Investigation

10

Cell Structure and Organelles

Introduction

A cell is a functional unit that carries on all metabolic activities associated with life. The outer limits of a cell are bounded by a continuous membrane that serves both to enclose its contents and to regulate passage of molecules into and out of the cell. Within the cell are a number of specialized stuctures called *organelles*. Each organelle is specially adapted for certain functions. One current theory suggests that many organelles and the outer membrane have been formed from one single membrane structure, the *unit membrane*. Along with a large dense structure called the *nucleus,* which serves as the control center of the cell, the organelles are embedded in the *cytoplasm*. *Prokaryotic cells* such as bacteria and blue-green algae lack an organized nucleus and lack membrane-bound organelles. *Eukaryotic cells* have a membrane-bounded nucleus as well as membrane-bounded organelles within the cytoplasm.

Much of the cytoplasm in a cell is a colloidal mixture of protein macromolecules and fat globules dispersed in water. Smaller molecules such as simple sugars and inorganic ions are mixed with water to form a true solution.

Before electron microscopy, some of the cell organelles could be viewed with light microscopes, but these had many limitations. Since their introduction, transmission electron microscopes and scanning electron microscopes have enhanced the study of cell organelles greatly.

Purpose

To study the structure and function of organelles in eukaryotic plant and animal cells.

Materials

Electron micrographs and drawings of eukaryotic plant and animal cells.

Procedure A

Answer the following questions while making reference to the electron micrographs and figures 1 to 15. Your text should also be used to help you answer the questions.

Questions

1. The cell membrane is made up of phospholipids and proteins (see figure 1). What is the function of the cell membrane?
2. Figure 1 shows two adjoining animal cells. Does there appear to be a space between the two adjoining cell membranes? If so, what would be found in this space?
3. On observing the cell membranes of two animal cells in figure 1, each membrane appears as a light layer sandwiched between two darker layers. Why is this so? Explain.
4. Microtubules, intermediate filaments, and microfilaments are components of a cell's cytoskeleton (see figure 2). What roles does the cytoskeleton play in the cell?
5. Look at figures 2b and 2c. Describe the structural differences between microtubules and microfilaments.

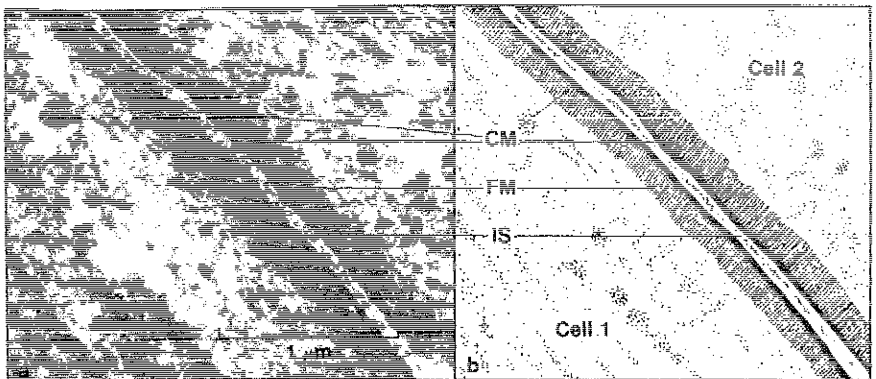


Figure 1a. *Electron micrograph showing the junction between two amphibian cardiac cells. Note the trilaminar appearance of the adjoining cell membranes (CM). The filamentous masses (FM) associated with each membrane internally are thought to be associated with microfilaments; intercellular space (IS). (×93 000)*

b. *A diagram showing a junction between two cells and the trilaminar appearance of the cell membrane of each cell.*

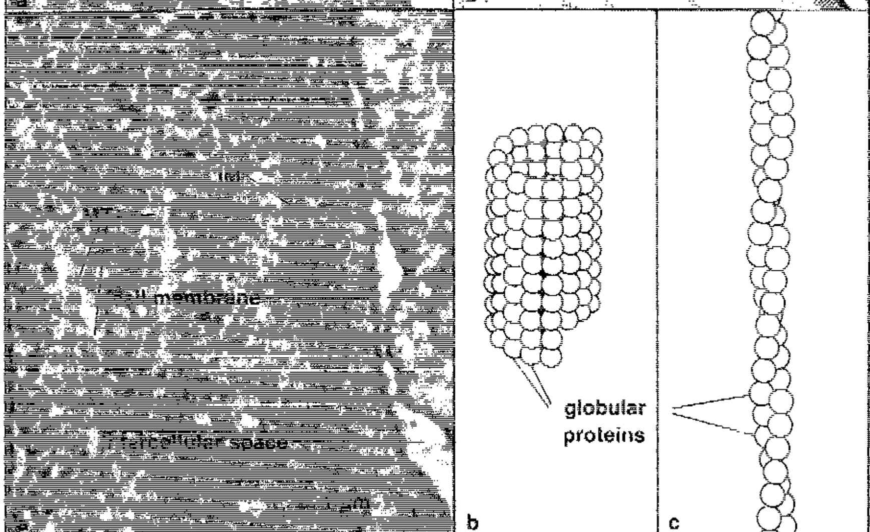


Figure 2a. *Longitudinal section through an amphibian small intestine cell displaying microtubules (MT) and intermediate filaments (IM). Intermediate filaments are intermediate in size between microtubules and microfilaments. Unlike microfilaments, they cannot contract and as a result play an important supportive function in the cytoplasm. (×35 500)*

b, c. *Drawings of a microtubule and a microfilament showing the arrangement of the globular proteins.*

