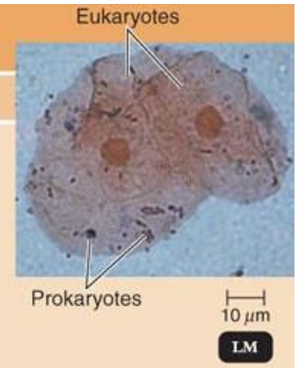
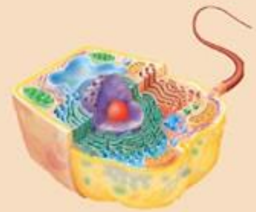
Functional Anatomy of Prokaryotic and Eukaryotic Cells

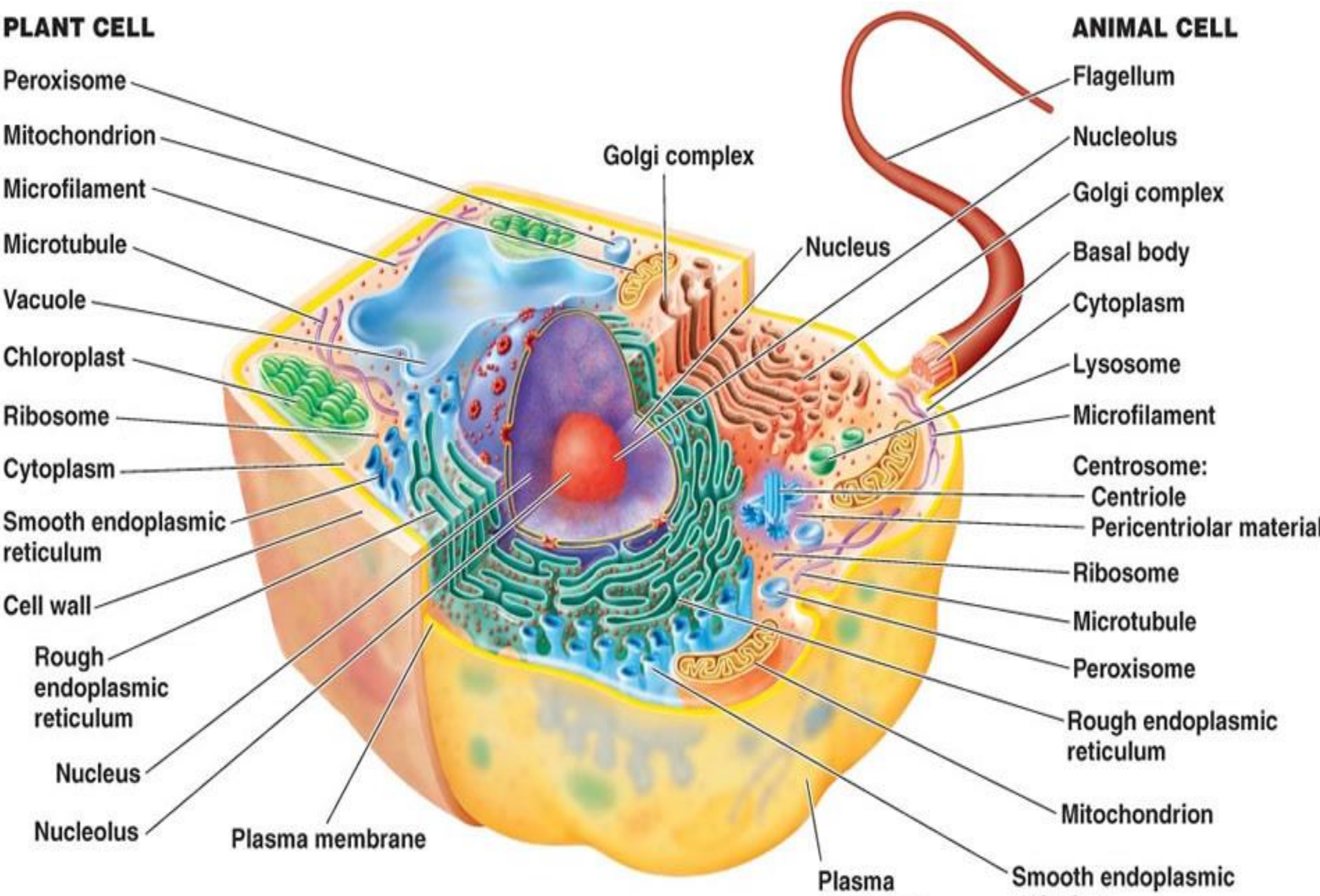
The Eukaryotic Cell

Table 4.2 Principal Differences between Prokaryotic and Eukaryotic Cells

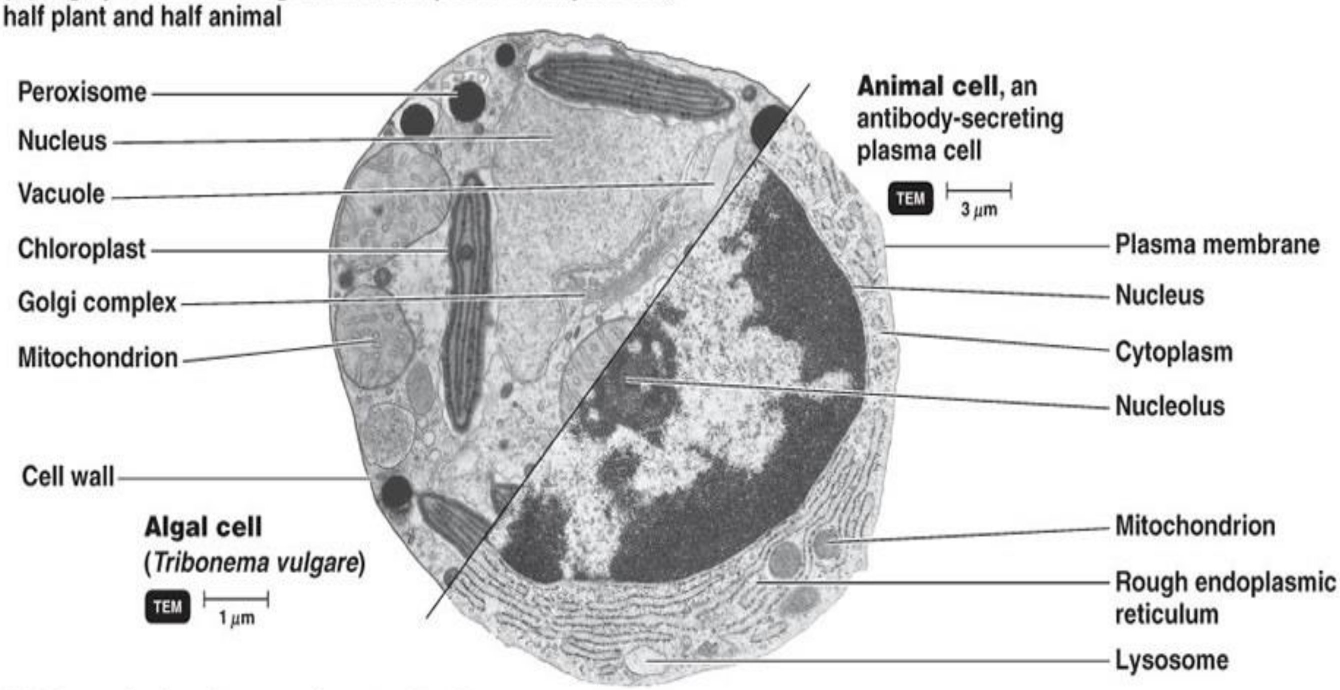


Characteristic	Prokaryotic	Eukaryotic
		
Size of Cell	Typically 0.2–2.0 μm in diameter	Typically 10–100 μm in diameter
Nucleus	No nuclear membrane or nucleoli	True nucleus, consisting of nuclear membrane and nucleoli
Membrane-Enclosed Organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, and chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell Wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple (includes cellulose and chitin)
Plasma Membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA)	Usually single circular chromosome; typically lacks histones	Multiple linear chromosomes with histones
Cell Division	Binary fission	Involves mitosis
Sexual Recombination	None; transfer of DNA only	Involves meiosis

Eukaryotic cells showing typical structures



(a) Highly schematic diagram of a composite eukaryotic cell, half plant and half animal



