ORGANELLES AND OTHER STRUCTURES IN CELL BIOLOGY

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1. Introduction

That the eukaryote cell is large and contains complex subcellular structures has been obvious since the beginning of light microscopy and this, of course, contrasts with the smaller and prokaryote cell without any major subcellular structures. Of the eukaryote subcellular structures observed, the mitochondrion and the chloroplast stand out because both are highly complex even under the light microscope. The latter also is the defining structure by which, in general, it is possible to tell plants from animals. The importance of both mitochondria and chloroplasts goes well beyond their visual impact even when viewed by electron microscopy.

Without these structures, life as we know it would not exist on Earth. They both provide, by two different mechanisms, the energy that allows eukaryotes to exist, evolve and change the Earth to what it is today. They have also helped to create the oxygen rich and temperate environment that we live in on Earth at present. Although the prokaryotes, particularly the photosynthetic cyanobacteria were probably responsible for the initial changes on Earth towards the present aerobic mild environment, without the plants in particular, today’s environment would be very different; and without the animals, the environment would be much more bare. Plants and animals as such would not exist without the two organelles, the mitochondrion and the chloroplast.
2. The distribution and function of the mitochondrion

Mitochondria are found in both animal and plant cells. Very few eukaryotic cells are without at least one mitochondrion although examples do exist, but in these cases it is not clear whether they lack of a mitochondrion is an ancestral or derived character. They are the sites of oxidative cell respiration. That is they generate large amounts of adenosine triphosphate (ATP) from the oxidation of glucose using oxygen as a final electron acceptor. Without the mitochondrion, eukaryotic cells are limited to fermentation which produces only a limited amount of ATP and would not allow the evolution of complex multicellular organisms with vast energy requirements.

2.1 The structure of the mitochondrion

![Diagram of mitochondrion](image)

Figure 1: Diagram of mitochondrion

Figure 1 show a basic structure for the mitochondrion as seen by electron microscopy with a double membrane and internal invaginations or cristae. Mitochondria range in size from 0.5 to 1 μm in diameter and a few μm in length. The respiratory proteins reside in the membrane and create ATP via a proton pump mechanism. However, the most significant piece of structural information about the mitochondrion is that it contains its own genetic material. That is that it has its own genome, separate from the DNA in the eukaryote nucleus. The presence of this DNA led to the hypothesis that mitochondria evolved from an endosymbiotic gram negative prokaryote and that the genome found in these organelles resembles that of their prokaryote ancestor (See 4.0). The mitochondrion have their own protein synthetic machinery, which is different from that of the eukaryotic cytoplasm and resembles to some extent that found in prokaryotes. These ribosomes have a different size (70S) from the cytoplasmic ribosomes (80S), being close to prokaryotic ribosomes in size. They also show sensitivity to antibiotics that affect prokaryotic ribosomes and resistance to antibiotics that inhibit protein synthesis by eukaryotic ribosomes. However, they are not completely self sufficient organisms, and although they
reproduce by fission independently of the cell nucleus, they are unable to reproduce if purified. This is because they are required to import a range of molecules including enzymes that are encoded by cell nucleus and synthesized outside of the mitochondrial membrane. Specific import systems are present to transport these molecules across the double mitochondrial membrane (Figure 1).

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356-368 (1981). (Where did microtubules come from?)


Biographical Sketch

Ralph Kirby is Professor of Microbiology at Rhodes University, Grahamstown, South Africa. He has held this position for the last ten years. He graduated with his B.A. at Trinity College, Cambridge, UK, in 1972, and completed his Ph.D. at the University of East Anglia, UK, in 1976. Post-doctoral research followed at the University of Bristol, UK, then a lectureship and senior lectureship at the University of Cape Town, South Africa. His major interests are the molecular genetics of Actinomycetes, horizontal gene transfer, molecular population genetics, and the interaction between law and science. He is presently completing a LL.B.

Timeline

Full Professor, Department of Life Science, National Yang-Ming University, Peitou, Taipei, Taiwan. 2003-onwards.

Full Professor, Department of Biochemistry, Microbiology and Biotechnology, Rhodes University, Grahamstown, South Africa. 1990-2003.

Senior Lecturer, Department of Microbiology, University of Cape Town, Rondebosch, Cape Town, South Africa. 1980-1989.

Postdoctoral Research Fellow, Department of Bacteriology, University of Bristol, Bristol, UK. 1975-1979.

John Innes PhD Studentship, Department of Genetics, John Innes Institute, Norwich, UK. 1972-1975.


Qualifications

LLB (UNISA) Intellectual Property and DNA Profiling in Criminal Procedure.

MA (Cantab) Genetics.

PhD (UEA) Genetic studies on Streptomyces coelicolor Plasmid One.


Research Interests
Molecular Population Genetics
1) Molecular Microbial Ecology of Sulfate Reducing Bioreactor System.
2) Molecular Microbial Ecology of thermophilic Actinomycetes.
3) Molecular evolution of lignin degrading enzymes.

Actinomycetes
1) Evolution, linear chromosomes and horizontal gene transfer in Actinomycetes.
2) Biotechnology application of lignin degrading enzymes from thermophilic Actinomycetes.
3) Genome scale analysis of various Streptomyces and the Actinomycetales using a Streptomyces coelicolor microarray.
4) Use of membrane bioreactors to produce Actinomycetes secondary metabolites.
5) Genome scale analysis of Streptomyces and related organisms using microarrays.
6) Development of a differential microarray between Streptomyces coelicolor A3(2) and Streptomyces.

Other
1) The law and molecular biotechnology.

Although Ralph Kirby has made a career as a full-time academic with research interests in genetics and Actinomycetes from PhD onwards, he have also had a long time interest in the law and is a qualified lawyer, although he does not practice. His legal interests revolve around DNA profiling in both criminal and civil cases as well as biotechnology as intellectual property and have involved both the academic aspects and court work. Also, he have been and am involved in a number of biotechnology start-up companies.