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Review

# Celebration of inorganic lives: Interview with Vincenzo Balzani

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**Abstract**

This interview gives a glimpse on the story of Vincenzo Balzani's scientific life. From the study of photochemical reactions of coordination compounds, to electron transfer processes, to molecular machines. He talks about the social values of teaching and research work and the need to tell children and citizens why chemistry is so important and useful. He also discusses research freedom, ethical problems, and the responsibility of scientists.


*Keywords:* History/philosophy; Molecular machines; Photochemistry; Public understanding; Teaching/learning


On December 4th, 2006, friends, colleagues and co-workers gathered, from Italy and abroad, at the "Giacomo Ciamician" Chemistry Department of the University of Bologna to celebrate the 70th birthday of Vincenzo Balzani and honor him as scientist, educator and man. Unaware of this celebration, after the morning teaching he found a large group waiting for him in his office, in silence, and bursting into cheering upon his entrance (Photo 1).

In 1960 he graduated in Chemistry, *cum laude*, at the University of Bologna, with a thesis related to the photochemistry of complex salts in solution. Since the early 1960s he studied systematically the photophysical and photochemical behavior of several families of coordination compounds. In 1970s he addressed the problem of solar energy conversion through photosensitized water splitting. In 1975 he demonstrated, for the first time, the oxidizing properties of the luminescent excited state of $[Ru(bpy)_3]^{2+}$, an extremely important complex, extensively used since then in many photochemical, chemiluminescent and electro-chemiluminescent processes. In 1980s he studied the photochemical and photophysical behavior of Ru(II)–polypyridine complexes, showing that the ground and excited state properties of such a class of compounds may be controlled by a suitable choice of ligands. He also investigated Pt(II), Pt(IV), Rh(III) and Pd(II) cyclometalated complexes, which are presently employed for the development of light-emitting diodes. Since 1983 he has been investigating the mechanism of bimolecular energy and electron transfer processes relevant to excited states of coordination compounds. An intense collaboration with Jean-Marie Lehn (University of Strasbourg, France) on luminescent complexes of lanthanide ions generated the idea of an artificial antenna systems. In 1984 he introduced the concept of supramolecular chemistry in the field of coordination compounds showing the possibility to control the photochemical and photophysical properties *via* an intelligent molecular architecture. In the last 15 years Vincenzo has devoted himself to the design, realization and characterization of "devices and machines" working at the molecular level, in collaboration with S. Campagna, F. Pina, F.

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Photo 1. Professor Jean-Marie Lehn writing the word "Lucifero" (carrier of light) on the blackboard in the occasion of Vincenzo Balzani's birthday.

Vögtle and, especially, J.F. Stoddart. By assembling molecular components and applying concepts derived from macroscopic devices he has been able to construct supramolecular systems performing specific functions upon stimulation with light or other external energy inputs (Fig. 1). Balzani's activity in chemistry is documented by more than 500 publications and his work has been recognized by many awards, most notably the Gold Medal S. Cannizzaro of the Italian Chemical Society (Photo 9), the Doctorate Honoris Causa from the University of Fribourg (Switzerland), the Franqui Chair of the University of Leuven (Belgium), the Italgas European Prize for Research and Innovation, the Porter Medal for Photochemistry, the Prix Franco–Italien de la Société Française de Chimie, the Ziegler-Natta Lecture of Gesellschaft Deutscher Chemiker (Germany) and many other named lectureships. He was also appointed Grande Ufficiale dell'Ordine al Merito della Repubblica Italiana (Photo 13). Vincenzo Balzani is a brilliant and enthusiastic teacher. He is able to explain difficult concepts in a simple way and has a particular skill to explain scientific concepts to a non-scientific audience. He is very concerned with social and ethical problems related to science and its applications, and this will be one of the topics of the interview.

**Let us start at the beginning: could you tell us a little about your childhood years?**

I was born in 1936 at Forlimpopoli (the Roman *Forum Popili*), a small town about 100 km east of Bologna, in the center of the region called Romagna. I was the second of three children. My grandfather and my father had a small factory for wine production. Our house was very large and, in winter, only the living room was heated. I remember that in the coldest nights the water of the glass on the bedside table became icy. It was a hard time, which became even harder a few years later with the World War II. In 1944 the front of the war crossing Italy stopped for several months on the "Linea Gotica", not far from our town and we were forced to spend many days and nights, together with several neighbouring families, in a refuge constructed under the basement of our house.

