Lecture Number 3: **Eukaryotic cells 1**

Topics:

- Prokaryotic vs Eukaryotic cells (**3:68-69, 88).**
- Division of labour in eukaryotic cells (**3:69-70**).
- Structure and function of nuclei (**3:70-72**).
- Structure and function of the mitochondrion (**3:79-80).**
- Structure and function of chloroplasts (**3:80-82).**
- Primary (**35:825**) and secondary (**35:833**) endosymbiosis and the origin of organelles.

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Recommended Reading: All citations are from: Knox, Ladiges, Evans & Saint" *Biology*" 3rd Edition (McGraw-Hill, 2005); citations are for Chap., page number, thus: **33:788**.

Theme/Objective: To understand the complex structure and differentiation of eukaryotic cells and the possible origin of mitochondria and chloroplasts through processes of endosymbiosis.

Keywords/concepts: Nucleus, nuclear envelope, nucleolus, mitochondrion (mitochondria), chloroplast, primary endosymbiosis, secondary or eukaryotic endosymbiosis.

Summary of Lecture:

1. Prokaryotic vs Eukaryotic: As we discussed last time, there are two fundamentally distinct kinds of cells, prokaryotes and eukaryotes, that differ most notably in the organisation of their genetic material. However, there are other major differences that will be discussed in lectures 2 and 3 on eukaryotic cells.

2. Division of labour: The eukaryotes are characterised by their structural and functional complexity, with their biochemical reactions isolated from one another within distinct cellular compartments. Eukaryotes may be unicellular or form complex multicellular organisms. Cells contain true nuclei, membrane-bound mitochondria (+ chloroplasts in plants), an endomembrane system, a cytoskeleton (including microtubules & actin), flagella, linear chromosomes with histones, large ribosomes and other features.

The great majority of organisms that we are familiar with are eukaryotic. In the 3 super kingdom system, there are 2 prokaryotic kingdoms (the bacteria and archaea), but 1 eukaryotic super kingdom, which includes 4 Kingdoms (the protists, fungi, animals and plants).

3. Nucleus: - aggregation of DNA, control centre for the cell. The nucleus is surrounded by a double membrane that is part of the endomembrane system to be discussed in the next lecture. The major components of the nucleus are the DNA and RNA. These molecules will be discussed in detail in the genetics section of 600-142.

4. Mitochondrion (or Mitochondria): - present in almost all eukaryotic cells as the power plant of the cell. Mitochondria contain enzyme systems for the breakdown of food molecules to release energy. Each organelle is surrounded by a double membrane, the inner membrane folds inward to produce finger-like projections called cristae.

5. Chloroplasts: - present in Kingdoms Plantae and Protista, catching light energy and synthesizing food molecules by the process of photosynthesis. Organisms with chloroplasts are therefore at the base of all food chains. Chloroplasts contain chlorophyll, a green pigment that traps light energy. Each organelle is surrounded by a double membrane envelope. The inner membrane has complex folds that form enclosed sacks of membrane called thylakoids. A stack of thylakoids is called a granum, while lamellae are thylakoids that connect two granae. The matrix that surrounds the membrane components is called the stroma. Chloroplast structure and pigmentation varies considerably between different kinds of organisms.

6. Endosymbiosis and the origin of organelles: - How did eukaryotic cells arise in the first place?

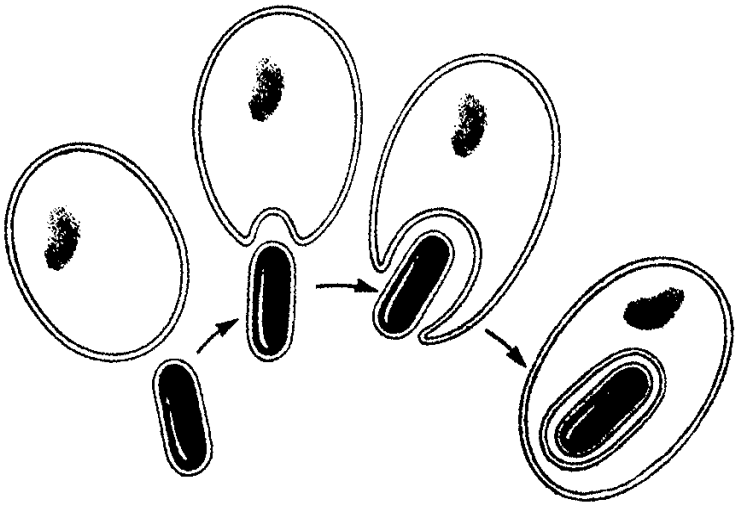
There is no real evidence to explain the origin of the nucleus, but it probably arose by the aggregation of flattened membrane spheres around a nucleoid containing DNA and RNA. The nuclear pores remain to allow communication between the nucleus and cytoplasm (for example, to allow for the passage of RNA out of the nucleus to the cytoplasm). The membrane probably came from invaginations of the cell membrane.

What about other membrane bound organelles, specifically the mitochondria and chloroplasts? The eukaryotic cell may actually be a chimera of other cells. Double membrane bound organelles (mitochondrion & chloroplast) are probably prokaryotes living permanently inside a eukaryotic cell. Evidence for an endosymbiotic origin of organelles is interesting, and is still accumulating in the scientific literature. This evidence will be discussed in detail in the lecture.

