

face and concave *trans* or the maturing face. The *cis* and the *trans* faces of the organelle are entirely different, but interconnected.

The golgi apparatus principally performs the function of packaging materials, to be delivered either to the intra-cellular targets or secreted outside the cell. Materials to be packaged in the form of vesicles from the ER fuse with the *cis* face of the golgi apparatus and move towards the maturing face. This explains, why the golgi apparatus remains in close association with the endoplasmic reticulum. A number of proteins synthesised by ribosomes on the endoplasmic reticulum are modified in the cisternae of the golgi apparatus before they are released from its *trans* face. Golgi apparatus is the important site of formation of glycoproteins and glycolipids.

#### 8.5.3.3 Lysosomes

These are membrane bound vesicular structures formed by the process of packaging in the golgi apparatus. The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases – lipases, proteases, carbohydrases) optimally active at the acidic pH. These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

#### 8.5.3.4 Vacuoles

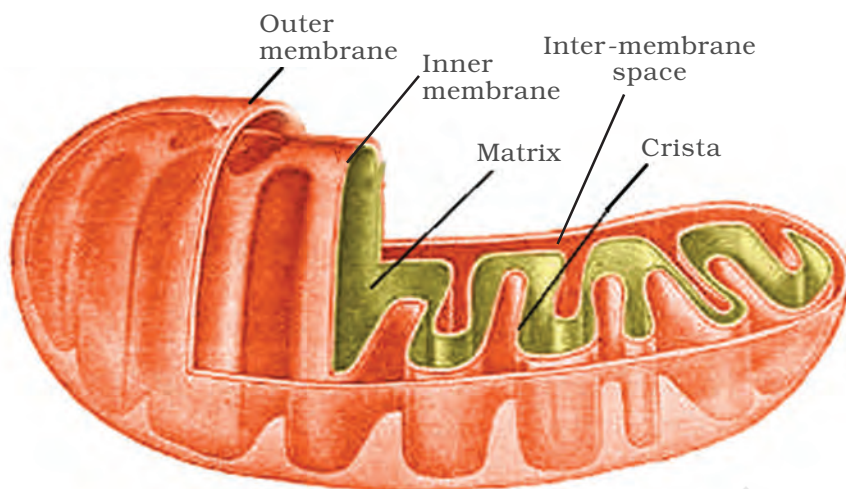
The vacuole is the membrane-bound space found in the cytoplasm. It contains water, sap, excretory product and other materials not useful for the cell. The vacuole is bound by a single membrane called tonoplast. In plant cells the vacuoles can occupy up to 90 per cent of the volume of the cell.

In plants, the tonoplast facilitates the transport of a number of ions and other materials against concentration gradients into the vacuole, hence their concentration is significantly higher in the vacuole than in the cytoplasm.

In *Amoeba* the **contractile vacuole** is important for osmoregulation and excretion. In many cells, as in protists, **food vacuoles** are formed by engulfing the food particles.

#### 8.5.4 Mitochondria

Mitochondria (sing.: mitochondrion), unless specifically stained, are not easily visible under the microscope. The number of mitochondria per cell is variable depending on the physiological activity of the cells. In terms of shape and size also, considerable degree of variability is observed. Typically it is sausage-shaped or cylindrical having a diameter of 0.2-1.0 $\mu\text{m}$  (average 0.5 $\mu\text{m}$ ) and length 1.0-4.1 $\mu\text{m}$ . Each mitochondrion is a double



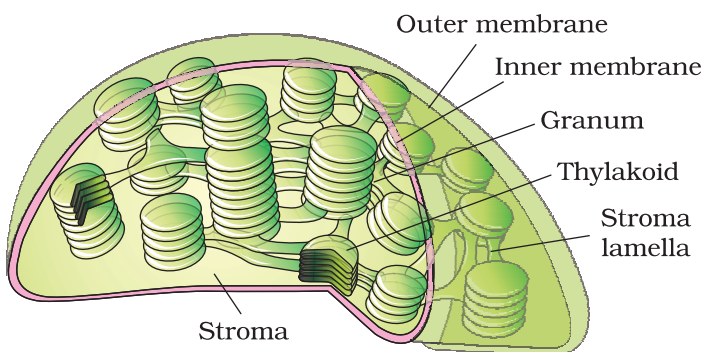
**Figure 8.7** Structure of mitochondrion (Longitudinal section)

membrane-bound structure with the outer membrane and the inner membrane dividing its lumen distinctly into two aqueous compartments, i.e., the outer compartment and the inner compartment. The inner compartment is filled with a dense homogeneous substance called the **matrix**. The outer membrane forms the continuous limiting boundary of the organelle. The inner membrane forms a number of infoldings called the cristae (sing.: crista) towards the matrix (Figure 8.7). The cristae increase the surface area. The two membranes have their own specific enzymes associated with the mitochondrial function. Mitochondria are the sites of aerobic respiration. They produce cellular energy in the form of ATP, hence they are called ‘power houses’ of the cell. The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. The mitochondria divide by fission.

### 8.5.5 Plastids

Plastids are found in all plant cells and in euglenoides. These are easily observed under the microscope as they are large. They bear some specific pigments, thus imparting specific colours to the plants. Based on the type of pigments plastids can be classified into **chloroplasts**, **chromoplasts** and **leucoplasts**.