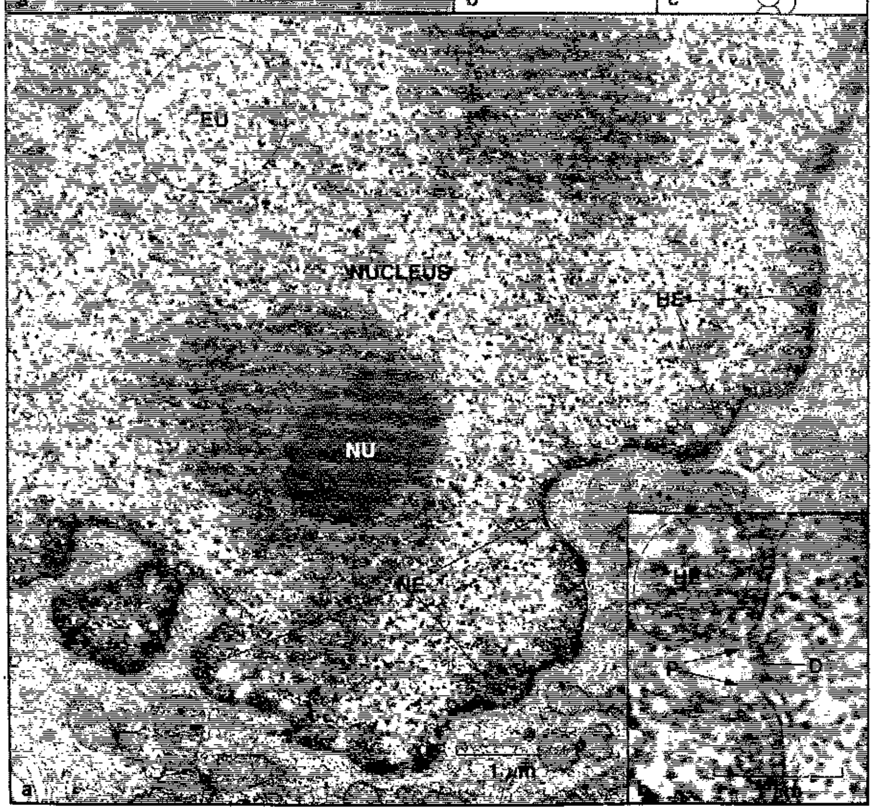


Figure 3a, b (inset). *Electron micrograph of an amphibian cardiac muscle cell showing a portion of the nucleus. Note the nucleolus (NU), nuclear envelope (NE), condensed chromatin or heterochromatin (HE) along the inner surface of the nuclear envelope and dispersed chromatin or euchromatin (EU) scattered throughout the nucleoplasm. Inset shows a pore (arrows) with a diaphragm (D) closing the pore. Heterochromatin is seen as clumps. (×13 900, inset ×34 900)*

6. Look at figure 3. Does the nuclear envelope seem to be made up of more than a single membrane? How many membranes are visible?
7. In figure 3 (inset), a pore whose opening is covered by a diaphragm is clearly visible. What role do the pores serve? What would be the role of the diaphragm?
8. Look at figure 3 and describe the physical differences between heterochromatin and euchromatin.
9. Note the nucleolus in figure 3. Describe the physical characteristics of this organelle.
10. Often free-floating ribosomes are organized into functional groups called polysomes (see figure 4). What is the function of polysomes?
11. Are polysomes larger than ribosomes?
12. Many ribosomes are attached to the membranes of the endoplasmic reticulum (see figure 4). What is their function?
13. Glycogen granules are often associated with muscle cells (see figure 4). What role might they serve in muscle cell function?
14. About half a dozen saccules comprise the Golgi apparatus as shown in figure 5. What seems to be the major role of this structure?
15. Lysosomes are special vesicles which are most likely formed by the Golgi apparatus (see figure 6b). What role do lysosomes play with respect to the metabolic activities within a cell?
16. List two other roles that lysosomes may play in the cell.
17. Two types of lysosomes may be observed in figure 6b. Vesicles that appear darker in an electron micrograph are residual bodies containing nondigested materials, while lighter coloured vacuoles are probably autodigestive vacuoles. Look at figure 6b and explain which of the two lysosomes is shown.
18. As observed in figure 6a, what seems to be the relationship between vacuoles and vesicles?
19. How are vesicles and vacuoles formed? Explain.
20. Note that in figure 7a, the inner membrane of a mitochondrion is invaginated to form shelf-like structures called cristae. How does this inner structure of the mitochrondrion aid its function? Explain.
21. Flagella and cilia are composed of a special arrangement of membrane-bounded microtubules (see figures 8b, c). List some functions of flagella and cilia.
22. How are basal bodies structurally related to cilia and flagella? (see figure 8b)
23. Look at figure 8c. Describe the microtubule arrangement of a flagellum.
24. Describe the structural differences between a desmosome and a tight junction (see figures 9 and 10).
25. What are the roles of the above two junctions?
26. Describe the structural differences between a gap junction and an intermediate junction (see figures 11 and 12).
27. Observe figures 9 to 12. Of all the junctions illustrated, which junctions seem to allow for the movement of molecules from cell to cell? Explain.

