Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Enduring understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

a. Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface area where reactions can occur.

EUKARYOTIC CELLS HAVE INTERNAL MEMBRANES THAT COMPARTMENTALIZE THEIR FUNCTIONS

Comparing Eukaryotic and Prokaryotic cells

- ALL cells share some common features:
  - plasma membranes (selective barrier)
  - cytosol (semifluid substance)
  - chromosomes (information carrier)
  - ribosomes (protein builders)

Although all cells share these common features the first and most distinct differences between cells are seen in the division between eukaryotes and prokaryotes.

- **PROKARYOTES**
  - **older, less complex**
  - **No nucleus (DNA in nucleoid region)**
  - **No membrane bound organelles**
  - **smaller**
- **EUKARYOTES**
  - **younger, more complex**
  - **Has nucleus (contains DNA)**
  - **Has membrane bound organelles**
  - **larger**

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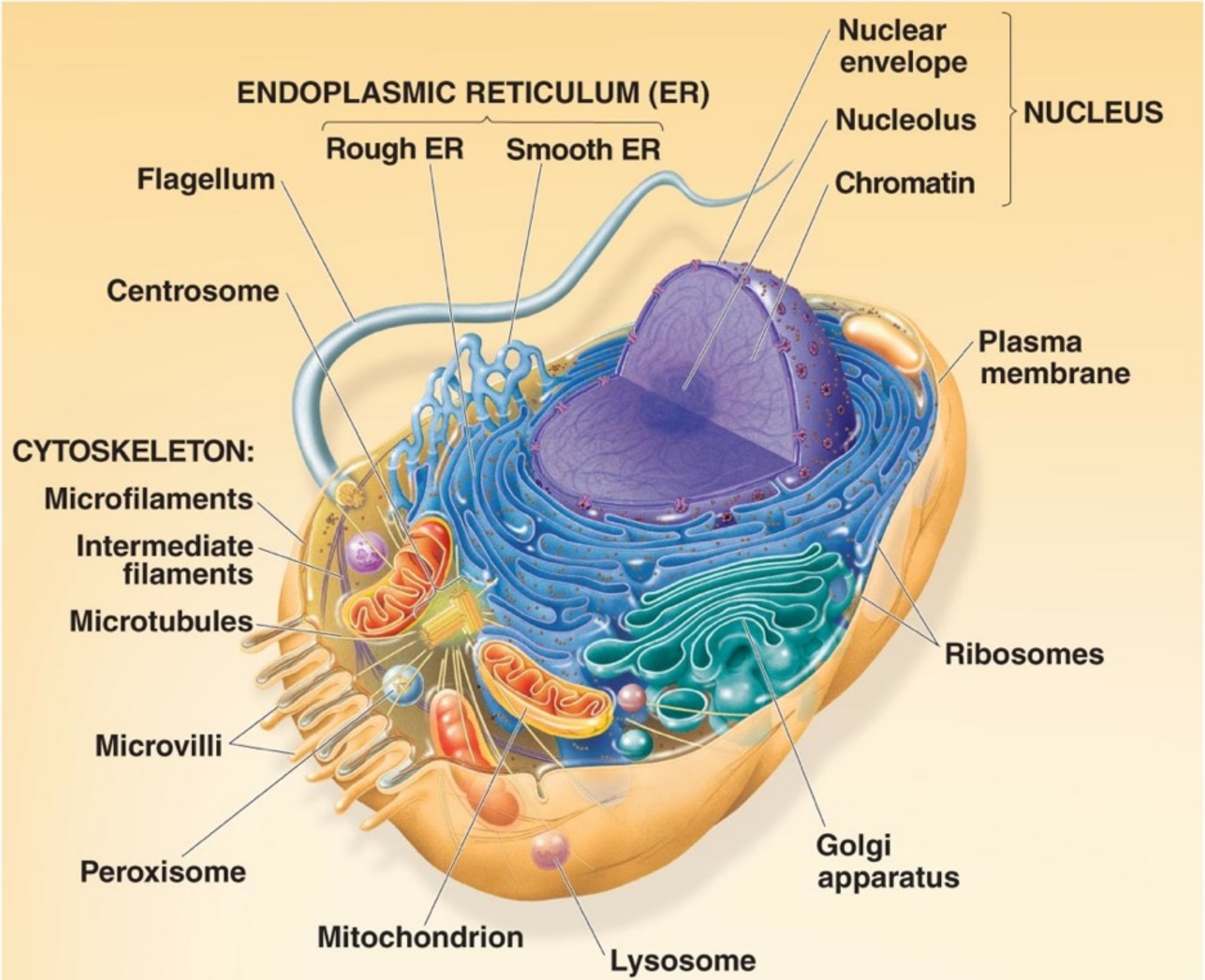
These differences are just the beginning a more comprehensive list is forth coming!

A Panoramic View of the Eukaryotic Cell

- Eukaryotic cells have elaborately arranged internal membranes that divide the cell into compartments.
    - Compartments provide different local environments that facilitate specific metabolic functions some of which are antagonistic.
- The membranes themselves are loaded with enzymes and thus participate directly in the cell's metabolism.

Membranes are so fundamental to the organization of cells and cellular functions


ENDOPLASMIC RETICULUM (ER)
Rough ER
Smooth ER
Nuclear envelope
Nucleolus
Chromatin
NUCLEUS
Flagellum
Centrosome
Plasma membrane
CYTOSKELETON:
Microfilaments
Intermediate filaments
Microtubules
Ribosomes
Microvilli
Peroxisome
Golgi apparatus
Mitochondrion
Lysosome

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

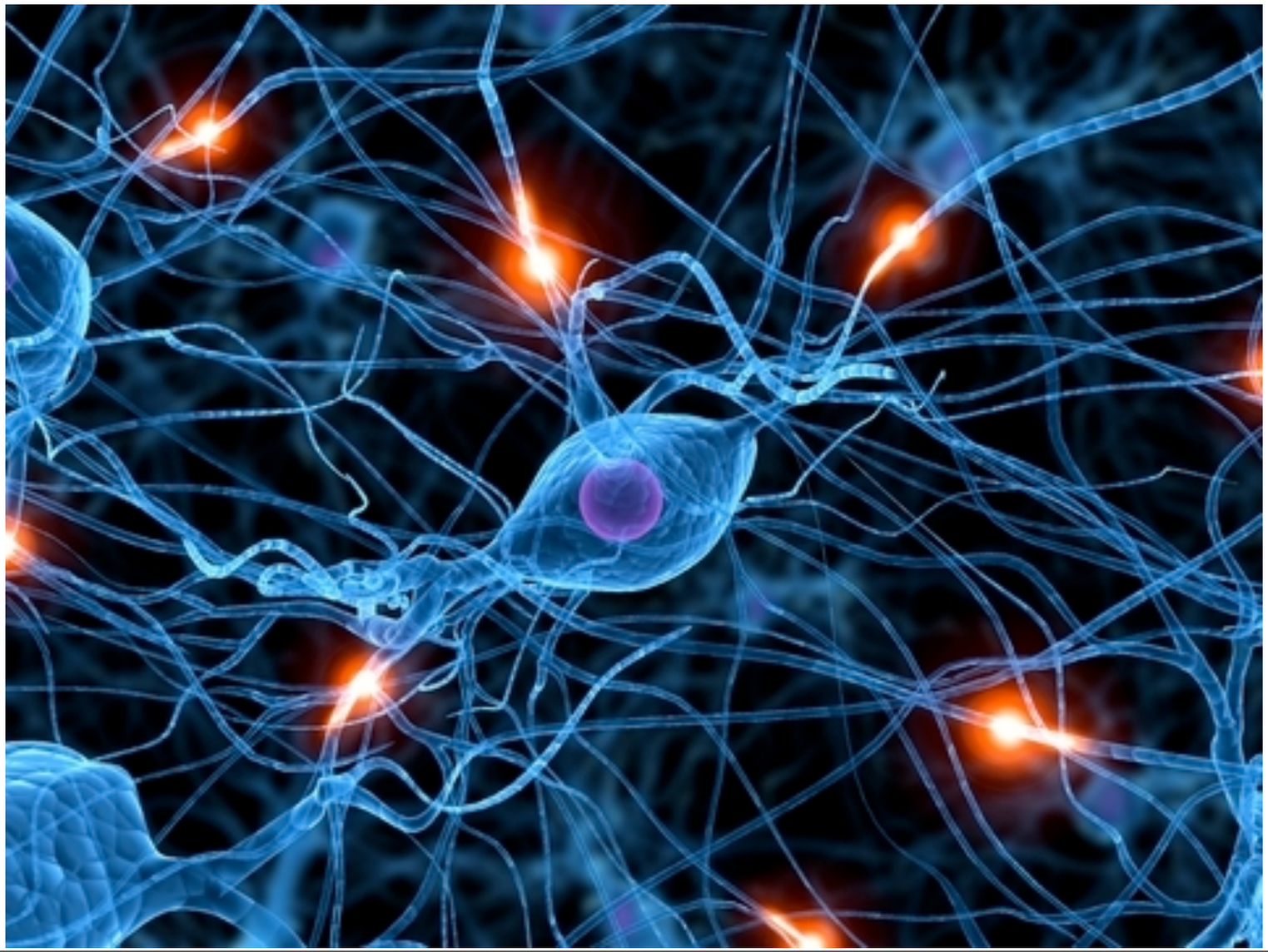
b. Membranes and membrane-bound organelles in eukaryotic cells localize (compartmentalize) intracellular metabolic processes and specific enzymatic reactions. [See also 4.A.2]

To foster student understanding of this concept, instructors can choose an illustrative example, such as:

endoplasmic reticulum
golgi apparartus
mitochondria
chloroplast
nuclear envelope:

Tour of the Cell

Main Idea: Membrane bound organelles work together to perform a variety of important metabolic functions.



THE ENDOMEMBRANE SYSTEM REGULATES PROTEIN TRAFFIC AND PERFORMS METABOLIC FUNCTIONS IN THE CELL

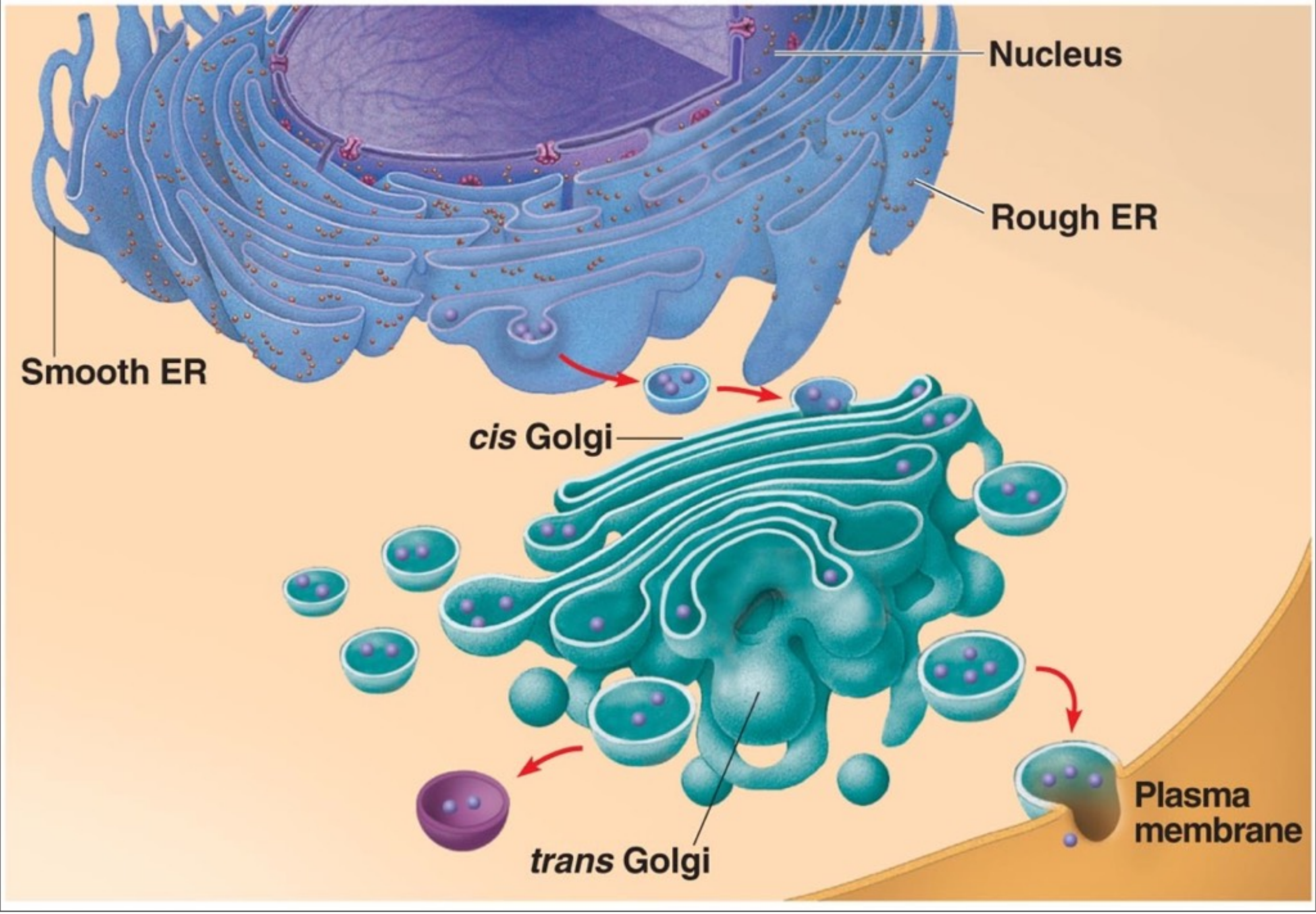
Structures

- Nuclear Envelope
- Endoplasmic Reticulum
- Golgi Apparatus
- Lysosomes
- Vesicles
- Plasma Membrane

Functions

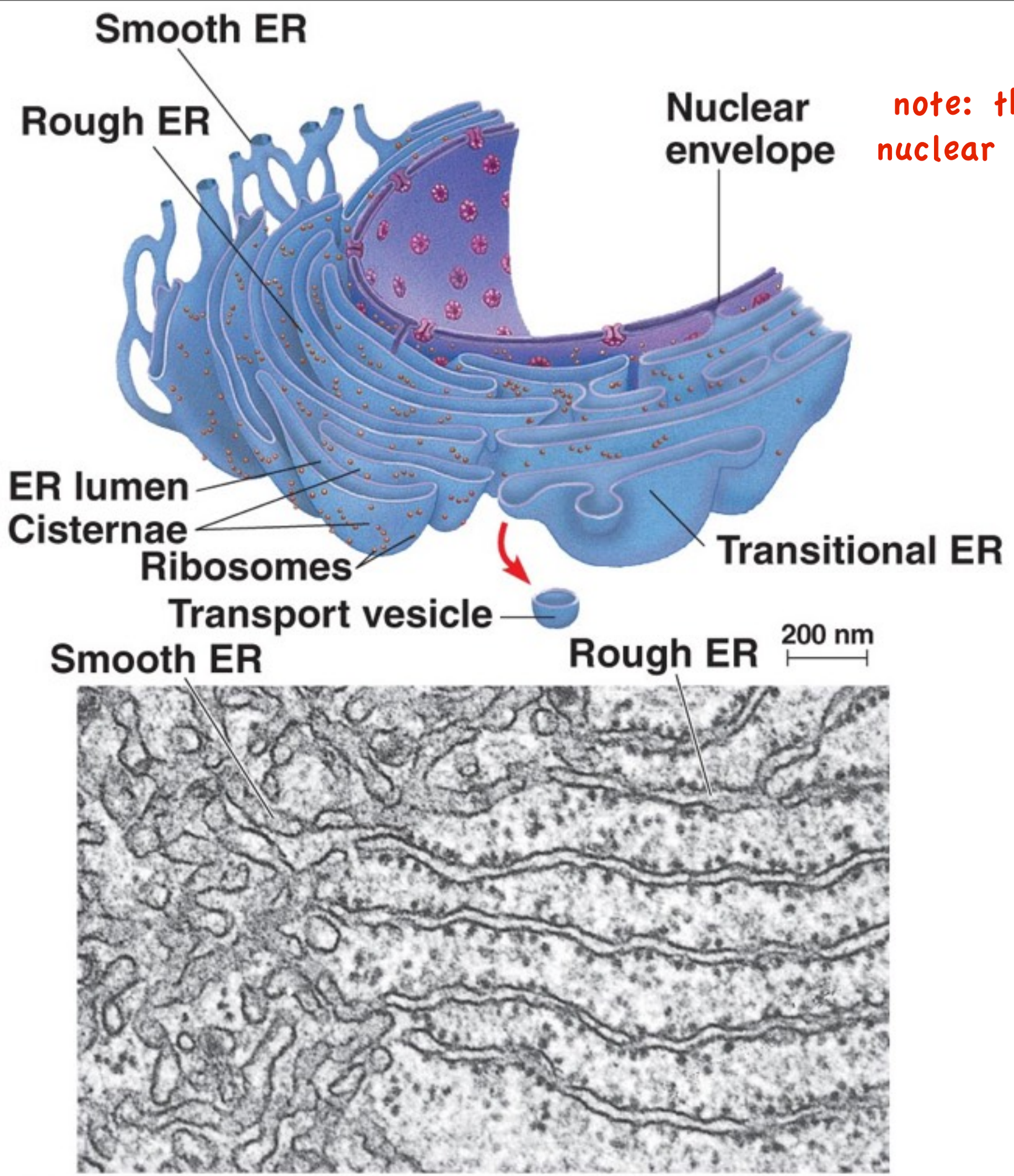
- Protein Synthesis
- Transportation of Proteins
- Chemical Reactions (metabolism)
- Transportation of Lipids
- Detoxification of Poisons

Endomembrane System



The Endoplasmic Reticulum: Biosynthetic Factory

- extensive network of membranes
- accounts for more than half of the total cell membrane
- two distinct types (each differs in structure and function)
- Smooth E.R. (lacks ribosomes)
- Rough E.R. (has ribosomes)



note: the cytoplasmic side of nuclear envelope has ribosomes

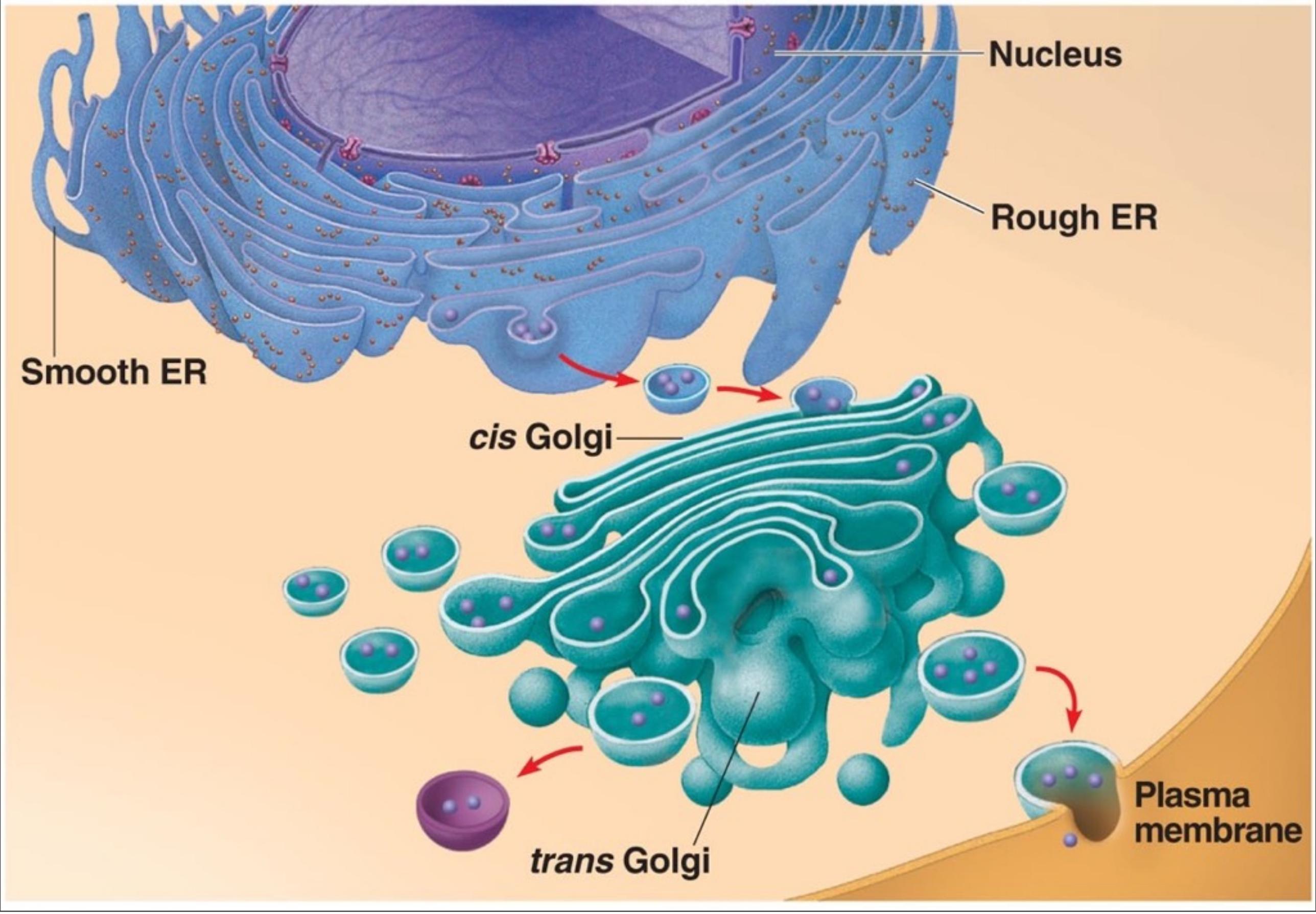
Functions of Smooth ER

- **Diverse functions that vary with cell type.**
  - **Synthesis of lipids, *phospholipids* and *steroids***
    - *testes, ovaries, adrenal glands* produce sex hormones as a result they have an abundance of smooth E.R.
  - **Enzymes that help detoxify drugs and poison**
    - adding hydroxyl groups to drugs/poison makes them more soluble and easier to secrete
    - drug addicts have more smooth E.R.
    - additional smooth E.R. contributes to their increased tolerance for drugs
  - **Stores calcium in muscle cells**

Functions of Rough ER

- **The rough E.R. is still "E.R." it has the same functions as the smooth E.R. + some!**
- The rough E.R. specializes in producing proteins that are destined for export or to become part of a membrane, they are called ***secretory proteins***
  - Most *secretory proteins* are ***glycoproteins***, they have sugars attached to them
    - These proteins are kept separate from cytoplasmic proteins by the endomembrane system
- ***Transport vesicles*** move these proteins from the E.R. to their destination

Let's take a look at this again



The Golgi Apparatus: Shipping & Receiving Center

- Receives products of E.R., *these products are modified then stored or sent to their destination.*
- The Golgi stacks have distinct structural directionality
  - The E.R. side is called the *cis side... it receives*
  - The side closest to the plasma membrane is called the *trans side...it ships*

Lysosomes: Digestive Compartments

- A membranous sac of hydrolytic enzymes that animal cell uses to digest macromolecules
- These hydrolytic enzymes work best in acidic environments, found in lysosomes
- **Theme: Internal environment different from external environment**

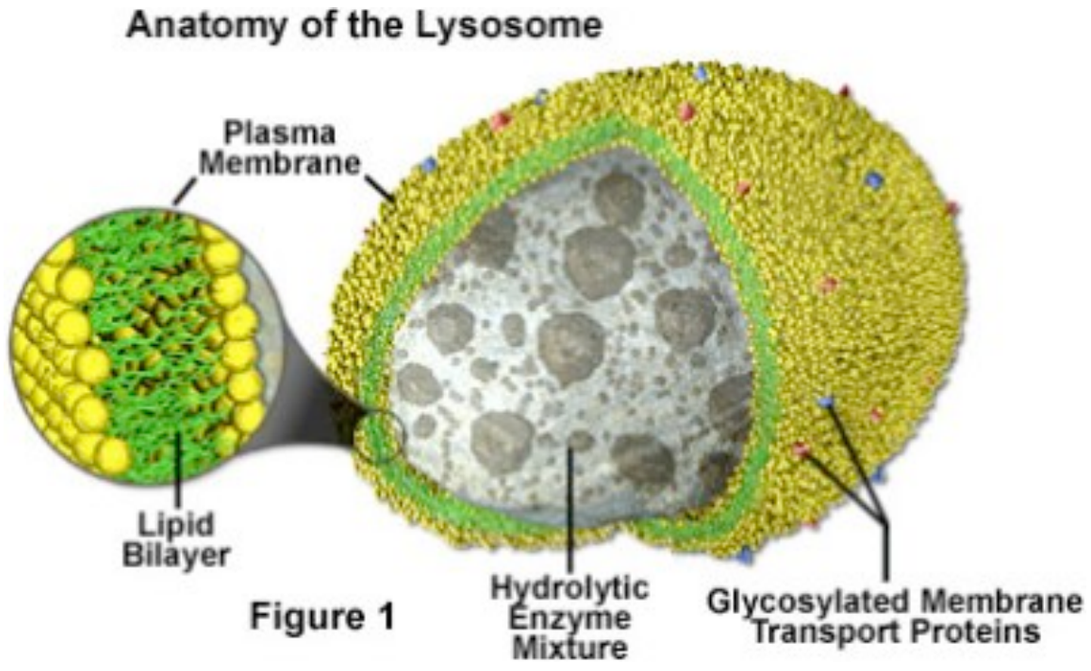


Figure 1

Lysosomes: Digestive Compartments

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Animal Cells Only

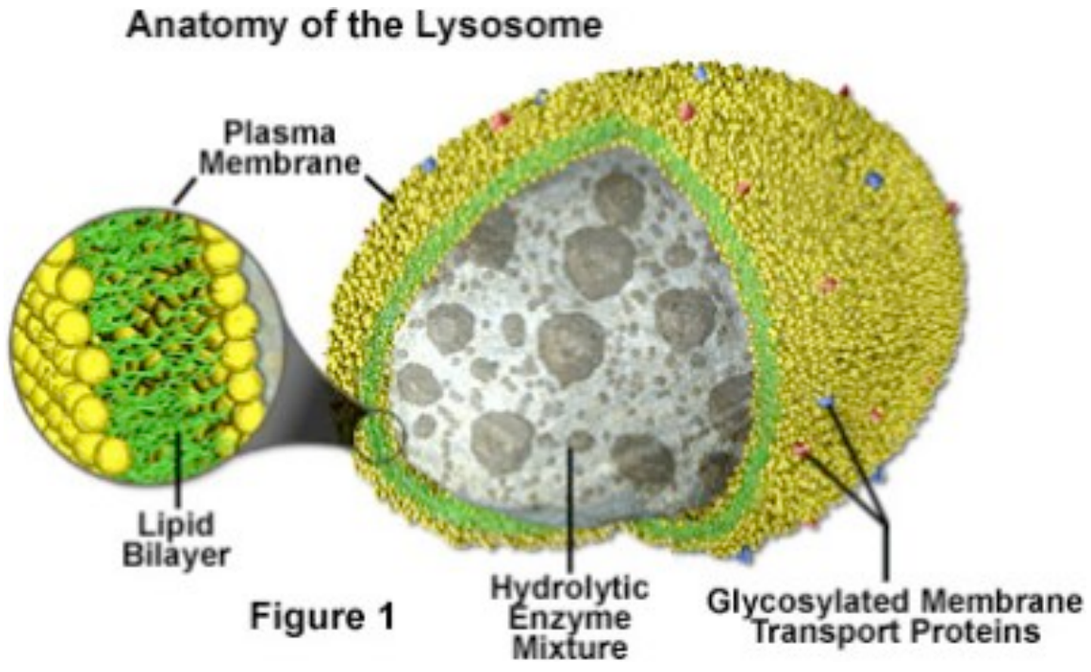
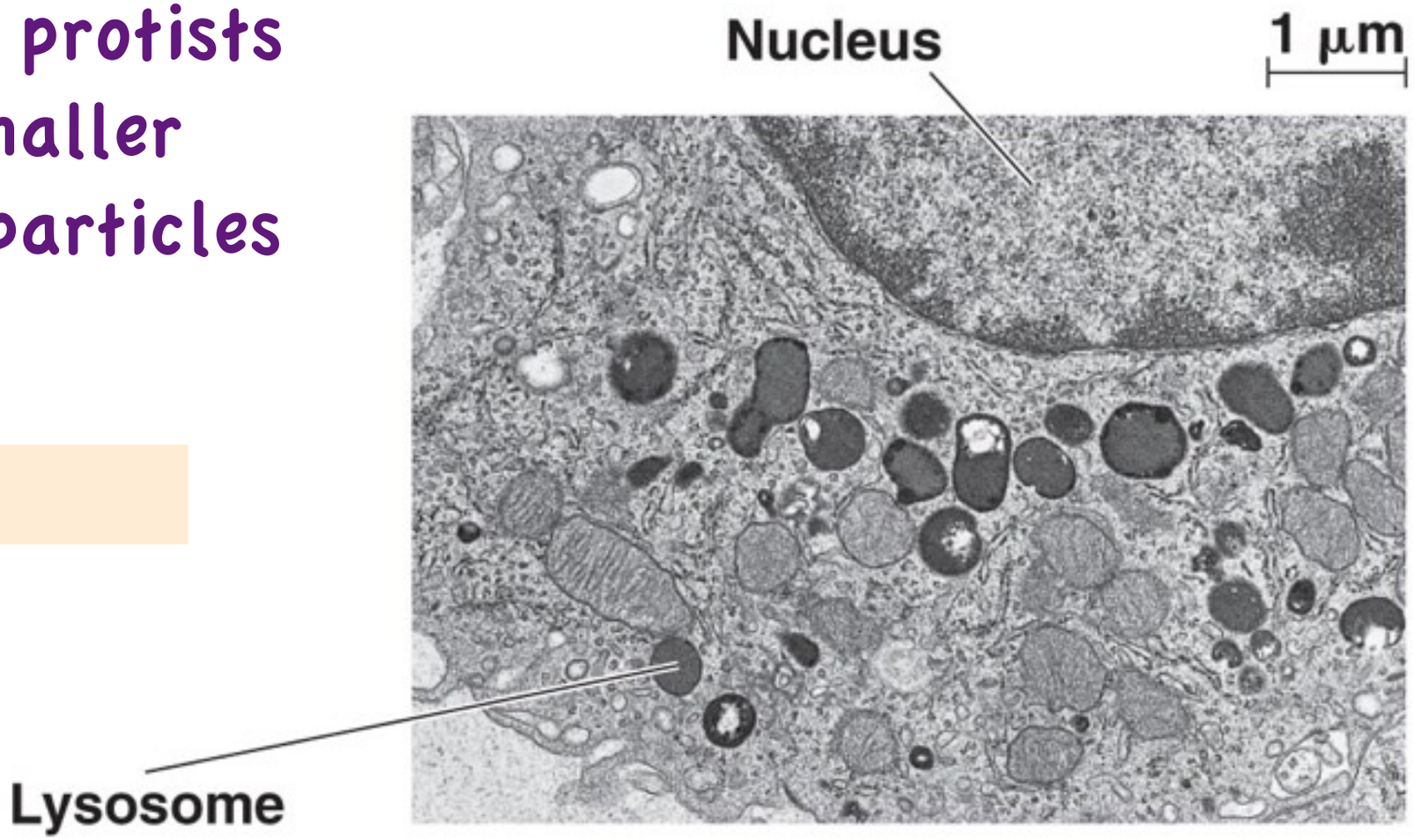
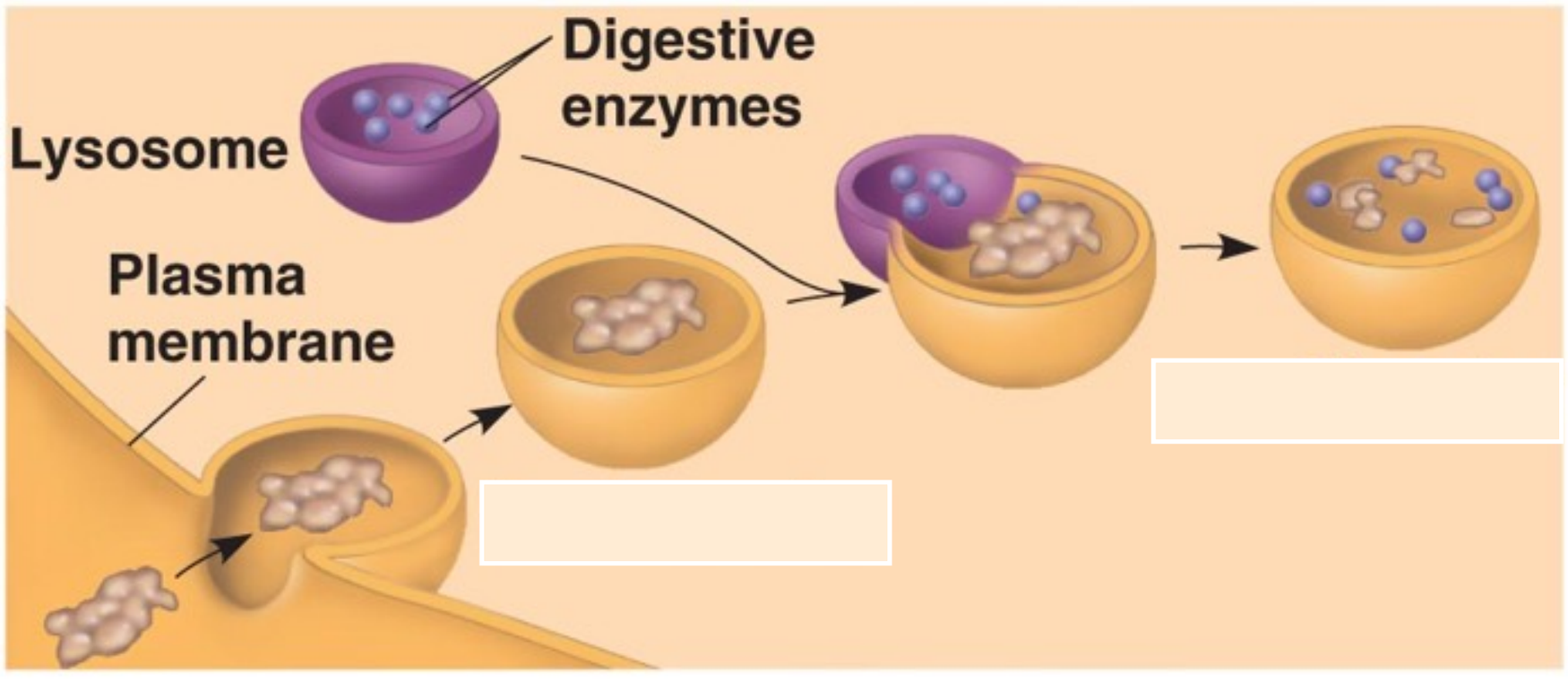


Figure 1

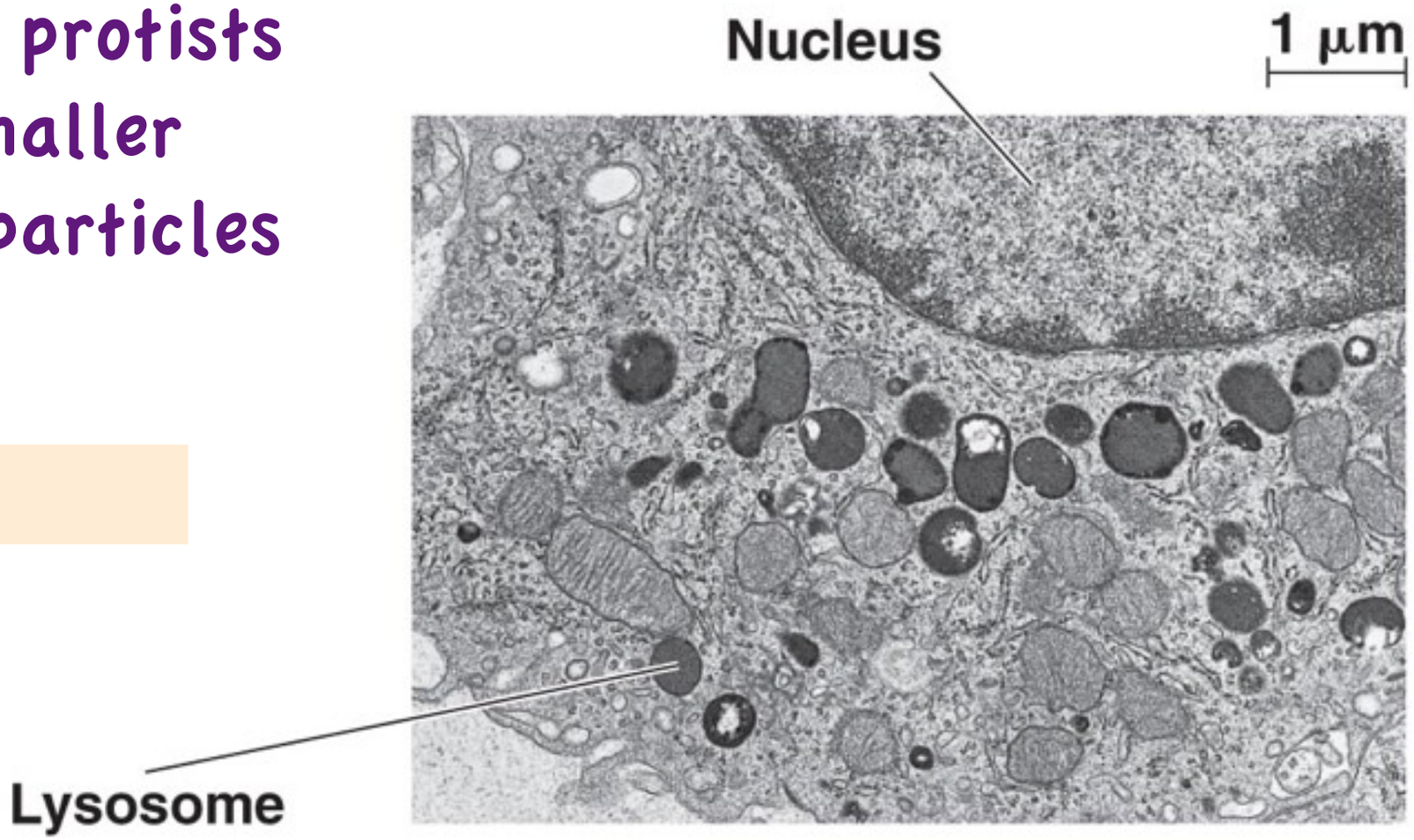
Amoebas and other protists eat by engulfing smaller organisms or food particles

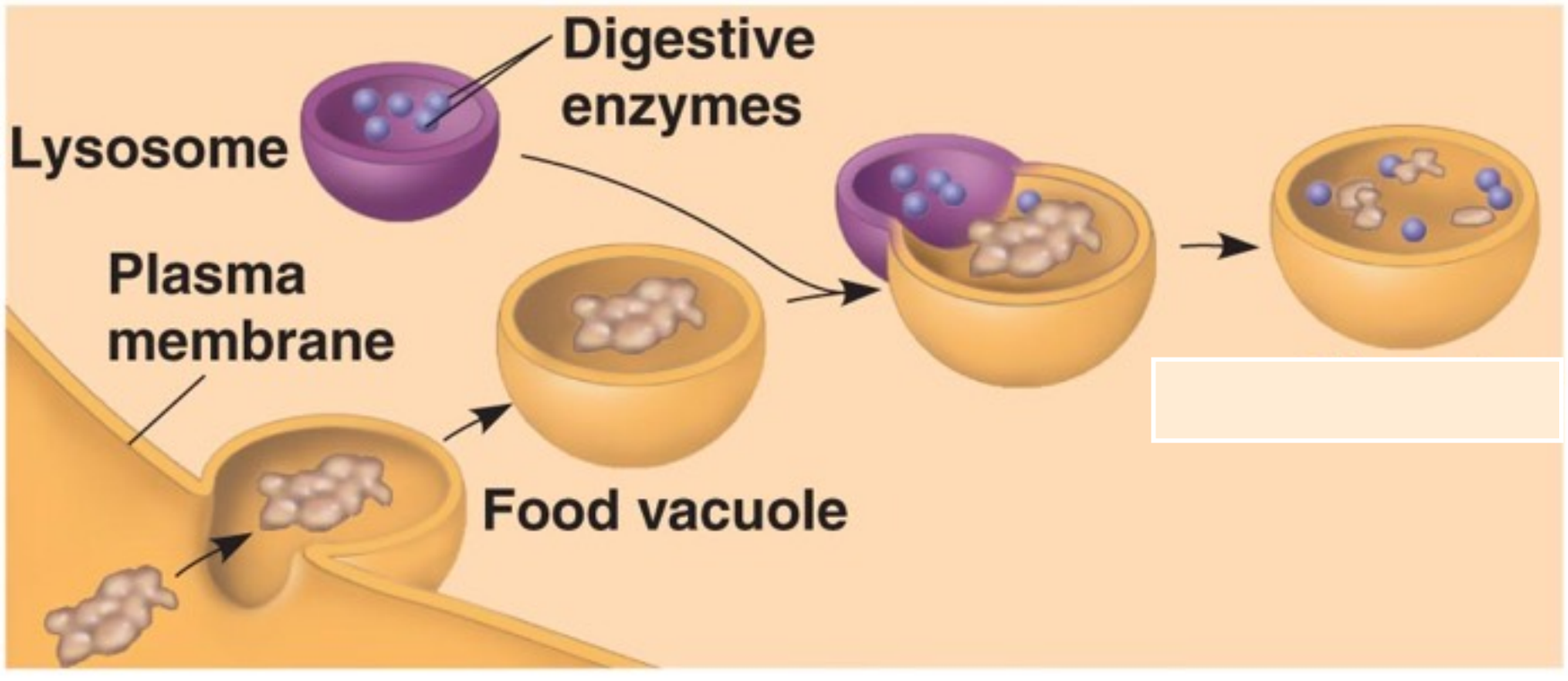




(a) Phagocytosis

Amoebas and other protists eat by engulfing smaller organisms or food particles





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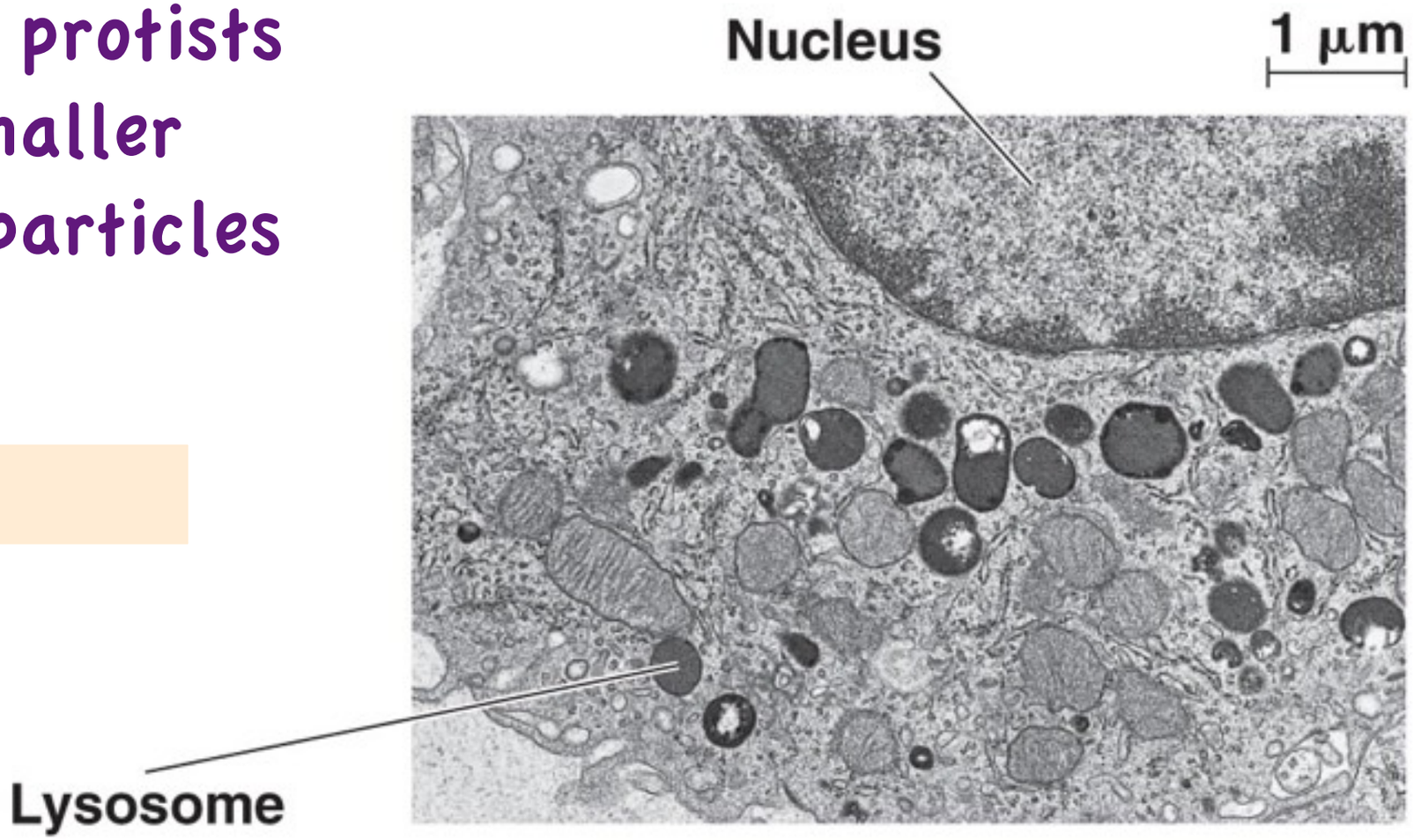
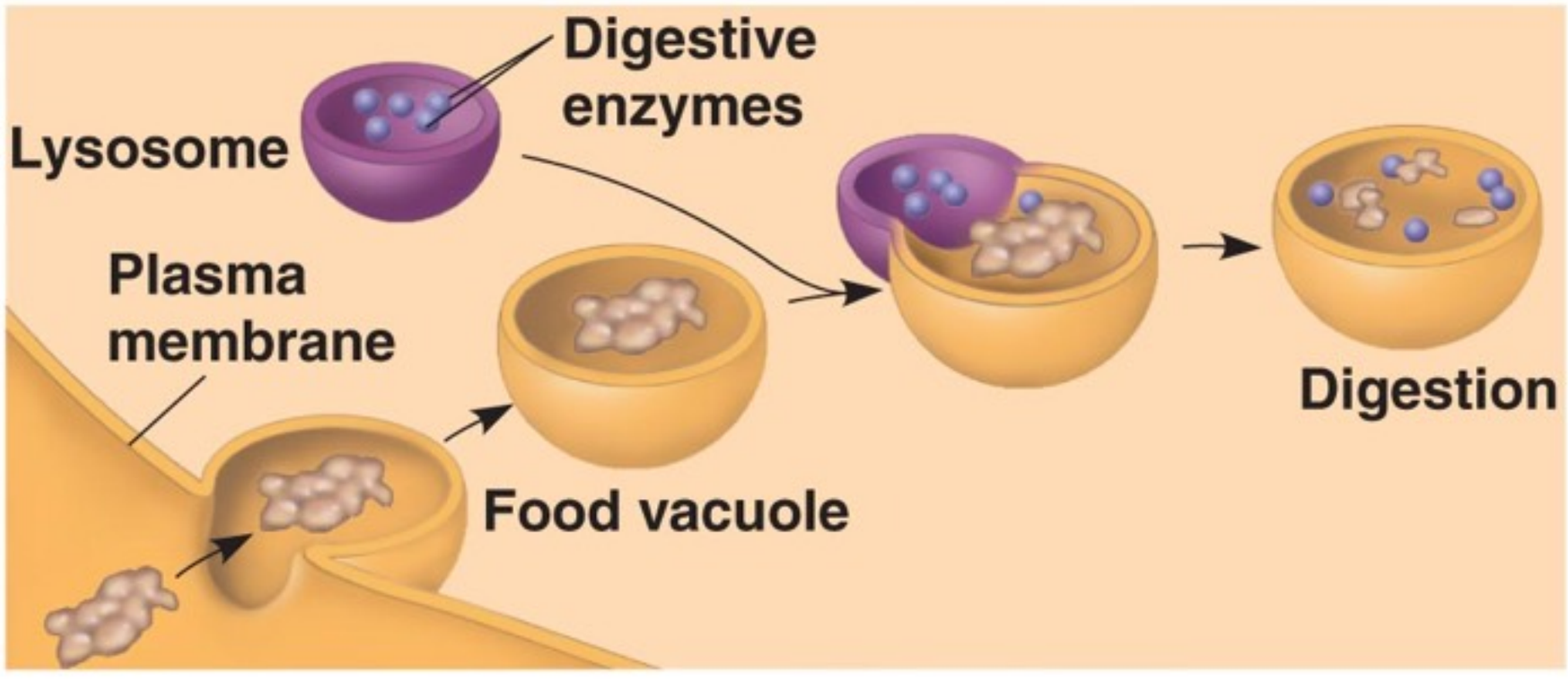
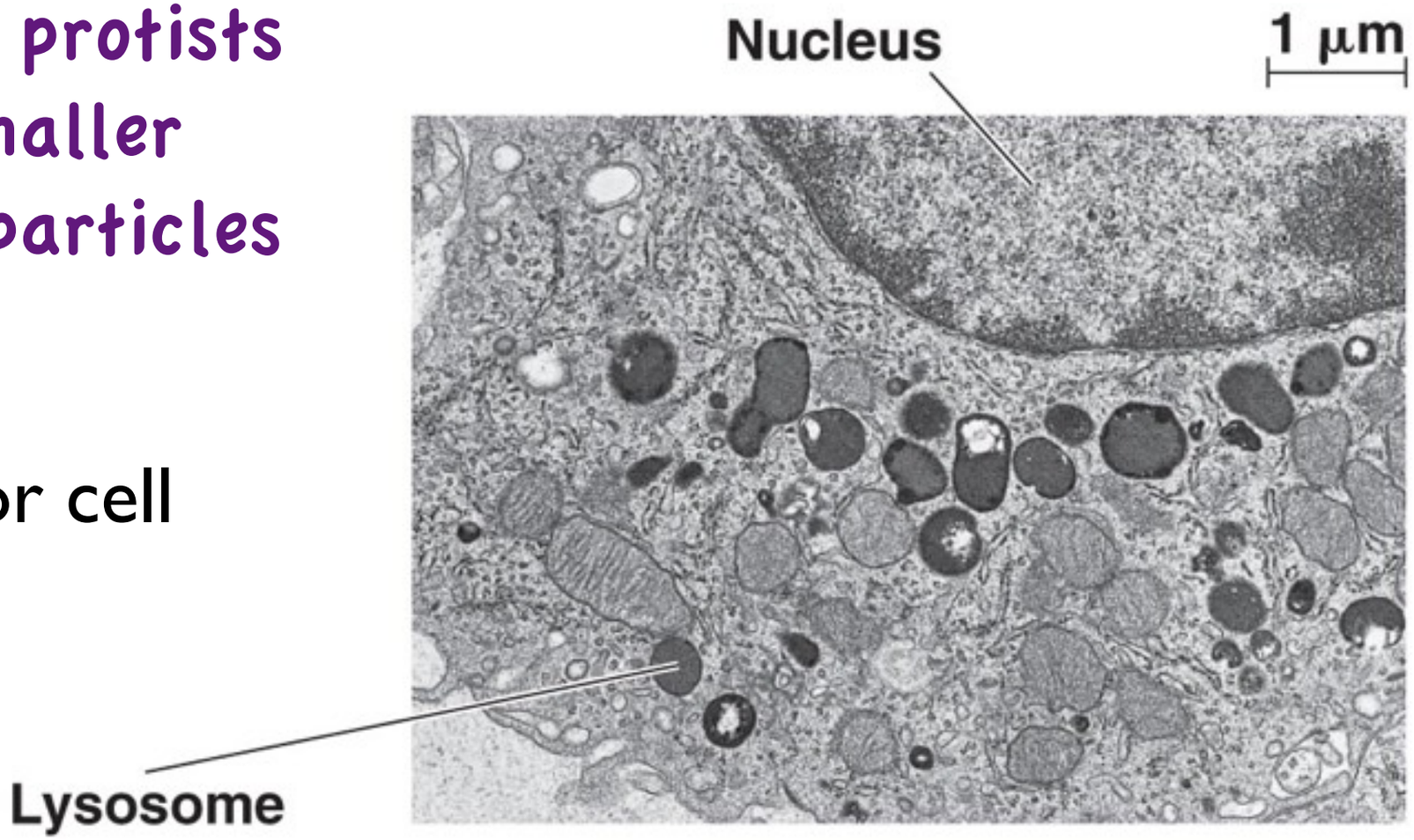


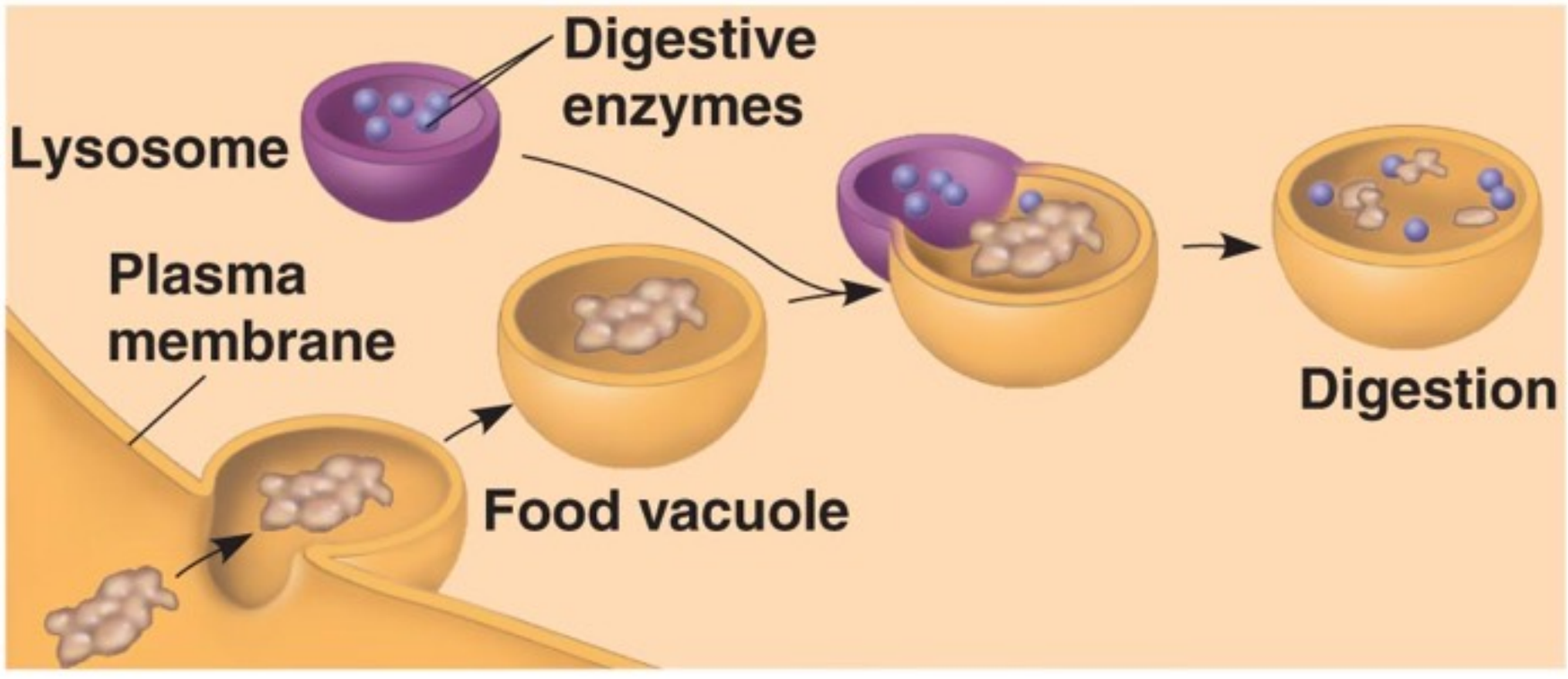


(a) Phagocytosis

Amoebas and other protists eat by engulfing smaller organisms or food particles

Now nutrients for cell





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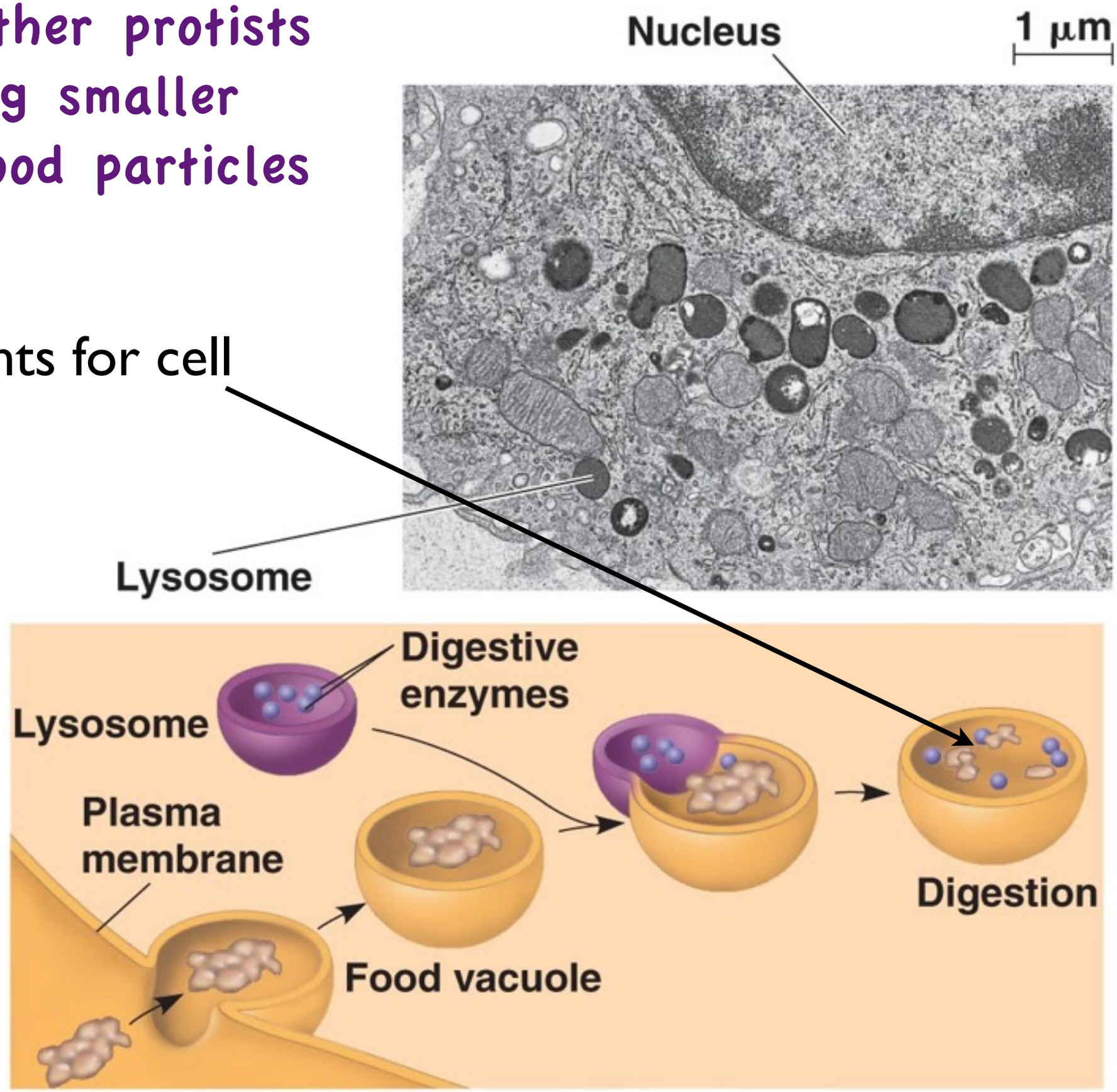

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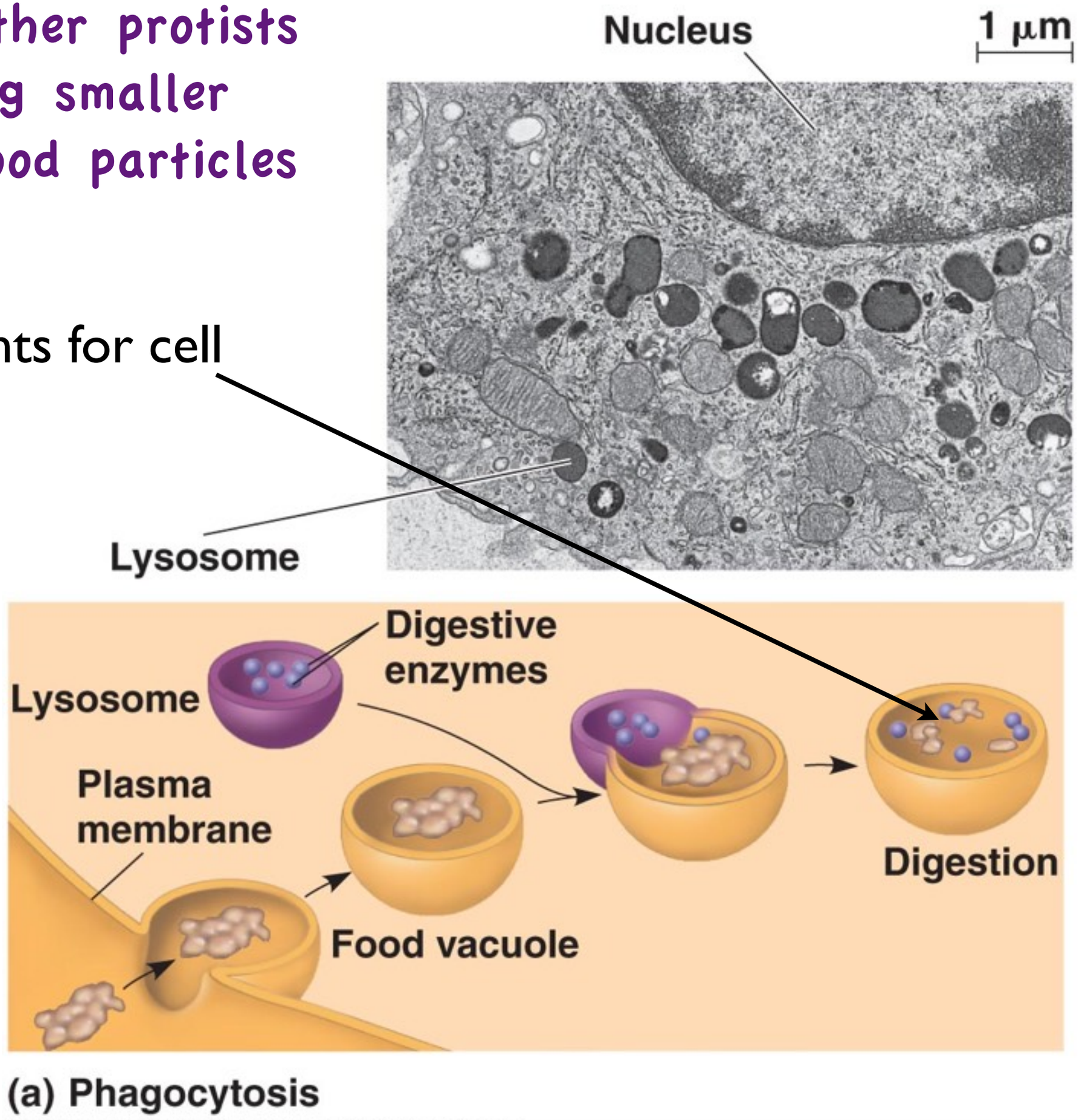
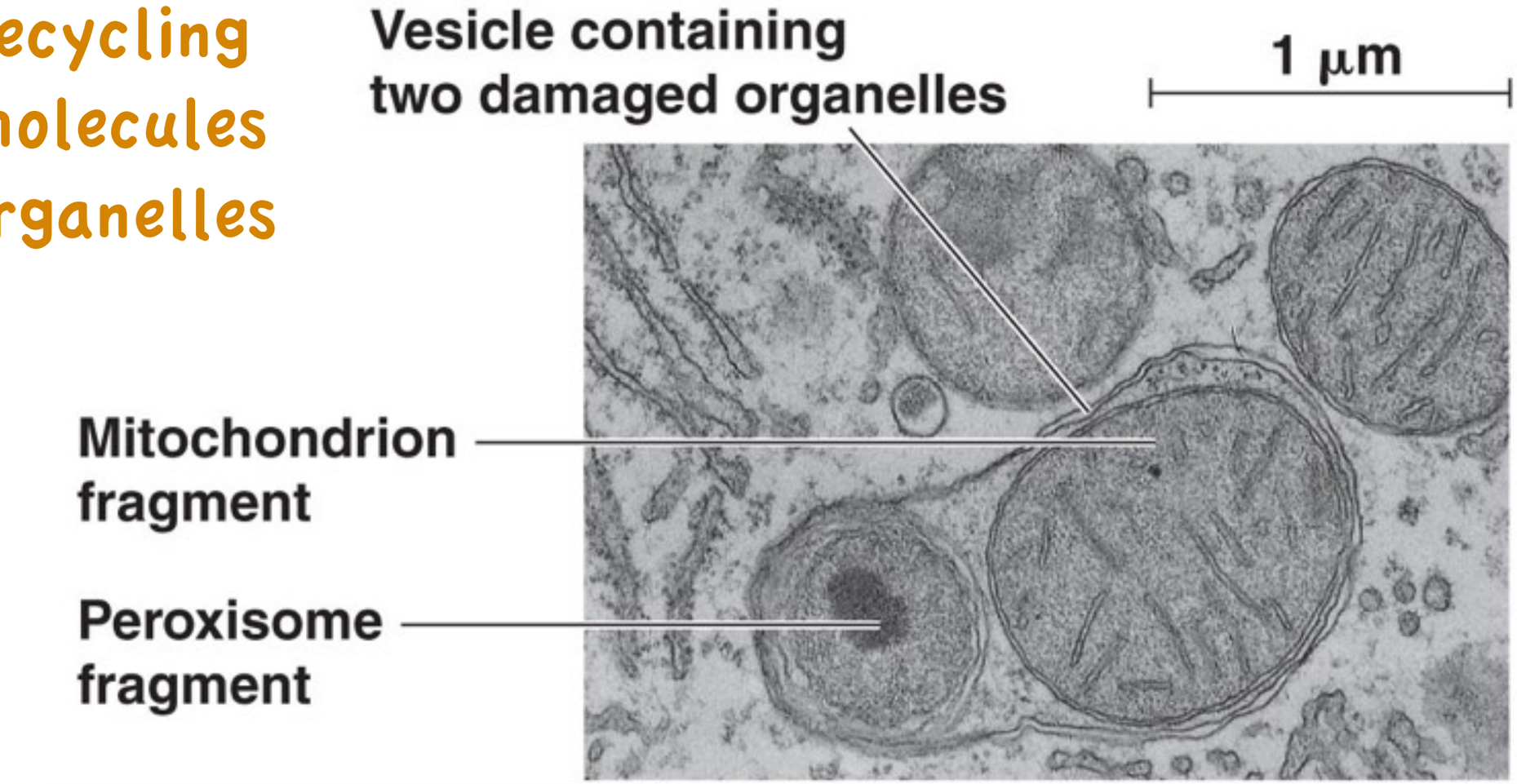
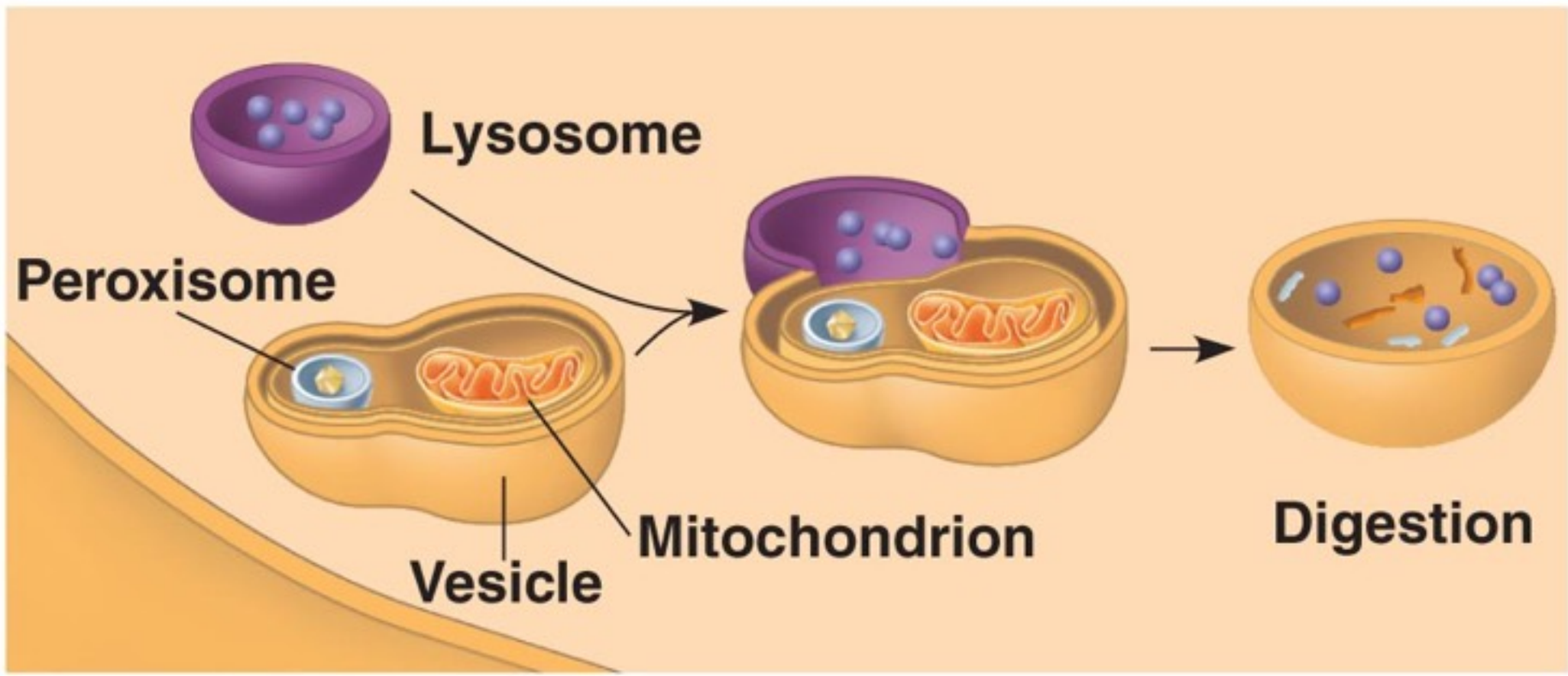


White Blood Cells fight infections through phagocytosis

Cellular Recycling of macromolecules and old organelles

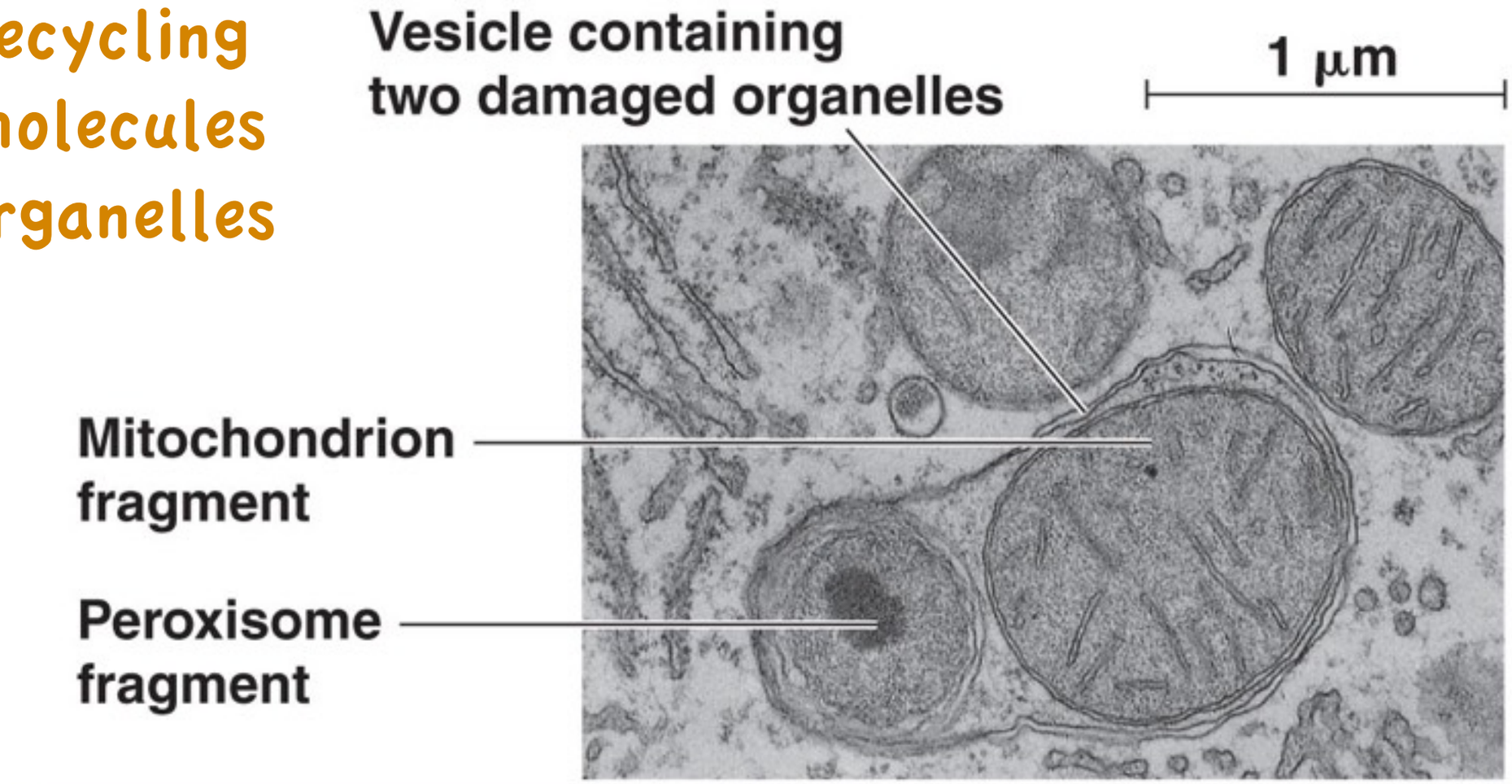


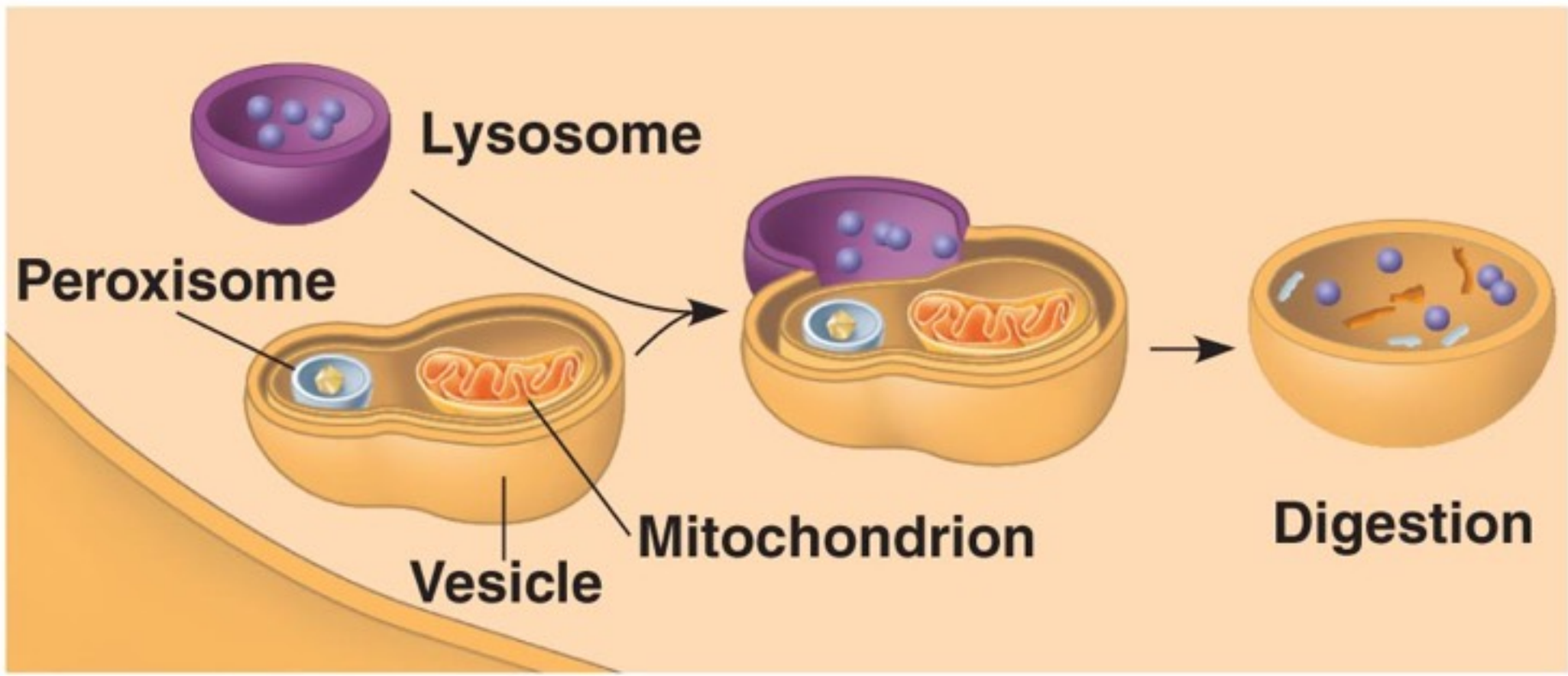


(b) Autophagy

Cellular Recycling of macromolecules and old organelles

Human liver cells recycle half of its molecules each week





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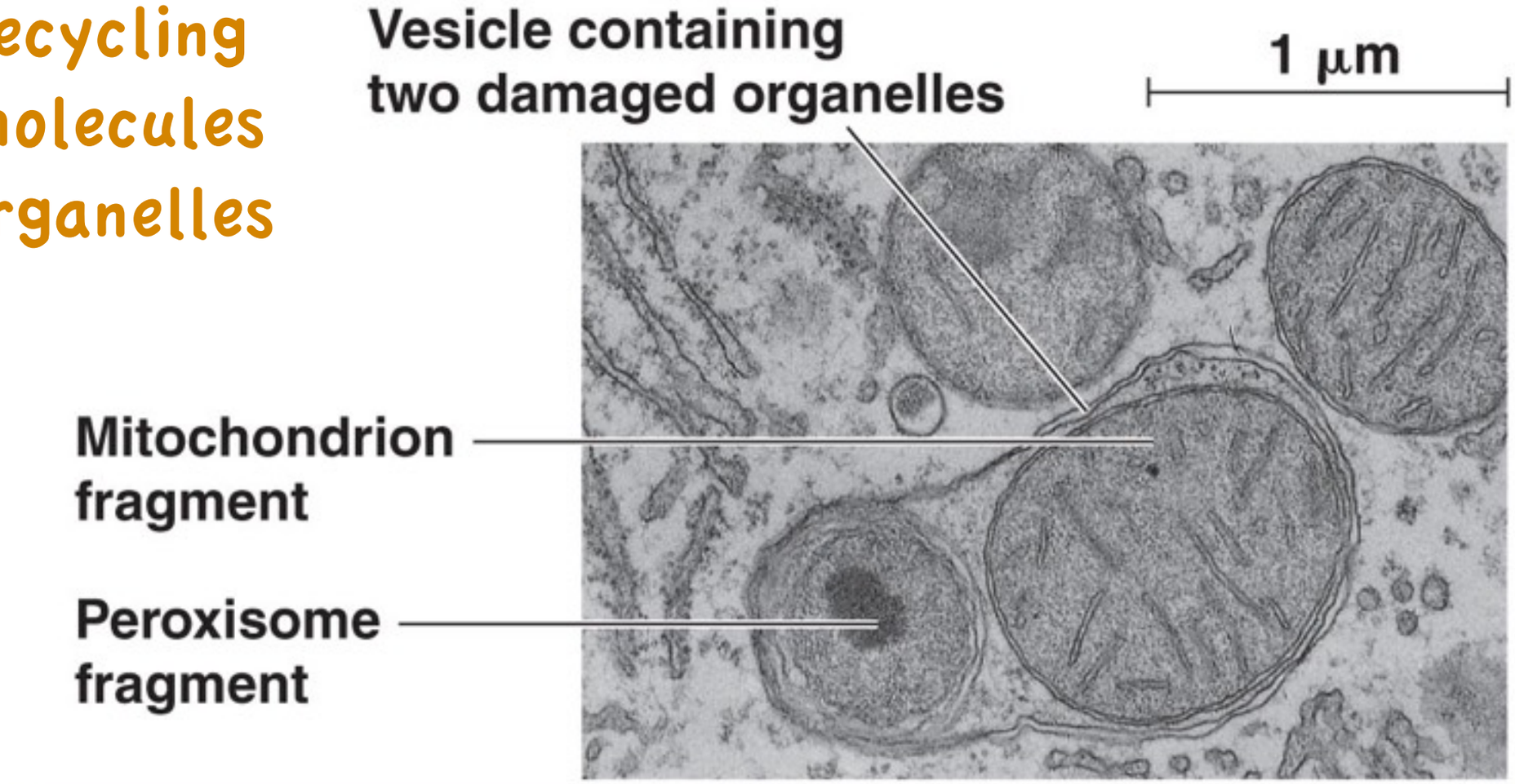
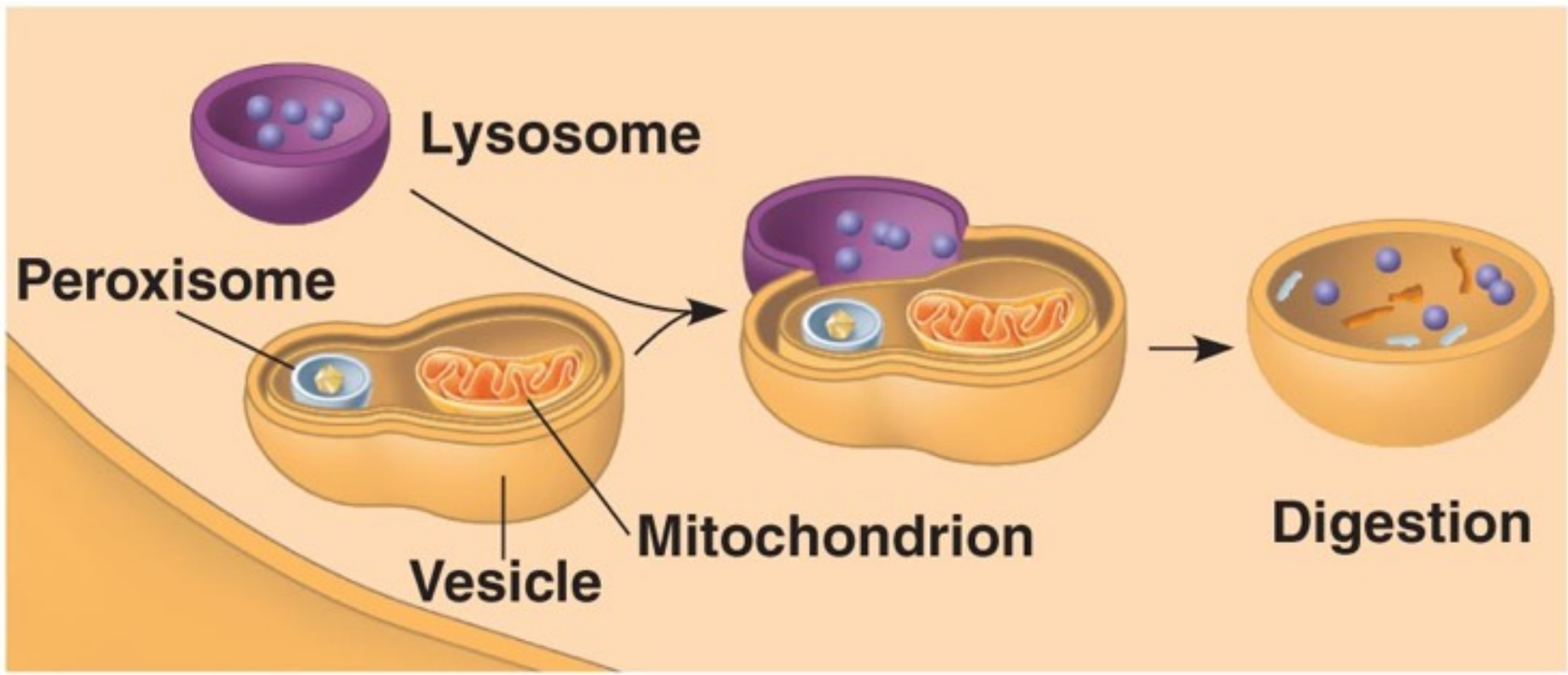


Lysosomal Disease: "Tay-Sachs" missing a lipid digesting enzyme in brain cells



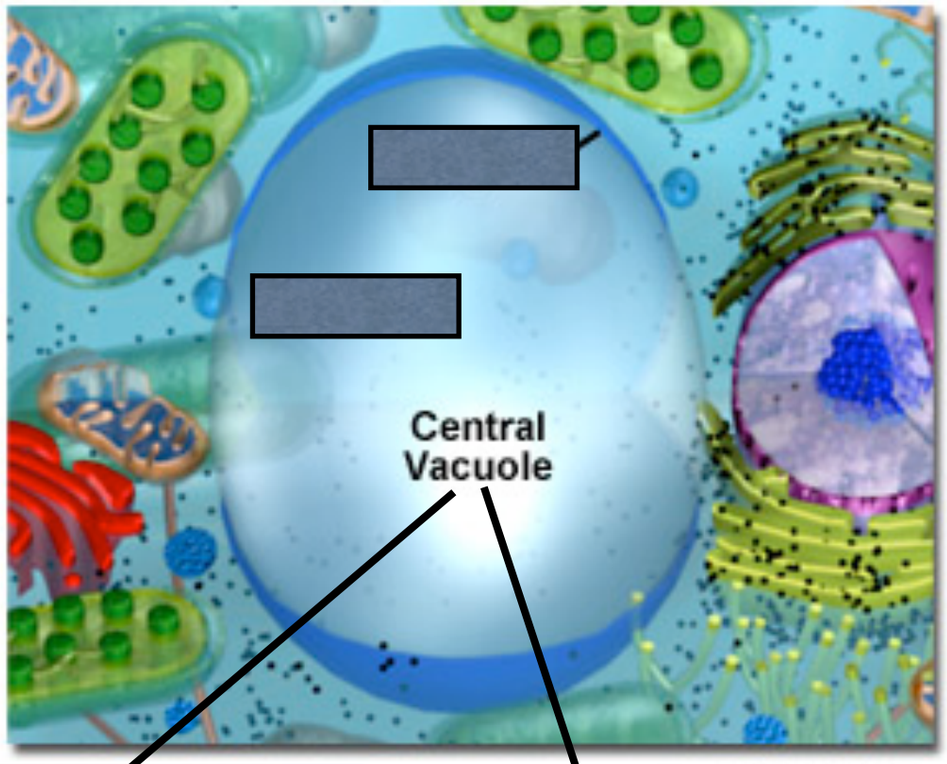
Vacuoles: Diverse Maintenance Compartments

- Large vesicles derived from E.R. or Golgi
  - **Theme: Internal environment different from external environment**
- Performs a variety of functions:
  - *Food vacuoles*; protists (last slide)
  - *Contractile Vacuoles*; freshwater protists (use them to pump out excess water thus controlling solute concentrations

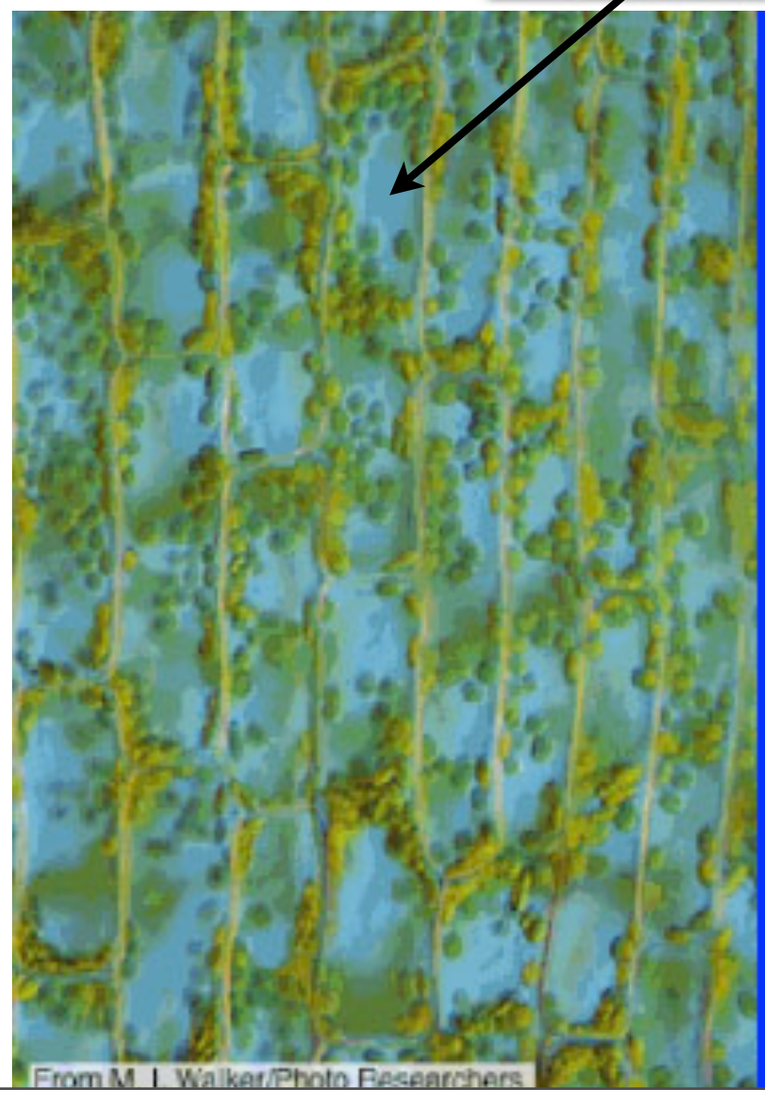
Vacuoles: continued

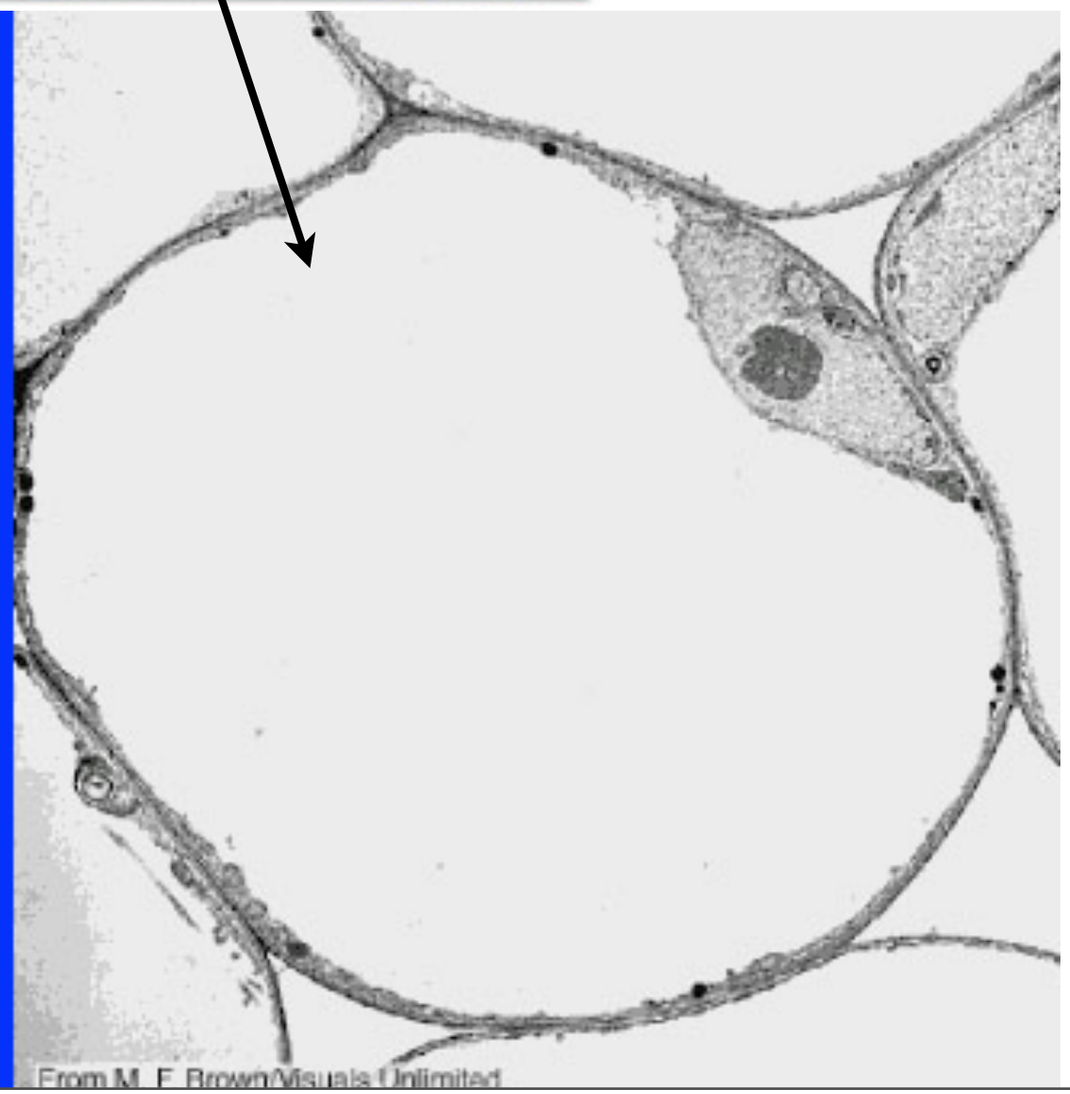
- Performs a variety of functions, perhaps plants and fungi show the most variation in their use of vacuoles:
  - *Hydrolytic vacuoles*; analogous to animal lysosomes
  - *Storage Vacuoles*;
    - a reserve of important organic compounds
    - a reserve of poisonous compounds for defense
    - container of pigments to attract pollinators
  - *Central Vacuoles*; a large vacuole that is repository of inorganic ions (calcium, potassium)
    - Important for plant cell growth, water is absorbed... cell enlarges with minimal investment in new cytoplasm

Plant Cell Central Vacuole

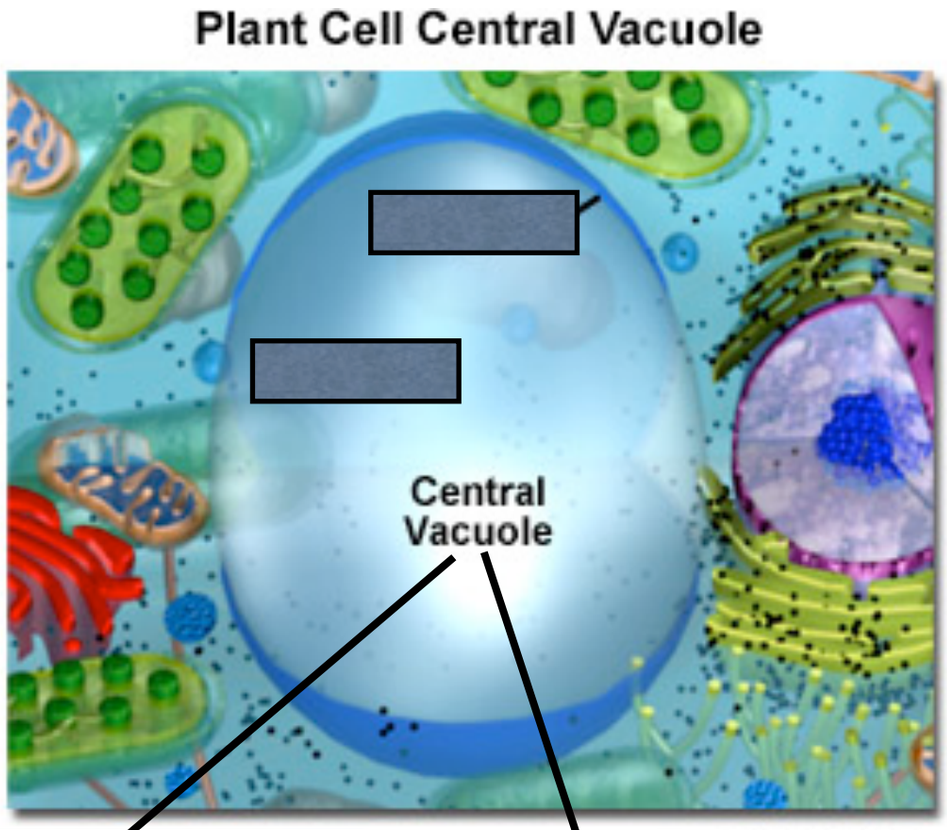


Can account for 50-70% of Cell Volume





Plant Cells Only



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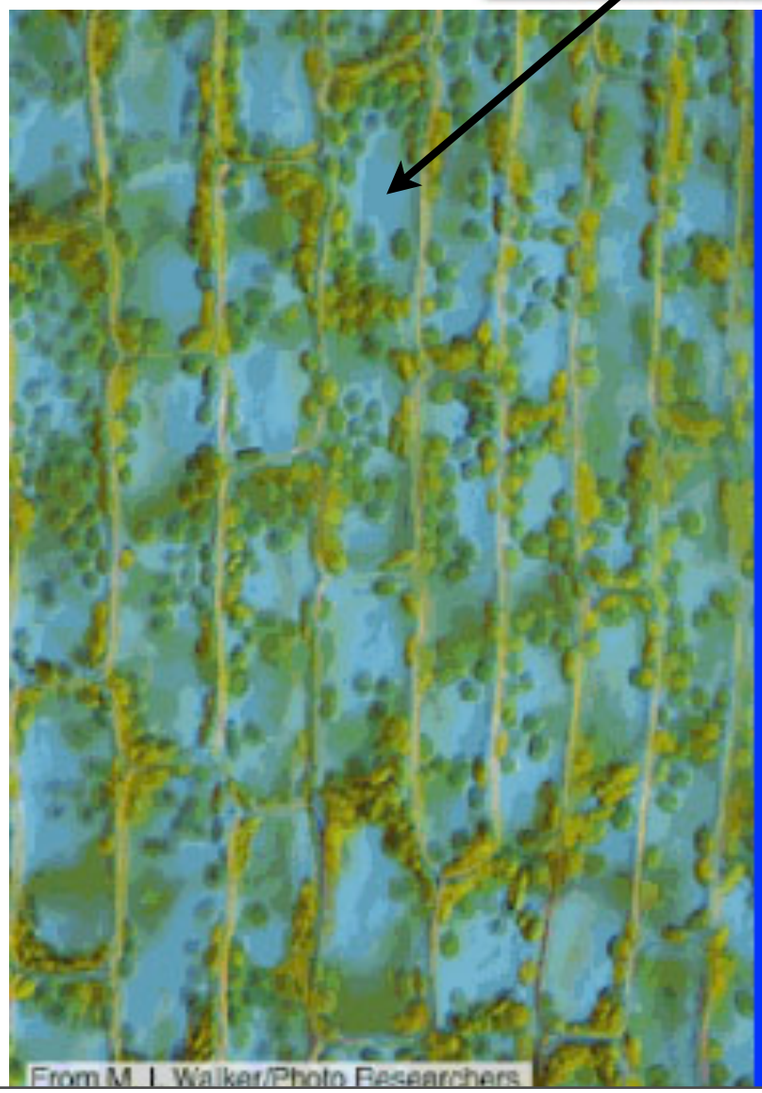

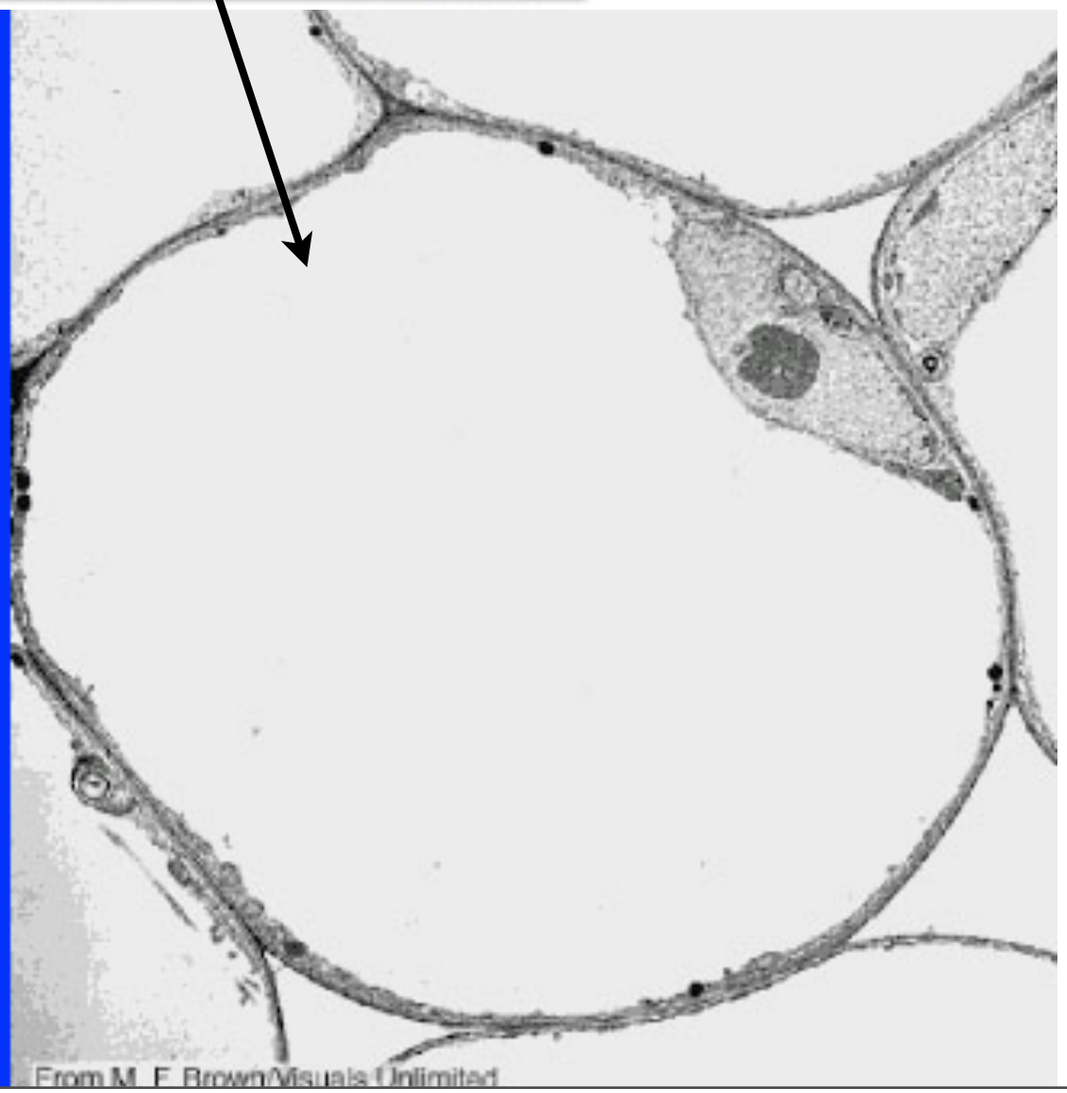

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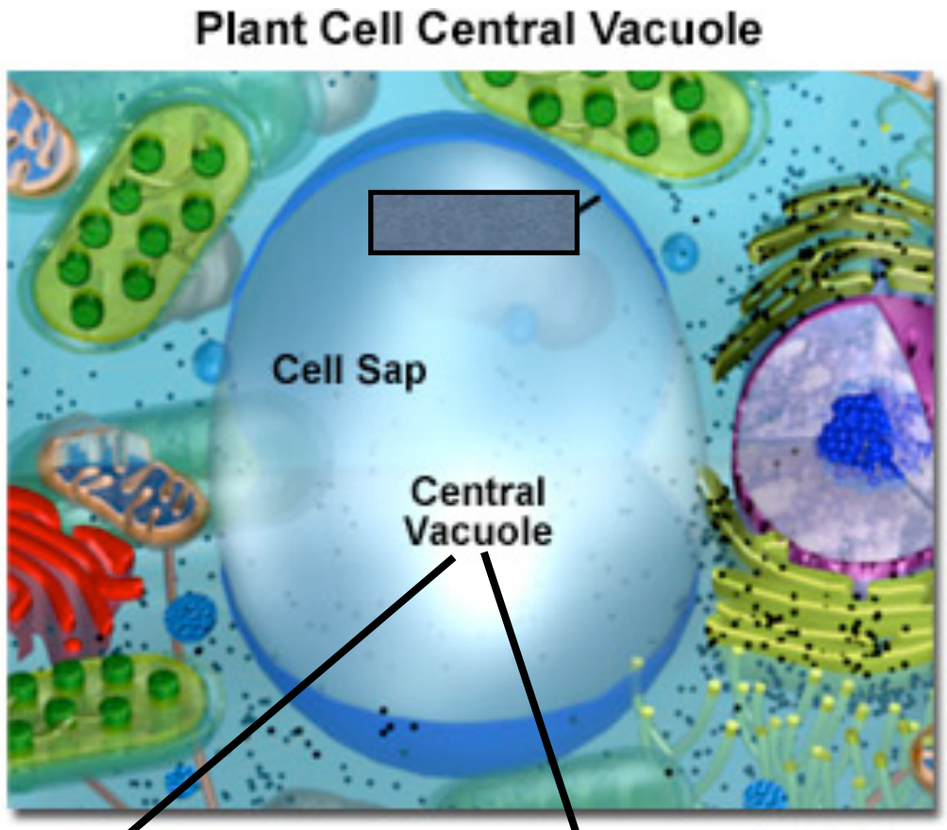

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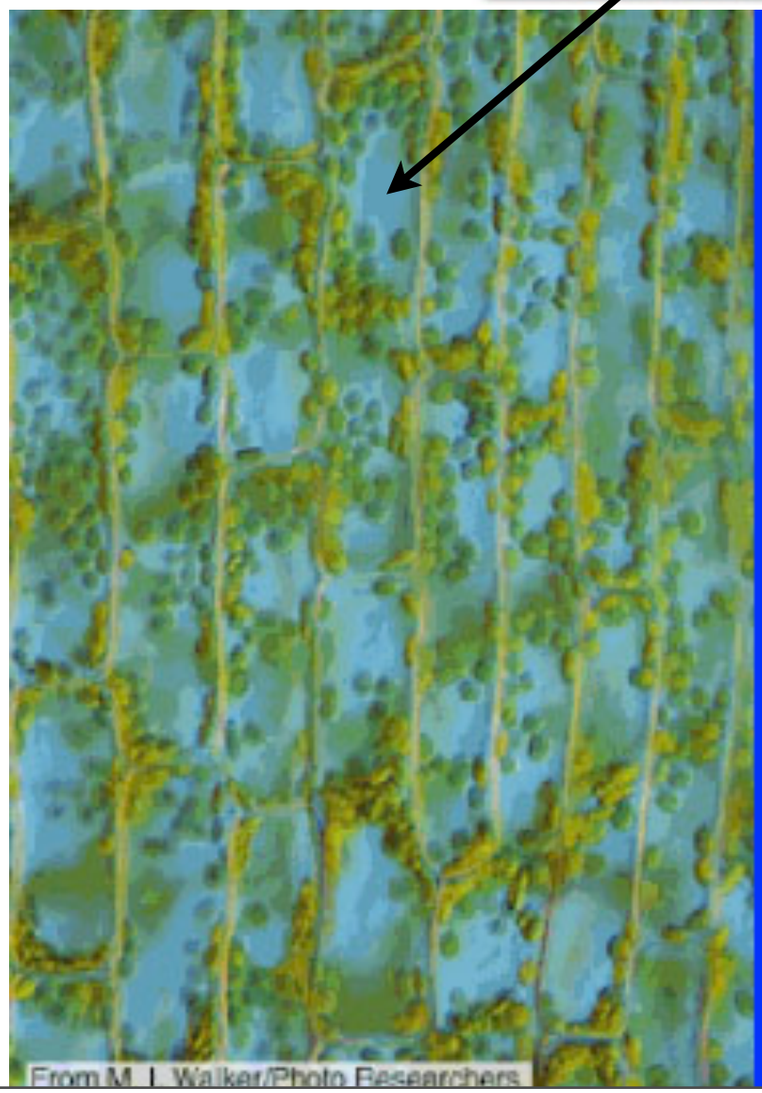

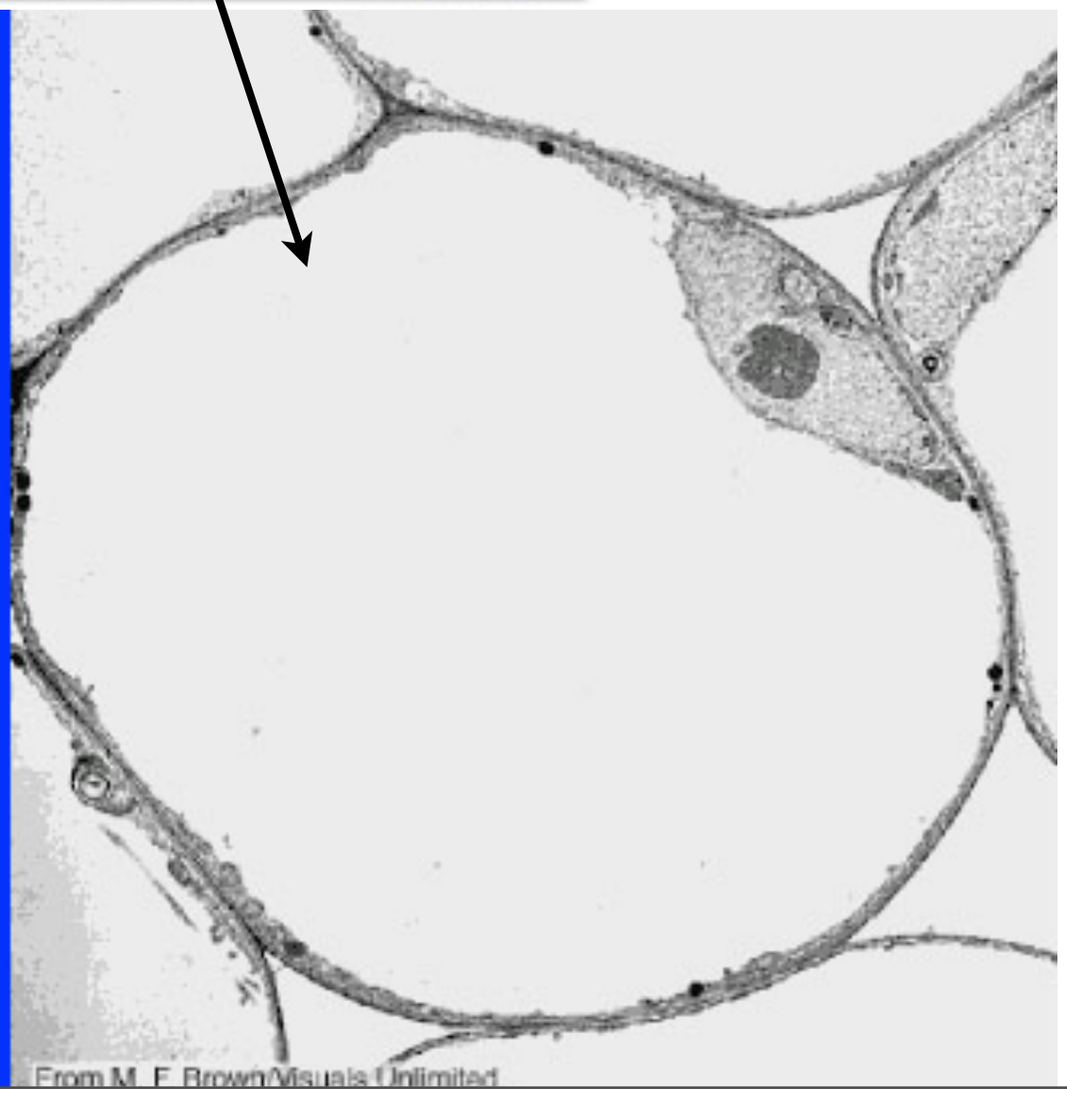

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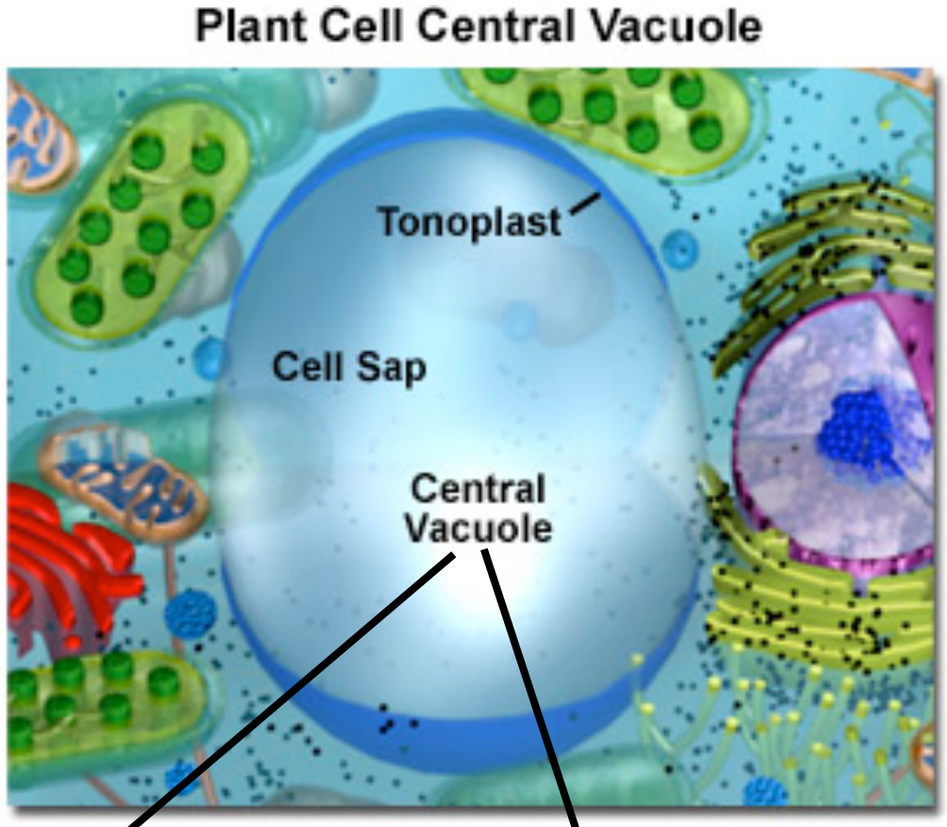

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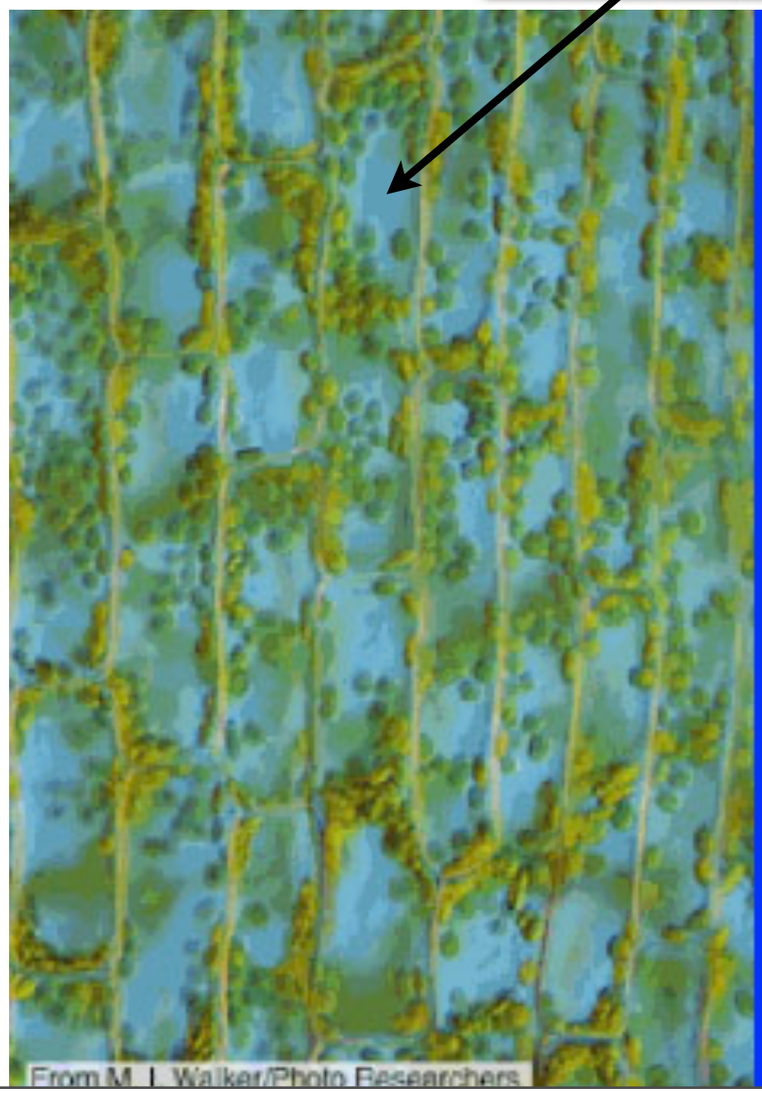
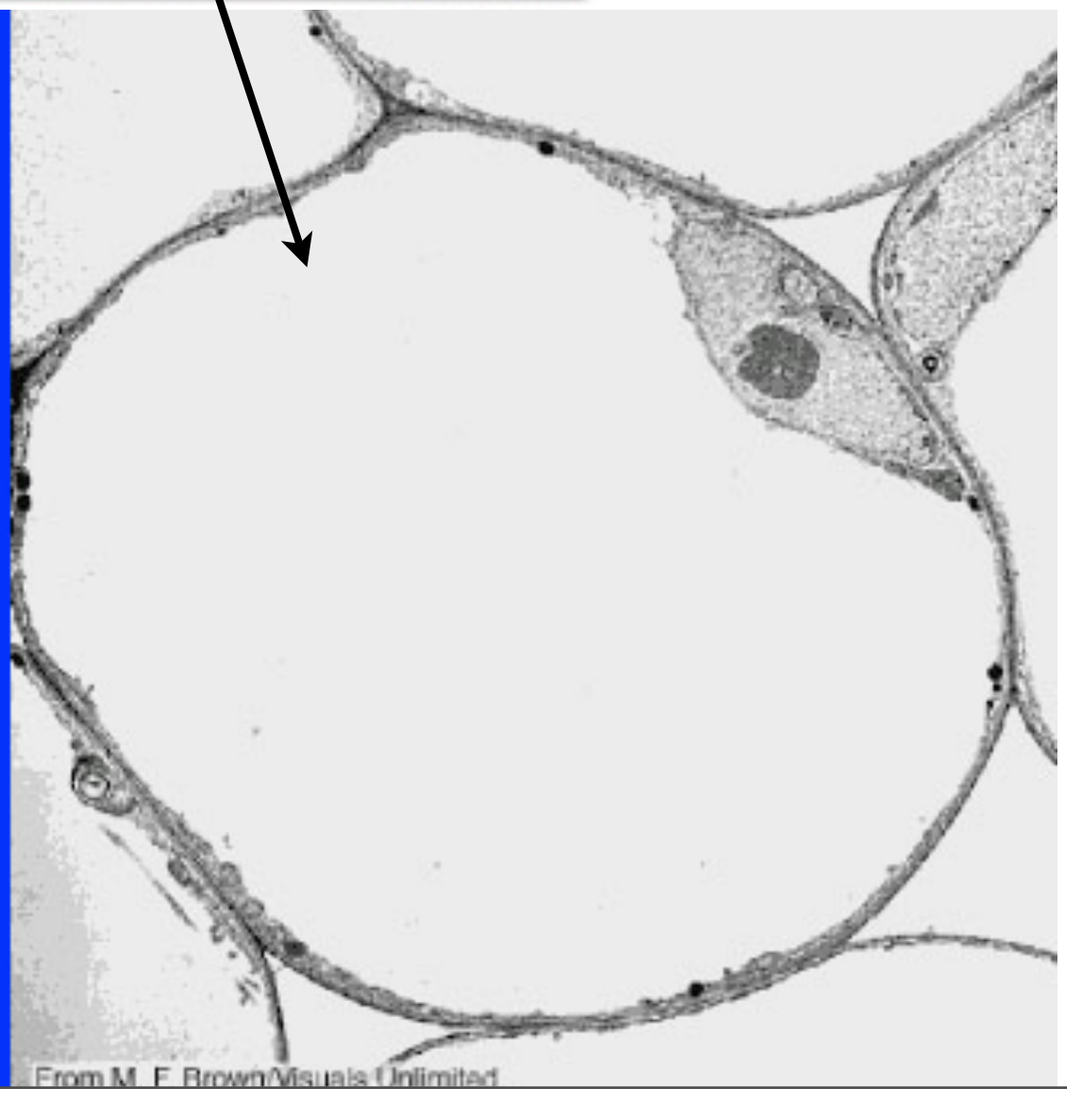
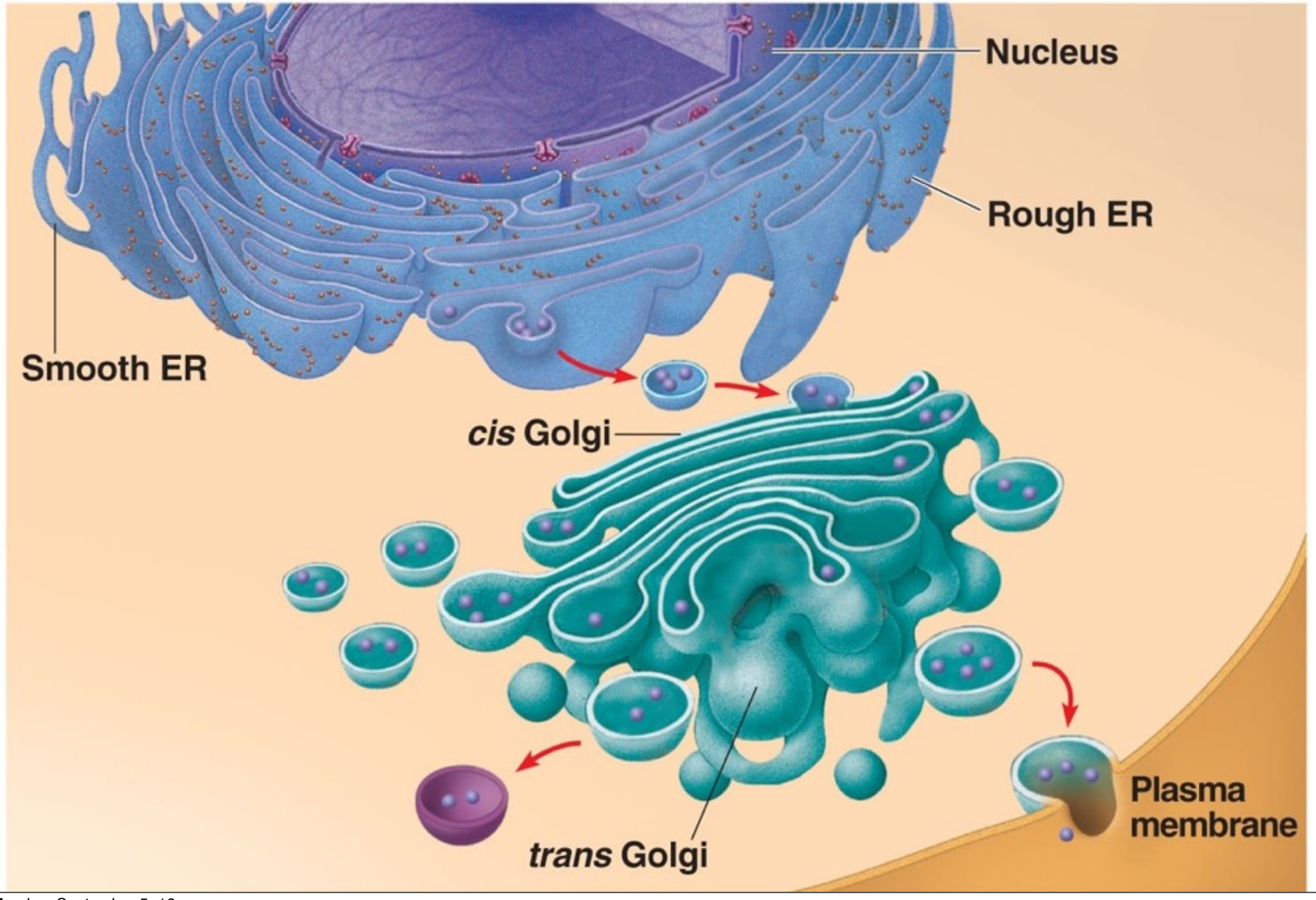




The Endomembrane System: Review



MITOCHONDRIA AND CHLOROPLASTS CHANGE ENERGY FROM ONE FORM TO ANOTHER

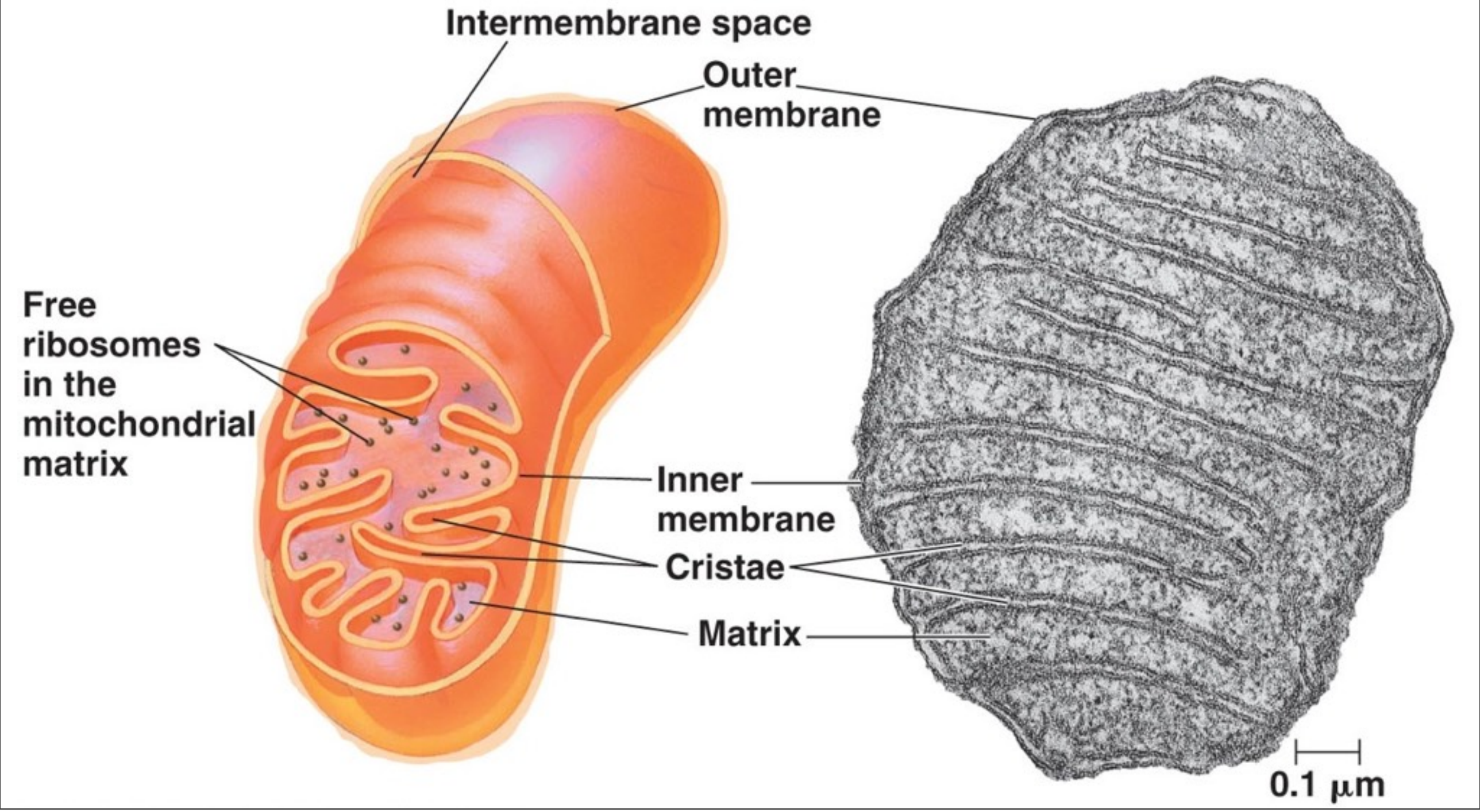
- ***Chloroplasts*** **use solar energy to build sugars from carbon dioxide and water.**

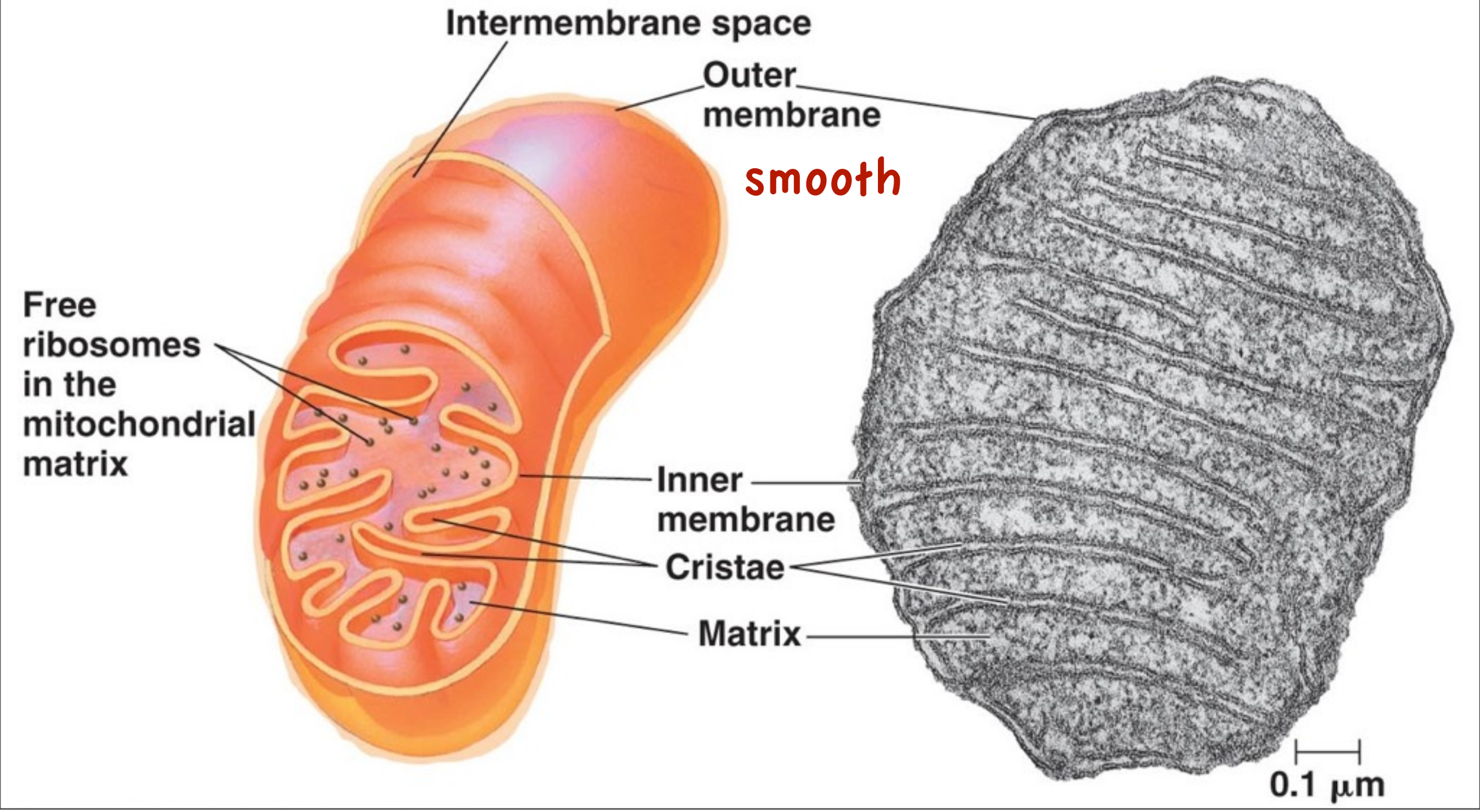
- ***Mitochondria*** **use the stored chemical energy in macromolecules such as sugars and fats to generate ATP (cellular fuel).**

Mitochondria: Chemical Energy Conversion

- **Found in nearly all eukaryotic cells**
  - animals, plants, fungi and most protists
- **A cell can have one, but more often has hundreds or thousands**
  - number correlates to metabolic level of the cell
- **Mitochondria are dynamic; they move, they grow and occasionally pinch into two**

Footnote: We will look at this organelle in more detail in the cell respiration unit.


Intermembrane space
Outer membrane
Free ribosomes in the mitochondrial matrix
Inner membrane
Cristae
Matrix
0.1 μm


Intermembrane space
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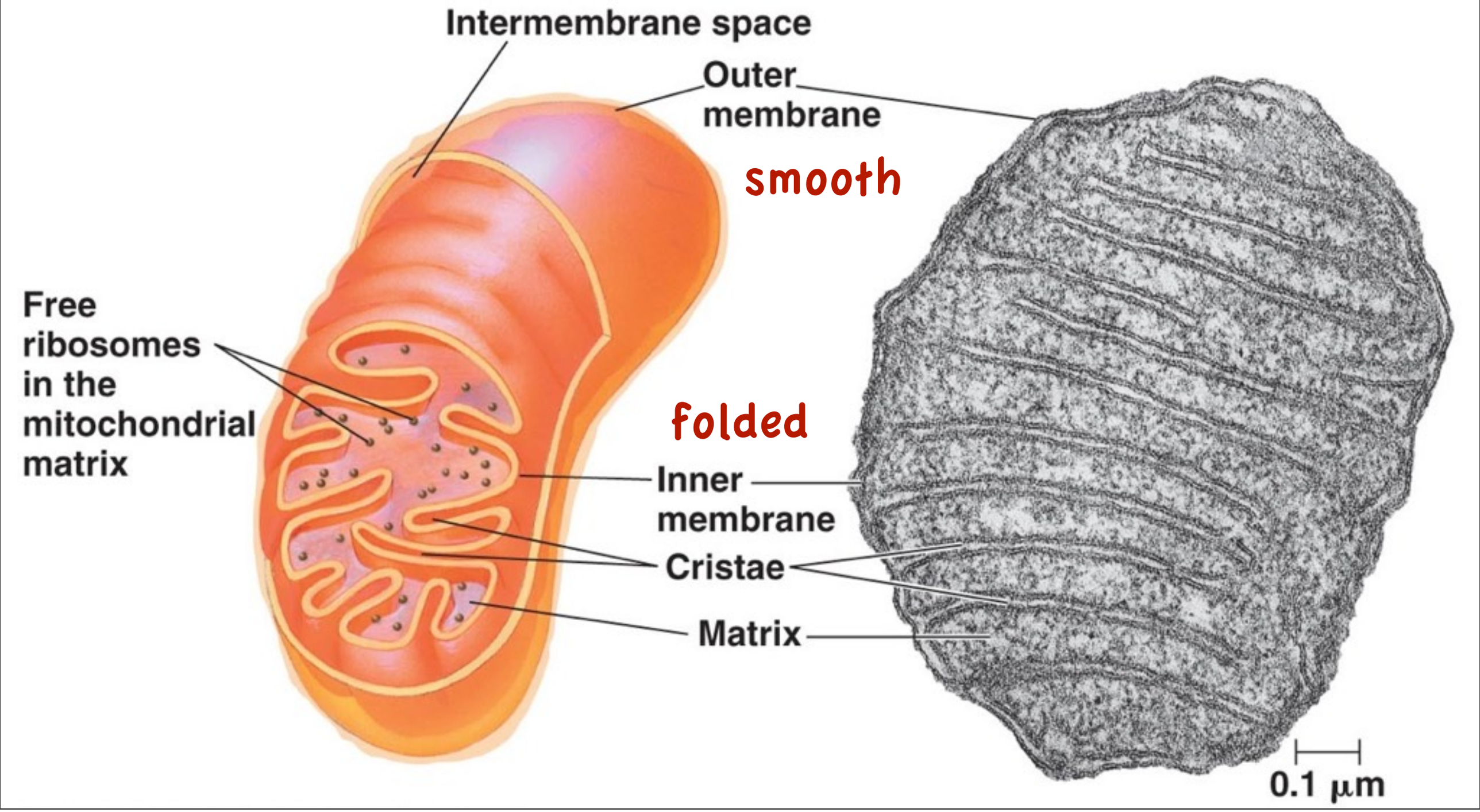
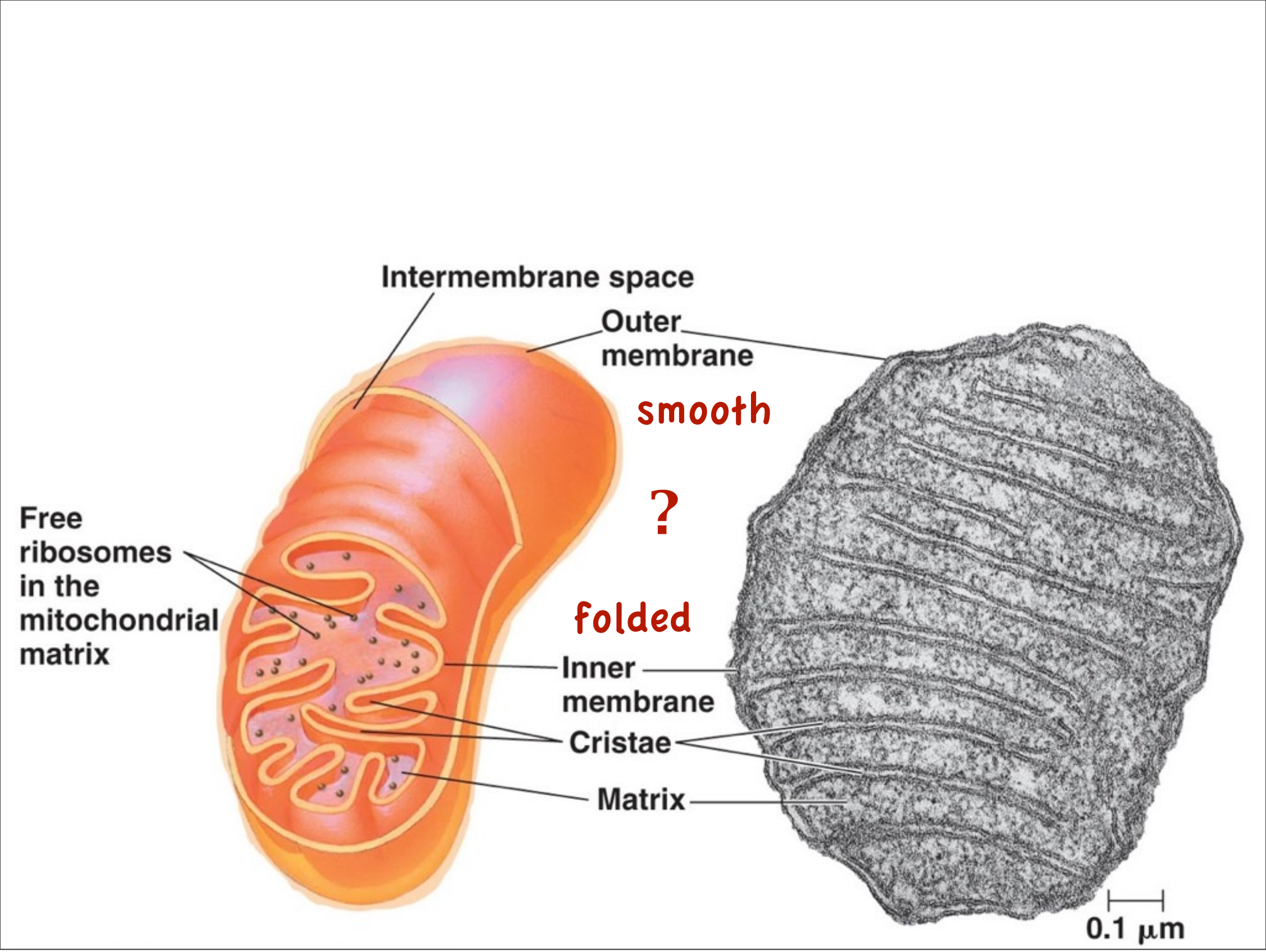
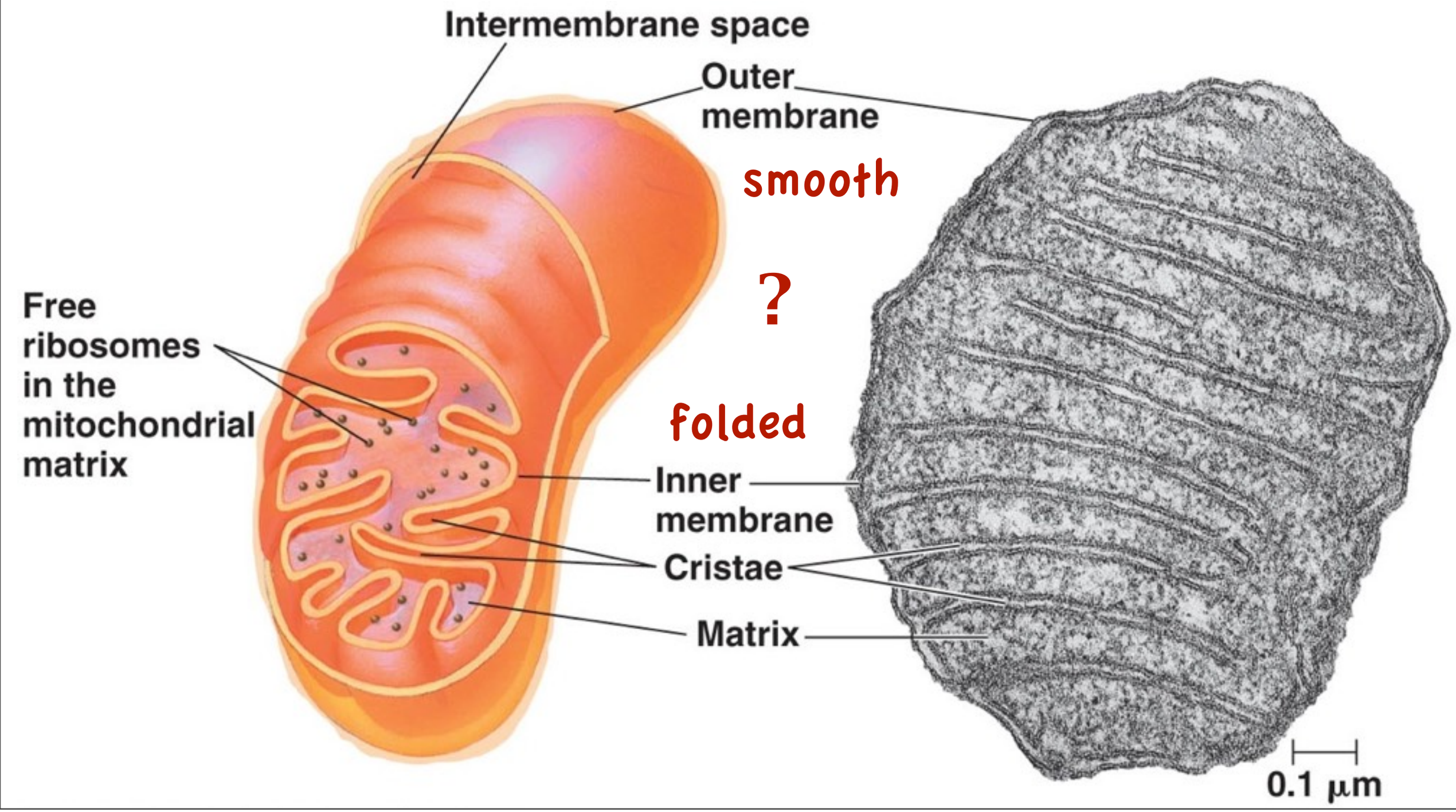

