"We're beginning to understand how life harvests sunlight"

For the last five years, Bolton's lab has been studying the process of electron transfer in the synthetic compound, and like Leblanc's Institute, it pays special attention to fluorescence. "When a photon is absorbed by the porphyrin ring," Bolton explained, "it pushes an electron up into an excited state; from here, the electron can either travel across the molecule to the quinone ring, or drop back to its 'ground state,' giving off the energy as light. This latter process, fluorescence, competes with electron transfer, and by measuring what we call fluorescence 'lifetimes,' we get data on the efficiency of this transfer in the molecule."

Bolton, and UWO collaborators Professor Alan Weedon (director of the synthesis program) and Professor Martin Stillman (who does the spectroscopy on the synthetic molecules) build variations into their reaction-centre mimic. It's a time-consuming process which can take up to a year to complete a single variation. They change the distance between the donor and acceptor, alter the orientation of the rings, tighten the bridge down so that it is rigid, and so on — in an attempt to learn which of the system's molecular features improves its ability to transfer electrons. Bolton:

"This is one of the problems we face with photosynthesis. We don't yet know what it is in the molecular structure that makes the transfer easy in the reaction-centre protein. For instance, we have little idea of its distance dependency. These fundamental questions must be answered if we are ever to understand the natural process."

Bolton pointed out that his molecule does approximately the same thing as the reaction-centre protein, but not nearly with the same efficiency. "In the plant, almost *every photon absorbed* results in an electron transfer across the reaction centre. In our molecule, for every hundred photons, only one or two electrons are transferred. But we're excited that we have anything to work with at all. What we're trying to do with these molecular modifications is improve this performance, or raise what we call the 'quantum efficiency' up into the region of the plant's near-100 per cent mark." But the real problem that Bolton's molecule and the plant chloroplast both face is the propensity of the separated electron to drop back to its home in the porphyrin ring. The electron must be tapped out of the system, and it must be done quickly.

Bolton: "The whole idea is that we are storing 1.4 electron volts of energy in this molecular system, and if the electron drops back, the energy is lost as heat. The plant has developed a means of removing this energy — an electron transport system — which is faster than the spontaneous return process. We're currently adjusting our molecular structure to see if we can create barriers against this electron 'backsliding'. Perhaps we can slow it to the point where the electron can be removed in some sort of external circuit."

Thus, James Bolton's lab has created a solar cell, but without the necessary wiring system that would make it possible to use the energy. He has shown that the cell works, albeit with an efficiency of only one to two per cent, and he and his colleagues at London are now trying to connect their molecule to the outside world.

"We're looking for a way to attach the wires," said Bolton.

Roger Leblanc shifted in his chair and glanced outside at the winterscape. The north wind drifting snow across the flat campus of the university belied all the talk of green plants and sunbeams. Both men agreed that it would take a very long time before the structure and function of the systems making up photosynthesis were fully understood. The last word went to Professor Leblanc: "James and I want to build molecular models that interact with light in a manner similar to the chloroplast's thylakoid membrane. The degree to which these 'spectroscopic descriptions' of our artificial creations match up with those of the chloroplast is a gauge of how close we are getting to the real thing. Nature gives up her secrets grudgingly in this area, but gradually we're beginning to understand how life harvests the sunlight."