Turro the researcher, mentor and teacher

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This issue is dedicated to Professor N. J. Turro, photochemist-extraordinaire, on the occasion of his 70th birthday. More than 100 of his students, collaborators and friends assembled at Columbia University on May 23, 2008 to celebrate his birthday. This was a special occasion for all of us who attended to express our gratitude to an exceptional teacher and his wife Sandy, who always kept our 'best' in mind. The excitement and energy of the Turro community on this occasion was a reflection of the Turros' warmth towards their students, associates and friends. This issue is an outgrowth of that memorable event and includes articles by Turro's students and friends.

Nick Turro's first publication in the area of photochemistry was in 1961 with Professor G. S. Hammond and P. A. Leermakers as co-authors. George Hammond was his Ph.D mentor at Caltech and Leermakers was his best friend from college days who advised him to work for Hammond upon completion of his B.A at Wesleyan University, CT. His work at Caltech resulted in a large number of publications that broke ground for future generations to explore the art and science of photochemistry and physical organic chemistry. Graduate study at Caltech was followed by a year of postdoctoral work at Harvard with Paul D. Bartlett. Thus Turro's interest in reactive molecules (excited states and radicals) was shaped by pioneers during the period 1960–64. As he completed his preparation towards becoming an independent researcher and educator, Turro was writing the now legendary textbook on photochemistry, 'Molecular Photochemistry' which was published in 1965. Thus he prepared himself as well as the scientific community to explore the exciting area of photosciences. This action early in his career reveals a selflessness on his part in sharing his knowledge with others that became his hallmark and continues to this day.

Turro's ability to collaborate colleagues was evident at the outset of his career. Two important independent publications, one as a graduate student with Leekmakers and another as a postdoctoral associate with Leermakers and Douglas Neckers shaped his early career at Columbia University where he became an instructor in 1964. Work on cyclopropanone, a beautiful small molecule whose synthesis was unknown prior to 1965, earned him tenure and promotion from Instructor to Full Professor within five years. Even as he was busy exploring the physical and chemical characteristics of cyclopropanone, he initiated a program to understand the excited state chemistry of carbonyl compounds. The first publication on this topic came out in 1967 and within a period of four years the ground rules for the excited state behavior of carbonyl compounds in general had been laid. Accounts articles on cyclopropanone and carbonyl compounds (1969 and 1972) are must reads for young researchers in physical organic chemistry and photochemistry.

While the work on carbonyl compounds was in full swing, Turro set his sights on other topics, *viz.*, chemiluminescence, dioxetanes, benzene valence isomers and other strained molecules. I was a graduate student (at University of Hawaii) at the time and recollect my awe upon reading communications from the Turro laboratory that appeared with remarkable frequency in *J. Am. Chem. Soc.* I am sure that other students of my generation were similarly inspired by these publications and motivated to dedicate their careers to exploring the behavior of excited state molecules. Turro summarized his work on dioxetanes in an *Accounts* article in 1974.

It is not obvious to me how Turro found time to work on yet another important problem during this period. However, in collaboration with William Dauben and Lionel Salem, Turro developed the use of correlation diagrams. It would not be an exaggeration to say that no textbook on photochemistry and physical organic chemistry is without the correlation diagrams developed by Turro, Salem and Dauben and published in *Accounts* in 1975. This illustrates the versatility of Turro in handling multiple tasks at the same time and is a testament to Turro's expert ability in multi-tasking, a word not heard often in those days.

Confident that the basics of excited state chemistry were under control, Turro published in 1978 his second book 'Modern Molecular Photochemistry' that remains the field's definitive text. The book serves as a tribute to Turro's ability to present complicated fundamental principles in a visual manner that the physical organic community finds useful and appealing and independent of changing experimental trends and advances. Remember, this book was written at a time prior to desktop computers and programs for Word processing or ChemDraw.

