Ascomycota

The division is a large and very diverse group that has historically been difficult to characterize. However, the one unifying characteristic is that all members produce **ascospores** inside of a sac-like cell called an **ascus** (pl.= **asci**) and during sexual reproduction (Fig. 1). There are typically eight ascospores produces per ascus. However, the number can vary from one to over a thousand. As does the ascus, which may be globose to cylindrical.

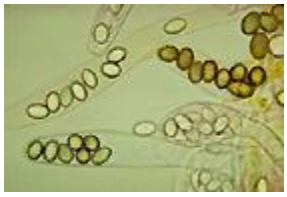


Figure 1: Cylindrical asci of *Ascobolus stercorarius*, with eight ascospores in each ascus.

Other characteristics are variable. The thallus is often mycelium that is septate. However, there are also many species that form a yeast thallus and some species have both and are said to be **dimorphic**. Most species produce asci and ascospores in an **ascocarp**, which is a complex fruiting body made up of tightly interwoven mycelium, but some produce "naked" asci, i.e. an ascocarp is not produced.

Based on recent molecular data, concepts concerning the phylogeny of this division has undergone major changes. Characteristics that have been traditionally used to classify the Ascomycota, such as thallus type, ascocarp type and development and ascus types, now appear to be less useful as indicators of phylogeny.

We will cover the Ascomycota by dividing them into two artificial groups, based on thallus type: Yeast and mycelial species.

Yeast and Yeast-like Ascomycota

The yeast and yeast-like fungi of the Ascomycota are structurally simple fungi. Many species are unicellular and reproduce asexually by **budding** (Fig. 2, 4)or **fission** (Fig. 3, 7). The process of budding begins in a mature yeast cell at predetermined areas of its cell wall. In *Saccharomyces cerevisiae*, for example, budding takes place at the poles of the cell. In these areas when budding is about to take place, the cell wall is softened and is "blown out" to form the so-called "bud", which will become the new cell. As the bud enlarges, mitosis of the nucleus occurs, with one of the nuclei moving into the newly formed cell. When the cell reaches the approximate size of the original cell, cell wall material is laid down in the passage between the two cells, which will then shortly separate.

Fission is a simpler process. In Schizosaccharomyces, during fission mitosis of the nucleus occurs, followed elongation of cell and the laying down of a cell wall that divides the cell in half, separating the two nuceli.

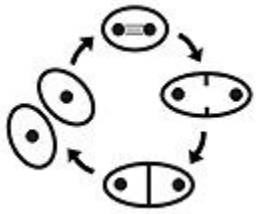


Figure 3: Asexual reproduction of a fission yeast. Mitosis of the nucleus occurs, followed by elongation of the cell and formation of a cell wall that divides the cell in half, separating the two nuclei.

We will describe the life cycle examples of a budding and a fission yeast. The representatives that are typically used are *Saccharomyces cerevisiae*, the brewer's yeast and *Schizosaccharomyces octosporus*, respectively. The two species were formerly placed in the class Hemiascomycetes, in one of the more conservative classifications. This was the class in which all the yeast and yeast-like members of the Ascomycota were placed. However, recent molecular evidence indicates that there are two distinct group of yeast, based primarily on DNA sequence analysis. The two representatives that we are using are now recognized to be in these two distinct lines. The *S. cerevisiae* is placed in the order Saccharomycetales, which usually is no longer placed in a class and *S. octosporus* is in the order Schizosaccharomycetales and in some classification schemes in the class Archiascomycetes. However, it should be noted that reference to fungi having yeast thalli has long been considered an artificial category in classifying fungi. In the Ascomycota, there are apparently two phylogenetic lines of yeast fungi. In addition, the next division that we will study, the Basidiomycota, will also have several phylogenetic lines that form yeast thalli. Thus, the term yeast should be and is here used only as a means of describing a thallus type.

Saccharomyces cerevisiae (Brewer's Yeast) is probably the most studied species of fungi because of its economic importance in the beer and wine industry. It is an example of a budding yeast.