**When you went to school did you enjoy it? What subjects did you like more?**

I liked to go to school because I enjoyed staying with other children. I liked to read and to write, but liked more to play football and go by bicycle up and down a hill nearby our town. At the junior high school I discovered that solving mathematical problems was quite rewarding. Therefore, as the next step, I decided to go to the *Liceo Scientifico* in the nearby town of Forlì, about 8 km from Forlimpopoli. My older brother was already attending the same school. For a few years we commuted by bus, wasting a lot of time. Then my father bought us a motorcycle which made our life easier.

(a) (b)



Fig. 1. (a) and (b) Prestigious journals have dedicated an issue to Vincenzo Balzani on the occasion of his 70th birthday.

**Why did you decide to follow a scientific career?**

At the Liceo Scientifico I was very good in physics and mathematics, and I also enjoyed philosophy and history. My first aspiration was to become a mechanical engineer. In the fourth class of the liceo I began to study chemistry and I was lucky to find a teacher, Professor Fiorenzo Fiorentini, who was able to organize a chemical laboratory, a quite unusual initiative in that period. I was fascinated by the chemical reactions occurring in the lab and even more so by the possibility to explain those changes with symbols and stoichiometric rules. Therefore, I changed my mind and I decided to choose chemistry instead of engineering at the university. It was a good choice indeed, because chemistry is not only useful and important but, I believe, also one of the most beautiful and creative branches of science.

**What were your interests outside of school?**

Mainly sport. I was lucky to have a good teacher of gymnastics since the beginning at the liceo. At that time there was also an attempt by the government to encourage students to practice light athletics. There were competitions within each school and, for the winners, at the province level. I liked very much to run and to jump and I attended several competitions. I was good on long jump and therefore I entered the athletics society of Forlì. I began to attend competitions at the regional and national level. My coach asked me to try with the triple jump and we discovered that I was particularly good in that specialty. It was, however, a hard job and soon I had troubles with my back. Therefore I stopped with athletics when I was about 18 years old.

As most young people of my region, I loved very much fast motorcycles and cars (remember that Ferrari, Maserati, Ducati, and Lamborghini are all built in Emilia-Romagna). For a few years I participated in regional rallies with a small fast car (Photo 2).

**How did you meet Carla, your future wife?**

At the liceo scientifico. We actually were in the same class since the beginning. At the end of the first year of school, when we were 15 years old, we fell in love. Now we have four daughters, two sons, and nine grand children.

**You are well known for your work on photochemistry. How did you become interested in this field?**

It was by chance. When I was a student during the second year of the Chemistry course at the University of Bologna, I began to attend the research laboratory of Professor Vittorio Carassiti. In that period, one of Carassiti's colleagues was trying to obtain the Raman spectra of cyanide complexes of Molybdenum and Tungsten. He did not succeed, however, because those complexes underwent decomposition upon irradiation with the Raman excitation lamp. That photodecomposition intrigued Carassiti, who was working on the (thermal) ligand–substitution processes of metal complexes. Therefore, he decided to begin a systematic investigation on the photochemical reactions of coordination compounds, a field completely unexplored at that time, and asked me to do the first experiments. I should add that in our Department there was an old tradition in organic photochemistry, going back to the beginning of the last century, when Giacomo Ciamician, one of the early pioneers, performed

Photo 2. Vincenzo Balzani in 1953 during a triple-jump competition.

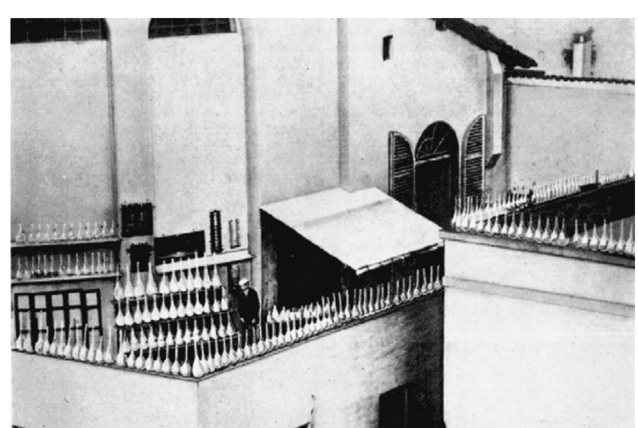
Photo 3. Professor Giacomo Ciamician, watching flasks under solar irradiation on the roof of his laboratory at the University of Bologna, Italy, 1910.

many experiments on the roof of the building using the sun as a light source (Photo 3).

