Figure 7.18aa

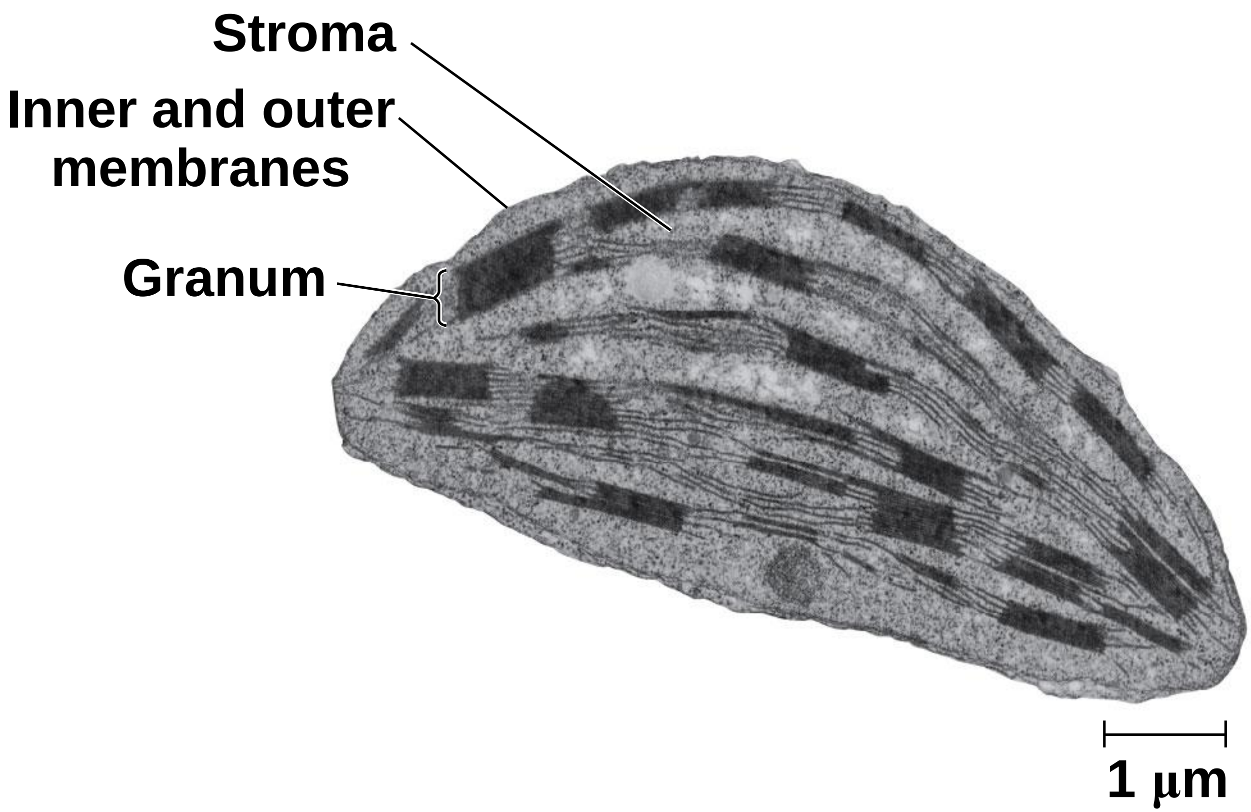
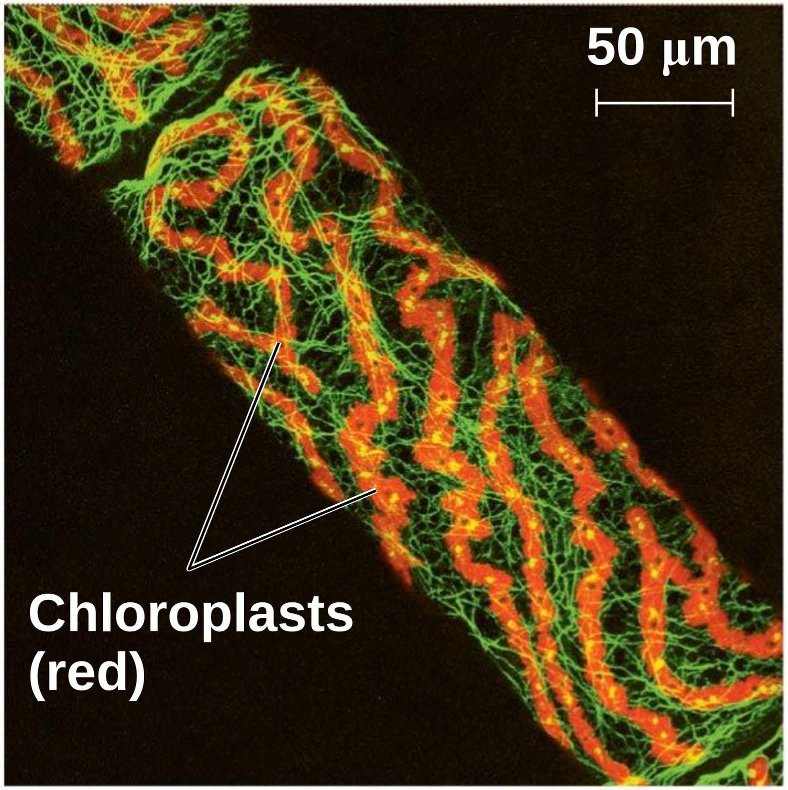


Figure 7.18b



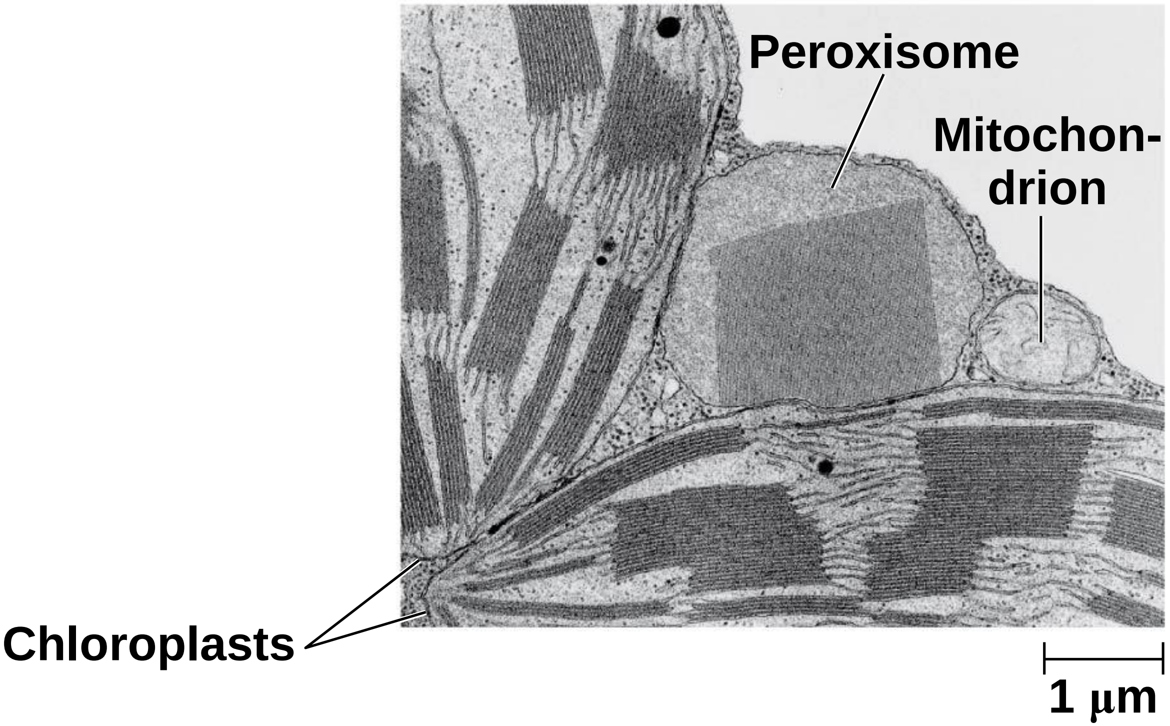
(b) Chloroplasts in an algal cell

- Chloroplast structure includes
  - **Thylakoids**, membranous sacs, stacked to form a **granum**
  - **Stroma**, the internal fluid
- The chloroplast is one of a group of plant organelles, called **plastids**

Peroxisomes: Oxidation

- **Peroxisomes** are specialized metabolic compartments bounded by a single membrane
- Peroxisomes produce hydrogen peroxide and convert it to water
- Peroxisomes perform reactions with many different functions
- How peroxisomes are related to other organelles is still unknown

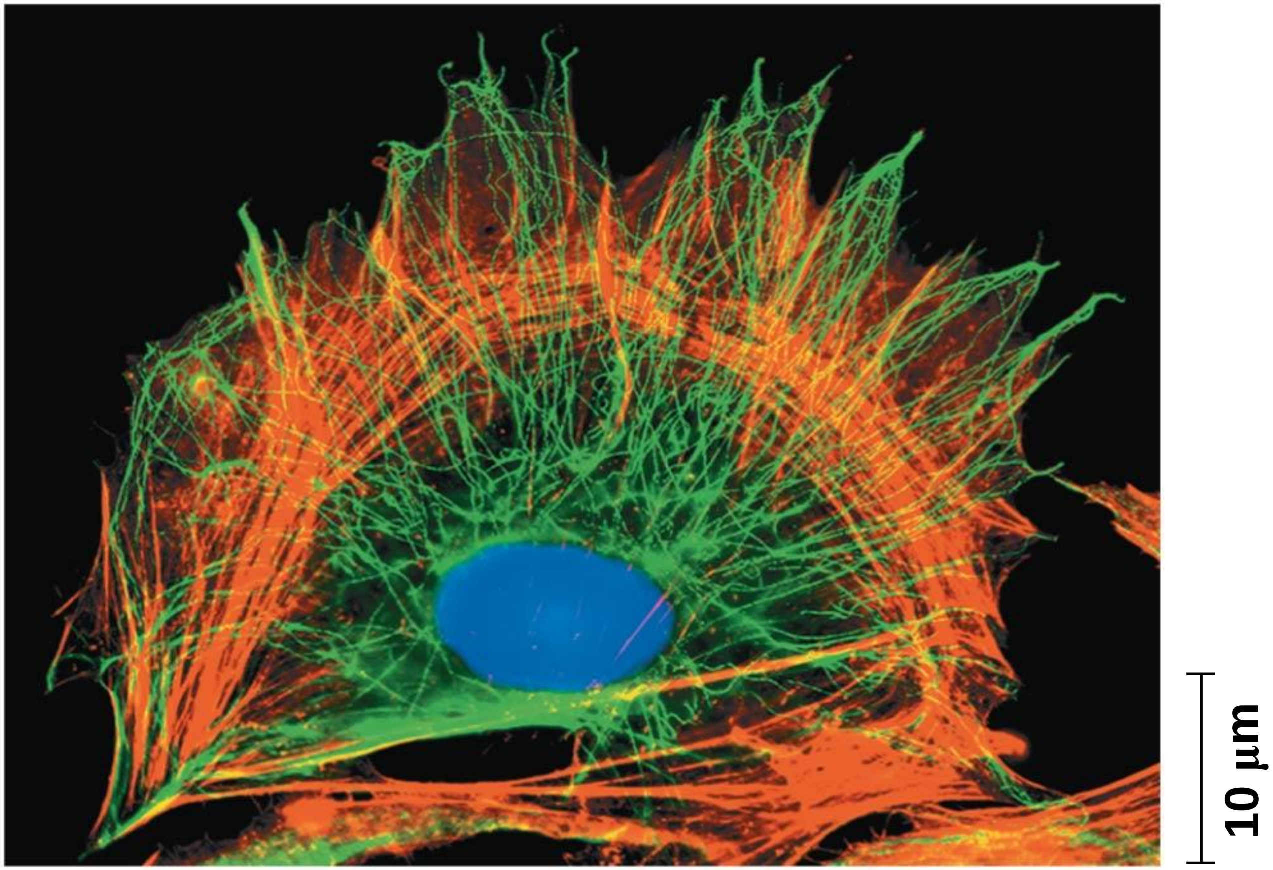
Figure 7.19



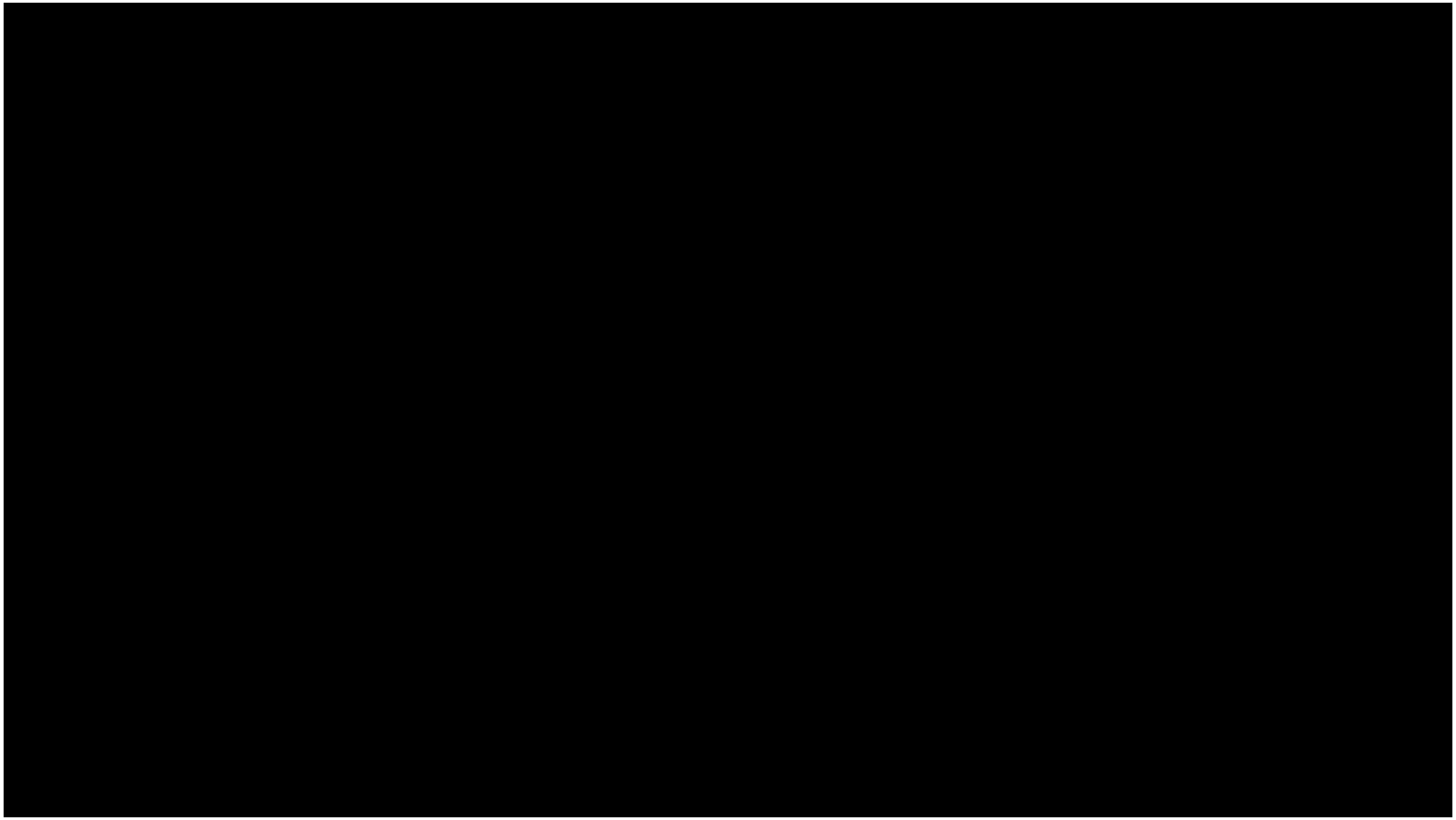
Concept 7.6: The cytoskeleton is a network of fibers that organizes structures and activities in the cell

- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm
- It organizes the cell’s structures and activities, anchoring many organelles
- It is composed of three types of molecular structures
  - Microtubules
  - Microfilaments
  - Intermediate filaments

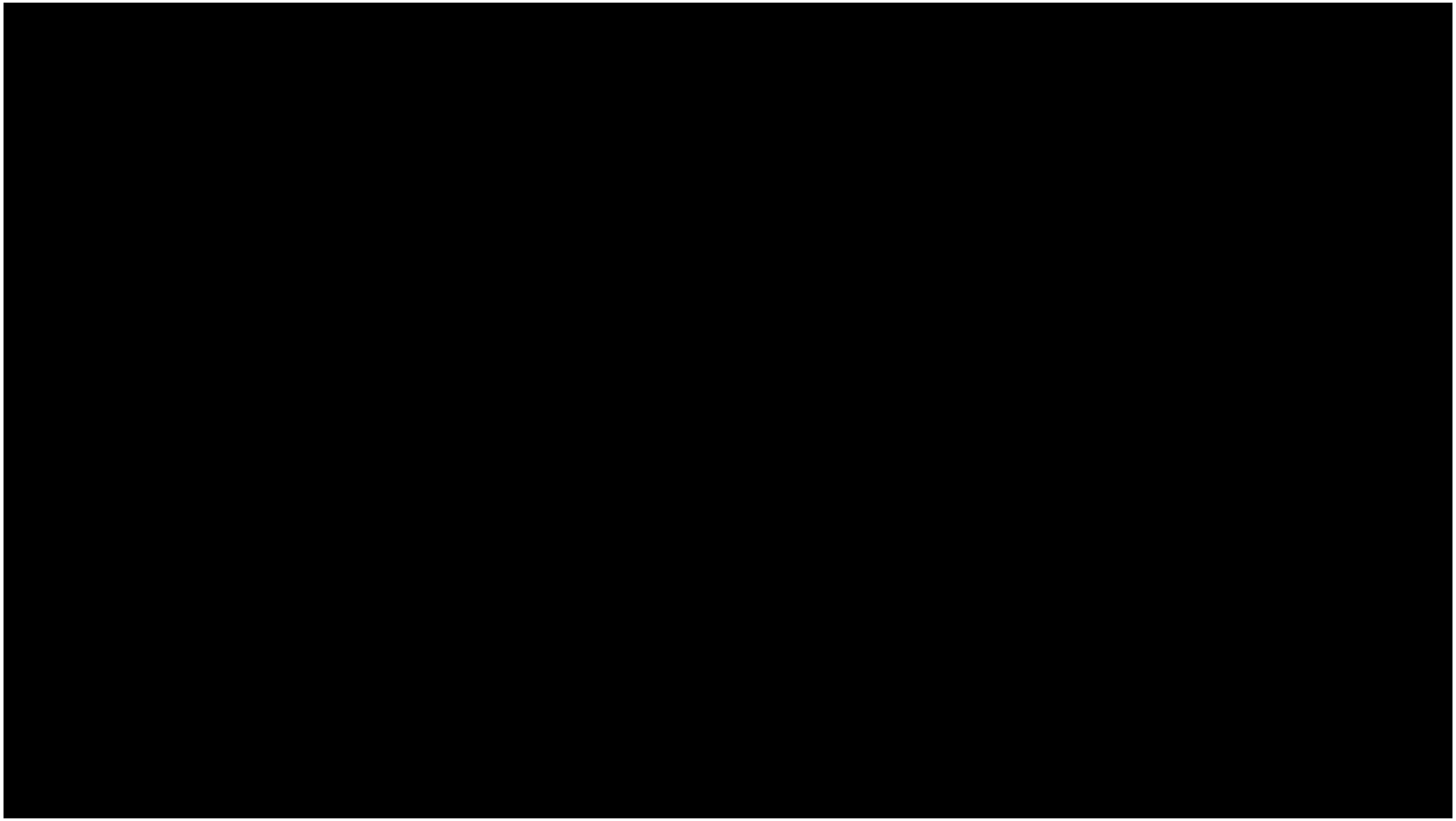
Figure 7.20



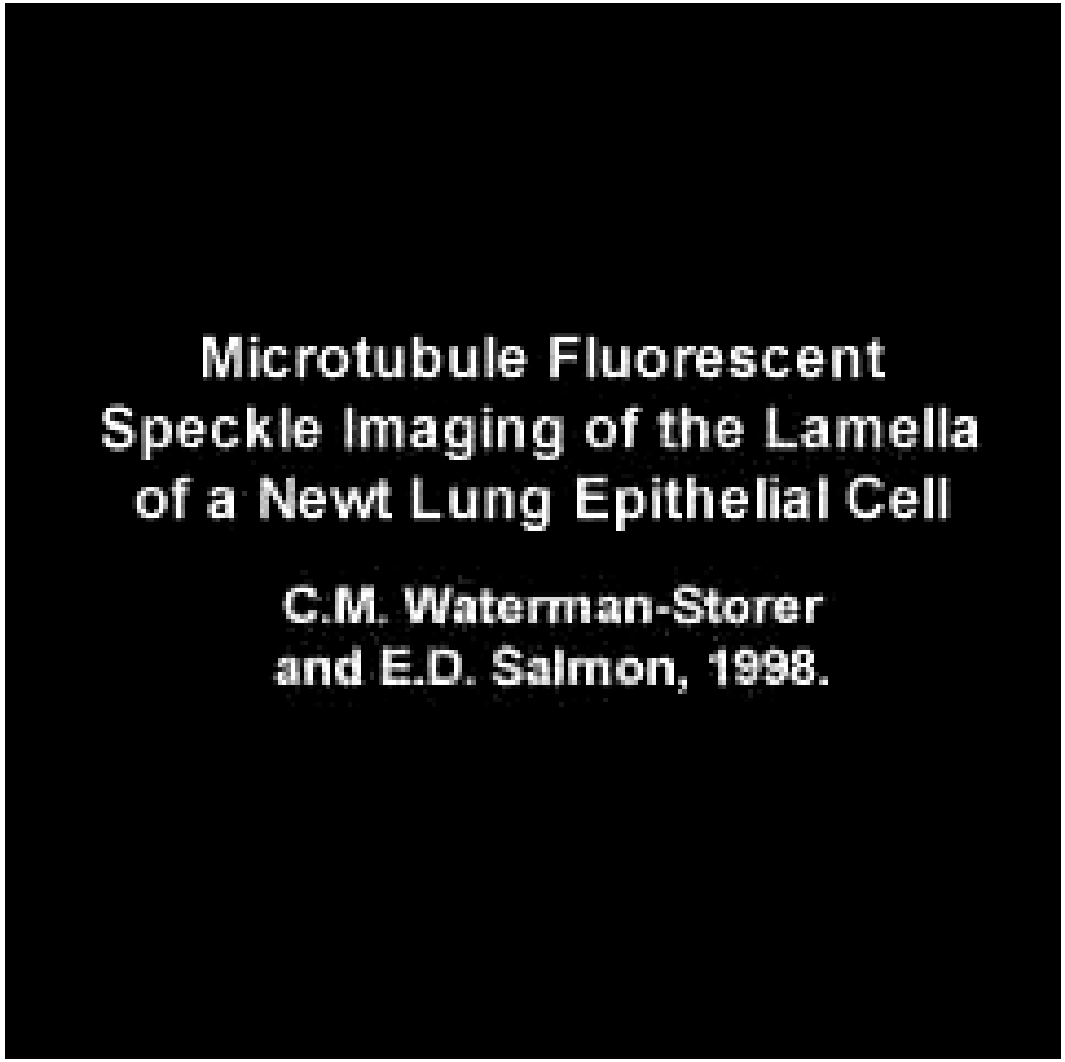
Video: The Cytoskeleton in Neuron Growth Cone