Saccharomyces cerevisiae

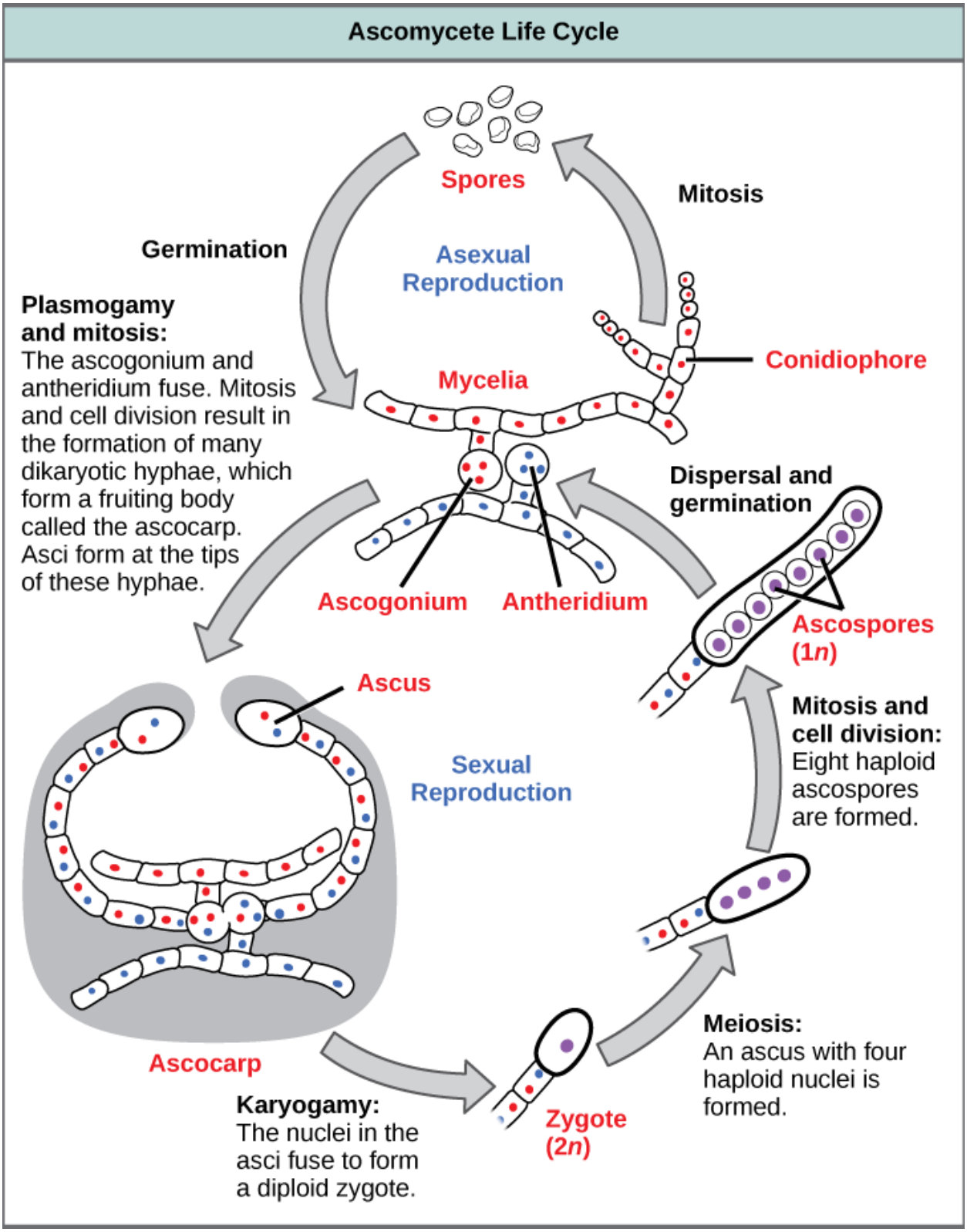
Saccharomyces cerevisiae is a heterothallic species and require the presence of two mating strains of yeast cells that have been designated as "a" and "□". Fusion of the two mating strains will produce the zygote. Unlike other species of fungi, the life cycle of this species is *not* zygotic. The diploid cell does not undergo meiosis and will assimilate food and reproduce asexually for a time. Thus, there is a true alternation of generations and this species has a sporic life cycle. The life cycle is completed when meiosis occurs in the diploid yeast cells and each of the four nuclei becomes an ascospore (Fig. 5). Two will be of the "a" and the other two will be of the "□" mating strains. The original cell wall of the diploid yeast cell is the ascus.

Schizosaccharomyces octosporus

Schizosaccharomyces octosporus is an example of a fission yeast, which also readily produce **asci** and **ascospores** *in vitro*. This differs from *S. cerevisiae*, however, in that it is homothallic and has a zygotic life cycle, which is typical of most fungi. Thus, any two yeast cells of this species can fuse to produce a zygote. Once the zygote is formed, it immediately undergoes meiosis. this is followed by a mitotic division, with each nucleus becoming an ascospore. The old zygote cell wall becomes the ascus (.Although many species in the order Saccharomycetales may be unicellular, some have short, septate, hyphal growth. Extensive mycelial growth does not occur. In these species, asci and ascospores are still borne naked and are not produced in an ascocarp. An example of a species with short hyphal growth is *Dipodascopsis uninucleatus*.

Dipodascopsis uninucleatus

*Dipodascus uninucleatus*is an example of a species in which limited hyphal growth occurs. This species is homothallic and sexual reproduction occurs when the septum separating adjacent gametangial cells disintegrates. Karyogamy occurs immediately, followed by formation of the ascus and numerous mitotic divisions. Thus, the mature ascus is filled with numerous ascospores (Figure 8). Students that follow the derivation of the Ascomycota from the Zygomycota believe the multispored ascus of *Dipodascopsis* to be homologous to the zygosporangium of the Zygomycota. However, recent molecular evidence does not indicate this to be the case. Asexual reproduction apparently does not occur in this species.


Ascomycete Life Cycle
Spores
Mitosis
Germination
Asexual Reproduction
Plasmogamy and mitosis:
The ascogonium and antheridium fuse. Mitosis and cell division result in the formation of many dikaryotic hyphae, which form a fruiting body called the ascocarp. Asci form at the tips of these hyphae.
Conidiophore
Mycelia
Dispersal and germination
Ascogonium
Antheridium
Ascospores (1n)
Ascus
Mitosis and cell division:
Eight haploid ascospores are formed.
Sexual Reproduction
Ascocarp
Meiosis:
An ascus with four haploid nuclei is formed.
Karyogamy:
The nuclei in the asci fuse to form a diploid zygote.
Zygote (2n)