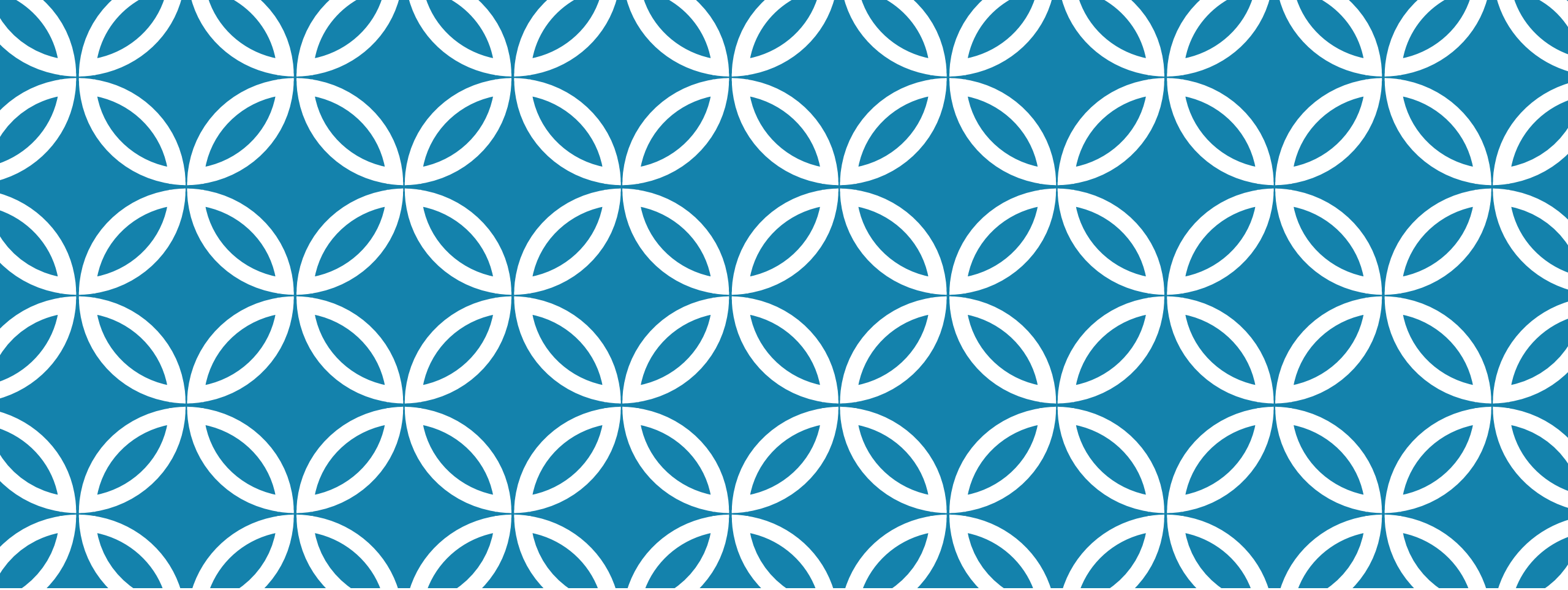
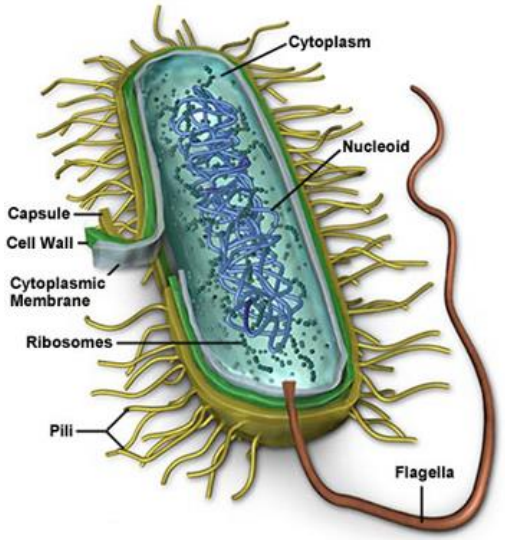


# CHAPTER 1.2

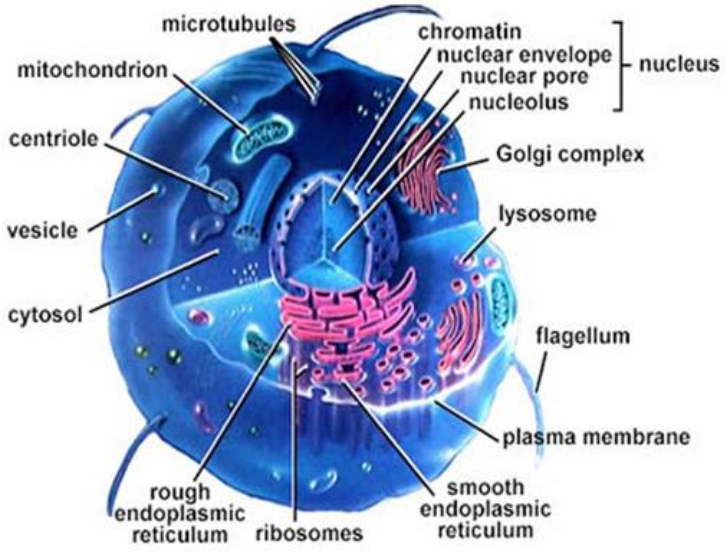
Ultrastructure of Cells

# BASIC IDEA

Eukaryotes have a much more complex cell structure than prokaryotes.




prokaryotic cell
(bacteria)




eukaryotic cell
(protists, fungi, animals, plants)

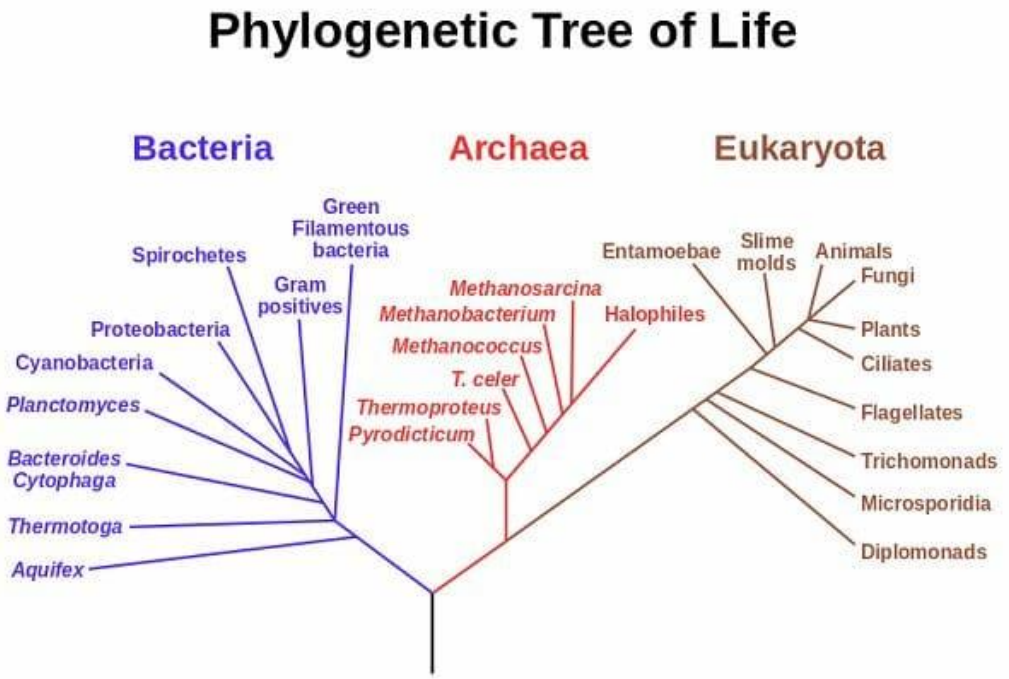
# RESOLUTION MICROSCOPES

| | resolution | | |
|---|---|---|---|
| | Millimetres (mm) | Micrometres (μm) | Nanometres (nm) |
| Human eye | 0.1 | 100 | 100,000 |
| Light microscopes | 0.0002 | 0.2 | 200 |
| Electron microscopes | 0.000001 | 0.001 | 1 |