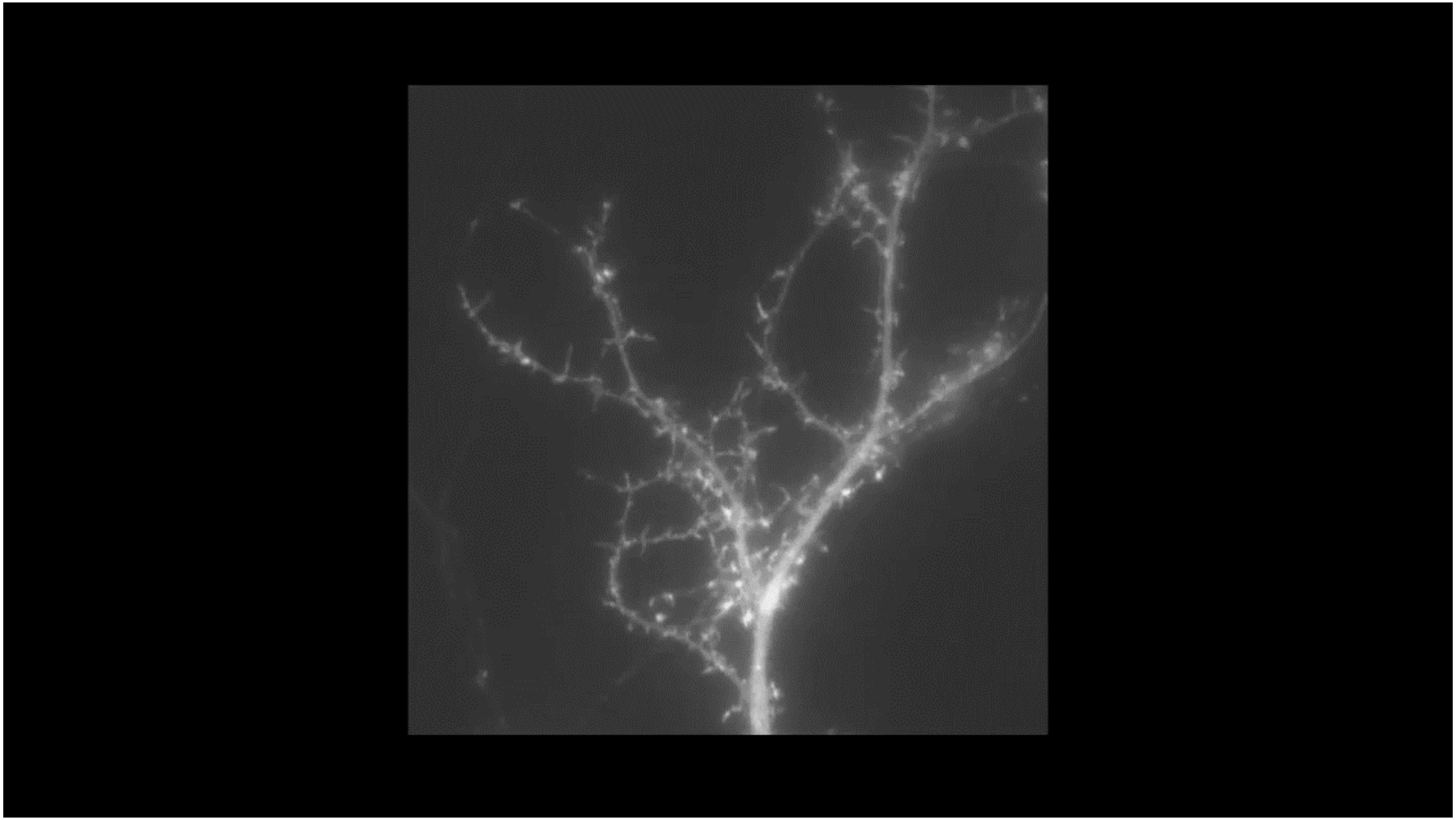
Video: Interphase Microtubule Dynamics



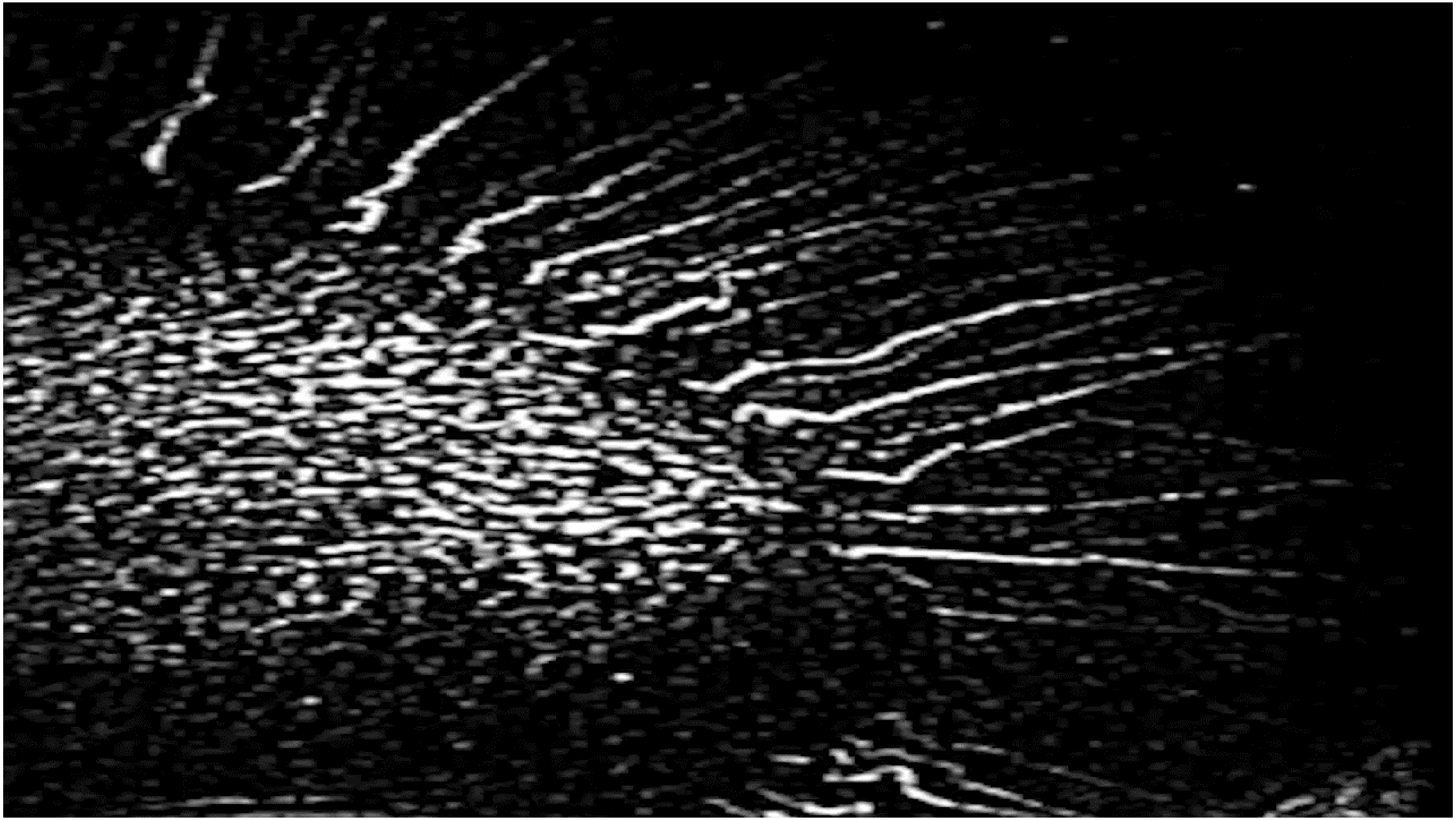
Video: Microtubule Dynamics



Video: Actin Visualization in Dendrites



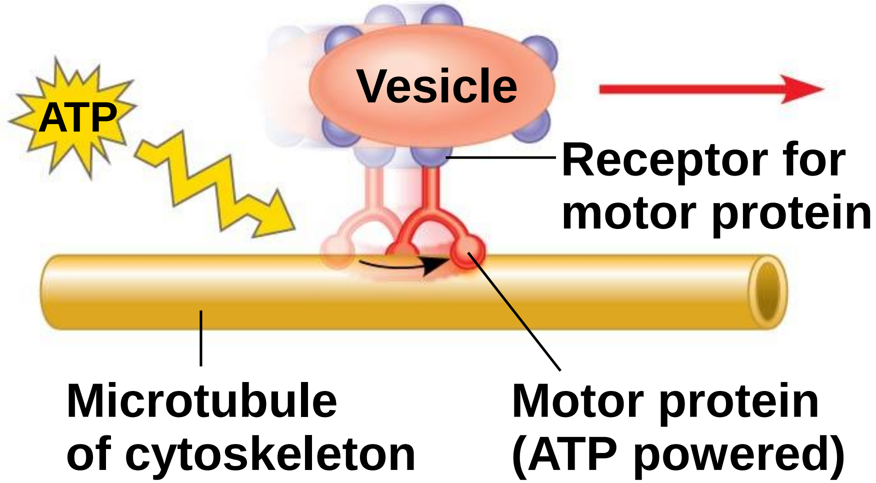
Video: Cytoskeletal Protein Dynamics



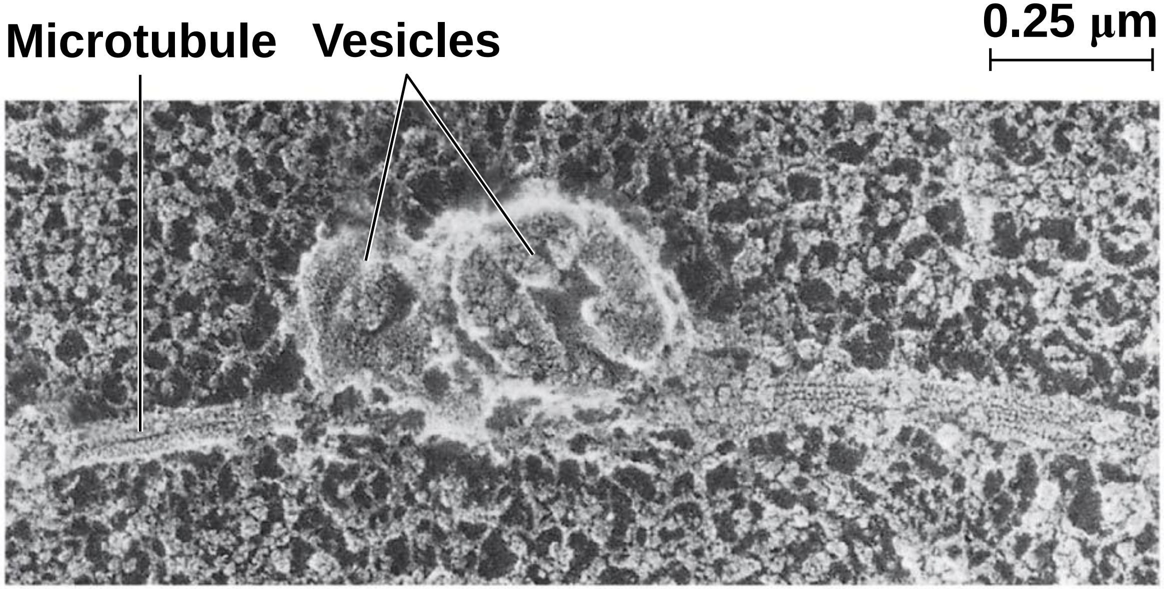
Roles of the Cytoskeleton: Support and Motility

- The cytoskeleton helps to support the cell and maintain its shape
- It interacts with **motor proteins** to produce cell motility
- Inside the cell, vesicles can travel along tracks provided by the cytoskeleton

Figure 7.21

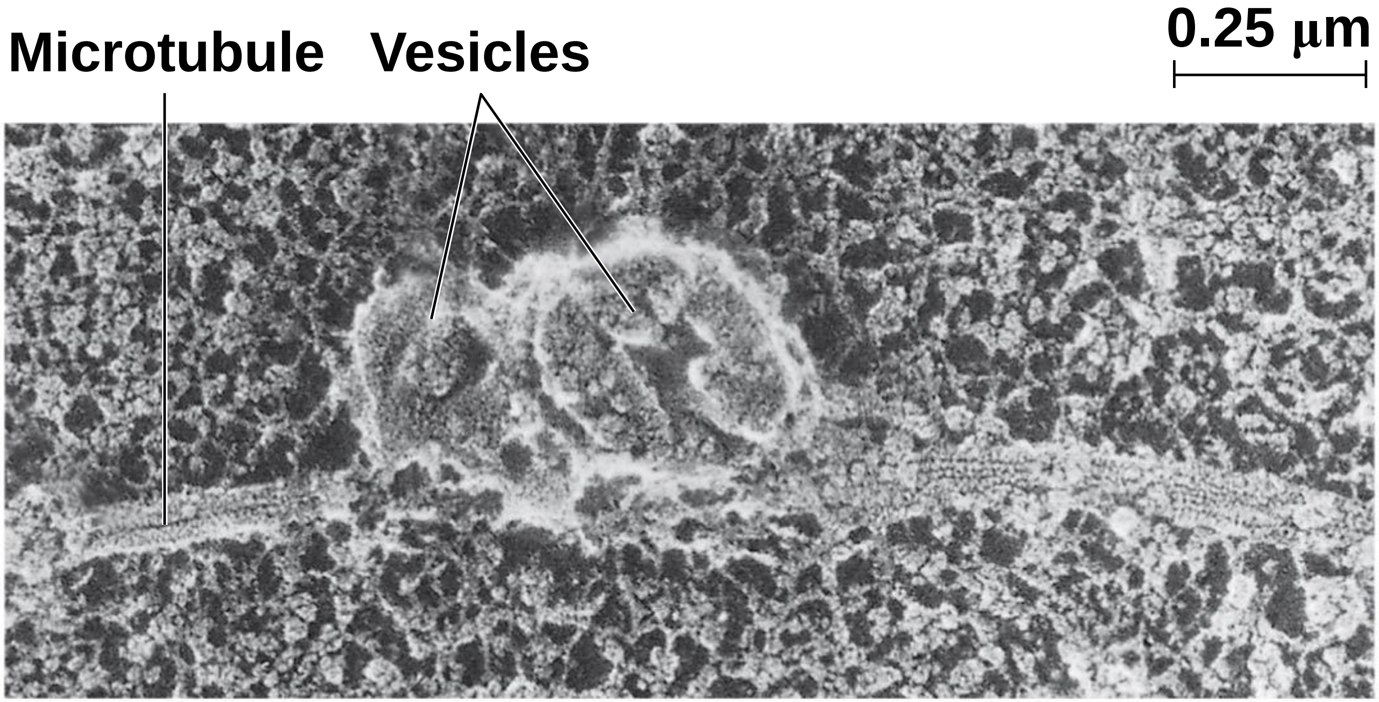


(a) Motor proteins "walk" vesicles along cytoskeletal fibers.



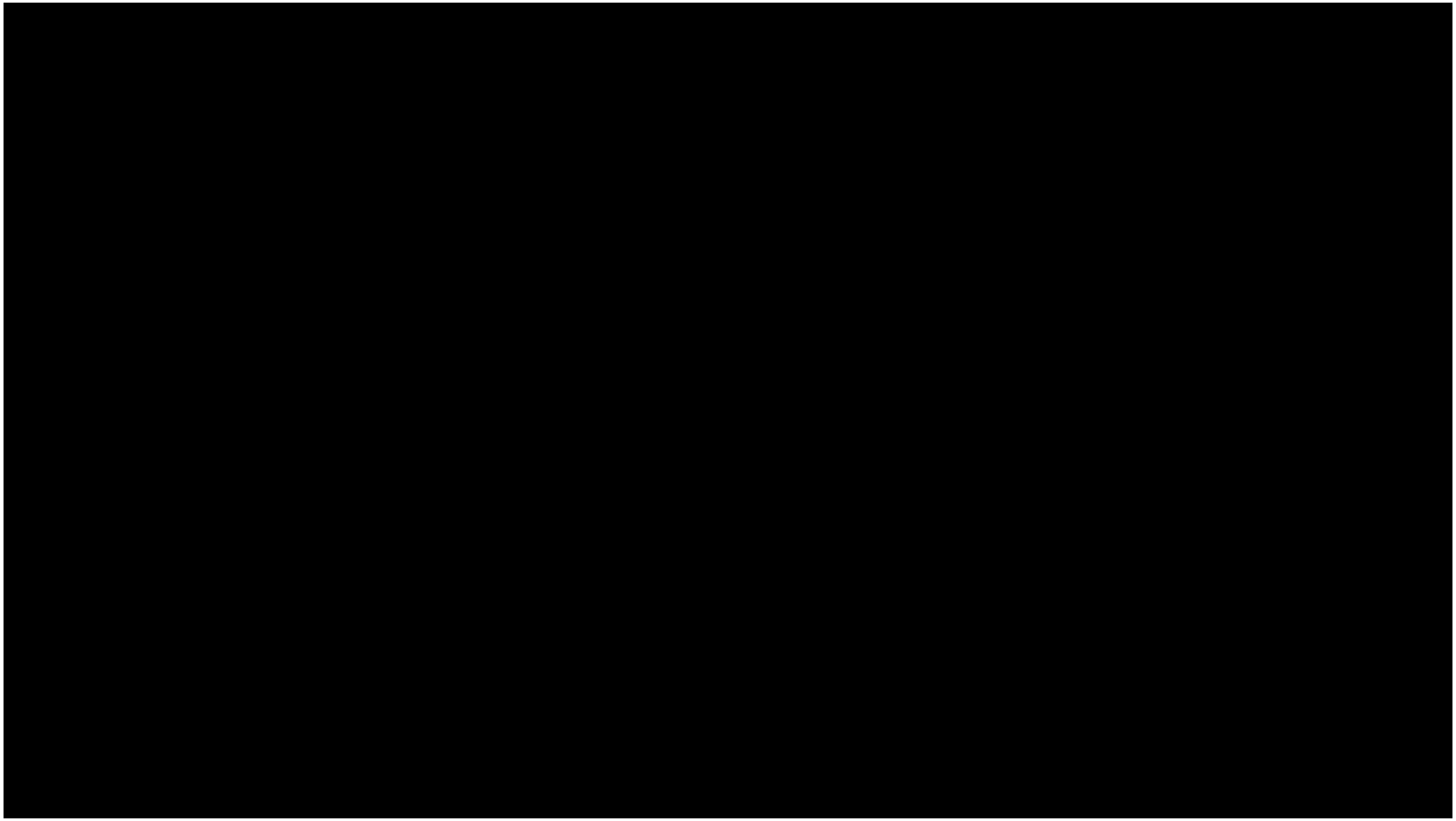
(b) Two vesicles move along a microtubule toward the tip of an axon (SEM).

Figure 7.21a

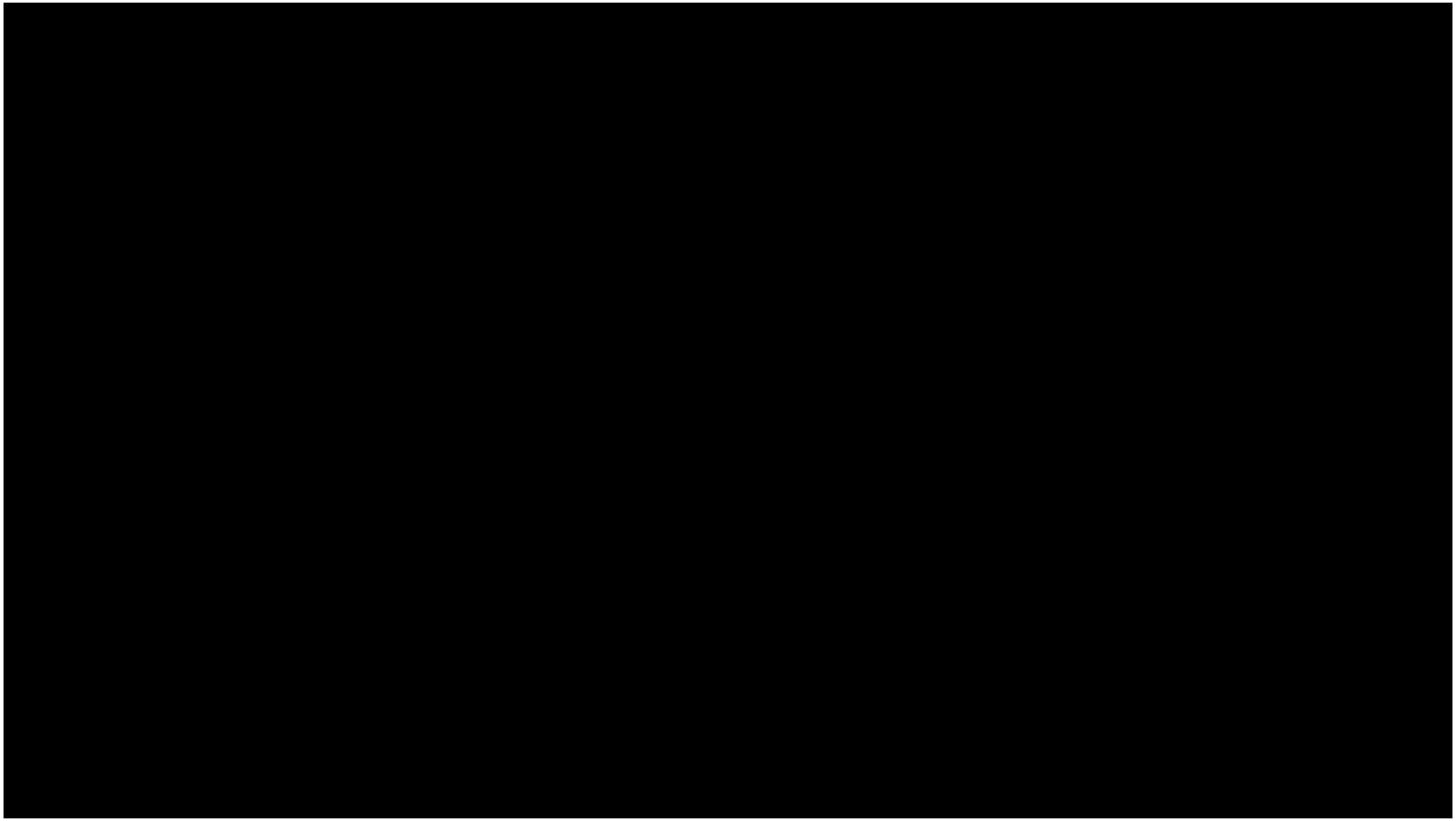


(b) Two vesicles move along a microtubule toward the tip of an axon (SEM).

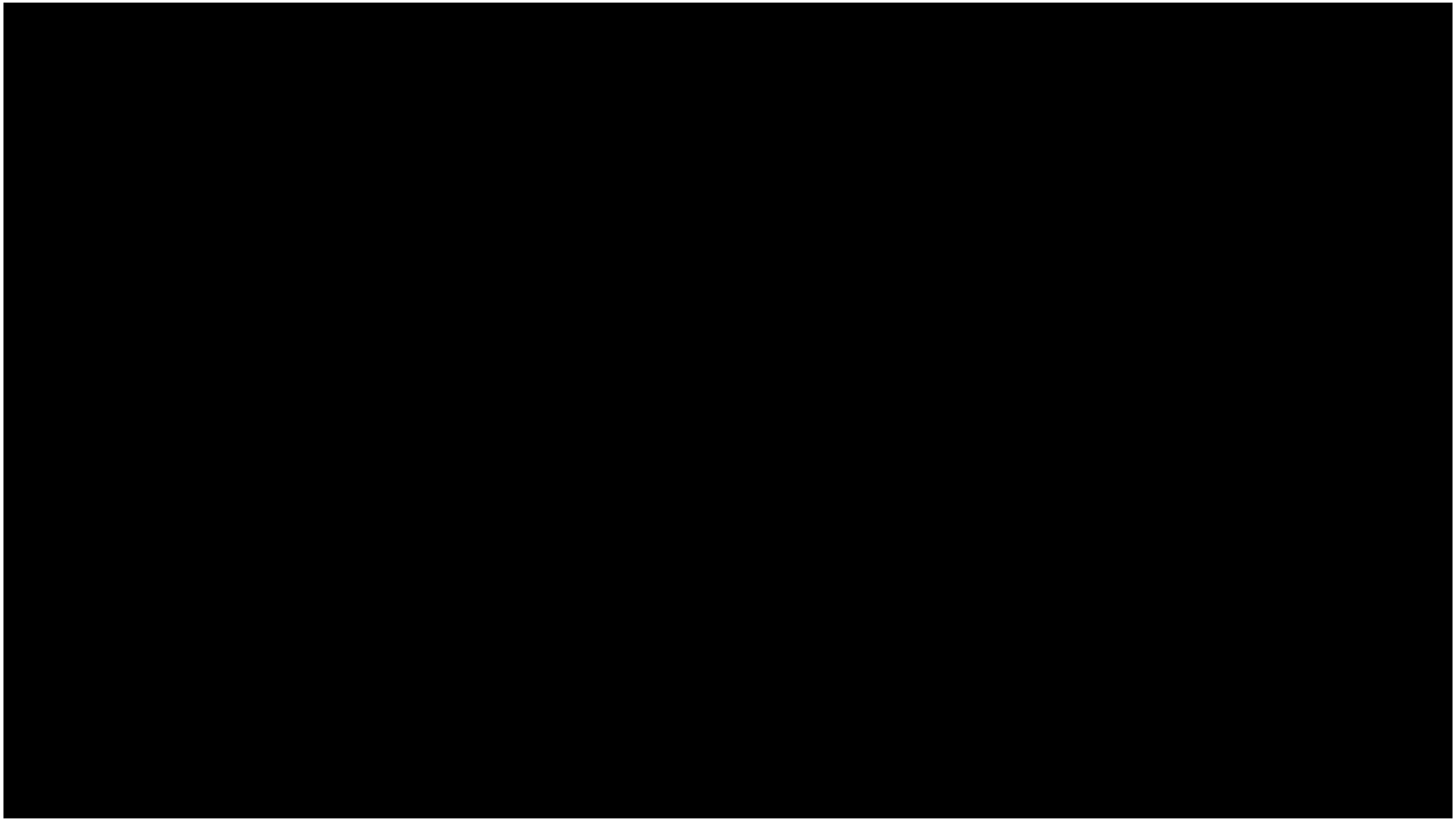
Video: Movement of Organelles *In Vitro*



Video: Movement of Organelles *In Vivo*



Video: Transport Along Microtubules



Components of the Cytoskeleton

- Three main types of fibers make up the cytoskeleton
  - Microtubules are the thickest of the three components of the cytoskeleton
  - Microfilaments, also called actin filaments, are the thinnest components
  - Intermediate filaments are fibers with diameters in a middle range

Figure 7.T01

Table 7.1 The Structure and Function of the Cytoskeleton

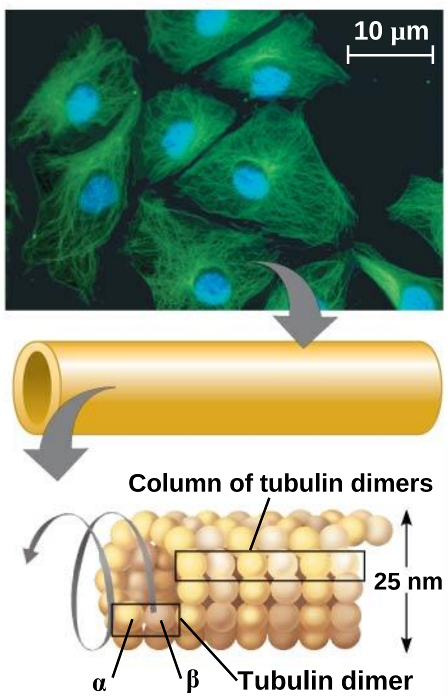
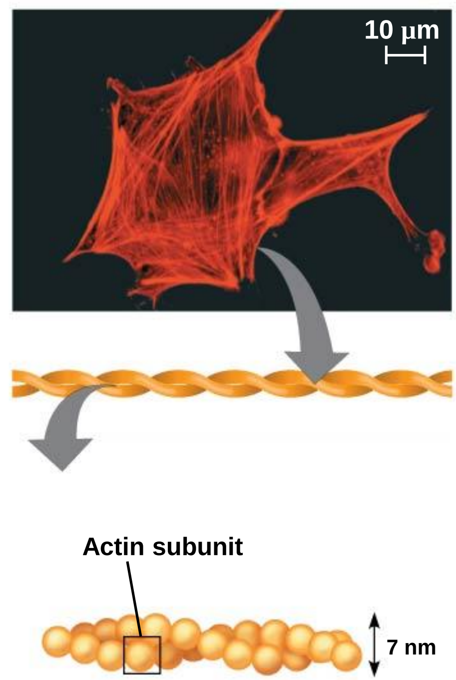
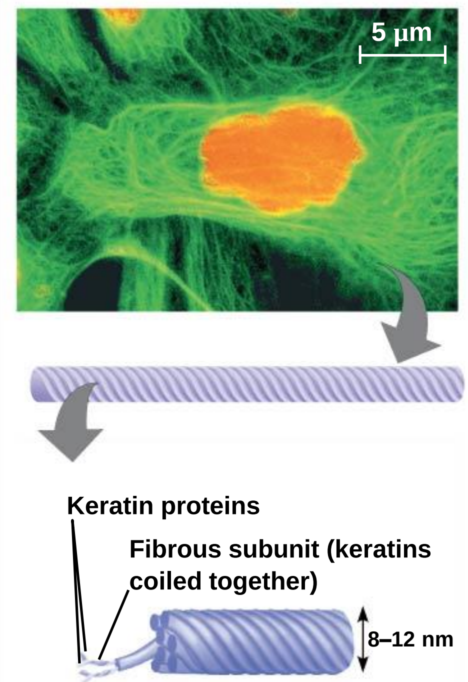
Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
Main functions	Maintenance of cell shape (compression-resisting “girder”); cell motility (as in cilia or flagella); chromosome movements in cell division; organelle movements	Maintenance of cell shape (tension-bearing elements); changes in cell shape; muscle contraction; cytoplasmic streaming in plant cells; cell motility (as in amoeboid movement); division of animal cells	Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina
Fluorescence micrographs of fibroblasts. Fibroblasts are a favorite cell type for cell biology studies because they spread out flat and their internal structures are easy to see. In each, the structure of interest has been tagged with fluorescent molecules. The DNA in the nucleus has also been tagged in the first micrograph (blue) and third micrograph (orange).			