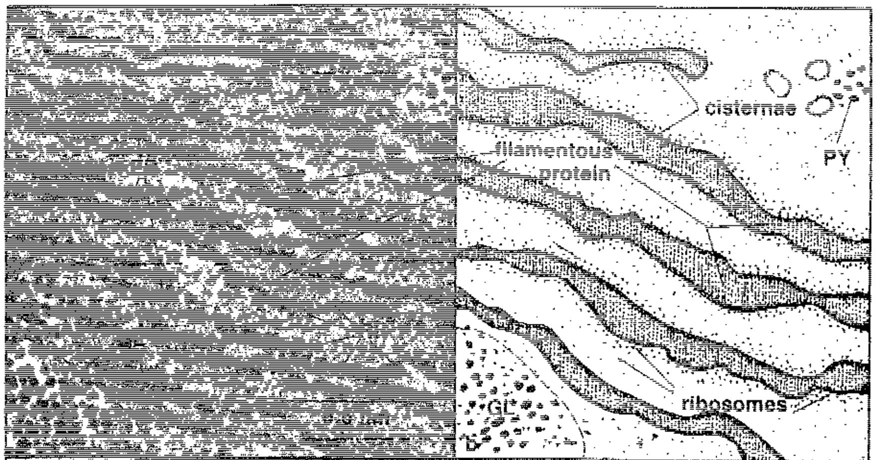


Figure 4a. *Electron micrograph of an amphibian muscle cell showing endoplasmic reticulum (ER) with numerous ribosomes (RI) attached. Clusters of ribosomes or polysomes (PY) and glycogen granules (GL) are evident as well. Filamentous protein material fills the endoplasmic cisternae. (×37 500)*

b. A drawing of rough endoplasmic reticulum cisternae.

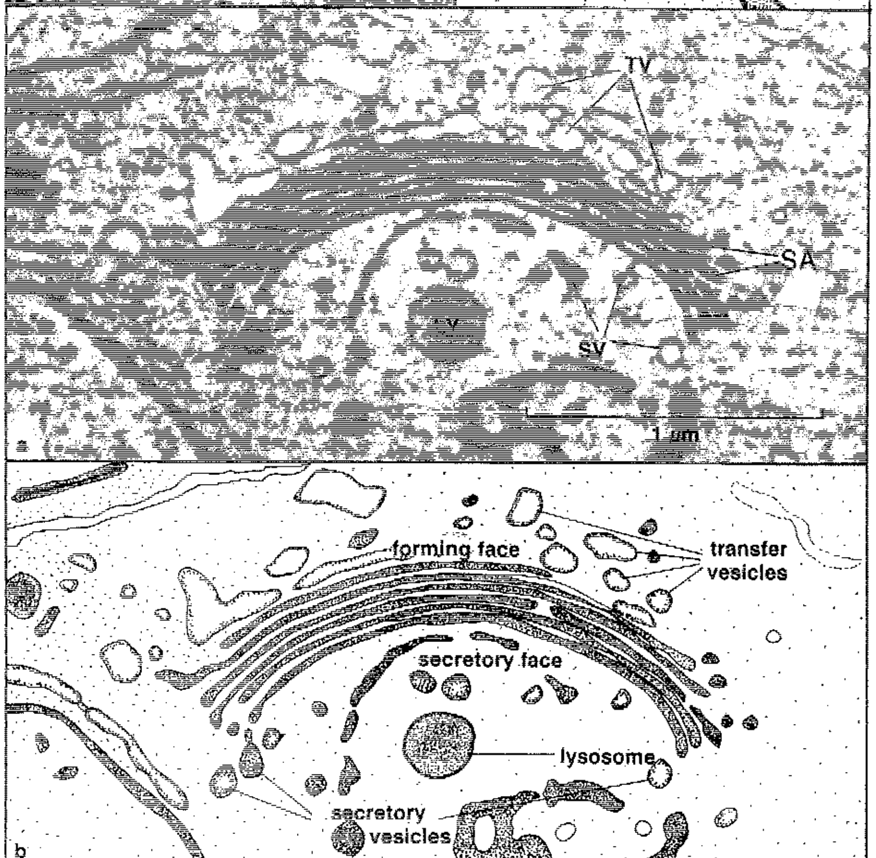


Figure 5a. *Electron micrograph of a brachiopod digestive gland showing a Golgi apparatus composed of saccules (SA). Note the transfer vesicles (TV) which are thought to be protein-filled vesicles from the endoplasmic reticulum moving to the forming face (convex side) of the Golgi apparatus. Lysosomes (LY) and secretory vesicles (SV) are pinched off from the edges of the saccules and from the secretory face (concave side). (×39 000)*

b. A schematic drawing of a stack of cisternae of a Golgi apparatus.

