

In the name of the most high

Introduction to Bioinformatics

Structure of Cells

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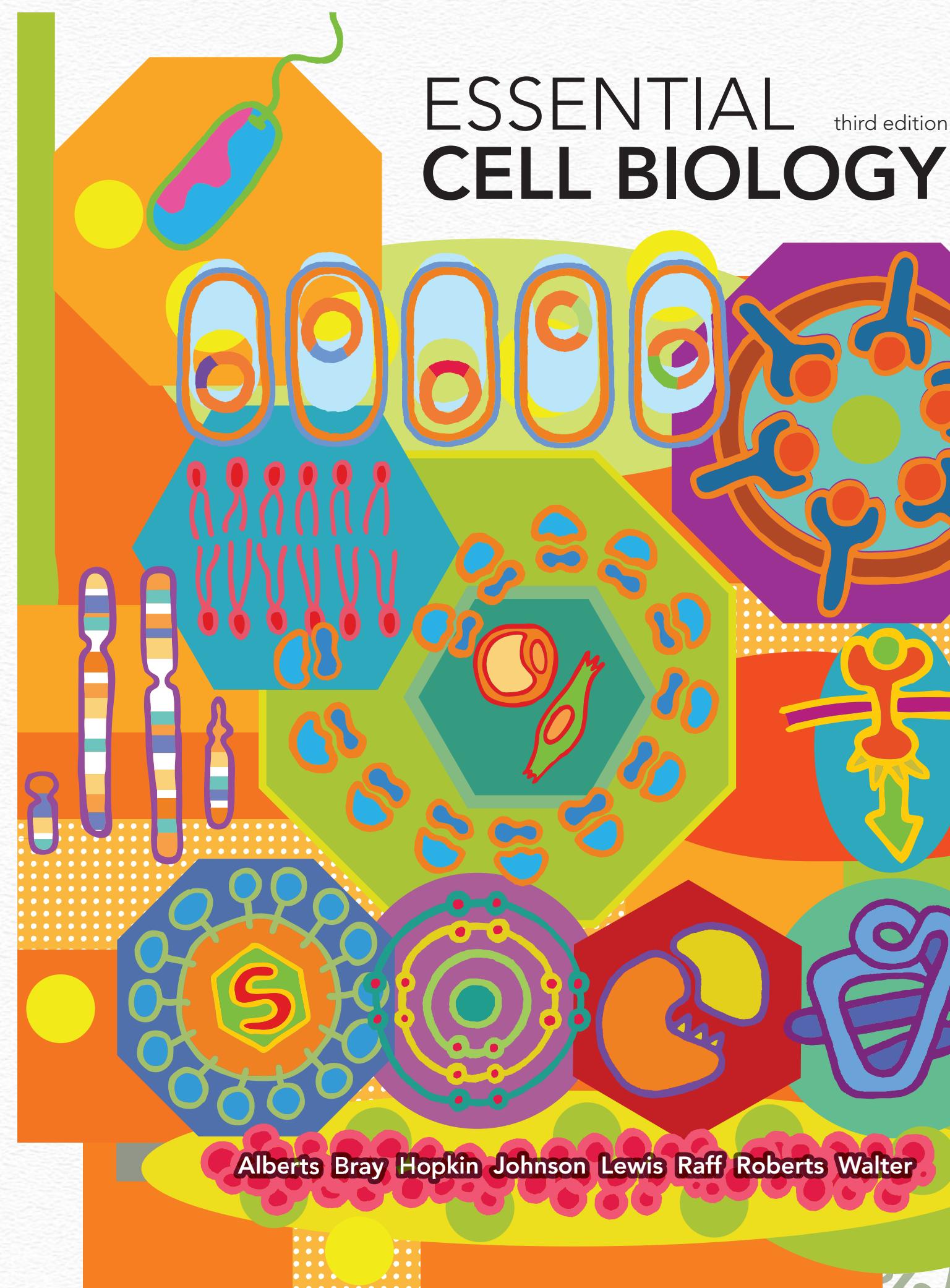
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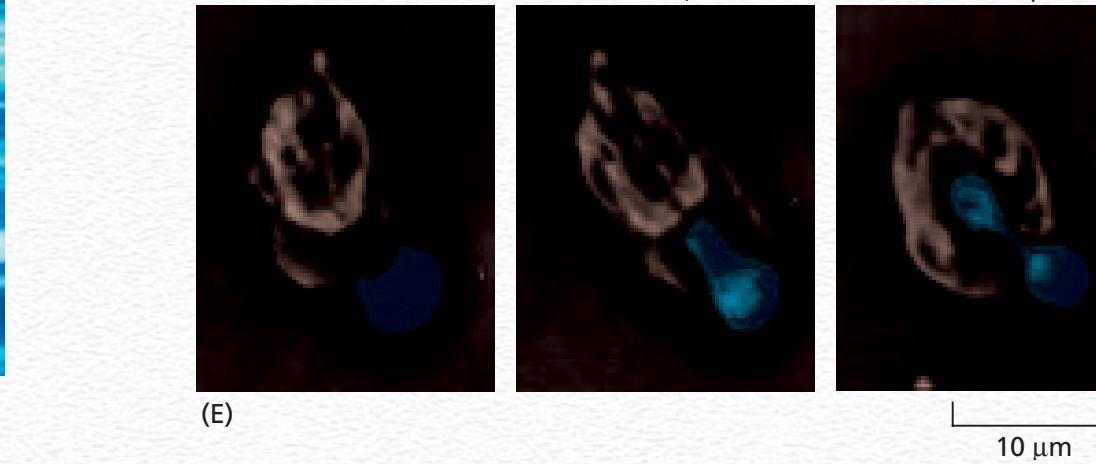
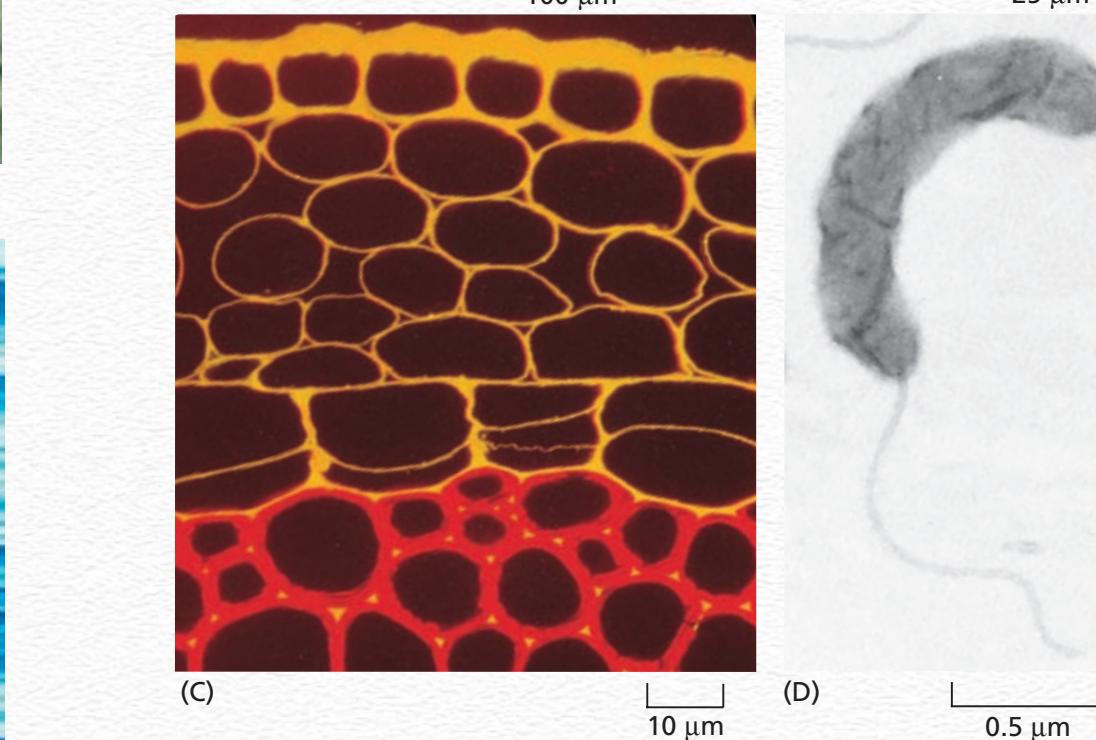
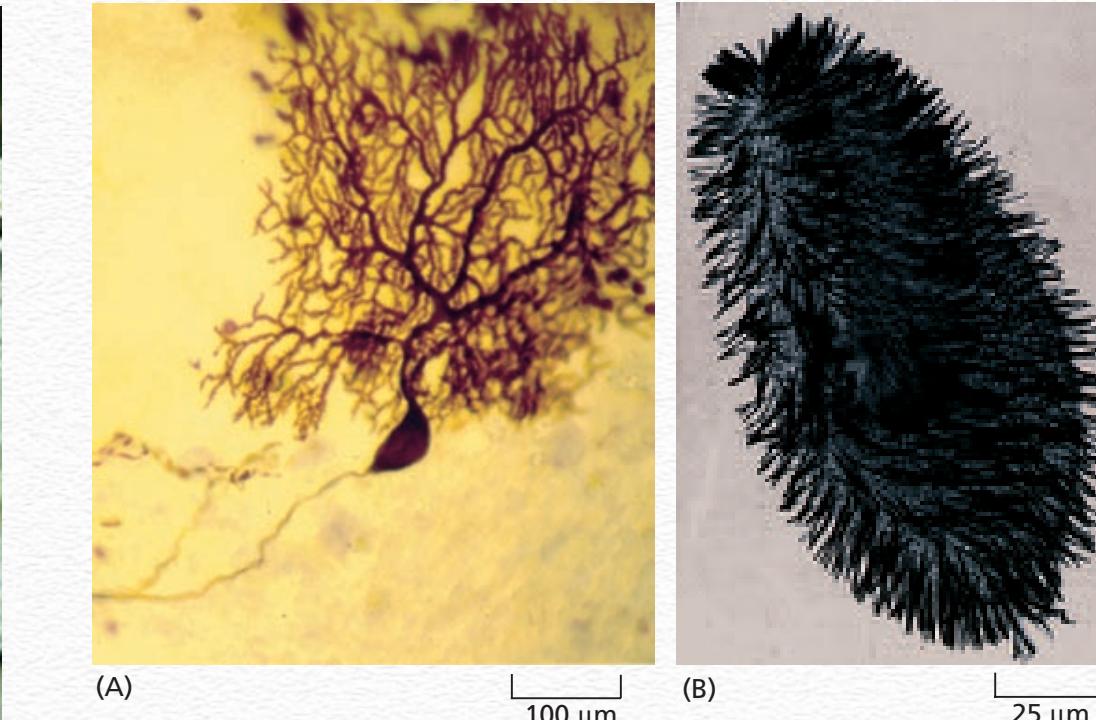
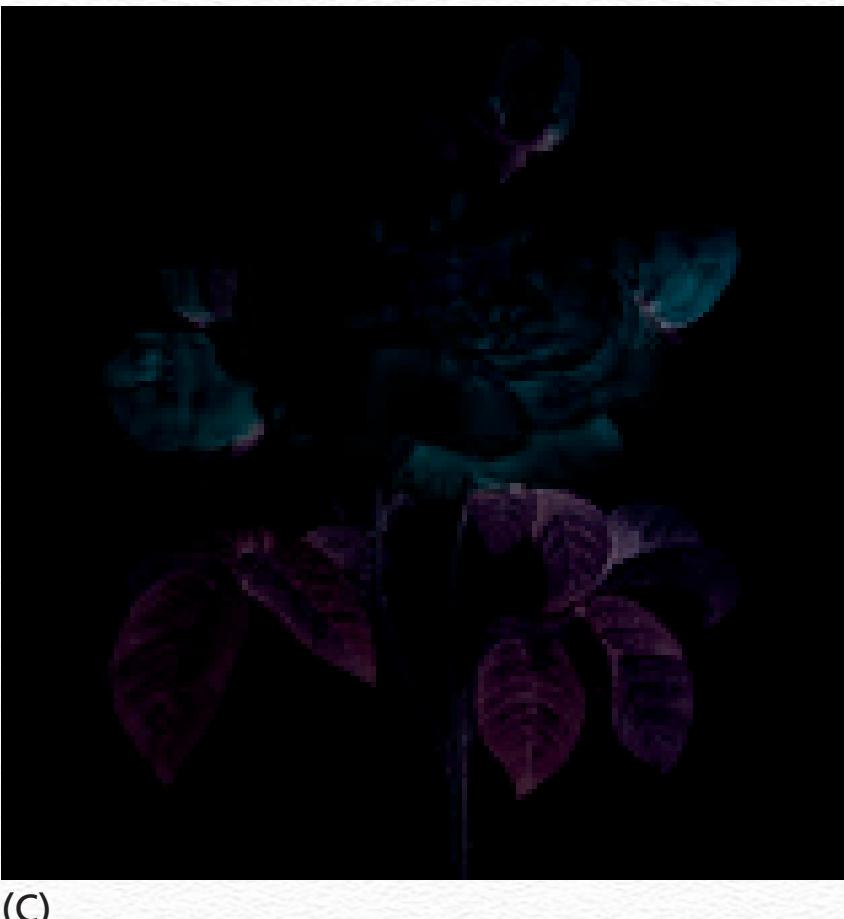
Cells

The Inner Life of the Cell

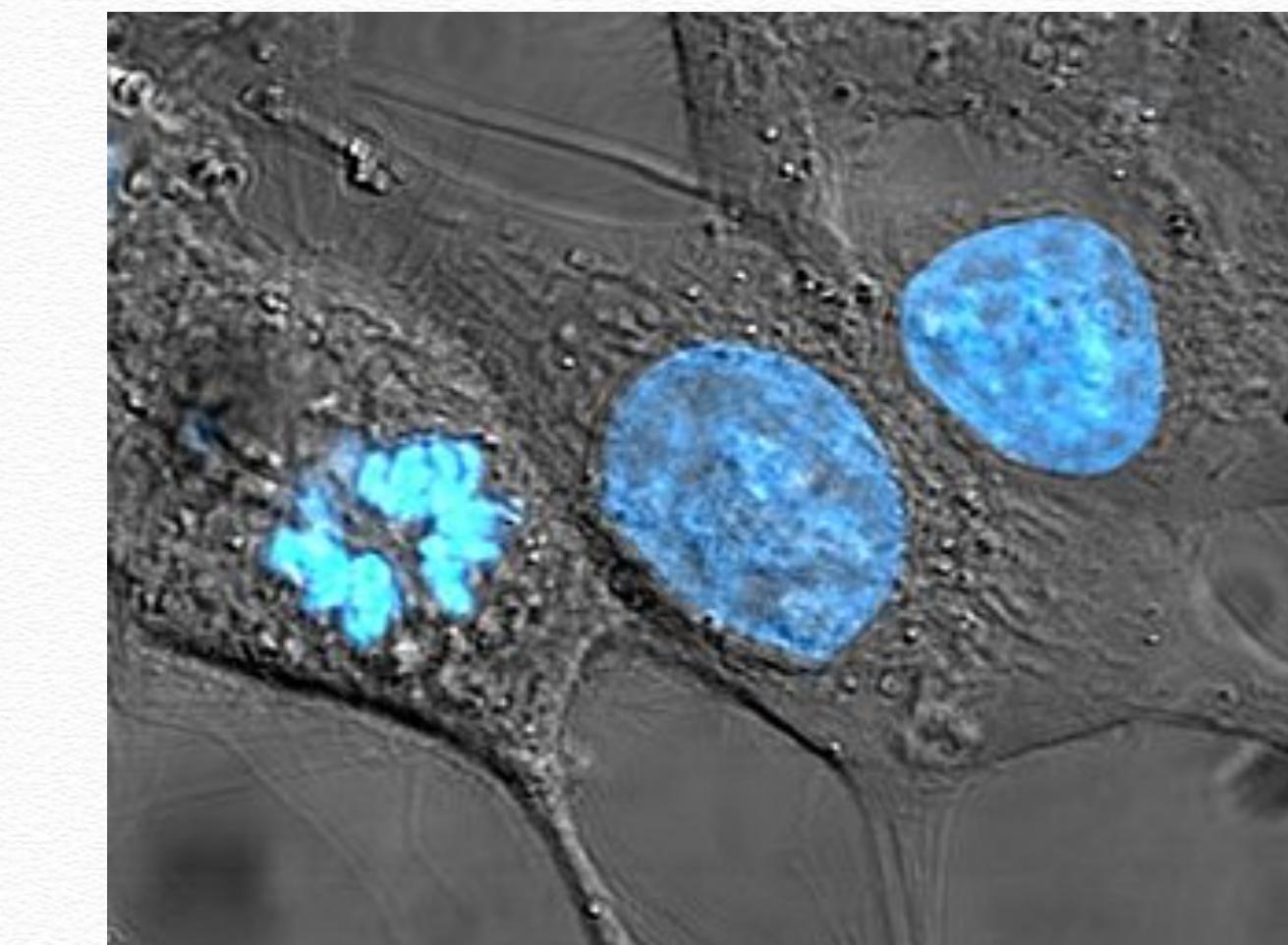
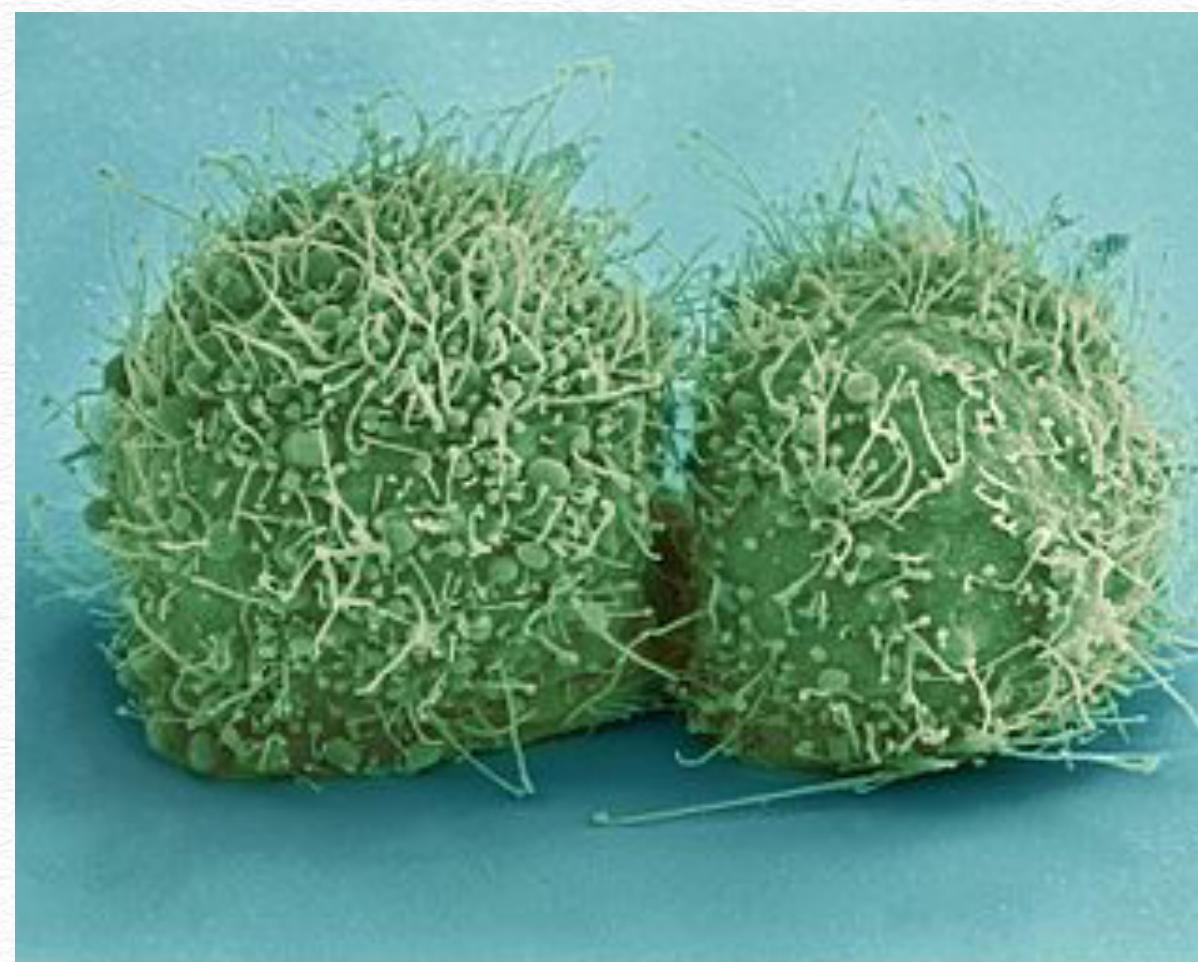
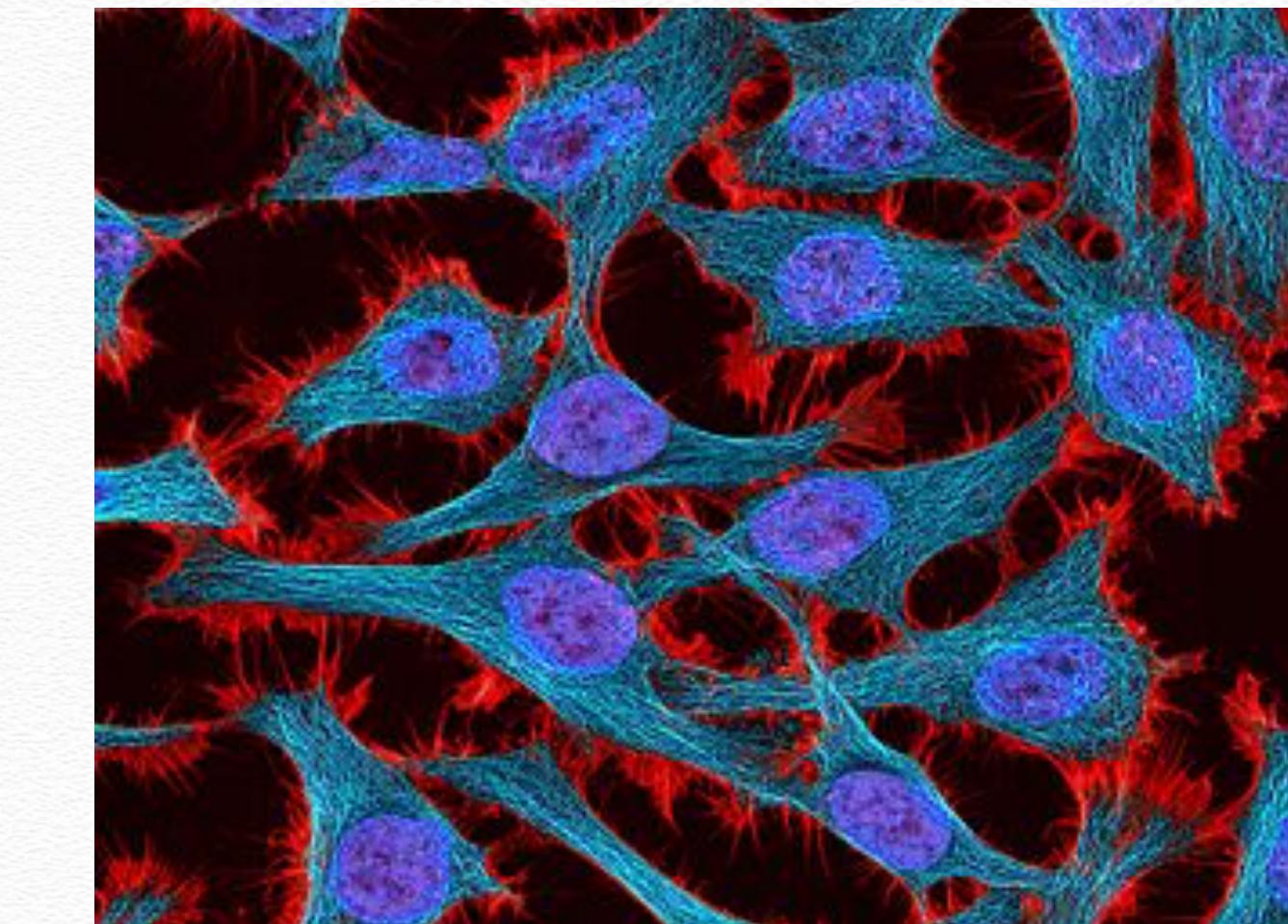
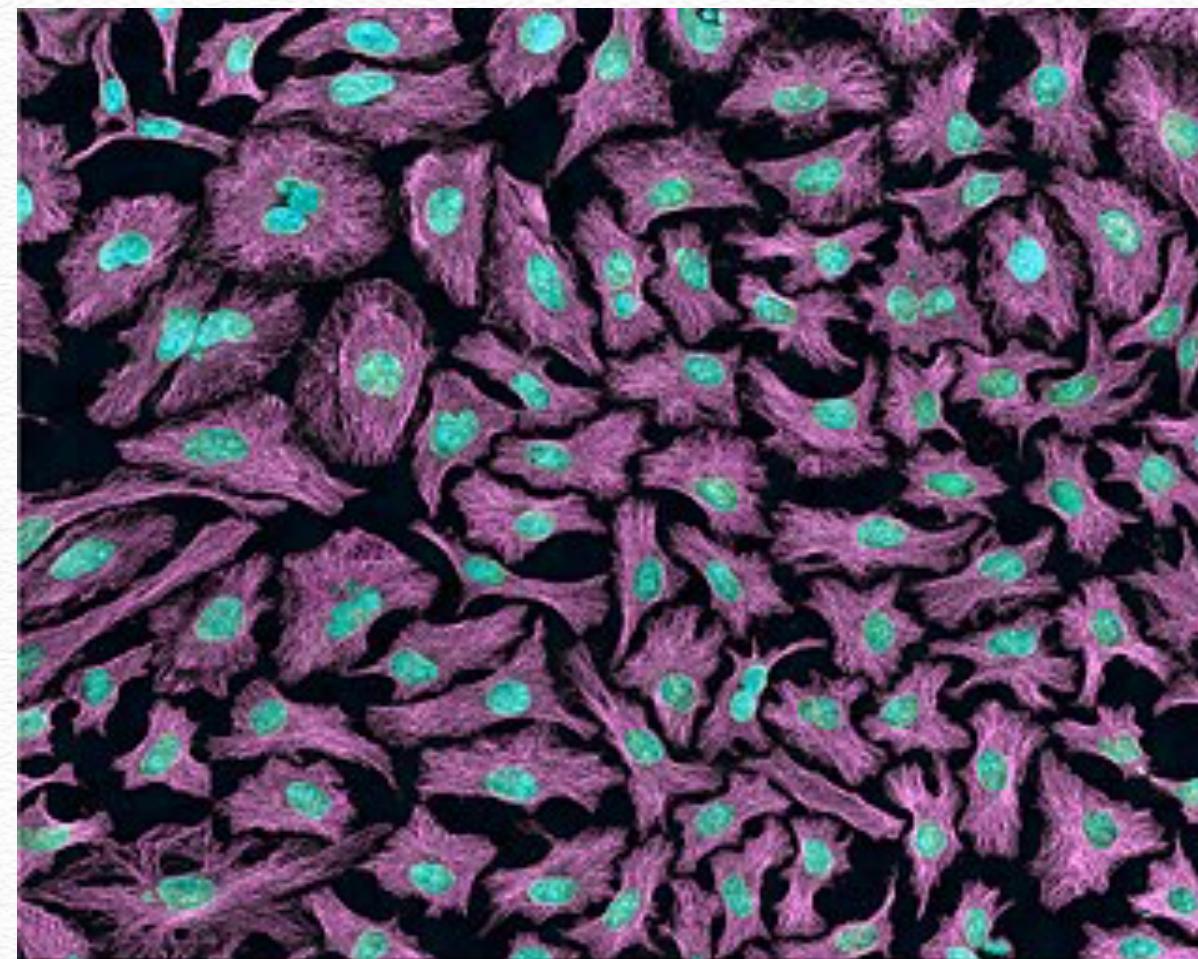
Syllabus