## Why is Giacomo Ciamician still so famous?

Giacomo Ciamician was Professor of Chemistry at the University of Bologna from 1889 to 1922. Inspired by the ability of plants to exploit solar energy, he was the first scientist who investigated the photochemical reactions in a systematic way. In a famous address presented before the VIII International Congress of Applied Chemistry, held in New York in 1912 [1], he suggested replacing "fossil solar energy" (i.e., coal) with the energy that the Earth receives from the sun every day. In particular, he forecasted the production of fuels by means of artificial photochemical reactions (artificial photosynthesis), which is still one of the most important goals of current research in the field of chemistry. The possibility to obtain fuels (particularly dihydrogen) from solar energy would indeed solve two great problems of present day society: energy and environment.

The final part of the Ciamician address is wonderful and is worth reporting almost completely:

> "*Where vegetation is rich, photochemistry may be left to the plants.... On the arid lands there will spring up industrial colonies without smoke and without smokestacks; forests of glass tubes and glass buildings will rise everywhere; inside of these will take place the photochemical processes that hitherto have been the guarded secret of the plants, but that will have been mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is. And if in a distant future the supply of coal becomes completely exhausted, civilization will not be checked by that, for life and civilization will continue as long as the sun shines! If our black and nervous civilization, based on coal, shall be followed by a quieter civilization based on the utilization of solar energy, that will not be harmful to progress and to human happiness*".

## What are your most interesting results in the photochemistry of coordination compounds?

For several years, first with Professor Carassiti and later on with my own group, I carried out investigations on the interaction of light with various families of coordination compounds (Photos 4–6). By using visible and UV lamps with suitable interference filters and chemical actinometers, we measured photoreaction quantum yields at different excitation wavelengths in order to understand the relationships between the nature of the irradiated band and observed photoreaction. Among other results, we showed that the quite different photoreactivity and photoluminescence of Co(III) and Cr(III) complexes could be easily explained on the basis of the different electronic configurations and redox properties of the two metal ions. After 10 years of intense studies, Professor Carassiti and I wrote the monograph *Photochemistry of Coordination Compounds* [2] which has been a source of inspiration for many young photochemists in the last 35 years.

Photo 4. Professor Vincenzo Balzani with the two fathers of inorganic photochemistry: Professors Vittorio Carassiti (center) and Arthur W. Adamson. Picture taken in 1992, on the occasion of an International Symposium organized in Ferrara (Italy) to honor A.W. Adamson.

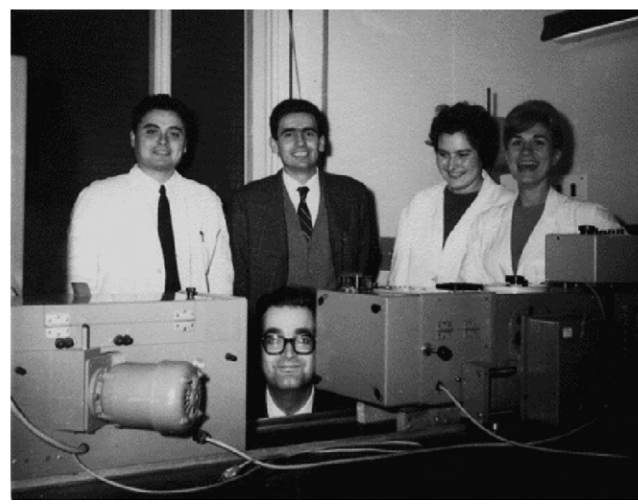

Photo 5. Vincenzo Balzani and his first co-workers (1970) very excited with a new spectrophotometer.

Photo 6. Vincenzo Balzani's group on the roof of "Ciamician" Department in 1973. Picture taken by V.B.