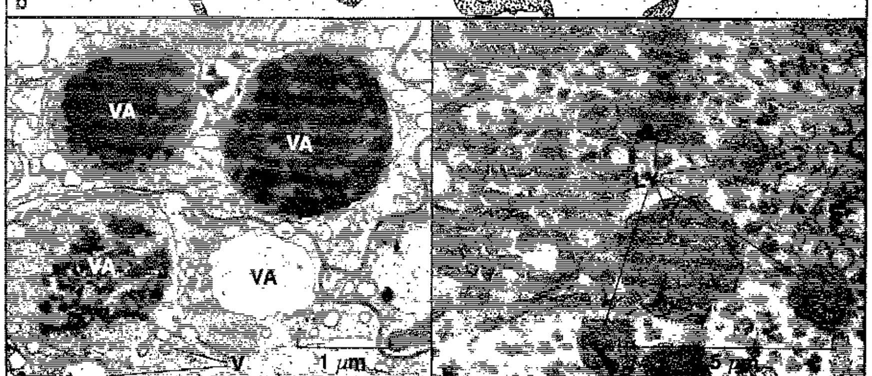


Figure 6a. *Electron micrograph of a muscle cell showing four large vacuoles (VA) filled with various products. Many small vesicles (V) are seen in the cytoplasm. (×12 700)*

b. Electron micrograph of primary lysosomes (LY) in a muscle cell. (×56 500)

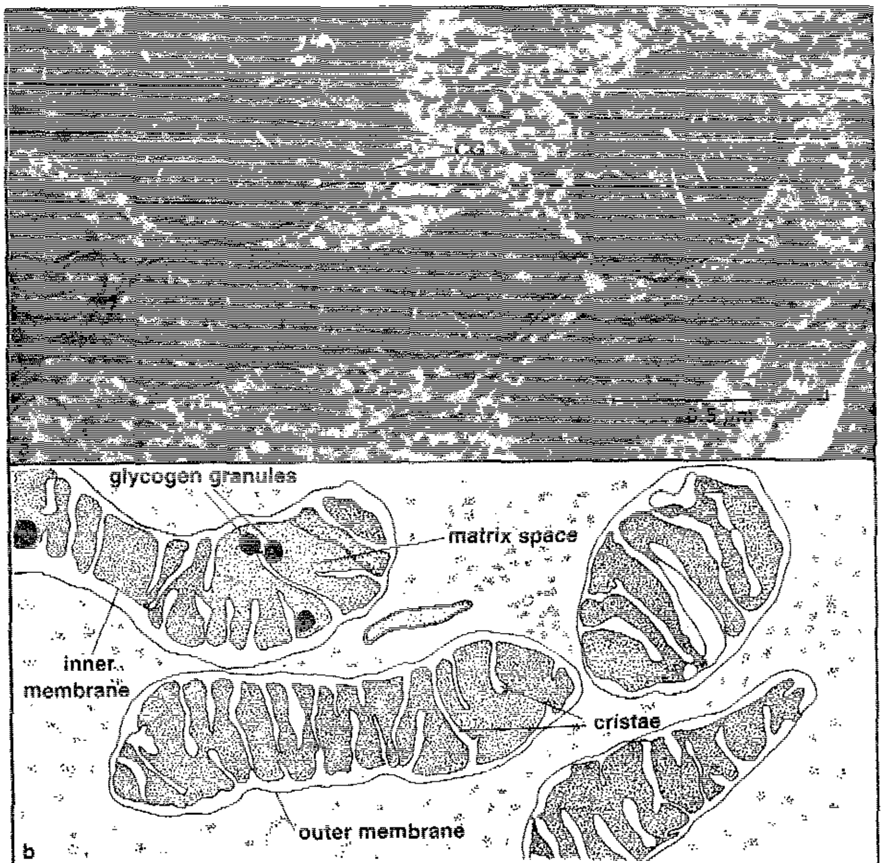


Figure 7a. *Longitudinal section of mitochondria in a cardiac muscle cell. Note the large calcium granules (CG) in the matrix space. These granules are found in cells noted for calcium depositions. (× 55 900)*

b. A schematic diagram of mitochondria depicting the double membrane, the outer smooth membrane and the convoluted inner membrane making shelf-like projections called cristae.