In 1978, Turro also initiated a research program in Supramolecular Photochemistry. Little was known about the photochemistry of molecules in micelles or other organized assemblies when he initiated studies in micelles. The first publication on this topic was on the photochemistry of dibenzylketone (DBK) in micelles in 1978. Since then DBK has become synonymous with the name Turro. Was Turro clairvoyant on the potential of this molecule when he initiated his studies in 1978? These studies led to the spectacular discovery that photolysis of ketones in micelles were subject to unprecedented, large magnetic field effects, which allowed the separation of magnetic isotopes from non-magnetic isotopes. The same theory that explained the magnetic isotope separation was employed to design systems with dramatic variation in the products of photolysis by the application of weak magnetic fields (no stronger than that of a magnetic stirrer bar!). This research created the field of organic spin chemistry and exemplified Turro's ability to pull together ideas from disparate fields, such as colloid chemistry. supramolecular chemistry, chemistry of radical pairs, and photochemistry with magnetic resonance theory in order to synthesize a new framework for studying physical organic mechanisms.

During the 80s and 90s Turro's interests and research covered a wide range of topics including supramolecular photochemistry, spin chemistry, effects of magnetic field on radical pairs, singlet oxygen chemistry, polymer photochemistry *etc.* This was in no way an easy feat as it also required that he stayed abreast of the literature on all these topics. For Turro, following the scientific literature is a Saturday morning routine. He could be found flipping page by page every new issue of every chemistry journal in the Departmental library. He was adept in keeping track of almost any paper dealing with 'light' and 'radicals' long before the advent of SciFinder. To my amazement, he is also very quick to adopt new technologies beyond his fields of interest, even with respect to literature collection. Before the Xerox machine became widely available, he kept track of the literature in hand written notebooks, but with the advent of Xerox machines he organized the literature through well-organized binders of xeroxed papers. Even in early 1980s, electronic data-bases of chemical literature were available in his laboratory. In the 21st century he quickly switched to Endnote and pdf files of photochemical literature.

Turro's research accomplishments in the above areas during the 80s and 90s are summarized in four *Accounts* articles. The topics include magnetic field effects, biradicals, dendrimers, DNA, and spin. Without offending our colleagues I would like to point out that Turro is among the few with a good 'feeling' for spin. He has an extraordinary ability to visualize complicated phenomenon while keeping the mathematical details to a minimum. This has helped him, in my view, to plan novel experiments and discover newer phenomena without getting bogged down in sophisticated equations.

Recognizing the importance of time resolved tools in solving photochemical problems, especially in supramolecular chemistry, Turro constructed a 'nanosecond systems laboratory' with nanosecond systems capable of studying transients produced by pulsed lasers by a wide range of spectroscopic methods, including UV/VIS absorption and emission, resonance Raman, IR, NMR (chemically induced dynamic nuclear polarization) and ESR (chemically induced dynamic electron polarization). Using these methods he pioneered systematic investigations of the photochemical reactions at a supramolecular level *i.e.* interaction of guest organic molecules in hosts such as micelles, porous silica and zeolites. His research on radical pairs in micelles and zeolites demonstrated how the interplay of electron exchange and magnetic effects (spin chemistry) can control the rate and selectivity of one of the most fundamental of all organic reactions, carbon–carbon bond formation. Turro's pioneering efforts also demonstrated how the reactivity and chemical selectivity of radical pair reactions can be fine tuned and rationally controlled by supramolecular and magnetic factors. His experimental approaches to the examination of supramolecular organic photochemistry have served as the basis for the widely accepted paradigms in this field.