Figure 7.T01a

Table 7.1 The Structure and Function of the Cytoskeleton

Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
25 nm with 15-nm lumen	7 nm	8–12 nm
Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
Maintenance of cell shape (compression-resisting "girders"); cell motility (as in cilia or flagella); chromosome movements in cell division; organelle movements	Maintenance of cell shape (tension-bearing elements); changes in cell shape; muscle contraction; cytoplasmic streaming in plant cells; cell motility (as in amoeboid movement); division of animal cells	Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina

Figure 7.T01b

Microtubules (Tubulin Polymers)
Hollow tubes
25 nm with 15-nm lumen
Tubulin, a dimer consisting of α-tubulin and β-tubulin
Maintenance of cell shape (compression-resisting “girder”); cell motility (as in cilia or flagella); chromosome movements in cell division; organelle movements

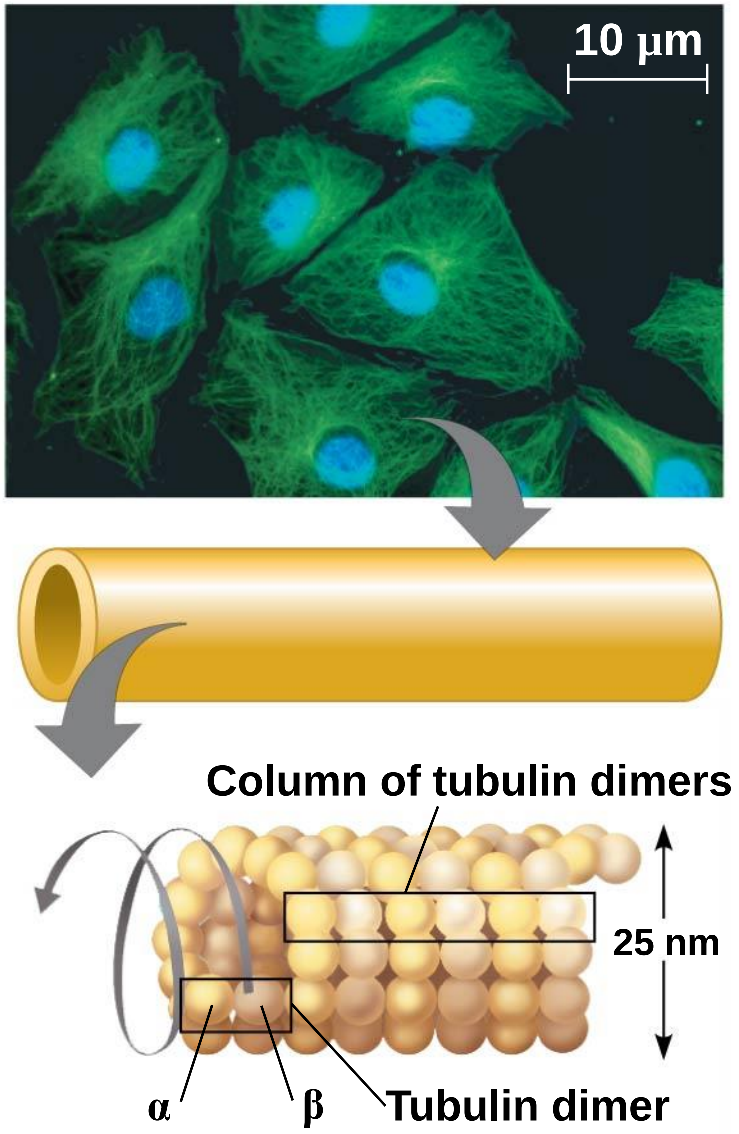


Figure 7.T01ba

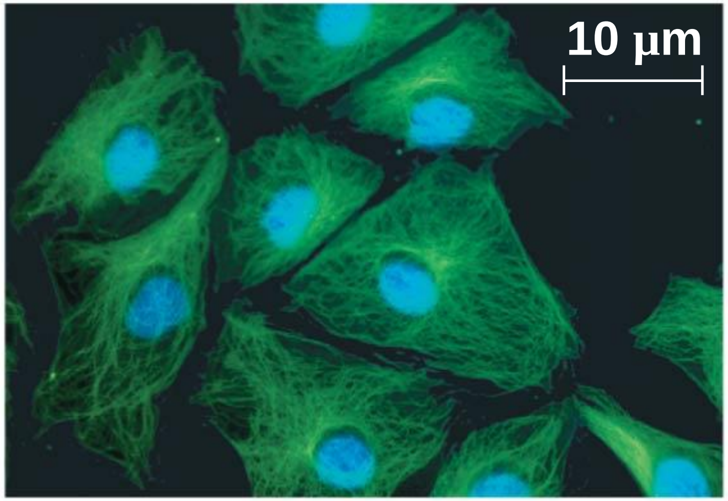


Figure 7.T01c

Microfilaments (Actin Filaments)
Two intertwined strands of actin
7 nm
Actin
Maintenance of cell shape (tension-bearing elements); changes in cell shape; muscle contraction; cytoplasmic streaming in plant cells; cell motility (as in amoeboid movement); division of animal cells

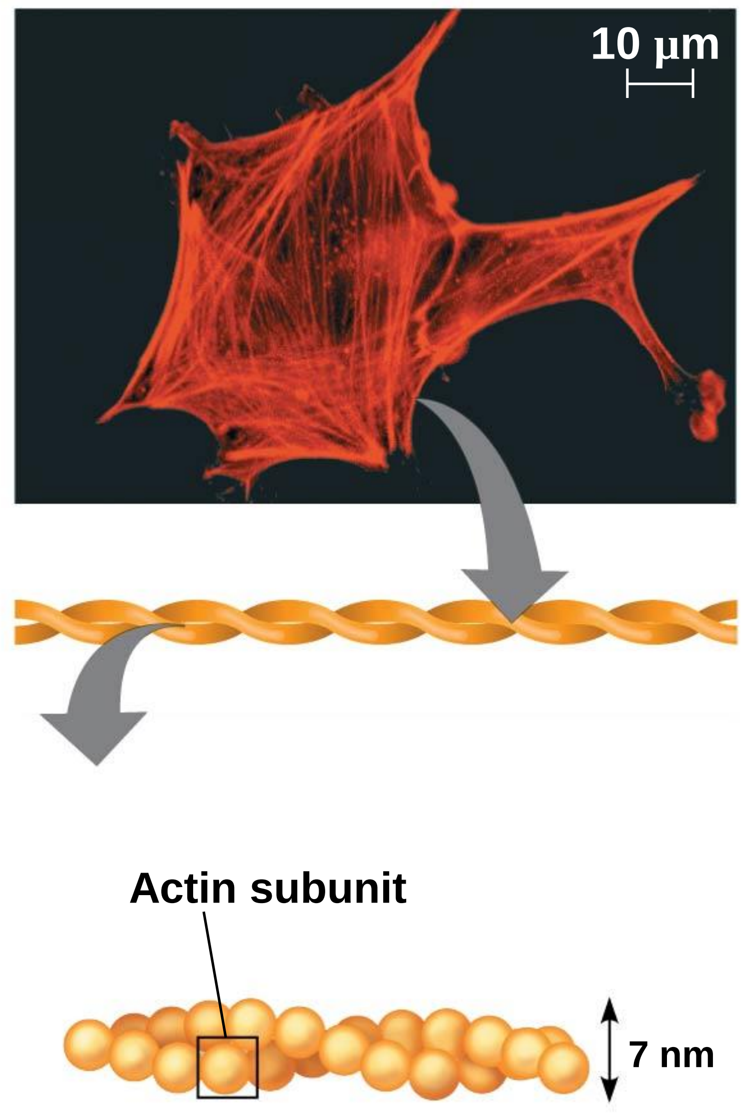


Figure 7.T01ca

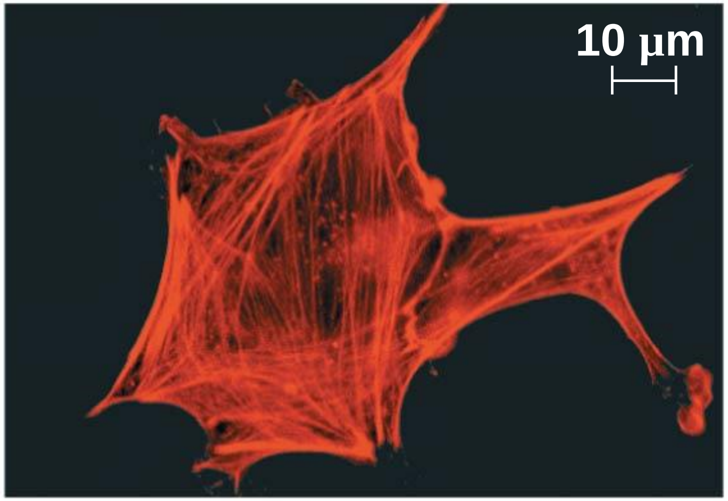


Figure 7.T01d

Intermediate Filaments
Fibrous proteins coiled into cables
8–12 nm
One of several different proteins (such as keratins)
Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina

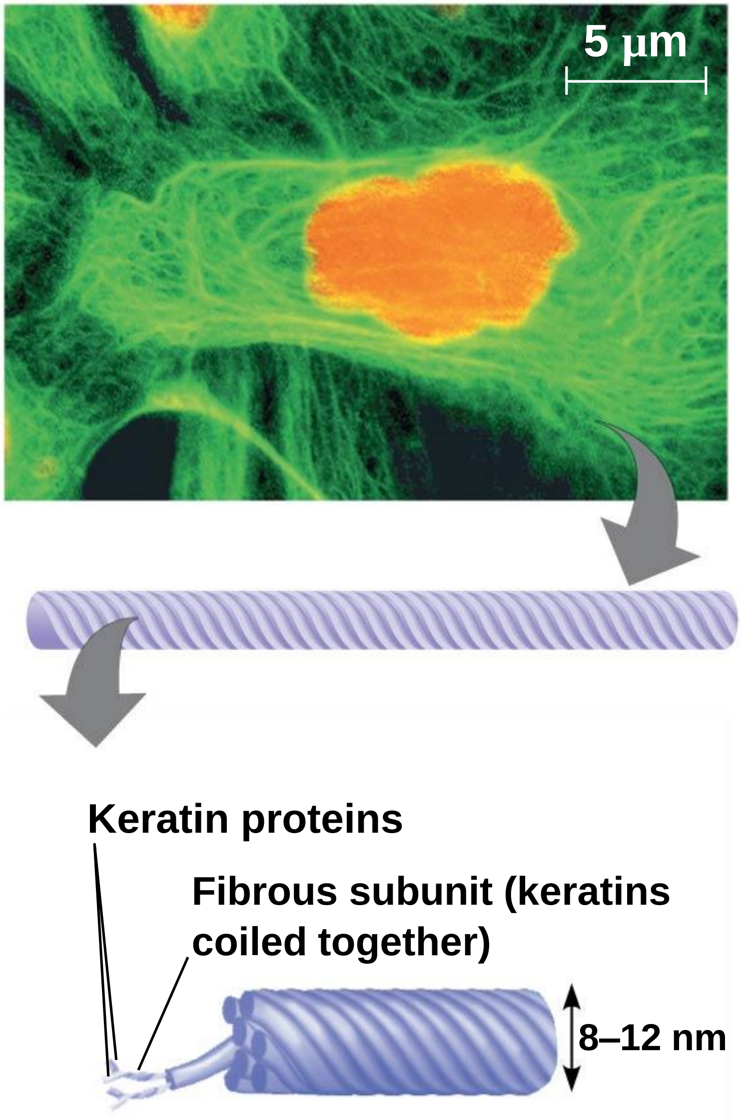
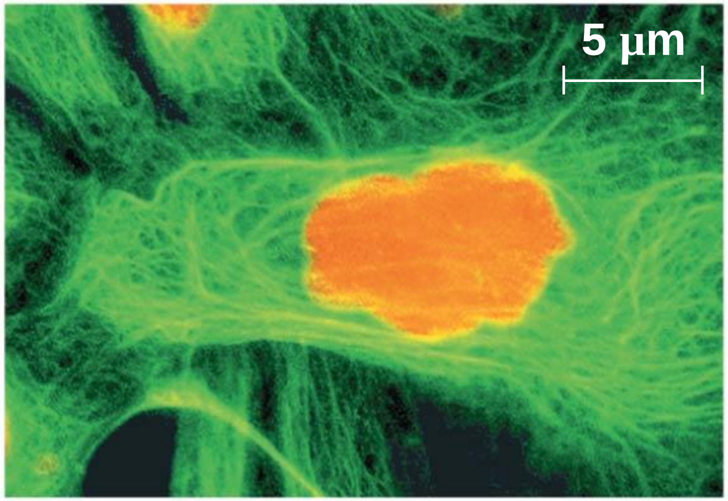


Figure 7.T01da



Microtubules

- **Microtubules** are hollow rods about 25 nm in diameter and about 200 nm to 25 microns long
- Microtubules are constructed of dimers of tubulin
- Functions of microtubules:
  - Shaping the cell
  - Guiding movement of organelles
  - Separating chromosomes during cell division

Centrosomes and Centrioles

- In animal cells, microtubules grow out from a **centrosome** near the nucleus
- In animal cells, the centrosome has a pair of **centrioles**, each with nine triplets of microtubules arranged in a ring

Figure 7.22

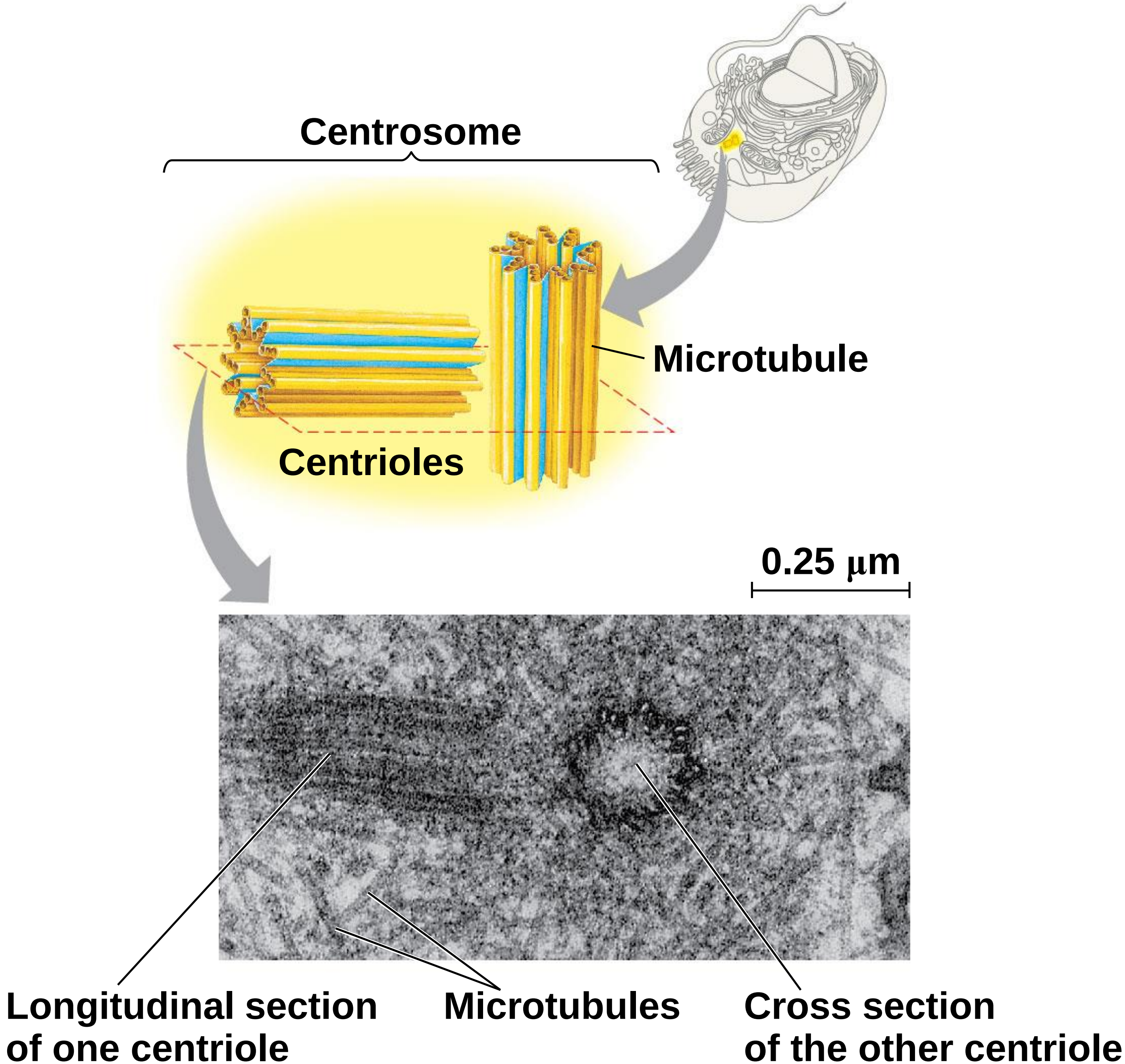
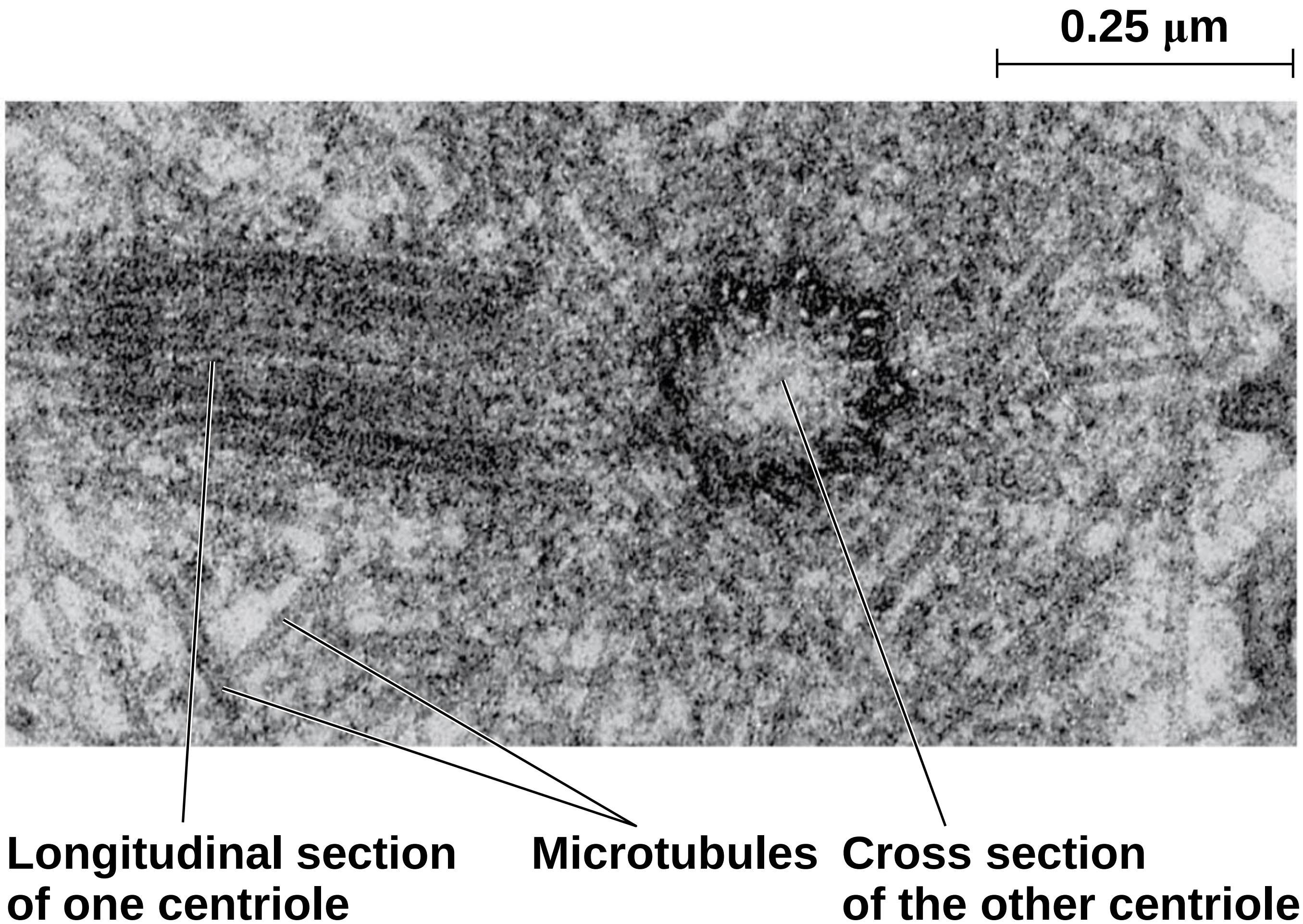

Centrosome
Microtubule
Centrioles
0.25 μm
Longitudinal section
of one centriole
Microtubules
Cross section
of the other centriole

Figure 7.22a


0.25 µm
Longitudinal section
of one centriole
Microtubules
Cross section
of the other centriole

Cilia and Flagella

- Microtubules control the beating of **flagella** and **cilia**, microtubule-containing extensions that project from some cells
- Many unicellular eukaryotes are propelled through water by cilia or flagella
- Cilia and flagella differ in their beating patterns

Figure 7.23

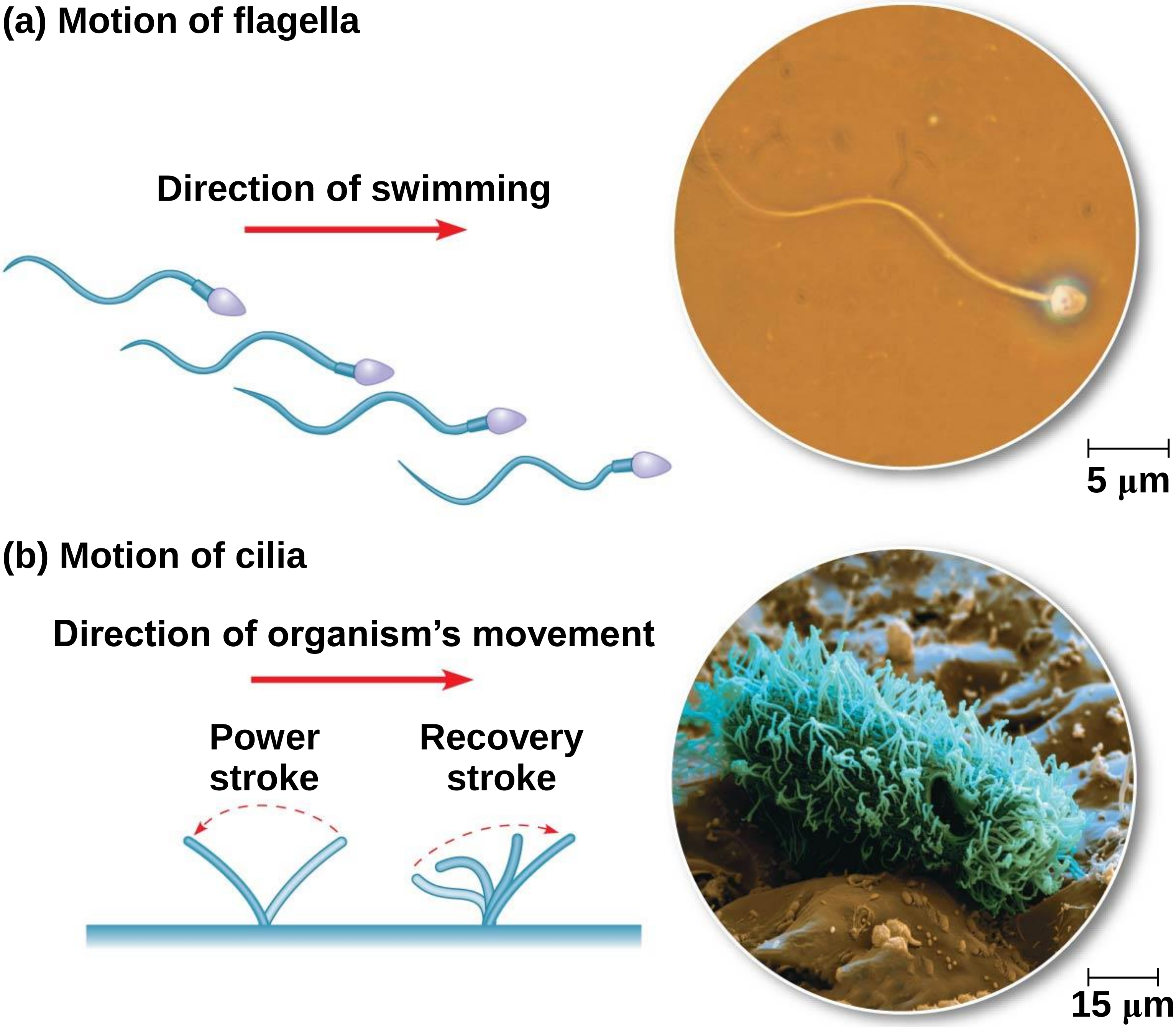

(a) Motion of flagella
Direction of swimming
5 µm
(b) Motion of cilia
Direction of organism's movement
Power stroke
Recovery stroke
15 µm

Figure 7.23a

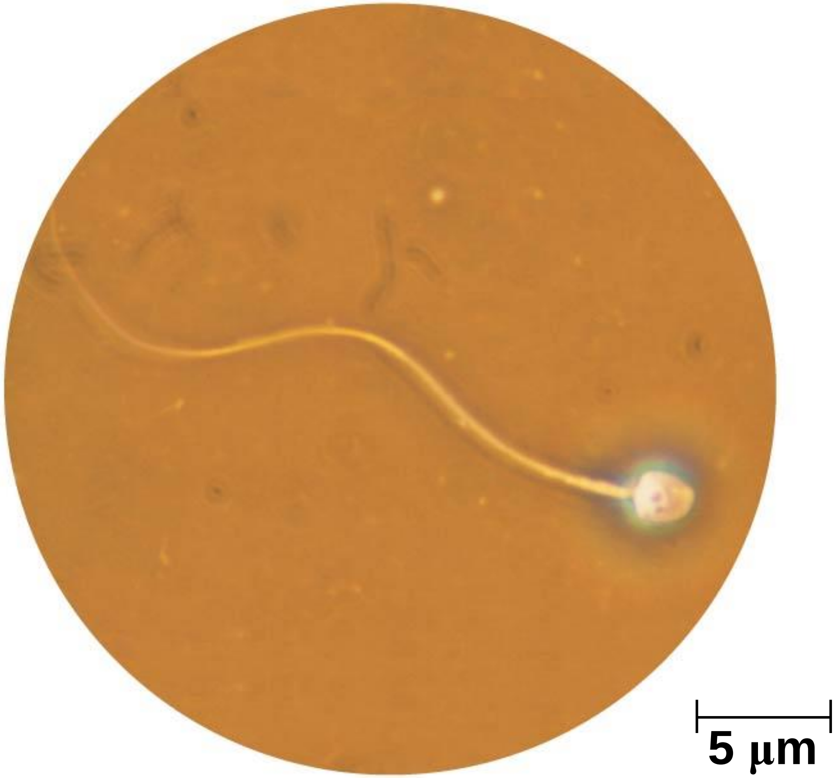
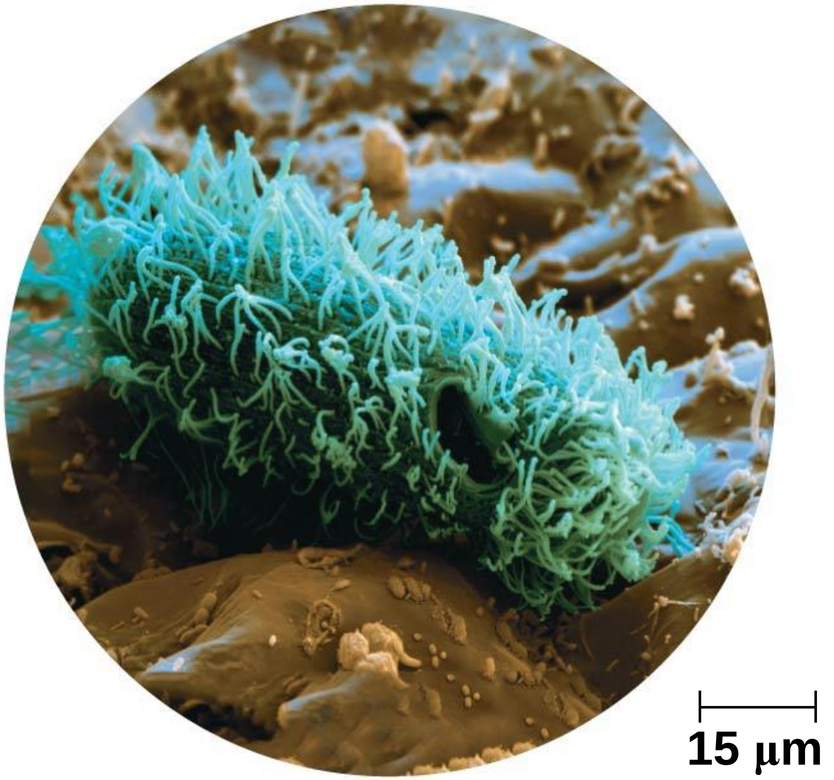
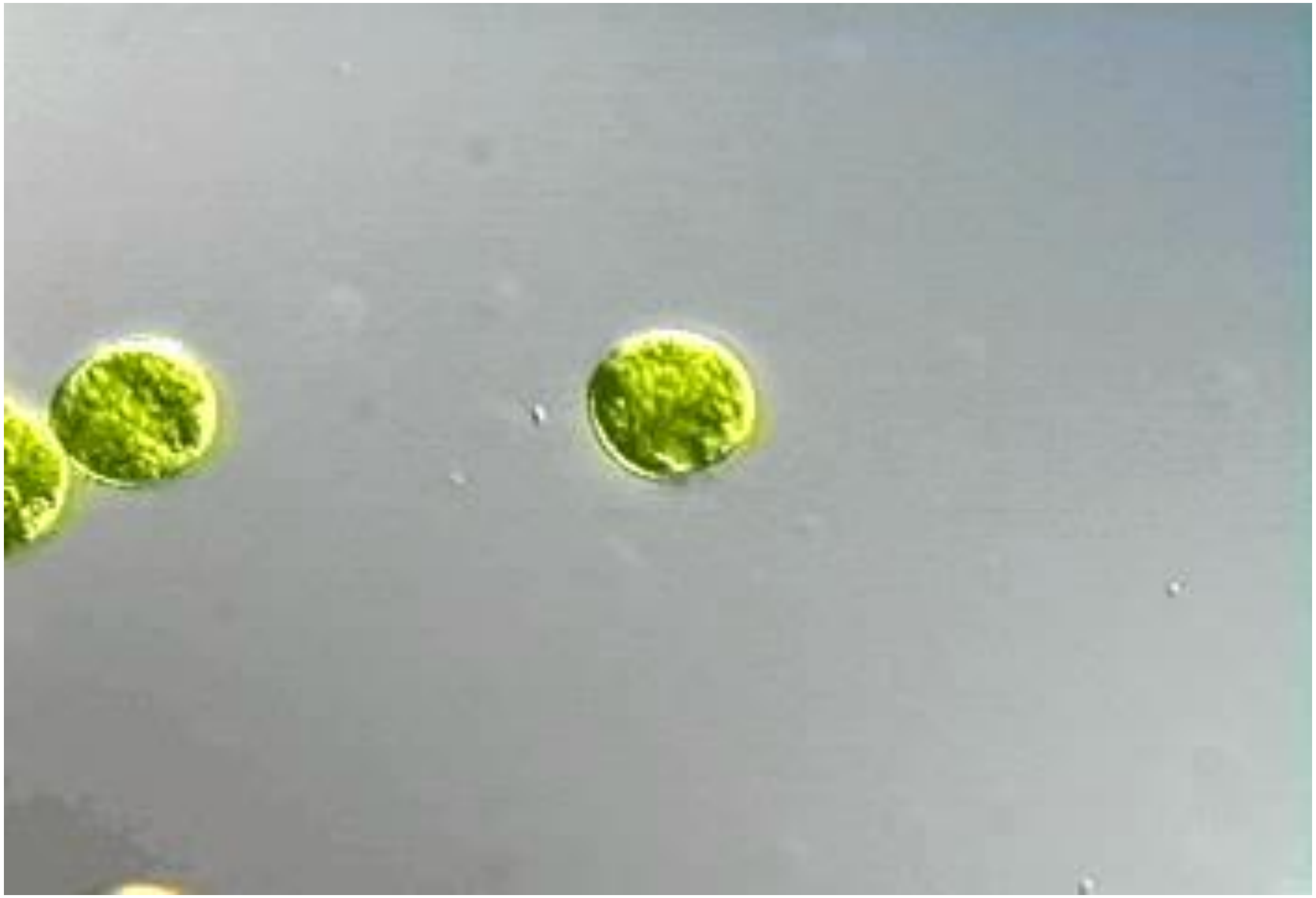


