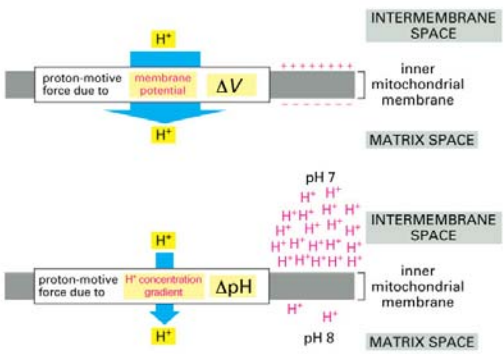
## Electron Transport Generates a Proton Gradient Across the Membrane

Each of respiratory enzyme complexes couples the energy released by electron transfer across it to an uptake of protons from water in the mitochondrial matrix, accompanied by the release of protons on the other side of the membrane into the intramembrane space. As result, the energetically favorable flow of electrons along the electron-transport chain pumps protons across the membrane out of the matrix. This event creates electrochemical protons across the inner membrane.

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## The Proton Gradient Drives ATP Synthesis

The electrochemical proton gradient across the inner mitochondrial membrane is used to drive ATP synthesis in the process of oxidative Phosphorylation. The device that makes this possible is a large membrane-bound enzyme called ATP synthase.

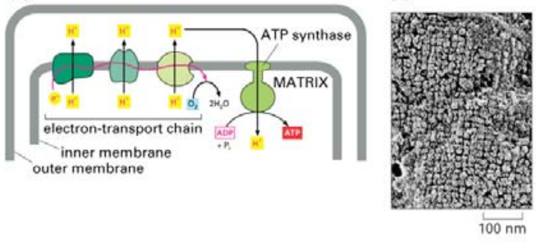


Figure 14-13 Essential Cell Biology, 2/e. (© 2004 Garland Science)

This enzymes creates a hydrophilic pathway across the inner mitochondrial membrane that allows protons to follow down their electrochemical gradient. As these ions thread their way through the ATP synthase, they are used to drive the energetically unfavorable reaction between ADP and Pi.

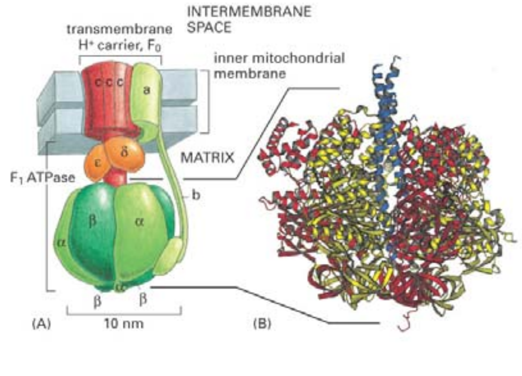


Figure 14-14 Essential Cell Biology, 2/e. (© 2004 Garland Science)

## Proton Gradients Produce Most of the Cell's ATP

Glycolysis alone produces a net yield of two molecules of ATP for every molecule of glucose, which is the total energy yield for the fermentation process that occur in the absence of oxygen. In contrast, during the oxidative Phosphorylation each pair of electrons donated by NADH produced mitochondria is thought to provide energy for the formation of the about 2.5 molecules of ATP, once one includes the energy needed for transporting this ATP to cytosol. Oxidative Phosphorylation also produces 1.5 ATP molecules per electron pair of FADH2, or from the NADH molecules produced by glycolysis in the cytosol.

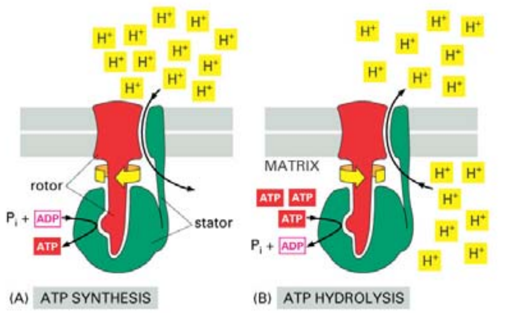


Figure 14-15 Essential Cell Biology, 2/e. (© 2004 Garland Science)

