How eukaryotic organisms came into existance

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According to the University of Utah (2010) contemporary science dictates that modern day eukaryotic cells (deriving from the Greek words eu-‘ true’, karyo-‘ nucleus’) have evolved from simple unicellular organisms known as prokaryotes (pro-‘ before’, karyo-‘ nucleus’) through a series of random mutations, others wise known as natural selection. They are both considered to be living organisms as both types of cells; can be organized in a hierarchy(depending on feeding patterns) , they contain chemical instructions, both engage in metabolic activities, regulate their internal conditions in order to accommodate to its surroundings (homeostasis) and we can observe changes in characteristics over generations (evolution).

There are several distinct differences between the structures of prokaryote and eukaryotic cells for instance; eukaryotic cells have a membrane bound nucleus whereas in a prokaryote the DNA is free, meiosis occurs in eukaryotes but not in unicellular organisms and most importantly eukaryotes have membrane bound organelles such as chloroplast or mitochondria, while prokaryotic cells do not posses such organelles, (Toole et al 1999). Scientists suggest that the reason why eukaryotic cells have membrane bound organelles is due to their origins.

The theory of endosymbiosis seems to pose a logical explanation as to how eukaryotic cells came into existence. The theory was popularised by Lynn Margulis (University of Massachusetts) although it was articulated by Andreas Schimper in 1883, (Toole et al 1999). Khanna (2010) writes that that it was neglected for many years, however much attention began to be paid to the theory after the discovery of mitochondria in the 1960s. The oxford dictionary defines endosymbiosis as being ‘ symbiosis [the interaction between two different organisms living in close physical association, typically to the advantage of both] in which one of the symbiotic organisms lives inside the other'. There are also conflicting theories such as the idea that organelles may have arisen as a result of invaginations of the plasma membrane which became ' pinched off' to give separate membrane-bound structures within the main cell (Toole et al 1999).

Scientists presume that microscopic unicellular organisms appeared on earth around 3. 5 billion years ago, in the oceans, when conditions on earth were hostile and virtually lifeless. The latest theory suggests that chemicals spewing from underwater vents solidified forming towers. This produced the idea conditions for the first cells to form. These early cells are believed to have been photosynthesising bacteria. The earliest evidences we have of such organisms are fossilised remains, such as stromatalites found in Sharks Bay, Western Australia (Russell et al 2007). Eukaryotic cells probably arose a little over a billion years ago; roughly 2. 5 million years after their prokaryotic ancestors were the first thought to have arisen (Toole et al 1999).

Margulis' theory of endosymbiosis suggests that some primitive cells would engulf others, and rather than digesting them, particular unicellular organisms began to develop symbiotic relationships with their host organisms. This apparently took place a number of times in succession; hence the cells we observe today contain numerous types of different organelles. She stated that eukaryotic cells had first started out separate prokaryotic organisms that developed symbiotic interactions (Russell et al 2007). This relationship benefited both the engulfed and host organisms. The organism that had been engulfed was protected from predators whereas the host cell was provided with a selective advantage another ATP output source, aerobic endosymbionts which may have turned into mitochondria or whether it was from photosynthetic endosymbionts which are believed to have evolved into chloroplasts. This process of endosymbiosis still takes place today for instance, Ciliate symbionts, these sand dwelling organisms ingest sulphur bacteria on its surface (Northern Arizona University, 2005).

Although there are several different variations of eukaryotic cells exist the two main types are animal and plant cells;

Mitochondria are organelles that can be located in the cytoplasm of all eukaryotic cells. They are believed to have begun to develop when photosynthetic and nonphotosynthetic prokaryotes coexisted in an oxygen rich atmosphere. They have a double membrane similar to that found in currently existing prokaryotic cells, the outer layer which controls the entry and exit of chemicals. The inner layer has a much greater surface area than the outer layer. This greater surface area is achieved because the inner layer is folded into what is known as cristae. This increases the area, in which respiratory reactions are able to occur. The mitochondria are also made up of the matrix, the remaining area which is made up of a partially rigid material that contains proteins, lipids and traces of DNA. The function of mitochondria is the production of ATP (adenine triphosphate), an energy source vital for the survival and function of cells. The number of mitochondria varies depending on the function of the cell, a highly metabolically active cell can contain up to 1000 mitochondria. (Parsons 2009)

Chloroplasts are a small flattened organelles found in plants. They have a function similar to mitochondria in animal cells, they are both considered to be the “ power source” of a cell. They use the process of photosynthesis to produce glucose for the plant which is stored as starch in the vacuole. As with mitochondria, chloroplast is surrounded by a double membrane (which is not unlike that found in prokaryotic cells of today) called the chloroplast membrane envelope, and also has membranes inside called thylakoid membranes. Thylakoid (fluid-filled sacs) are stacked up in some parts of the chloroplast to form structures called grana. Grana are linked together by lamellae, thin flat pieces of thylakoid membrane. Chloroplasts contain photosynthetic pigments (e. g. chlorophyll a and chlorophyll b and carotene). These are coloured substances that absorb the light energy needed for photosynthesis. The pigments are found in the thylakoid membranes- they are attached to proteins. The protein and pigment is called a photosystem. A photosystem contains two types of photosynthetic pigments- primary pigments and accessory pigments. Primary pigments are reaction centre where electrons are excited during the light-dependant reaction. Accessory pigments surround the primary pigments and transfer light energy to (Parsons 2009).

When Margulis originally proposed the endosymbiotic theory, she predicted that, if the organelles originated as prokaryotic symbionts they would still bare many similar characteristic. The most prominent similarity can be found in the DNA of mitochondria and chloroplast. She expected that the DNA of the organelles would that resembled bacterial DNA. This is in fact true as unlike other organelles mitochondria and chloroplast contain their own DNA much like prokaryotes do. Similarly the DNA found in mitochondria and chloroplasts are circular, the same as that which is observed in the chromosomes of bacteria and differing from the DNA located in the nucleus of the cell (University of California, Santa Barbara, 2002). A further support of Murgulis' theory is in the size of ribosomes, mitochondria and chloroplasts have ribosomes of similar size to those prokaryotes.

Mitochondria and chloroplast also contain several differences which set them apart from other organelles; these characteristics are evidences that they were originally prokaryotic cells. The first major difference between them and other organelles is that they contain their own DNA that loops around, this is a similar characteristic observed in bacteria. Another similarity that they have with bacteria is they manufacture many of their own proteins, and they both reproduce by binary fission (Indiana University-Purdue University Indianapolis, 2002). These similarities between mitochondria, chloroplast and bacteria have led scientist to believe that these organelles may have evolved from prokaryotic cells that developed symbiotic relationships with other prokaryotes.

On the other hand despite all the supposedly convincing pieces of evidence which support the theory of endosymbiosis as being a reliable theory to explain how complex cells came into existence there are still numerous counterarguments to Margulis' theory. Extensive studies of DNA show that mitochondria and plastids do not show many similarities with the DNA of prokaryotes. For instance mitochondria and chloroplast contain introns, regions of non-coding nucleic acids, which are found in nuclear DNA but not in the DNA of prokaryotes (Scheffler 1999). Another counterargument to

Margulis' theory is the fact that neither mitochondria nor chloroplast area able to survive outside a cell.

Nevertheless there is an increasing amount of evidence to support the hypothesis, rather than opposing it. Lynn Margulis' theory of endosymbiosis has become well respected and highly supported throughout the scientific field, and as of yet the only opposition to her ideas of the origins of life are that of religious explanation of creation. The argument that eukaryotic cells have their origins as prokaryotates seems to be a logical one and is well supported by what some may consider being fact.