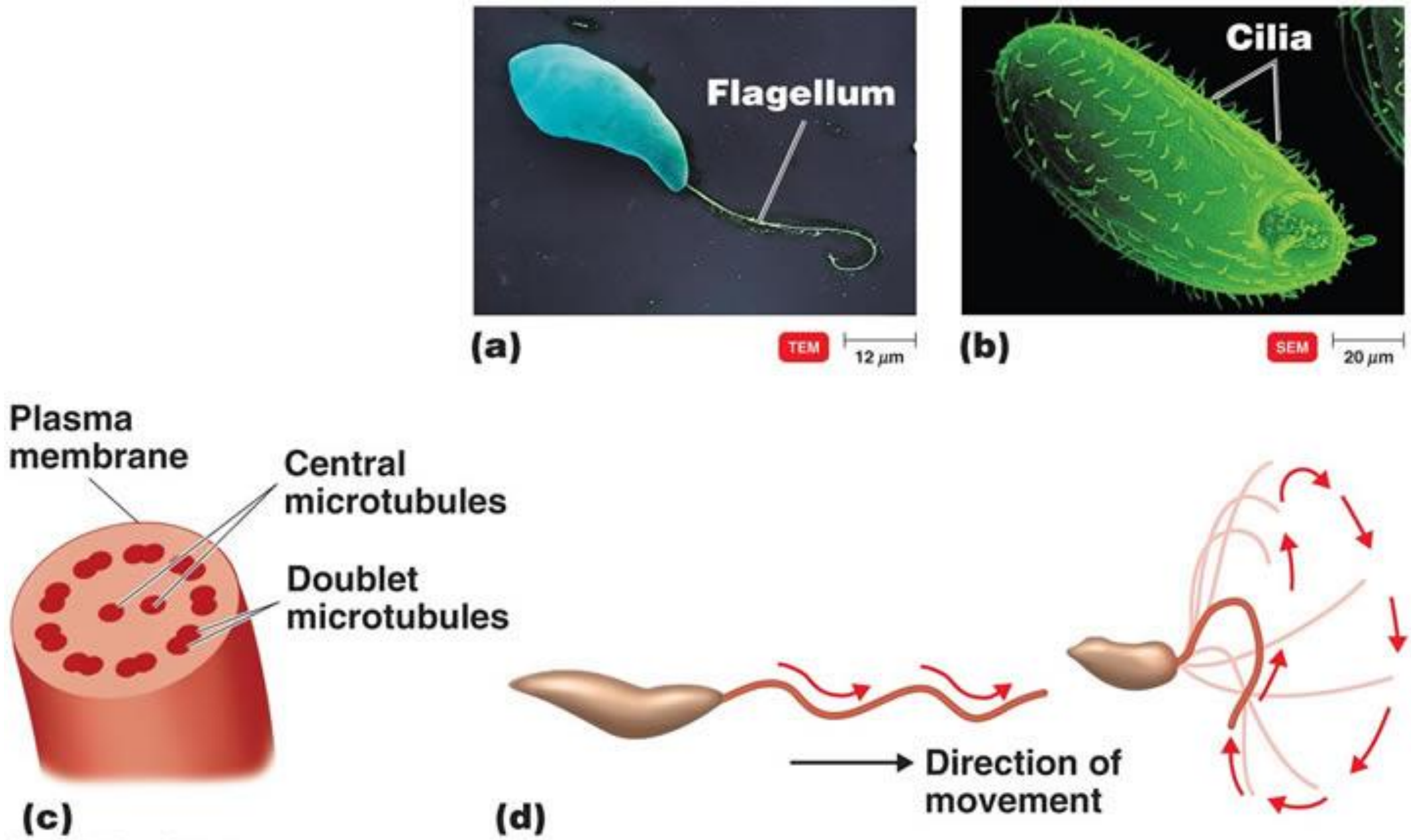
(b) Transmission electron micrographs of plant and animal cells.

Flagella And Cilia

Flagella are few and long in relation to cell size; cilia are numerous and short.

Flagella and cilia are used for motility, and cilia also move substances along the surface of the cells.

Both flagella and cilia consist of an arrangement of nine pairs and two single microtubules.



The Cell Wall And Glycocalyx

The cell walls of many algae and some fungi contain cellulose.

The main material of fungal cell walls is chitin.

Yeast cell walls consist of glucan and mannan.

Animal cells are surrounded by a glycocalyx, which strengthens the cell and provides a means of attachment to other cells.