At the time Turro began investigations of the photobehavior of molecules in zeolites, not many photochemists knew much about zeolite. Since his first publication on this topic in 1984 Turro has demonstrated remarkable control of the photochemistry (chemoselectivity, regioselectivity and stereoselectivity) through the supramolecular photochemistry of guest@zeolite systems. He showed how variations of the guest or the host structure can lead to control of the selectivity of reactions, clearly demonstrating the need to think "supramolecularly" about a guest@zeolite system. He further demonstrated how the extension of classical steric effects to supramolecular steric effects could produce "supramolecular strain", which would stabilize radical pairs when compared to their combination products! These studies demonstrated the ability to produce radical@zeolite system that are stable for months at room temperature, yet are able to react when small molecular substrates are added. An *Accounts* article on this topic by Turro in 2000 summarizes his group's accomplishments in the area of zeolite chemistry.

Turro's versatility positioned him well to tackle complex problems of the 21st Century that are a mix of chemistry, biology and materials science. During the past several years his pioneering research which applies the principles of physical organic chemistry, supramolecular chemistry, photochemistry and spin chemistry to a range of areas of organic chemistry has continued unabated. His research on the remarkable enantioselective reactions of singlet molecular oxygen and the use of fluorescent molecular beacons for tracking RNA in cells have both been reviewed recently in *Accounts.* He has demonstrated that the two allotropes of the hydrogen molecule (*ortho*-H_2 and *para*-H_2) incarcerated inside a fullerene can be interconverted, using the principles of spin chemistry.

Turro began his research career in the 60s as a Molecular Photochemist, became a Modern Molecular Photochemist in the 70s, turned himself into a Supramolecular Photochemist in the 80s and the 90s and is well on his way to becoming the Übersupramolecular Photochemist of the 21st Century. We are grateful to Turro for tirelessly leading us down a path of excitement and discovery. 'Be prepared for change' seems to be the underlying theme of Turro's scientific research life. To state in one line, Turro's research has been characterized by a striking breadth, encompassing synthetic organic chemistry, colloidal and interface chemistry, chemical physics, magnetic resonance theory and its applications, mechanistic aspects of molecular and supramolecular organic and inorganic chemistry and sophisticated experimental techniques.

Turro was elected to two of the most prestigious academies, National Academy of Sciences and the American Academy of Arts and Sciences, at the age of 43! Several awards from the American Chemical Society, Inter-American Photochemical Society, European Photochemical Society and Japanese Photochemical Society have recognized Turro's research accomplishments.

In addition to his research accomplishments, Turro is an outstanding and dedicated teacher and mentor. He has trained over 180 postdoctoral associates, 80 graduate students and 100 undergraduate students. His research accomplishments have been summarized in over 850 publications in addition to many more that are still in the laboratory notebooks. All of his students and associates, and colleagues who have met him at conferences know he is selflessness in terms of sharing his knowledge and his willingness to give any amount of time to explain concepts using physically intuitive models.

What the *Photochemical & Photobiological Sciences* community may not know is that Turro is also an extraordinary classroom teacher who enjoys teaching General Chemistry, a task which many people try to avoid. He takes teaching young minds seriously and I have personally noted that he is hard to reach on days when he has a class. At Columbia he has pioneered the use of information technologies and computers for the enhancement and enrichment of undergraduate education in chemistry. His educational ideas and products are employed at universities and colleges across the nation. These accomplishments have been recognized by his selection as a Distinguished Teacher Scholar by the National Science Foundation in 2002 and the Pimentel Award in Chemical Education in 2004 by the American Chemical Society.

Turro has a lovely and happy personal life that he cherishes. He married Sandy in 1960, has two daughters and five grand children. He never forgets that science is only a part of life. In addition to biological daughters and grand children, Nick and Sandy Turro treat all those who pass by the 7th floor of Chandler Hall as members of their extended chemical family. They show extraordinary warmth towards any one whom they know. The Turros treat every human being with respect and love and are genuinely interested in the well being of their family, students, friends and colleagues. All of us who have passed through the 7th floor of Chandler consider ourselves lucky to be a part of the Turro family. In addition to celebrating Turro's scientific contribution, this issue is an outgrowth of special bonding of his students, friends and associates with Nick and Sandy.

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