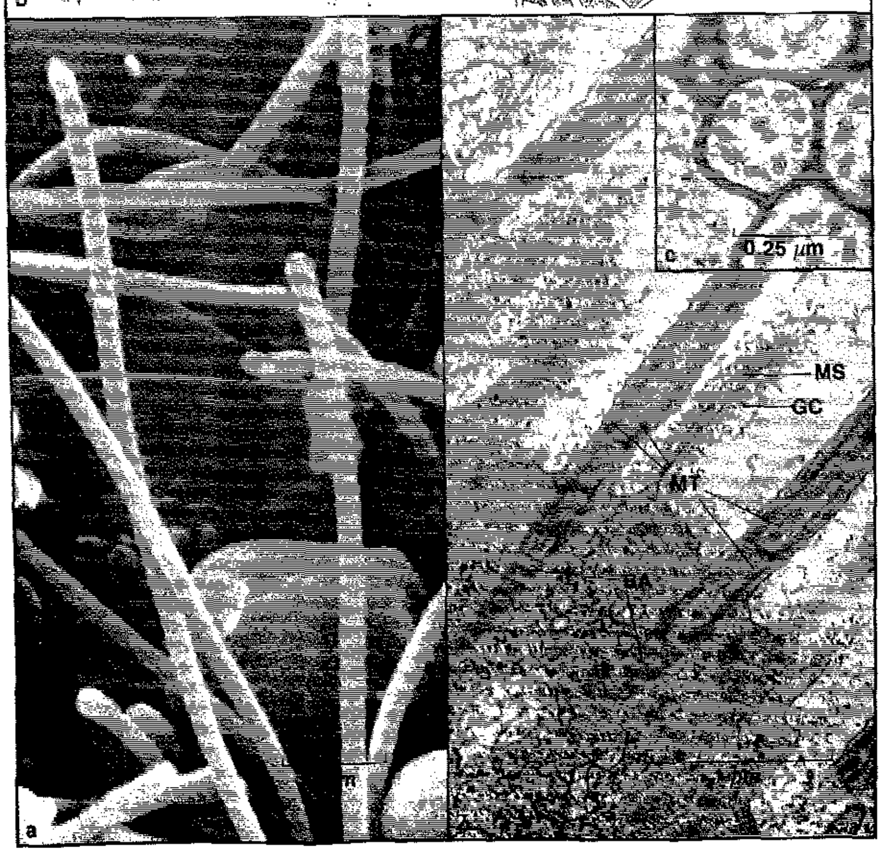


Figure 8a. *Scanning electron micrograph of flagella found on a cell lining the tubefoot of a starfish. (×13 600)*

b. *Longitudinal section of flagella found on a tunicate branchial basket. Centriolar components of two basal bodies (BA) are seen to be continuous with microtubules (MT) extending into the ciliary shaft; microvillus (MS), glycocalyx (GC). (×25 000)*

c. *A cross section in a plane indicated at the arrow shown at a higher magnification. Note the typical 9 + 2 ciliary arrangement of microtubules. (×53 500)*

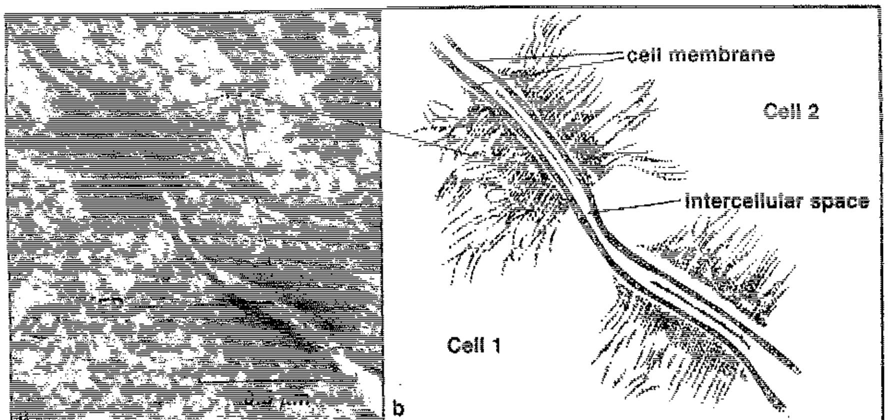


Figure 9a. *Electron micrograph showing desmosomes binding two adjacent cells. Note the fibrous plaque (FP) to the inside of each cell membrane and the extracellular plaques (EP) in the intercellular space. These two dense mats of filaments give cells greater stability. (×43 500)*

