Chapter 9

Symbioses

Objectives

Symbioses. Understand the types of symbioses. Know examples of symbioses.

Mycorrhizae. Define the two major types of mycorrhizae. Understand how mycorrhizal associations in plants are beneficial to the associated plants and fungi. Know the abundance and specificity of mycorrhizal associations in plants. Know, in general, how mycorrhizae are visualized.

Symbiotic Associations

Coexistence of species has led to co-evolution and symbiosis. Symbiosis is a close association between two or more different species. Symbiotic associations are broadly categorized as parasitic, commensal, or mutual. Parasitism involves one organism that benefits and another that is harmed. Viruses, bacteria, fungi, animals, and even other plants may parasitize plants. Commensalism involves one organism that benefits from and another that is not affected by the association. One example of commensalism in plants is epiphytes, such as orchids and bromeliads, which grow on the stems and branches of high trees and benefit by gaining access to light, but do not harm or help the growth of the tree. Mutualism involves two species that both benefit from the association. Lichens are a mutualistic relationship between a fungus, which provides minerals and protection from dehydration, and a population of cells, algal or cyanobacterial, which provide fixed carbon and, if cyanobacterial, can provide fixed nitrogen. Lichens growing on tree trunks are a mutual symbiosis (fungus and algae or cyanobacteria) in a commensal symbiosis (tree and lichen).

Many plants are involved in an important mutual symbiosis with prokaryotes, the only organisms that can fix nitrogen ($N_2 \rightarrow NH_4^+$). The establishment of symbiosis between plant roots and nitrogen-fixing bacteria, commonly called rhizobia, is termed nodulation[1], in which tumor-like growths, nodules, form and consist of root cortical cells and bacteria. The plant provides energy and a low O_2 environment (O_2 inhibits nitrogen fixation by denaturing nitrogenase) and the bacterium provides fixed nitrogen, which is limiting second to water.

At least 80-90% of angiosperms, and all investigated gymnosperms are involved in a mutual symbiosis, termed mycorrhizae, with fungi. The plant provides carbohydrates and vitamins to the fungus and the fungus provides essential elements (especially phosphorous), protection against soil-dwelling pathogens, and an increased potential for water absorption[2]. Although many types of associations occur, there are two major types of mycorrhizal associations, endomycorrhizae and ectomycorrhizae. During endomycorrhizal associations[3], fungal hyphae evaginate against the plasma membrane, but do not enter the protoplast, of root cortical cells and form highly branched structures called arbuscules that increase in the surface area of contact between fungal and plant cells. Endomycorrhizal associations most often involve Glomales fungi (once an order of Zygomycetes), are not highly specific, and are more common that ectomycorrhizae. During

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[1] Figs. 29-9, 29-10, 29-11
[2] Fig. 14-39
[3] Fig. 14-40

ectomycorrhizal associations[4], fungal hyphae are usually found between epidermal and cortex cells and surround cells, but the plasma membrane does not invaginate. Ectomycorrhizal associations most often involve basidiomycetes and some are highly specific.

Investigating Mycorrhizal Associations

The goal is to observe, with staining, mycorrhizal associations and determine which types of associations are present in/around roots of selected species.

In your laboratory notebook, formulate a hypothesis based on your knowledge of mycorrhizal associations. Include rational for your hypothesis.

Protocol for staining mycorrhizae in roots

Caution: Wear proper laboratory clothing and gloves to protect your skin. Some chemicals in this protocol are hazardous.

1. Remove fresh root tissue from the specimen.
2. Rinse in tap water.
3. Transfer root tissue to a beaker containing 10mL (enough to cover roots) of 10% KOH.
4. Add 40μL of 30% H_2O_2 (hydrogen peroxide) and incubate for 10 minutes; however, if the solution turns to a yellowish brown color within the first 2-3 minutes, refresh the solution.
5. Transfer root tissue to a Petri dish containing tap water. Swirl the tissue in the tap water and let incubate for 5 minutes.
6. Transfer the roots to a Petri dish containing 10% HCl and incubate for 5 minutes.
7. Transfer the roots to a glass vial containing 0.05% aniline blue. Close the vial and place in water bath at 80°C for 30 minutes.
8. Transfer the roots to a Petri dish containing 85% lactic acid. Swirl gently and incubate for 10-15 minutes.
9. Make two wet mounts of the roots.
10. Observe and draw the results. Draw at least one wet mount and compare/contrast with the other wet mount specimen.
11. Describe the fungal structures (*e.g.* hyphae, arbuscules) in each of the roots observed.
12. In your lab notebook, answer the following questions.
    a. How are fungal hyphae distinguished from plant cells?
    b. What are your conclusions regarding the presence of mycorrhizae in the specimens observed?

Review Questions

1. How do you think fertilization affects mycorrhizal associations?
2. How are fungi ecologically important? Give at least two ways.

[4] Figs. 29-1, 14-41, 14-42, 14-43

3. A plant-involving example of each type of the three major symbioses is presented in this chapter. Present an animal-involving example of each type of the three major symbioses.