Cells



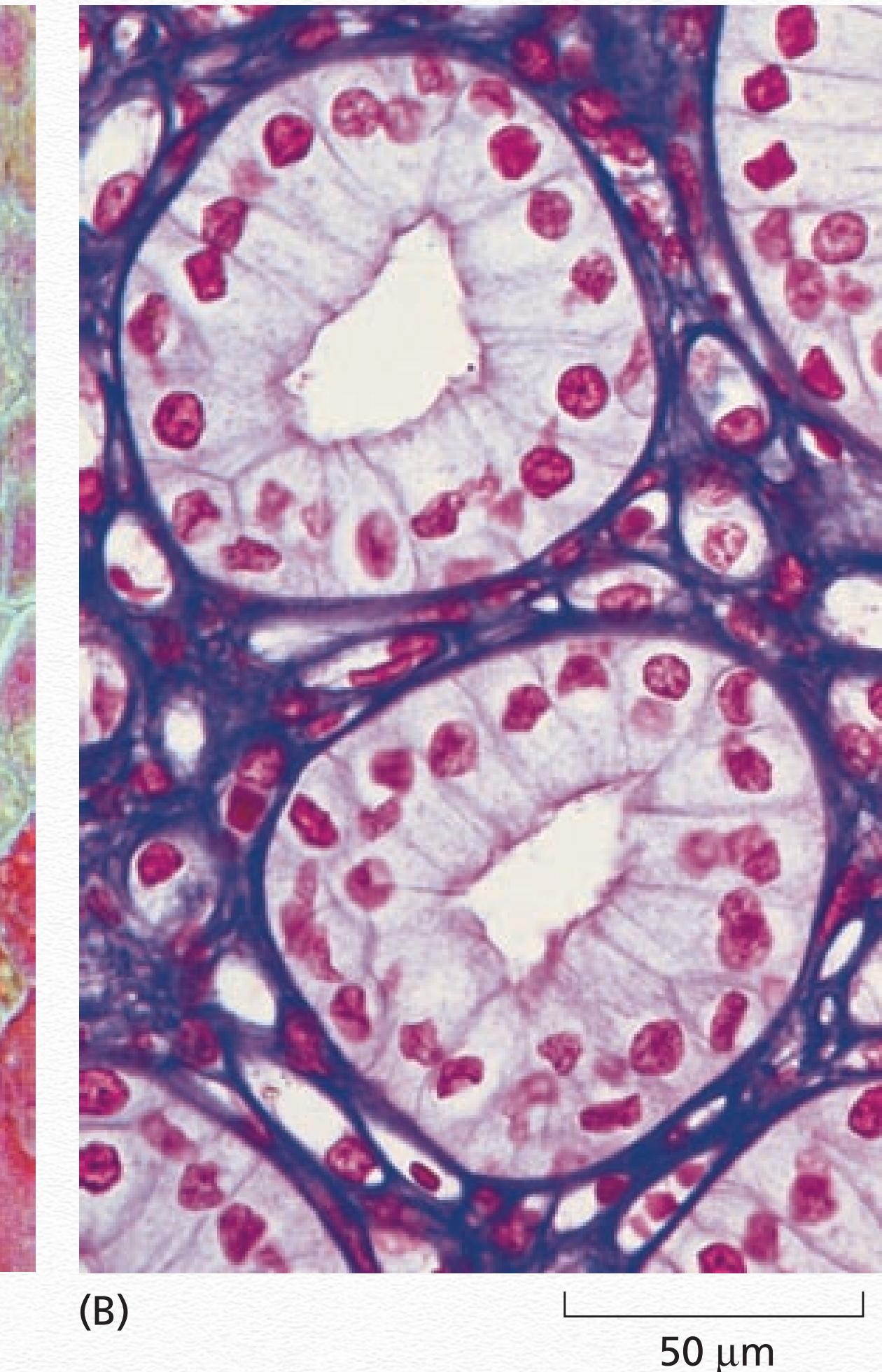
HeLa Cells



Cells in Embryos



Tissues



Life Kingdoms

Kingdoms of Life

❖ Prokaryotes

- Bacteria

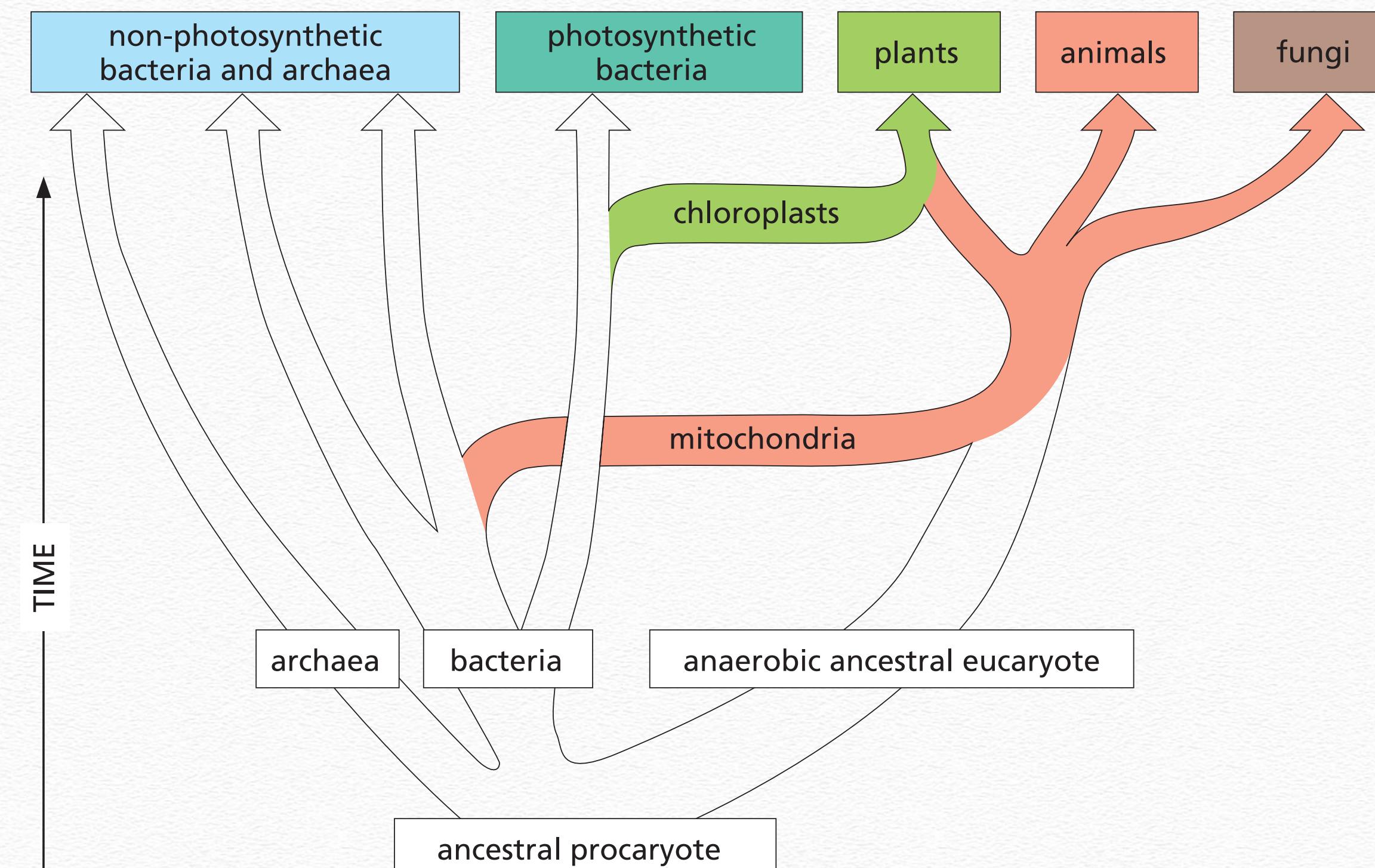
- Archaea

❖ Eucaryotes

- Animals

- Plants

- Fungi



Prokaryotes

- ❖ Mostly, **single**-celled organisms
- ❖ Some **join** together to form chains or clusters
- ❖ In shape and structure: **simple** and limited
- ❖ In **chemistry**: Most diverse and **inventive** class
- ❖ From hot puddles of **volcanic muds**, to interiors of other living cells

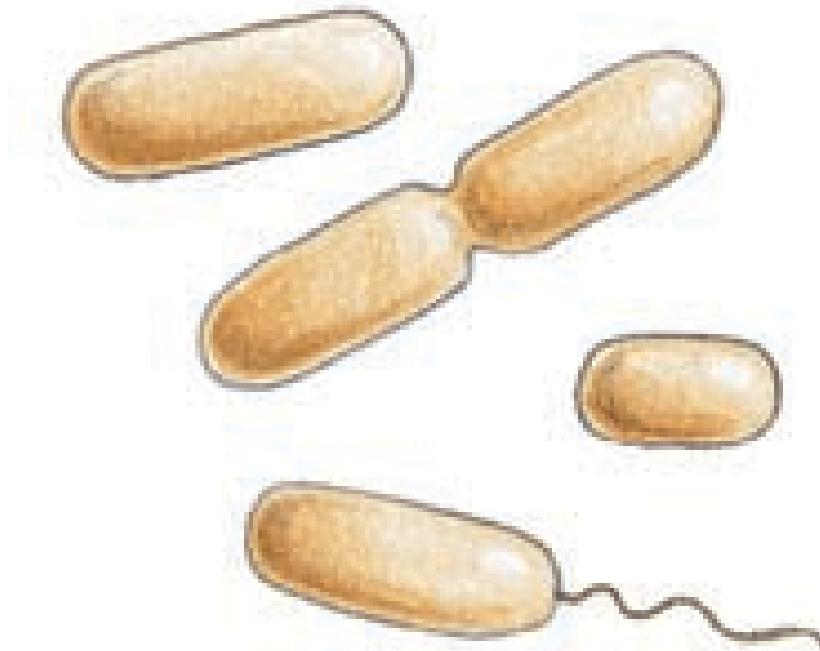
Prokaryotes

- ❖ Vastly **outnumber** other living organisms on Earth
- ❖ Some are **aerobic**, using oxygen to oxidize food molecules
- ❖ Some are strictly **anaerobic** and are **killed** by the slightest exposure to oxygen

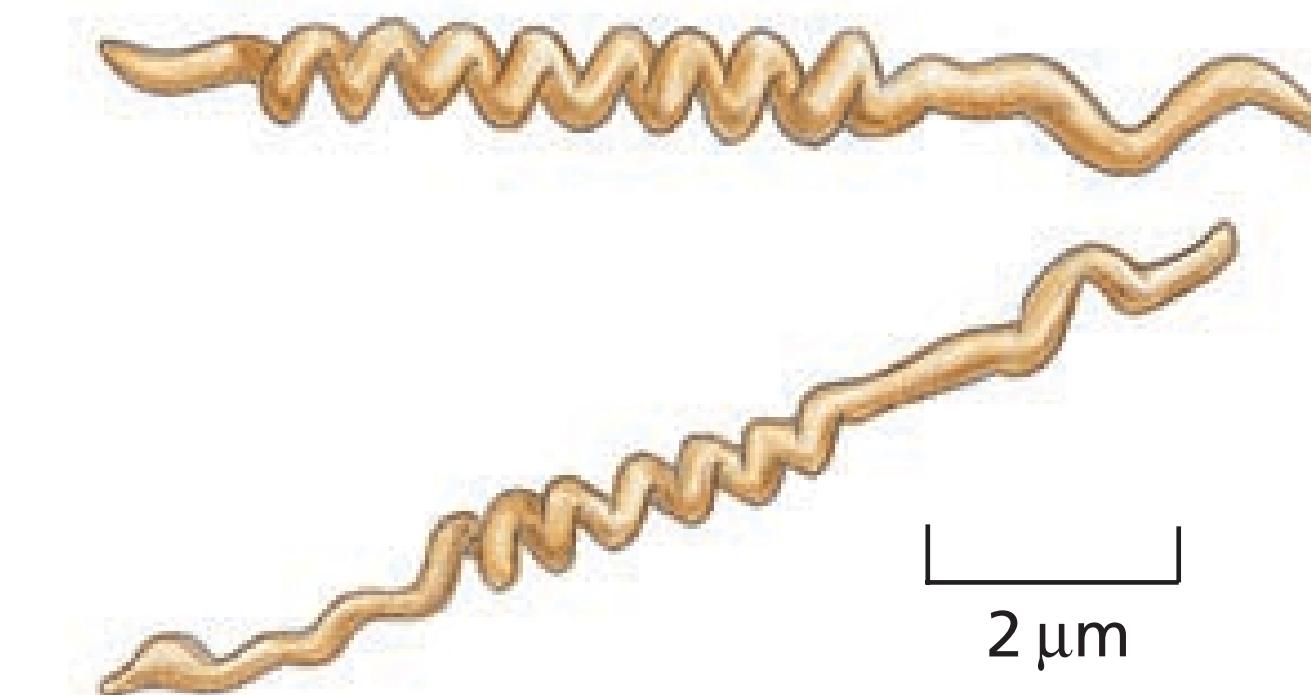
Shapes of Bacteria



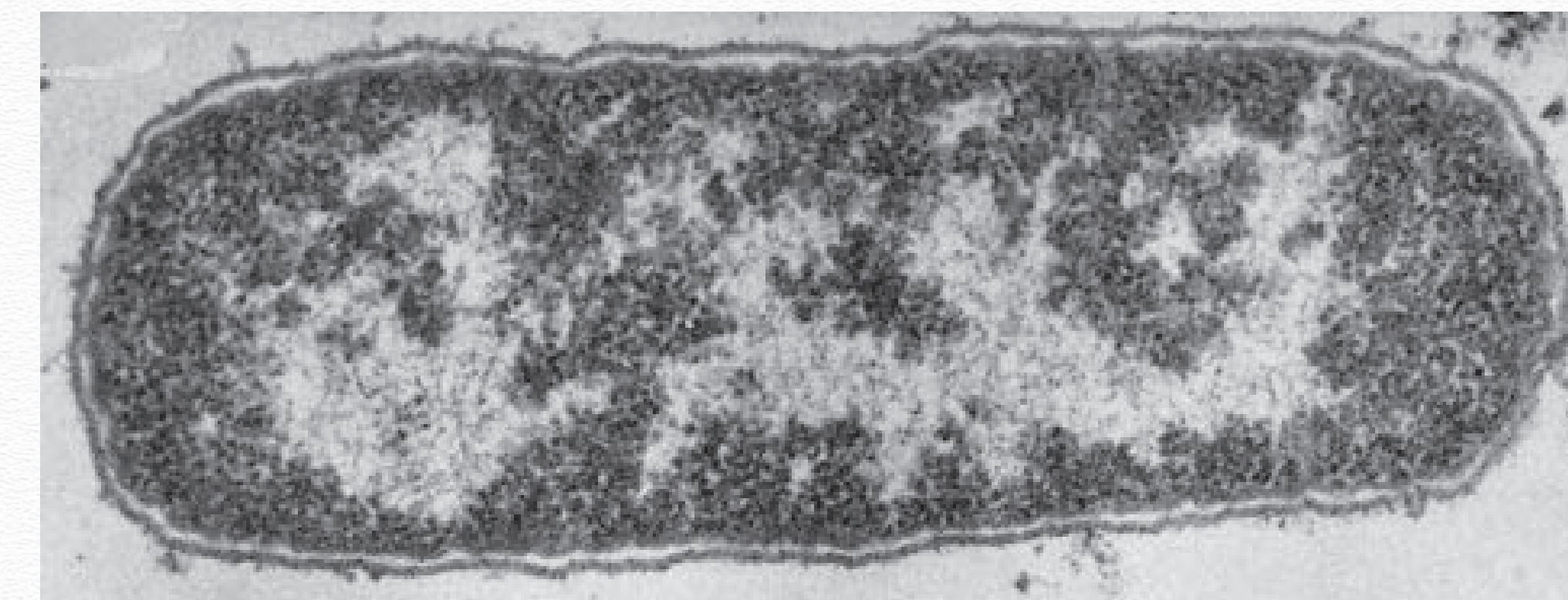
spherical cells,
e.g., *Streptococcus*



rod-shaped cells,
e.g., *Escherichia coli*,
Salmonella



spiral cells,
e.g., *Treponema pallidum*



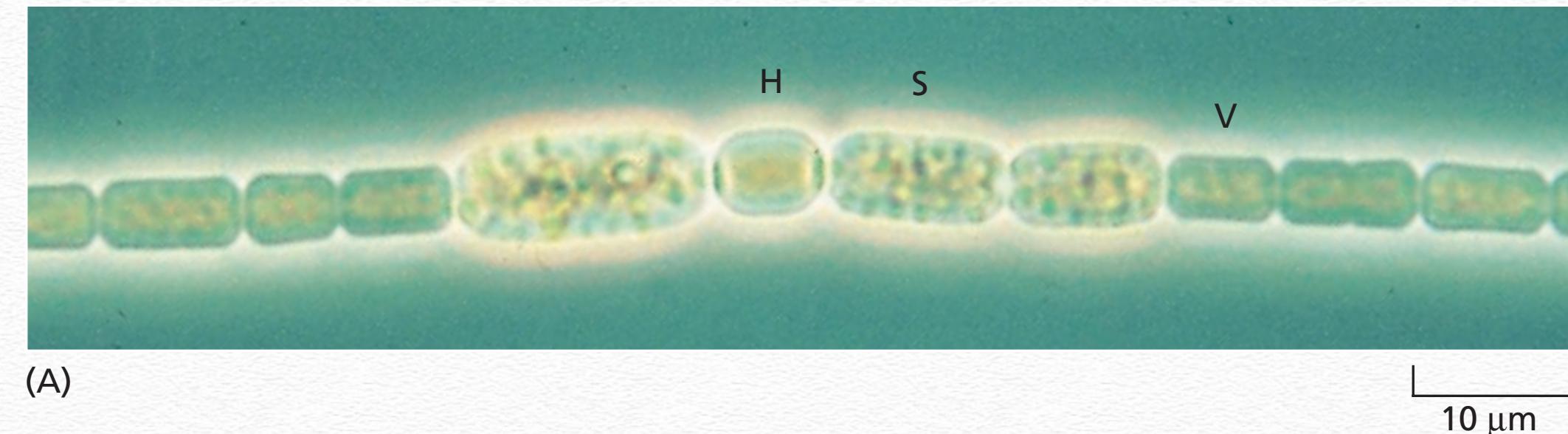
1 μm

Prokaryotic Metabolism

- ❖ Virtually **any organic material**, from wood to petroleum, can be used as food by one sort of bacterium or another
- ❖ Some prokaryotes can live entirely on **inorganic substances**: CO₂, N₂, O₂, H₂, S and P from air, water and inorganic material

Prokaryotic Sources of Energy

- ❖ Some do **photosynthesis**: getting energy from sunlight



Prokaryotic Sources of Energy

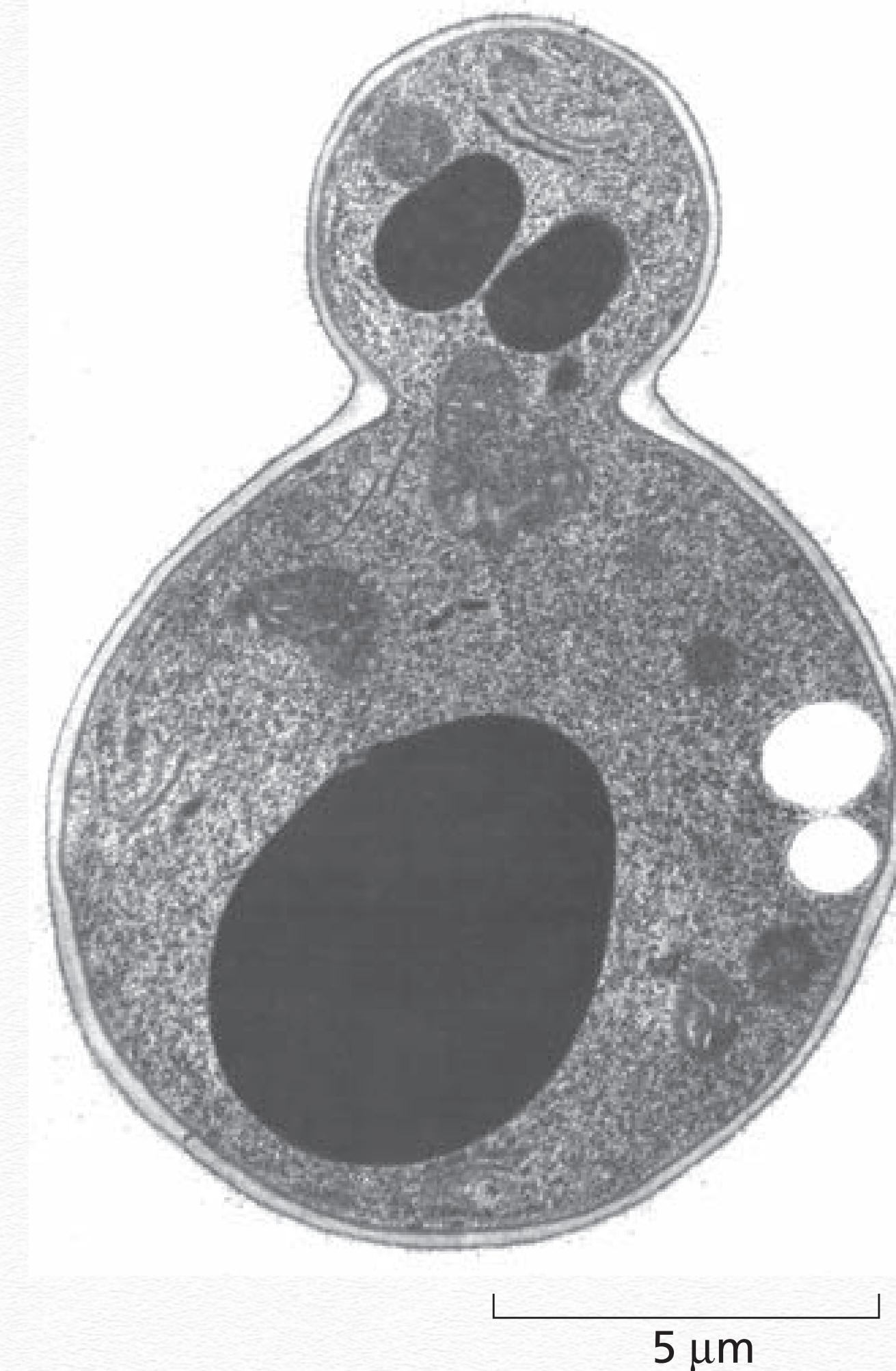
- ❖ Others derive energy from the **chemical reactivity** of inorganic substances in the environment



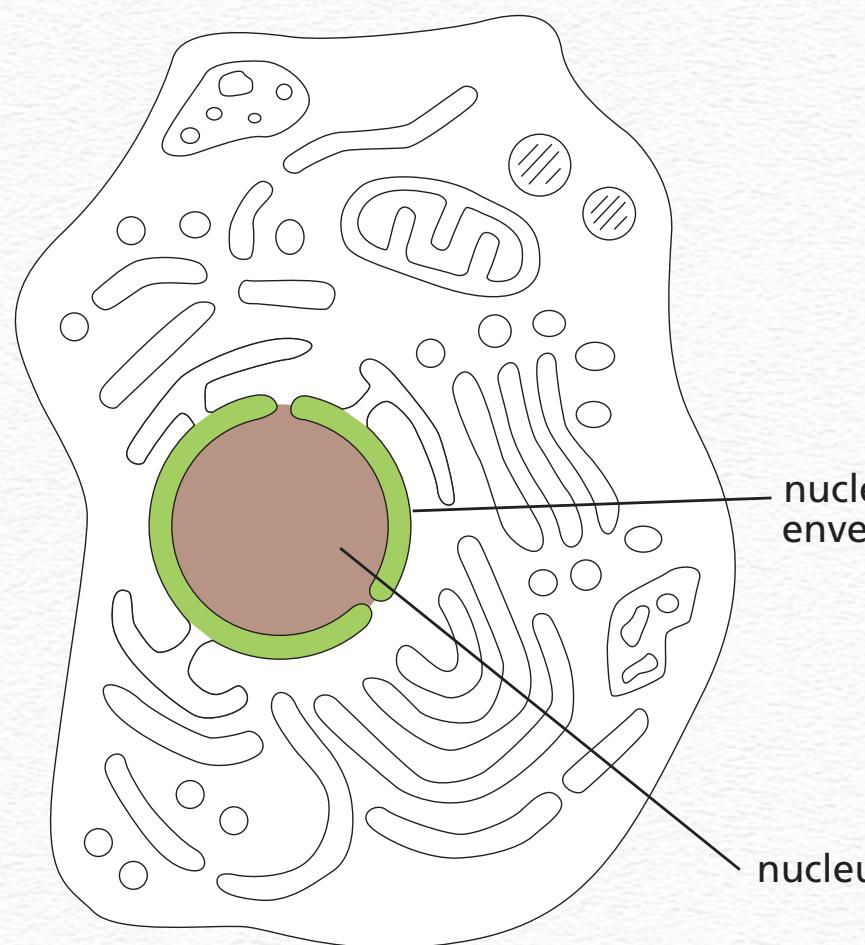
6 μm

Eucaryotes

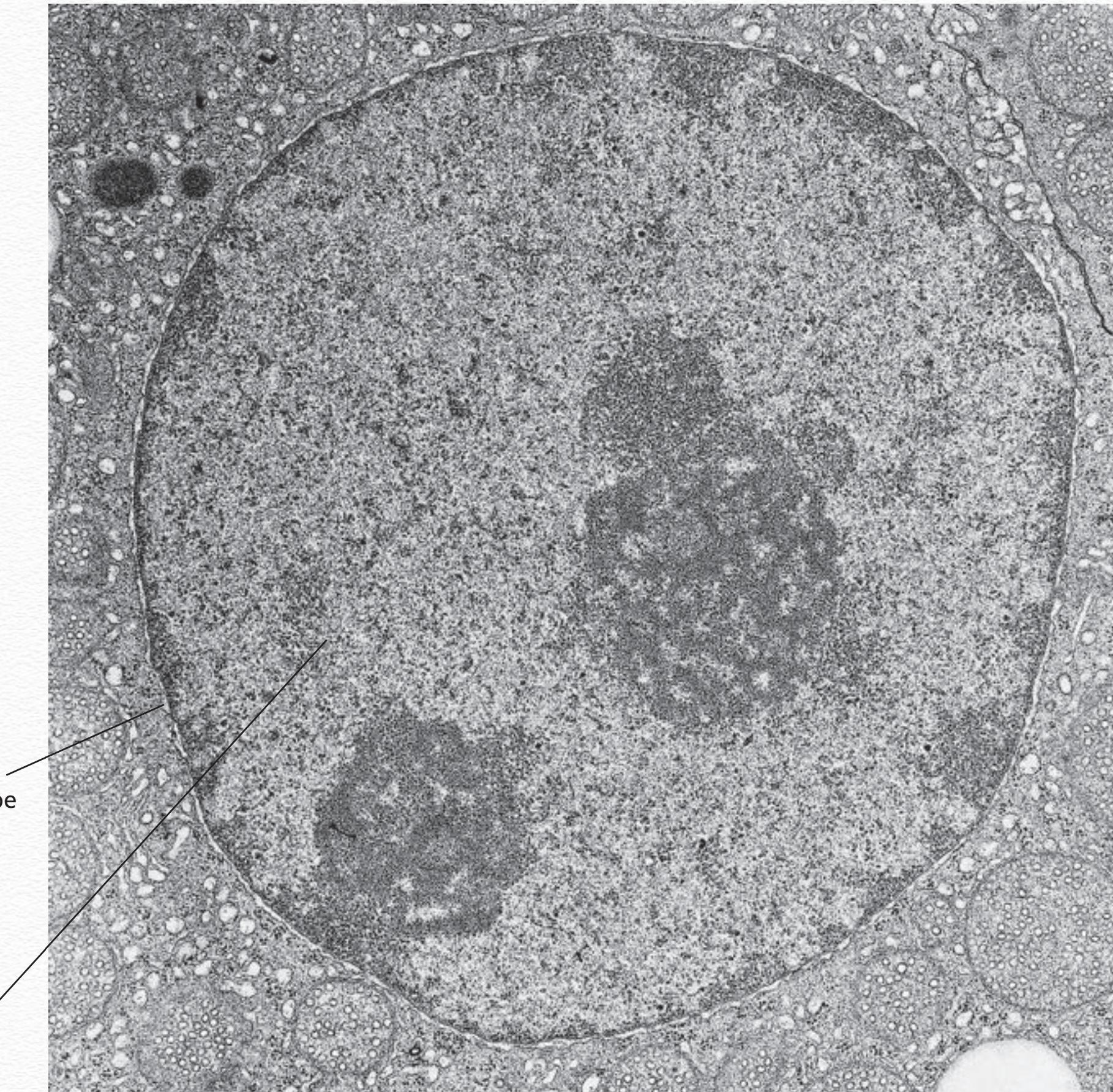
- ❖ Eucaryotic cells, in general, are **bigger** and more elaborate than bacteria and archaea
- ❖ Some live **independent** lives as single-celled organisms, such as amoebae and yeasts
- ❖ Others live in **multicellular** assemblies



Nucleus: the information store of the Cell

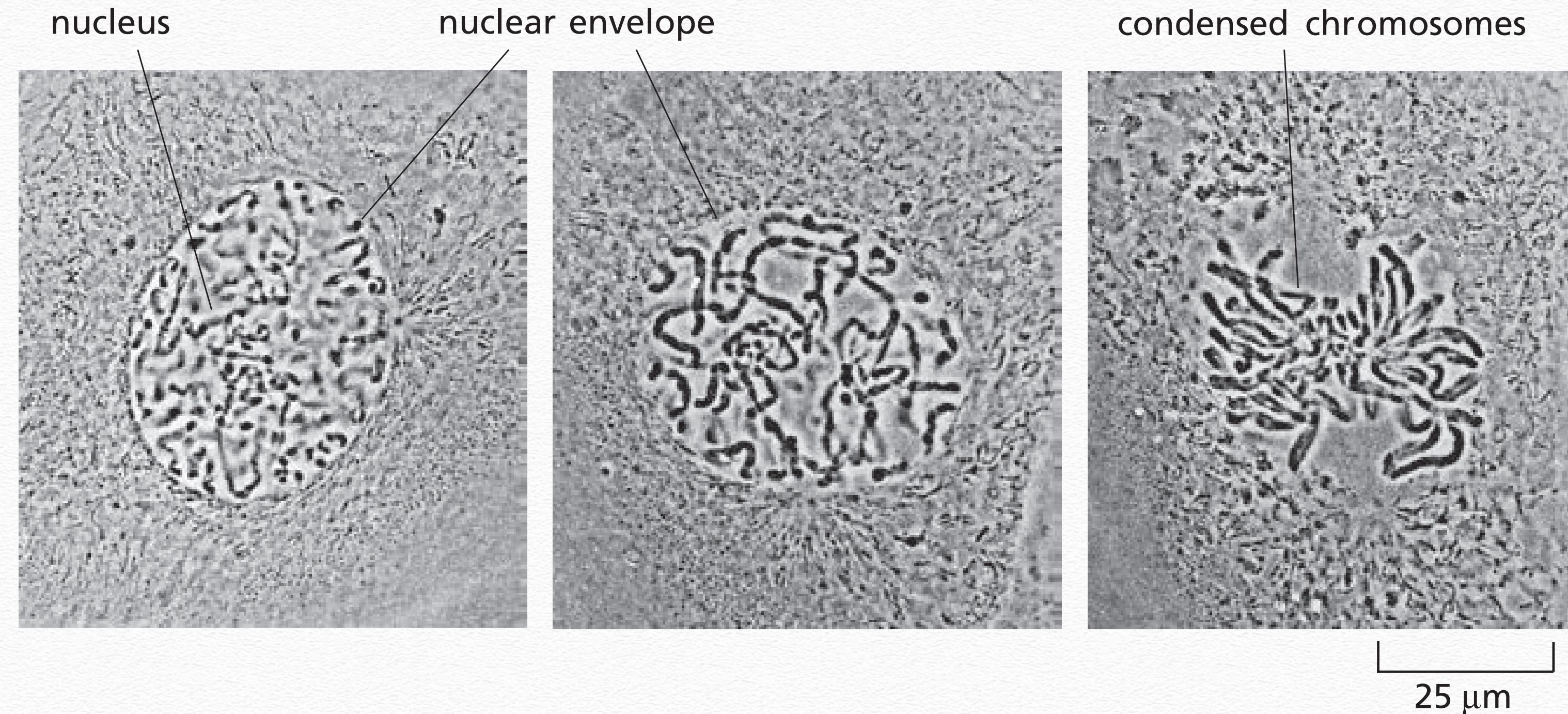


(A)



(B)

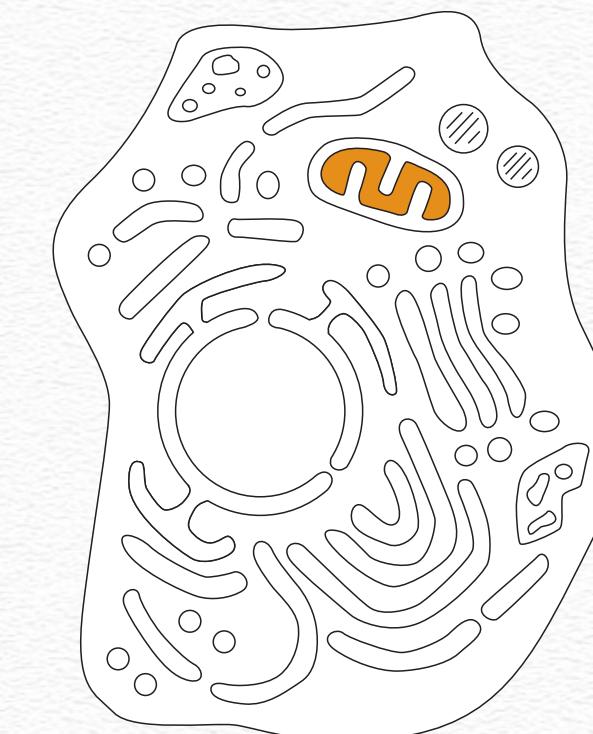
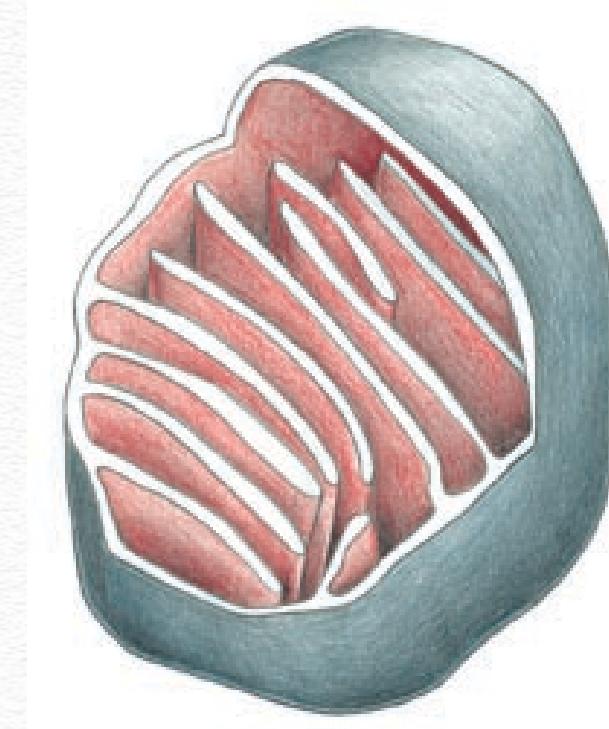
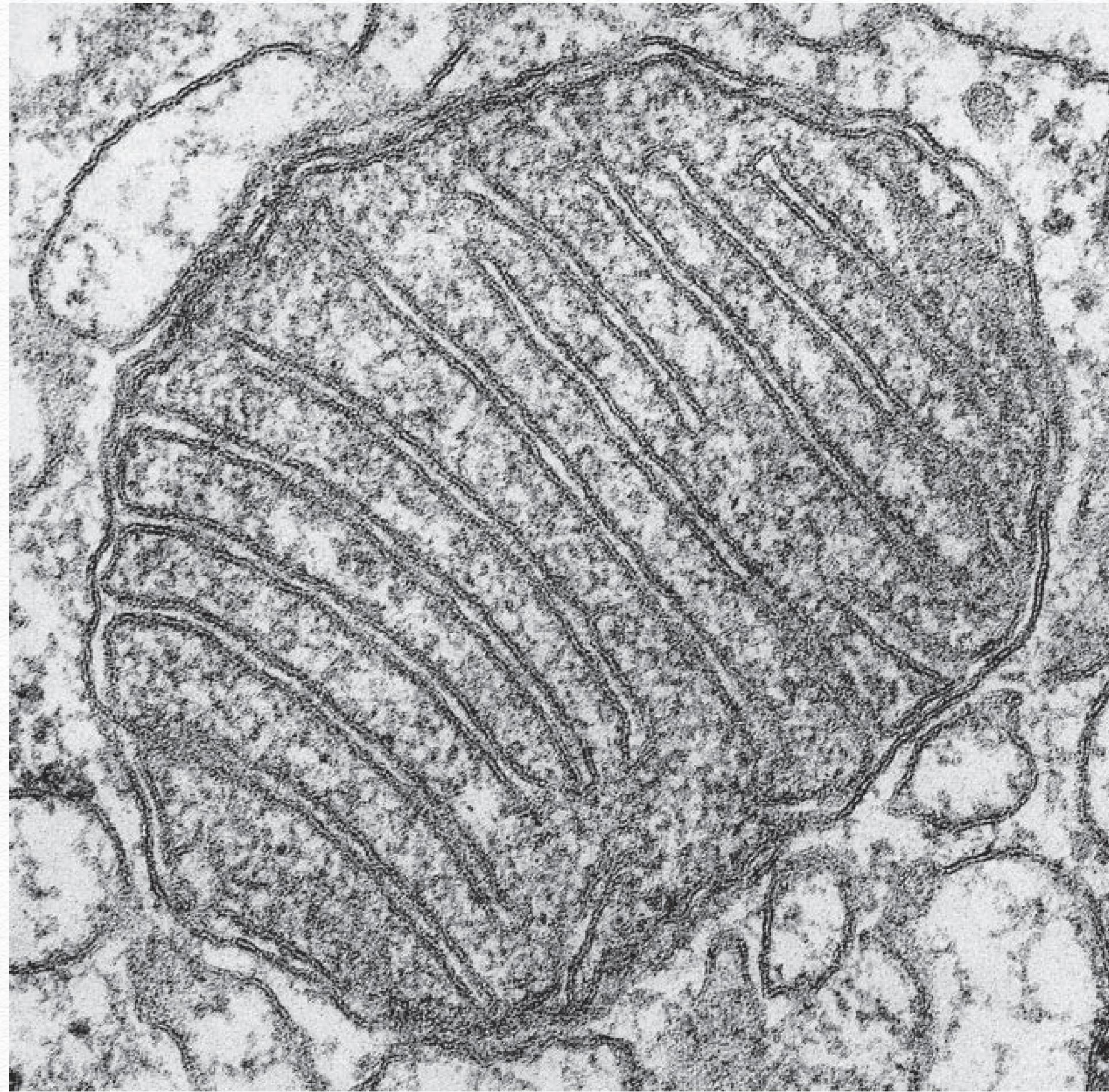
Nucleus



Mitochondria

- ❖ Mitochondria generate usable **energy** from food to power the Cell
- ❖ They are present in essentially **all eucaryotic cells**, and very visible
- ❖ Mitochondria contain **their own DNA** and reproduce by **dividing** in two

gtdt



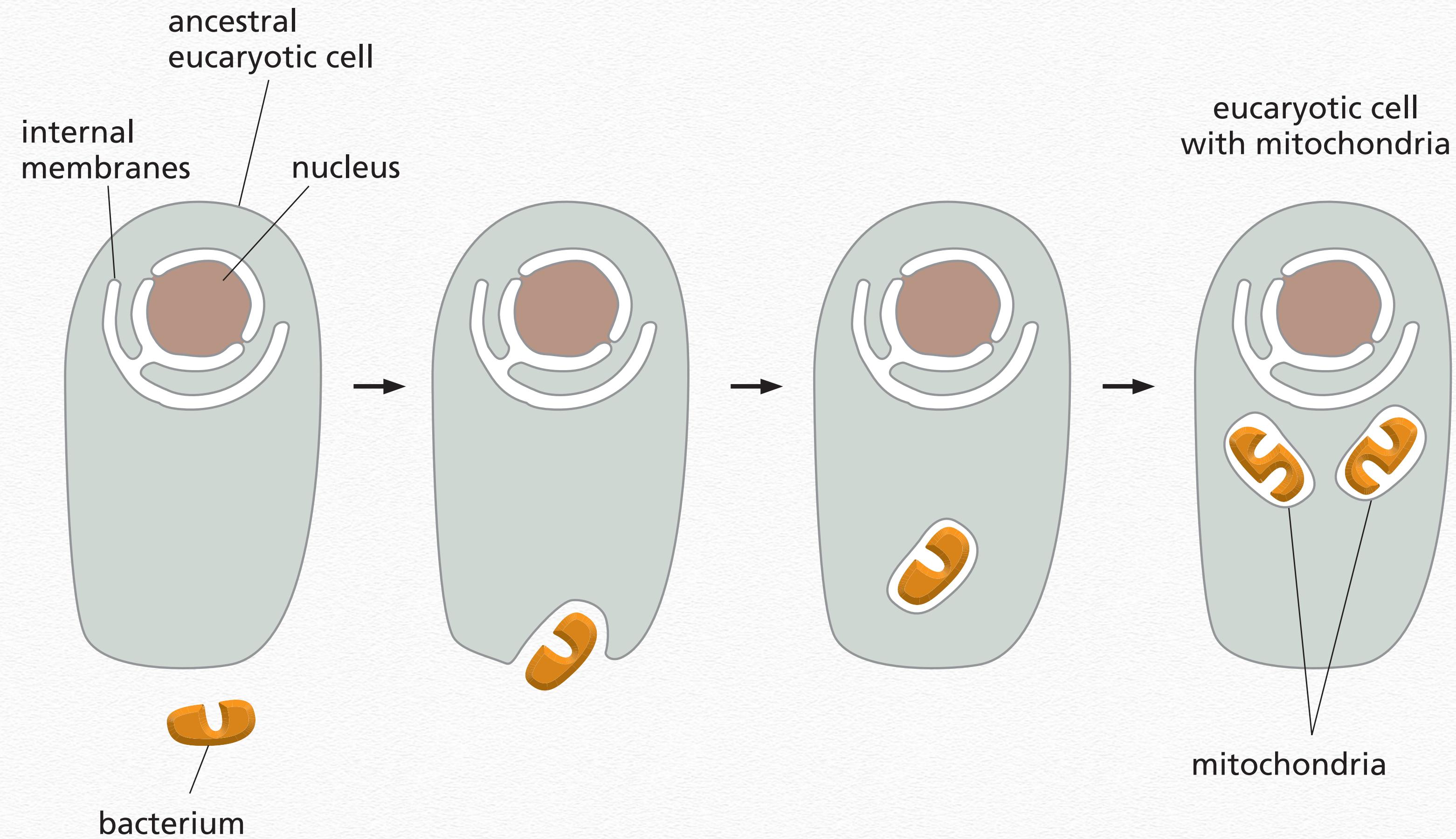
Mitochondria Function

- ❖ Their function was discovered by **breaking** open cells and then spinning the soup of cell fragments in a **centrifuge**
- ❖ This separates the **organelles** according to size, shape, density
- ❖ Purified mitochondria were then tested to see what **chemical processes** they could perform
- ❖ This revealed that mitochondria are generators of cell energy by oxidation of food to produce **adenosine triphosphate**, or **ATP**
- ❖ Called **cellular respiration** since consumes O₂ and releases CO₂

Mitochondria Function

- ❖ Without it, animals, fungi, and plants would be **unable to use oxygen** to extract the maximum amount of energy from food molecules
- ❖ Oxygen would be a **poison** for them, they would be **anaerobic**
- ❖ There are even a few **anaerobic** eucaryotes, such as the intestinal parasite Giardia, that **lack mitochondria** and live only in environments that are low in oxygen

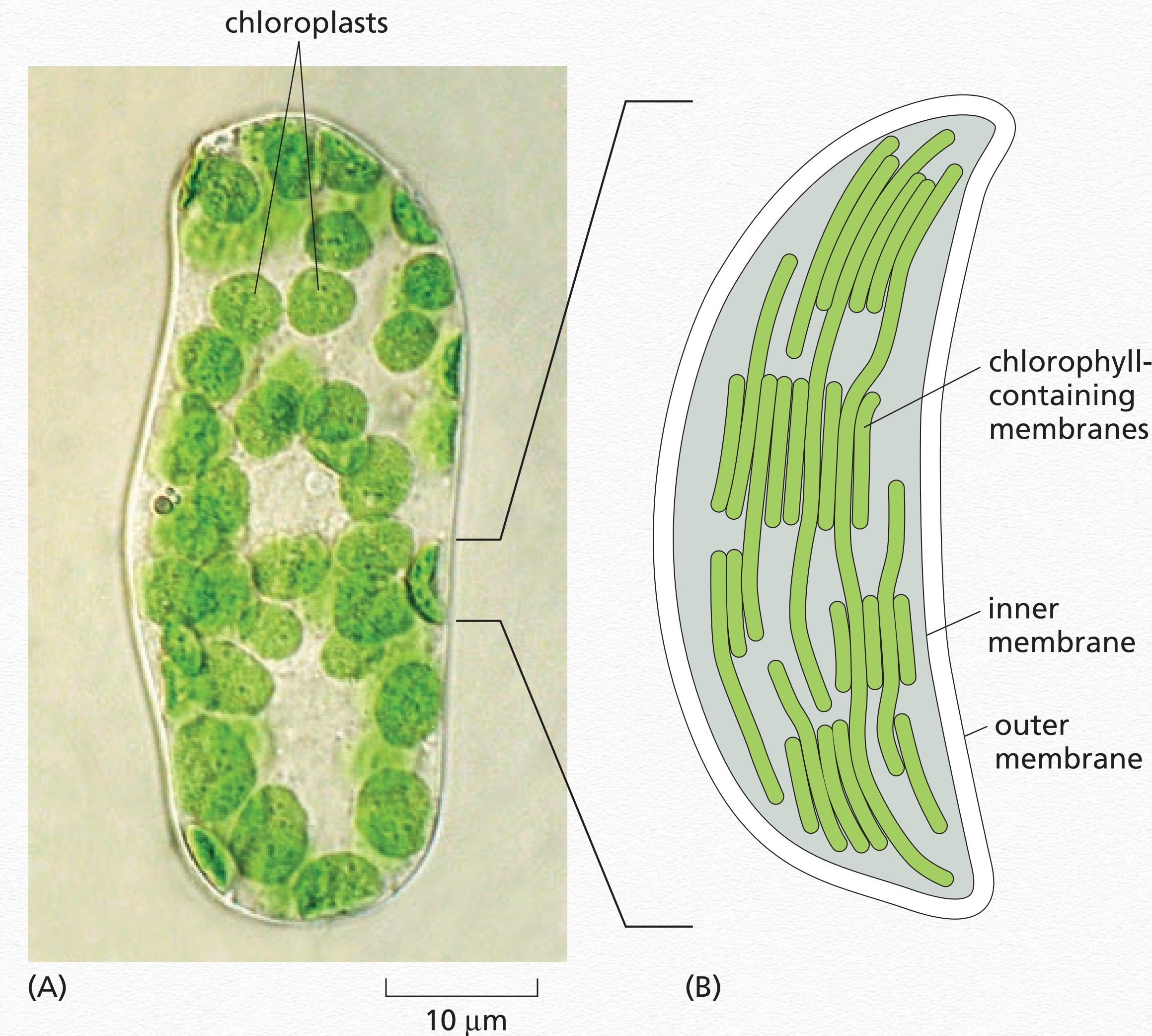
Mitochondria Origin



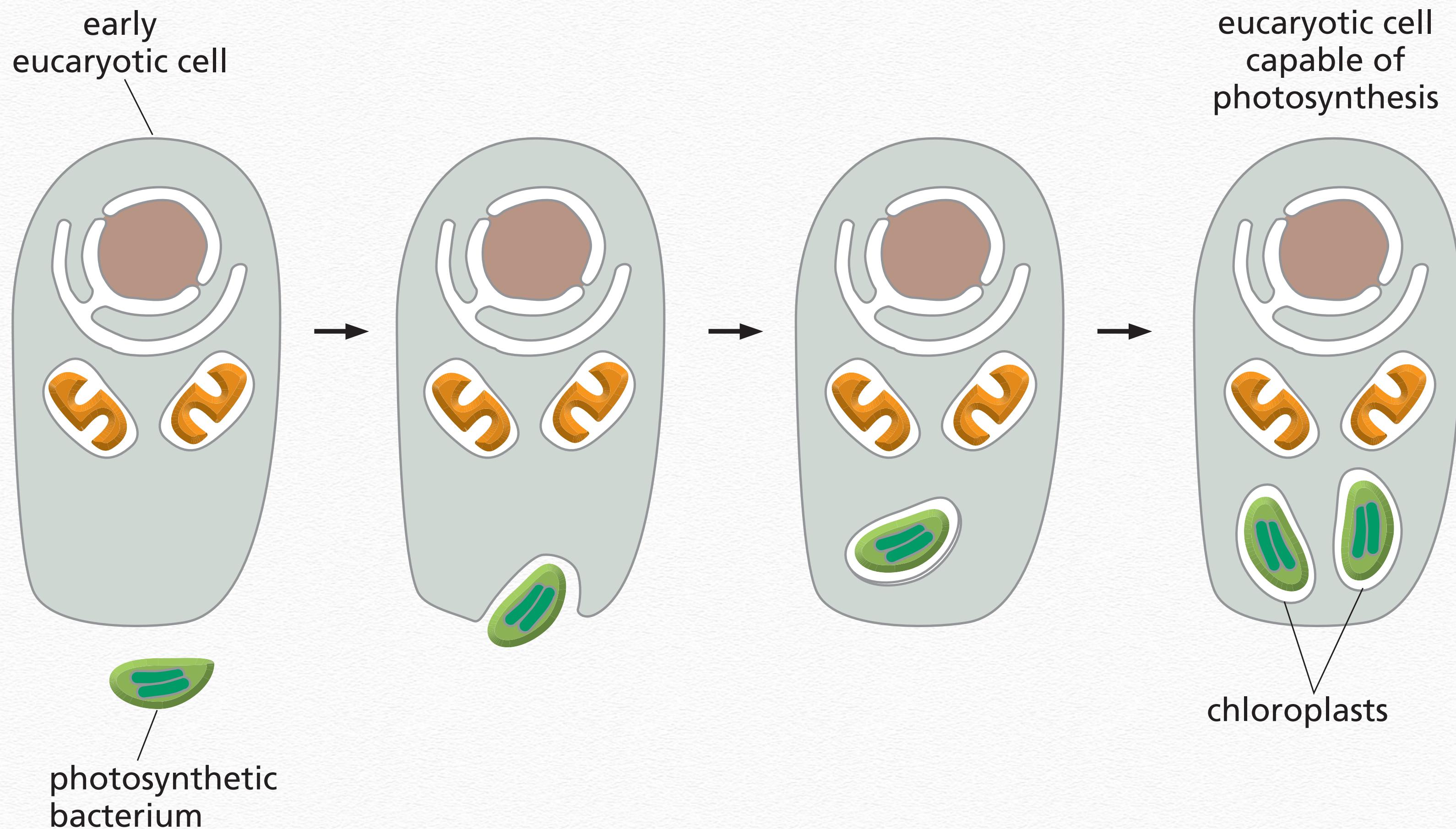
Chloroplasts

- ❖ Chloroplasts capture energy directly from **sunlight**
- ❖ The process is called **photosynthesis**
- ❖ Large green organelles that are found only in the cells of **plants** and **algae**
- ❖ Animals can only consume chemical energy from products of other living things
- ❖ More complex structure than mitochondria: two surrounding membranes and internal **stacks of membranes** containing the green pigment **chlorophyll**

Chloroplasts



Chloroplast Origin



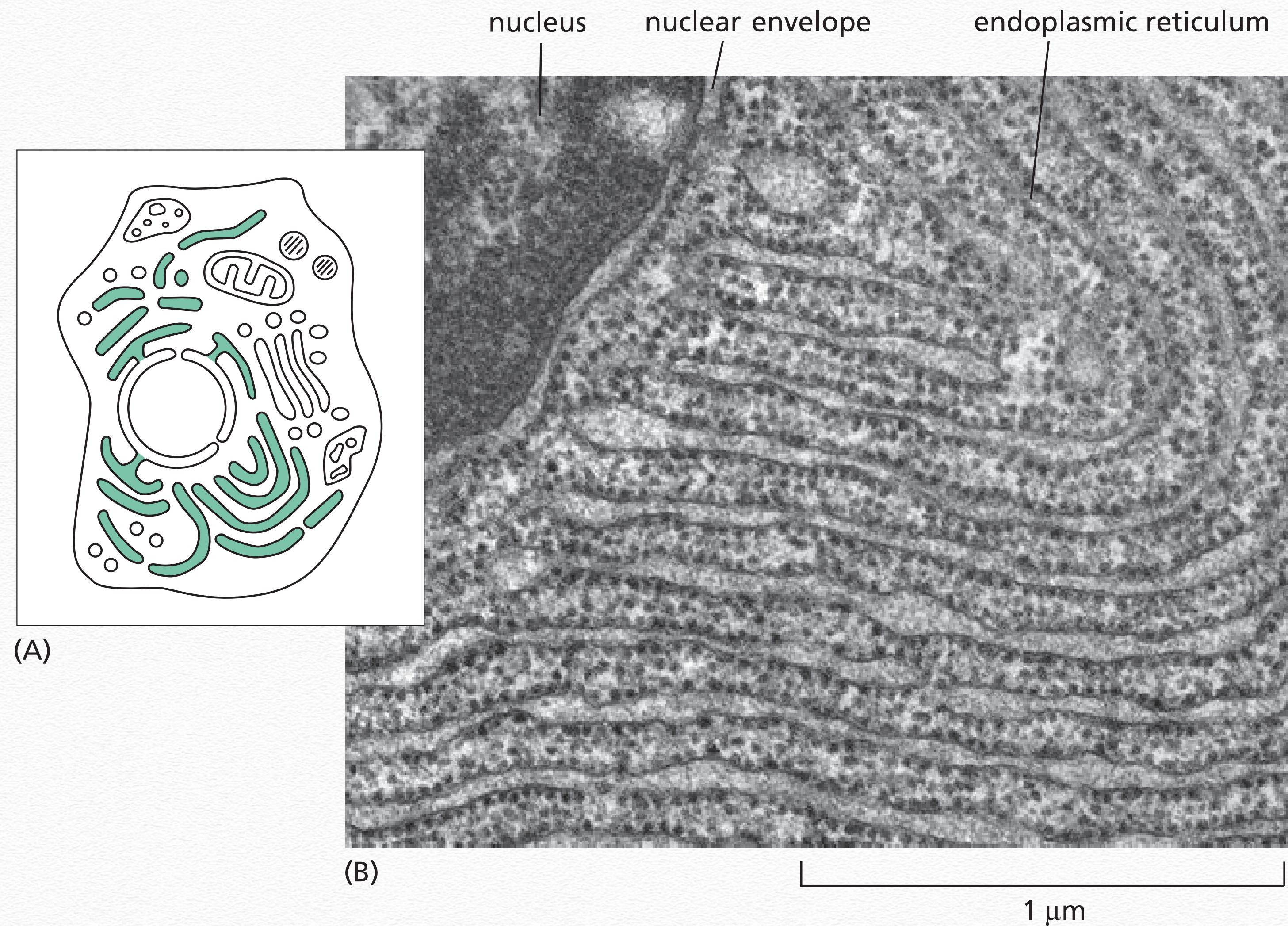
Other Organelles

- ❖ Cytoplasm contains many other organelles, mostly surrounded by single membranes, with many **distinct functions**
- ❖ Some are involved with the cell's ability to **import** raw materials and to **export** manufactured substances and waste products
- ❖ Some are enormously enlarged and specialized for the **secretion of proteins**
- ❖ Others are plentiful in cells specialized for the **digestion of foreign bodies**

Endoplasmic Reticulum

- ❖ An irregular **maze** of interconnected spaces enclosed by a membrane
- ❖ The site where most cell **membrane components** and materials destined for **export** are made
- ❖ Hosts **ribosomes**: the protein synthesis unit of cells
- ❖ Because of its appearance, ribosome-coated ER is often called **rough ER**

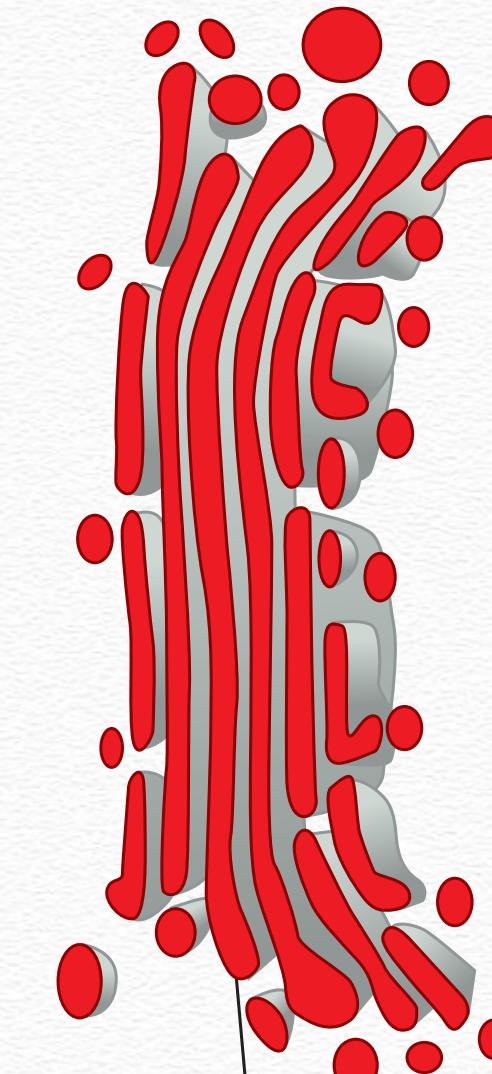
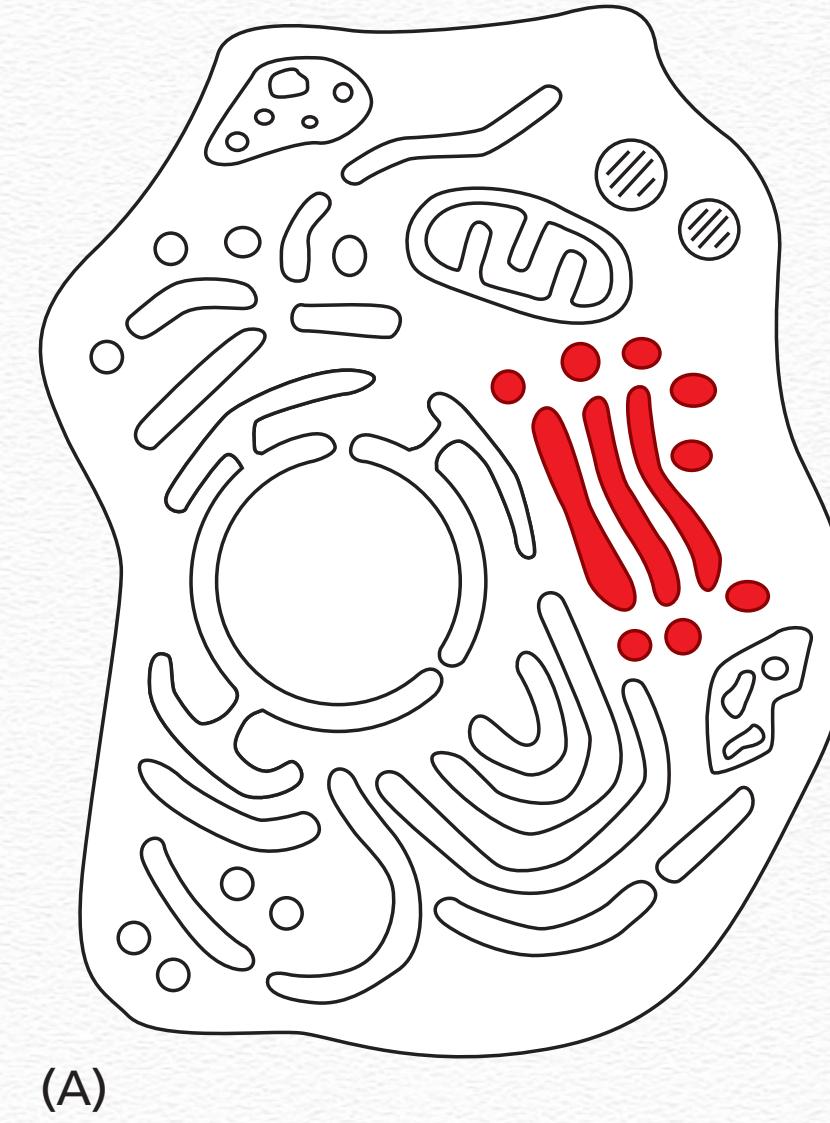
Endoplasmic Reticulum



Golgi Apparatus

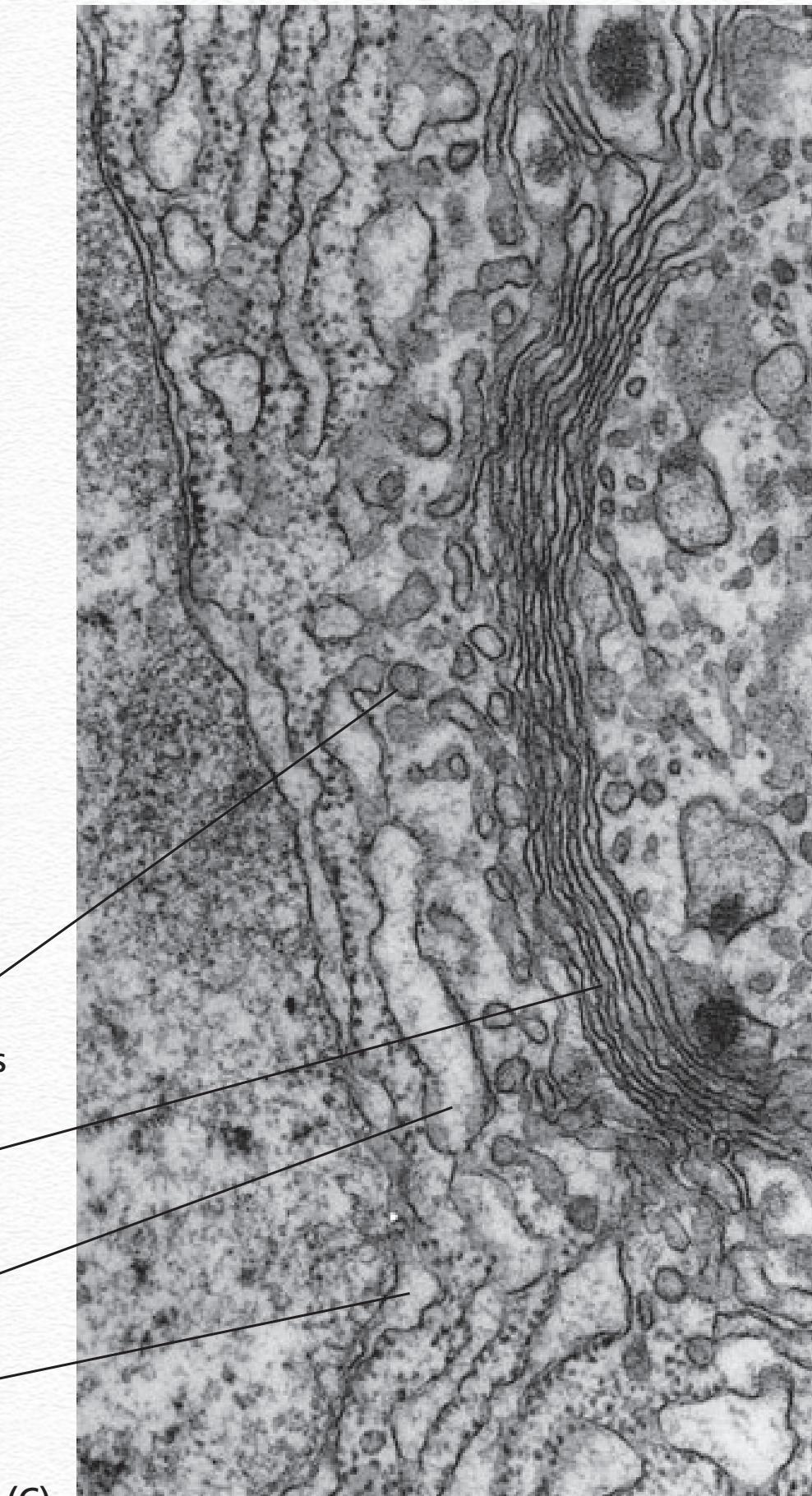
- ❖ Stacks of flattened membrane-enclosed **sacs**
- ❖ Receives and often **chemically modifies** the molecules made in the endoplasmic reticulum
- ❖ Then **directs** them to the exterior of the cell or to various locations inside the cell

Golgi Apparatus



(B)

- membrane-enclosed vesicles
- Golgi apparatus
- endoplasmic reticulum
- nuclear envelope



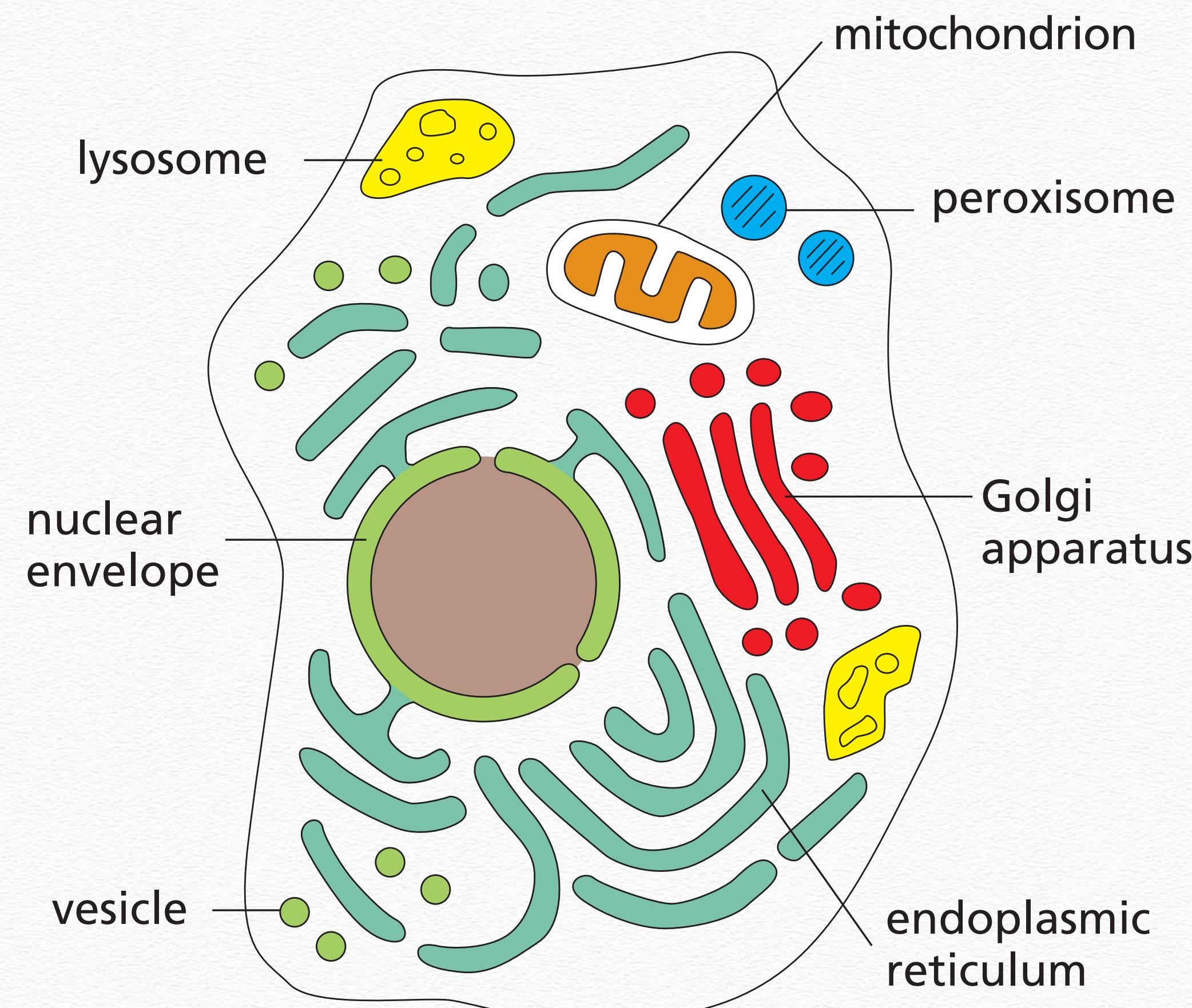
(C)

$1 \mu\text{m}$

Lysosomes & Peroxisomes

- ❖ Lysosomes are small, irregularly shaped organelles
- ❖ Intracellular digestion occurs in lysosomes, releasing nutrients from food particles and breaking down unwanted molecules for recycling or excretion
- ❖ Peroxisomes are small, membrane-enclosed vesicles
- ❖ They provide a contained environment for reactions in which hydrogen peroxide, a dangerously reactive chemical, is generated and degraded

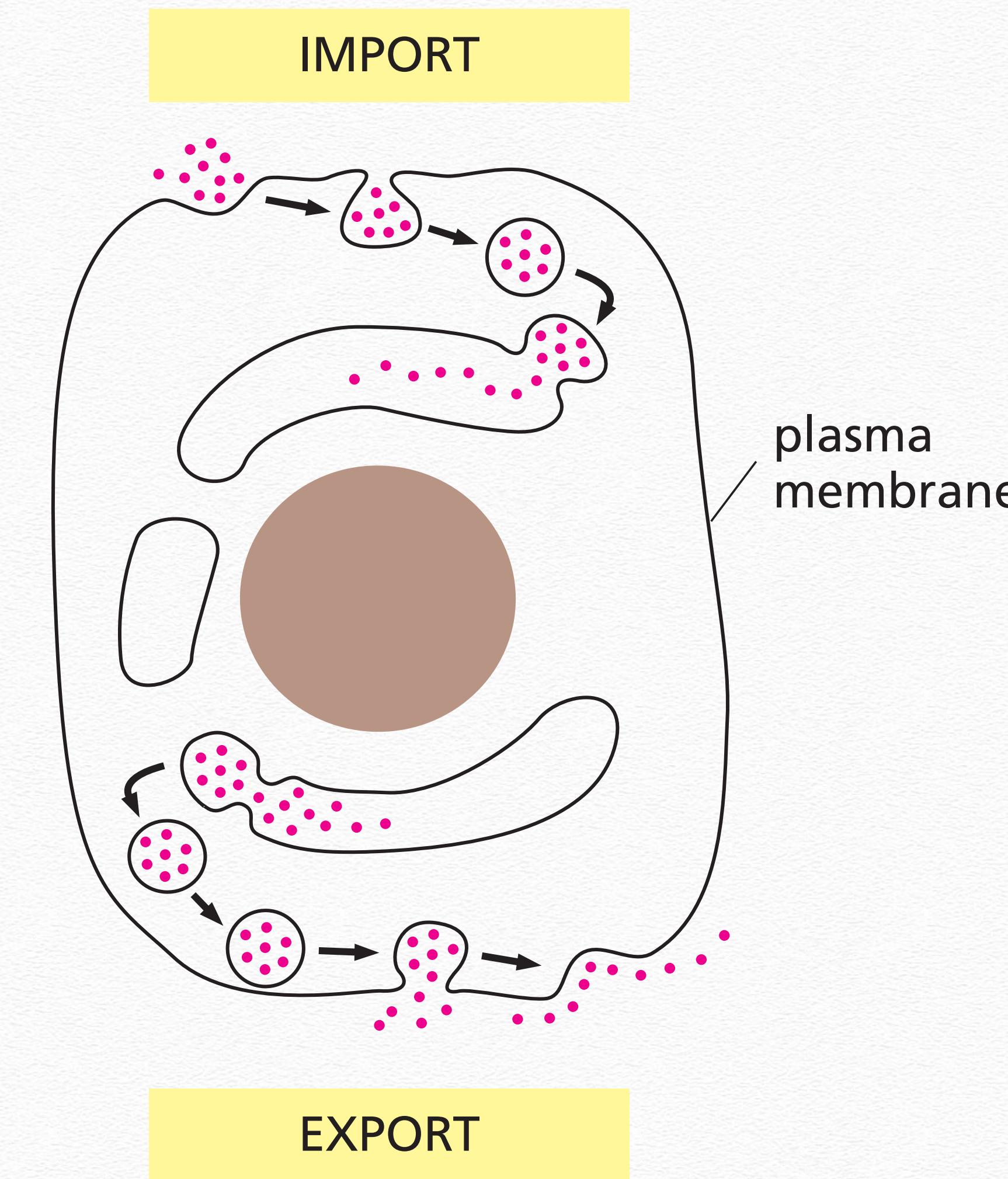
Organelles



Vesicles

- ❖ Membranes form many different types of small **vesicles**
- ❖ They are involved in the **transport** of materials between one membrane-enclosed organelle and another, or with outside of the cell
- ❖ They pinch off from the membrane of one organelle and fuse with another, like tiny **soap bubbles** budding from and rejoining larger bubbles

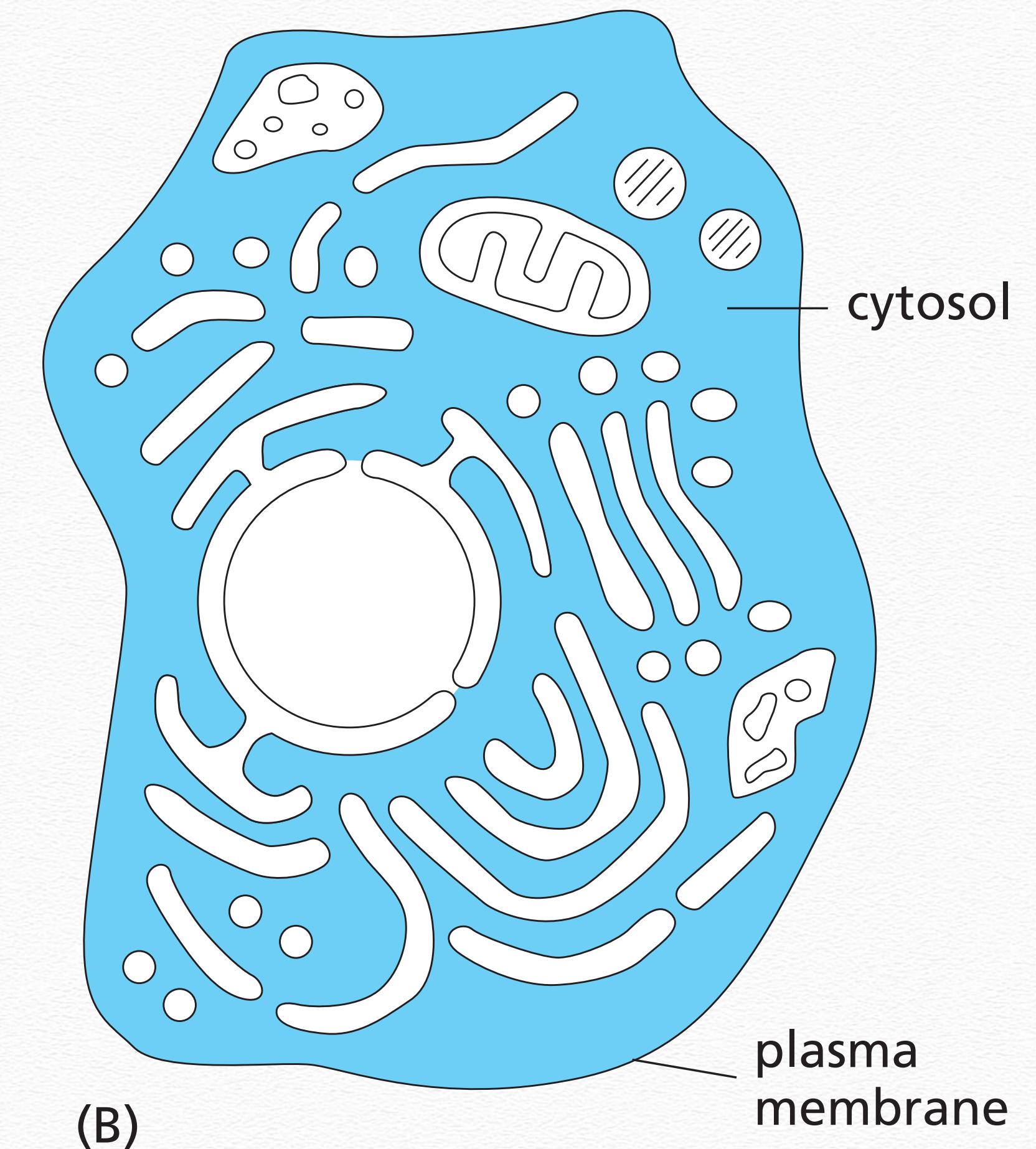
Vesicles



Endocytosis & Exocytosis

- ❖ Vesicles can import external material and fuse with membrane-enclosed **endosomes**, which mature into **lysosomes**, where the imported material is **digested**
- ❖ Animal cells can engulf **very large particles**, or even **entire foreign cells**, by this process of **endocytosis**
- ❖ The reverse process, **exocytosis** is also a common cellular activity, mediated by **exosomes**, for releasing hormones, neurotransmitters, and other signaling molecules

Cytosol



Cytosol

- ❖ Cytosol is the part of the cytoplasm that is not partitioned off within intracellular membranes
- ❖ In most cells, the largest single compartment, a host of large and small molecules, crowded together which makes it more like a water-based gel than a liquid solution
- ❖ Site of many chemical reactions, such as breakdown of nutrient molecules, and manufacture of proteins
- ❖ Ribosomes, the molecular machines that make the protein molecules, often attached to the cytosolic face of the endoplasmic reticulum

Ribosomes in Cytosol

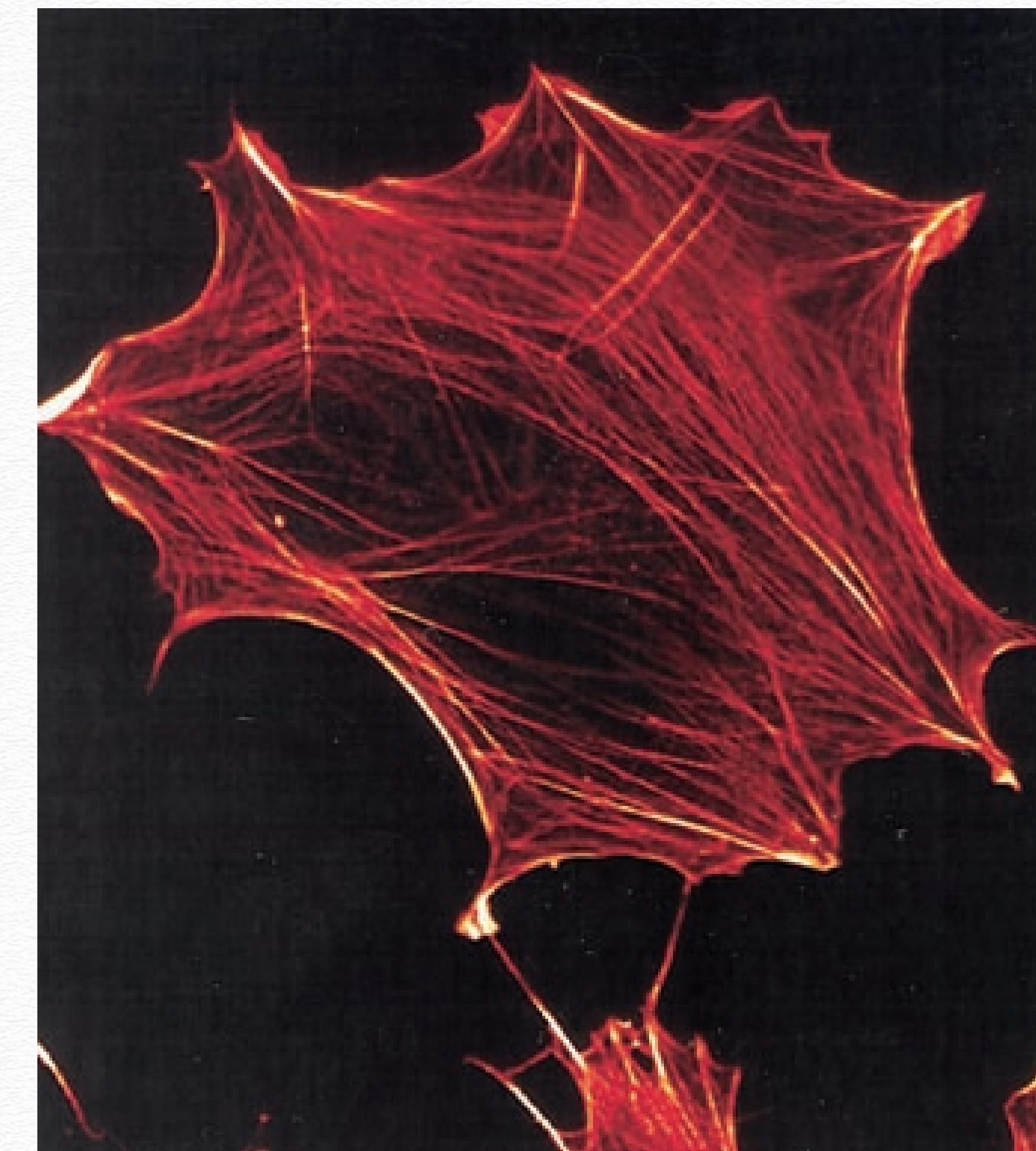


Cytoskeleton

- ❖ Cytoplasm is **not** just a **structureless soup** of chemicals and organelles
- ❖ Cytosol is criss-crossed by long, fine **filaments** of protein. They anchor at one end to the **plasma membrane** or to radiate out from a central site adjacent to the **nucleus**
- ❖ **Cytoskeleton** is responsible for directed cell movements

Actin filaments

- ❖ The **thinnest** filaments
- ❖ Present in **all** eukaryotic cells
- ❖ Large number inside **muscle** cells
- ❖ Part of the machinery that generates **contractile** forces

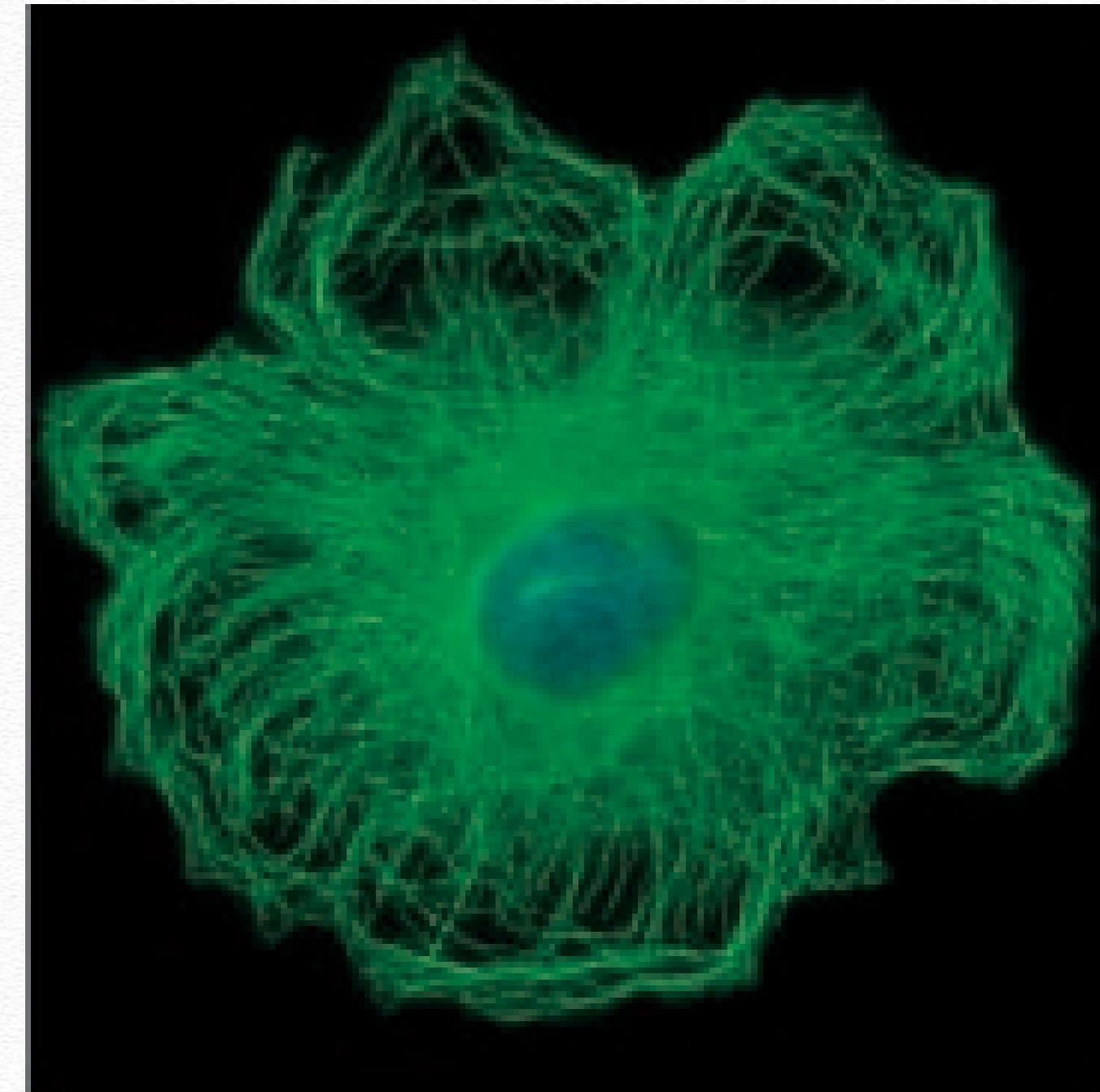


(A)

50 μm

Microtubules

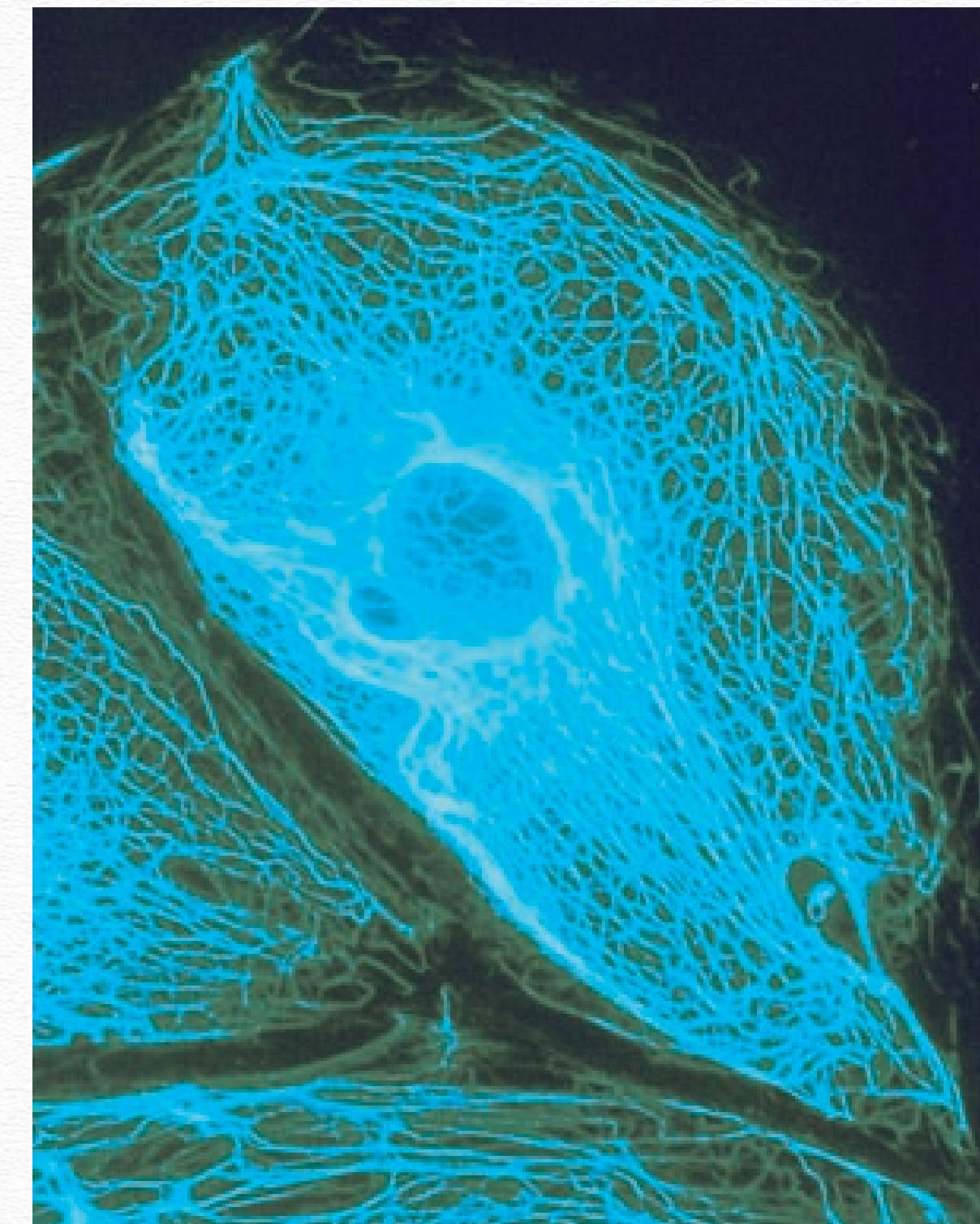
- ❖ The **thickest** filaments
- ❖ Minute **hollow tubes**
- ❖ In **dividing cells** they form a spectacular array that helps pull the duplicated chromosomes in opposite directions and distribute them equally to the two daughter cells



(B)

Intermediate filaments

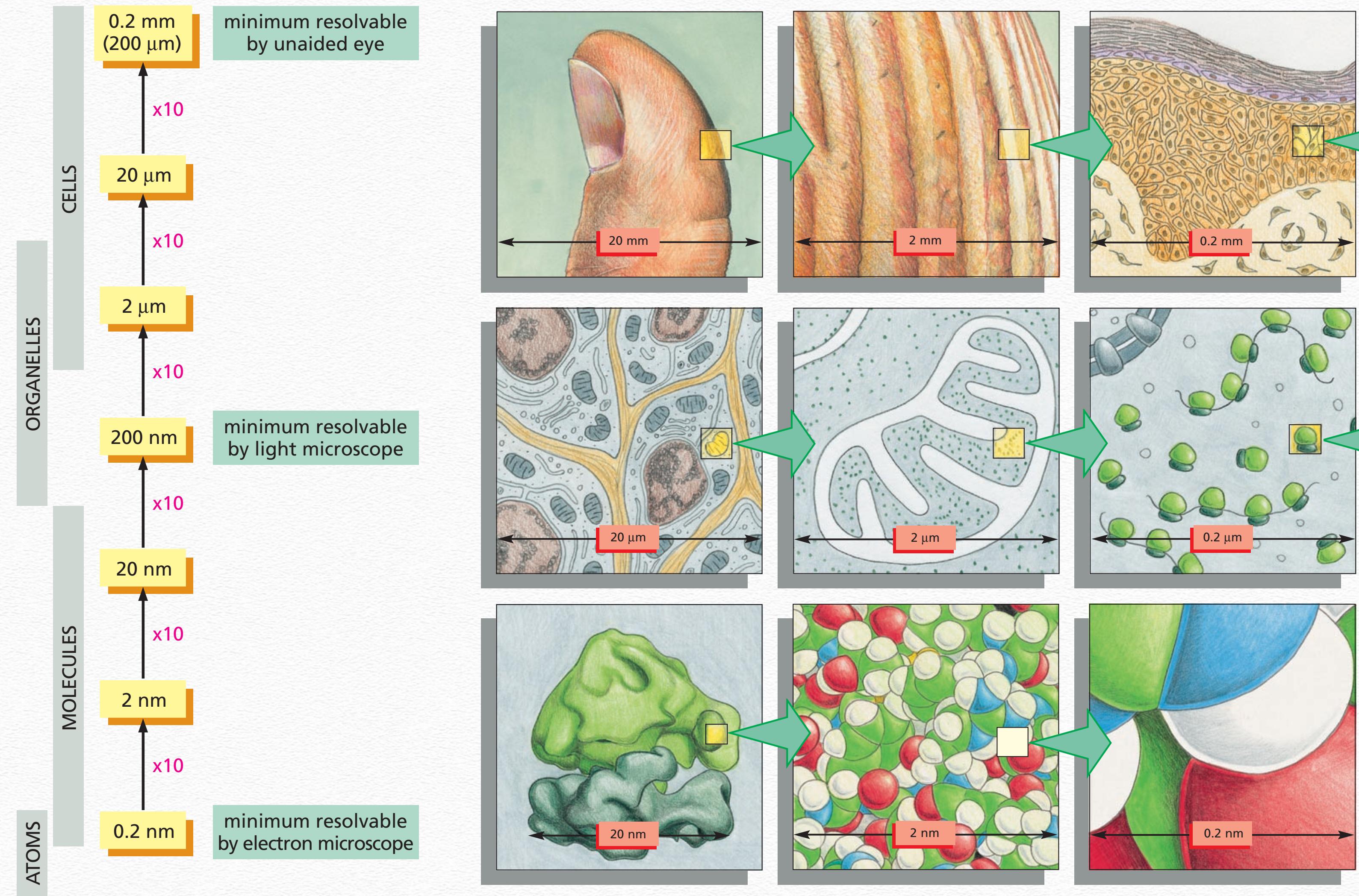
- ❖ Strengthen the cell mechanically
- ❖ Actin & intermediate filaments and microtubules, together with other proteins that attach to them, form a system of **girders**, **ropes**, and **motors** that gives the cell its mechanical strength, controls its shape, and drives and guides its movements



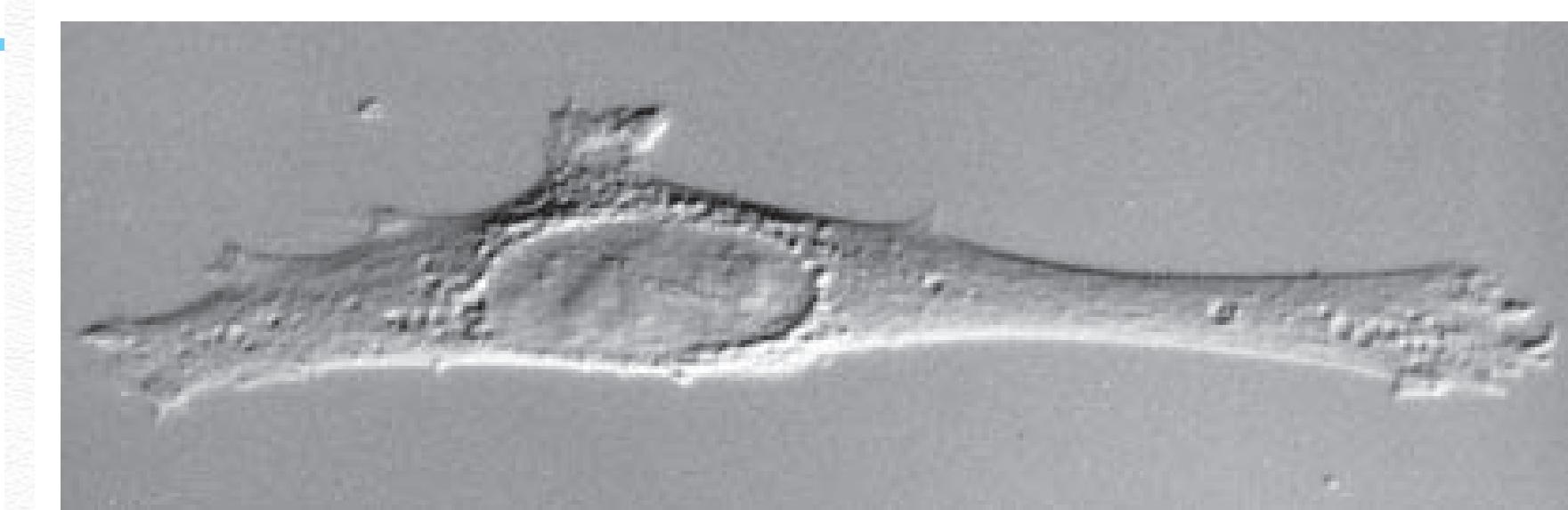
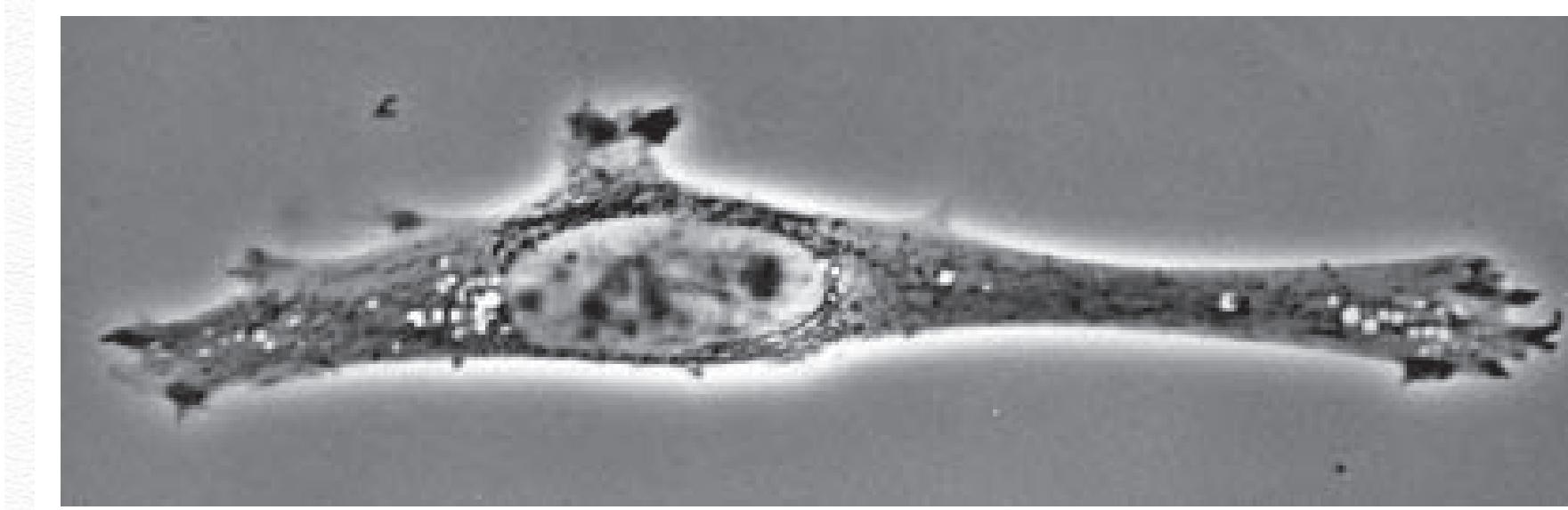
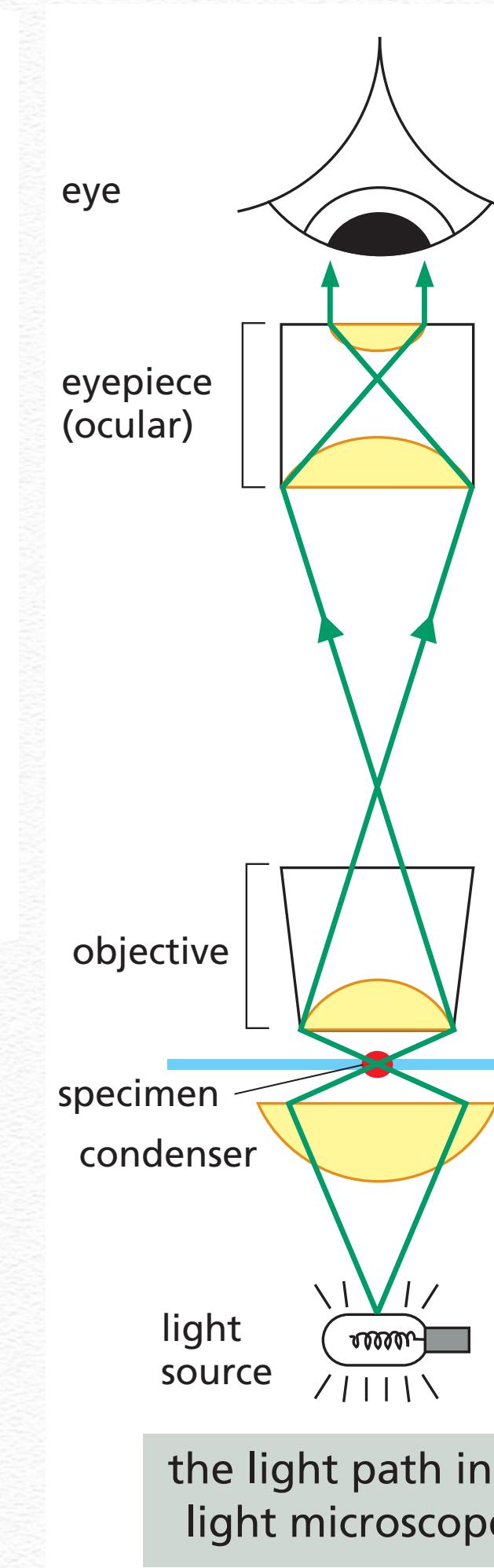
(C)

How to see cells?

What can we see?

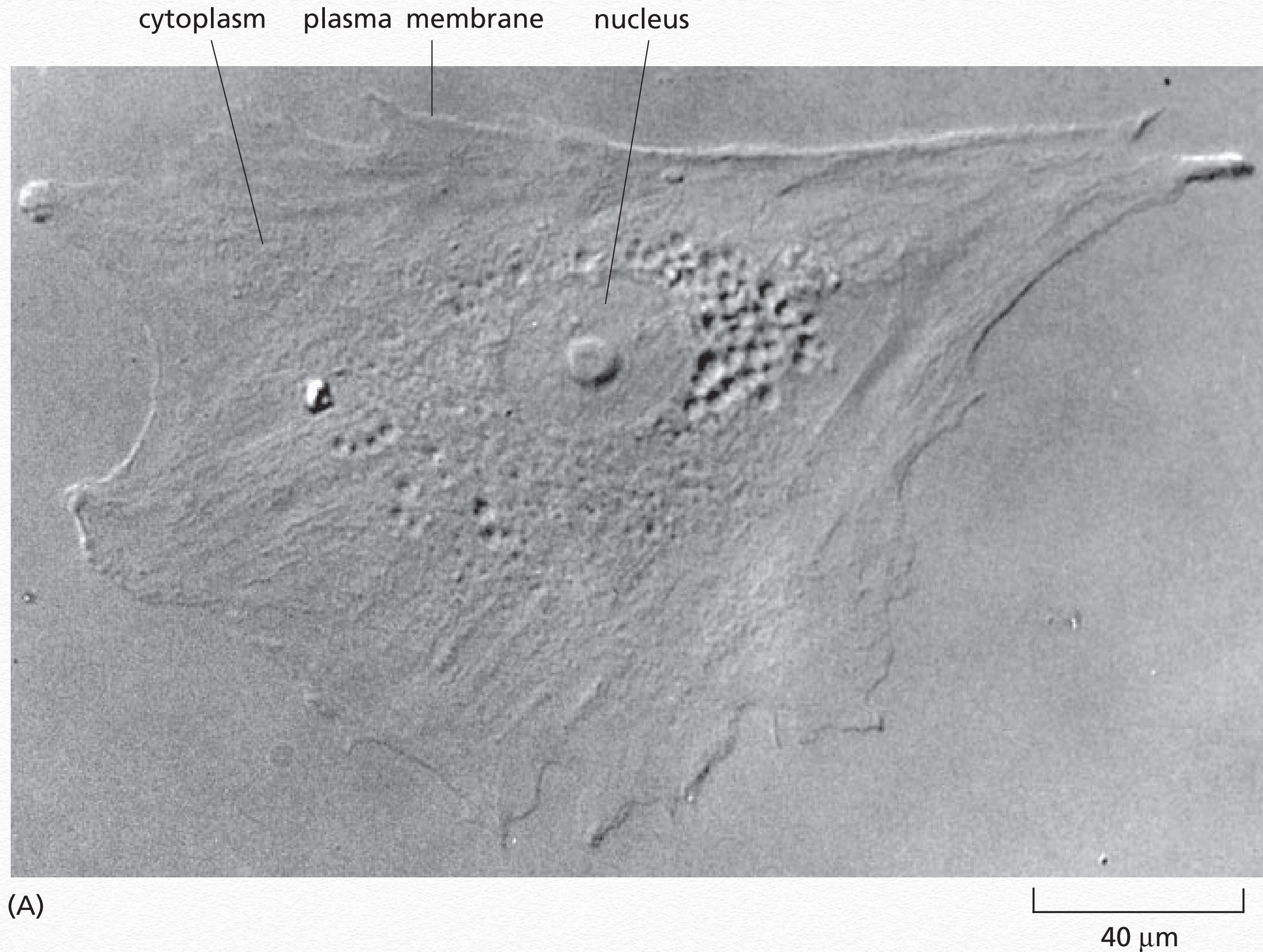


Light Microscope

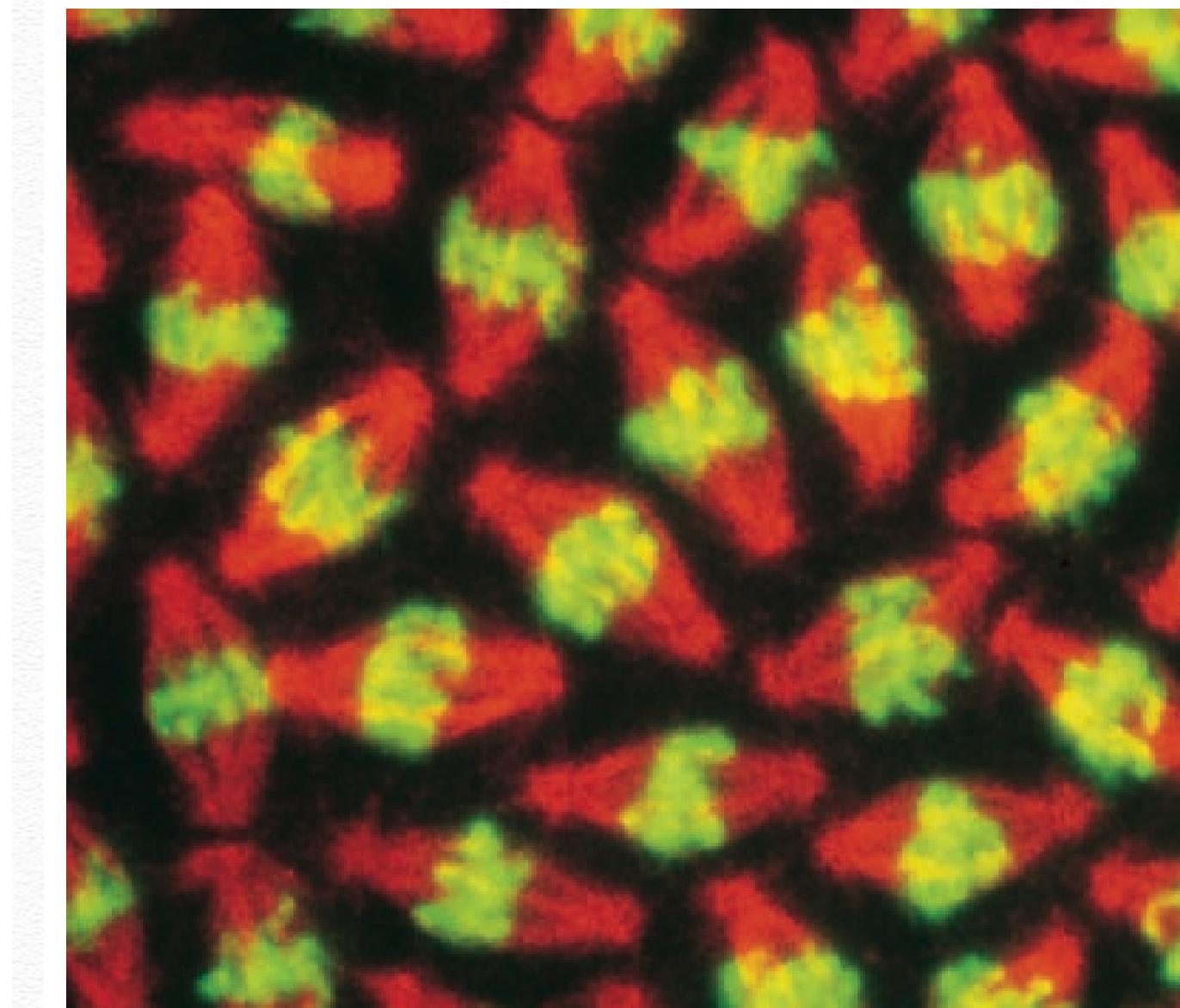
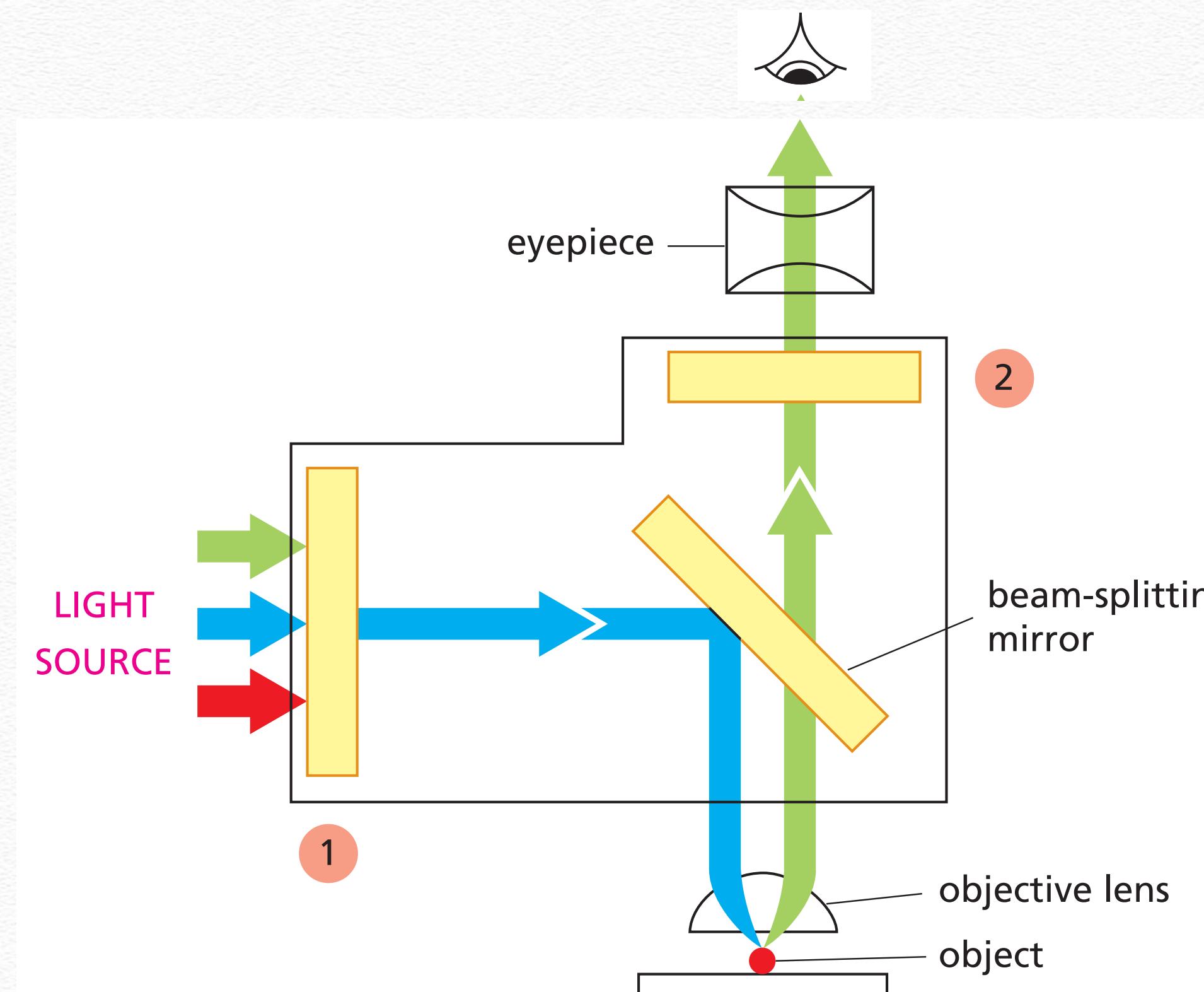


