How eukaryotic organisms came into existence

Living systems (LST) are self-organising systems that interact with the environment. Flows of information, energy and matter maintain these systems in order and balance. Miller (1978) defines LST as a “ set of related definitions, assumptions, and propositions which deal with reality as an integrated hierarchy of organizations of matter and energy”. LST is as an excellent and powerful tool in aiding an individual to understand and interpret reality, especially its living part. However when it comes to intervention, design and change, the LST gives little or no guidance concerning what to do and what actions and approaches to select. So although the LST provides extensive amount of knowledge in regards to life and living systems nevertheless it mentions nothing to do with that knowledge. Multicellular organisms are thought to have evolved at least 1. 7 billion years ago; organisms consisted of many or more than one cell which have interdependent cells (differentiated cells) that perform specialised functions in an organism. Examples of multicellular organisms are humans, plants and animals which can be seen by the naked eye. Cells are separated into two main classes primarily by whether they contain a nucleus. Prokaryotic cells (bacteria) lack a nuclear envelope whereas eukaryotic cells have a nucleus in which genetic material is split from the cytoplasm. In general prokaryotic cells are smaller and simpler than eukaryotic cells. In addition to the absence of a nucleus prokaryotic genomes are less complex and they do not contain organelles in its cytoplasm or cytoskeleton. In spite of all these differences, the same basic molecular mechanisms manage the lives of both prokaryotes and eukaryotes which indicate that all present-day cells have descended or evolved over time.

The endosymbiotic theory explains and provides evidence of cell evolution which claims that bacteria cells evolved to animal and plant cells by phagocytosis through a process called endosymbiosis. [endo= inside; sym= together; bio= life]. Symbiosis describes the close relationship between two or more organisms of different species, where they are not always benefiting each member. The relationship of algae and fungi in lichens and of bacteria living in the intestines or on the skin of animals are forms of symbiosis. Some scientists believe that many multicellular organisms evolved from symbiotic relationships between unicellular ones and that the DNA-containing organelles within certain eukaryotic cells (such as mitochondria and chloroplasts) are the product of symbiotic relationships in which the participants became interdependent.

A significant step in the breakthrough of the evolution of eukaryotic cells was the knowledge gained of membrane-enclosed sub-cellular organelles, allowing the progress of the complexity characteristic of these cells. The organelles are thought to have been acquired as a result of the relationship of prokaryotic cells eukaryotes. Studies show that the theory of endosymbiosis shows evidence that origin of mitochondria and chloroplasts which are organelles of eukaryotic cells are thought to have evolved from bacteria living in larger cells. Both chloroplast and mitochondria are similar to bacteria in size and like bacteria they reproduce by a process called binary fission.

The American microbiologist Lynn Margulis formulated the endosymbiosis theory that mitochondria and chloroplasts evolved from prokaryotic bacteria. Although now an acknowledged theory and biologist, she and her theory

were rejected by many biologists for a number of years, her breakthrough came due to her persistence, and vast amounts of research and data gathered by her and many other biologists over the last 30 years. The discovery of mitochondria having similarities in structures played a key role in making her theory widely accepted by the science world. According to her hypothesis these mitochondria and chloroplasts originated as separate prokaryotic organisms that were taken inside the cell as endosymbionts. Mitochondria evolved from aerobic bacteria (proteobacteria) and chloroplasts from photosynthetic bacteria (cyanobacteria).

The contraction of aerobic bacteria would have provided an anaerobic cell with the ability to carry out oxidative metabolism. The acquisition of photosynthetic bacteria would have provided the nutritional freedom given by the ability to perform photosynthesis. The Endosymbiotic theory proposes that mitochondria and chloroplasts were once prokaryotic cells, living inside larger host cells. The prokaryotes were known to have been ingested in the larger cell but somehow escaping digestion. It is not known for the reason why they were ingested and interned but purely for advantageous reasons to the host cells which ingested them. The endosymbionts provided crucial nutrients to the host cell by chloroplasts and the mitochondria helping to have exploit oxygen from extracting energy. The endosymbionts were protected with in a safe environment inside the host cell which they lived for many millions of years.

Charles Darwin (1809-1882) theory of natural selection which we know today from the famous quote of “ Survival of the fittest” supports the endosymbiosis theory. Early eukaryotic cells gained an advantage over their

neighbours, once mitochondria (high energy source), were ingested in larger host cells. Mitochondria and their hosts increasingly were relying more and more on each other to survive. Eventually, neither could succeed alone but as a force united they produced millions of descendents, establishing a whole new domain of life.

