3. How are Meiosis I and Meiosis II different?

4. How do oogenesis and spermatogenesis differ?

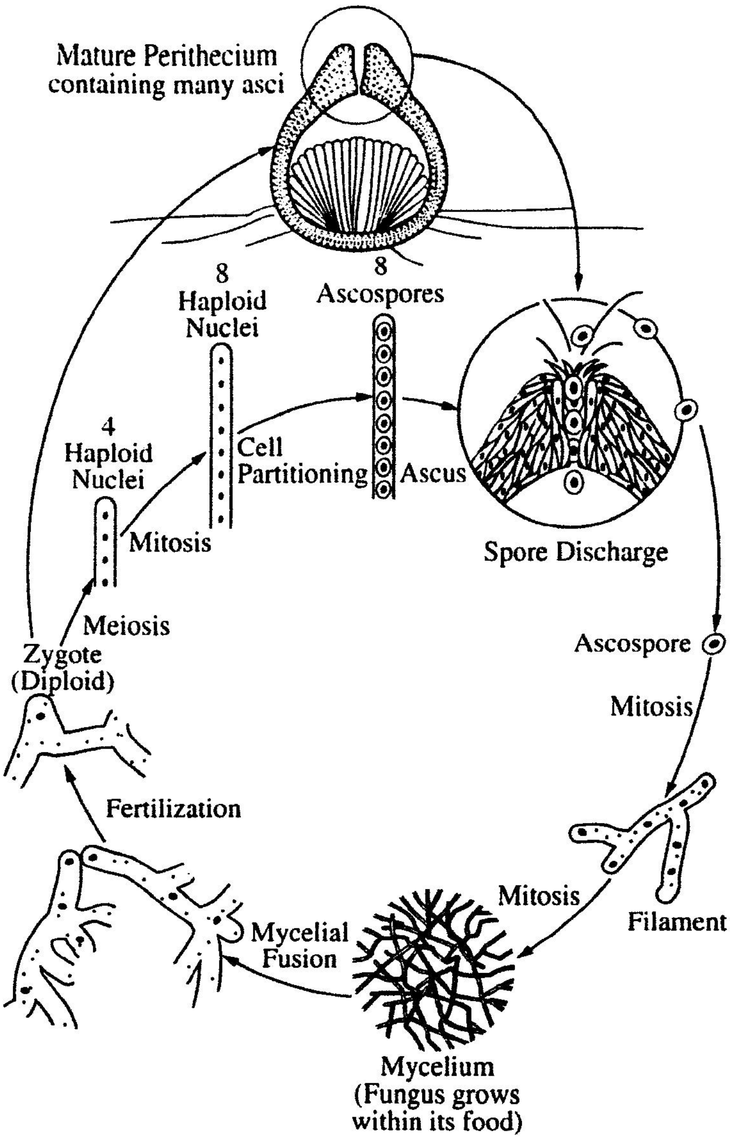
5. Why is meiosis important for sexual reproduction?

EXERCISE 3B.2: Crossing Over during Meiosis in *Sordaria*

Sordaria fimicola is an ascomycete fungus that can be used to demonstrate the results of crossing over during meiosis. *Sordaria* is a **haploid** organism for most of its life cycle. It becomes **diploid** only when the fusion of the mycelia (filamentlike groups of cells) of two different strains results in the fusion of the two different types of haploid nuclei to form a diploid nucleus. The diploid nucleus must then undergo meiosis to resume its haploid state.

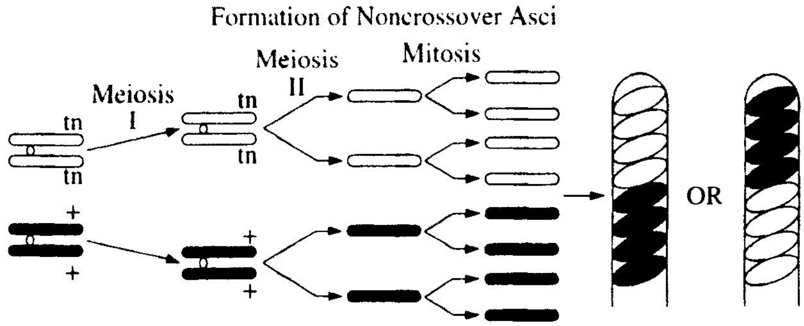
Meiosis, followed by mitosis, in *Sordaria* results in the formation of eight **haploid ascospores** contained within a sac called an **ascus** (plural, **asci**). Many asci are contained within a fruiting body called a **perithecium**. When ascospores are mature the ascus ruptures, releasing the ascospores. Each ascospore can develop into a new haploid fungus. The life cycle of *Sordaria fimicola* is shown in Figure 3.13.

Figure 3.13



To observe crossing over in *Sordaria*, one must make hybrids between wild-type and mutant strains of *Sordaria*. Wild-type *Sordaria* have black ascospores (+). One mutant strain has tan spores (tn). When mycelia of these two different strains come together and undergo meiosis, the asci that develop will contain four black ascospores and four tan ascospores. The arrangement of the spores directly reflects whether or not crossing over has occurred. In Figure 3.14, no crossing over has occurred. Figure 3.15 shows the results of crossing over between the centromere of the chromosome and the gene for ascospore color.