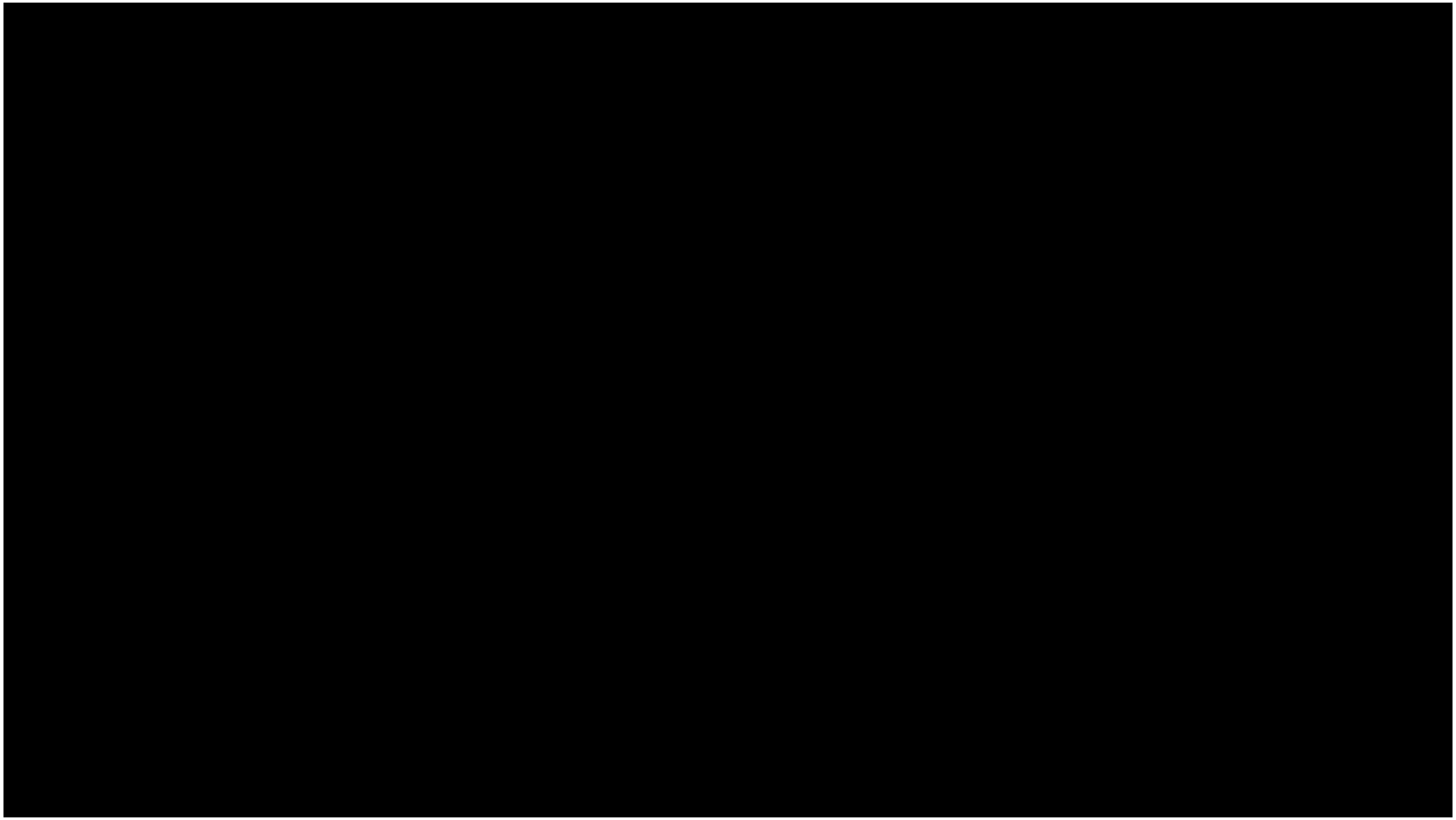
Figure 7.23b



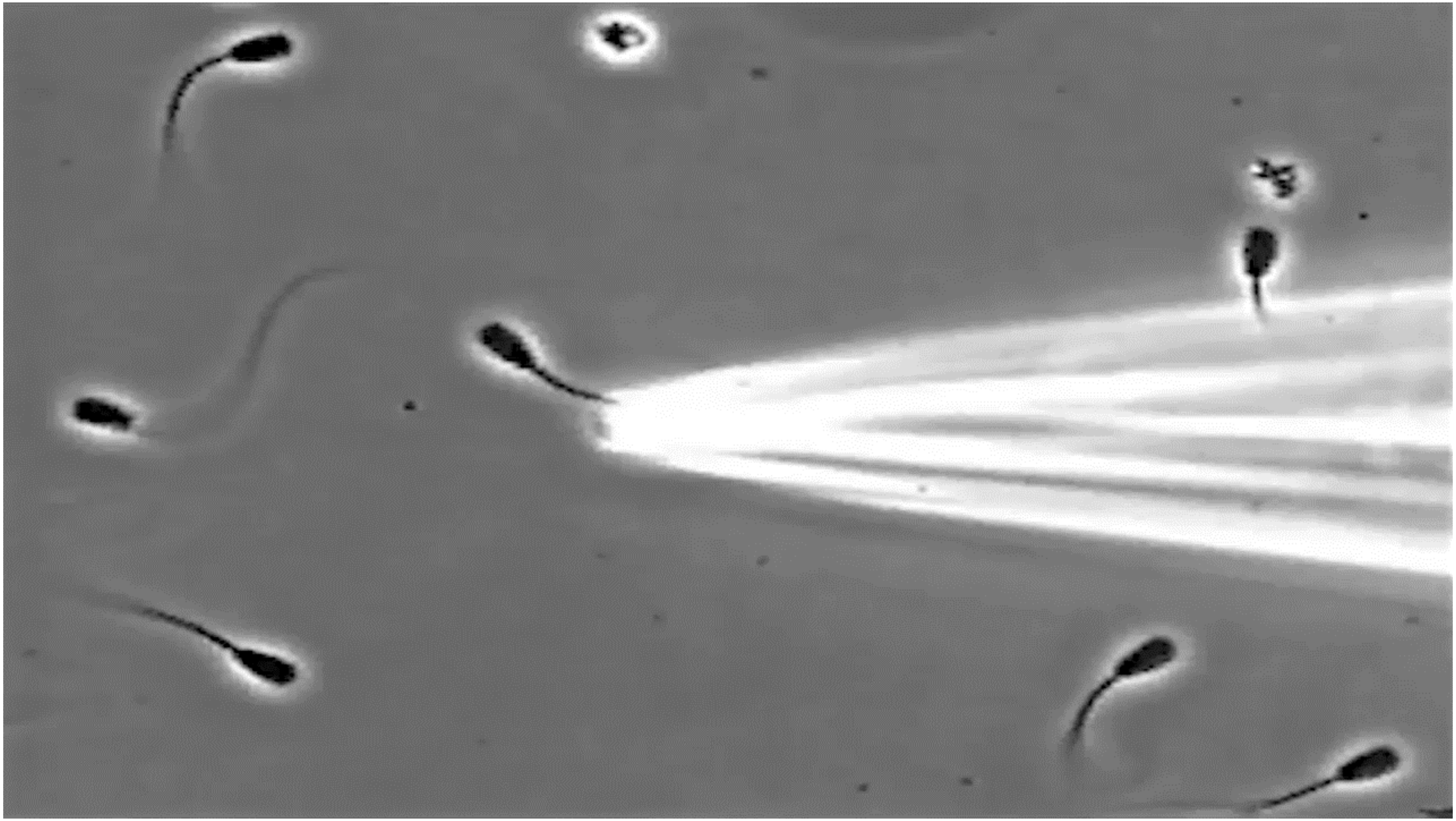
Video: *Chlamydomonas*



Video: Flagellum Movement in Swimming Sperm



Video: Motion of Isolated Flagellum

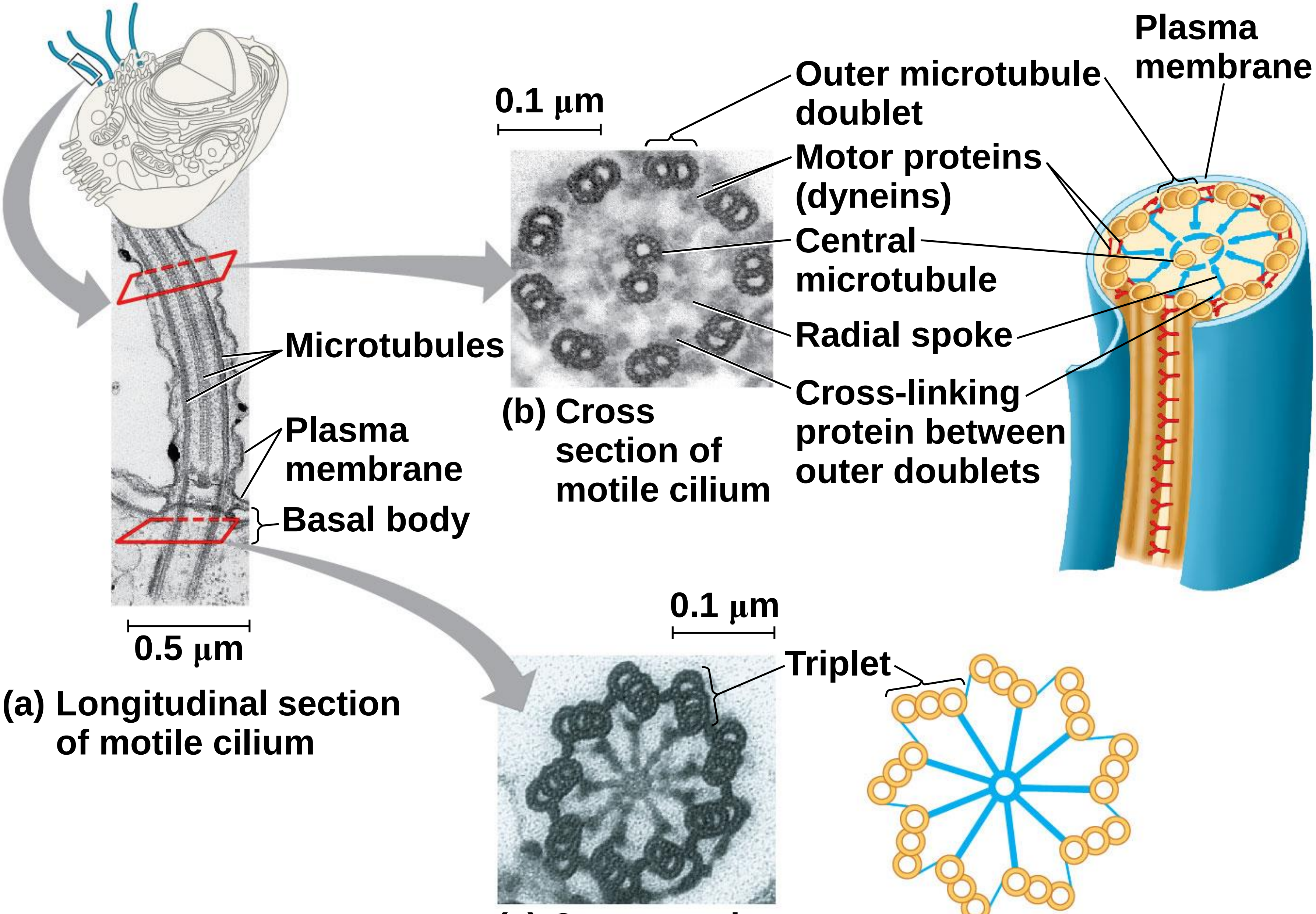


Video: *Paramecium* Cilia

Video: Ciliary Motion

- Cilia and flagella share a common structure
  - A group of microtubules sheathed by an extension of the plasma membrane
  - A **basal body** that anchors the cilium or flagellum
  - A motor protein called **dynein**, which drives the bending movements of a cilium or flagellum

Figure 7.24

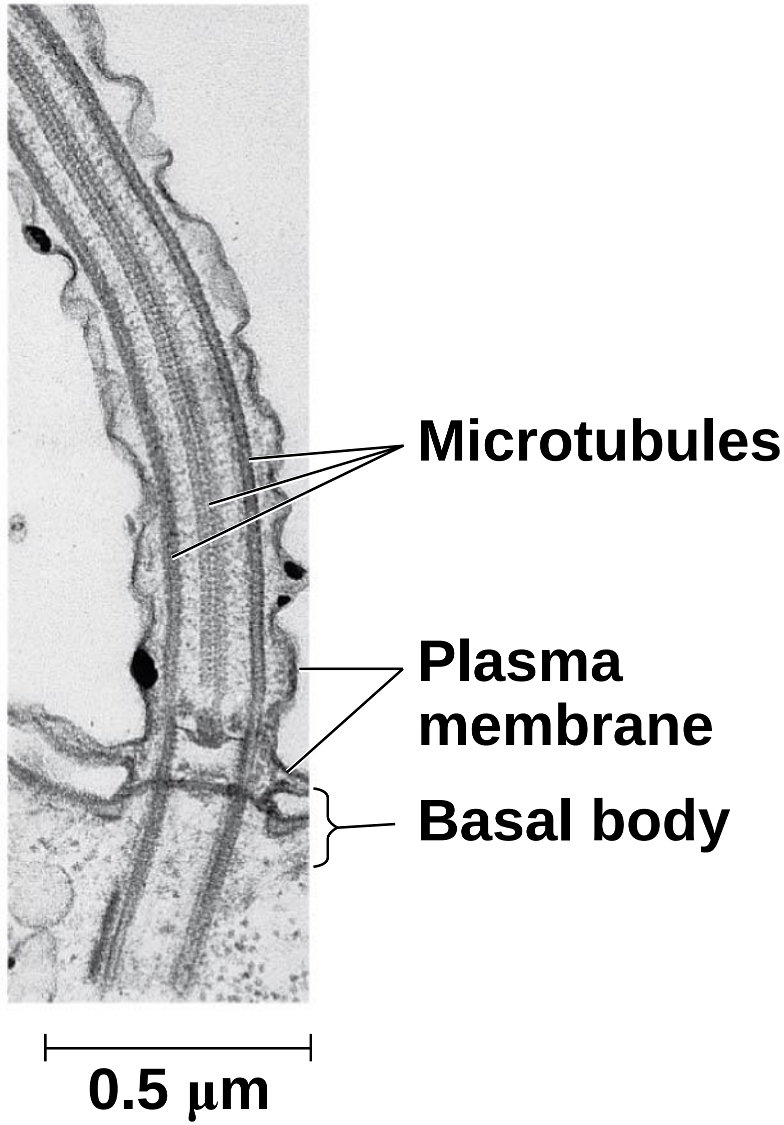


(a) Longitudinal section of motile cilium

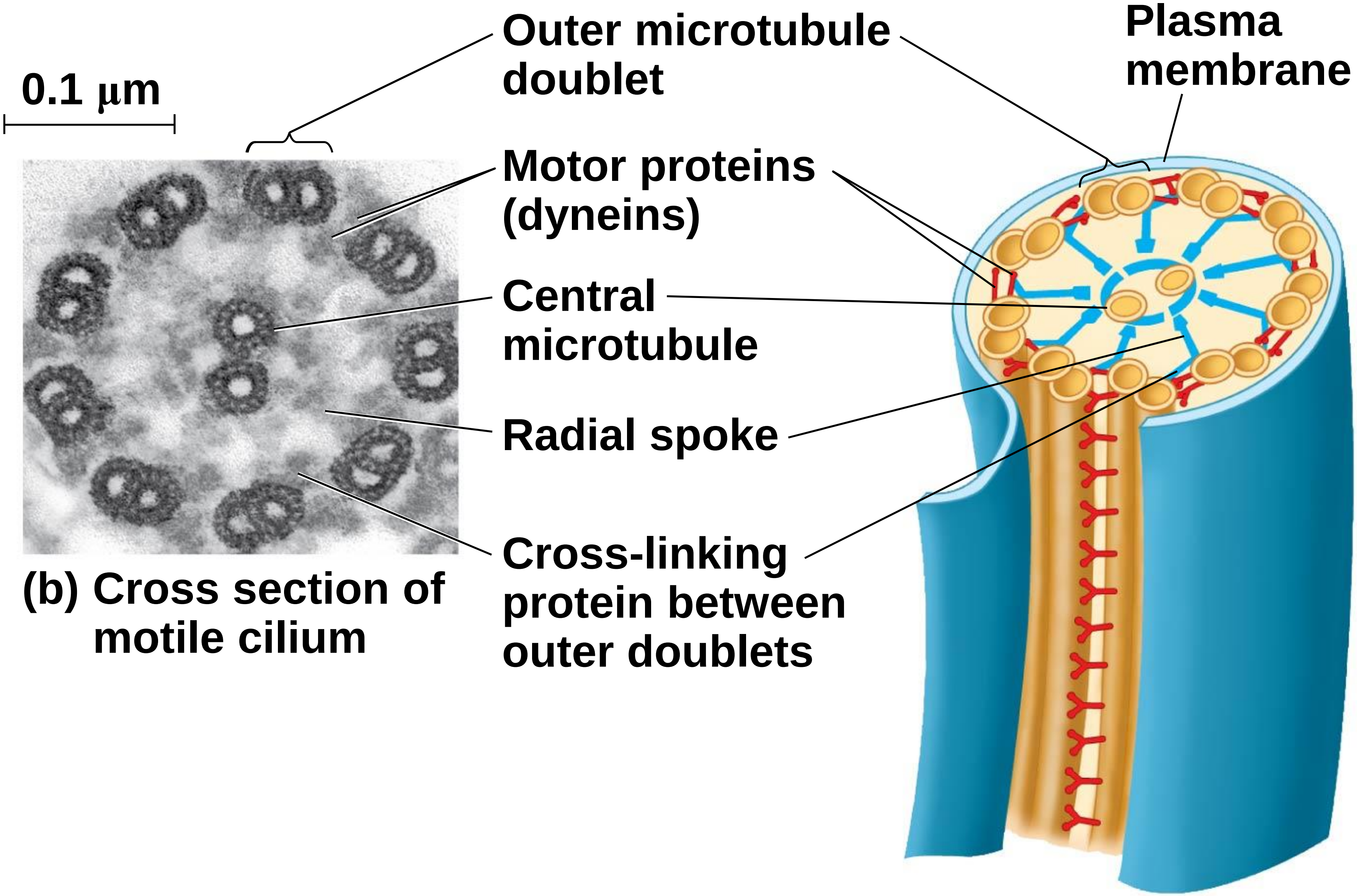
(b) Cross section of motile cilium

(c) Cross section of basal body

Figure 7.24a

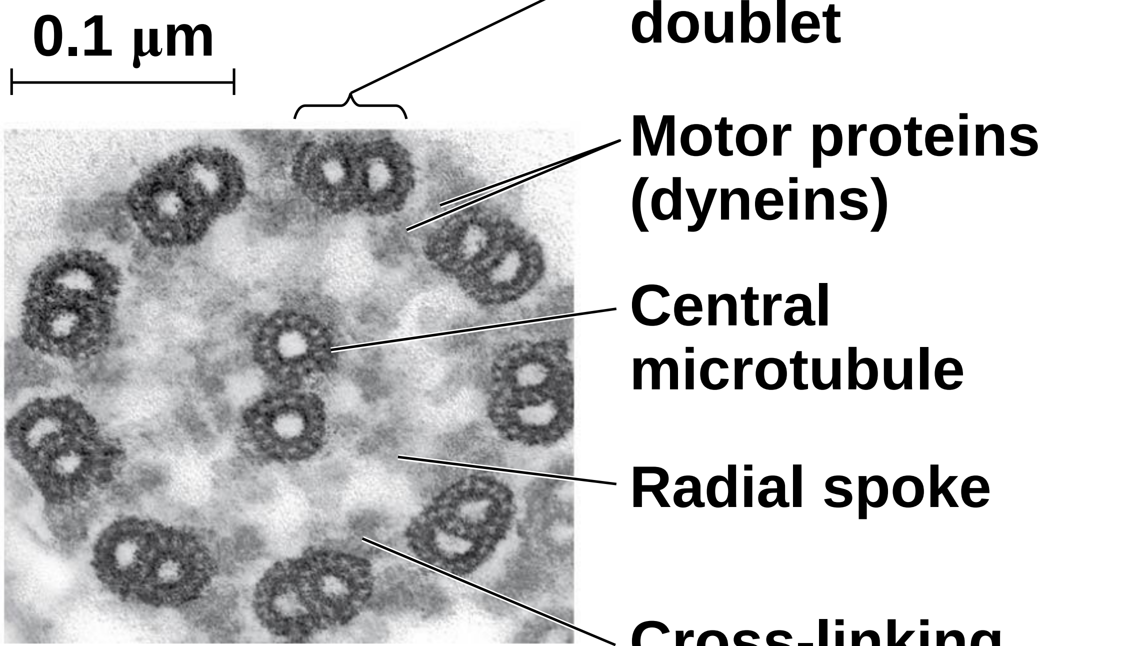


(a) Longitudinal section of motile cilium



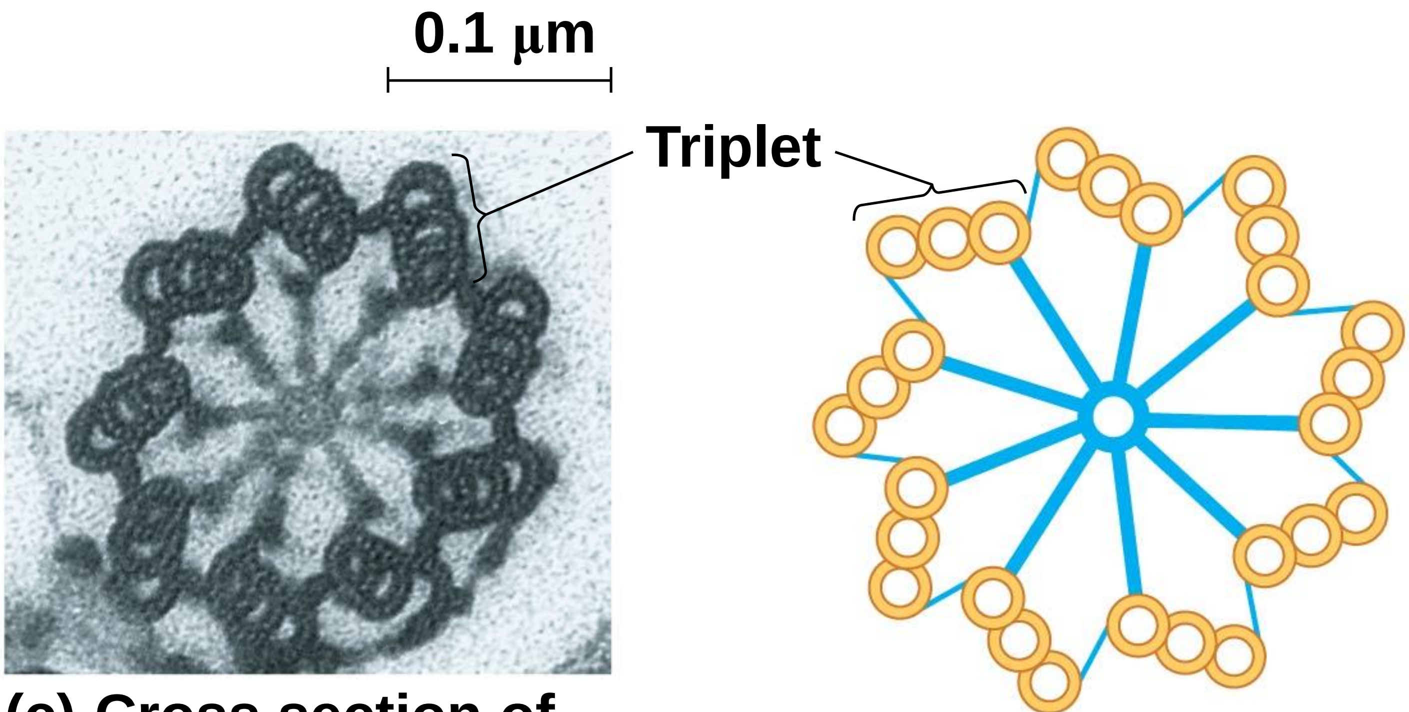
(b) Cross section of motile cilium

Figure 7.24ba



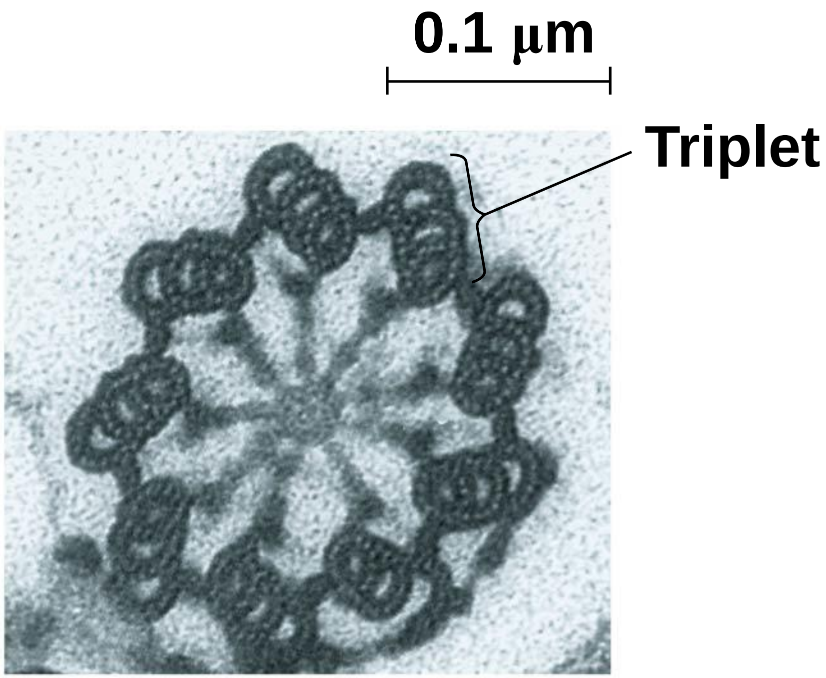
(b) Cross section of motile cilium

Figure 7.24c



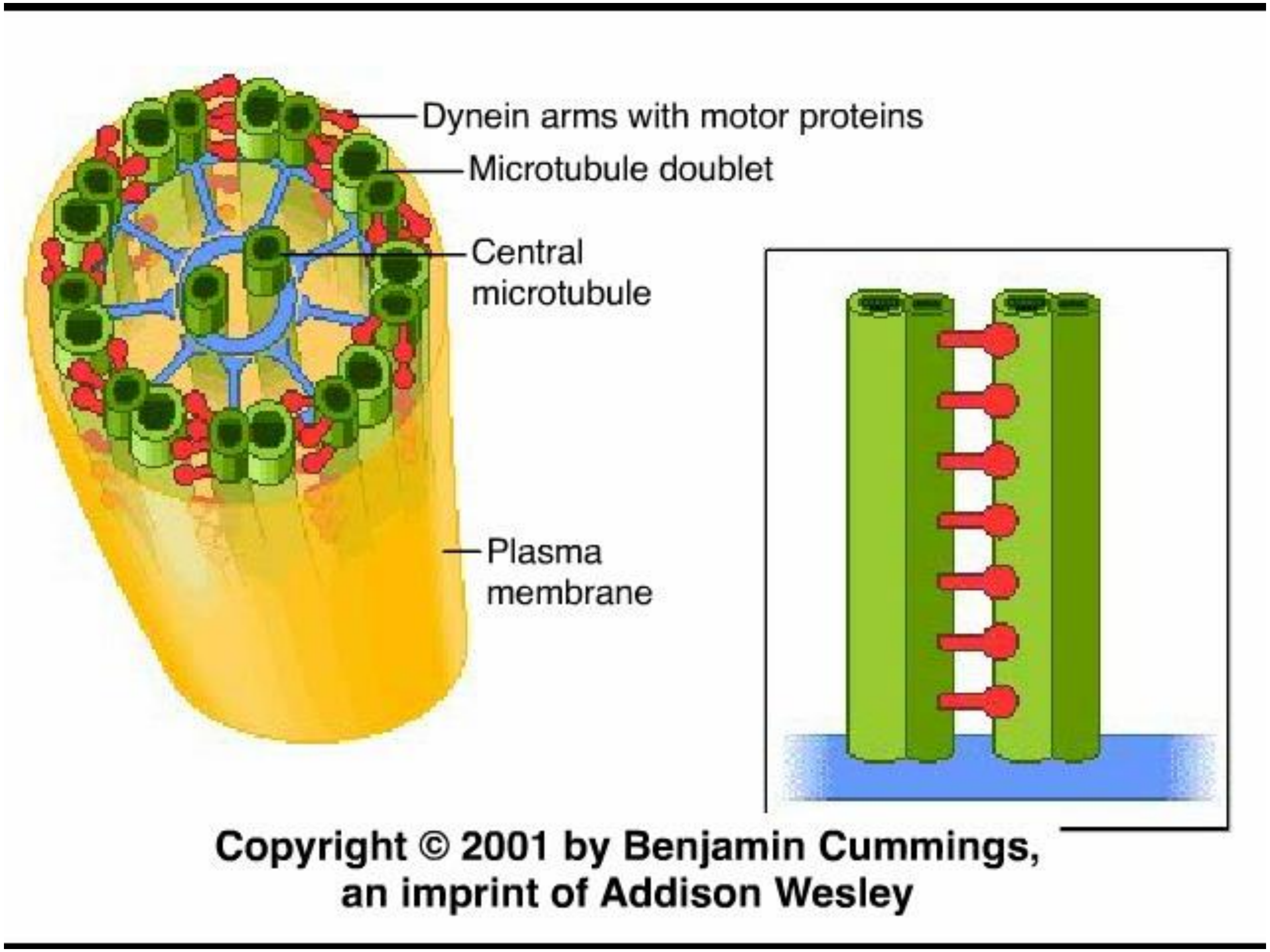
(c) Cross section of basal body

Figure 7.24ca

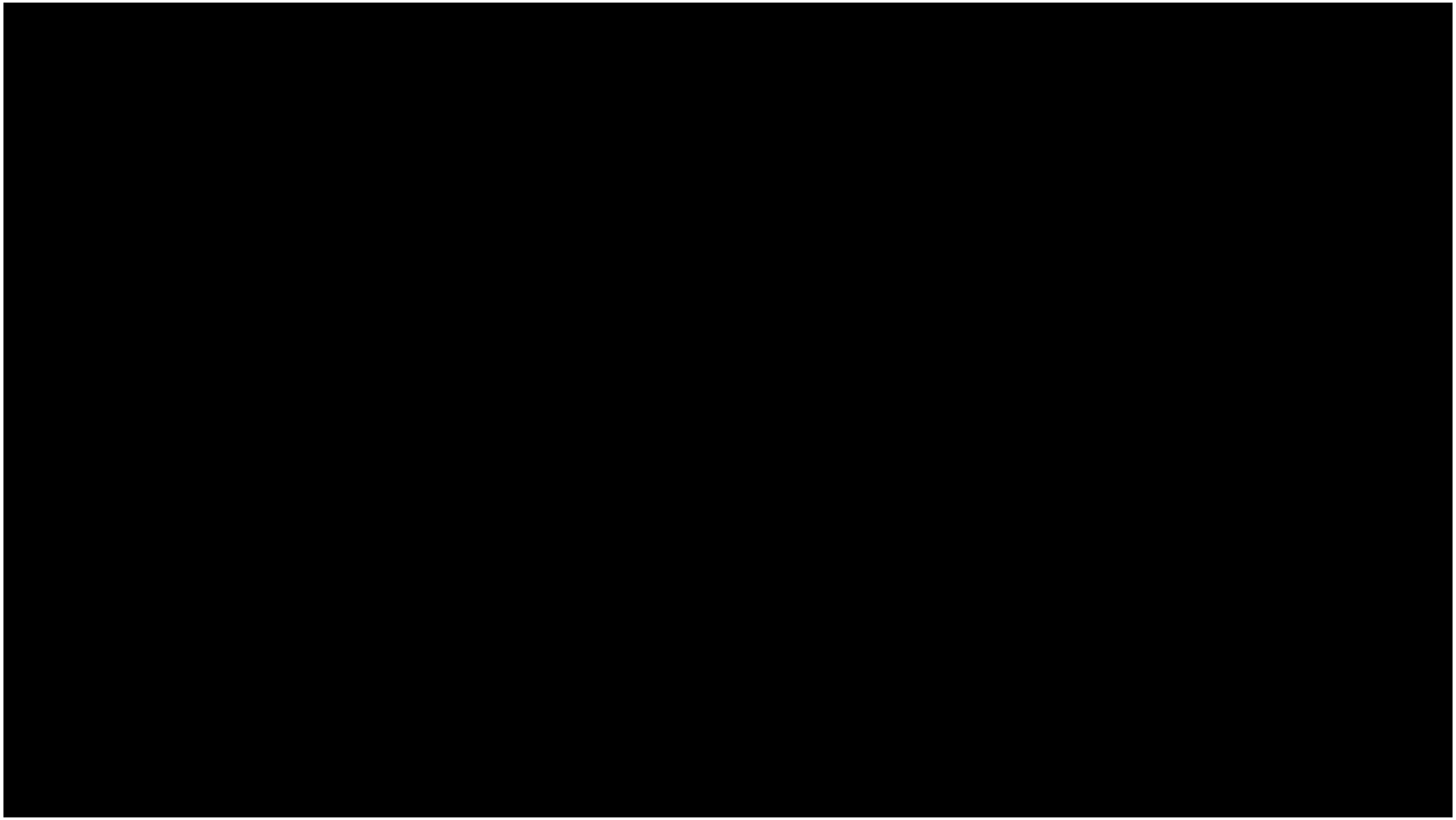


(c) Cross section of basal body

Animation: Cilia and Flagella



Video: Microtubule Sliding in Flagellum Movement

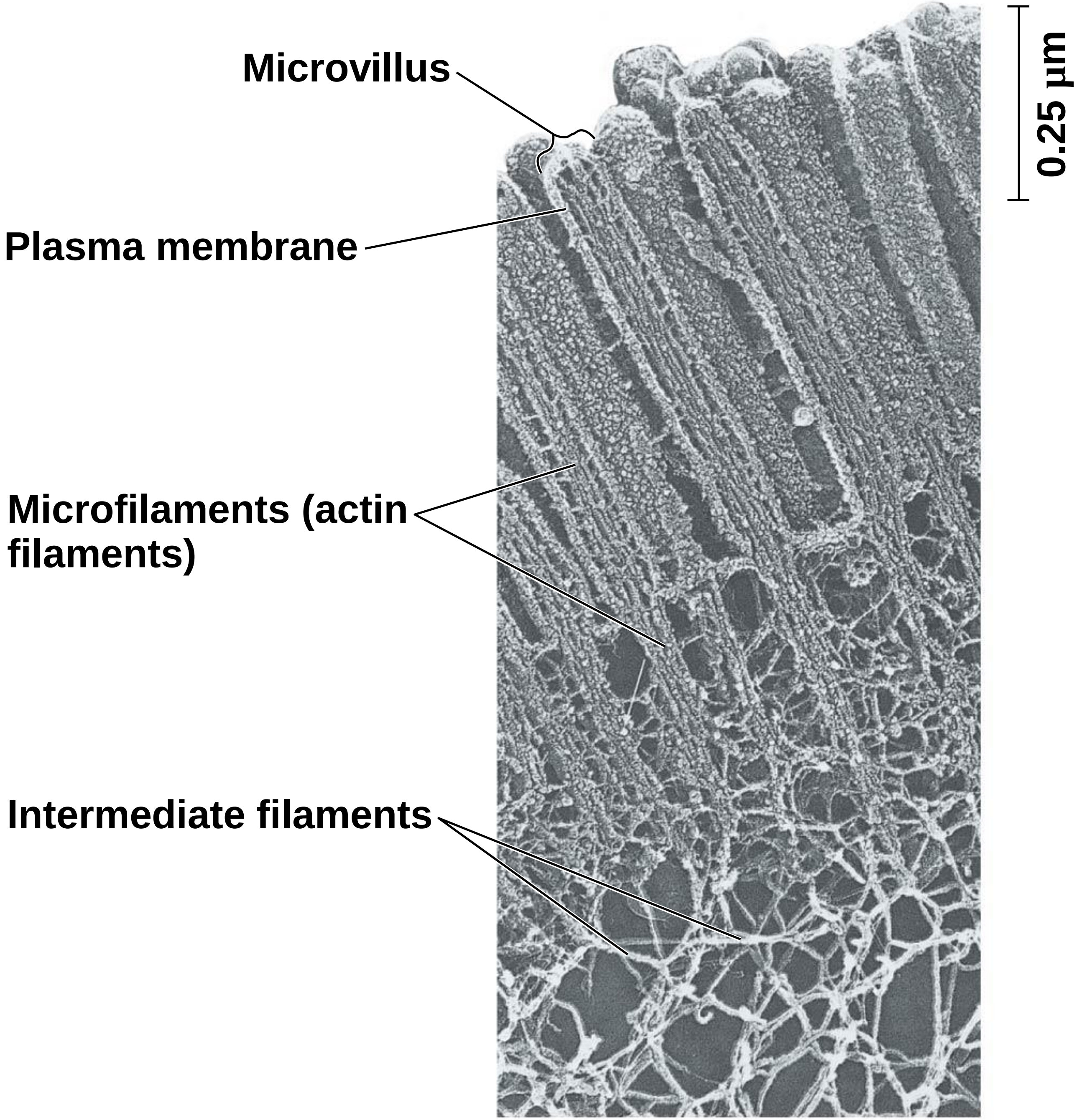


- Dynein has two “feet” that “walk” along microtubules
- One foot maintains contact, while the other releases and reattaches one step farther along
- Movements of the feet cause the microtubules to bend, rather than slide, because the microtubules are held in place

Microfilaments (Actin Filaments)

- **Microfilaments** are solid rods about 7 nm in diameter, built as a twisted double chain of **actin** subunits
- A network of microfilaments helps support the cell’s shape
- They form a **cortex** just inside the plasma membrane to help support the cell’s shape
- Bundles of microfilaments make up the core of microvilli of intestinal cells

Figure 7.25



Microvillus
Plasma membrane
Microfilaments (actin filaments)
Intermediate filaments
0.25 µm

- Microfilaments that function in cellular motility contain the protein **myosin** in addition to actin
- Cells crawl along a surface by extending **pseudopodia** (cellular extensions) and moving toward them
- **Cytoplasmic streaming** is a circular flow of cytoplasm within cells, driven by actin-myosin interactions

Figure 7.26

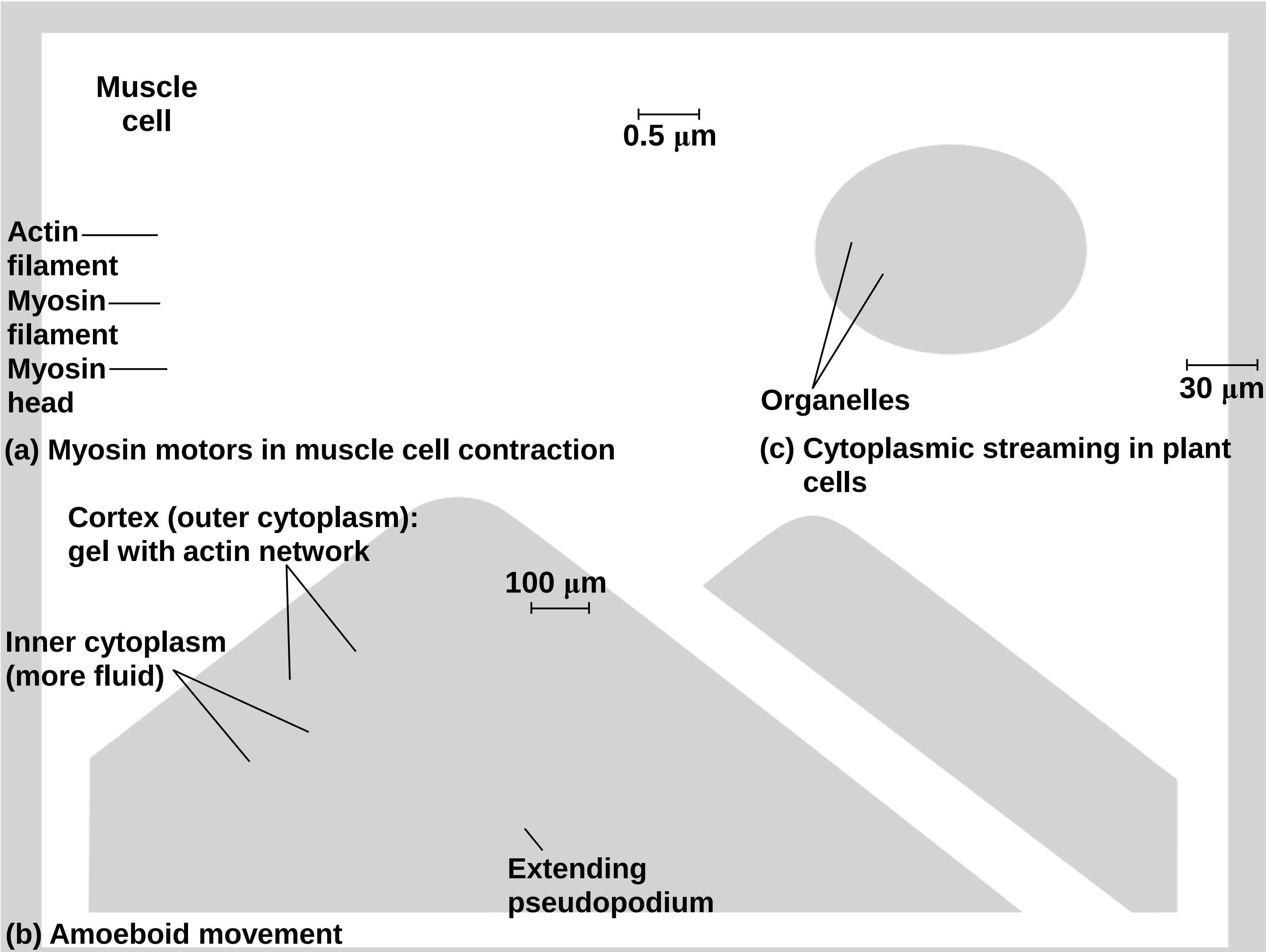
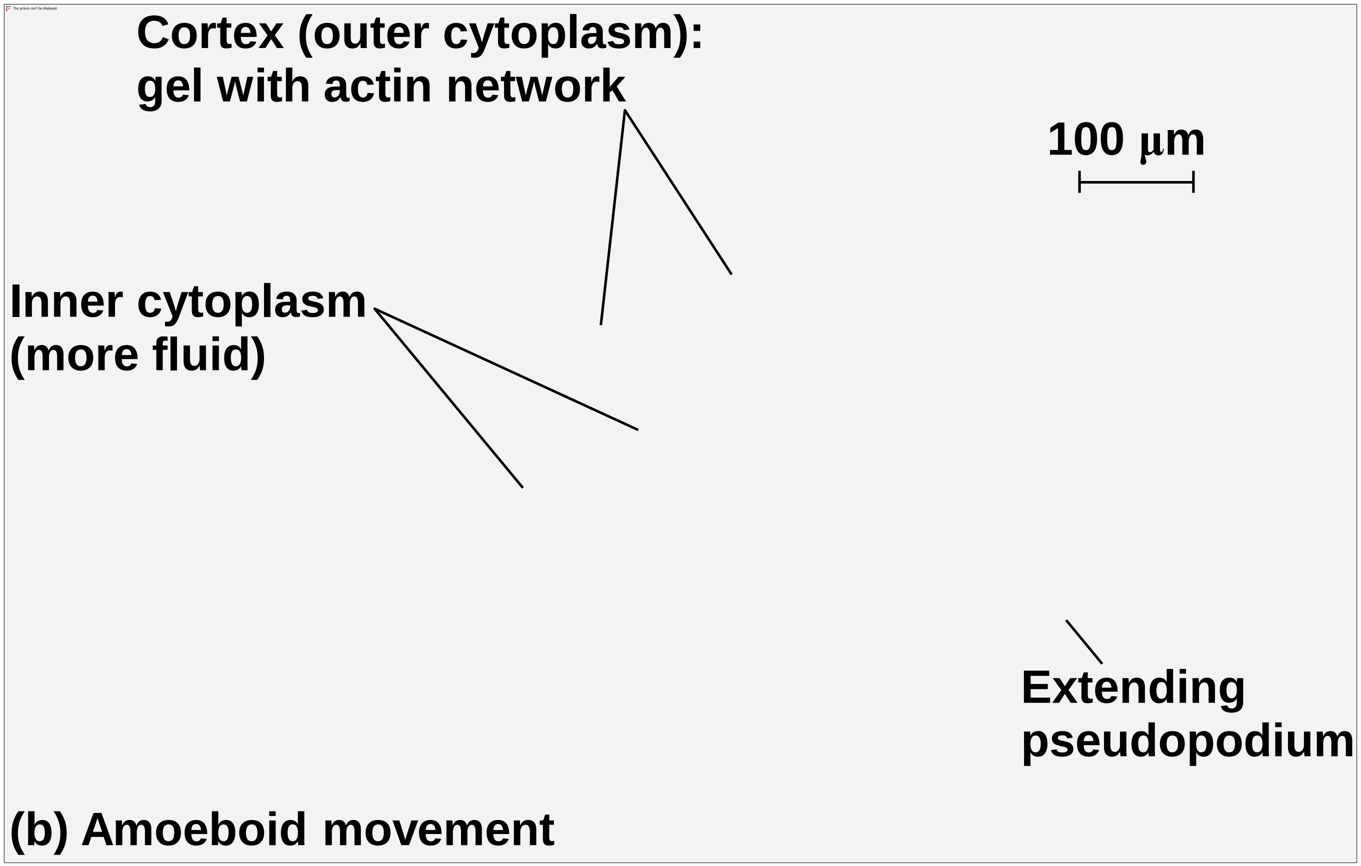

Muscle cell
0.5 µm
Actin filament
Myosin filament
Myosin head
(a) Myosin motors in muscle cell contraction
Organelles
30 µm
(c) Cytoplasmic streaming in plant cells
Cortex (outer cytoplasm): gel with actin network
100 µm
Inner cytoplasm (more fluid)
Extending pseudopodium
(b) Amoeboid movement

Figure 7.26a

(a) Myosin motors in muscle cell contraction

Figure 7.26aa

Figure 7.26b

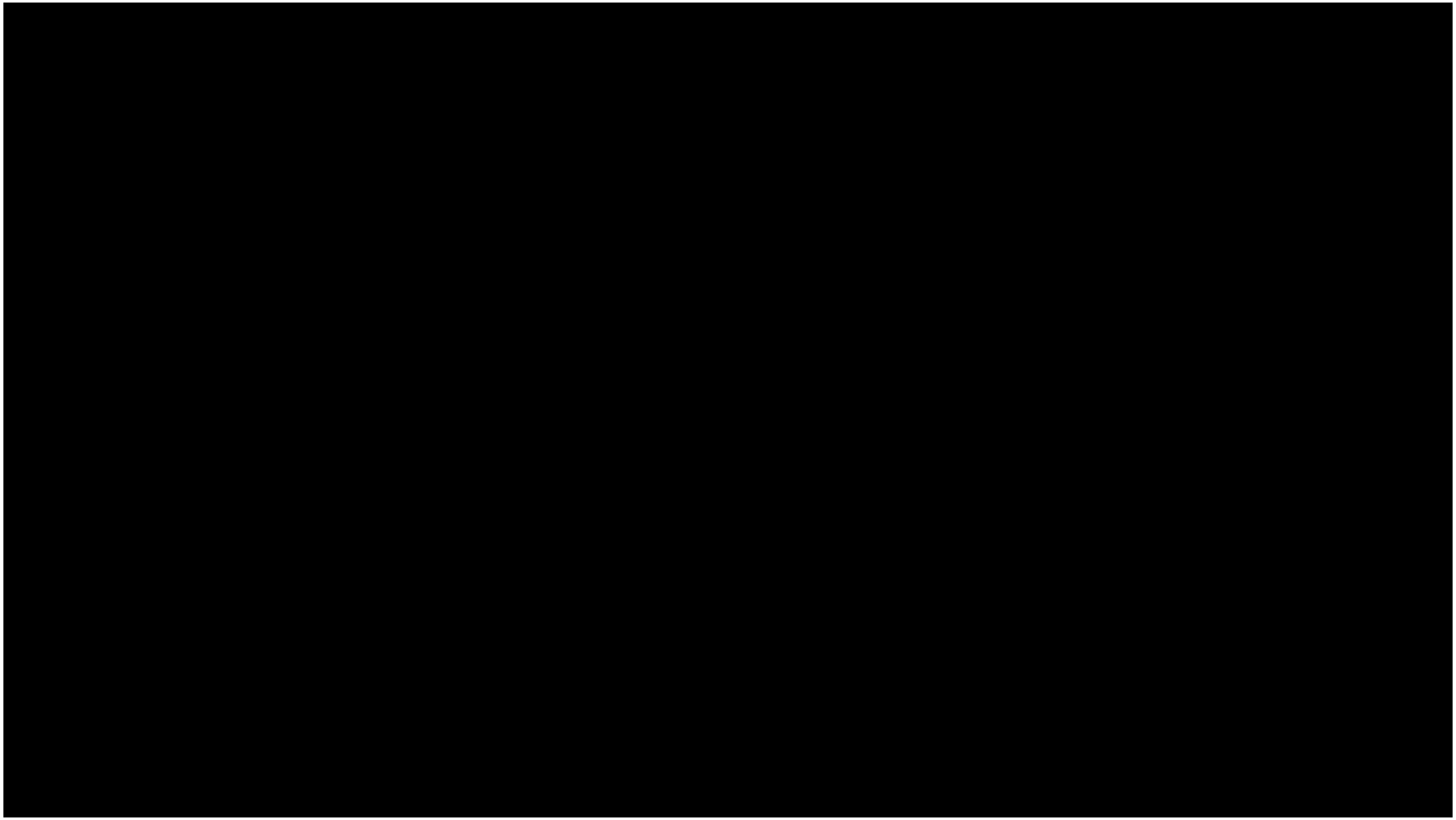


(b) Amoeboid movement

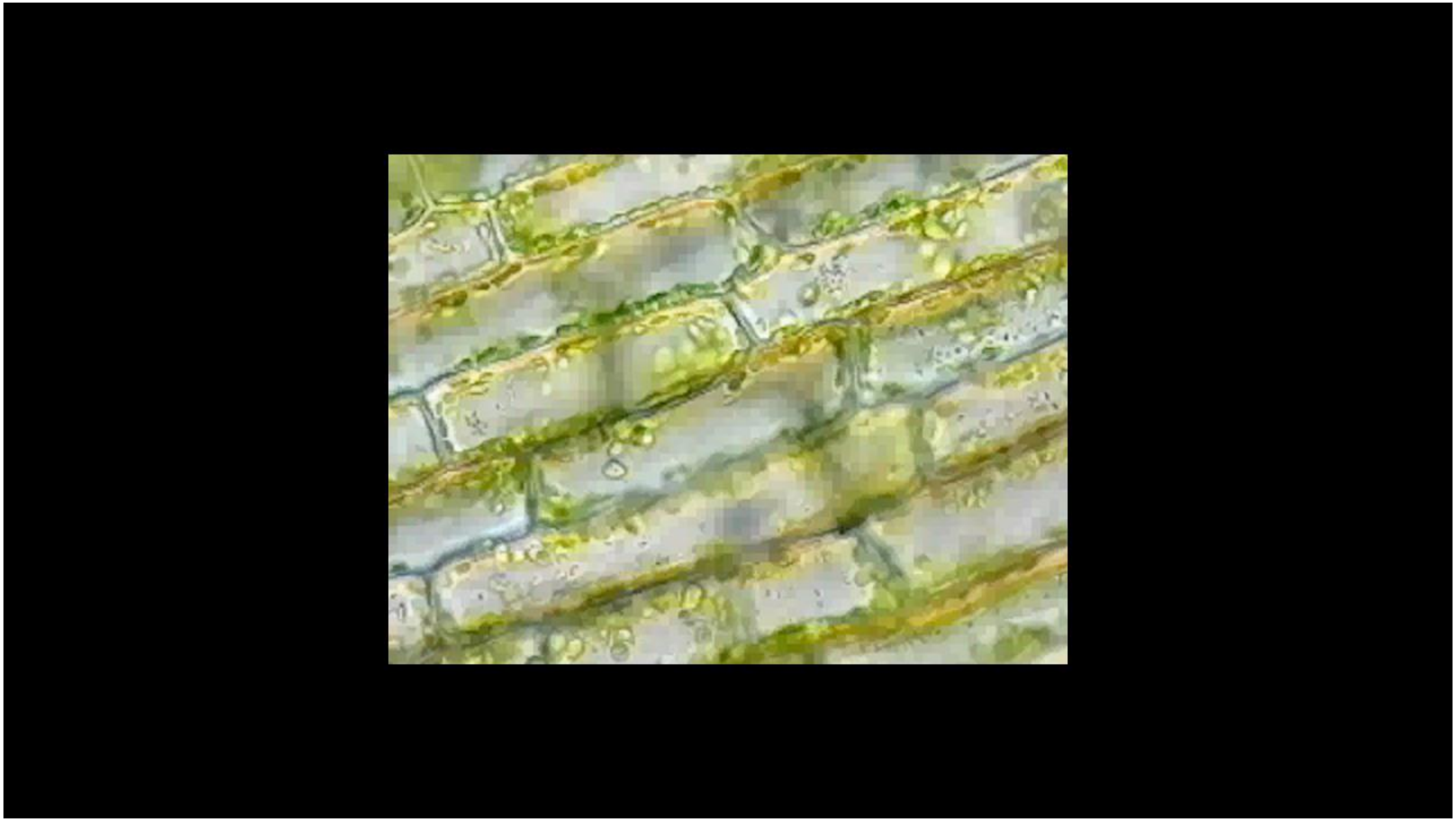
Figure 7.26c

(c) Cytoplasmic streaming in plant cells

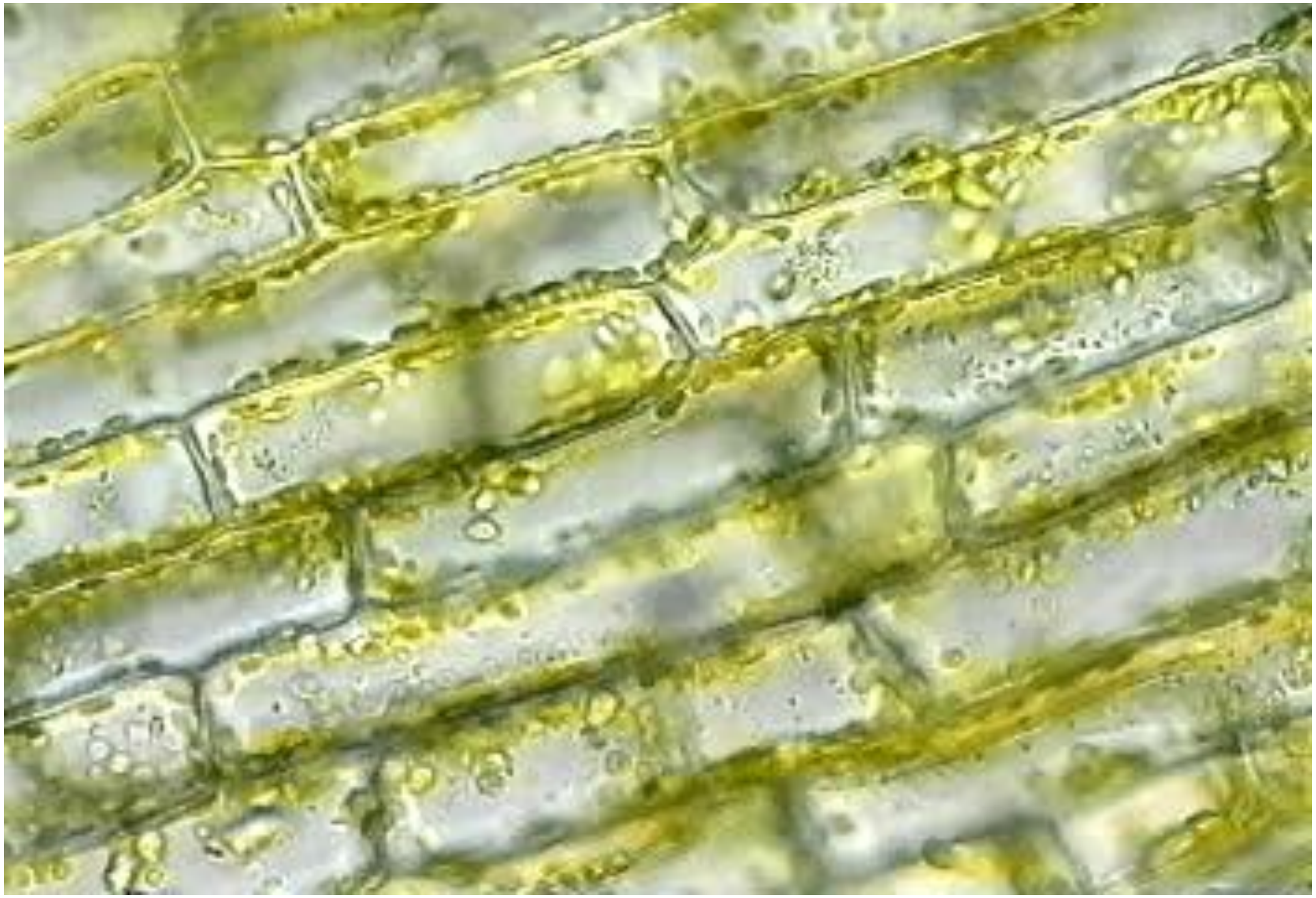
Video: Actin Network in Crawling Cells



Video: Chloroplast Movement



Video: Cytoplasmic Streaming



Intermediate Filaments

- **Intermediate filaments** range in diameter from 8 to 12 nanometers, larger than microfilaments but smaller than microtubules
- Intermediate filaments are more permanent cytoskeleton fixtures than the other two classes
- They support cell shape and fix organelles in place

Concept 7.7: Extracellular components and connections between cells help coordinate cellular activities

- Most cells synthesize and secrete materials that are external to the plasma membrane
- These extracellular materials and structures are involved in a great many cellular functions

Cell Walls of Plants

- The **cell wall** is an extracellular structure that distinguishes plant cells from animal cells
- Prokaryotes, fungi, and some unicellular eukaryotes also have cell walls
- The cell wall protects the plant cell, maintains its shape, and prevents excessive uptake of water
- Plant cell walls are made of cellulose fibers embedded in other polysaccharides and protein

- Plant cell walls may have multiple layers:
  - **Primary cell wall**: Relatively thin and flexible
  - **Middle lamella**: Thin layer between primary walls of adjacent cells
  - **Secondary cell wall** (in some cells): Added between the plasma membrane and the primary cell wall

Figure 7.27

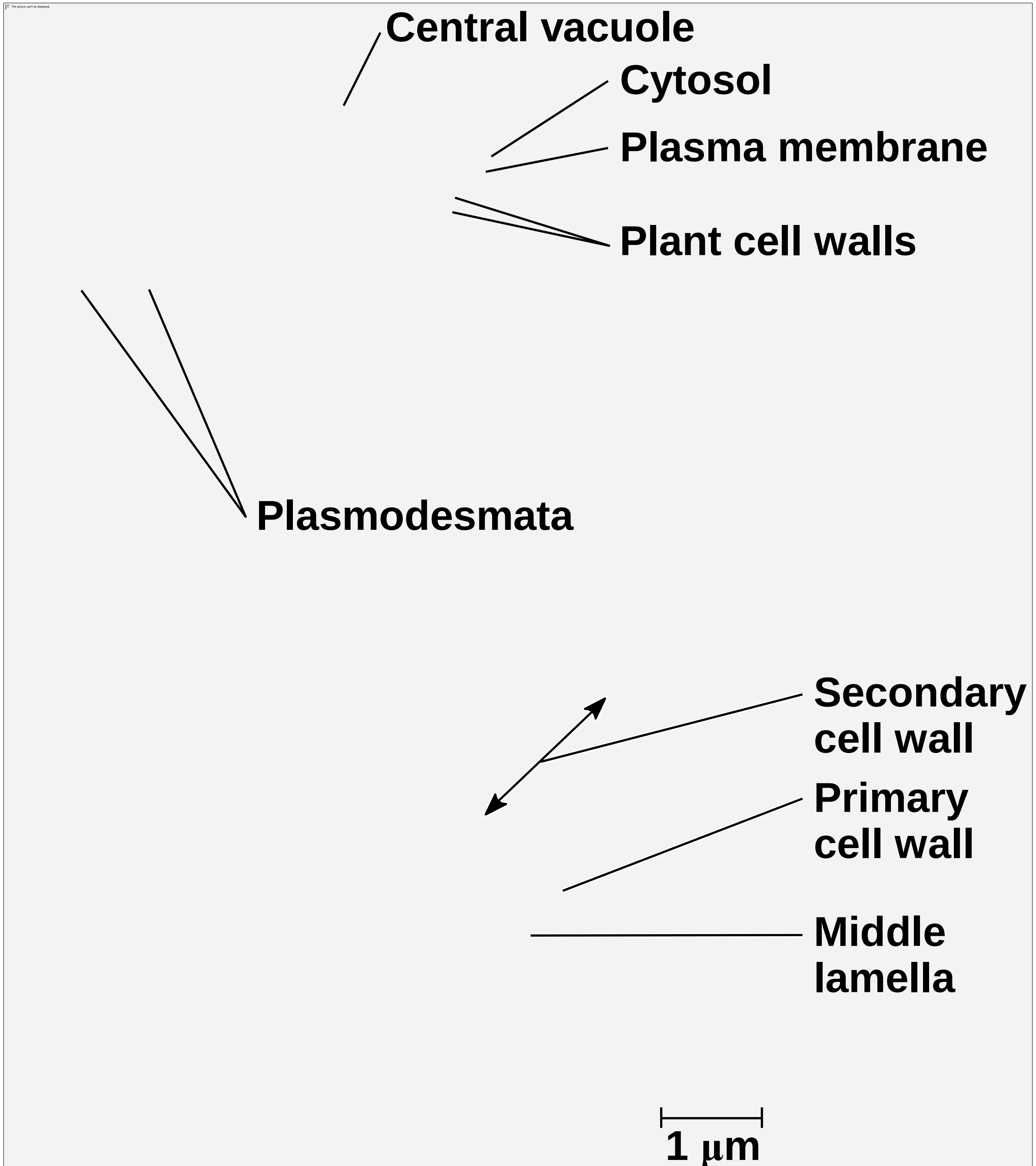
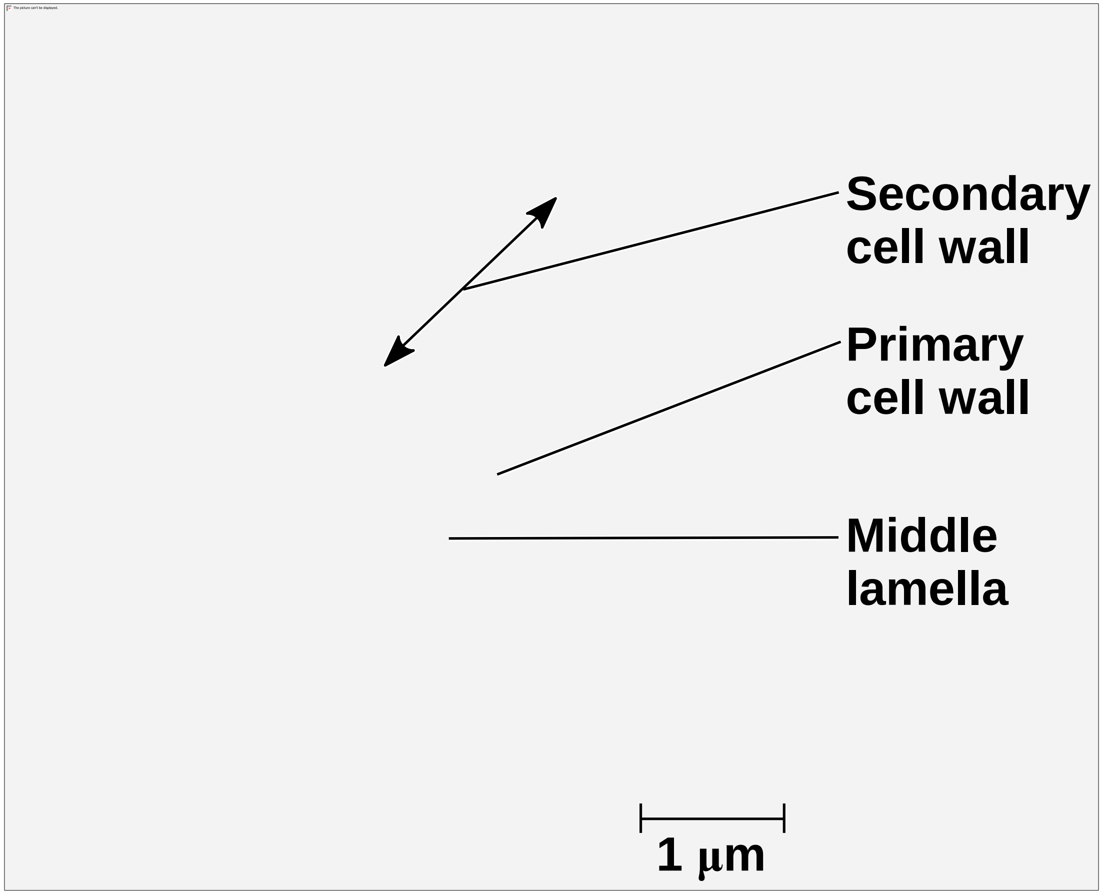

Central vacuole
Cytosol
Plasma membrane
Plant cell walls
Plasmodesmata
Secondary cell wall
Primary cell wall
Middle lamella
1 μm

Figure 7.27a



The Extracellular Matrix (ECM) of Animal Cells

- Animal cells lack cell walls but are covered by an elaborate **extracellular matrix (ECM)**
- The ECM is made up of glycoproteins such as **collagen**, **proteoglycans**, and **fibronectin**
- ECM proteins bind to receptor proteins in the plasma membrane called **integrins**

Figure 7.28

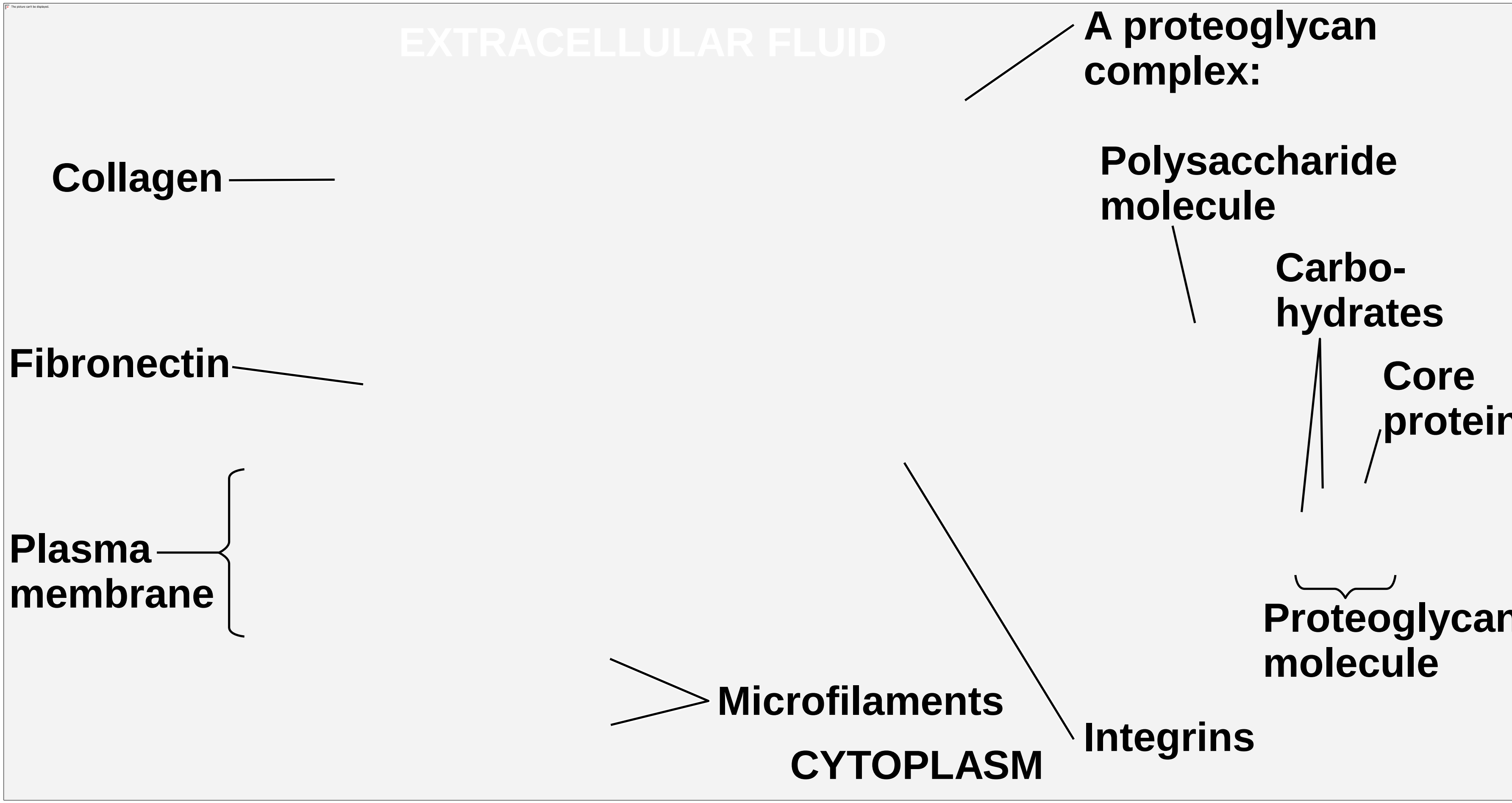
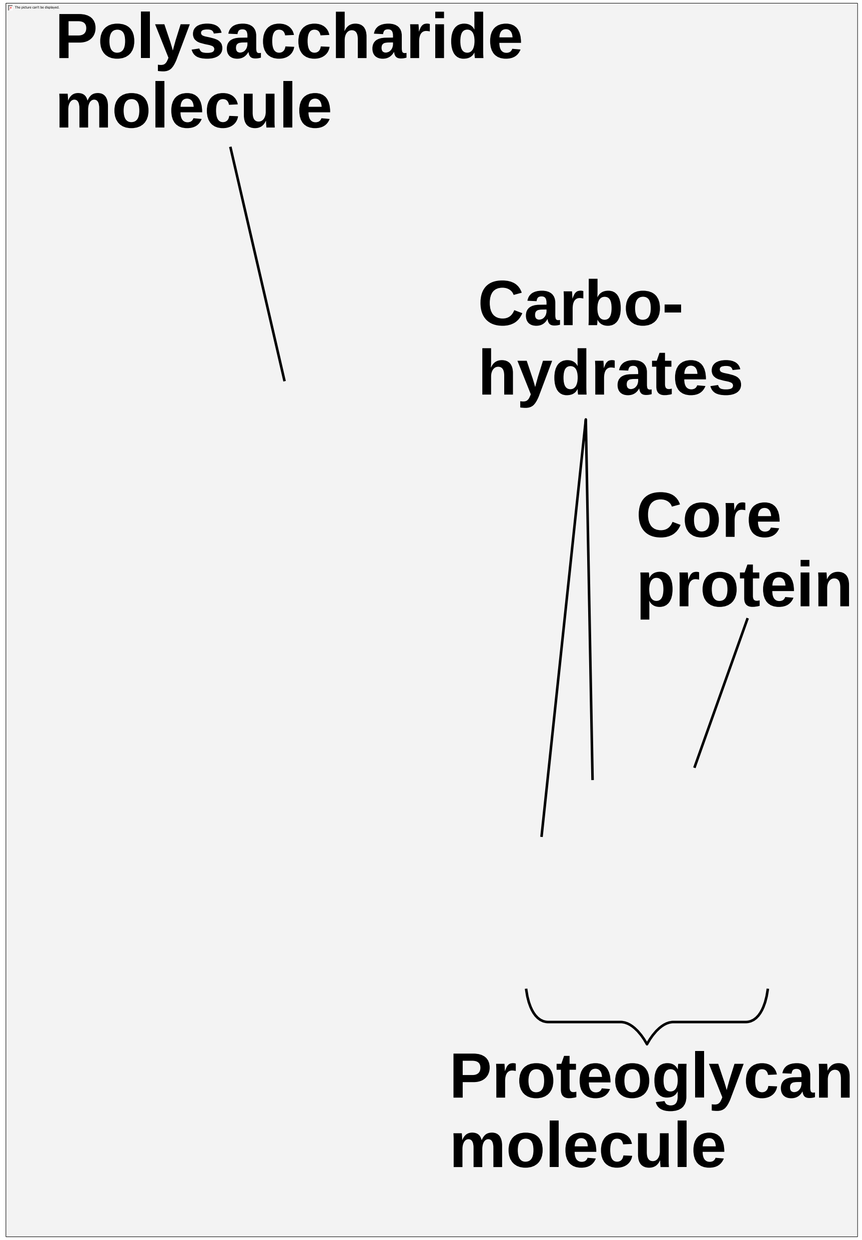
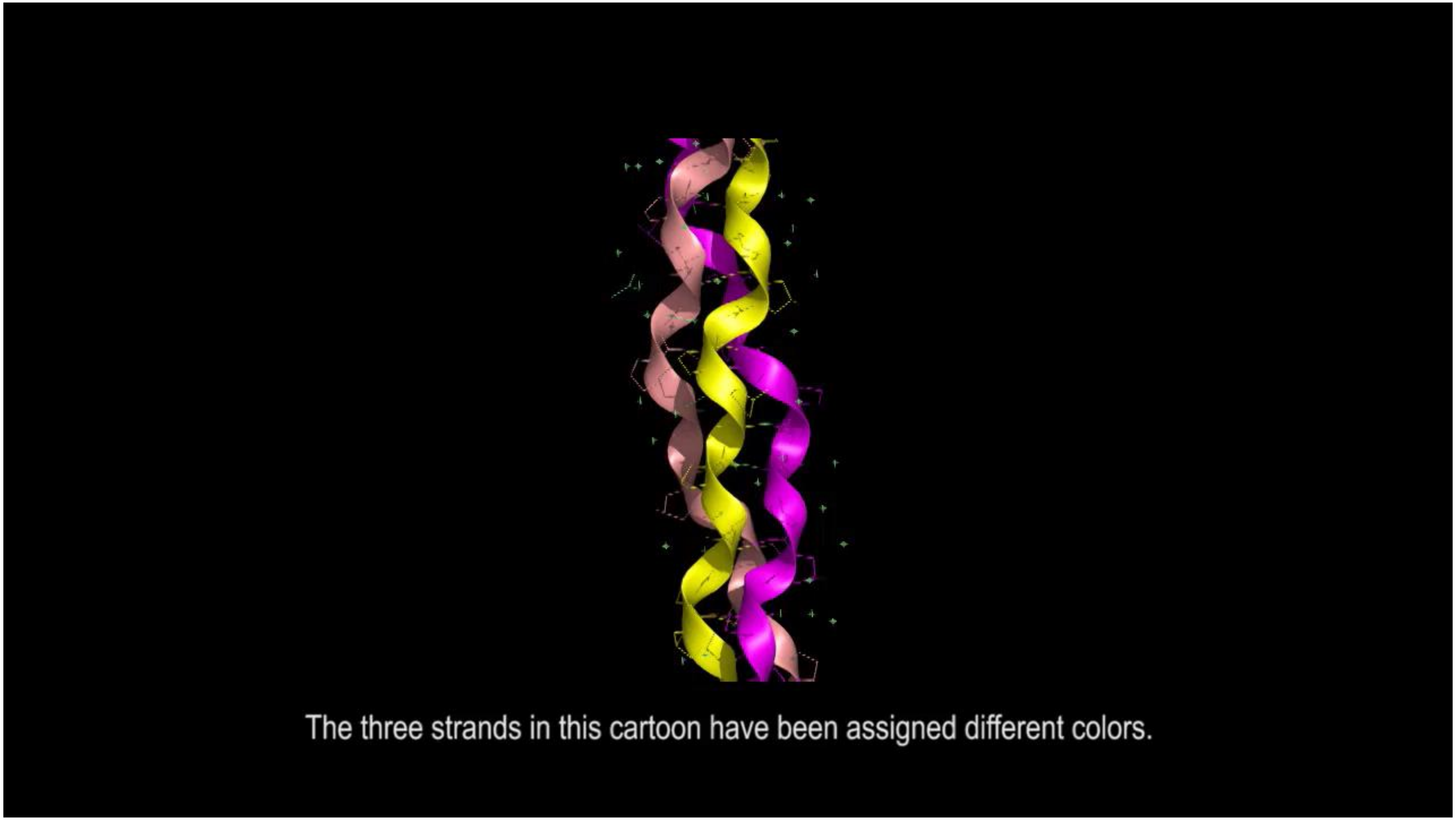

EXTRACELLULAR FLUID
A proteoglycan complex:
Polysaccharide molecule
Carbo-hydrates
Core protein
Proteoglycan molecule
Collagen
Fibronectin
Plasma membrane
Microfilaments
Integrins
CYTOPLASM

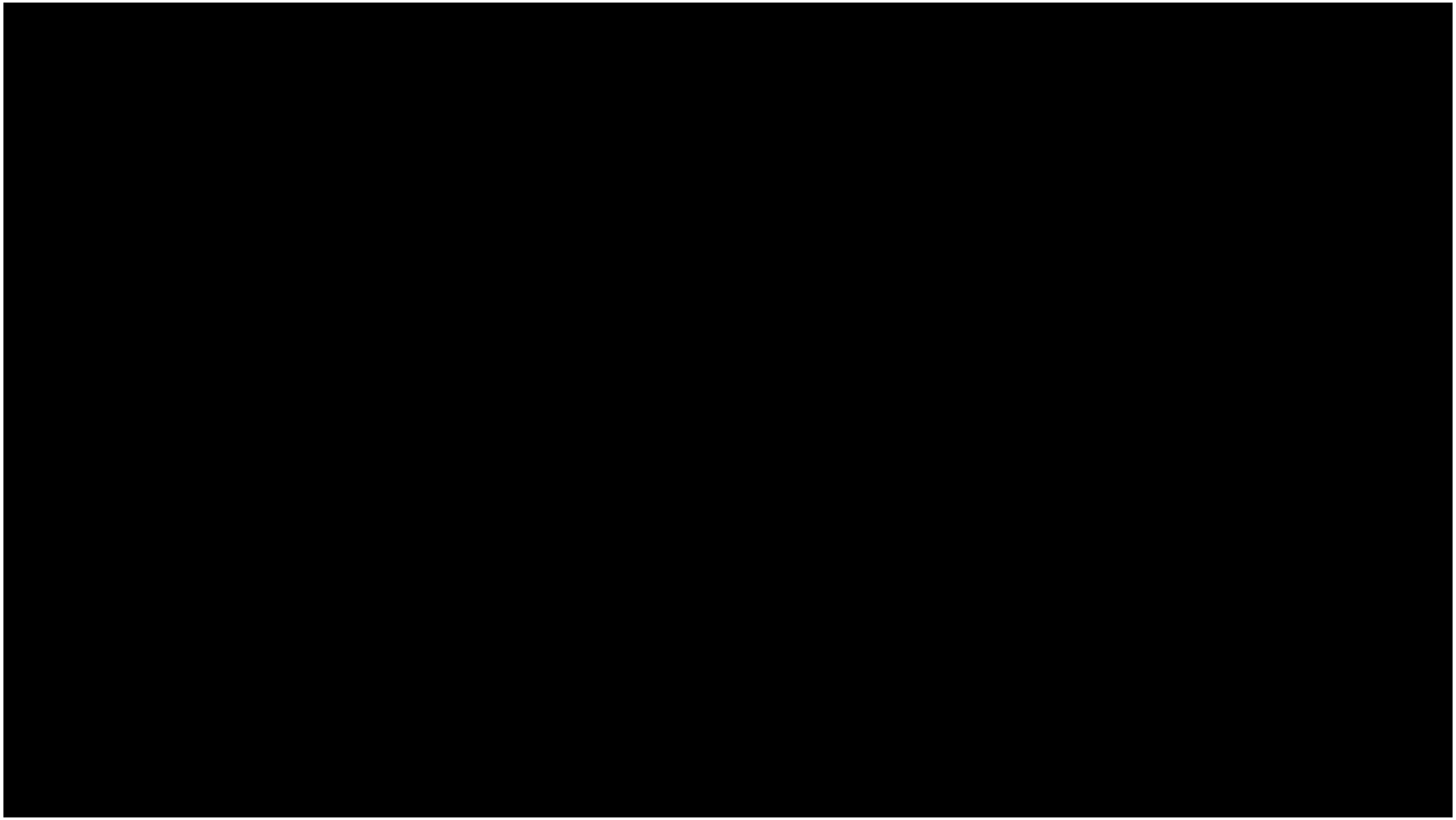
Figure 7.28a


Polysaccharide molecule
Carbo-hydrates
Core protein
Proteoglycan molecule

Video: Cartoon Model of a Collagen Triple Helix



Video: Fibronectin Fibrils



- The ECM has an influential role in the lives of cells
- ECM can regulate a cell's behavior by communicating with a cell through integrins
- The ECM around a cell can influence the activity of gene in the nucleus
- Mechanical signaling may occur through cytoskeletal changes that trigger chemical signals in the cell

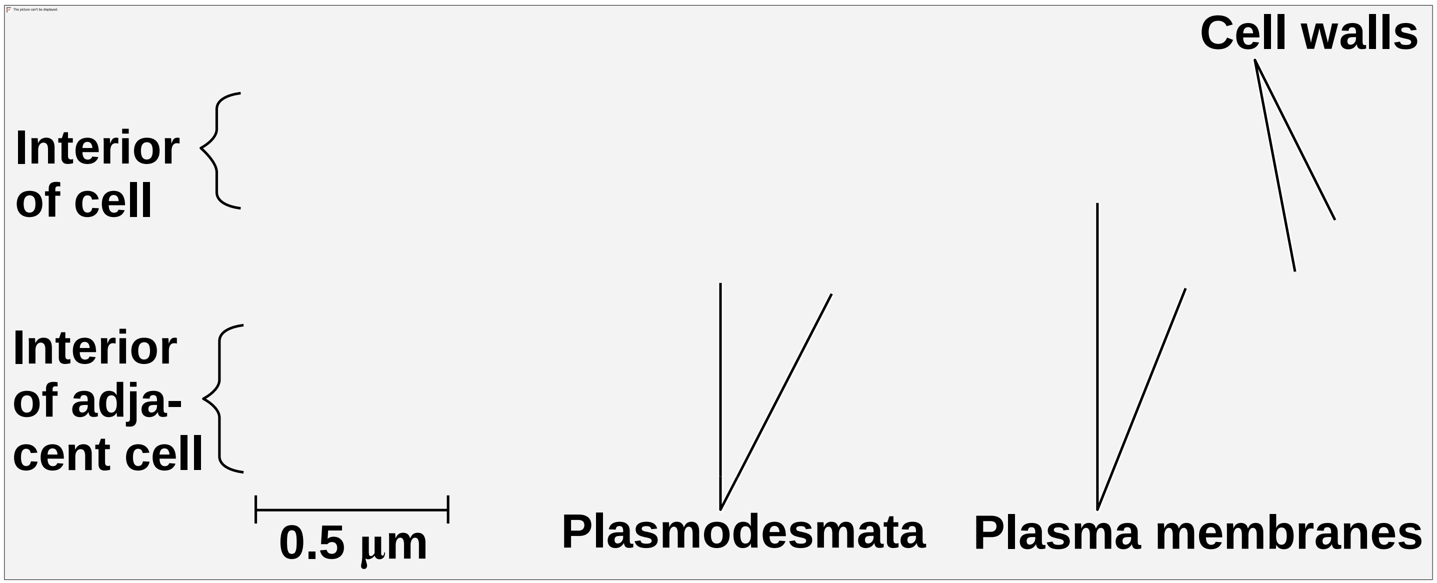
Cell Junctions

- Neighboring cells in tissues, organs, or organ systems often adhere, interact, and communicate through direct physical contact

Plasmodesmata in Plant Cells

- **Plasmodesmata** are channels that perforate plant cell walls
- Through plasmodesmata, water and small solutes (and sometimes proteins and RNA) can pass from cell to cell

Figure 7.29


Cell walls
Interior of cell
Interior of adja- cent cell
0.5 µm
Plasmodesmata
Plasma membranes

Tight Junctions, Desmosomes, and Gap Junctions in Animal Cells

- Three types of cell junctions are common in epithelial tissues
  - At tight junctions, membranes of neighboring cells are pressed together, preventing leakage of extracellular fluid
  - Desmosomes (anchoring junctions) fasten cells together into strong sheets
  - Gap junctions (communicating junctions) provide cytoplasmic channels between adjacent cells

Figure 7.30

Tight junctions prevent fluid from moving across a layer of cells.

Tight junction

TEM

0.5 μm

Tight junction

Intermediate filaments

Desmosome

Desmosome (TEM)

1 μm

Gap junction

Ions or small molecules

Extracellular matrix

TEM

0.1 μm

Plasma membranes of adjacent cells

Space between cells

Gap junctions

Figure 7.30a

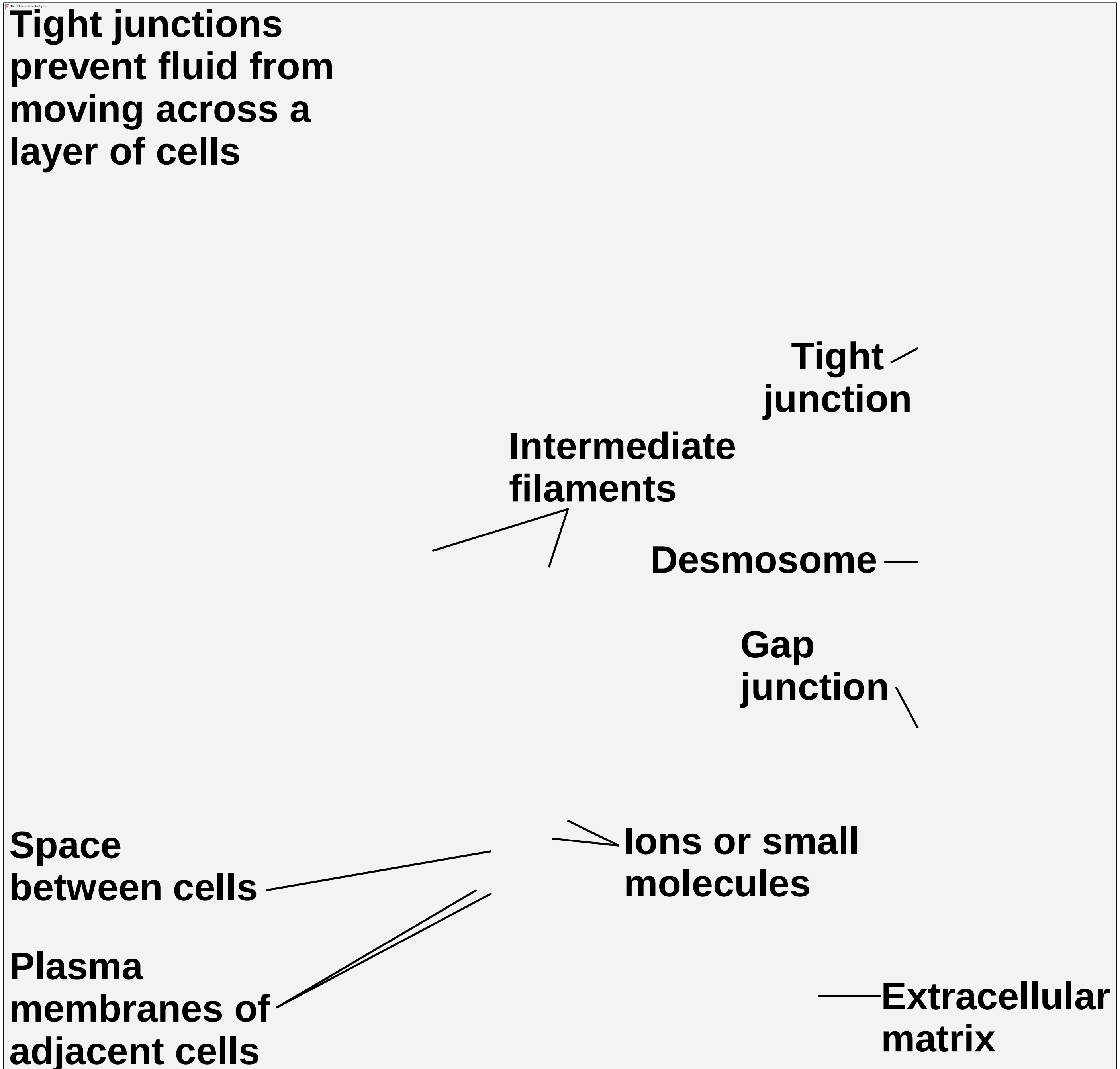

Tight junctions prevent fluid from moving across a layer of cells
Tight junction
Intermediate filaments
Desmosome
Gap junction
Ions or small molecules
Space between cells
Plasma membranes of adjacent cells
Extracellular matrix

Figure 7.30b

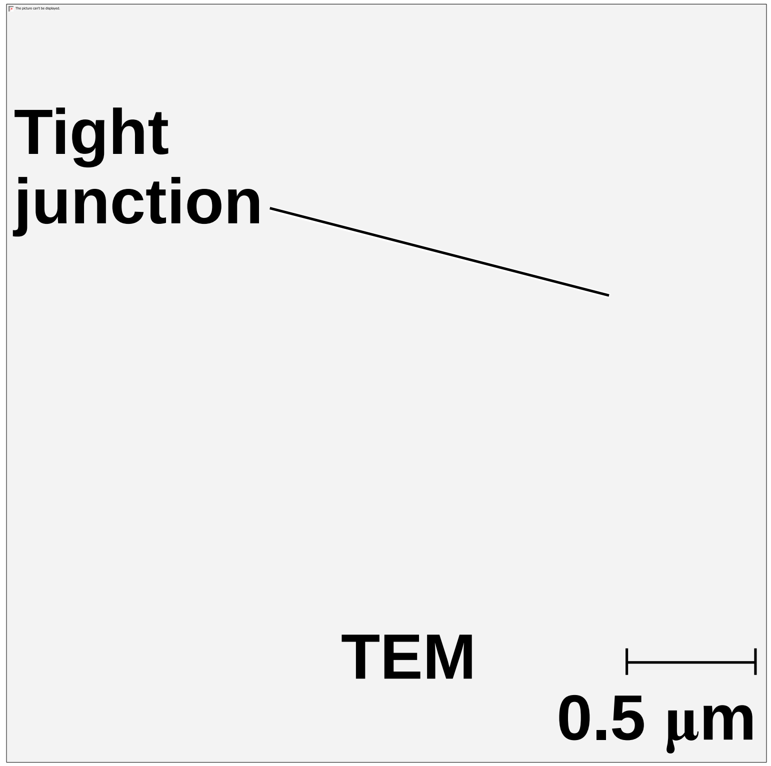


Figure 7.30c

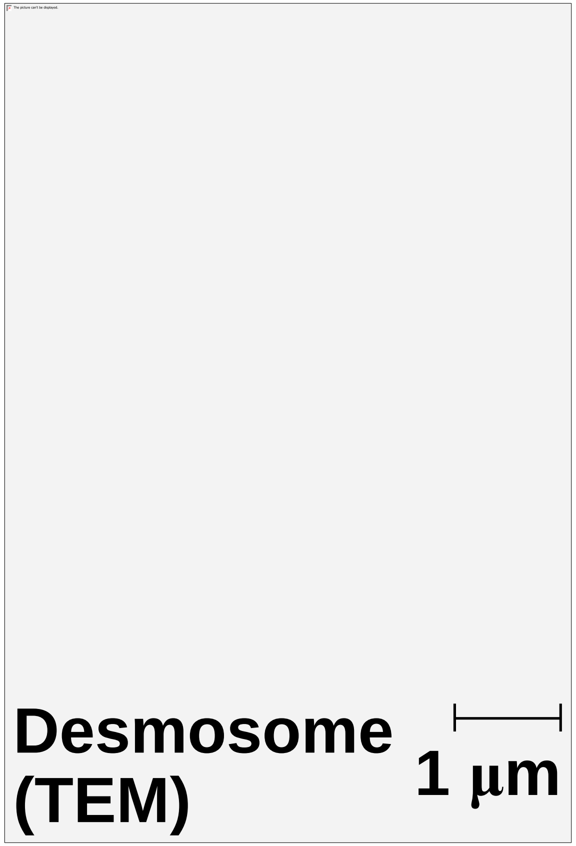
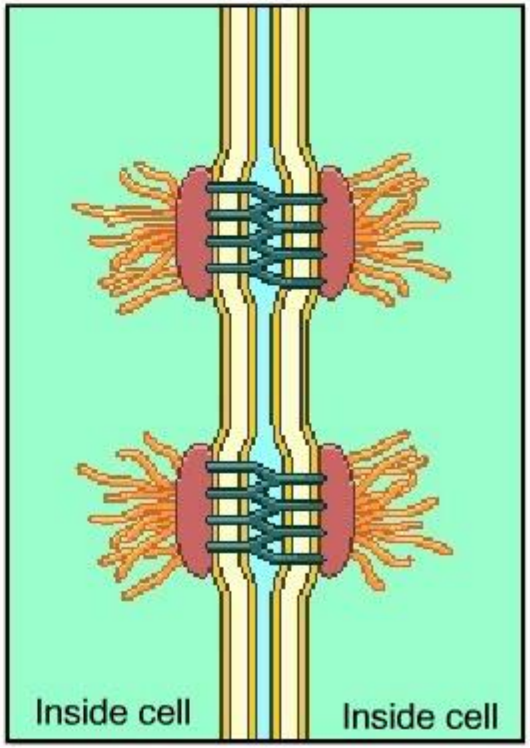


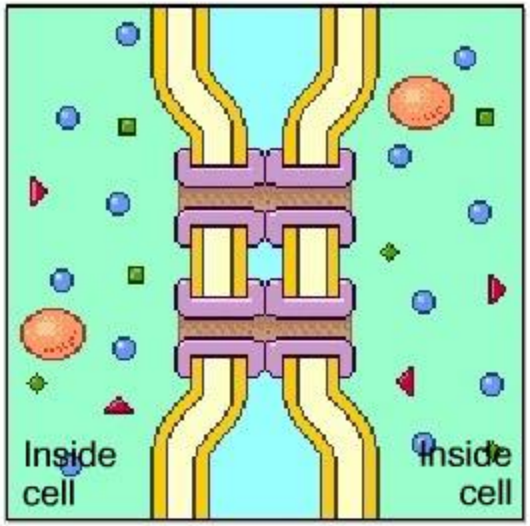
Figure 7.30d

Gap junction

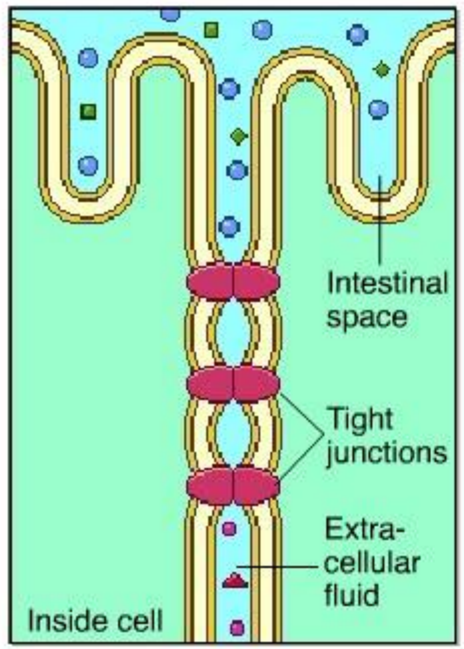
Animation: Desmosomes



Animation: Gap Junctions



Animation: Tight Junctions



Concept 7.8: A cell is greater than the sum of its parts

- Cells rely on the integration of structures and organelles in order to function
- For example, a macrophage's ability to destroy bacteria involves the whole cell, coordinating components such as the cytoskeleton, lysosomes, and plasma membrane

Figure 7.31

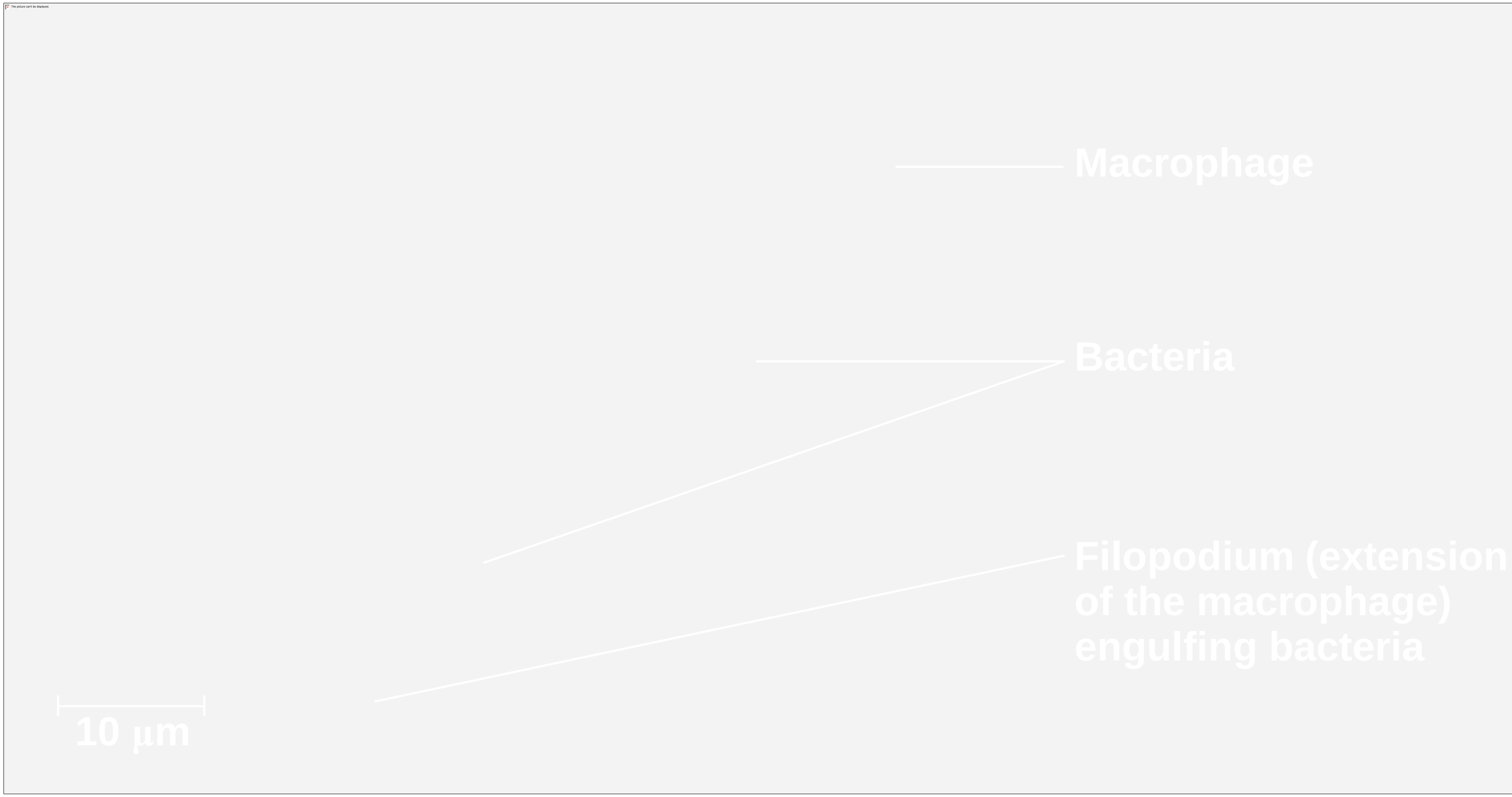

Macrophage
Bacteria
Filopodium (extension of the macrophage) engulfing bacteria
10 µm

Figure 7.32a


Plasma membrane
Cell wall
Scale within cell
25 nm
Chloroplast
Membrane proteins
Mitochondrion
Photo-synthesis
Cellular respiration

Figure 7.32b

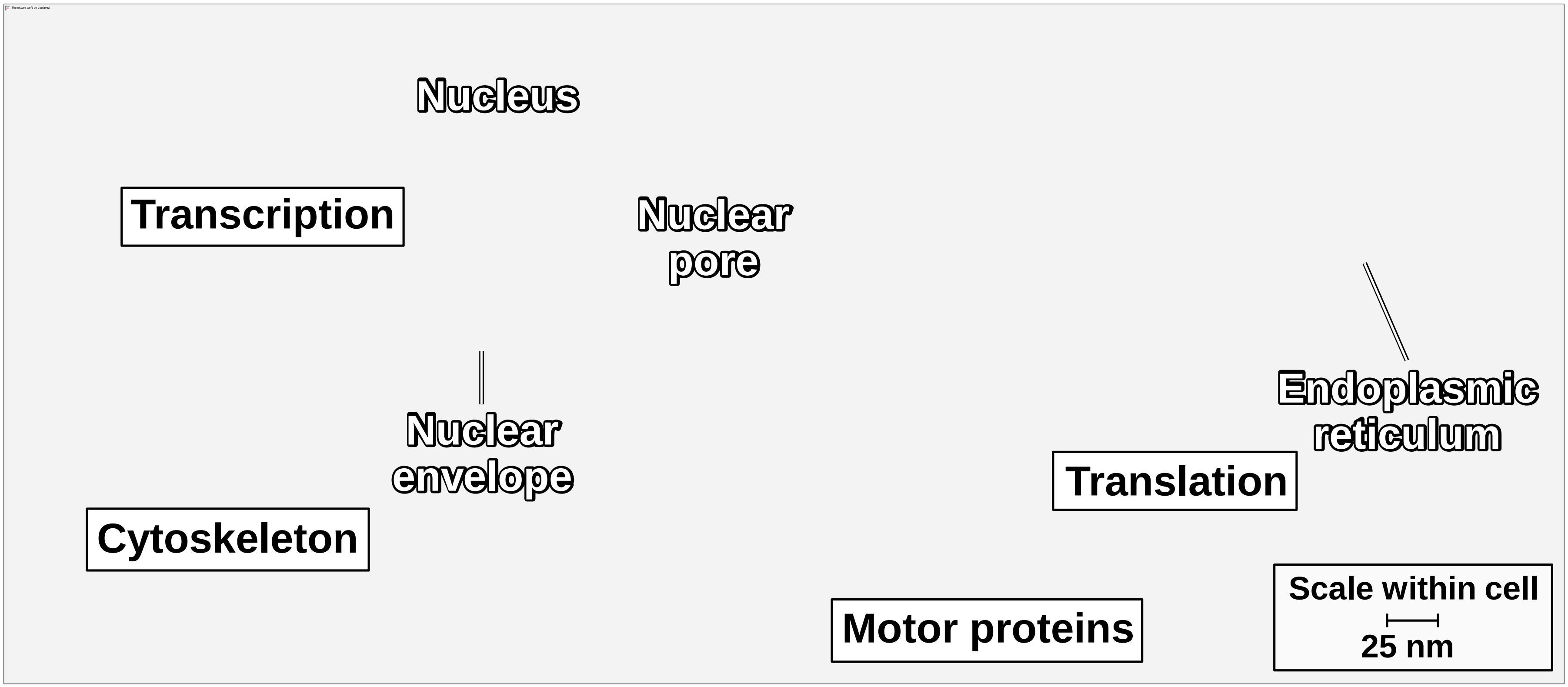

Nucleus
Transcription
Nuclear pore
Nuclear envelope
Endoplasmic reticulum
Translation
Cytoskeleton
Motor proteins
Scale within cell
25 nm

Figure 7.32c

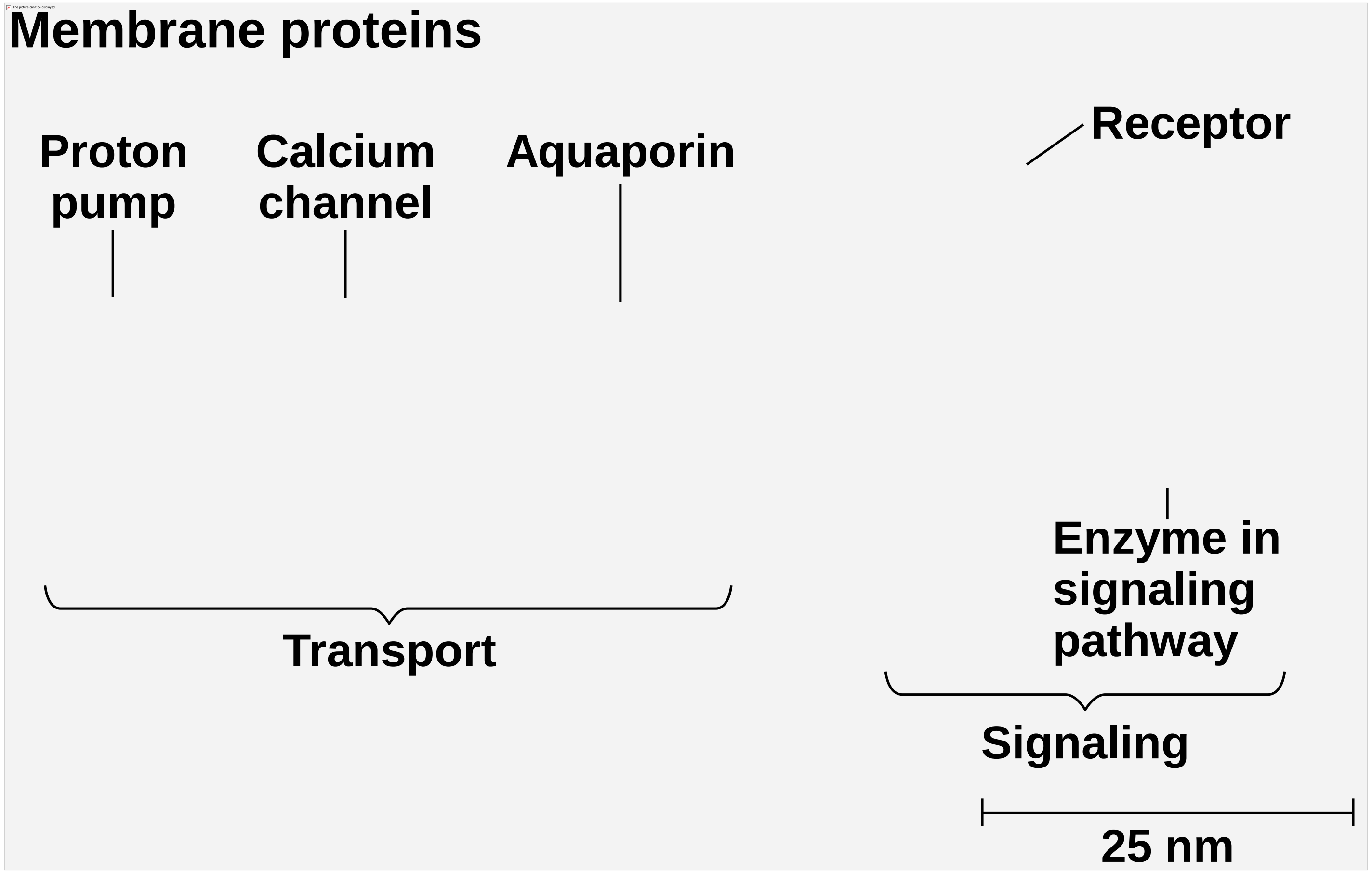

Membrane proteins
Proton pump
Calcium channel
Aquaporin
Receptor
Enzyme in signaling pathway
Transport
Signaling
25 nm

Figure 7.32d

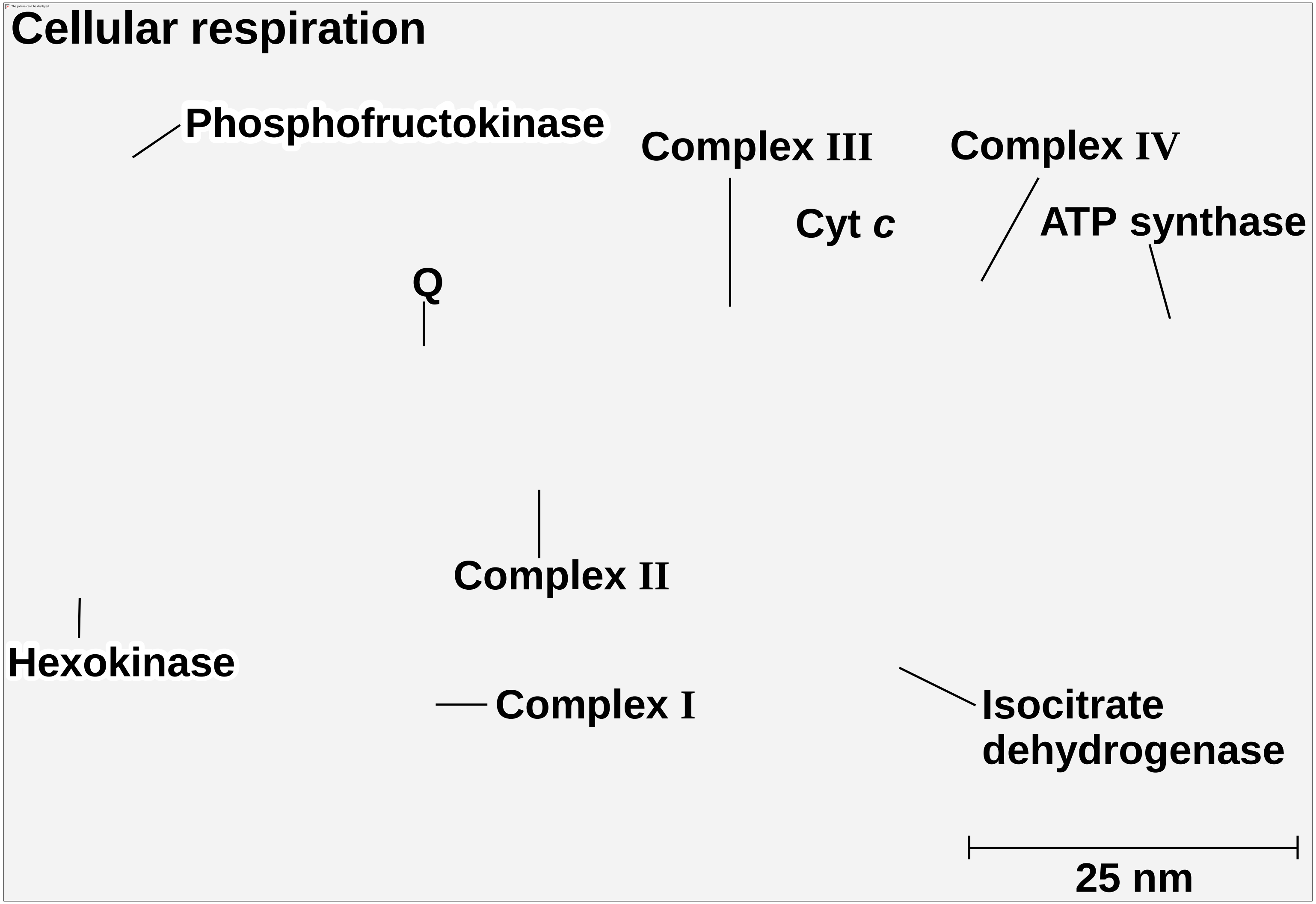

Cellular respiration
Phosphofructokinase
Complex III
Complex IV
Cyt c
ATP synthase
Q
Complex II
Hexokinase
Complex I
Isocitrate
dehydrogenase
25 nm

Figure 7.32e

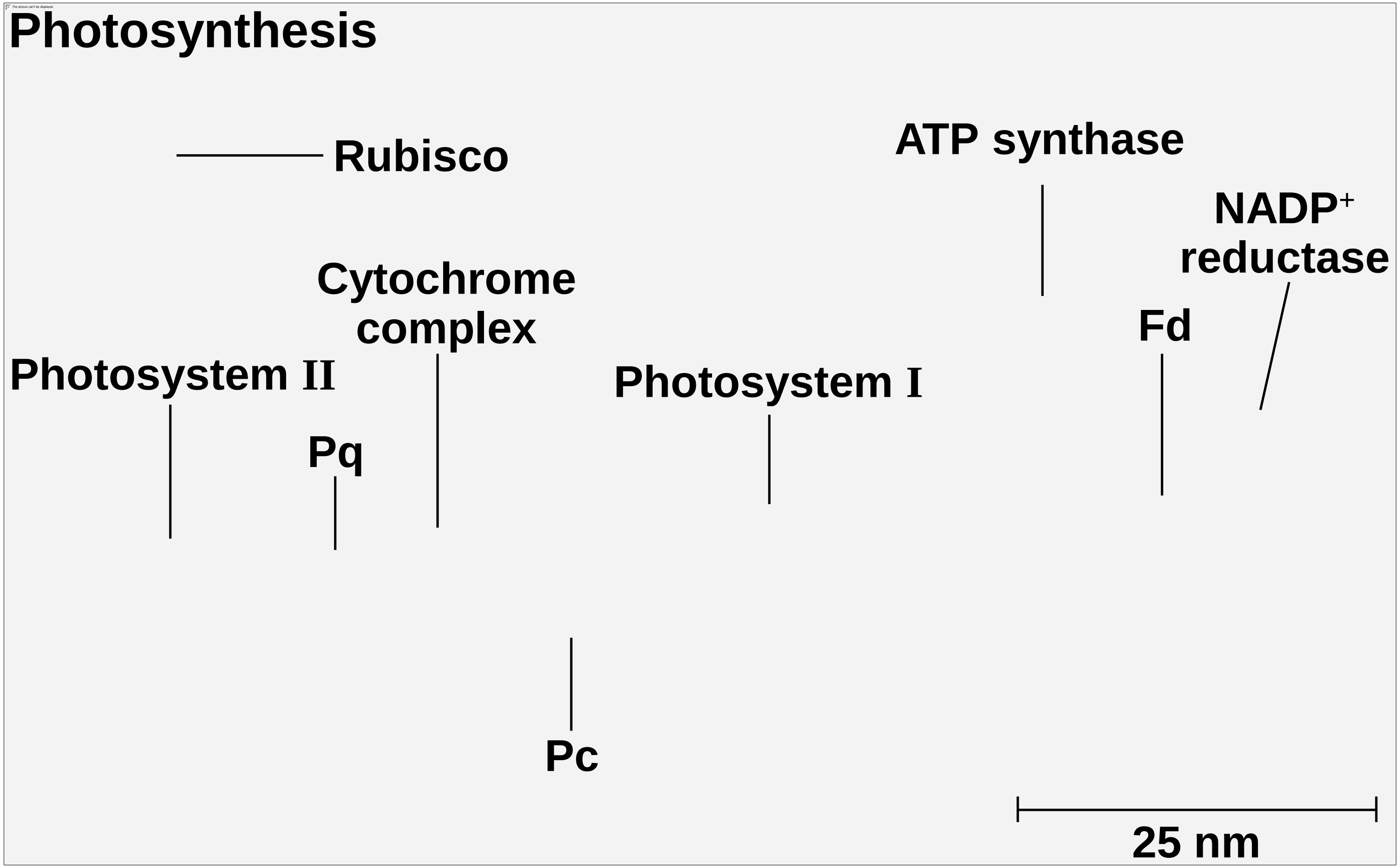

Photosynthesis
Rubisco
ATP synthase
NADP+ reductase
Cytochrome complex
Fd
Photosystem II
Photosystem I
Pq
Pc
25 nm

