**L.11- Biotechnology Mycology D.Ibtihal Muiz**

**Division: Basidiomycota**

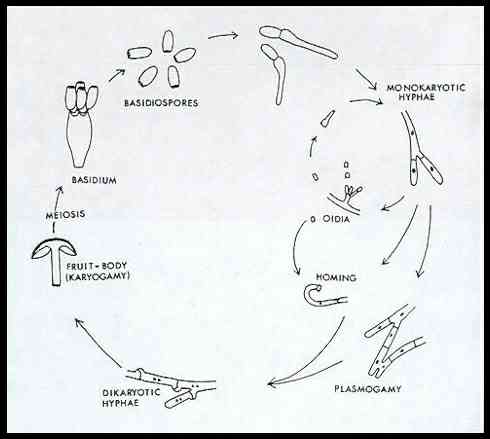
**Introduction**

The fungal group **basidiomycota** is best known for the production of large fruit bodies such as the mushrooms, puffballs, brackets, etc. However, the group also contains some microscopic fungi, including the important rust fungi and smut fungi that parasitise plants ([Biotrophic parasites](http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/biotroph.htm#Top)), and some yeasts. One of these yeasts, Sporobolomyces roseus, is very common on moribund leaf surfaces and is a cause for concern because its basidiospores are respiratory allergens. Another is Cryptococcus neoformans, which grows commonly on old "weathered" bird droppings, and which can cause a fatal systemic infection of immunocompromised people. Its air-borne basidiospores initiate infection via the lungs, leading to the disease termed cryptococcosis. This is now the fourth most important life-threatening diseases of AIDS patients in the USA, and common also in Europe.

Many of the basidiomycota with the larger fruit bodies (toadstools etc.) are common and important agents of wood decay (see [Wood decay](http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/armill.htm#Top)) or decomposers of leaf litter, animal dung, etc. Others are mycorrhizal on forest trees (see [Mycorrhizas](http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/mycorrh.htm#Top)). Several species are grown commercially for food, including the common cultivated mushroom, Agaricus bisporus, and some more exotic species which can be found on supermarket shelves. For example, the supermarket package below contains the brown-coloured Shiitake mushroom (Lentinus edodes, traditionally grown in south-east Asia) and a mixture of grey, pink and yellow forms of the oyster fungus (Pleurotus ostreatus, reportedly an aphrodisiac).

**Distinctive features and life cycle of the basidiomycota**

As a group, the basidiomycota have some highly characteristic features, which separate them from other fungi. They are the most evolutionarily advanced fungi, and even their hyphae have a dinstinctly "cellular" composition. This point is best illustrated by the life cycle below.



The **basidiospores** usually have a single haploid nucleus. When these spores germinate they produce hyphae with usually a single nucleus in each compartment. Because these hyphae have only one nuclear type they are termed **monokaryons** (from the Greek, mono = one; karyos = kernel or nucleus). At some stage in their growth, two monokarons of different compatibility groups (mating types) fuse. This can occur either by simple hyphal fusions or by fusion of a hypha with a small spore termed an **oidium**. The fusion event is termed **plasmogamy**. Then the nuclei divide and the daughter nuclei pair so that each hyphal compatment comes to contain two nuclei - one of each mating type. At this stage the fungus is termed a **dikaryon** (i.e. with two nuclear types).

Many basidiomycota grow for most of their lives as dikaryons, until environmental signals induce them to produce fruibodies, such as a toadstool. All the hyphae that make up the toadstool are dikaryotic. At a late stage of development, some of these hyphae produce special cells termed **basidia** (singular, basidium). For example, the cells that line the gills of the common mushroom are basidia. Finally, the two haploid nuclei in each basidium fuse - a process termed **karyogamy**) to form a diploid nucleus. This then undergoes meiosis to produce four haploid nuclei, and these haploid nuclei migrate into the basidiospores, which develop on small stalks (termed sterigmata) from each basidium (see the image below). The dispersal of these monokaryotic spores completes the life cycle.

In many basidiomycota there is a rather elaborate mechanism for ensuring that the dikaryotic condition is maintained during growth of the hyphae. As shown in the diagram below, the two nuclei in each tip cell divide at the same time, but one divides along the axis of the hypha, and the other divides so that a daughter nucleus enters a small, backwards-projecting branch. Then a septum forms to separate the original apical cell into two cells, and the branch fuses with the sub-terminal cell so that the nucleus in the branch migrates into this cell. The small branches at each septum are termed **clamp connections**. They can be seen at high magnification of a normal compound microscope (see the image below the diagram).