Both organelles are surrounded by two or more membranes where the innermost of the membranes show differences in composition from other membranes of the cell. The composition is like that of a prokaryotes cell membrane, while the outer membrane may have formed from food vacuoles as the host cell devoured the prokaryote. The inner membrane of these mitochondria and chloroplasts contains enzymes and transport systems, showing more similarities to that of prokaryotes.

The inner membrane of mitochondria has a larger surface area which arose due to the inner layer being folded into what is called cristae. This is turn means that there is more area for the respiratory reaction occur in the organelle. Mitochondria can be found in they cytoplasm of eukaryotic cells similar to shape and size to chloroplasts. The primary function of mitochondria is the production of ATP which is an energy source vital for the proper functioning and survival of the organelle. The outer membrane is a relatively simple phospholipid bilayer, ions, nutrients; ATP, ADP, etc. can pass through with ease. The matrix is where diffusion happens, this is a very slow process due to the folds of the cristae, the matrix is close to the inner membrane, resulting in the diffusion rate to the inner membrane complexes and transport proteins within a short time.

Chloroplasts are only found in plants, with a similar function to that of mitochondria, where they both provide energy in the cell. There appearance is that of flattened discs, using a process called photosynthesis to extract carbon dioxide from the surrounding and converting and releasing as oxygen to form glucose, which is stored a starch a food source. Chloroplasts are complex organelles which differ to those of mitochondria, as chloroplasts have there a double membrane called the chloroplast envelope and membranes of thylakoids inside. Chlorophyll is vital and is found in thylakoids membranes in the chloroplast, it is a coloured pigment which converts light energy for photosynthesis. Thylakoids are fluid-filled sacs stacked up in the chloroplast to form structures called grana. Grana which are flat thin pieces of thylakoids membrane are linked together by lamellae.

Mitochondria and chloroplasts both have their own DNA molecules. Their DNA’s are not duplicates of nuclear DNA but their DNA is exclusive and vital to the mitochondrion or the chloroplast. Genes are carried by mitochondrial DNA; these genes are replicated each time the organelle divides, and the genes they encode are transcribed within the organelle and translated on the organelle ribosomes. Thus mitochondria and chloroplasts contain there own genetic systems, which are distinct and dissimilar to the genetic material of nucleus. Unlike the DNA in the nucleus, mitochondrial and chloroplast DNA’s are exposed and circular similar to that of a prokaryotic cells DNA.

Genes of the nucleus can not duplicate these. Each organelle has its own ribosomes; these ribosomes are different to those found in the cytoplasm of a cell. The proteins coded for by the mitochondrial genes are produced by

mitochondrial ribosomes, and those coded for by the chloroplast genes are produced by chloroplast ribosomes. These ribosomes are more closely related to those of bacteria that those encoded by the nuclear genomes of eukaryotes. Bacteria show more similarities to these organelles as size is also a similarity.

To conclude on the question on “ discuss how eukaryotic organisms came into existence”, I believe that the evidence and information regarding the theory of endosymbiosis is reliable but not 100% valid as there are many counter arguments to Lynn Margulis’s theory. Numerous studies of DNA show that in fact mitochondria and chloroplasts do not show many similarities that of prokaryotes. For instance neither mitochondria nor chloroplasts can survive in oxygen or outside of the cell indicating that the cell would have lost many vital genes on the way. However both mitochondria and chloroplast are similar in size to prokaryotes, they lack a normal nucleus found in eukaryotic cells but have circular DNA which lacks histones similar to that of eukaryotic cells. Also symbiosis supports the fact that the host cells became dependant on the organelles which it ingested and the lack of DNA within the nucleus and the organelles having their own DNA explains that they would have been independent cells. Both organelles reproduce by division in a process called binary fission, prokaryotic cells also reproduce the same way.

On the other hand there are many questions still to be answered. How did the cell manage to reproduce in such a tight space and inside another cell? How did the DNA of the ingested cell pass into the hosts DNA, as the DNA should have been blocked as the host would have responded by degrading

the foreign DNA and detect it as a virus. However this can be counter argued against as similarities in structure of both organelles can prokaryotic cells can be explained by their functions and processes and not through their structures. In photosynthesis both chloroplast and cyanobacteria convert carbon dioxide and water with light energy into glucose and oxygen.

Nevertheless there is more evidence to sustain the endosymbiotic hypothesis; the evidence outweighs the questions and arguments against. Lynn Margulis' theory of endosymbiosis is widely used and accepted by the scientists and science world of today and the more valid and important ideas of the origin and evolution of the cell are of creationists. Finally I agree with the argument that some eukaryotic cells have derived and evolved from prokaryotes and the theory of endosymbiosis seems valid and vital in the way we understand evolution of the cell today.

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