Figure 7.32f

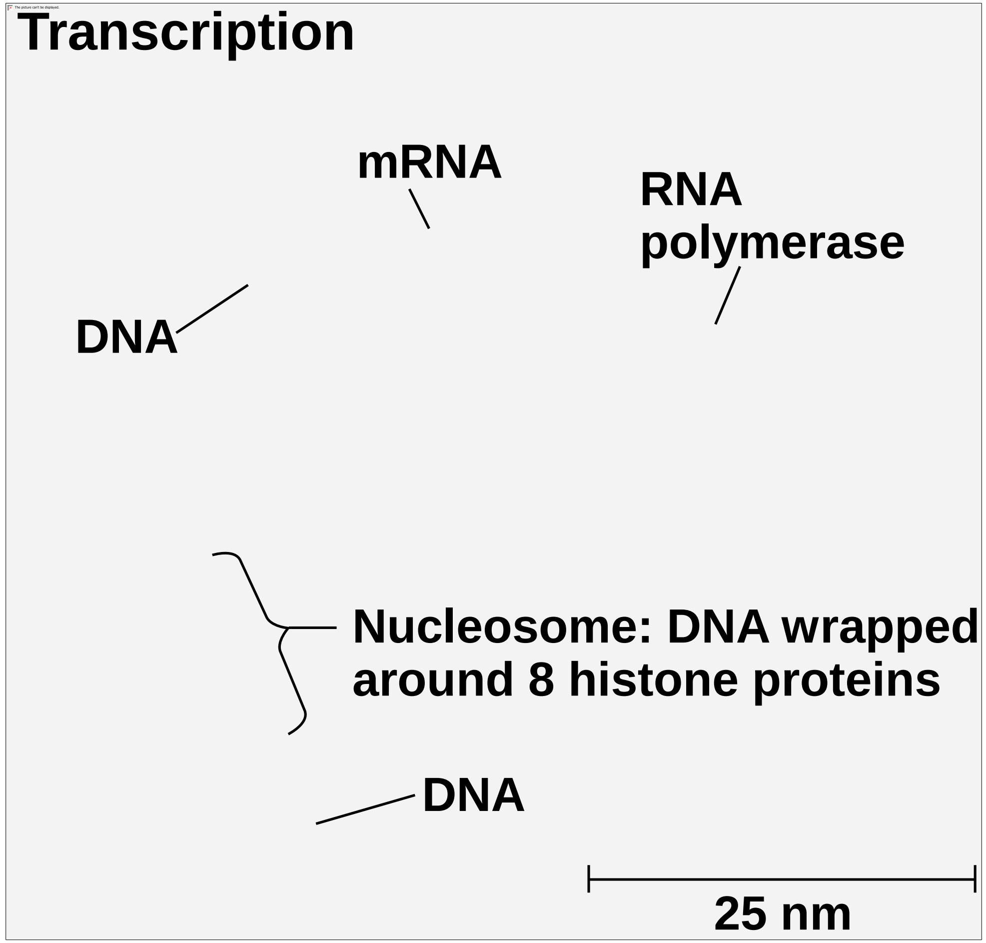

Transcription
mRNA
RNA
polymerase
DNA
Nucleosome: DNA wrapped
around 8 histone proteins
DNA
25 nm

Figure 7.32g

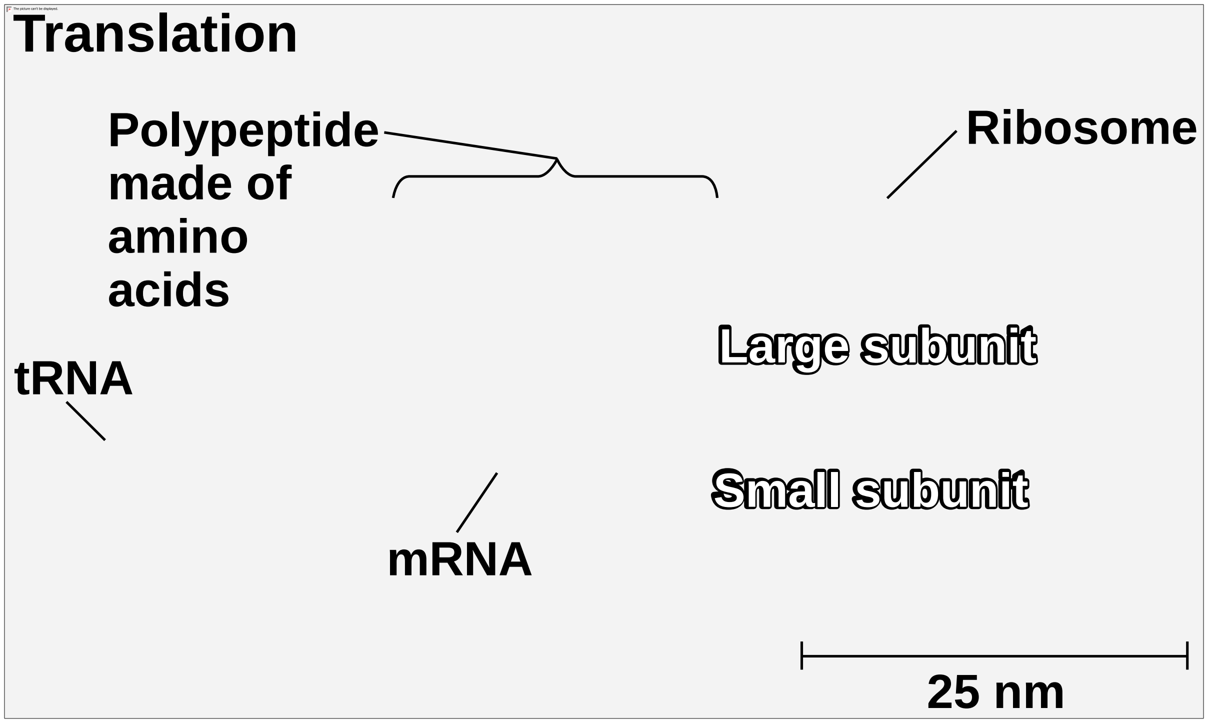

Translation
Polypeptide made of amino acids
Ribosome
Large subunit
tRNA
Small subunit
mRNA
25 nm

Figure 7.32h

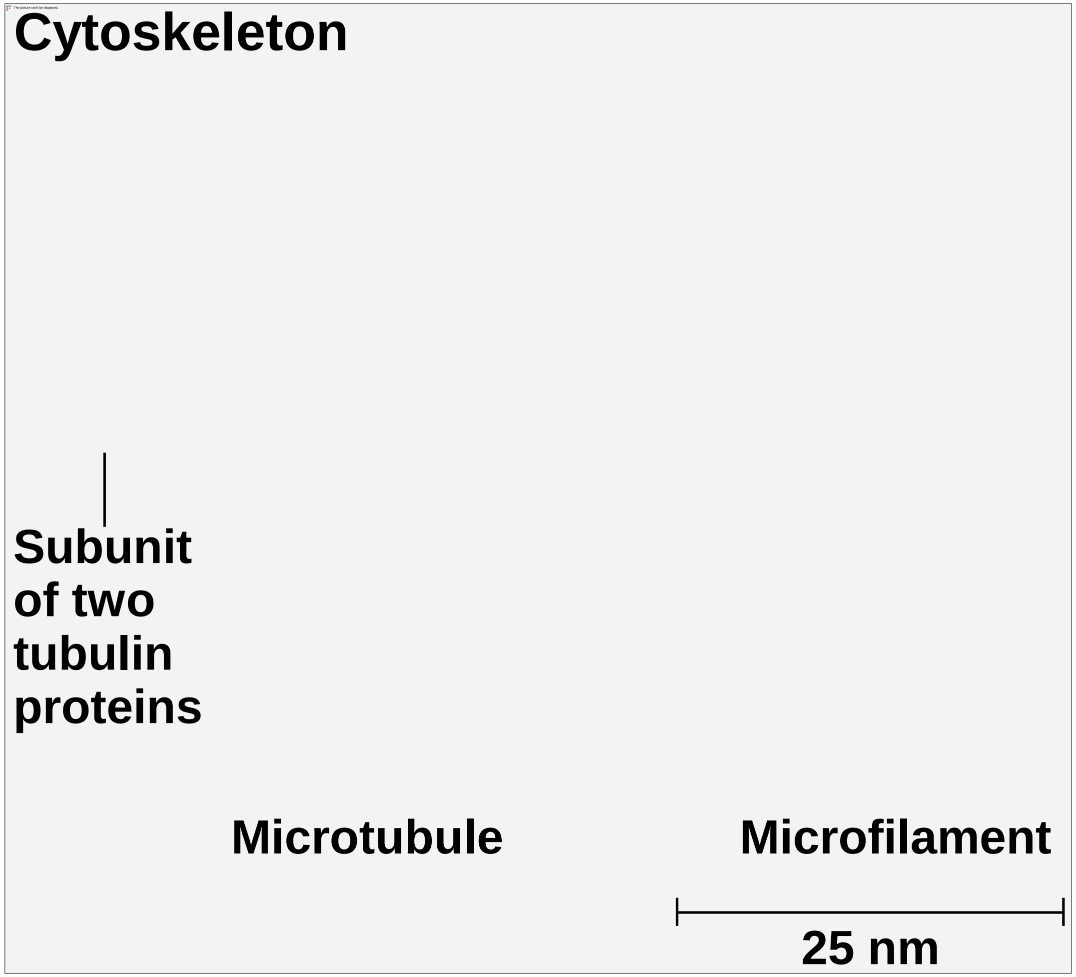

Cytoskeleton
Subunit of two tubulin proteins
Microtubule
Microfilament
25 nm

Figure 7.32i

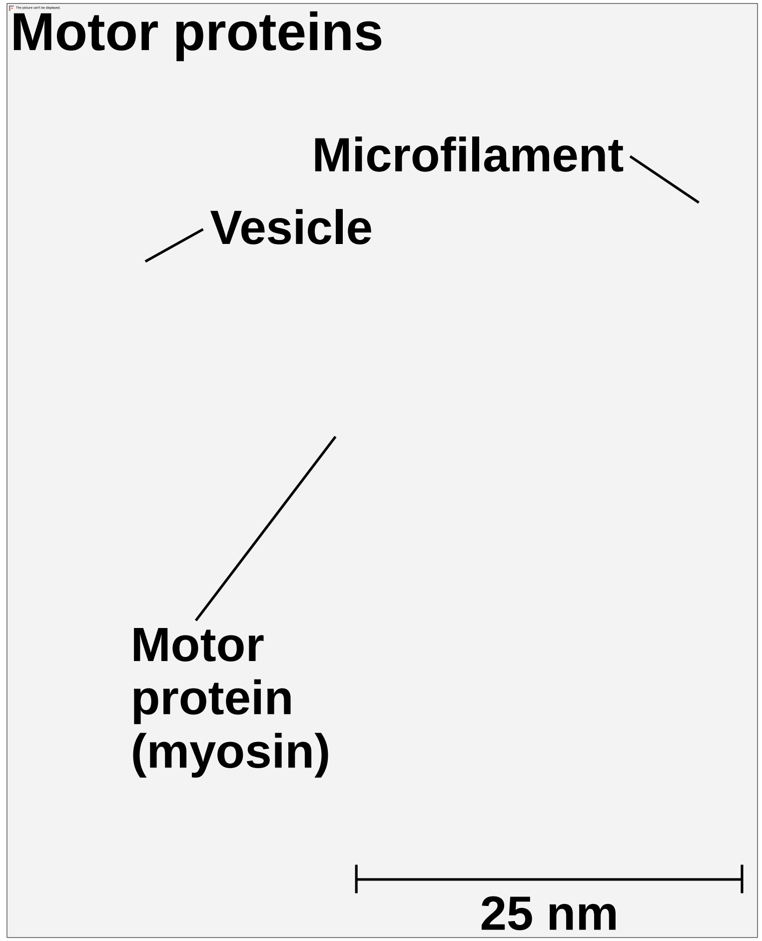

Motor proteins
Microfilament
Vesicle
Motor protein (myosin)
25 nm

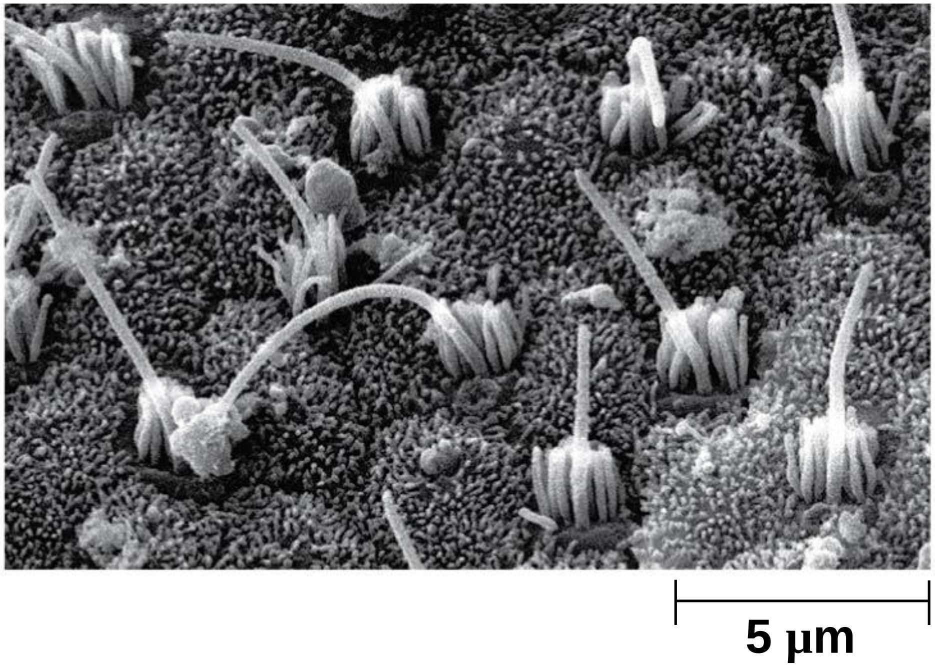
Figure 7.32j

The picture can't be displayed.

Figure 7.0

UNIT 2: CELL BIOLOGY

Dr. Elba Serrano

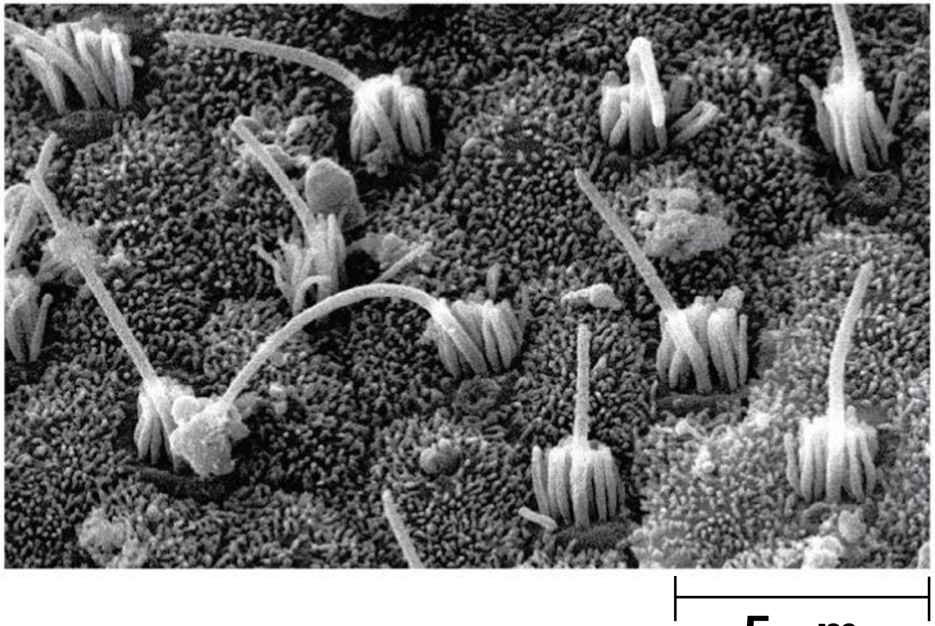


Inner ear “hair” cells with bundles of rod-like protrusions that detect sound waves (SEM)

“Membranes are like borders—very dynamic places where a lot of things happen.”

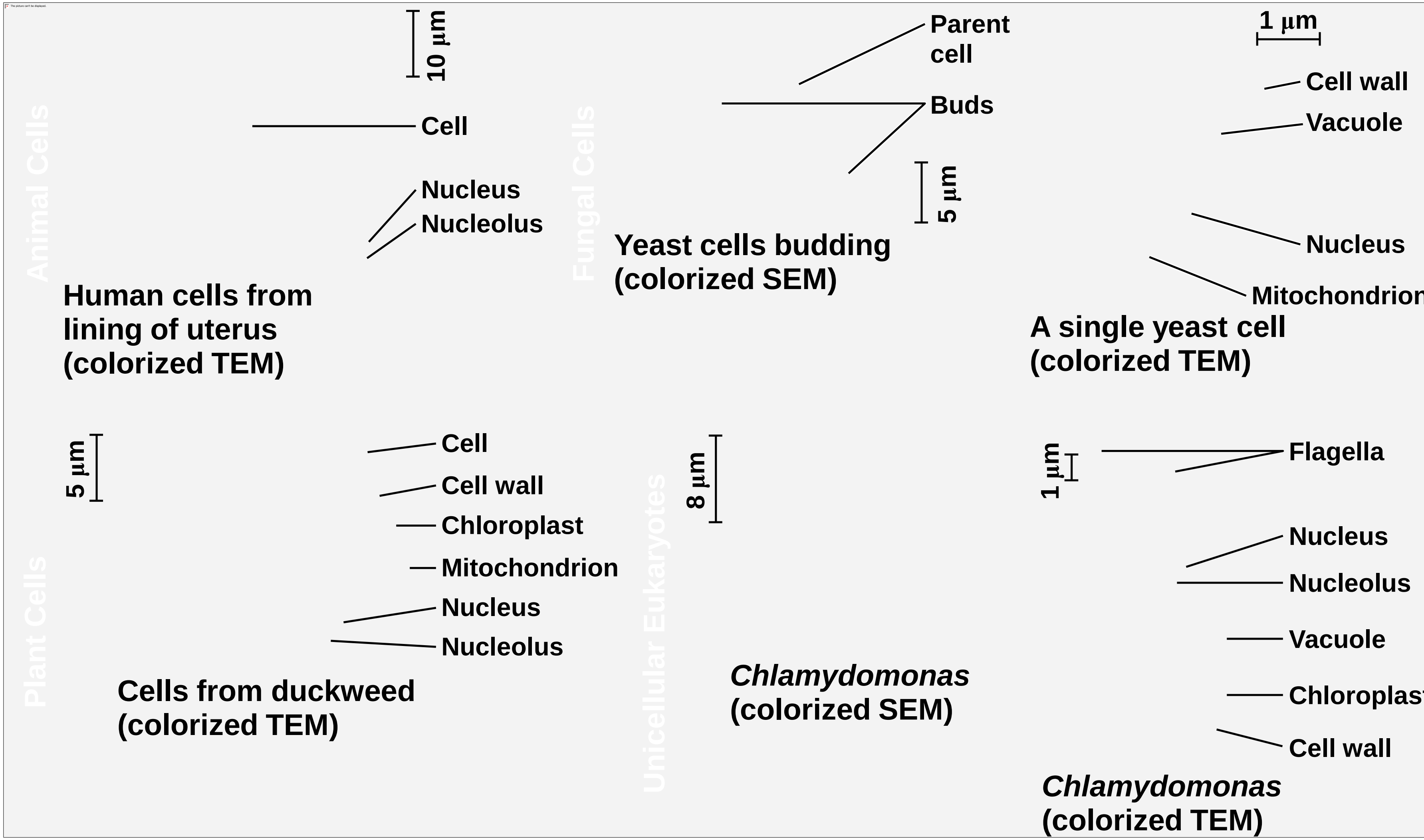
Figure 7.0a

Dr. Elba Serrano



Inner ear “hair” cells with bundles of rod-like protrusions that detect sound waves (SEM)

Figure 7.8c



Animal Cells
10 µm
Cell
Nucleus
Nucleolus
Human cells from lining of uterus (colorized TEM)
Fungal Cells
Parent cell
Buds
5 µm
Yeast cells budding (colorized SEM)
1 µm
Cell wall
Vacuole
Nucleus
Mitochondrion
A single yeast cell (colorized TEM)
Plant Cells
5 µm
Cell
Cell wall
Chloroplast
Mitochondrion
Nucleus
Nucleolus
Cells from duckweed (colorized TEM)
Unicellular Eukaryotes
8 µm
Chlamydomonas (colorized SEM)
1 µm
Flagella
Nucleus
Nucleolus
Vacuole
Chloroplast
Cell wall
Chlamydomonas (colorized TEM)

Figure 7.UN01a

Mature parent cell

Budding cell

1 μm

Micrograph from Kelly Tatchell, using yeast cells grown for experiments described in L. Kozubowski et al., Role of the septin ring in the asymmetric localization of proteins at the mother-bud neck in *Saccharomyces cerevisiae, Molecular Biology of the Cell* 16:3455–3466 (2005).

Figure 7.UN01b

$$V = \frac{4}{3}\pi r^3$$

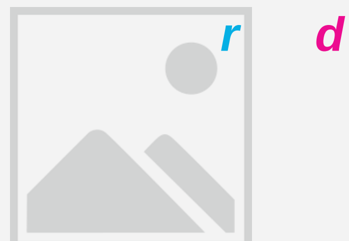


Figure 7.UN02

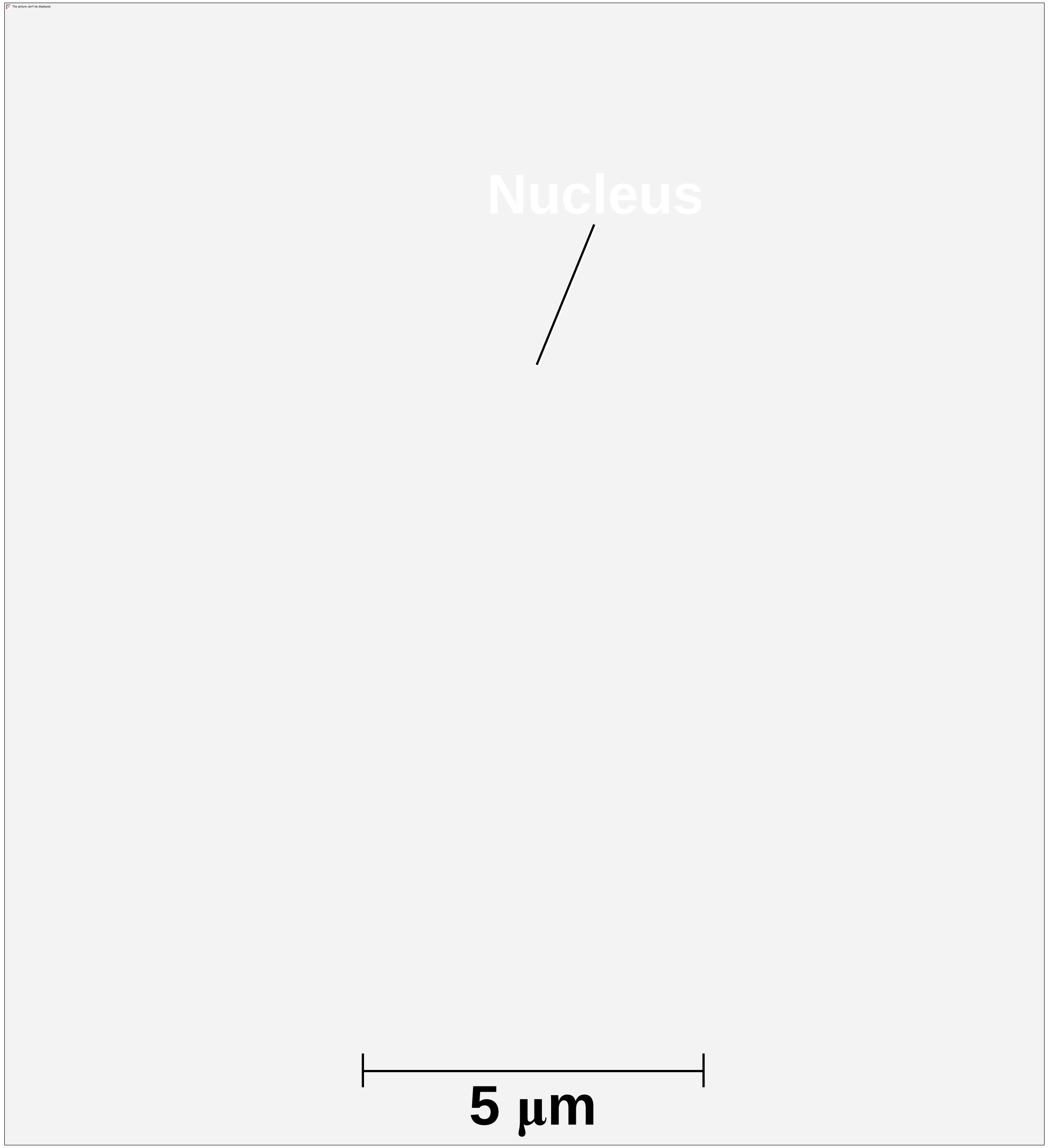


Figure 7.UN03

Cell Component	Structure	Function
Nucleus	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores; nuclear envelope continuous with endoplasmic reticulum (ER)	Houses chromosomes, which are made of chromatin (DNA and proteins); contains nucleoli, where ribosomal subunits are made; pores regulate entry and exit of materials
(ER)		
Ribosome	Two subunits made of ribosomal RNAs and proteins; can be free in cytosol or bound to ER	Protein synthesis

Figure 7.UN04

Cell Component	Structure	Function
Endoplasmic reticulum (ER) (Nuclear envelope)	Extensive network of membrane-bounded tubules and sacs; membrane separates lumen from cytosol; continuous with nuclear envelope	Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons Rough ER: aids in synthesis of secretory and other proteins on bound ribosomes; adds carbohydrates to proteins to make glycoproteins; produces new membrane
Golgi apparatus	Stacks of flattened membranous sacs; has polarity (*cis* and *trans* faces)	Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released In vesicles
Lysosome	Membranous sac of hydrolytic enzymes (in animal cells)	Breakdown of ingested substances, cell macromolecules, and damaged organelles for recycling
Vacuole	Large membrane-bounded vesicle	Digestion, storage, waste disposal, water balance, cell growth, and protection

Figure 7.UN05

Cell Component	Structure	Function
Mitochondrion	Bounded by double membrane; inner membrane has infoldings	Cellular respiration
Chloroplast	Typically two membranes around fluid stroma, which contains thylakoids stacked into grana	Photosynthesis (chloroplasts are in cells of photosynthetic eukaryotes, Including plants)
Peroxisome	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer H atoms from substrates to oxygen, producing H_2O_2 (hydrogen peroxide), which is converted to H_2O.

Figure 7.UN06