The chloroplasts contain **chlorophyll** and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis. In the chromoplasts fat soluble **carotenoid** pigments like carotene, xanthophylls and others are present. This gives the part of the plant a yellow, orange or red colour. The leucoplasts are the colourless plastids of varied shapes and sizes with stored nutrients: **Amyloplasts** store carbohydrates (starch), e.g., potato; **elaioplasts** store oils and fats whereas

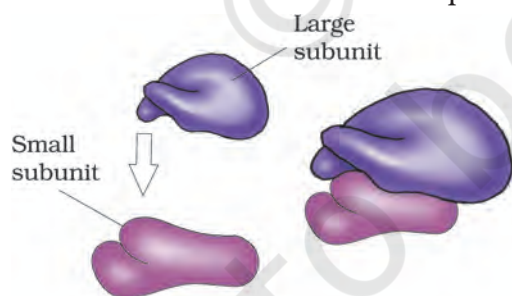


**Figure 8.8** Sectional view of chloroplast

the **aleuroplasts** store proteins. Majority of the chloroplasts of the green plants are found in the mesophyll cells of the leaves. These are lens-shaped, oval, spherical, discoid or even ribbon-like organelles having variable length (5-10 $\mu$ m) and width (2-4 $\mu$ m). Their number varies from 1 per cell of the *Chlamydomonas*, a green alga to 20-40 per cell in the mesophyll. Like mitochondria, the chloroplasts are also double membrane bound. Of the two, the inner chloroplast membrane is relatively less permeable. The space limited by the inner membrane of the chloroplast is called the stroma. A number of organised flattened membranous sacs called the **thylakoids**, are present in the stroma (Figure 8.8). Thylakoids are arranged in stacks like the piles of coins called grana (singular: granum) or the intergranal thylakoids. In addition, there are flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana. The membrane of the thylakoids enclose a space called a lumen. The stroma of the chloroplast contains enzymes required for the synthesis of carbohydrates and proteins. It also contains small, double-stranded circular DNA molecules and ribosomes. Chlorophyll pigments are present in the thylakoids. The ribosomes of the chloroplasts are smaller (70S) than the cytoplasmic ribosomes (80S).

### 8.5.6 Ribosomes

Ribosomes are the granular structures first observed under the electron microscope as dense particles by George Palade (1953). They are composed of ribonucleic acid (RNA) and proteins and are not surrounded by any membrane.

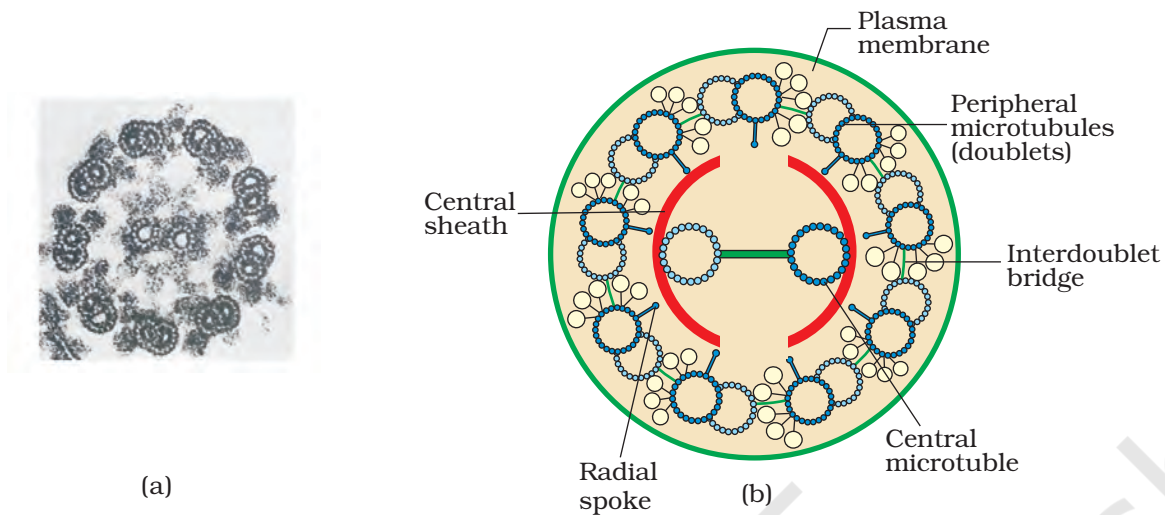


**Figure 8.9** Ribosome

The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. Each ribosome has two subunits, larger and smaller subunits (Fig 8.9). The two subunits of 80S ribosomes are 60S and 40S while that of 70S ribosomes are 50S and 30S. Here 'S' (Svedberg's Unit) stands for the sedimentation coefficient; it is indirectly a measure of density and size. Both 70S and 80S ribosomes are composed of two subunits.

### 8.5.7 Cytoskeleton

An elaborate network of filamentous proteinaceous structures consisting of microtubules, microfilaments and intermediate filaments present in the cytoplasm is collectively referred to as the **cytoskeleton**. The cytoskeleton in a cell are involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.



**Figure 8.10** Section of cilia/flagella showing different parts : (a) Electron micrograph (b) Diagrammatic representation of internal structure

### 8.5.8 Cilia and Flagella

Cilia (sing.: cilium) and flagella (sing.: flagellum) are hair-like outgrowths of the cell membrane. Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella are comparatively longer and responsible for cell movement. The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.

The electron microscopic study of a cilium or the flagellum show that they are covered with plasma membrane. Their core called the **axoneme**, possesses a number of microtubules running parallel to the long axis. The axoneme usually has nine doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules. Such an arrangement of axonemal microtubules is referred to as the 9+2 array (Figure 8.10). The central tubules are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublets by a radial spoke. Thus, there are nine radial spokes. The peripheral doublets are also interconnected by linkers. Both the cilium and flagellum emerge from centriole-like structure called the basal bodies.

### 8.5.9 Centrosome and Centrioles

**Centrosome** is an organelle usually containing two cylindrical structures called centrioles. They are surrounded by amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the cartwheel. They are