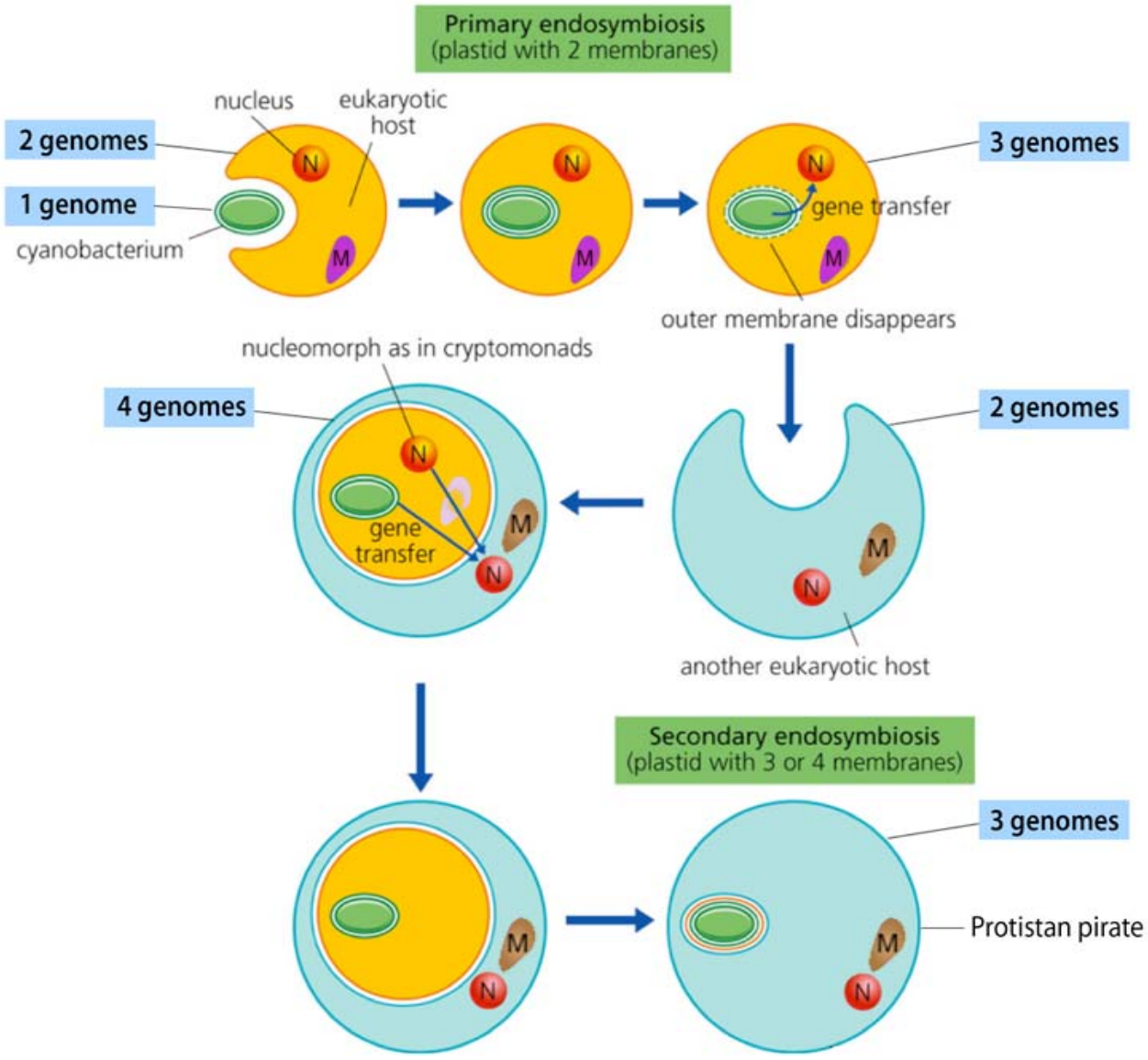
Where did mitochondria and chloroplasts come from?

Mitochondrion:	thought to have originated as symbiotic, aerobic bacteria (purple bacterium)
Chloroplast:	believed derived from a symbiotic, photosynthetic bacteria (or cyanobacterium)

How might endosymbiosis occur? The following simple diagram illustrates what probably happened during the origin of the mitochondrion and chloroplast.



7. Secondary or Eukaryotic endosymbiosis: There are organisms today that appear to be in the process of obtaining organelles, particularly chloroplasts, from other organisms. If a eukaryotic cell devours another eukaryotic cell and obtains a chloroplast from it, the process is referred to as **secondary or eukaryotic endosymbiosis.** An example is a cryptomonad cell. This process is illustrated below in a modified slide from page 833 in your text (3rd edition) that includes the origin of the mitochondrion and lists the number of genomes in each organism


Primary endosymbiosis
(plastid with 2 membranes)
nucleus
eukaryotic host
2 genomes
1 genome
cyanobacterium
N
M
3 genomes
gene transfer
outer membrane disappears
nucleomorph as in cryptomonads
4 genomes
gene transfer
2 genomes
another eukaryotic host
Secondary endosymbiosis
(plastid with 3 or 4 membranes)
3 genomes
Protistan pirate