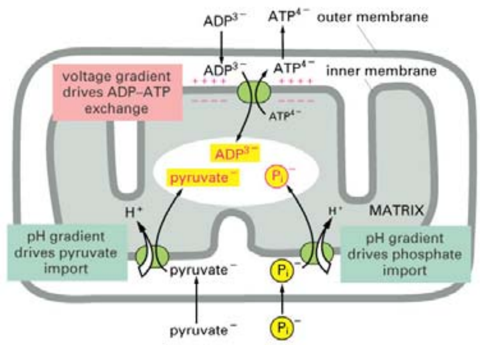


Figure 14-16 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Table 13-1 Summary of Product Yields from the Oxidation of Sugars and Fats**

| |
|---|
| A. Net products from oxidation of one molecule of glucose |
| In cytosol (glycolysis) |
| glucose → 2 pyruvate + 2 NADH + 2 ATP |
| In mitochondrion (pyruvate dehydrogenase and citric acid cycle) |
| 2 pyruvate → 2 acetyl CoA + 2 NADH |
| 2 acetyl CoA → 6 NADH + 2 $FADH_2$ + 2 GTP |
| Net result in mitochondrion |
| 2 pyruvate → 8 NADH + 2 $FADH_2$ + 2 GTP |
| B. Net products from oxidation of one molecule of palmitoyl CoA (activated form of palmitate, a fatty acid) |
| In mitochondrion (fatty acid oxidation and citric acid cycle) |
| palmitoyl CoA → 8 acetyl CoA + 7 NADH + 7 $FADH_2$ |
| 8 acetyl CoA → 24 NADH + 8 $FADH_2$ |
| Net result in mitochondrion |
| palmitoyl CoA → 31 NADH + 15 $FADH_2$ |



## Chloroplast and Photosynthesis

Virtually all of the organic materials required by present-day living cells are produced by photosynthesis. It is the series of light driven reactions that created organic molecules from atmospheric $CO_2$. Plants and algae, and the most advanced bacteria, such as cyanobacteria, use electrons from water and the energy of sunlight to convert $CO_2$ into organic compounds. During this process a vast amount of $O_2$ is released into the atmosphere. Photosynthesis is carried out by a specialized organelle called chloroplast.

**Chloroplast Resembles Mitochondria but Have an Extra Compartment**

Chloroplasts carry out their energy interconversions by means of proton gradients in much the same way that mitochondria do. Both mitochondria and chloroplast have highly permeable outer membrane, a much less permeable inner membrane and narrow intermembrane space. Together these membranes form the chloroplast envelop. The inner membrane surrounds a large space called the stroma, which is analogues to the mitochondrion.

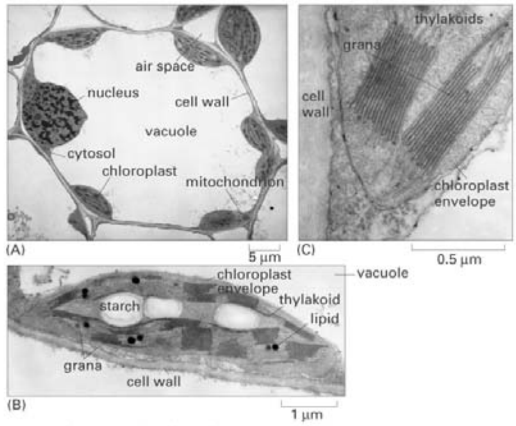


Figure 14-29 Essential Cell Biology, 2/e. (© 2004 Garland Science)

There is, however, an important difference between the organization of mitochondria and that of chloroplast. The inner membrane of the chloroplast doesn't contain the electron-transport chains. Instead, the light capturing system, the electron-transport chains, and ATP synthase are all contained in thylakoid membrane, a third membrane that forms a set of flattened disclike sacs, the thylakoids.

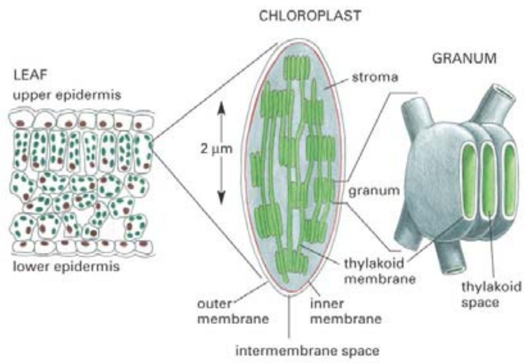


Figure 14-30 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Chloroplast Capture Energy from Sunlight and Use It to Fix Carbon**

The Many Reactions that occur during the photosynthesis in plants can be grouped into two broad categories.