The Plasma (Cytoplasmic) Membrane

Like the prokaryotic plasma membrane, the eukaryotic plasma membrane is a phospholipid bilayer containing proteins.

Eukaryotic plasma membranes contain carbohydrates attached to the proteins and sterols not found in prokaryotic cells (except *Mycoplasma* bacteria).

Eukaryotic cells can move materials across the plasma membrane by the passive processes used by prokaryotes, in addition to active transport and endocytosis (phagocytosis and pinocytosis).

Cytoplasm

The cytoplasm of eukaryotic cells includes everything inside the plasma membrane and external to the nucleus.

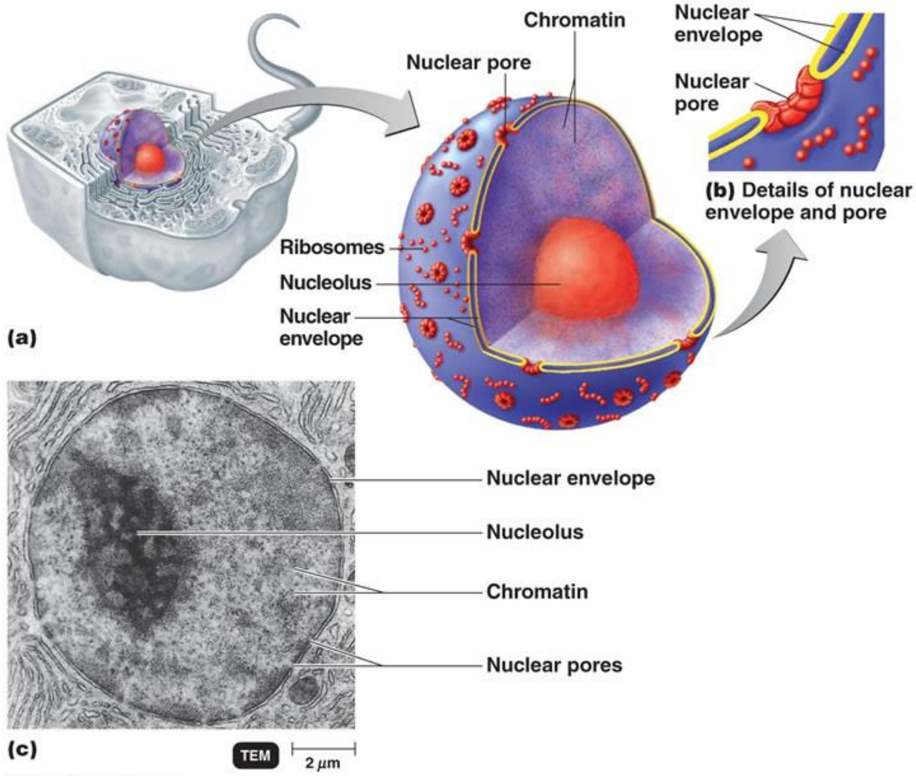
The chemical characteristics of the cytoplasm of eukaryotic cells resemble those of the cytoplasm of prokaryotic cells.

Eukaryotic cytoplasm has a cytoskeleton and exhibits cytoplasmic streaming.

