Disease	**Causative organisms**	**Incidence**
Sporotrichosis	Sporothrix spp.	Rare
Chromoblastomycosis	*Fonsecaea*, *Phialophora*,	Chromoblastomycosis
Phaeohyphomycosis	*Cladophialophora*, *Exophiala*,	Phaeohyphomycosis
Mycotic mycetoma	*Scedosporium*,*Madurella*, *Trematosphaeria*,	Mycotic mycetoma
Subcutaneous zygomycosis (Entomophthoromycosis)	*Basidiobolus ranarum* *Conidiobolus coronatus*	Rare
Subcutaneous zygomycosis (Mucormycosis)	*Rhizopus*,*Mucor*, *Rhizomucor*, *Lichtheimia*, *Saksenaea etc.*	Rare
Lobomycosis	*Loboa loboi*	Rare
Rhinosporidiosis	*Rhinosporidium seeberi*	Rare

A- Sporotrichosis (also known as "*rose* gardener's disease)

is primarily a chronic mycotic infection of the cutaneous or subcutaneous tissues and adjacent lymphatics characterized by nodular lesions which may suppurate and ulcerate. Infections are caused by the traumatic

implantation of the fungus into the skin, or very rarely, by **inhalation into the lungs**. Secondary spread to articular surfaces, bone and muscle is not infrequent, and the infection may also occasionally involve the central nervous system, lungs or genitourinary tract.

Fixed cutaneous sporotrichosis:

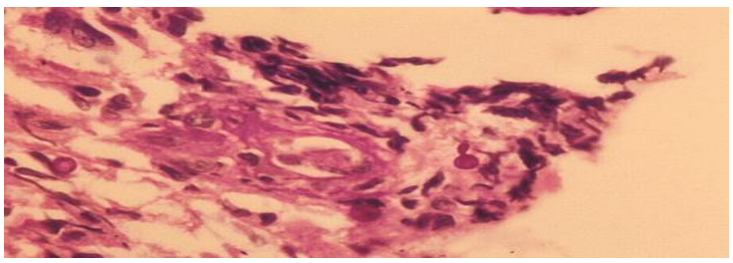
Primary lesions develop at the site of implantation of the fungus, usually at more exposed sites mainly the limbs, hands and fingers. Lesions often start out as a painless nodule which soon become palpable and ulcerate often discharging a serous or purulent fluid. Importantly, lesions remain localised around the initial site of implantation and do not spread along the lymphangitic channels. Isolates from these lesions usually grow well at 35C, but not at 37C.

Lymphocutaneous sporotrichosis:

Primary lesions develop at the site of implantation of the fungus, but secondary lesions also appear along the lymphangitic channels which follow the same indolent course as the primary lesion , they start out as painless nodules which soon become palpable and ulcerate. No systemic symptoms are present. Isolates from these lesions usually grow well at both 35C and 37C.

Pulmonary sporotrichosis:

This is a rare entity usually caused by the inhalation of conidia but cases of haematogenous dissemination have been reported. Symptoms are nonspecific and include cough, sputum production, fever, weight loss and upper-lobe lesion.



Causative agents: *Sporothrix schenckii* .

B-Phaeohyphomycosis

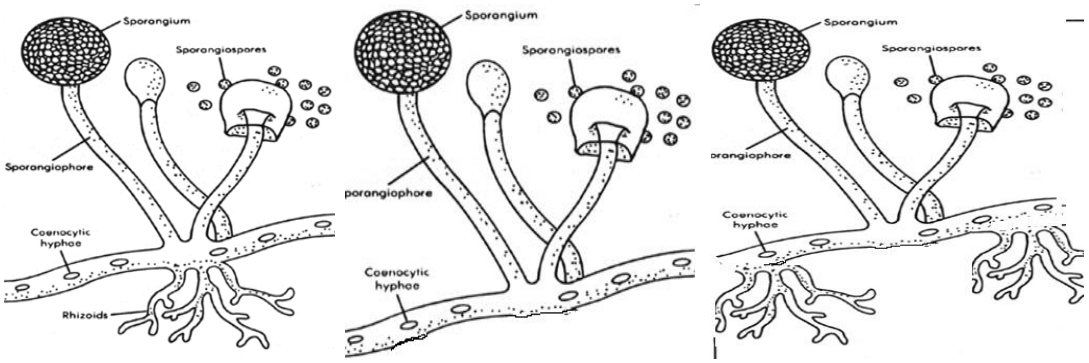
A mycotic infection of humans and lower animals caused by a number of dematiaceous (brown-pigmented) fungi where the tissue morphology of the causative organism is mycelial. This separates it from other clinical types of disease involving brown-pigmented fungi where the tissue morphology of the organism is a grain (mycotic mycetoma) or sclerotic body (chromoblastomycosis). The etiological agents include various **dematiaceous hyphomycetes** especially species of *Exophiala* ,*Phialophora* ,*Bipolaris*,*Cladophialophora*,*Aureobasidium*,*Cladosporium*, *Curvularia* and *Alternaria*.

