

Endosymbiotic Theory

Evolution from Simple Prokaryotes to Complex Eukaryotes?

Now that we have examined both the Prokaryotic and Eukaryotic cells, we can see that the cell has sustained very dynamic changes over time. Specifically, we have seen the appearance of numerous cell organelles as well as the implementation of a more organized cell structure. The question is how did these changes occur? A fundamental concept of evolution is the belief in the natural progression *from the simple, to the more complex*. For the evolution of the eukaryotic cell, the predominating theory is known as the Endosymbiotic Theory.

Endosymbiotic Theory

The Endosymbiotic Theory of Eukaryote Evolution (**Symbiotic Theory**) was first proposed by former Boston University Biologist [Lynn Margulis](#) in the 1960's and officially in her 1981 book "*Symbiosis in Cell Evolution*". Although now accepted as a plausible theory, both she and her theory were ridiculed by mainstream biologists for a number of years. Thanks to her persistence, biology can now offer a plausible explanation for the evolution of eukaryotes.

The theory maintains that ancestors of eukaryotic cells were "**symbiotic consortiums**" of prokaryote cells with at least one and possibly more species (**endosymbionts**) involved.

In other words, perhaps oxygen breathing bacteria invaded an anaerobic amoeba-like bacteria, and each performed *mutually benefiting* functions. The bacteria would breathe for the anaerobic amoeba-like bacteria, and the amoeba-like bacteria would navigate through new oxygen-rich waters in search of food. This way, each of the organisms would be benefiting from their symbiotic relationship as the waters and atmosphere of the Precambrian changed. In support of this, notice that oxygen begins to accumulate between the first fossil records of Prokaryotes and Eukaryotes.

years ago	Important Dates
4.5 Billion	Origin Of The Earth
3.5 Billion	Prokaryote Bacteria Dominate
2.5 Billion	Oxygen Accumulates In Atmosphere
1.5 Billion	Eukaryotes —First Nucleated Cell
0.5 Billion	Cambrian Explosion Of Multicellular Eukaryote Organisms

Figure 1-1

Professor Kwang Jeon's Supporting Discovery

Seem more like a creative story than a plausible theory? Let's examine the case of Professor Kwang Jeon of the University of Tennessee. In 1987, Professor Jeon noticed that his collection of amoeba were developing a large number of dots. These large number of dots turned out to be bacteria, which were quickly killing off Jeon's collection. Jeon noted the least sick ones and began keeping records of their progress. The least sick ones apparently were more resistant to the bacteria since they survived and returned to their normal modes. However, some 40,000 of the invading bacteria were still present within each of the surviving amoebas! Through transplanting experimentation, Jeon found that the nucleus of the amoebas could *not* live without the once pathogenic bacteria. Jeon's accidental discovery proves that it is possible for an organism to become dependent on and a functional part of invading organisms. *Rather than eliminating competitors, evolution eliminated competition itself on the basis of symbiotic relationships.*

Functional Description

Now that we have an idea of how symbiosis occurred, let's take a functional look at the entire process and how specific organelles evolved. Notice the diagram to the right which illustrates this process.

The original prokaryotic host cell, located at the top of the diagram, ate or otherwise ingested aerobic bacteria (which may also have been a parasite), which reproduced such that subsequent generations of this new cell would also contain the newly ingested bacteria. These aerobic bacteria survived via the nutrients from the host prokaryotic cell, while multiple invaginations of the cell membrane helped prepare the aerobic bacteria for their new roles. Over time, both the prokaryotic host as well as the bacteria endosymbionts developed a mutually satisfying or beneficial existence and both entities lost their ability to function without the other. The ingested aerobic bacteria, which by definition are pro-oxygen, controlled and made possible the oxidative metabolism of what was the prokaryotic host cell.

As the external world changed during the Precambrian times, the aerobic bacteria began to utilize and adapt their former roles to very similar functions with the prokaryotic cell. As discussed previously in the "Eukaryote" section, we recognize this former aerobic bacteria to have assumed the role of **mitochondria**.

Eukaryotic animals, fungi, and some protists in the cell, indicated in the lower right corner of the figure, evolved from this newly adapted cell.

The evolution of eukaryotic plants and some of the other protists incorporated photosynthetic bacteria endosymbionts whereby a similar process occurred as with aerobic bacteria and mitochondria. The photosynthetic bacteria utilized its ability to perform photosynthesis for the former prokaryotic host cell, rather than just for itself. We recognize this to be the **chloroplast**.

But What About The DNA?

Prior to Margulis' conception of the Symbiotic Theory in the 1960's, biologists believed that organelles were coded into the eukaryote's genetic master plan/blueprint, or **DNA**. In other words, the organelles existed because they were stipulated to exist by the DNA, much like why all humans have hands or feet. When Margulis initially proposed the Symbiotic Theory, she predicted that, if the organelles were really bacterial (prokaryotic) symbionts, they would have their own DNA. If her theory was true, she reasoned, the DNA should resemble other bacteria and be different from the cell's DNA (located in the nucleus membrane). Amazingly, in the 1980's this was proven to be the case for two classes of organelles, the mitochondria and chloroplasts. Further, in the late 1980's a team of Rockefeller University investigators announced their similar discovery regarding **centrioles**, structures that provide the eukaryotic cell with the ability of locomotion and cell division.

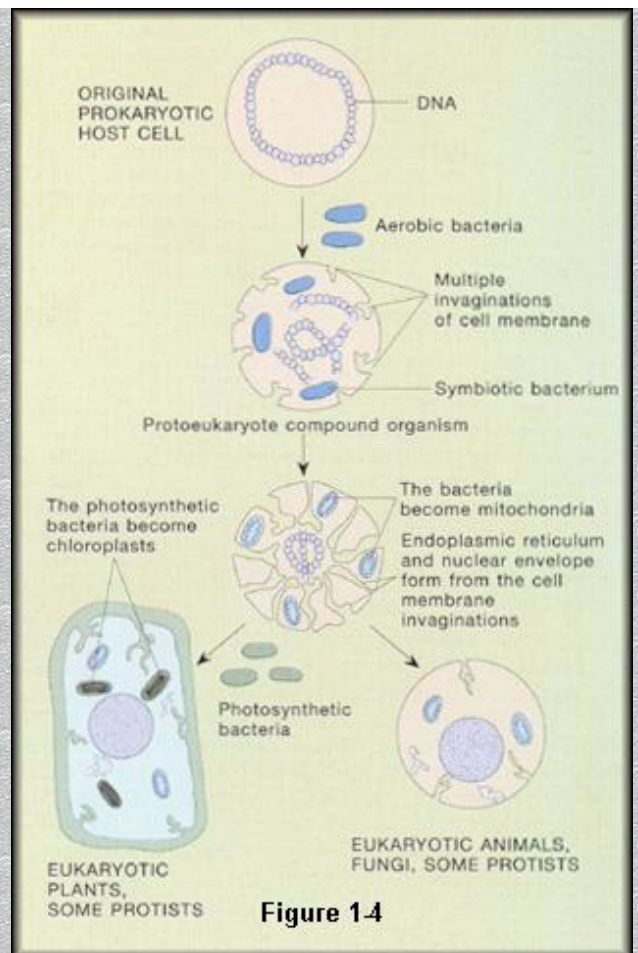


Figure 1-4