50 μm

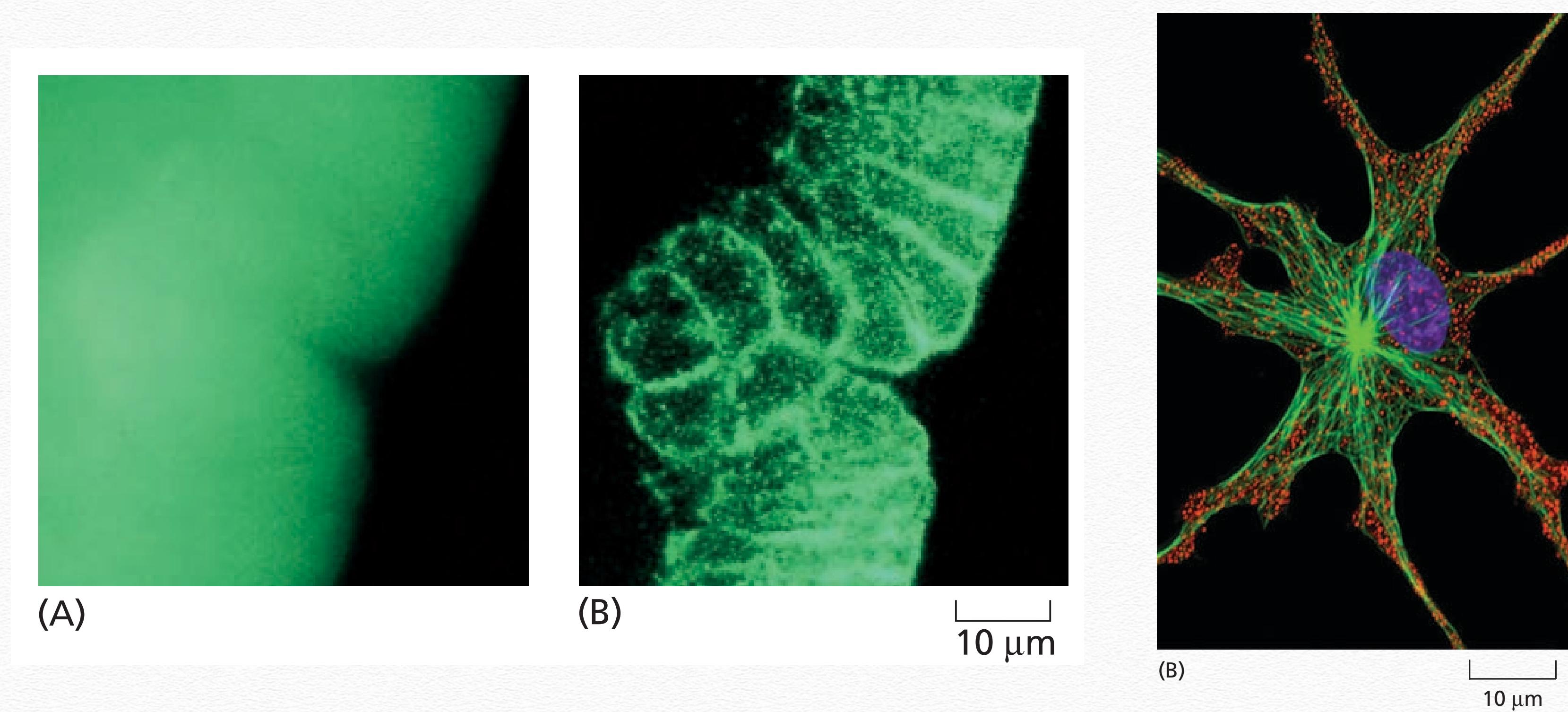
Light Microscope



Fluorescence Microscopy

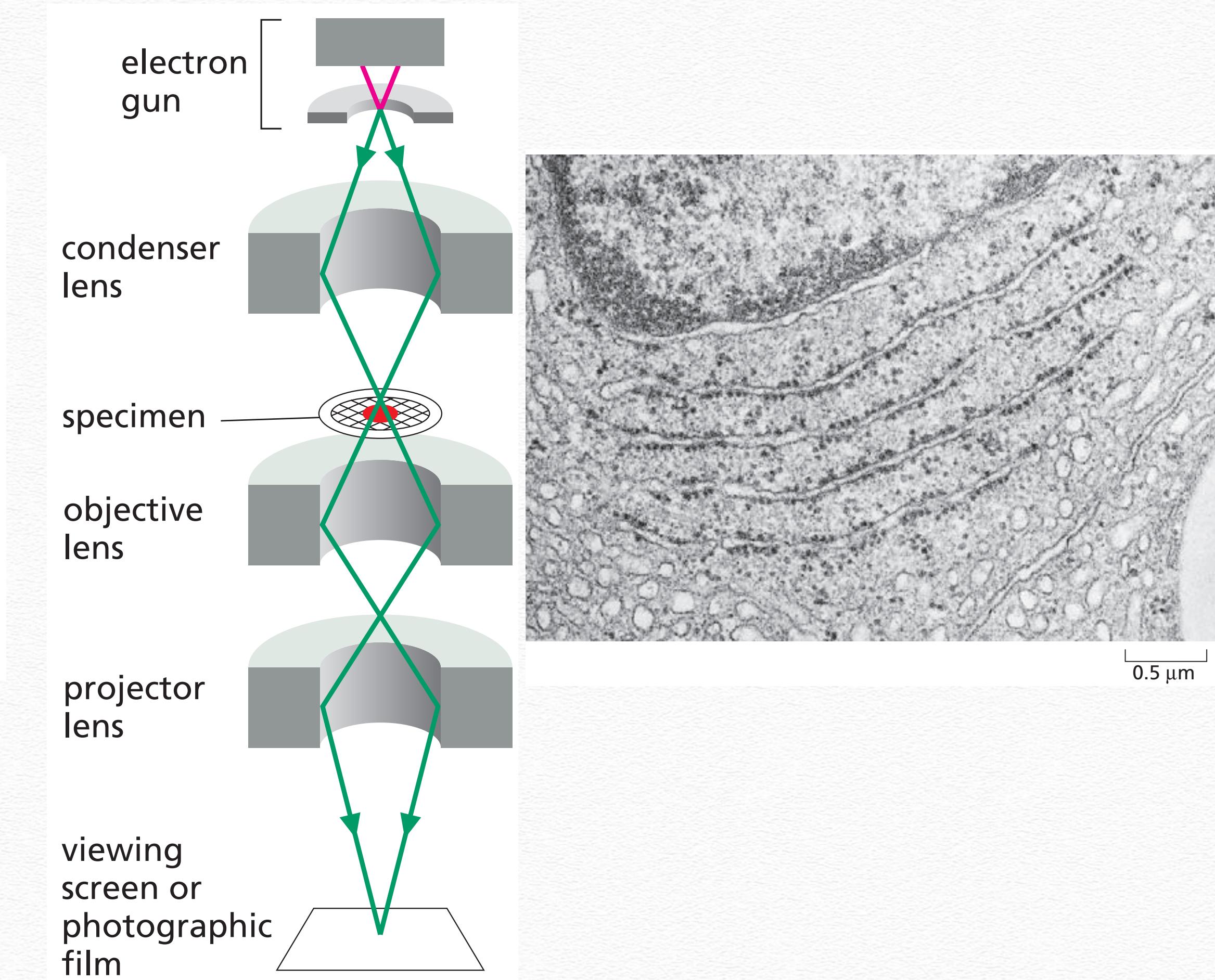


Confocal Microscopy

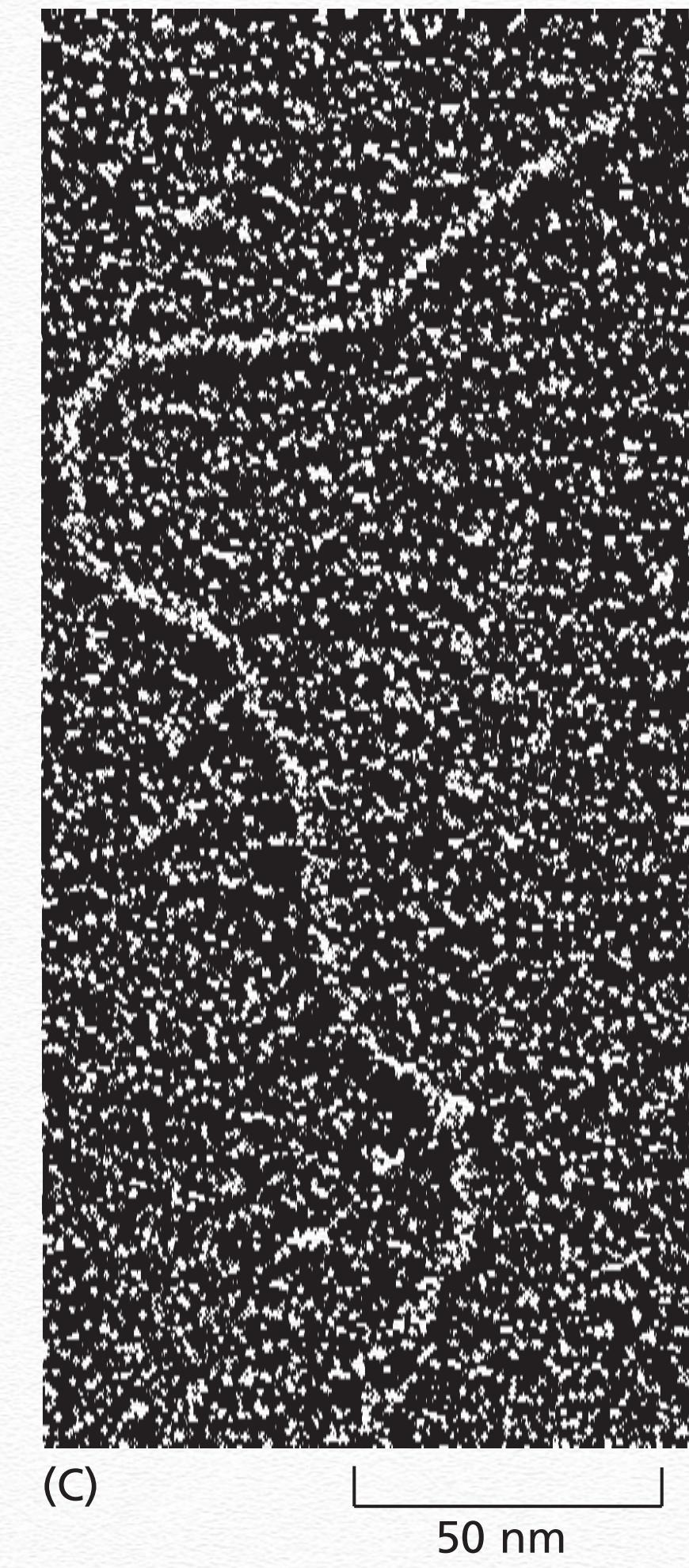
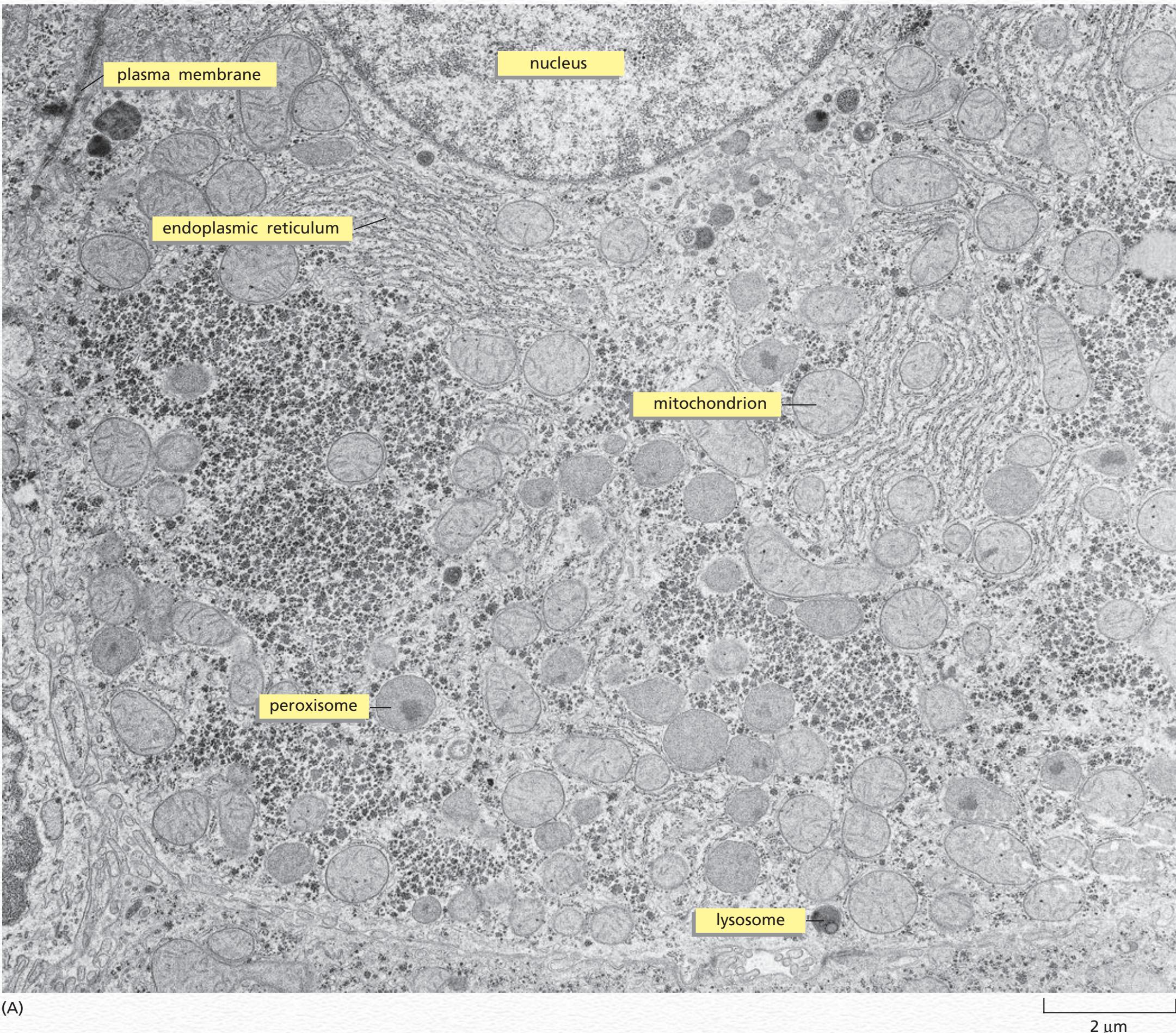


Transmission Electron Microscopy

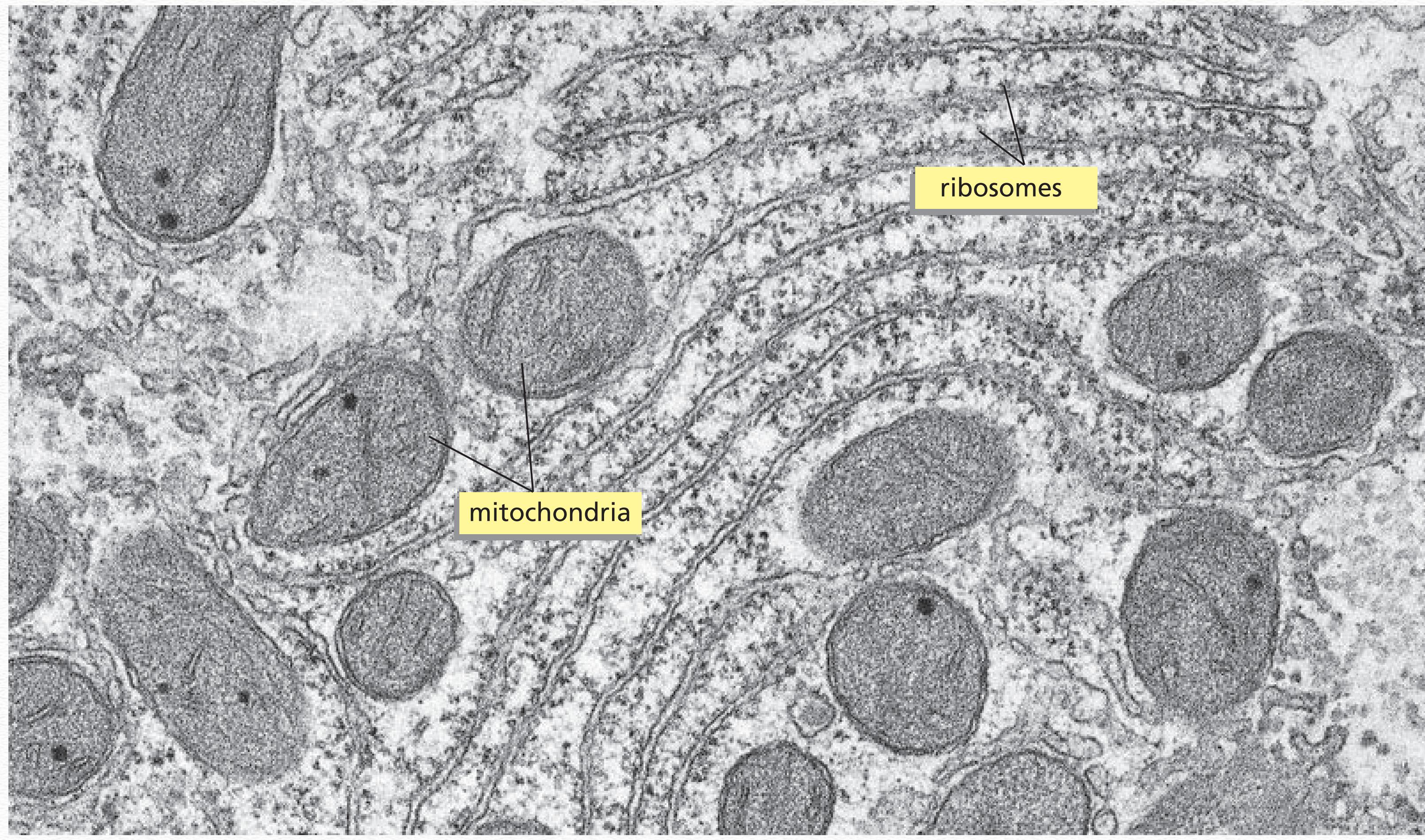
Courtesy of Philips Electron Optics, with permission from FEI Co.



Transmission Electron Microscopy



Transmission Electron Microscopy



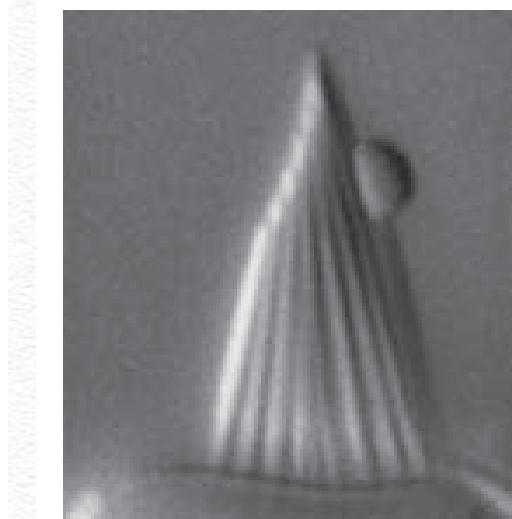
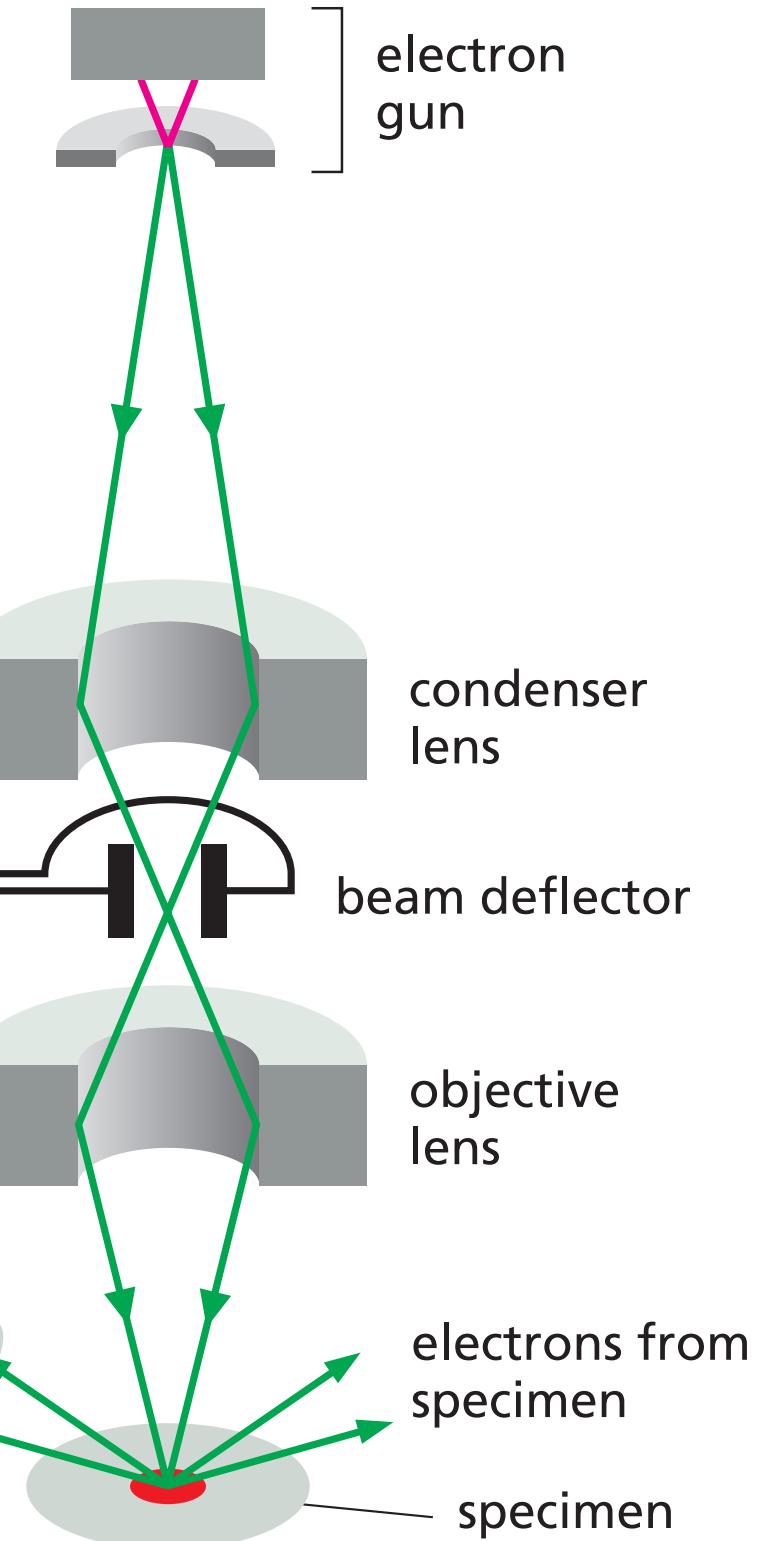
(B)

2 μm

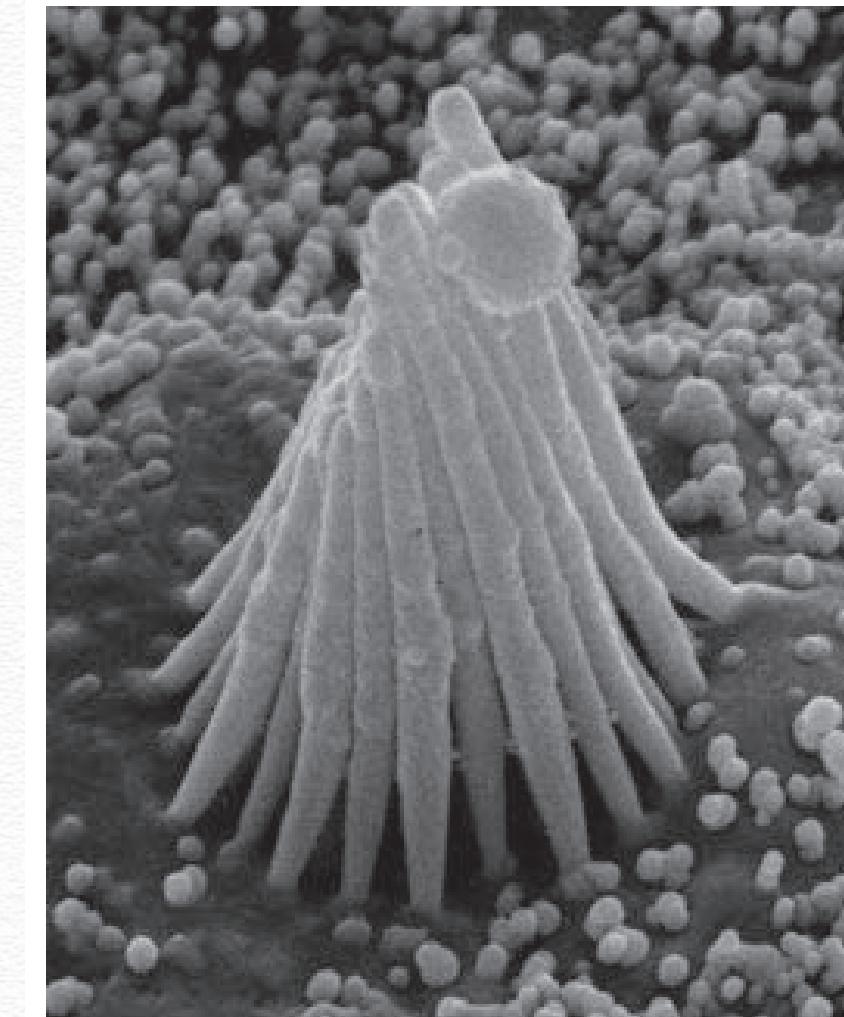
Scanning Electron Microscopy



SCANNING ELECTRON MICROSCOPY



5 μm



1 μm