b. *A schematic drawing of desmosomes connecting two cells.*

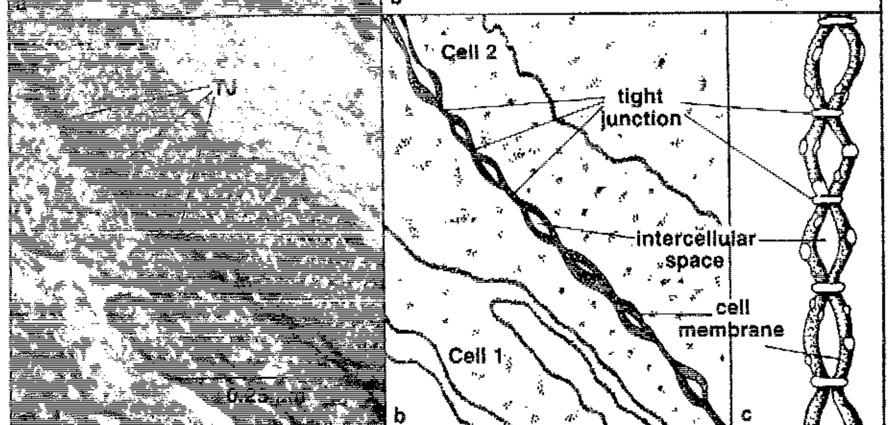


Figure 10a. *Electron micrograph of two tunicate (sea squirt) epidermal cells bound together by a tight junction (TJ). (×100 300)*

b, c. *Schematic drawings of a tight junction.*

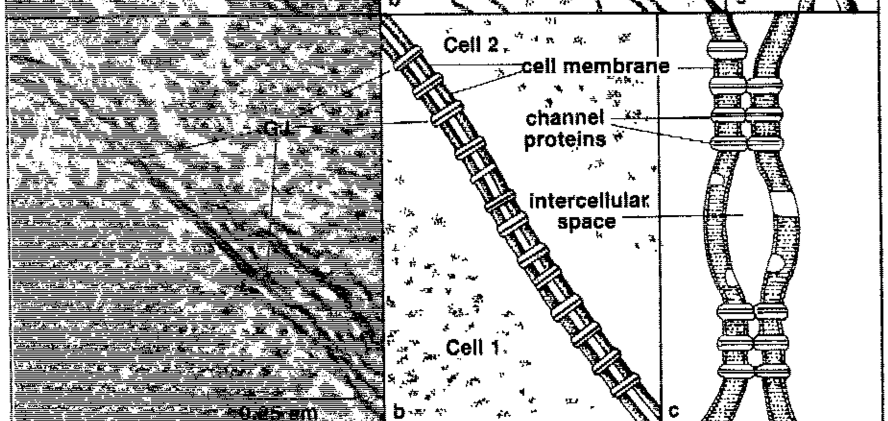


Figure 11a. *Electron micrograph showing a portion of two tunicate muscle cells connected by a gap junction (GJ). (×78 400)*

b. *A drawing showing a gap junction.*

c. *A schematic drawing showing channels in proteins embedded in cell membranes which allows exchange of molecules between cells.*

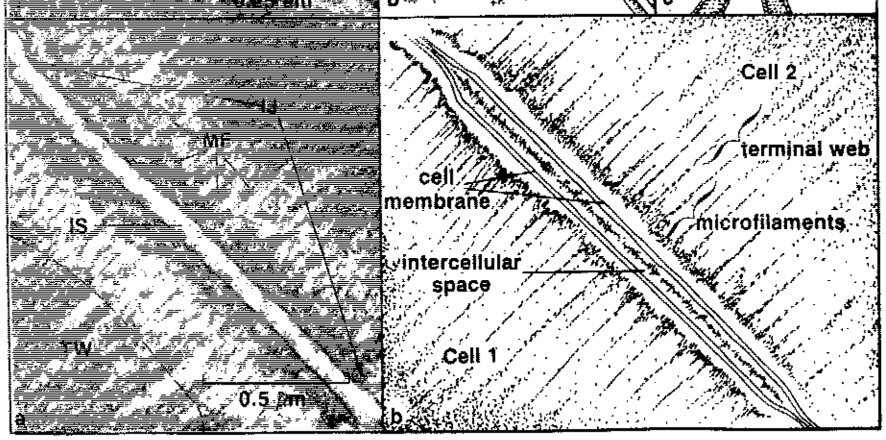


Figure 12a. *Electron micrograph showing an intermediate junction (IJ) between two tunicate muscle cells. Microfilaments (MF) of the terminal web (TW) attach to the cell membranes at the intermediate junction. (×39 500); intercellular space (IS).*

b. *A drawing of an intermediate junction.*

Figure 13. *Electron micrograph of an embryonic cell from a tunicate branchial basket. The nucleus surrounded by the nuclear envelope (NE) fills most of the embryonic cell. Pores (P) with a diaphragm covering the pore (black arrows) are visible. A single nucleolus (NU) occupies a large portion of the nucleus. Vesicles (V), cisternae of rough endoplasmic reticulum (RER), mitochondria (MI), glycogen granules (GL) as well as free ribosomes (FR) are clearly visible. Cells are seen interdigitating (white arrows) to aid in holding cells together. Intercellular spaces (IS) and cell membranes (CM) are visible. (×35 100)*