**What about your studies on electron-transfer reactions?**

It was photochemistry that led me into the field of electron transfer processes. In the early 1970s it became clear that the electronically excited states of molecules are both better oxidants and better reductants than the corresponding ground state. At that time we were extensively using $[Ru(bpy)_3]^{2+}$ as an energy transfer photosensitizer. We decided to investigate the redox properties of the luminescent excited state of this complex and we demonstrated that it was indeed able to play the role of a reductant [3]. In the following years we used the photoredox chemistry of $[Ru(bpy)_3]^{2+}$ to convert not only light into chemical energy (endoergonic reactions), but also chemical energy into light (chemiluminescent and electro-chemiluminescent processes). A brilliant spin-off of those studies was the discovery of an "artificial firefly" obtained by coupling the chemiluminescent properties of $[Ru(bpy)_3]^{2+}$ with the oscillating Belousov–Zhabotinski reaction [4]. In the period 1980–1988, in collaboration with the group of A. von Zelewsky (University of Fribourg, CH), we investigated the photochemical and luminescent behavior of more than one hundred Ru(II)–polypyridine complexes, showing that it is possible to tune their ground and excited state properties by a suitable choice of the ligands [5]; this paper has so far received more than 2000 citations in the literature. This work has opened the way to an extensive use of polypyridine metal complexes in a variety of photoinduced electron-transfer processes of fundamental and applied interest, e.g., dye-sensitization of photoelectrochemical cells. My interest in electron-transfer reactions has never ended. In 2001, I edited a five-volume handbook on Electron Transfer in Chemistry [6] with contributions from dozens of experts in the various topics of this field (Fig. 1).

**What are molecular machines and how it is possible to construct them?**

In middle 1980s we realized that supramolecular chemistry was opening the way to the design and construction of molecular-level devices and machines. I first illustrated this topic at a NATO Meeting (Capri, Italy, 1987) [7] and a few years later in the monograph *Supramolecular Photochemistry* written with F. Scandola [8]. Our idea was that the macroscopic concepts of a device or a machine can be extended to the molecular level. A molecular device or machine is an assembly of a discrete number of molecules designed to achieve a specific function: each molecular component performs a simple act, while the entire supramolecular structure performs a more complex function, which results from the cooperation of the various molecular components. Of course ideas are not sufficient in chemistry, and we were lucky to begin long lasting and most profitable collaborations with several synthetic groups, particularly those of Fraser Stoddart (at that time in Birmingham, now at UCLA) and Fritz Vögtle (Bonn University, Germany). Molecular devices and machines, like those of the macroscopic world, need energy to operate. The most obvious way to supply energy to a molecular machine is, at first sight, through an exergonic chemical reaction.

Photo 7. Vincenzo Balzani with Professor J. Fraser Stoddart at the International Conference on Molecular Machines and Sensors (ICMMS'07) Shanghai, May 2007, on the occasion of the 65th birthday of Professor Stoddart.

Working by inputs of chemical energy, however, implies addition of fresh reactants ("fuel") at any step of the working cycle, with the concomitant formation of waste products. Our photochemical background suggested us that an alternative, and much more convenient, energy source to make molecular machines work, is light. Following this idea, in the last 15 years we have investigated a variety of light-powered artificial molecular-level devices and machines. A further advantage offered by light is that, besides supplying energy, it can also be used "to read" the state of the system and thus to control and monitor its functions. These and several other concepts have been discussed in a monograph [9] that has been translated in Chinese and Japanese (Photos 7 and 8).


Photo 8. Vincenzo Balzani with Alberto Credi and Margherita Venturi, co-authors of the book "Molecular Devices and Machines", showing the English and Chinese editions of the book.