Figure 3.14: Meiosis with no crossing over



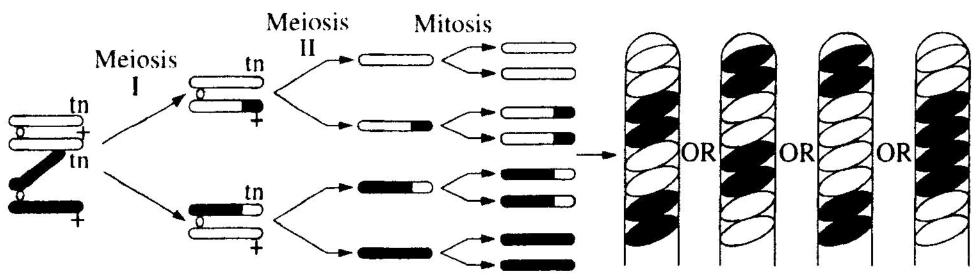
Two homologous chromosomes line up at metaphase I of meiosis. The two chromatids of one chromosome each carry the gene for tan spore color (tn) and the two chromatids of the other chromosome carry the gene for wild-type spore color (+).

The first meiotic division (MI) results in two cells each containing just one type of spore color gene (either tan or wild-type). Therefore, segregation of these genes has occurred at the first meiotic division (MI).

The second meiotic division (MII) results in four cells, each with the haploid number of chromosomes (1N).

A **mitotic** division simply duplicates these cells, resulting in 8 spores. They are arranged in the 4:4 pattern.

Figure 3.15: Meiosis with crossing over



In this example, crossing over has occurred in the region between the gene for spore color and the centromere. The homologous chromosomes separate during meiosis I.

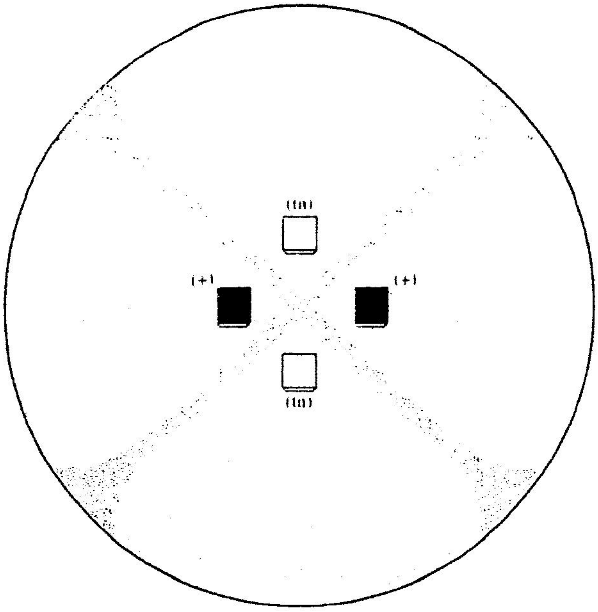
This time, the MI results in two cells, each containing both genes (1 tan, 1 wild-type); therefore, the genes for spore color have not yet segregated.

Meiosis II (MII) results in segregation of the two types of genes for spore color.

A **mitotic** division results in 8 spores arranged in the 2:2:2:2 or 2:4:2 pattern. Any one of these spore arrangements would indicate that crossing over has occurred between the gene for spore coat color and the centromere.

Two strains of *Sordaria* (wild-type and tan mutant) have been inoculated on a plate of agar. Where the mycelia of the two strains meet (Figure 3.16), fruiting bodies called perithecia develop. Meiosis occurs within the perithecia during the formation of asci. Use a toothpick to gently scrape the surface of the agar to collect perithecia (the black dots in the figure below).

Figure 3.16



Place the perithecia in a drop of water on a slide. Cover with a coverslip and return to your workbench. Using the eraser end of a pencil, press the coverslip down gently so that the perithecia rupture but the ascospores remain in the asci. Using the 10X objective, view the slide and locate a group of hybrid asci (those containing both tan and black ascospores). Count at least 50 hybrid asci and enter your data in Table 3.3.

Table 3.3

Number of 4:4 ●●●●○○○○ ○○○○●●●●	Number of Asci Showing Crossover ○○●●○○●● ●●○○●●○○ ○○●●●●○○ ●●○○○○●●	Total Asci	% Asci Showing Crossover Divided by 2	Gene to Centromere Distance (Map Units)

The frequency of crossing over appears to be governed largely by the distance between genes, or in this case, between the gene for spore coat color and the centromere. The probability of a crossover occurring between two particular genes on the same chromosome (linked genes) increases as the distance between those genes becomes larger. The frequency of crossover, therefore, appears to be directly proportional to the distance between genes.

A **map unit** is an arbitrary unit of measure used to describe relative distances between linked genes. The number of map units between two genes or between a gene and the centromere is equal to the percentage of recombinants. Customary units cannot be used because we cannot directly visualize genes with the light microscope. However, due to the relationship between distance and crossover frequency, we may use the map unit.

Analysis of Results

1. Using your data in Table 3.3, determine the distance between the gene for spore color and the centromere. Calculate the percent of crossovers by dividing the number of crossover asci (2:2:2:2 or 2:4:2) by the total number of asci x 100. To calculate the map distance, divide the percentage of crossover asci by 2. The percentage of crossover asci is divided by 2 because only half of the spores in each ascus are the result of a crossover event (Figure 3:15). Record your results in Table 3.3.

2. Draw a pair of chromosomes in MI and MII, and show how you would get a 2:4:2 arrangement of ascospores by crossing over. (Hint: refer to Figure 3:15).