Biotechnology 6.1

Mimicking Photosynthesis

No chemist has yet to come up with a series of reactions that harnesses solar energy and converts it to chemical energy as elegantly as nature does in photosynthesis. Although we understand how many parts of the process occur, photosynthesis remains somewhat of a mystery. How can such a straightforward set of reactions require so many large and complex molecules? Can researchers use the chemicals of photosynthesis, or perhaps other molecules, to reconstruct the events in the laboratory? Attempts to do so indicate just how complicated photosynthesis is.

Devens Gust and his coworkers at Arizona State University in Tempe have created a single-photosystem mimic of the light reactions of photosynthesis. It is based on a liposome, which is a bubblelike phospholipid bilayer similar to a cell membrane. First, they assembled an artificial reaction center. It consists of three molecules, covalently bonded to each other (a carotene, a porphyrin, and a fullerene) and placed within the liposome bilayer (fig. 6.B). In a plant cell, the reaction center consists of reactive chlorophyll *a* molecules anchored within the thylakoid membranes.

Artificial photosynthesis starts as light impinges upon the porphyrin, which is a chromophore, a molecule, or part of a molecule that captures photon energy. (Chlorophyll contains a porphyrin, as does hemoglobin, the molecule that transports oxygen in blood.) An electron from the porphyrin becomes excited and jumps over to the fullerene, which is a huge ball of 60 carbon atoms. Meanwhile, the carotene donates an electron to replace the one zapped out of the porphyrin. From the fullerene, the electrons are passed through electron carriers, and they power the buildup of protons inside the liposome cavity, just as happens in the thylakoid space in a chloroplast.

Included in the liposome are embedded molecules of ATP synthase, taken from spinach cells. The buildup of protons within the liposomes forms a gradient that causes them to exit the liposome through the channels in the ATP synthase. The exodus of protons triggers ATP formation.

Being able to mimic parts of photosynthesis in the laboratory will enable researchers to more closely study the process. It may also have practical applications. ATP can be used industrially to power many types of chemical reactions used in the manufacture of diverse products. If the entire process of photosynthesis can be duplicated and scaled up, it could be useful in providing a new, clean energy source or in countering the buildup of carbon dioxide in the atmosphere that may be contributing to global warming.

FIGURE 6.B
Studying Photosynthesis.
An artificial thylakoid system developed by chemists at Arizona State University mimics the light reactions. It uses a reaction center consisting of carotene, porphyrin, and fullerene to capture photon energy and generate a proton buildup inside a liposome. The protons then diffuse out of channels in ATP synthase molecules embedded in the liposome membrane, triggering ATP formation.