Endosymbiosis

Symbiosis, which means "living together" is an ecological interaction in which two or more species live in or on each other in close contact. Thus, **endosymbiosis** is when an organism actually lives within another organism. **Mutualistic symbioses** are such interactions where the two parties benefit each other in terms of the ability of each partner to survive and reproduce.

Certain such mutualistic symbioses are some of the most important ecological interactions on the planet today. For instance, the interaction between coral polyps (animal phylum cnidaria, class anthozoa) and their endosymbiotic zooxanthellae (mostly dinoflagellates, but also other photosynthetic partners) are essential to the productivity and long-term survival of coral reef ecosystems. Likewise, the well-know partnership between legumes (plant family leguminaceae) and nitrogen-fixing bacteria (genera *rhyzobium* and *bradyrhyzobium*) is pivotal to the survival of terrestrial plant communities. Termites (insect order isoptera) harbor endosymbiotic protists, without which they would not be able to digest wood, and in many tropical communities, termites are essential for the process of returning the nutrients locked in wood to the soil. In hydrothermal vent systems, productivity is driven partially by chemoautotrophic archaeans living in an endosymbiotic relationship with tube worms (actually their own phylum, the vestimentaria, genus *riftia).* Mutualistic endosymbioses between two partners are often complex associations that are regulated by the genetic interactions of the partners, and many are very ancient. For instance, it is likely that the ecological interactions between corals and zooxanthellae go back to the Triassic period, at the beginning of the age of dinosaurs. Some endosymbiotic mutualisms are much older than that.

Endosymbioses are also thought to be important in an evolutionary context as well. As you shall see, the serial endosymbiosis theory, or SET, postulates that a series of endosymbiotic events enabled the evolution of eukaryotes, as evidenced by the DNA still present in mitochondria and chloroplasts. Aspects of this theory are becoming increasingly well supported (by phylogenetic studies, and other evidence from subcellular ultrastructure), and it is possible that endosymbiosis is a major mechanism of macroevolution, allowing an organism to acquire major new functions by incorporating the genome of another lineage into itself. Such an event is referred to as a primary endosymbiotic event. Secondary endosymbiotic events occur when an organism that has already underwent endosymbiosis is incorporated into still another organism via endosymbiosis. For instance, it is probable that green and red algae acquired photosynthesis via a primary endosymbiosis with cyanobacteria. Very likely, other groups of protozoa have acquired photosynthesis via secondary endosymbisis with either green algae (euglenoids, such as *Euglena arcus*), red algae (diatoms, certain dinoflagellates, and others), or both. Some groups are even tertiary endosymbiotes.

In lab today, you will observe some of the organisms involved in endosymbiosis and learn about the details of cellular biology that pertain to their evolution.

Prelab Questions
(Just answer what you know before coming to lab, you do not have to look these up.)

1. What is the difference between horizontal and vertical transmission of symbiont(s)?
a. horizontal transmission is sex-linked; vertical transmission is not
b. horizontally transmitted symbionts are acquired again each generation; vertically transmitted symbionts are acquired during reproduction
c. horizontally transmitted symbionts cannot live away from the host; vertically transmitted symbionts can be freeliving or symbiotic
d. horizontal transmission is genetic, vertical transmission is environmental

2. What structural feature of predatory prokaryotes allows for increased motility?
a. flagellum
b. cilia
c. cell wall
d. spindle

3. mDNA is the genetic material of a _____. It is arranged in a _____ shape.
a. mouse, helical
b. mouse, circular
c. mitochondrion, helical
d. mitochondrion, circular

4. Oxidative metabolism allows certain organisms to increase their energy output in the presence of _____.
a. oxygen
b. sulfur
c. nitrogen
d. water

5. _____ are capable of phagocytosis.
a. Prokaryotes
b. Archaeans
c. Salmonella
d. Viruses

6. List the following in their order of appearance in evolutionary history, from longest ago to most recent.
a. archaeans, eukaryotes, algae
b. eukaryotes, algae, archaeans,
c. algae, archaeans, eukaryotes
d. eukaryotes, archaeans, algae

Questions for Discussion

(check the syllabus and read the textbook before you come to discussion)

A) Approximately how old is the Earth? How much time passed between the origin of the Earth and the appearance of the first eukaryote? The first multicellular plants and animals?

B) Summarize the major differences between bacteria, archaea, and eukaryotes.

C) What is rRNA? Why is it of particular significance when constructing phylogenetic trees of events that occurred a very long time ago? Do chloroplasts and mitochondria have DNA as well?

D) Describe two cases of mutualistic endosymbiosis.

E) Name several major groups of "protists" and mention a few major features.

F) Speculate as to what the eukaryote might have been like.

G) Describe the endosymbiotic theory for the evolution of chloroplasts and mitochondria. What data support this theory?

The Lab Exercise

1. In lab today, there are organisms that represent extant examples of mutualistic endosymbioses.

For each organism, on a separate sheet of paper.

1) Examine it closely.
2) Draw it.
3) List the partners in the endosymbiosis and what they do for each other.

2. On the bench in the center of the room, there will be either a computer-based learning module, or a series of cards with information. Please go through the module or read the cards. Take notes in the space below: