BIOL 200 (Section 921)
Lecture # 8 (Unit 6)
June 28, 2006

UNIT 6: MITOCHONDRIA AND CHLOROPLASTS

Reading:

ECB 2nd ed. **Chap 14**, pp. 453-492 and related questions, especially 14-3; 14-11B,C,E, H;14-13; 14-16.
ECB 1st ed. **Chap 13**, pp. 407-442 and related questions, especially 13-3; 13-11B,C,E, H;13-13; 13-17.

I. MITOCHONDRIA AND THE CHEMIOSMOTIC ATP FORMATION

Learning Objectives

- Application of chemiosmotic theory to understand the structure-function relationships of the mitochondrial energy transduction system.
- Understand the role of electron transport complexes in the establishment of mitochondrial proton gradient

Main Points

- Mitochondria consist of two compartments, the intermembrane space and the matrix.
- The enzymes of the matrix carry out the TCA cycle. This series of metabolic transformations results in reduction of NAD^+ (electrons being added to NAD^+). NADH is a electron carrier that donates electrons to the electron transport chain.
- The electron transport chain is a series of three molecular complexes in the inner mitochondrial membrane. As elecctrons are passed through each of these complex protons are pumped from the matrix to the intermembrane space.
- Electrons are finally added to oxygen as the terminal electron acceptor.
- Energy stored in the proton gradient across the inner mitochondrial membrane is used to drive the phosphorylation of ADP to produce ATP by the chemiosmotic process
- Dependent on glycolysis, but do not do it themselves
- Transfer electrons from NADH along an electron transport chain (ETC).
- TCA cycle -tricarboxylic acid cycle - citric acid cycle
- Produce CO_2 and ATP
- Build an ETC-linked H^+ gradient

Exercise: Prepare a list of what mitochondria do to produce ATP. The issue is the structural and functional organization of the organelles - how the organelle as a whole operates.

II. CHLOROPLAST, PHOTOSYNTHESIS AND PHOTOPHOSPHORYLATION

Learning Objectives

- Application of chemiosmotic theory to understand the structure-function relationships of the chloroplast energy transduction system.
- Understand the role of electron transport complexes in the establishment of chloroplast proton gradient

Main Points

- Photosynthesis is carried out in chloroplasts. Chloroplasts are one type of the organelle class called **PLASTIDS**. Plastids are specialized for different functions. Examples:
  o **Chloroplasts** are green plastids specialized for photosynthesis.
  o **Chromoplasts** are plastids filled with orange or yellow pigments that give colour to flowers and fruit.
  o **Amyloplasts** are plastids that store starch in storage tissues such as seeds, roots and stems. Amyloplasts in the root cap fall to one side of a cell and signal gravity perception
  o **Etioplasts** are plastids which develop in tissues in the dark and lack pigments.
  o **Proplastids** are a juvenile form of plastid that occurs in embryos and apical meristems. They give rise to all other types of plastids depending on requirements of each differentiated plant cell.

- Chloroplasts have three membrane systems; the outer and inner membranes, and the thylakoid membrane
- The light-capturing systems, the electron transport chain, and ATP synthase are contained in a thylakoid membrane.
- Sunlight provides energy for the photosynthetic electron transport.
- The electron transport results in pumping of the protons across the thylakoid membrane.
- Energy stored in the proton gradient is used to drive the phosphorylation of ADP to produce ATP by the chemiosmotic process
- The ATP and NADPH produced by the photosynthetic electron transport serve as the source of energy and reducing power, respectively, to form carbohydrates from CO_2.
- Mitochondria and chloroplasts have a procaryotic origin

Table 1: Some structural and functional comparisons of mitochondria and chloroplasts relating to chemiosmotic generation of ATP

	Mitochondria	**Chloroplasts**
Site of Electron transport chains	Inner membrane- cristae	thylakoid membrane
Protons pumped from	Matrix	Stroma
Protons pumped to	Intermembrane space	thylakoid space

Protons return through ATP synthase channel to	Matrix	Stroma
Electron donor	Reduced carbon compounds --> NAD	Water
Terminal electron acceptor	oxygen (O_2)	NADP --> CO_2

Table 2: Some properties of genomes and the protein synthesizing systems of bacteria, mitochondria and chloroplasts as compared with the eukaryotic system

Trait	**Gram-negative bacteria**	**Mitochondria**	**Chloroplasts**	**Eukaryotes**
ribosomal RNAs	23s, 16s	23s or smaller, 16s or smaller	23s or smaller, 16s or smaller	28s, 5.8s, 18s
ribosomes	70s total 50s, 30s subunits	70s or smaller	70s or smaller	80s total, 60s, 40s subunits
genome	circular DNA, no centromere	circular DNA, no centromere	circular DNA, no centromere	linear DNA with telomeres and centromeres
number of genes	~5000	5-35 (varies among eukaryotic groups)	~120	15,000-100,000
translation inhibitors	chloramphenicol, streptomycin	chloramphenicol, streptomycin	chloramphenicol, streptomycin	cycloheximide