**1.** Light reactions (photosynthetic reactions): in this step, energy derived from light energizes an electron in the green organic pigment chlorophyll, enabling electron to move along an electron-transport chain in the thylakoid membrane. The chlorophyll obtains its electrons from water by producing oxygen as a by products. During the electron transport process H+ is pumped across the thylakoid membrane, and resulting electrochemical proton gradient drives the synthesis of ATP in the stroma. In final step high energy loaded onto NADP+.

**2.** Dark reactions (carbon fixation reactions). ATP and NADPH that are produced in first step are going to be utilized for fixing CO2 into sugar.

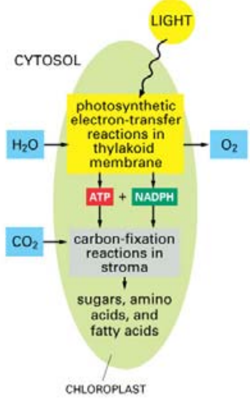


Figure 14-32 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Excited Chlorophyll Molecules Funnel Energy into a Reaction Center**

When sunlight is absorbed by a molecule of the green pigment chlorophyll, electrons in the molecule interact with photons of light and are raised to a higher energy level. In plant thylakoid membranes and in the membranes of photosynthetic bacteria, the light-absorbing chlorophylls are held in large multiprotein complexes called photosystems. The antenna portion of a photosystem consists of hundreds of chlorophyll molecules that light energy in the form of excited electrons. These chlorophylls are arranged so that the energy of an excited can be passed from one chlorophyll molecule to another, funneling the energy into an adjacent protein complex in the membrane-reaction center.

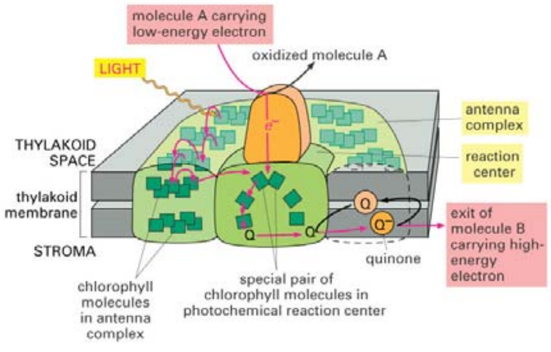


Figure 14-34 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Light Energy Drives the Synthesis of ATP and NADPH**

To build its molecular components, the cell needs both only energy in the form of ATP, but also reducing power in the form of the hydrogen carrier NADPH. Because a primary function of photosynthesis is to synthesize organic molecules from CO2, the process has a huge requirement for both ATP and reducing power. The need for reducing power is met by making NADPH from NADP+, using the energy captured from sunlight to convert low-energy electrons in NADPH.

The production of ATP and NADPH occur in two steps.

**1.Photosystem II.** High-energy electron is propelled via an electron transport chain toward the second next photosystem.

**2.Photosystem I.** Electron arrives at the second photosystem in the pathway, where it fills a positively charged hole left in the reaction center of this photosystem when it absorbs a second photon of light. Because photosystem I is designed to start at higher energy level than photosystem II, it is able to boost electrons to the higher energy level need to make NADPH.

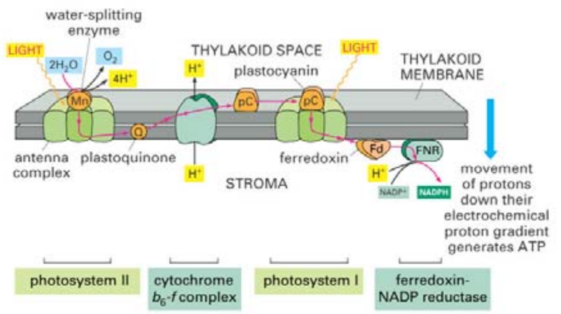


Figure 14-36 Essential Cell Biology, 2/e. (© 2004 Garland Science)