C-Zycomycosis

The term zygomycosis describes in the broadest sense any infection due to a member of the Zygomycetes. These are primitive, fast growing, terrestrial, largely saprophytic fungi with a cosmopolitan distribution. To date, some 665 species have been described although infections in

humans and animals are generally rare. Medically important orders and genera include:

1. **Mucorales and Mortierellales**, causing subcutaneous and systemic zygomycosis (Mucormycosis) - *Rhizopus*, *Lichtheimia*, *Rhizomucor*,



Rhizopus ***Mucor*** ***Absidia***

2. **Entomophthorales**, causing subcutaneous zygomycosis (Entomophthoromycosis) - *Conidiobolus* and *Basidiobolus.*

4- Systemic Mycoses (Dimorphic Systemic Mycoses)

These are fungal infections of the body caused by fungal pathogens which can overcome the physiological and cellular defences of the normal human host by changing their morphological form. They are geographically restricted and the primary site of infection is usually pulmonary, following the inhalation of conidia.

Disease	Causative organisms	Incidence
Blastomycosis	***Blastomyces dermatitidis***	**Rare***
Coccidioidomycosis	***Coccidioides immitis***	**Rare***
Histoplasmosis	***Histoplasma capsulatum***	**Rare***
Paracoccidioidomycosis	***Paracoccidioides brasiliensis***	**Rare***
Talaromyces marneffei infection	***Talaromyces marneffei***	**Rare***

*more common in endemic areas.

Histopathology is especially useful and is one of the most important ways of alerting the laboratory that they may be dealing with a potential pathogen.

Tissue morphology of dimorphic pathogens:

Mycosis	Tisue morphology
Blastomycosis	Large broad base unipolar budding yeast cells (8-10um).
Coccidioidomycosis	Spherules (10-80um) with endospores (2-5um).
Histoplasmosis	Small narrow base budding yeast cells (1-5um; 5-2um in var.duboisii)
Paracoccidioidomycosis	Large narrow base, multi-budding yeast cells (20-60um).
Talaromyces marneffei	Small, oval to ellipsoidal yeast-like cells (3 µm in diameter).
Sporotrichosis	Small narrow base budding yeast cells (2-5um).

WARNING:

Cultures of *Blastomyces dermatitidis*, *Coccidioides immitis*, *Histoplasma capsulatum* and *Talaromyces marneffei* represent a severe biohazard to laboratory personnel and must be handled with extreme caution in an appropriate pathogen handling cabinet.

A-Blastomycosis:

Blastomycosis is a chronic granulomatous and suppurative disease having a primary pulmonary stage that is frequently followed by dissemination to other body sites, chiefly the skin and bone. Although the disease was long thought to be restricted to the North American continent, in recent years autochthonous cases have been diagnosed in Africa, Asia and Europe. All available clinical and epidemiological evidence indicates that humans and

lower animals contract blastomycosis from some source in nature. However, the natural habitat of *B. dermatitidis* has yet to be clearly delineated, despite some reports of its isolation from soil.

B-Coccidioidomycosis:

Coccidioidomycosis is initially, a respiratory infection, resulting from the inhalation of conidia, that typically resolves rapidly leaving the patient with a strong specific immunity to re-infection. However, in some individuals the disease may progress to a chronic pulmonary condition or to a systemic disease involving the meninges, bones, joints and subcutaneous and cutaneous tissues. *Coccidioides immitis* is a soil inhabiting fungus endemic in south-western U.S.A., northern Mexico and various centres in South America. Several cases have now been diagnosed in Australia, all in patients with a history of travel to endemic areas.

C-Histoplasmosis:

Histoplasmosis is an intracellular mycotic infection of the reticuloendothelial system caused by the inhalation of conidia from the fungus *Histoplasma capsulatum.* Histoplasmosis has a world wide distribution, however, the Mississippi-Ohio River Valley in the U.S.A. is recognized as a major endemic region. Africa, Australia and parts of East Asia, in particular India and Malaysia are also endemic regions.

Environmental isolations of the fungus have been made from soil enriched with excreta from chicken, starlings and bats. Three varieties of Histoplasma capsulatum are recognised, depending on the clinical disease: var. *capsulatum* is the common cause of histoplasmosis; var. *duboisii* is the African type and var. *farciminosum* causes lymphangitis in horses. *Histoplasma* isolates may also resemble species

of *Sepedonium* and *Chrysosporium*. Traditionally, positive identification required conversion of the mould form to the yeast phase by growth at 37C on enriched media, however for laboratory safety, culture identification by either exoantigen test or DNA sequencing is now preferred.