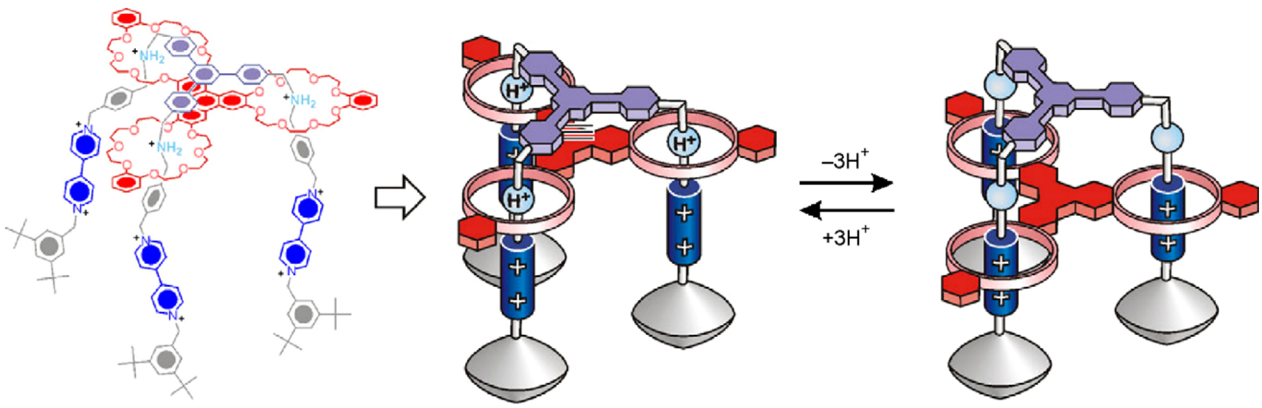


Fig. 2. A molecular lift.

Two particularly interesting examples of molecular machines, investigated in collaboration with the group of Professor Fraser Stoddart, are illustrated below.

The two-component molecular device shown in Fig. 2 behaves as a nanoscale lift [10]. This interlocked compound, which is ca. 2.5 nm in height and has a diameter of ca. 3.5 nm, consists of a tripod component containing two different notches – one ammonium centre and one 4,4′-bipyridinium unit – at different levels in each of their three legs. The latter are interlocked by a tritopic host, which plays the role of a platform that can stop at the two different levels. The three legs of the tripod end with bulky feet that prevent the platform to escape. Initially, the platform resides exclusively on the 'upper' level, i.e., with the three rings surrounding the ammonium centers. This preference results from strong $N^{+}–H\cdots O$ hydrogen bonding and weak stabilizing π–π stacking forces between the aromatic cores of the platform and tripod components. Upon addition of a strong, non-nucleophilic phosphazene base to an acetonitrile solution, deprotonation of the ammonium center occurs and, as a result, the platform moves to the 'lower' level, that is, with the three macrocyclic rings surrounding the bipyridinium units. This conformation is stabilized mainly by electron donor–acceptor interactions between the electron rich aromatic units of the platform and the electron deficient bipyridinium units of the tripod component. Subsequent addition of acid restores the ammonium centers, and the platform moves back to the upper level. The 'up and down' lift-like motion corresponds to a quantitative switch and can be repeated, can be monitored by NMR spectroscopy, electrochemistry, and absorption and fluorescence spectroscopy. Interestingly, the experimental results also show that the platform operates by taking three distinct steps associated with each of the three deprotonation–reprotonation processes. Hence, this molecular machine is more reminiscent of a legged animal than of a lift. The acid–base controlled mechanical motion is associated with remarkable structural modifications, such as the opening and closing of a large cavity and the control of the positions and properties of the bipyridinium legs. This behavior can, in principle, be used to control the uptake and release of a guest molecule, a function of interest for the development of drug delivery systems.

The rotaxane shown in Fig. 3 was specifically designed to achieve photoinduced ring shuttling in solution [11]. This compound has a modular structure; its ring component R is a π-electron donating bis-*p*-phenylene-34-crown-10, whereas

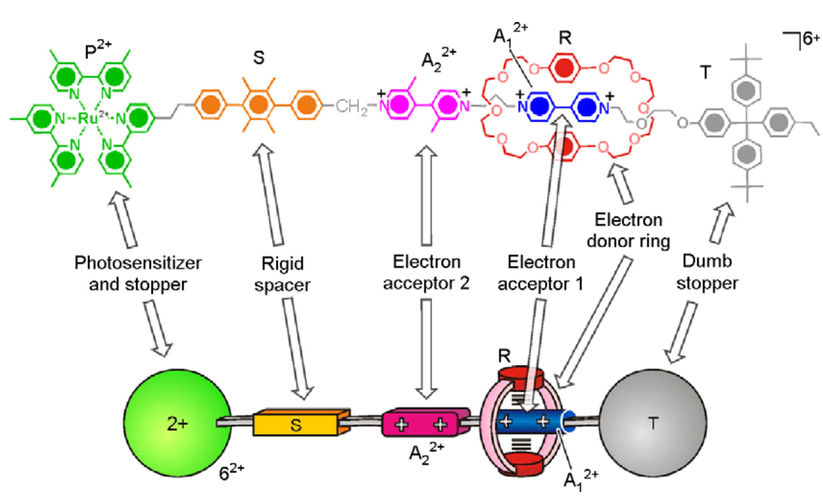


Fig. 3. A nanomotor powered by visible light.