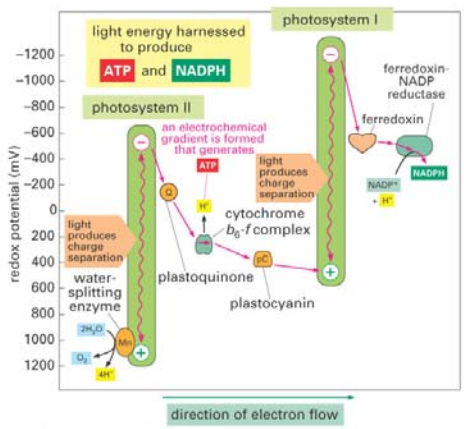


Figure 14-37 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Carbon Fixation Is Catalyzed by Ribulose Bisphosphate Carboxylase**

Once ATP and NADPH are formed in light reactions, these high energy compounds will be utilized during the carbon fixation.
The central reactions of photosynthetic carbon fixation, in which an atom of inorganic carbon is converted to organic carbon, is from atmosphere combines with the five-carbon sugar derivative ribulose 1,5-bisphosphate plus water to give two molecules of the three carbon compound 3-phosphoglycerate.

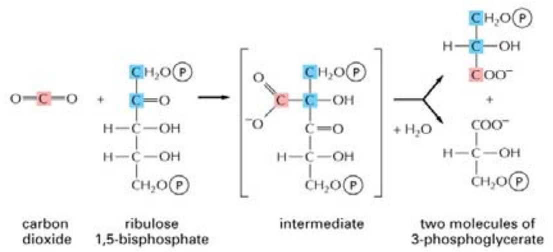


Figure 14-38 Essential Cell Biology, 2/e. (© 2004 Garland Science)

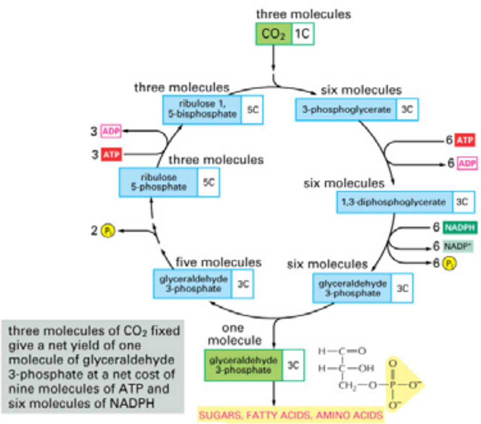


Figure 14-39 Essential Cell Biology, 2/e. (© 2004 Garland Science)

## Chapter 11
## Membrane Structure

**A living cell is a self-reproducing system of molecules that held inside a container. That container is the plasma membrane- a fatty film so thin and transparent that it cannot be seen directly in the light microspore.**

**The cellular membrane is simple in form: its structure is based on a two-ply sheet of molecule about 5 nm thick.**

**It serves as a barrier to prevent contents of cell from escaping and mixing with the surrounding medium.**

**Cell membranes as barriers**

**Membranes serve as barriers between two compartments--either between the inside and the outside of the cell (A) or between two intracellular compartments (B). In either case the membrane prevents molecules on one side from mixing with those on the other.**

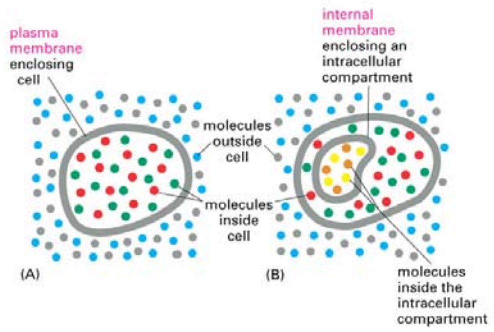


Figure 11-1 Essential Cell Biology, 2/e. (© 2004 Garland Science)

If a cell is to survive and grow, nutrients must pass inward, across the plasma membrane; and waste products must out. This is facilitated a specialize proteins that are located within the plasma membrane. Channels and proteins pumps are examples for such functions. There are some other proteins located within the plasma membrane that they act as sensor. Cells will respond to the environmental stimulus via these proteins.

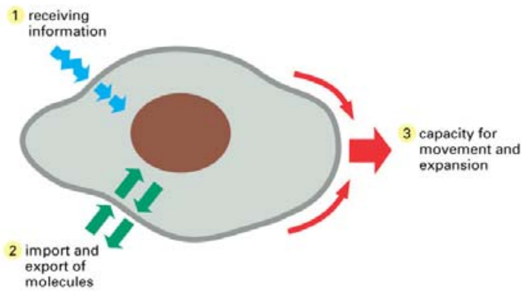


Figure 11-2 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Membranes form the many different compartments in a eucaryotic cell**

The membrane-enclosed organelles in a typical animal cell are shown here. Note that the nucleus and mitochondria are each enclosed by two membranes.