Organelles

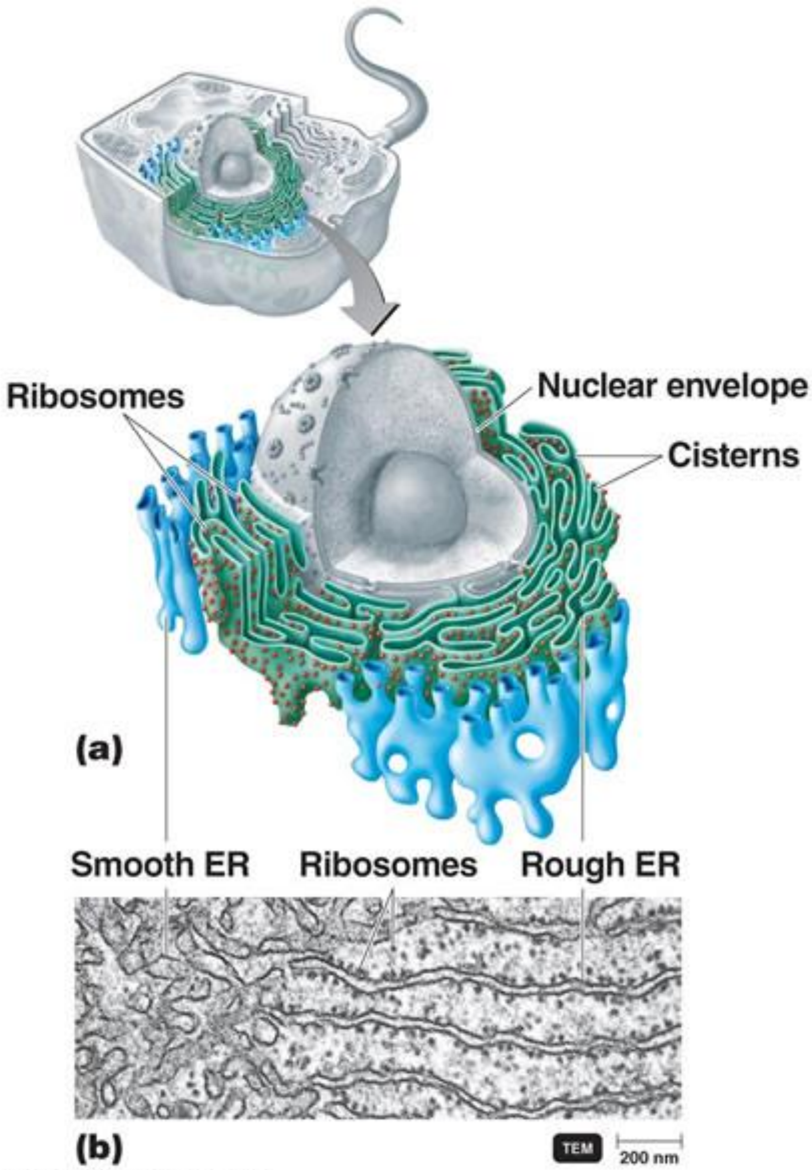
Organelles are specialized membrane-enclosed structures in the cytoplasm of eukaryotic cells.

The nucleus, which contains DNA in the form of chromosomes, is the most characteristic eukaryotic organelle.



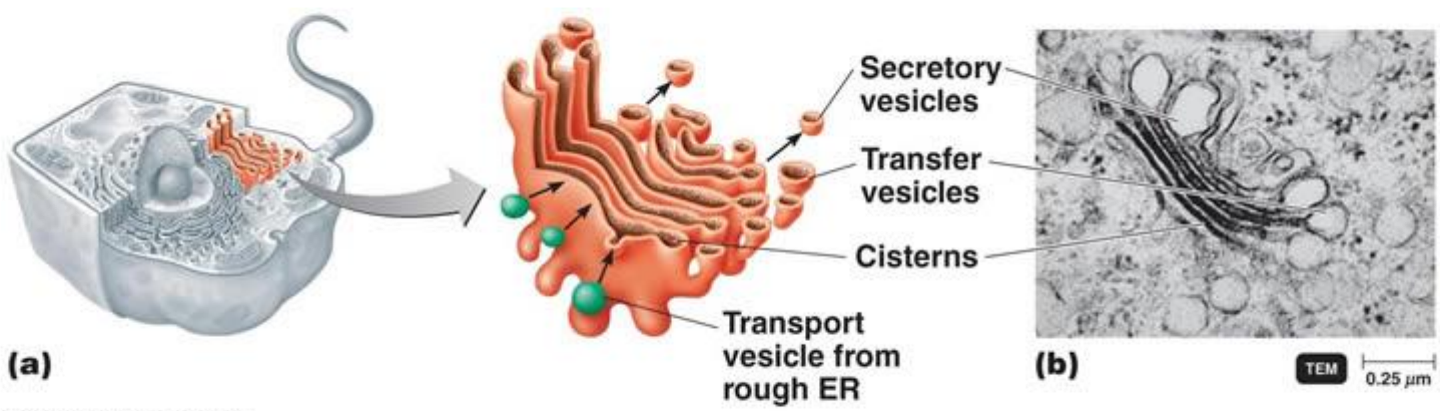
The nuclear envelope is connected to a system of membranes in the; cytoplasm called the endoplasmic reticulum (ER).

The ER provides a surface for chemical reactions, serves as a transporting network, and stores synthesized molecules. Protein synthesis and transport occur on rough ER; lipid synthesis occurs on smooth ER.