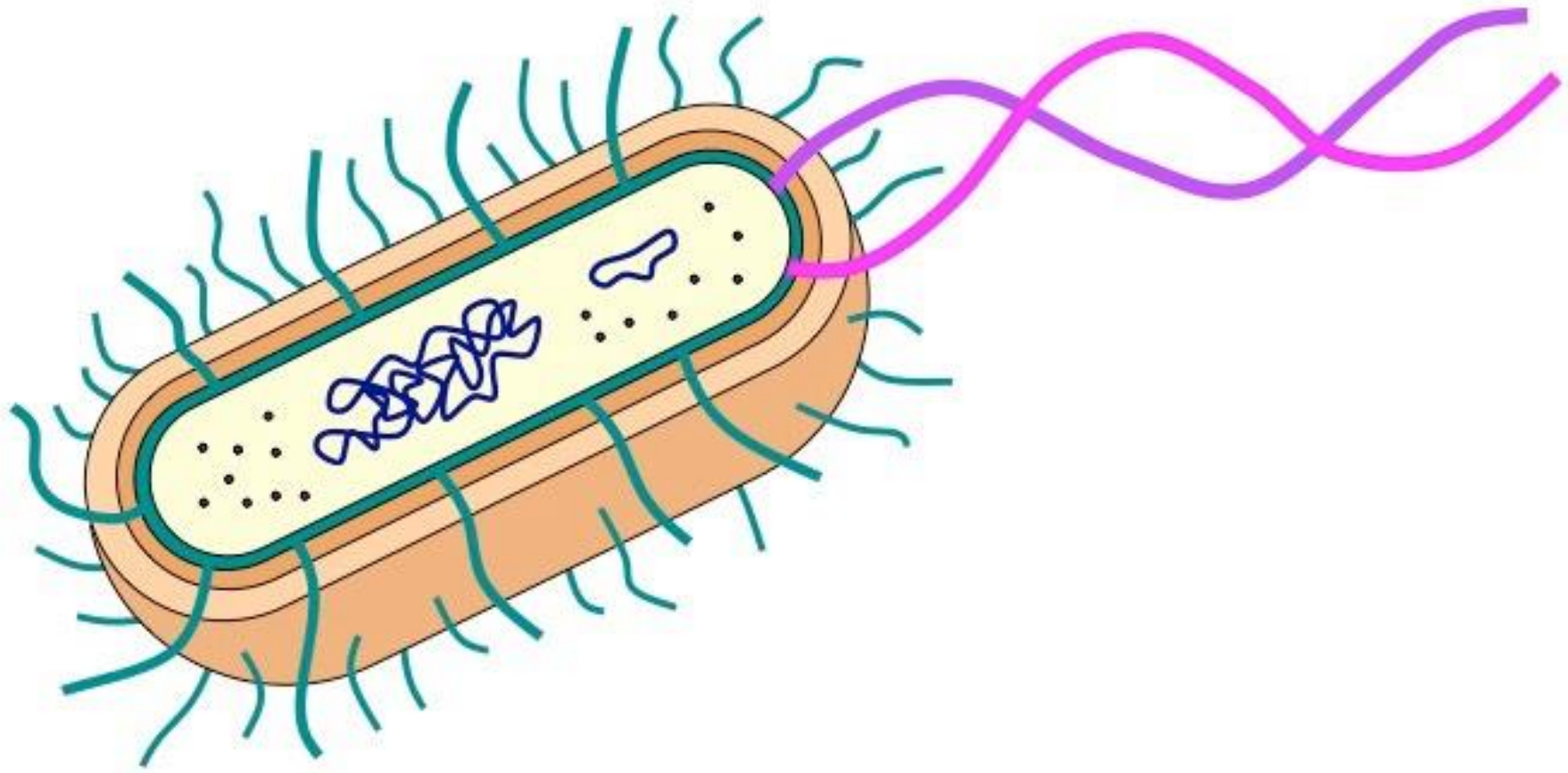
# PROKARYOTIC CELLS

- Prokaryotes have a simple cell structure without compartmentalization

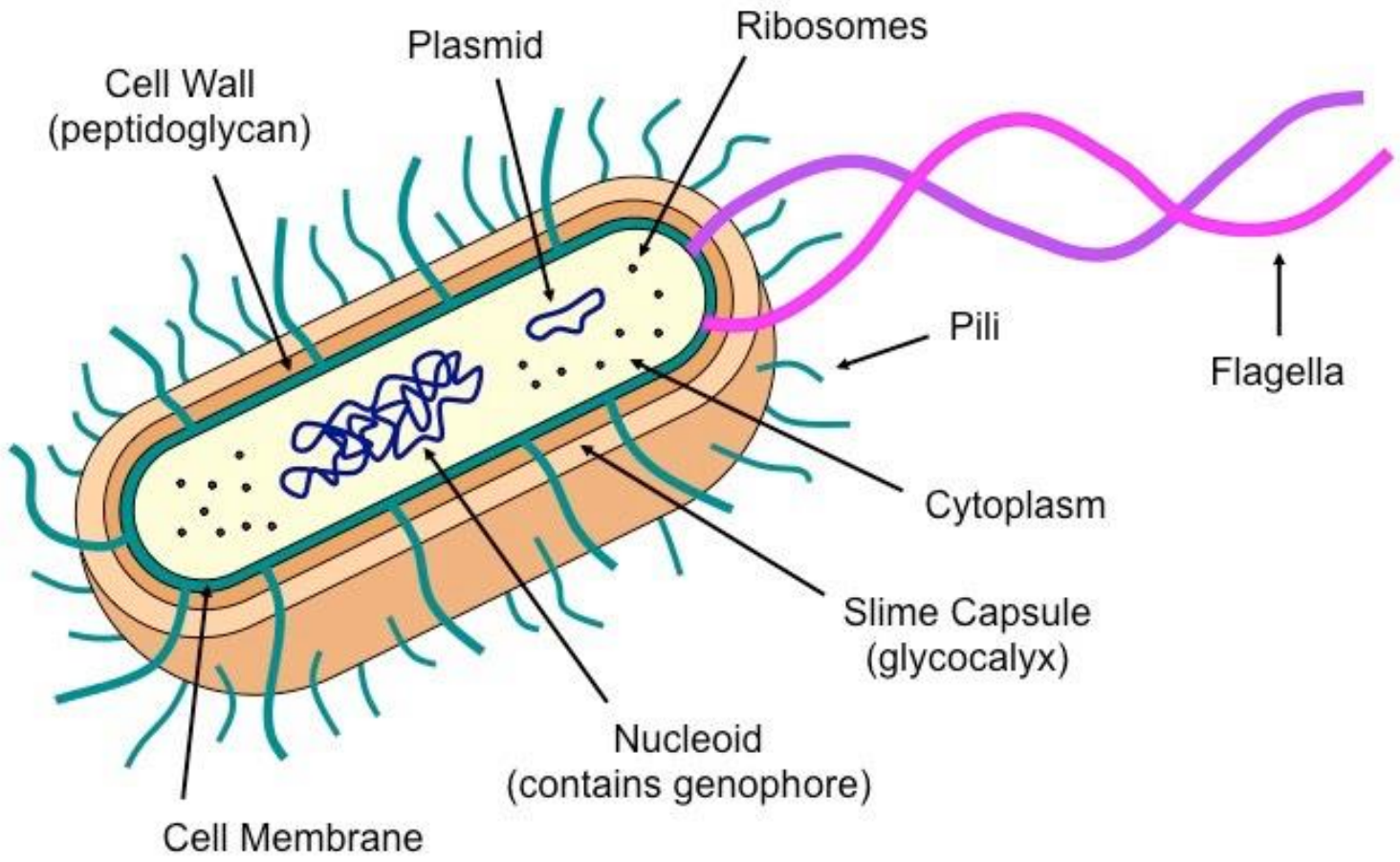
- Two domains:
  - Eubacteria: “traditional bacteria”
  - Archaea: found in extreme environments



# ULTRASTRUCTURE OF PROKARYOTES



# ULTRASTRUCTURE OF PROKARYOTES



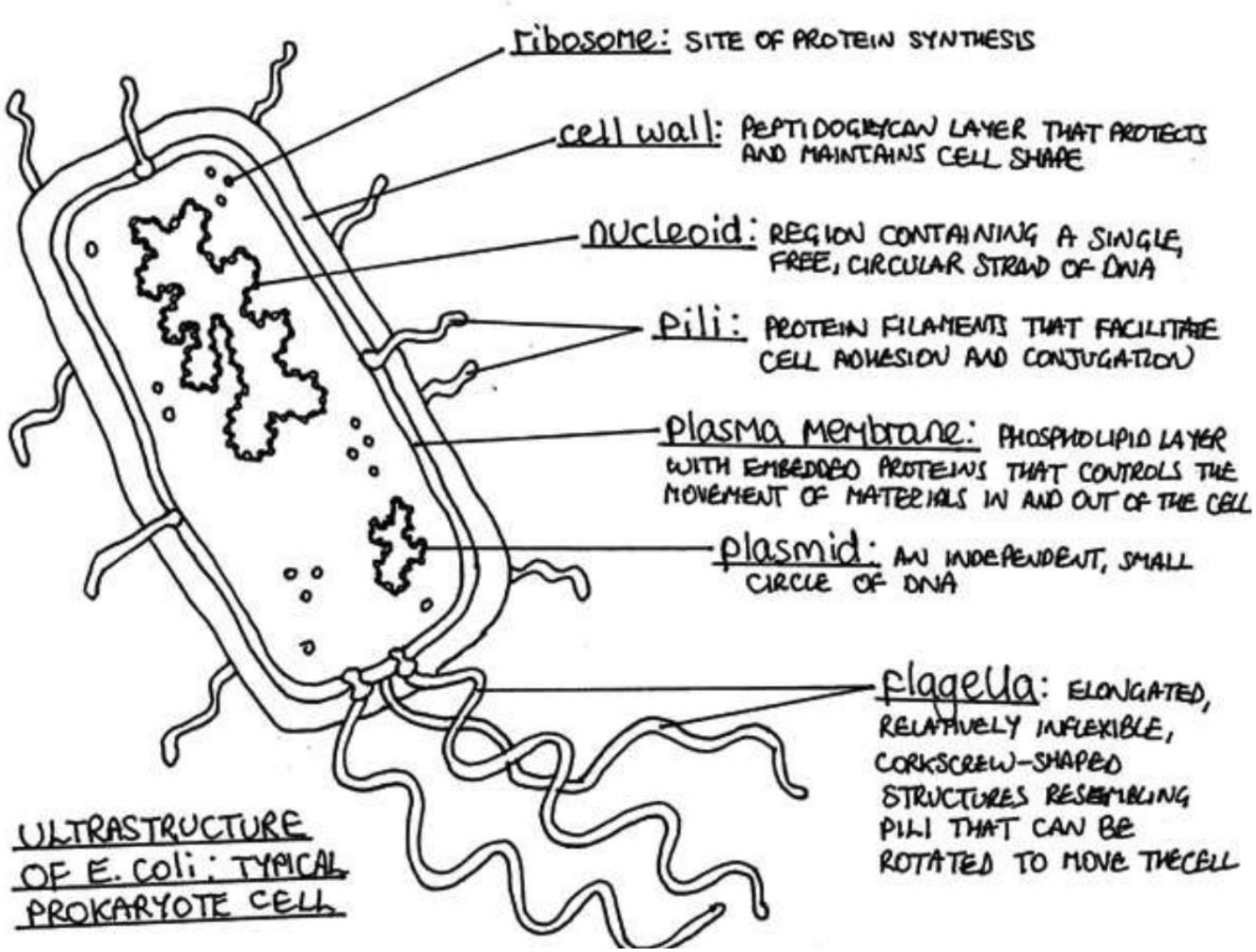

*Nucleoid* – region of the cytoplasm where the DNA is located (DNA strand is circular and called a genophore