D-Paracoccidioidomycosis:

Paracoccidioidomycosis is a chronic granulomatous disease that characteristically produces a primary pulmonary infection, often inapparent, and then disseminates to form ulcerative granulomata of the buccal, nasal and occasionally the gastrointestinal mucosa. The disease in its inception and development is similar to blastomycosis and coccidioidomycosis. The only etiological agent, *Paracoccidioides brasiliensis* is geographically restricted to areas of South and Central America.

E-Talaromyces marnrffei infection

Talaromyces marneffei exhibits thermal dimorphism by growing in living tissue or in culture at 37C as a yeast-like fungus or in culture at temperatures below 30C as a mould. It has a propensity to cause disease in the normal host, as well as in immunosuppressed patients, but significantly, it has now become a major opportunistic pathogen in HIV positive patients in Indochina. Over 300 cases have been reported with the majority of these coming from Chiang Mai in northern Thailand. Other predisposing factors include lymphoproliferative disorders, bronchiectasis and tuberculosis, autoimmune diseases and corticosteroid therapy. To date, all naturally occurring infections have been in residents of, or travellers to, southeast Asia; especially northern Thailand, Vietnam, Hong Kong, Taiwan and southern China. Imported cases of *P.*

marneffei infections have been reported from Australia, France, Italy, Netherlands, UK and USA.

5-Opportunistic Systemic Mycoses

These are fungal infections of the body which occur almost exclusively in debilitated patients whose normal defence mechanisms are impaired.

The organisms involved are cosmopolitan fungi which have a very low inherent virulence. The increased incidence of these infections and the diversity of fungi causing them, has parallelled the emergence of AIDS, more aggressive cancer and post-transplantation chemotherapy and the use of antibiotics, cytotoxins, immunosuppressives, corticosteroids and other macro disruptive procedures that result in lowered resistance of the host.

Disease	**Causative organisms**
Candidiasis	Candida, Debaryomyces, Kluyveromyces, Meyerozyma, Pichia, etc.
Cryptococcosis	Cryptococcus spp. especially C. neoformans/C. gattii
Aspergillosis	*Aspergillus fumigatus* complex, *A. flavus,* complex, *A. terreus* complex etc.
Scedosporiosis (Pseudallescheriasis)	*Scedosporium* and *Lomentospora*.
Zygomycosis (Mucormycosis)	*Rhizopus, Mucor, Rhizomucor, Lichtheimia* etc.
Hyalohyphomycosis	*Penicillium, Paecilomyces, Beauveria, Fusarium, Scopulariopsis* etc.
Phaeohyphomycosis	*Cladophialophora, Exophiala, Bipolaris, Exserohilum etc.*

A-Candidiasis

Candidiasis is a primary or secondary mycotic infection caused by members of the genus *Candida* and other related genera. The clinical manifestations may be acute, subacute or chronic to episodic. Involvement may be localized to the mouth, throat, skin, scalp, vagina, fingers, nails, bronchi, lungs, or the gastrointestinal tract, or become systemic as in septicemia, endocarditis and meningitis. In healthy individuals, *Candida* infections are usually due to impaired epithelial barrier functions and occur in all age groups, but are most common in the newborn and the elderly. They usually remain superficial and respond readily to treatment. Systemic candidiasis is usually seen in patients with cell-mediated immune deficiency, and those receiving aggressive cancer treatment, immunosuppression, or transplantation therapy.

B-Cryptococcosis

Cryptococcosis is a chronic, subacute to acute pulmonary, systemic or meningitic disease, initiated by the inhalation of infectious propagules (basidiospores and/or desiccated yeast cells) from the environment. Primary pulmonary infections have no diagnostic symptoms and are usually subclinical. On dissemination, the fungus usually shows a predilection for the central nervous system, however skin, bones and other visceral organs may also become involved. Although *C. neoformans* and *C. gattii* are regarded as the principle pathogenic species, *Cryptococcus albidus* and *C. laurentii* have on occasion also been implicated in human infection.

C-Aspergillosis

Aspergillosis is a spectrum of diseases of humans and animals caused by members of the genus *Aspergillus*. These include (1) mycotoxicosis due to ingestion of contaminated foods; (2) allergy and sequelae to the presence of conidia or transient growth of the organism in body orifices; (3) colonisation without extension in preformed cavities and debilitated tissues; (4) invasive, inflammatory, granulomatous, narcotising disease of lungs, and other organs; and rarely (5) systemic and fatal disseminated disease. The type of disease and severity depends upon the physiologic state of the host and the species of Aspergillus involved. The etiological agents are cosmopolitan and include *Aspergillus fumigatus* complex, *A. flavus* complex, *A. niger* complex, *A. nidulans* and *A. terreus* complex.