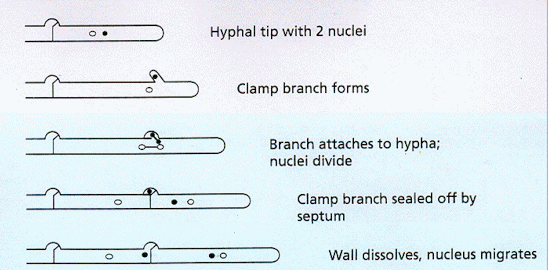


Diagram to show the role of clamp connections in maintaining a dikaryon

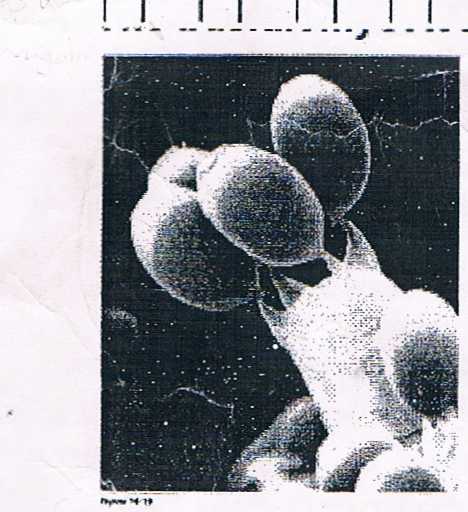


Clamp connections at the septa of a basidiomycota hypha

**The basidiomycetes**Mycelium/ hyphae   
• generally produce an extensive mycelium, the largest organisms in the world are basidiomycetes   
• the phylum contains some yeast-like forms   
• hyphae are regularly septate with one to two nuclei per cell in vegetative hyphae   
• vegetative hyphae occur as monokaryon or dikaryon (dikaryotic mycelia often extensive)   
• cell walls composed primarily of chitin

**Three classes**   
• class Basidiomycetes includes mushrooms, tooth fungi and shelf fungi   
• class Teliomycetes includes species of obligate plant parasitic fungi commonly known as the ‘rusts’   
• class Ustomycetes includes parasites of flowering plants commonly known as the ‘smuts’

**What they have in common**   
• most form an extensive dikaryon   
• many form clamp connections



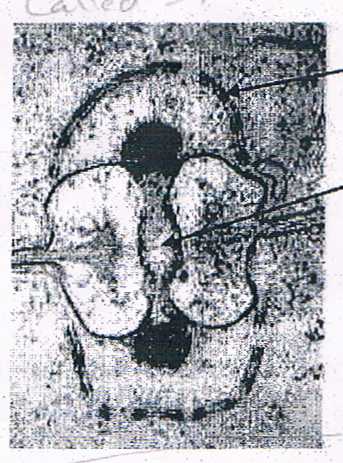
**What they have in common**

• all with meiotic spores (basidiospores) produced on basidia   
• the major groups differ slightly in the morphology of their basidia

**A clamp connection**

Is a hyphal branch that form in association with synchronous division of the two nuclei in the apical cell of adikaryotic hypha. One of the nuclei divides in the main axis of the hyph, while the other divides into the clamp. Septa are formed across each of the mitotic spindles. The apex of the back ward growing monokaryotic clamp cell fuses with the sub apical cell, reestablishing the dikaryotic condition. All fungi that produce clamp connection are members of the Basidiomycota produce clamp connection. clamp connection must have devdoped carly in Basidiomycota evolution because they are found in the earliest diverging lineages.

**Dolipore Septum :**there is a complex wall structure to the septum and also acomplex of endoplasmic reticulum associated with the septal pore founded in basidiomycetes**.**

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Septal pore cap (parenthosome)

Central pore

Mycorrhizae

Two main types of Mycorrhizae

Endomycorrhizae= the fungus produces highly branched structures (arbuscules ) that penetrate the cortical cells of the root .