its dumbbell component is made of several covalently linked units. They are a Ru(II) polypyridine complex ($P^{2+}$), a *p*-terphenyl-type rigid spacer (S), a 4,4′-bipyridinium ($A_1^{2+}$) and a 3,3′-dimethyl-4,4′-bipyridinium ($A_2^{2+}$) π-electron accepting stations, and a tetraarylmethane group as the terminal stopper (T). The Ru-based unit plays the dual role of a light-fueled power station and a stopper, whereas the mechanical switch consists of the two electron-accepting stations and the electron donor-macrocycle. In the stable translational isomer of the rotaxane the R component encircles the $A_1^{2+}$ unit, in keeping with the fact that this station is a better electron acceptor than the other one. Light excitation of the photoactive unit $P^{2+}$ is followed by the transfer of an electron from the excited state to the $A_1^{2+}$ station, which is 'deactivated'. As a consequence, the ring moves for 1.3 nm from the reduced station $A_1^{+}$ to $A_2^{2+}$. Then, a back electron-transfer process from the 'free' reduced station $A_1^{+}$ to the oxidized unit $P^{3+}$ restores the electron-acceptor power to the $A_1^{2+}$ station. As a consequence, back movement of the ring from $A_2^{2+}$ to $A_1^{2+}$ takes place. In conclusion, absorption of visible light by the Ru–complex $P^{2+}$ causes a forward and back ring movement without generating any waste product.

**Such unbelievable achievements defy imagination. Could you suggest some didactic use of them?**

I believe that such kinds of chemistry can help young students to understand that chemistry is not an ensemble of unfriendly formulae, difficult to write, and reactions difficult to balance, and that there is an unexplored and exciting world to be discovered at the molecular, nanometer level.

**What interested in nanotechnology?**

Because the bottom-up design, construction and operation of devices and machines on the molecular scale is indeed part of nanoscience and nanotechnology [12]. Chemists are able to manipulate molecules (i.e., the smallest material entities with distinct shapes and properties) and are therefore in the ideal position to develop bottom-up strategies for the construction of nanoscopic devices and machines.

**What is your opinion on these new developments? Where is the field going?**

These are important questions. I am still involved in nanoscience research, and I enjoy very much doing this job. In the last few years, however, I began to ask myself where is this science going. My personal feeling is that science and technology alone will not take us where we need to be in a few decades. This is the reason why, in the second edition of our book on Molecular Devices and Machines, Alberto Credi, Margherita Venturi and I have included a chapter entitled "Science and society". From the scientific viewpoint, I hope that nanoscience and nanotechnology, in the hands of chemists, will find more efficient means for converting sunlight into useful forms of energy (Photo 8).

**You are known to be concerned about ethical problems and involved in peace movements. Is there any relation between ethical values and teaching efficacy?**

Teaching is a great responsibility. Of course, the students and the society expect that a science professor teaches science at the best possible level. But I believe that is not enough. We need to teach students not only what science is and how to make use of it, but also to distinguish what is worth making with science. We need teachers telling students that science and technology have to be used for peace, not for war; for alleviating poverty, not for maintaining privileges; for reducing, not for increasing the gap between developed and underdeveloped countries; for protecting, not for destroying our planet that, beyond any foreseeable development of science, will remain the only place where mankind can live. I know by experience that students like very much to have teachers motivated by ethical values. As Giacomo Ciamician said about 100 years ago, the first duty of a teacher should be that of "forming", not that of "informing" students. Young people need models for shaping their life and their attitudes.