80s ribosomes are found in the cytoplasm or attached to the rough ER and nuclear membrane.

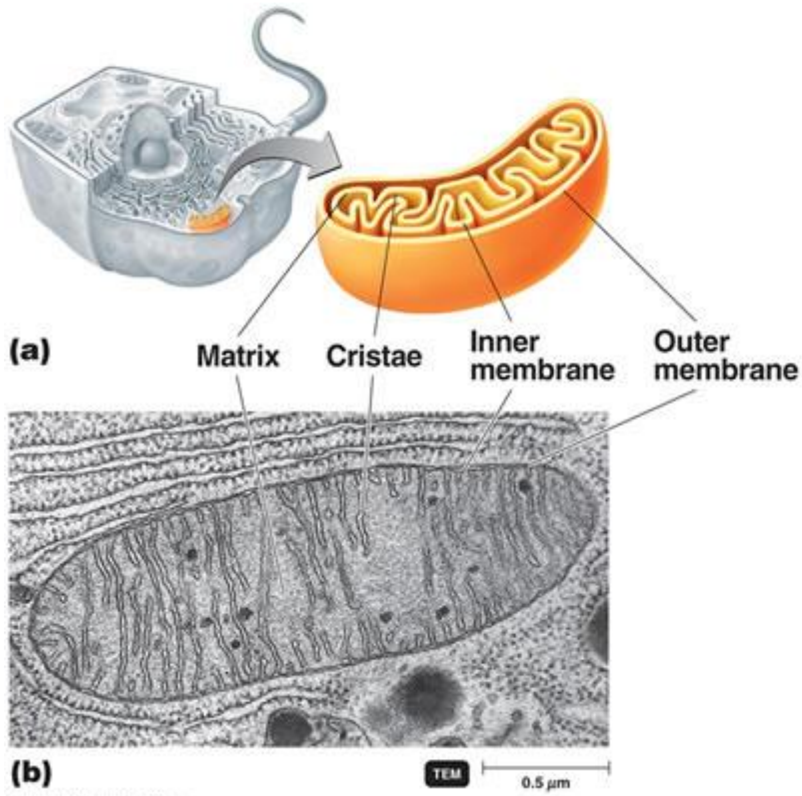
The Golgi complex consists of flattened sacs called cisterns. It functions in membrane formation and protein secretion.



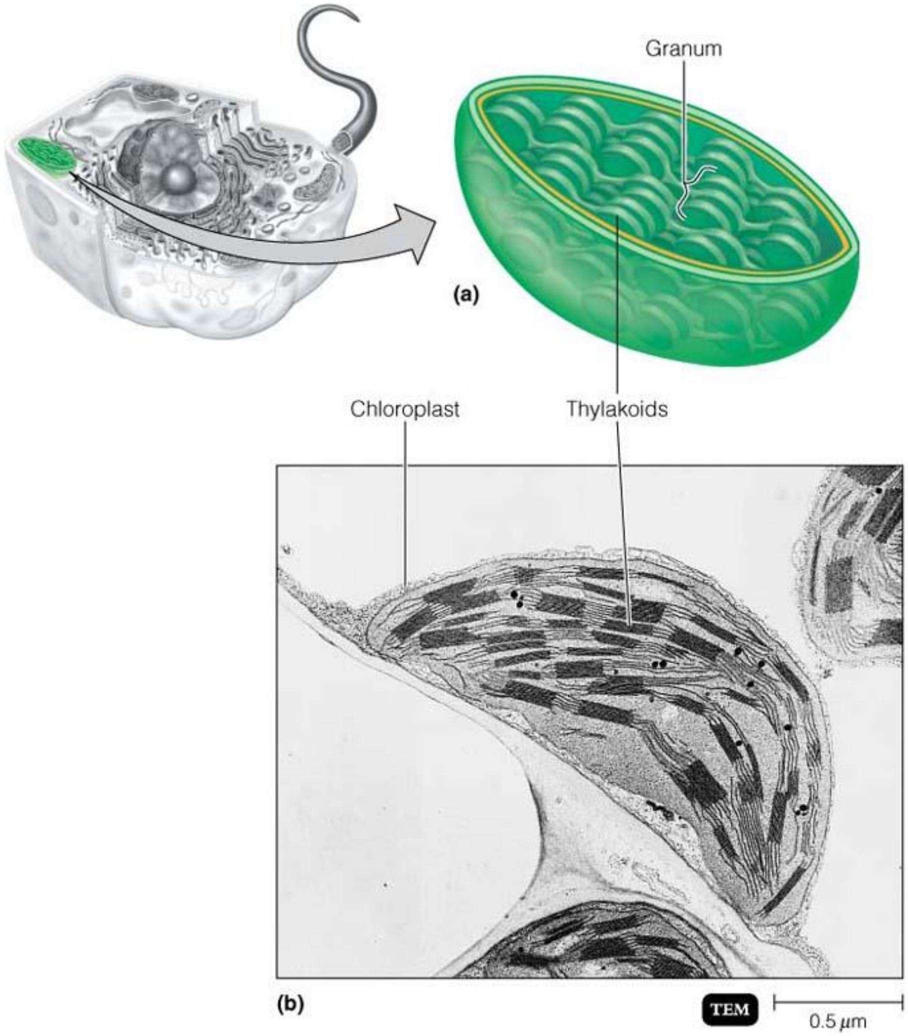
Lysosomes are formed from Golgi complexes. They store powerful digestive enzymes.