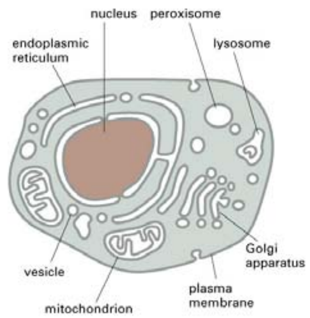


Figure 11-3 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Regardless of their location, all cell membranes are composed of lips and proteins and share common general structure. The lipid component consists of many millions of lipid molecules arranged into two closely opposed sheets, forming bilayer.**

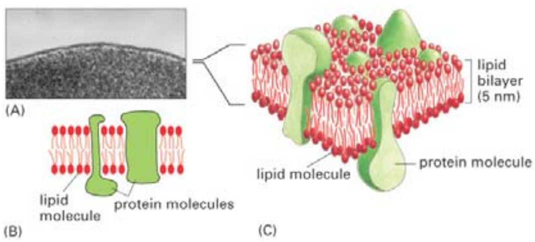


Figure 11-4 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**The Lipid Bilayer**
**Membrane Lipids Form Bilayers in Water**

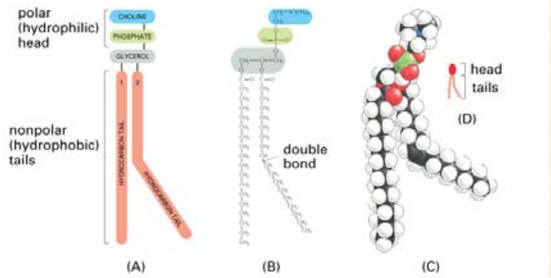


Figure 11-6 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Different types of membrane lipids are all amphipathic.**

Each of the three types shown here has a hydrophilic head and one or two hydrophobic tails. The hydrophilic head (shaded *blue* and *green)* is serine phosphate in phosphatidylserine, an –OH group in cholesterol, and a sugar (galactose) and an –OH group in galactocerebroside.

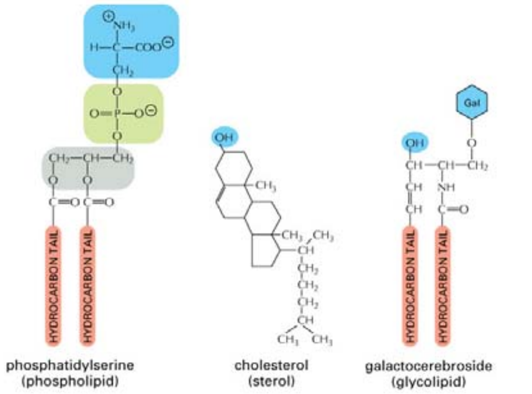


Figure 11-7 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Hydrophobic molecules like fats cells and the oils found in plant seeded coalesce into a single large drop when dispersed in water.

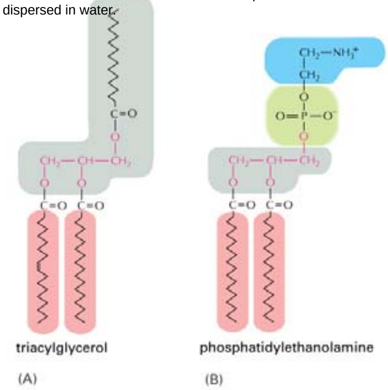


Figure 11-10 Essential Cell Biology, 2/e. (© 2004 Garland Science)

**Phospholipid bilayers spontaneously close in on themselves to form sealed Compartment**

The closed structure is stable because it avoids the exposure of the hydrophobic hydrocarbon tails to water, which would be energetically unfavorable.

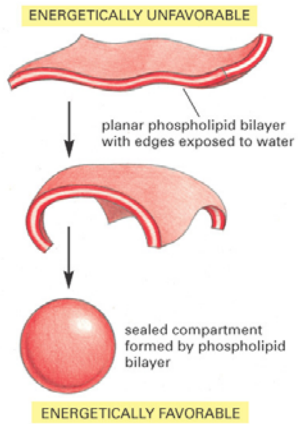


Figure 11-12 Essential Cell Biology, 2/e. (© 2004 Garland Science)