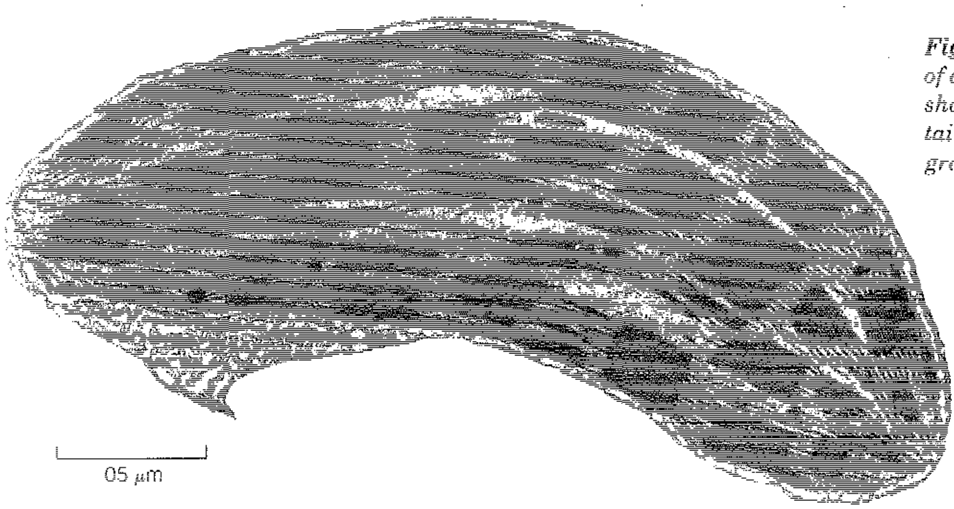
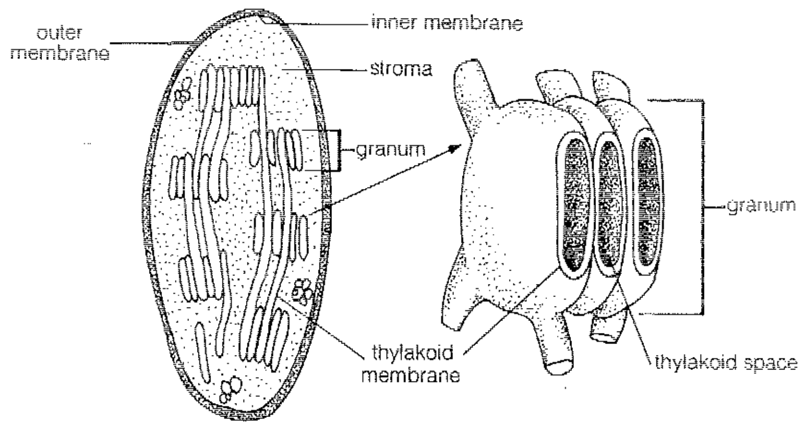


Figure 14a. *Longitudinal section of a chloroplast from a corn leaf cell showing stacks of chlorophyll-containing sacks which make up a granum. (×40 000)*



b. A schematic drawing showing a chloroplast composed of organized thylakoid membranes. Individual thylakoid sacks are interconnected and they tend to stack to form grana. (sing. granum). Surrounding the grana is a colourless matrix, the stroma. The stroma and the inter-connecting thylakoid membranes are enclosed by a pair of membranes.

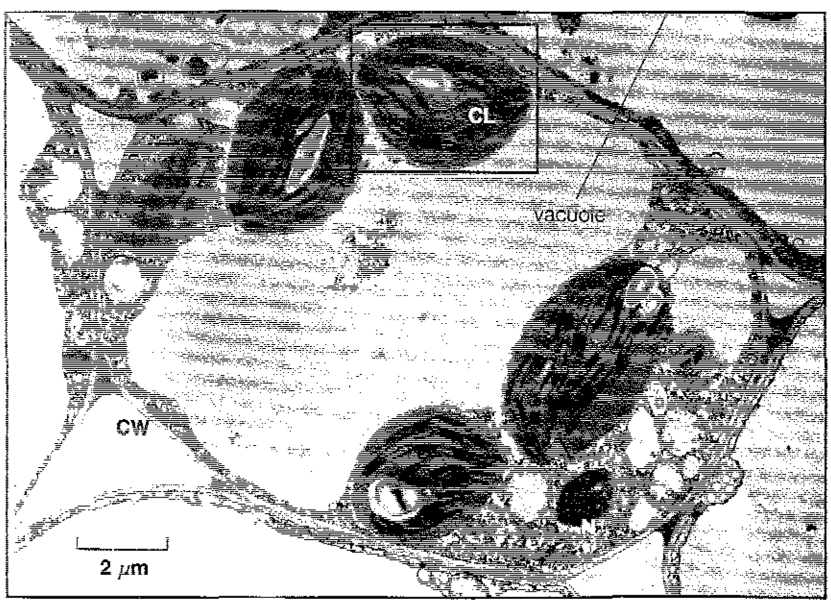
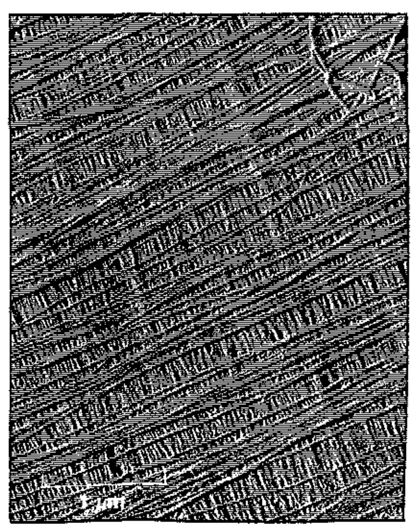