**What is the role of scientists in our world today?**

Some scientists are only interested in their own research. They do not care about the situation of the world; at most, they are marginally interested in small problems of their local communities. They believe that science should be absolutely free to grow because "knowledge has an intrinsic value". Therefore, they struggle to have more funds for their own research and do not mind receiving money from pharmaceutical industries that deceive consumers, multinational enterprises that deprive underdeveloped countries, and even the military establishment. I strongly disagree with this way of thinking. We are no longer in the old days when science could be done just for fun and scientists could live in an ivory tower. It is unacceptable to create only because we can. History shows that creativity has most often a dark satanic side: pollution, atomic bombs, biologic weapons.... But there is another, not less important, feature that is usually neglected by most of us, scientists of the affluent part of the globe: in the present situation, scientific research usually benefits the rich only, and thereby increases the gap between the rich and the poor. Responsible scientists, while creating new science and technology with the greatest moral care, should also play a role as authoritative, informed, and concerned citizens of the planet Earth. We need scientists capable of producing first class science, but also engaged in helping to change what is wrong in the social and political organization of our nations and of the entire world.

**With your co-workers, you are engaged to show the importance of chemistry to children and to citizens. Why?**

Because chemistry permeates everyday life anywhere, and thus some knowledge of chemistry is essential to citizens. In our public conferences we try to fight chemophobia and to explain that chemistry is a beautiful science that should not be mistaken with the results (e.g., pollution) of its bad use. We also show that "chemical" is not the opposite of "natural", as some deceiving advertisements would suggest, because *everything has a chemical nature*. The entire world, including ourselves, is a book written by using atoms and molecules, i.e. in a chemical language.

**What are your suggestions for inspiring students, for getting them to give their utmost?**

The first suggestion is: choose to work in the field you like more. If you do not like what you are doing, there is no hope achieve useful and interesting results. I believe that the attitude of a scientist toward his research should be that of a lover. A scientist has to plan experiments and to look at the results obtained with care and love. Only in this way can one succeed. As Szent-Gyorgyi said: "Discoveries consist in seeing what everybody has seen and thinking what nobody has thought". If you love what you are doing, you will never say that you are working hard and you will be able to think what nobody has thought.

**In several countries, young people do not like to study science. Is it possible to teach Chemistry in an appealing way?**

Chemistry is the world around us, which is very complex indeed, but also fascinating, intriguing and, to some extent, understandable. The study of Chemistry is appealing if one starts from observations of what happens in the real world; for example how does it happen that, if we have a rose in our hand, we perceive its smell; or why wine can turn into vinegar. Chemistry is appealing when we unveil the astonishing world of molecules, these nanometer scale objects that, because of their specific size, form, structure, and properties, are capable of ignoring or recognizing one another, self assembling, reacting, absorbing or emitting photons, accepting or donating electrons. In order to give people an idea of what chemistry is, we also find it useful to show the similarity between chemistry and language: atoms are the letters of matter, molecules are the words, supramolecular systems are the sentences, and so on, with man and library at the top of the respective complexity scale.

**We are close to an energy crisis, and development is going to reach a limit. Do scientists have any suggestions?**

Energy is the number one but, by no means, the unique problem for humanity. Food, water, health, environment, education, population, war, democracy are other important issues. Indeed, our world is very fragile. Politicians should realize that the Earth is a spaceship with limited resources which carries 6.5 billion people. Excluding the light coming from the Sun, Earth is a closed system. This simple consideration tells us that in the long run we can only rely on solar energy [13]. Apparently, neither politicians nor their economical advisors are acquainted with this unavoidable conclusion. Neither are they acquainted with the principle that an unlimited economic growth on a finite planet is not possible. In affluent countries we live in societies where the concepts of "enough" and "too much" have been removed, while we do not care about underdeveloped countries. Learning to say enough, however, is a necessary condition for a sustainable world. Establishing equity is not only a moral duty, but also a basic need for creating a peaceful world. Scientists should clearly explain these concepts to all citizens and especially to economists and policy makers.

The problems of sustainability and equity, in fact, put humanity at the crossroads: if we take the way of ethics, based on resource conservation, reduced waste, human relationships and global solidarity, we can construct a pleasant and peaceful world; the other way, that of consumption, personal benefit, and egoism will lead to robberies, invasions, revolutions, massive migrations, and wars, and will end up with the destruction of the planet.