Ectomycorrhizae =the fungus surrounds the plant root cells (i.e.does not penetrate them )

**Basidiomycetes**

The class Basidiomycetes includes those members that produce their basidia and basidiospores on or in a basidiocarp. The morphology of the basidium is variable. Until recently the morphology of the basidium was believed to be a key to determining relationship in the Basidiomycota. Basidial morphology was once the basis for classifying the fungi to class or subclass. However, rDNA sequencing analyst (Swann and Taylor, 1993), **septal pore** morphology and cell wall biochemistry (McLaughlin et al, 1995) have determined that far too much emphasis was placed on this characteristic and all members of the Basidiomycota that produce basidiocarps are now included in a single class, the Basidiomycetes, and the morphology of the basidiocarp and basidium are characteristics that are now used to classifying fungi into the various orders of this class.

Order: **Agaricales**

This is the order of Basidiomycetes with which most of us are familiar. This is the order that is commonly referred to as mushrooms. Basidiocarps of this order typically are "fleshy" and have a **stipe** (=stalk), **pileus** (=cap), and **lamellae** (=gills) where the basidia and basidiospores are borne (Fig. 1-4). The Basidiospores in this order of fungi are forcibly ejected from the basidium, into the area between the lamellar edges, which then allows the spores to fall free from the mushroom and be dispersed by wind. **A demonstration of this mechanism can be observed** [**here**](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/Spore_Dispersal.gif).

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| [Mushroom-t.jpg (17257 bytes)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/Mushroom.jpg) | | Figure 1: Typical mushroom of Agaricales: Stipe, annulus, lamella and pileus. Basidia and basidiospores are produced in an hymenium on the lamella surface. | |
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| [[coprin1t](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin1.JPG)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin1.JPG) | Figure 2: Low magnification of a cross section through the lamella of a mushroom | |
| [[coprin2t](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin2.JPG)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin2.JPG) | Figure 3: Higher magnification of section through the lamella of mushroom. Basidiospores now visible on the upper and lower edge of lamella. | |
| [[coprin3t](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin3.JPG)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/coprin3.JPG) | Figure 4: High magnification of basidia. Center basidium shows two basidiospores of four on sterigmata. | |

The [mushroom life cycle](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/Mushroom_Lifecycle.htm) will be used as representative of the basidiomycete life cycle. Although clamp connections are present in the dikaryon of some species of, they are also absent in many. Clamp connections are believed to function in ensuring that each cell has a compatible pair of nuclei. **The formation of a clamp connection is described** [**here**](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/Clamp_connection_formation.htm).

**Some examples of of Agaricales that occur in Hawai‘i** **(Fig 5-9):**

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|  | Figure 5: *Amanita marmorata* ssp *myrtacearum*. Commonly associated with *Eucalyptus*, *Melaleuca* and *Casuarina.* |
| [[cortint](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/cortin.jpg)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/cortin.jpg) | Figure 6: *Cortinarius clelandii.* Commonly associated with *Eucalyptus*, *Melaleuca* and *Casuarina.* |
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Species in this order are often coriaceous, leathery to woody, but may also be fleshy. The basidiocarps and hymenia are more variable than in the Agaricales. Examples of members of this order can be observed below (Figs. 10-14). As in the case of the Agaricales, the basidiospores are forcibly ejected from the basidium and are then dispersed by wind.

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| [[r_fragit](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/r_fragil.jpg)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/r_fragil.jpg) | Figure 10: *Ramaria fragilima*, a coral fungus. The basidia and basidiospores are formed at the tips of the basidiocarp. |
| [[p_sanqut](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/p_sanqu.jpg)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/p_sanqu.jpg) | Figure 11: *Pycnoporous sanguineus*, a polypore. The basidia and basidiospores are formed in the pores of the hymenium surface on the basidiocarps (see Fig 12). |
| [Porous_hymenium-t.jpg (30209 bytes)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/Porous_hymenium.jpg) | Figure 12: Porous hymenium from a prepared slide. |
| [G_applanatum-t.jpg (27915 bytes)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/G_applanatum.jpg) | Figure 13: *Ganoderma applanatum*, another polypore. |
| [[h_peckt](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/h_peck.jpg)](http://www.botany.hawaii.edu/faculty/wong/Bot201/Basidiomycota/h_peck.jpg) | Figure 14: *Hydnellum peckii*. The basidia and basidiospores are formed on the spines of the hymenium surface of the basidiocarp. |