*Plasmids* – autonomous circular DNA molecules that may be transferred between bacteria (horizontal gene transfer)

*Slime capsule* – a thick polysaccharide layer used for protection against drying out and phagocytosis

# ULTRASTRUCTURE OF E.COLI AS AN EXAMPLE

Prokaryotes → parts of a cell/ultrastructure not organelles



# CELL DIVISION IN PROKARYOTES

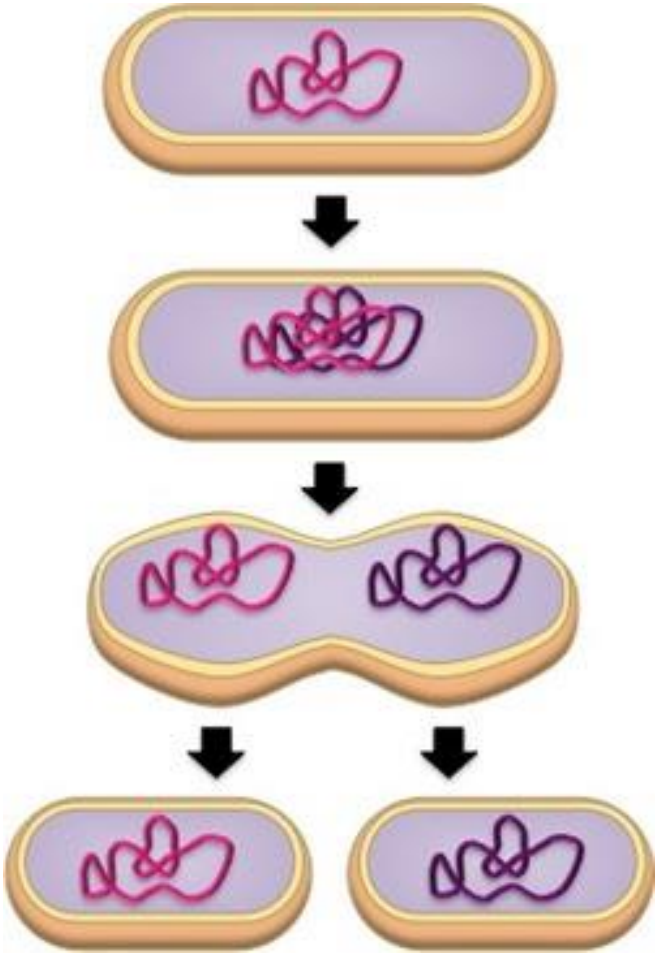
- Division of pre-existing cells (see cell theory)
- prokaryotes → binary fission (asexual reproduction)

1.) DNA is replicated semi-conservatively (see DNA replication).

2.) Two DNA loops attach to membrane

3.) The membrane elongates and pinches off (cytokinesis), forming two cells

# CELL DIVISION IN PROKARYOTES



←DNA is replicated semi-conservatively (see DNA replication).

← Two DNA loops attach to membrane

←The membrane elongates and pinches off (cytokinesis), forming two cells

# EUKARYOTES ARE COMPARTMENTALIZED

Advantages:

- Enzymes can be more concentrated than if they were spread through cytoplasm = more efficient metabolism
- Conditions (such as pH) can be maintained at an ideal level (different processes, different pH lvls)
- Damaging substances can be isolated (e.g. digestive enzyme that could digest the cell itself is stored in lysosome).
- Organelles + contents can be moved around within the cell

# EUKARYOTES

- organisms whose cells contain a nucleus (‘*eu*’ = good / true ; ‘*karyon*’ = nucleus)
- more complex structure
- are believed to have evolved from prokaryotic cells (via endosymbiosis)
- organelles surrounded by membranes
-organelles perform specific functions

# EUKARYOTES

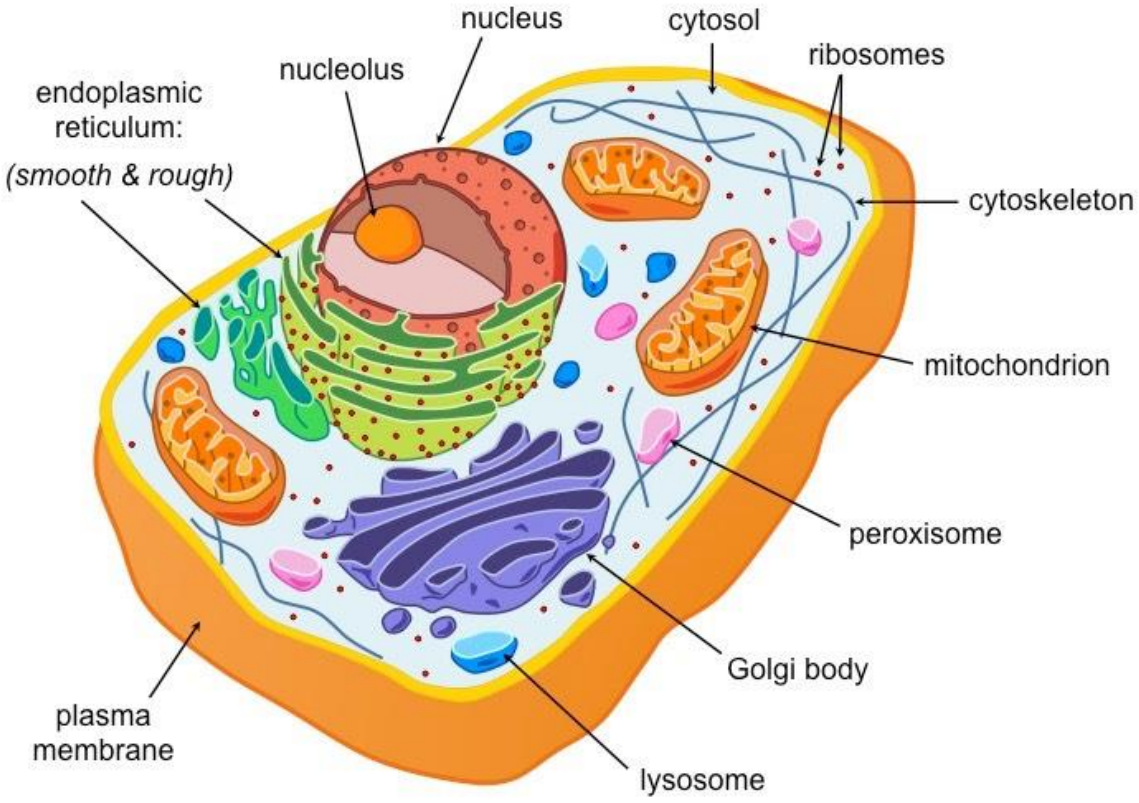
**Protista –** unicellular organisms

**Fungi –** have a cell wall & nutrition via absorption

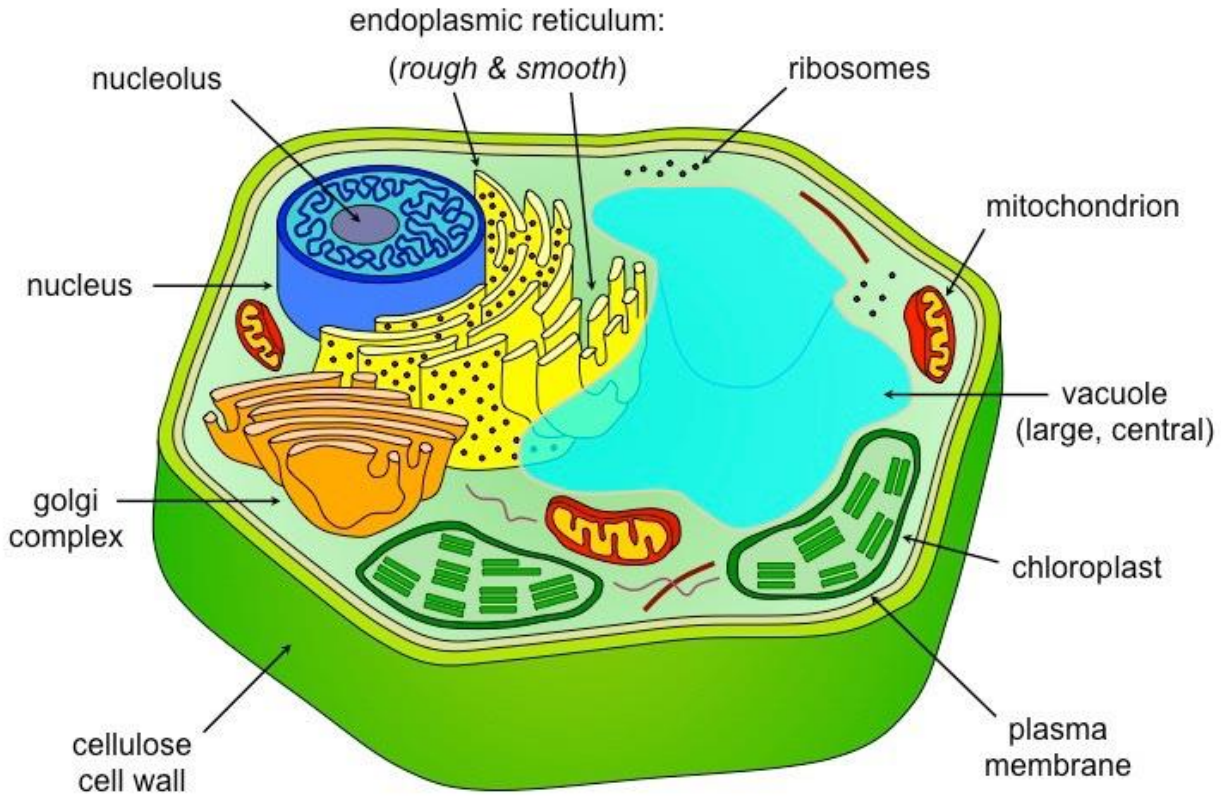
**Plantae –** have a cell wall made of cellulose and obtain nutrition autotrophically (via photosynthesis)

**Animalia –** no cell wall and obtain nutrition via heterotrophic ingestion

# STRUCTURE OF EUKARYOTIC CELLS




Animal cell




Plant cell

# UNIVERSAL STRUCTURES (PROKARYOTES & EUKARYOTES)

**Ribosomes**

*Structure:* Two subunits made of RNA and protein; eukaryotes (80S) - prokaryotes (70S)

*Function:* Site of polypeptide synthesis (translation)

**Cytoskeleton**

*Structure:* A filamentous scaffolding within the cytoplasm

*Function:* internal structure & intracellular transport (less developed in prokaryotes)

**Plasma membrane**

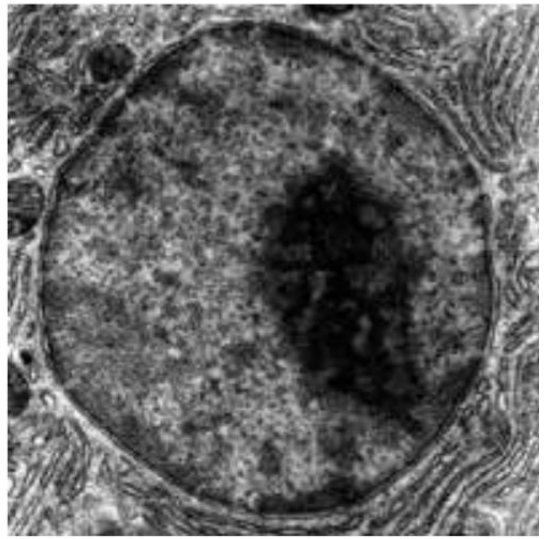
*Structure:* Phospholipid bilayer embedded with proteins

*Function:* Semi-permeable and selective barrier surrounding the cell

# EUKARYOTES - ORGANELLES

- Nucleus
- ER (rough and smooth)
- Golgi apparatus
- Lysosomes
- Mitochondria
- Ribosomes
- Chloroplast
- Vacuoles and Vesicles
- Microtubules and Centrioles
- Cilia and Flagella

# NUCLEUS



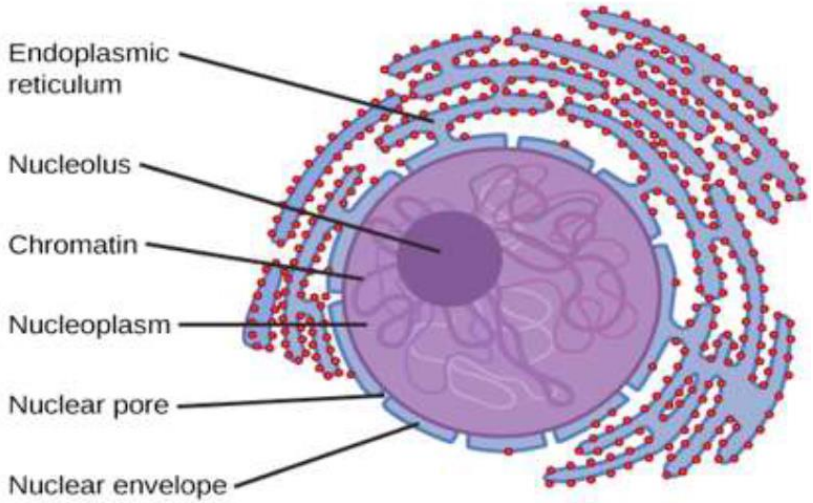
- double membrane + pores

- contains chromosomes (DNA + histone proteins)

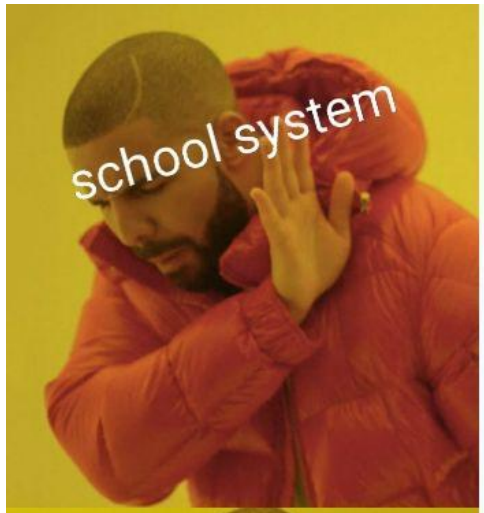
- Chromatin = uncoiled (usually at the edges + darker areas)

- where DNA is replicated and transcribed → mRNA leaves nucleus via pores

- mRNA exported to the cytoplasm → protein synthesis



# MITOCHONDRIA



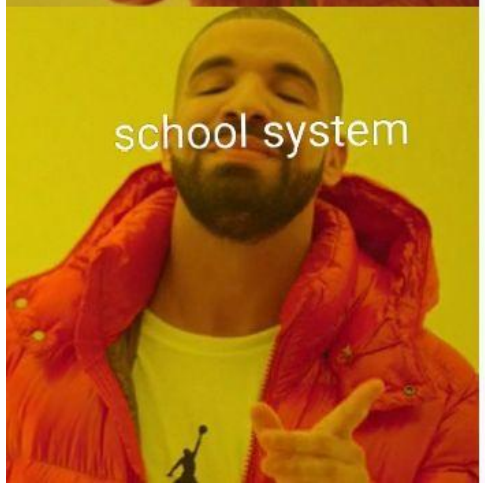

how to pay taxes

how to defend yourself in court

how to get a drivers licence

how to get legaly married

how to get a job




Mitochondria is the Powerhouse of the Cell

# MITOCHONDRIA

When someone asks “what’s the most important thing you remember from school?”

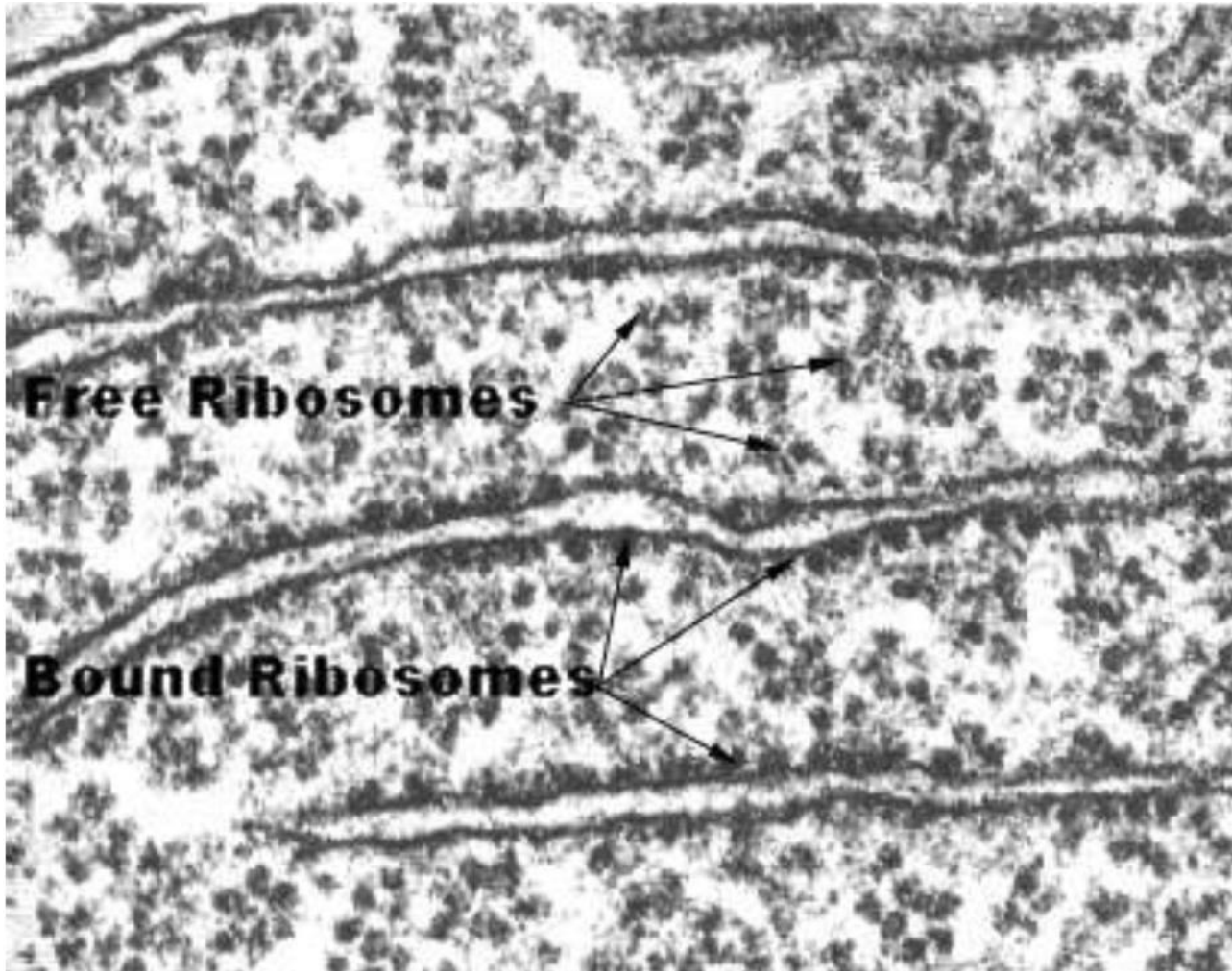
# MITOCHONDRIA (A POEM)

# MITOCHONDRION (PL.MITOCHONDRIA)


- surrounded by double membrane
- smooth outer membrane &  folded inner membrane
- folds are called cristae
- fluid inside is called matrix
- shape varies
- ATP production by aerobic respiration
- fat is digested here if being used as an energy source in cell

# FREE RIBOSOMES

- appear as dark granules in cytoplasm
- 80s
- not surrounded by membrane
- cunstructed in nucleolus
- Synthesizes proteins to work in cytoplasm, for use within the cell, e.g. enzymes



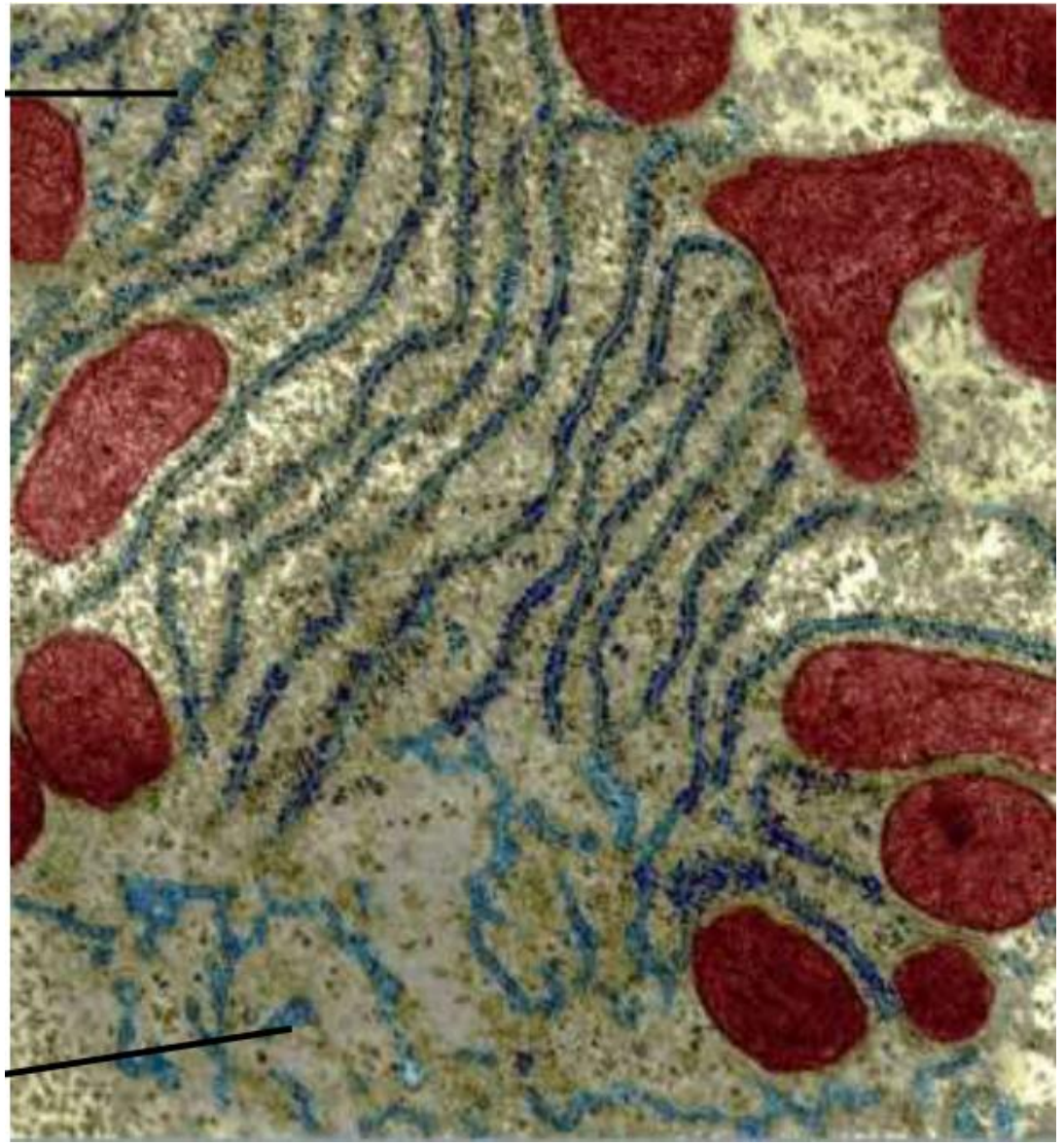
# ROUGH ENDOPLASMIC RETICULUM

- consists of flattened membrane sacs (=cisternae)

- often located near nucleus

- 80s ribosomes attached to outside of cisternae

- rER synthesizes proteins → transported to the golgi apparatus (via vesicles) for modification → then secreted outside the cell

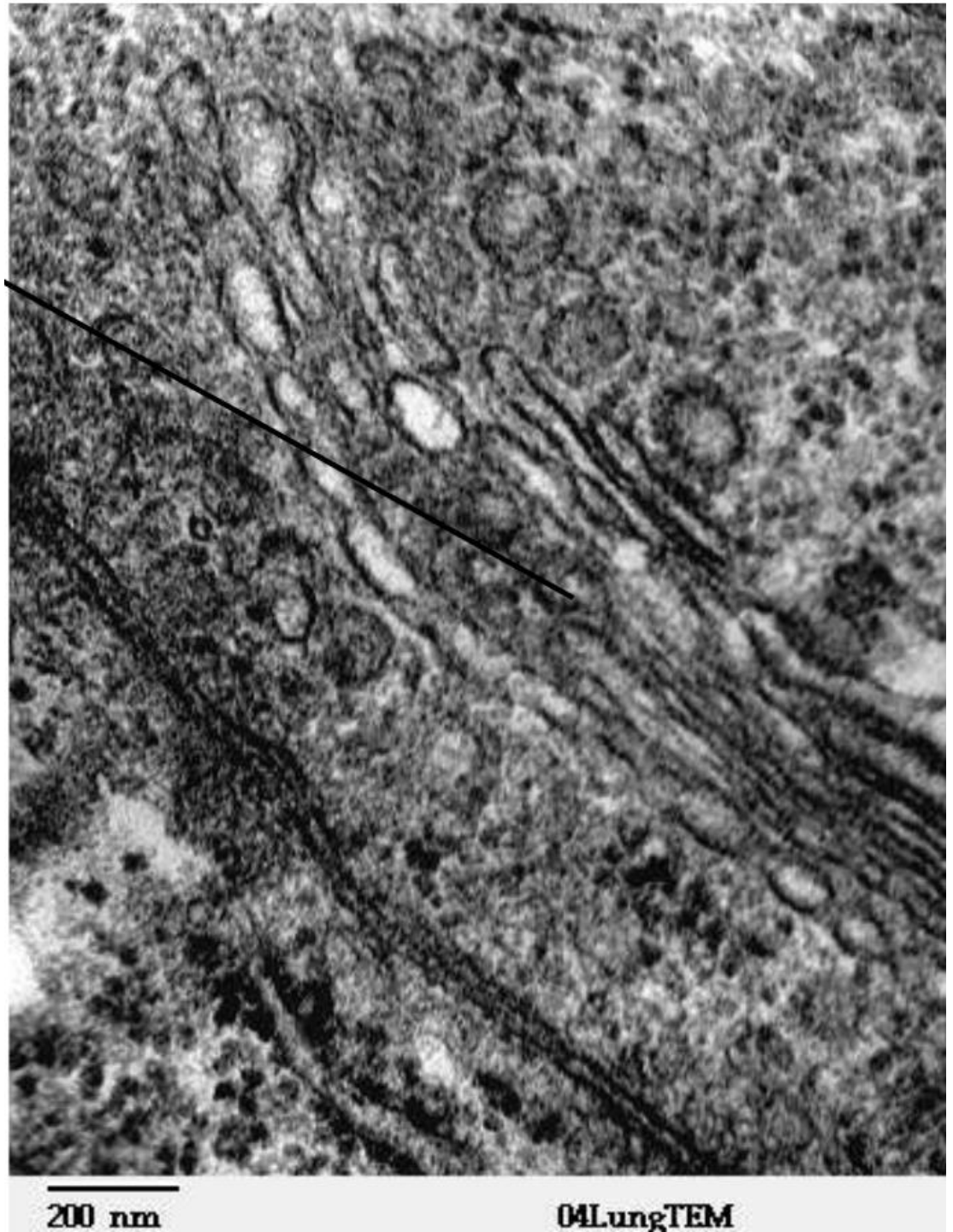


# THE GOLGI APPARATUS

- also consists of cisternae

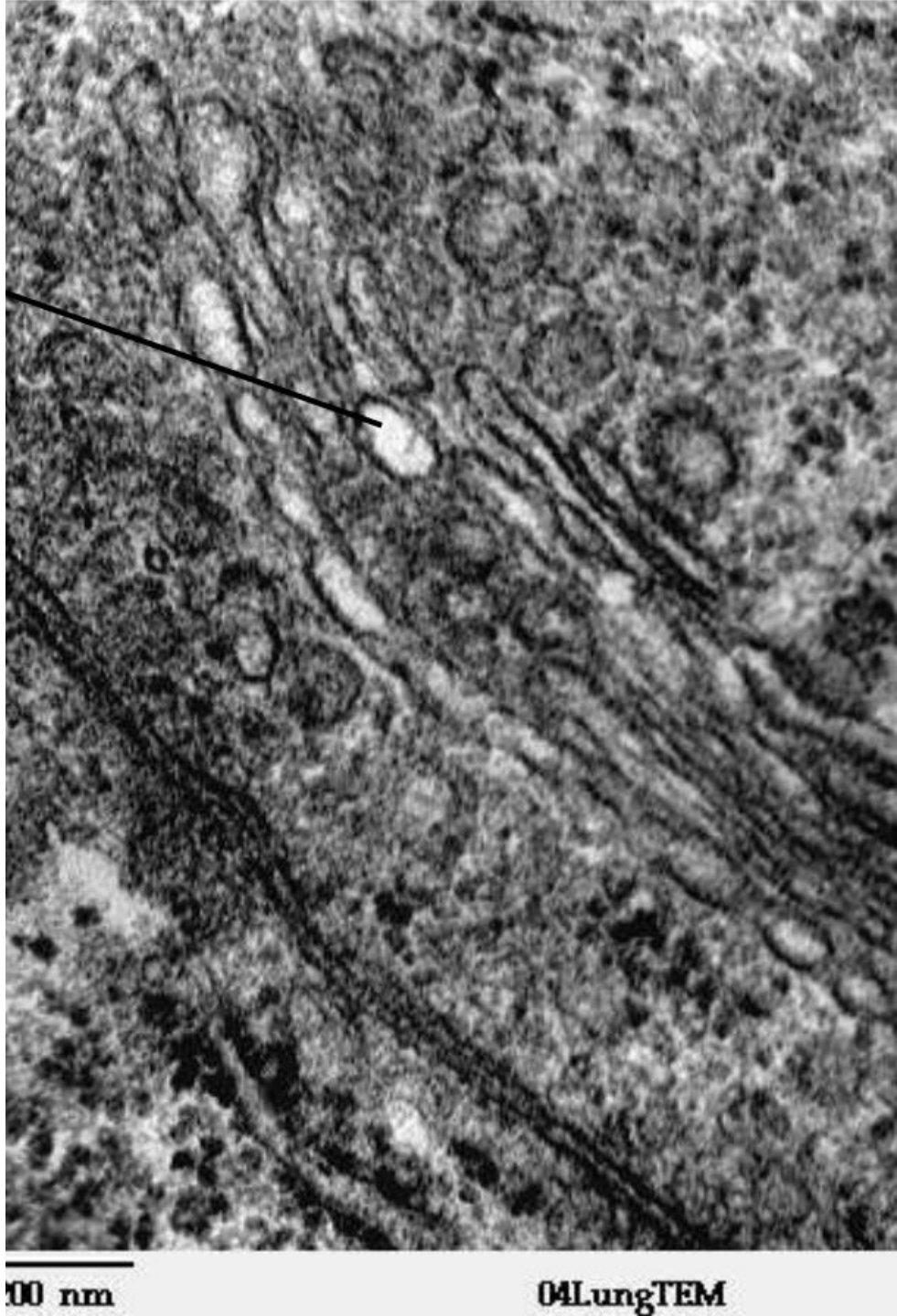
- different to rER:
  - no attached ribosomes
  - often close to the plasma membrane
  - cisternae shorter and more curved

- processes (modifies) proteins from from the rER
- → repackaged in vesicles for secretion outside the cell.



# VESICLES

- single membrane with fluid inside
- Very small in size
- Used to transport materials inside of a cell



# LYSOSOMES

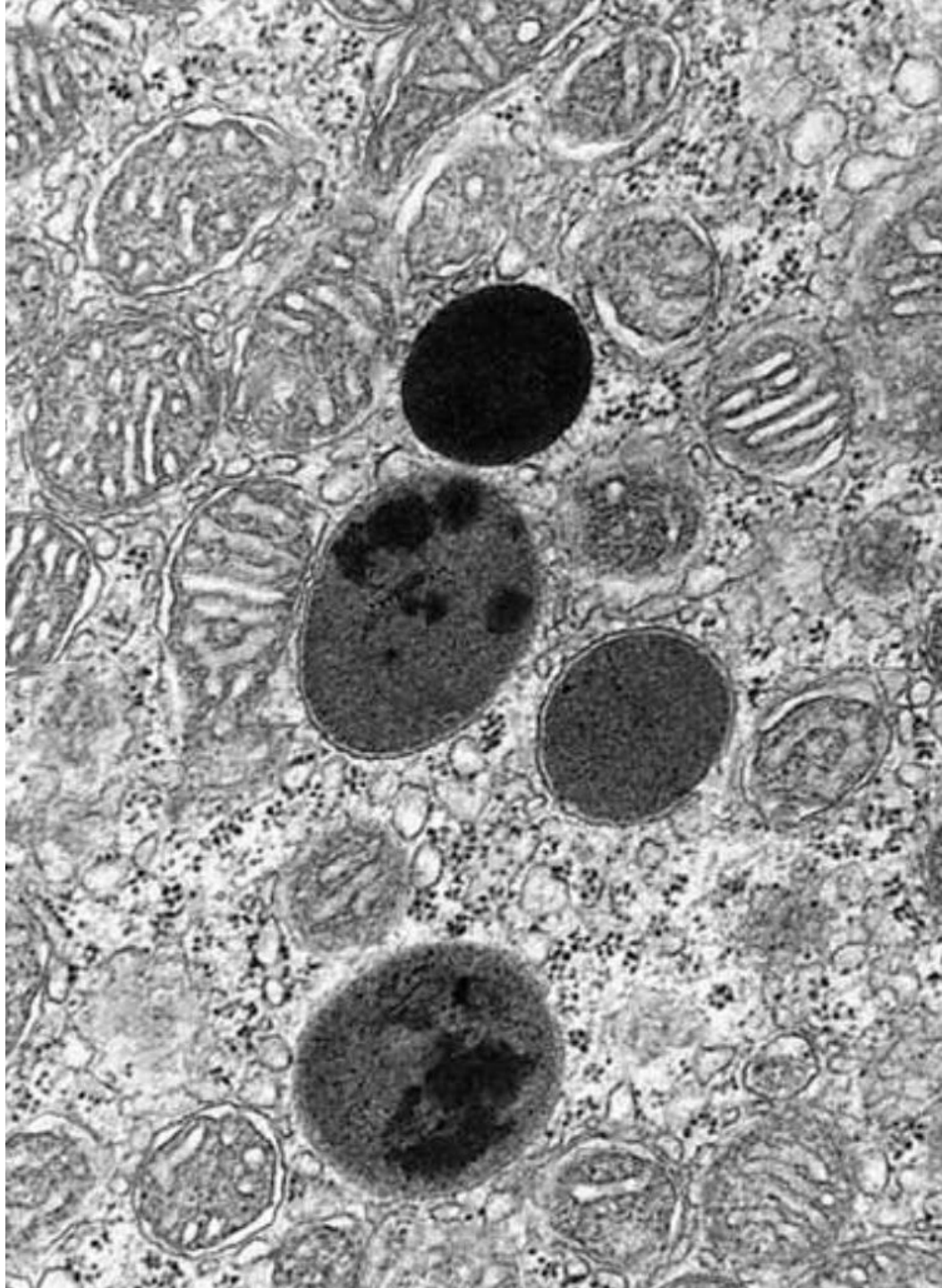
- usually in animal cells

- single membrane

- formed from Golgi vesicles

- digestive enzymes for breakdown of
  - ingested food in vesicles
  - unwanted/damaged organelles
  - the cell itself

- high concentration of enzymes → dark on mikrographs



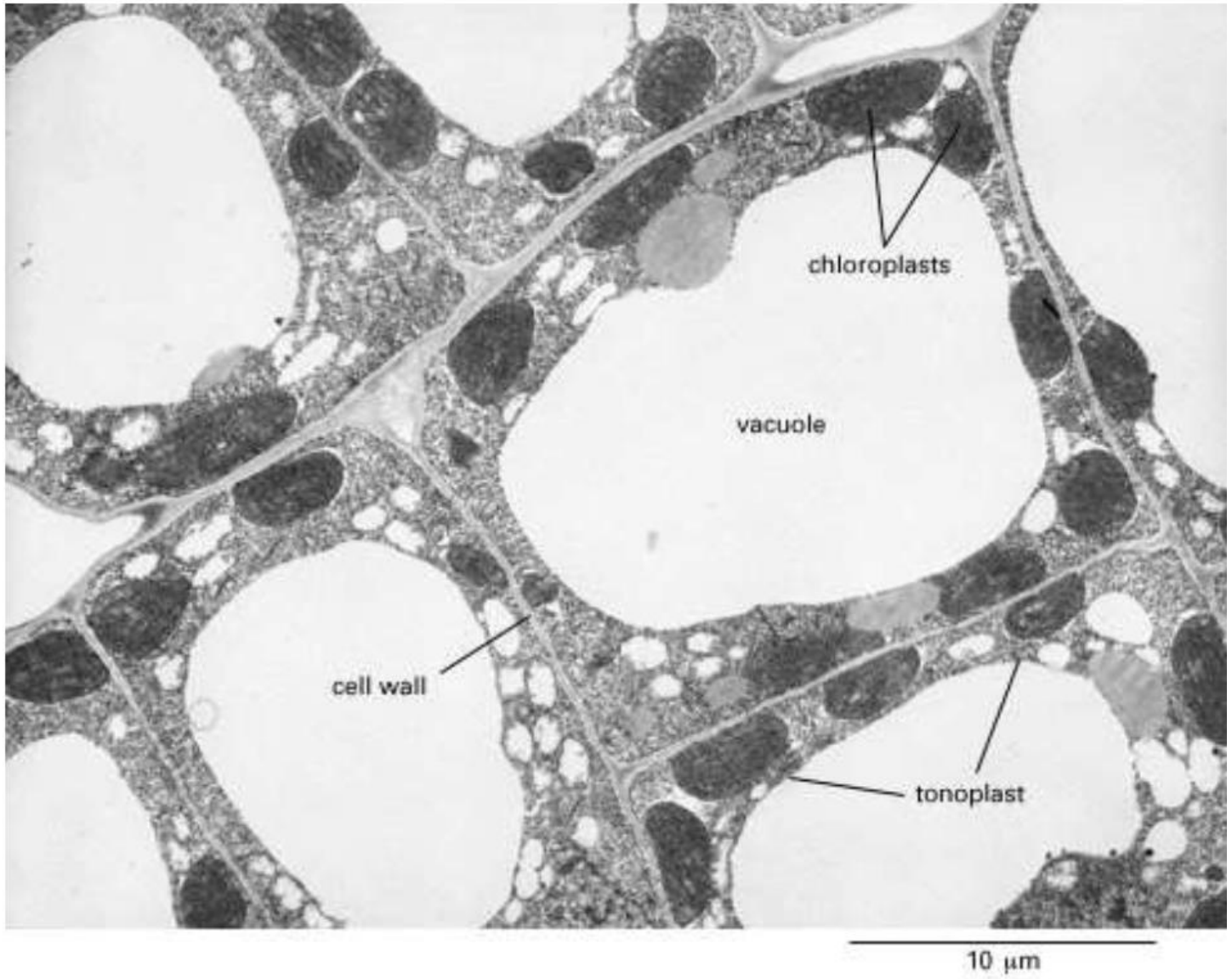
# VACUOLES

- single cell membrane with fluid inside

- maintains hydrostatic pressure

- plant cells: large and permanent

- animal cells:
  - only sometimes
  - smaller
  - temporary
  - various reasons (e.g. food digestion)



# CILIA AND FLAGELLA (ANIMALS ONLY)

- whip-like structures projecting from cell surface
- contain microtubules
- flagella larger and usually only one  (e.g. sperm)
- cilia smaller and many present
- movement or to create a current in a fluid

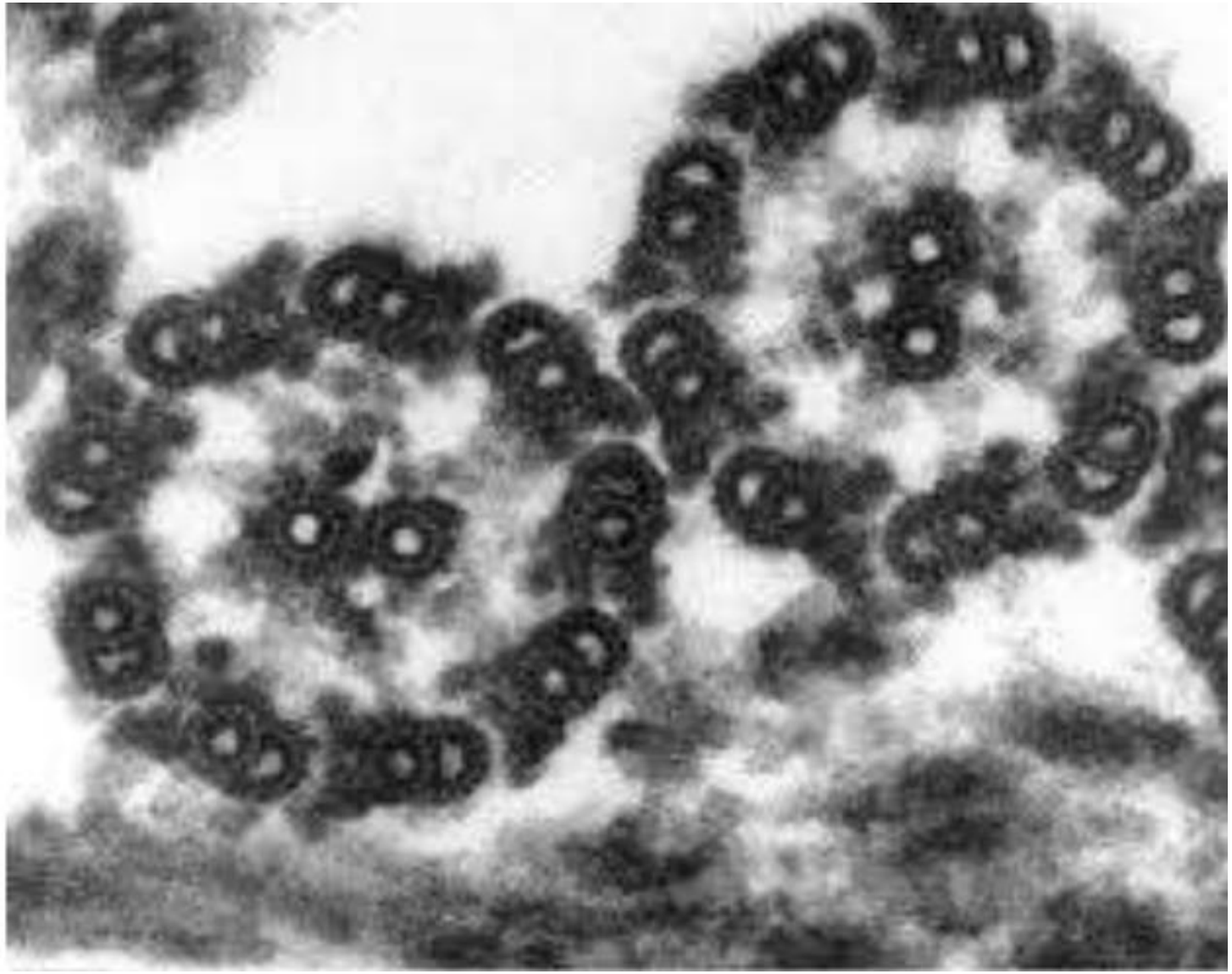
# MICROTUBULES AND CENTRIOLES

Microtubules

- small cylindrical fibres called microtubules
- have a variety of functions, e.g. part of the structure of flagella or cell devision

Centrioles

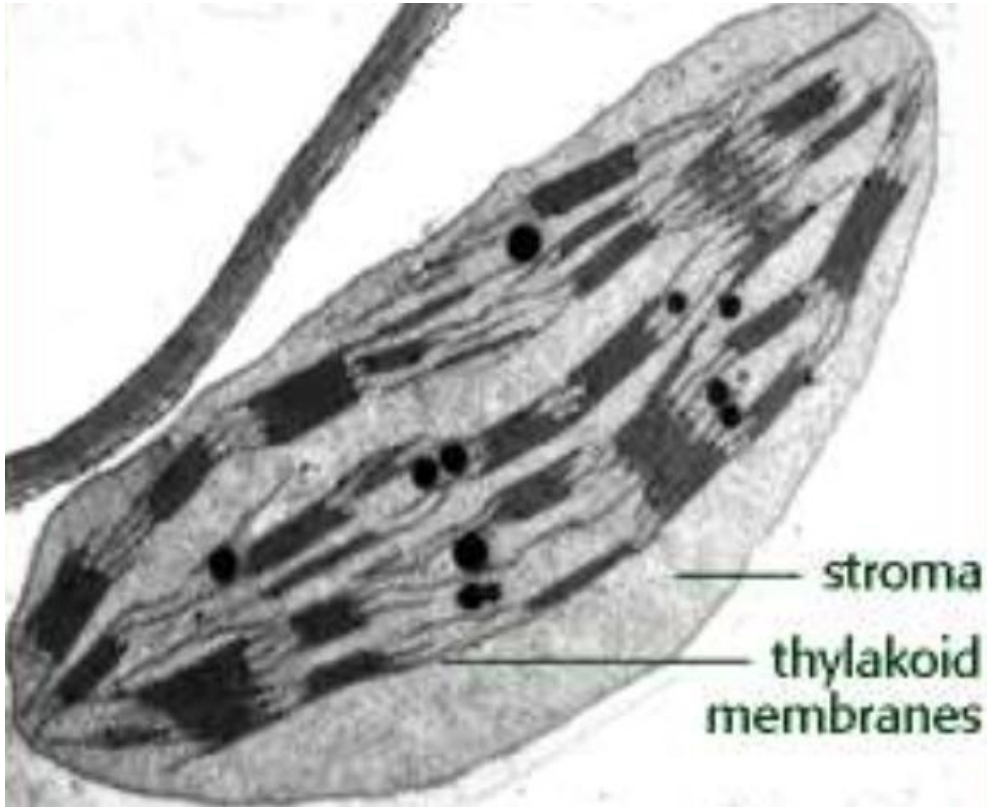
- anchor point for microtubules



Mr. Prantner: "ThE mItOcHoNdRiA iS tHe pOwErHoUsE oF tHe cElL."
Chloroplasts:

# CHLOROPLASTS (PLANTS ONLY)

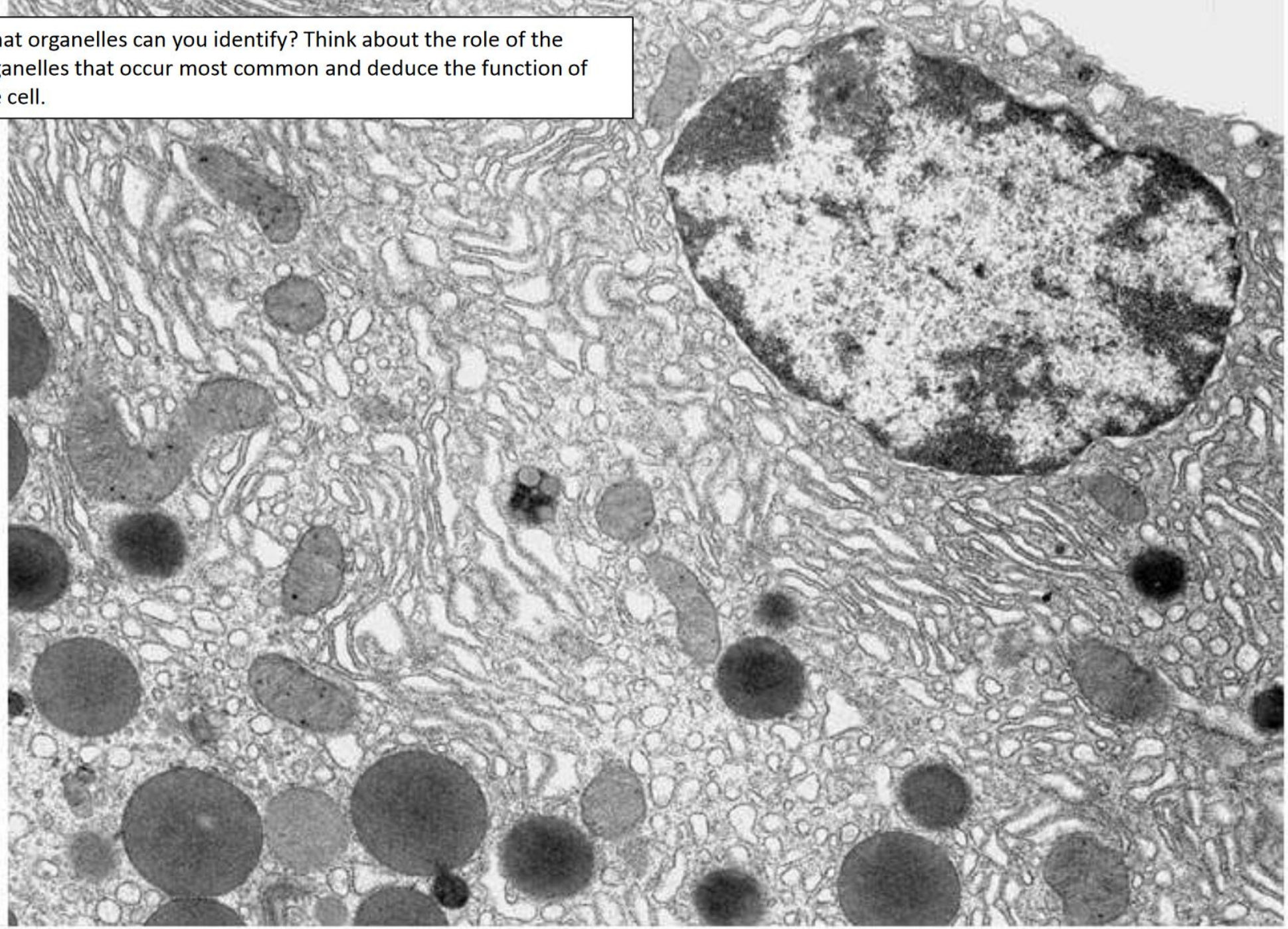
- **Many, but not all, plant cells** contain chloroplasts
- double membrane
- Inside are stacks of thylakoids
- thylakoid = disc of flattened membrane
- shape = variable (usually ovoid)
- glucose is produced via photosynthesis
- Starch grains maybe present if photosynthesis is happening quickly



# CELL WALL (PLANTS ONLY)

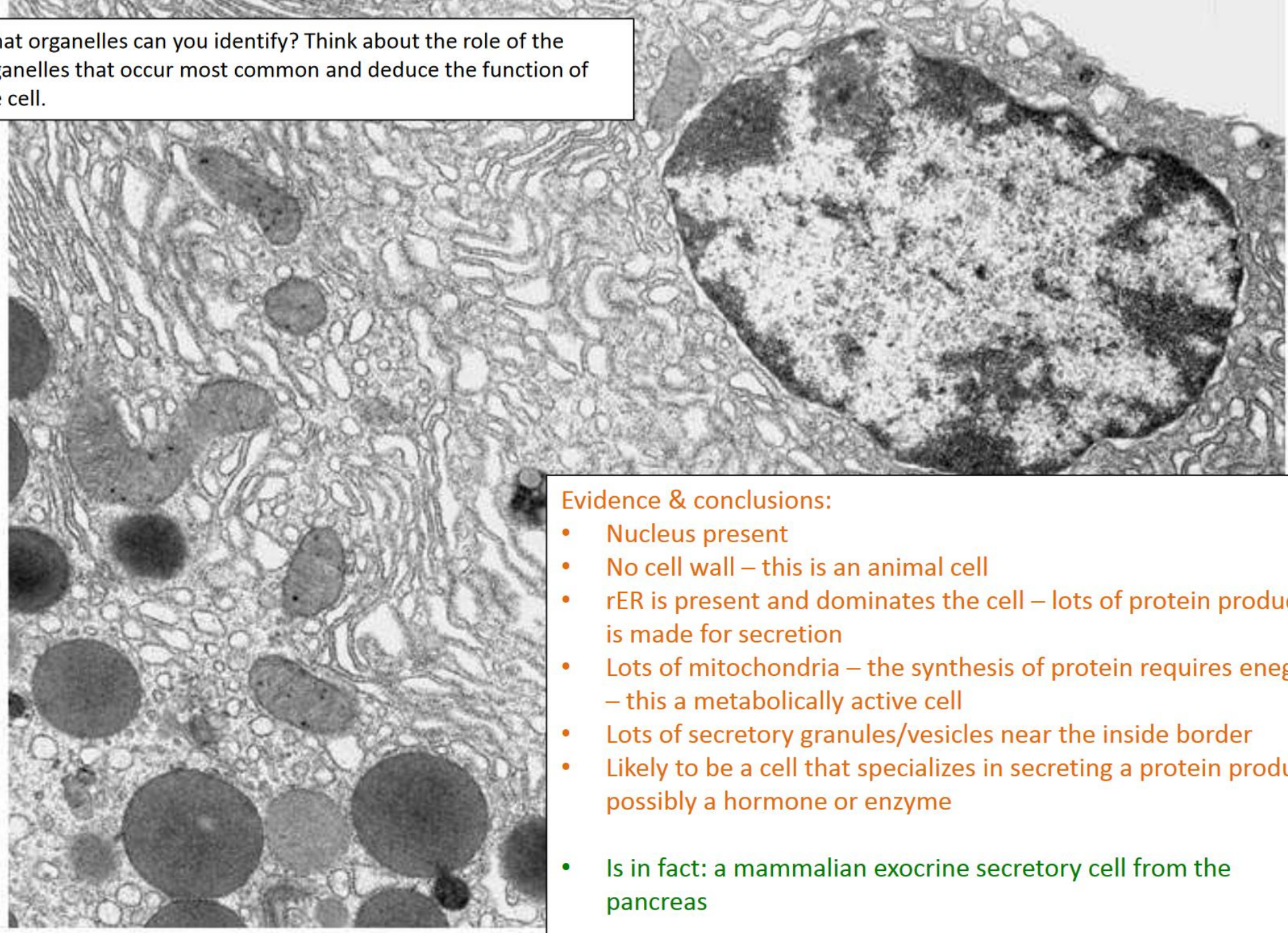
- extracellular component, not an organelle
- all plant cells, fungi and some protists
- consists mainly of cellulose
  - permeable (does not affect transport)
  - strong (gives support)
  - hard to digest (resistant to being broken down)

What organelles can you identify? Think about the role of the organelles that occur most common and deduce the function of the cell.



Courtesy of T. Howard, Cold Spring Harbor. Noncommercial, educational use only.

What organelles can you identify? Think about the role of the organelles that occur most common and deduce the function of the cell.



Courtesy of T. Howard, Cold Sp

Evidence & conclusions:

- Nucleus present
- No cell wall – this is an animal cell
- rER is present and dominates the cell – lots of protein product is made for secretion
- Lots of mitochondria – the synthesis of protein requires enegy – this a metabolically active cell
- Lots of secretory granules/vesicles near the inside border
- Likely to be a cell that specializes in secreting a protein product, possibly a hormone or enzyme

- Is in fact: a mammalian exocrine secretory cell from the pancreas