Vacuoles are membrane-enclosed cavities derived from the Golgi complex or endocytosis. They are usually found in plant cells that store various substances, help bring food into the cell, increase cell size, and provide the rigidity to leaves and stems.

Mitochondria are the primary sites of ATP production. They contain 70s ribosomes and DNA, and they multiply by binary fission.



Chloroplasts contain chlorophyll and enzymes for photosynthesis. Like mitochondria, they contain 70s ribosomes and DNA and multiply by binary fission.



A variety of organic compounds are oxidized in peroxisomes. Catalase in peroxisomes destroys H_2O_2.

The centrosome consists of the pericentriolar area and centrioles. Centrioles are 9 triplet microtubules involved in formation of mitotic and flagellar microtubules.

The Evolution Of Eukaryotes

According to the endosymbiotic theory, eukaryotic cells evolved from symbiotic prokaryotes living inside other prokaryotic cells.

The Origin of Eukaryotes (Endosymbiotic Theory)

Back in the shrouded mists of a time long ago there was a prokaryotic cell that we'll call the "Universal Ancestor" (OK, probably there were a lot of cells that arose in different places and environments but just go with this).

The original "Universal Ancestor" showed up around 3.5 billion years ago, and for a couple of billion years or so life proceeded as a prokaryotic kind of deal.

Somewhere around 1.5 billion years ago a renegade prokaryote showed up.

It is hypothesized, by Lynn Margulis and others, that this cell (which is a descendant of the "Universal Ancestor") somehow managed to lose its cell wall and get its plasma membrane folded around its chromosome.

This was the beginning of the nucleoplasmic lineage - this cell had a rudimentary nucleus. It is assumed that the propensity for shedding one's cell wall and surrounding one's nucleus with plasma membrane material was somehow coded for in the original nucleoplasmic cell's DNA, otherwise this characteristic couldn't have been passed on to the daughter cells, but then a lot of viruses were probably moving a lot of genetic material around at the time, so there were probably a lot of "genetic experiments" that were the result of random recombination events, some of which worked pretty well (and many more that failed).

These nucleoplasmic cells got bigger somewhere along the way, probably when they first formed. It's thought that the first eukaryotic cell may have actually been the product of a symbiotic relationship between an anaerobic, autotrophic, methanogenic, archaeabacterium that had a strict requirement for hydrogen and an anaerobic, heterotrophic eubacterium that could respire and produced hydrogen as a waste product. They basically fused. And they were anaerobic because that's how the world was at that time.

Somewhere along the line the descendants of the original nucleoplasmic cell, after establishing that they were going to live without a cell wall and with a nuclear membrane, began to form a mutually beneficial arrangement (a symbiotic relationship) with smaller prokaryotic cells.

The eukaryotic cell and its intracellular symbiotic bacterium evolved together and eventually lost the ability to live apart. The formerly free-living bacterium had become an essential organelle (mitochondria) inside the eukaryotic cell.

And chloroplasts arose from photosynthetic bacteria that got into eukaryotic cells. Basically.

I still don't know how those eukaryotic ribosomes got to be 80s...