Intermembrane space
Outer membrane
smooth
Free ribosomes in the mitochondrial matrix
folded
Inner membrane
Cristae
Matrix
0.1 μm


Intermembrane space
Outer membrane
smooth
?
folded
Free ribosomes in the mitochondrial matrix
Inner membrane
Cristae
Matrix
0.1 μm

We will learn more about each area and its contents and functions in the cell respiration unit

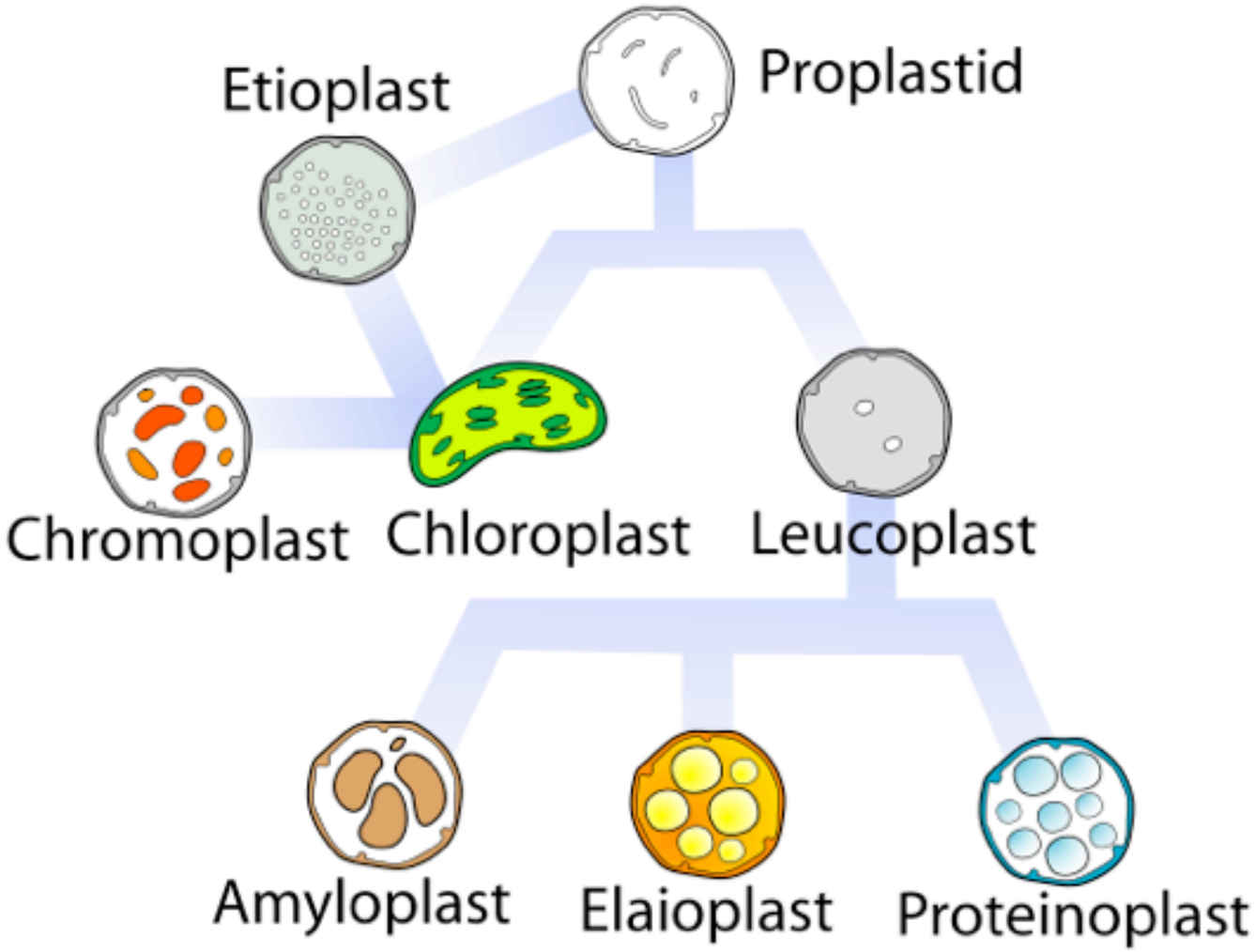


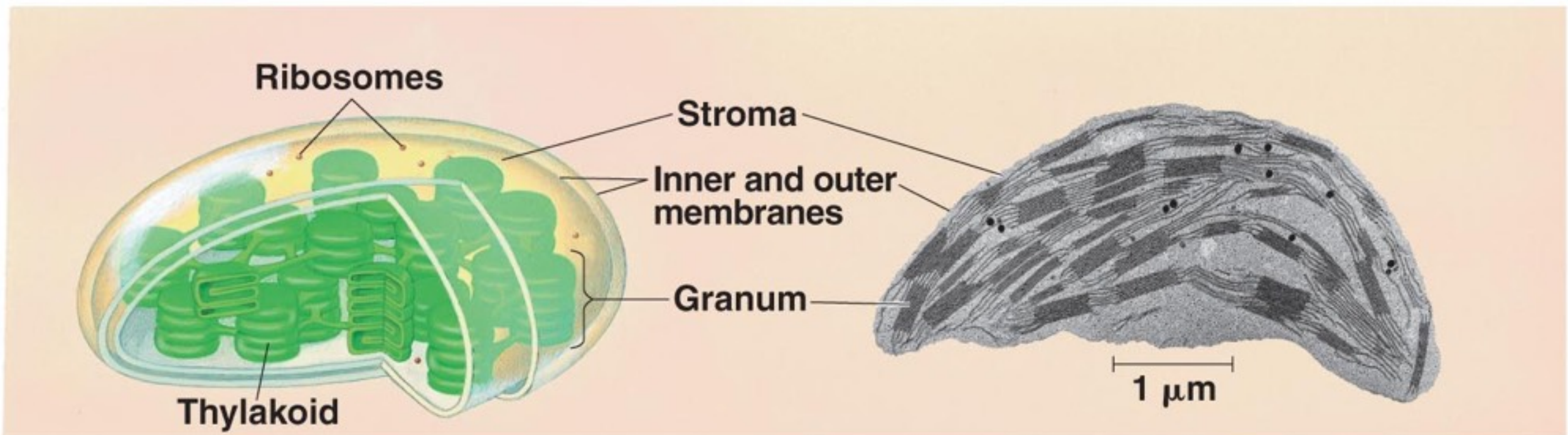
Chloroplasts: Capture of Light Energy

- **Found in plants and algae**
  - chloroplasts contain a green pigment called chlorophyll
- **Chloroplasts are dynamic; they move, they grow and occasionally pinch into two**
- **Belong to the family of plastids, organelles that manufacture and store compounds. Most contain pigments. (see next slide)**

Footnote: We will look at this organelle in more detail in the cell respiration unit.

Plastids


Etioplast
Proplastid
Chromoplast
Chloroplast
Leucoplast
Amyloplast
Elaioplast
Proteinoplast


Ribosomes
Stroma
Inner and outer membranes
Granum
Thylakoid
1 μm

Comparing Mitochondria and Chloroplasts

Mitochondria	Chloroplasts
• Converts energy to useable forms.	• Ditto
• Not part of endomembrane system.	• Ditto
• Has double membrane.	• Ditto
• Grows and reproduces.	• Ditto
• Has its own DNA and ribosomes.	• Ditto
• Semi-autonomous.	• Ditto
• Site for cell respiration	• Site for photosynthesis
• Found in both animal and plant cells	• Found in plant cells and eukaryotic algae

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

c. Archaea and Bacteria generally lack internal membranes and organelles and have a cell wall.

EUKARYOTIC CELLS HAVE INTERNAL MEMBRANES THAT COMPARTMENTALIZE THEIR FUNCTIONS

Comparing Eukaryotic and Prokaryotic cells

- ALL cells share some common features:
  - plasma membranes (selective barrier)
  - cytosol (semifluid substance)
  - chromosomes (information carrier)
  - ribosomes (protein builders)

Although all cells share these common features the first and most distinct differences between cells are seen in the division between eukaryotes and prokaryotes.

- **PROKARYOTES**
  - **older, less complex**
  - **No nucleus (DNA in nucleoid region)**
  - **No membrane bound organelles**
  - **smaller**
- **EUKARYOTES**
  - **younger, more complex**
  - **Has nucleus (contains DNA)**
  - **Has membrane bound organelles**
  - **larger**

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These differences are just the beginning a more comprehensive list is forth coming!

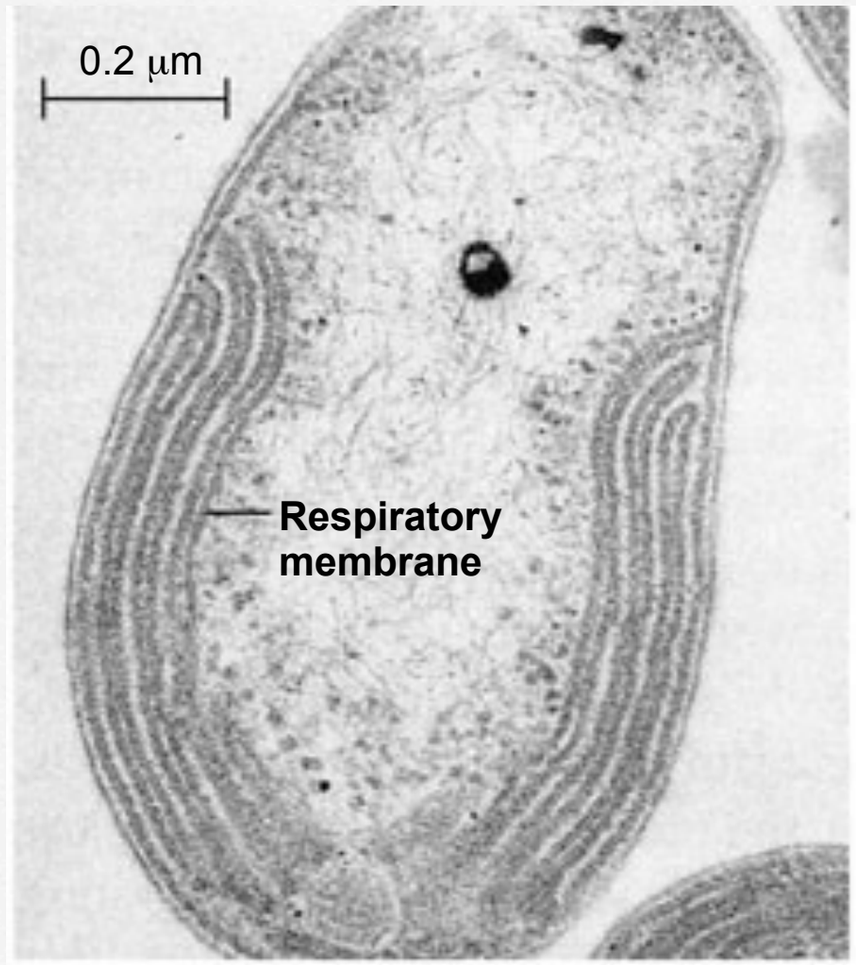
Bacterial Organelles

- Prokaryotic cells are simple
  - They have cytosol
  - They have ribosomes
  - They have inclusions
    - *deposits of nutrient/chemical reserves*
  - They lack membrane bound organelles.
  - *They lack the complex "compartmentalization" found in eukaryotic cells*

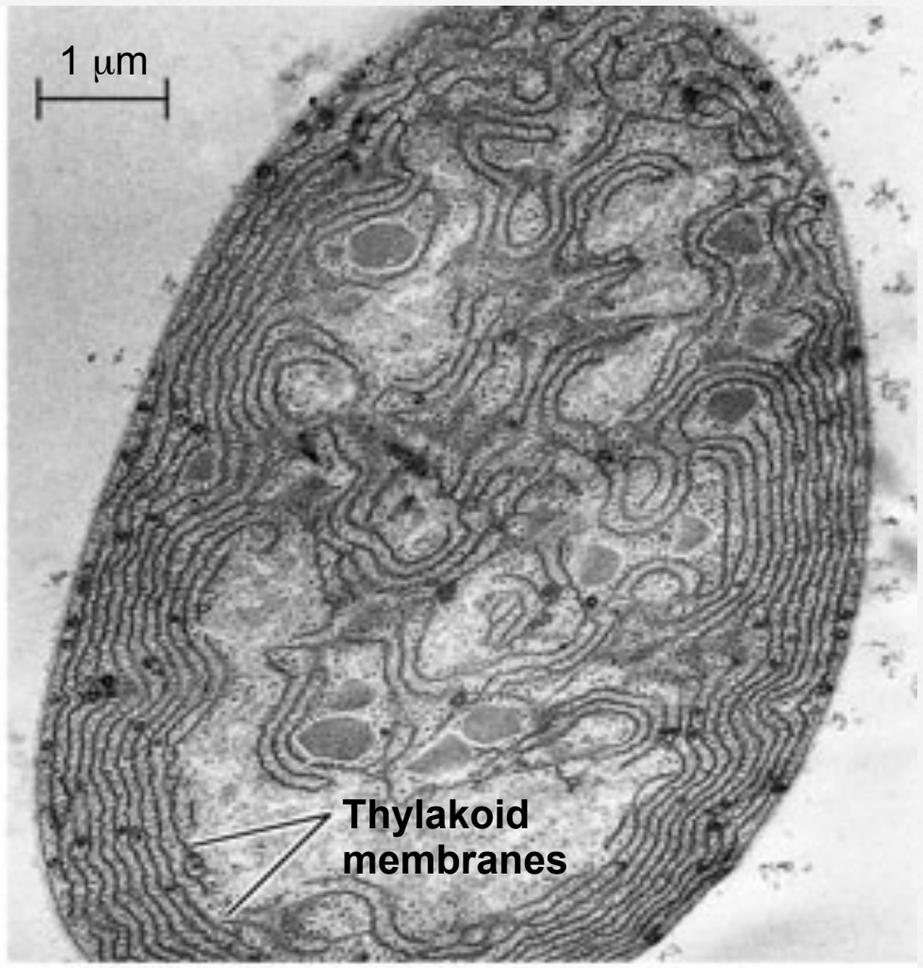
Bacterial Organelles

- Prokaryotic cells make up for the lack of specialized membrane bound organelles such as *mitochondria* and *chloroplasts* with specialized membranes.

Some have membranes that perform metabolic functions.



(a) Aerobic prokaryote

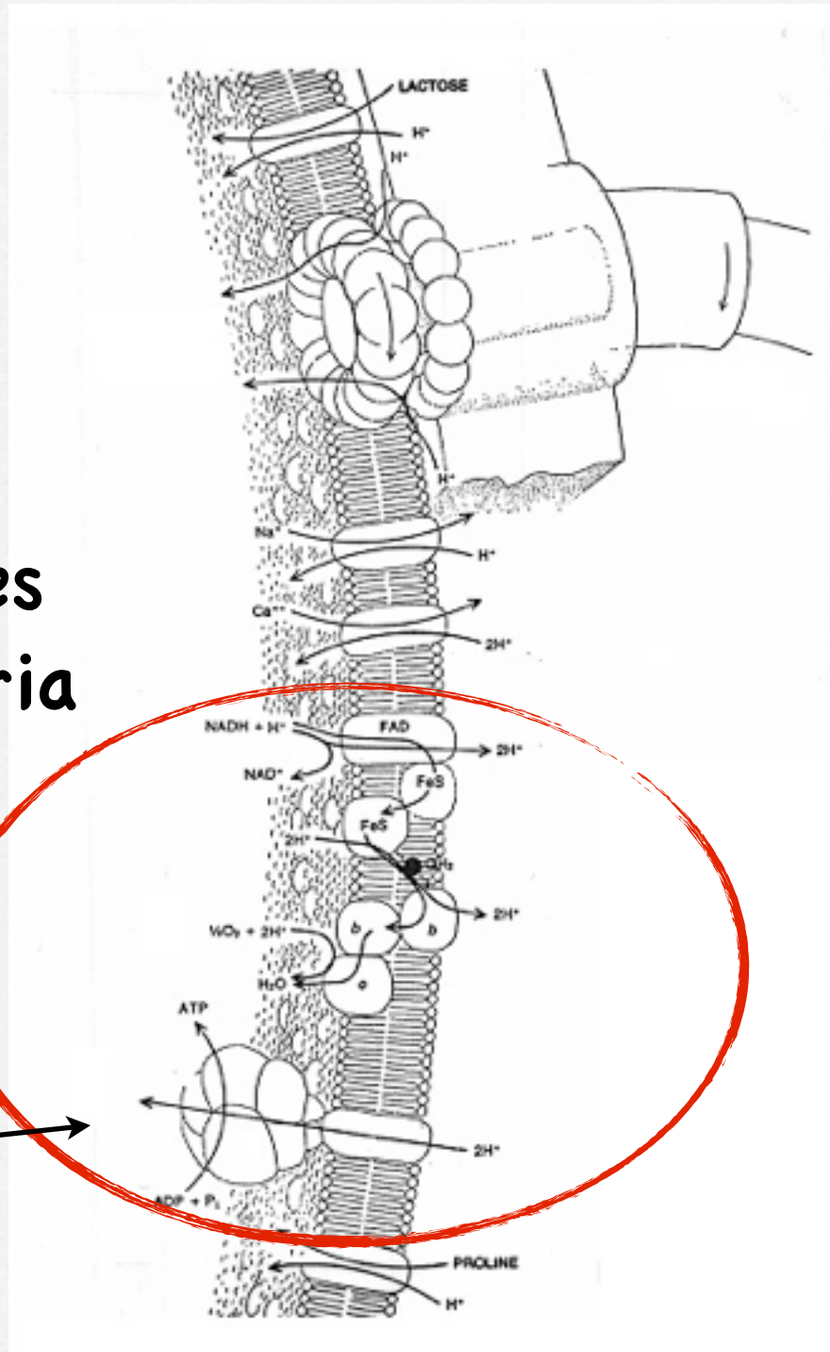


(b) Photosynthetic prokaryote

Bacterial Organelles

Some have membranes that perform metabolic functions, like <u>cellular respiration</u>.

Electron Transport Chain, found in eukaryotic mitochondria here it resides in the plasma membrane of the bacteria



ATP Synthase

Learning Objectives:

LO 2.13 The student is able to explain how internal membranes and organelles contribute to cell functions. [See SP 6.2]

LO 2.14 The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells. [See SP 1.2, 1.4]