Figure 15a. *Electron micrograph of a plant leaf cell. Note the large central vacuole which makes up the largest part of the cell volume. Note the nucleus (N), chloroplasts (CL) and cell wall (CW). (×6000)*



b. Cellulose fibres of a primary cell wall of a green alga. (×17 000) Higher plants are composed of large numbers of cells cemented together in fixed positions by rigid cell walls that surround them.

28. In figure 13, note the size of the nucleus in comparison to the size of the cell. As cells mature, the size of the nucleus in relation to cell volume decreases. How could you explain this?
29. Note in figure 13 that the cytoplasm appears to be granular due to numerous free ribosomes suspended in the cytoplasm. Distinguish between the function of free ribosomes and attached ribosomes.
30. Look at figure 13. What organelle seems to fill most of the nucleus?
31. Look at figures 14b, c. The chloroplast envelope is a double membrane enclosing a matrix called the stroma in which stacks of thylakoid sacks (grana) are embedded. Where in the chloroplast is chlorophyll found?
32. How many membranes enclose the contents of the chloroplast? (see figures 14b, c)
33. Are the outer membranes of a chloroplast continuous with the thylakoid membranes? (see figures 14b, c)
34. How are the thylakoid sacks of one granum interconnected with thylakoid sacks of another granum? (see figures 14b, c)
35. Look at figure 15a. The cell wall lies externally to the cell membrane and is much thicker than the cell membrane. What is the main function of the cell wall?
36. Look at figures 15a, b. Describe the structure of the cell wall.
37. Look at figure 15b. Would the cell wall be permeable or impermeable to molecules? Explain.
38. In figure 15a, note the large central vacuole in the plant cell. What is the role of the central vacuole?
39. Observe figure 15a. Explain why the organelles located in the cell cytoplasm are near the cell wall.
40. Some smaller vacuoles (vesicles) arise from the infolding of the cell membrane or by the pinching action of the Golgi apparatus. How does the large central vacuole found in a plant cell arise?

Procedure B

Figures 16a and 16b represent electron micrographs of plant and animal cells. Various organelles and cellular structures have been numbered. For each cell construct a table like the one shown below. Identify by name each of the numbered structures and list its function(s). Estimate the size of each numbered structure by referring to the scale indicator in the lower right hand corner of each photomicrograph. Figures 1 to 15 may also be used to find the sizes of the various organelles. All values may also be expressed in nanometres, since

$$1\ \mu m = 1000\ nm$$

Identification of Plant Cell Parts			
Number	Name	Size (μm or nm)	Function
1			
2			
3			

Figure 16a. Electron micrograph of a plant cell with numbered cellular structures.

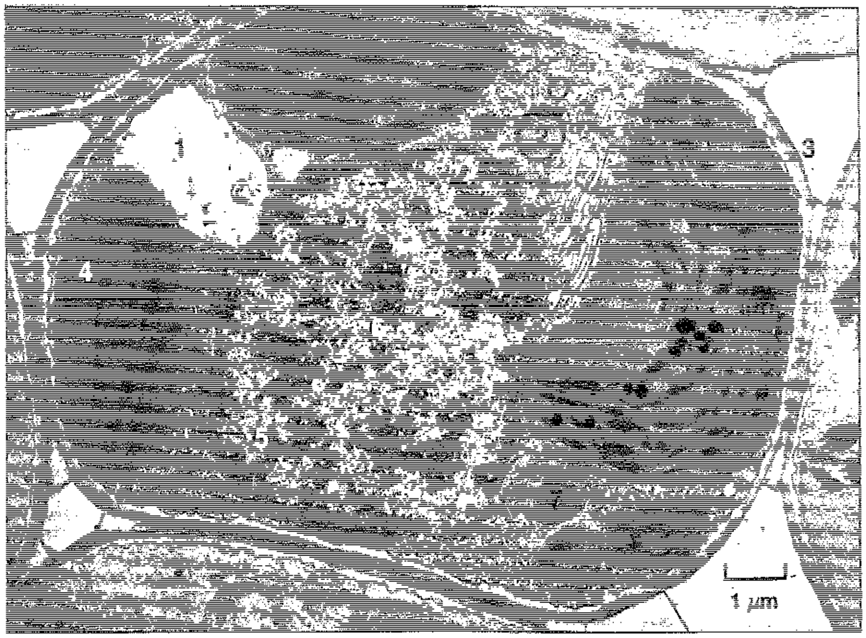


Figure 16b. Electron micrograph of an animal cell with numbered cellular structures.