The second hypothesis may be regarded as pessimistic. But it arises from the awareness of the gravity of the situation. An old proverb says that the only difference between an optimist and a pessimist is that the latter is better informed. A short-sighted optimism based on unawareness will not allow mankind to move toward a real progress. To live in the third millennium, we need new thinking and new ways of perceiving world's problems. There is a great need for spreading information about the condition of our world. Only knowledge can help us to take right decisions in order to reach sustainability and remedy disparities, so as to make our space-ship Earth less fragile during its trip along this new century.

Going back to energy, I believe that fission nuclear energy is not the right answer to fight inequities and to create a more peaceful world. We should reduce energy consumption and rely on renewable energies which are distributed all over the world. As to solar energy, we should intensify our efforts, not only to increase the conversion efficiency into heat and electricity, but also towards the achievement of photochemical water splitting, a process proposed by my group many years ago [14]. Efficient generation of hydrogen from water by solar energy would solve the energy crisis as well as several environmental problems. Finding a breakthrough for solving the energy crisis is indeed the "grand challenge" of Chemistry.

**Research freedom is a matter of debate. What do you think about using human embryos for research?**

Most of the scientists say that there should be no restriction on research. In principle, I agree, but I would like to make two observations. First, research is very expensive today, so that priorities have to be established. This is an intrinsic limitation to research freedom. For example, should we give priority to stem cell research, which can be useful to cure the Alzheimer disease of wealthy people in Western countries, or to research on malaria, HIV and other diseases that affect poor people in underdeveloped countries?

Second, and more important, in order to *know*, man has to *act*. Any human action is indeed inspired by aims and values,

Photo 9. Vincenzo Balzani receiving a medal from the Chairman of the Italian Chemical Society, Professor Franco De Angelis, at the General Congress of the Society, Florence (Italy), September, 2006.

and aims and values are never "neutral". To act means to use methods and to cause effects, both material and cultural. Therefore, I believe that research freedom cannot be an absolute value in a civilized society. Ethics comes first. Concerning embryos, I believe that they should not be produced and used for scientific research.

**What about your research group and your many collaborations?**

I had, and still have, the invaluable privilege of working in a group made of highly motivated, reliable, and friendly colleagues and co-workers. Most of the merit for my achievements goes to them. Of course sometimes there are problems and difficulties, but we succeed to overcome them by frank discussions. We have group meetings every week, and also a long lasting tradition of joyful picnics. The one taking place in May at my country house collects 50–60 people including children of co-workers and students. My only regret is that in the last 5 years I could not afford to participate in the football mach that regularly takes place on such an occasion.

Particularly important, of course, have also been, year after year, the collaborations with outstanding scientists all over the world: Franco Scandola, Alex von Zelewsky, Jean-Marie Lehn, Sebastiano Campagna, Jean-Pierre Sauvage, Fernando Pina, Fritz Vögtle, Fraser Stoddart and several others. Such collaborations have allowed us to reach results that would have been otherwise impossible to achieve and, not less important, have created a network of friendships that have made our work much more pleasant and amenable (Photo 10).

**You collaborate with many outstanding scientists. What could you say about Jean-Marie Lehn?**

In my opinion Jean-Marie is the best living scientist in the field of Chemistry. He has many fantastic new ideas. I admire the fact that he continued to work in chemistry even after the Nobel Prize. In most cases, a scientist, as soon as he receives the Nobel Prize, believes to be like God and begins to talk sententiously on everything. One should never forget what Niccolò Macchiavelli said: "There are people who believe they know everything, but this is all they know" (Photos 11 and 12).

**Is there any one question you wish I had asked?**

Yes. The question would be: what role did your wife, Carla, play in your career? And the answer is: Carla has been a constant source of support and encouragement since we met at the high school when we were 15 years old. She stopped her career as researcher in the field of mineralogy to dedicate herself to our growing family. We have now six children and nine grandchildren. As any other family, we have passed through difficult

Photo 10. Vincenzo Balzani playing football with members of his group in 1995.

Photo 11. Professor Vincenzo Balzani with Professor Jean-Marie Lehn in 2006.


Photo 12. Vincenzo Balzani delivering the opening lecture at the 17th ISPPCC, Dublin, June 2007.

Photo 13. Vincenzo Balzani with the President of the Italian Republic, Carlo Azeglio Ciampi, and President's wife, Lady Franca Pilla at Quirinale, 2001.

periods, but we are lucky persons because of the strength of our marriage.

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