Prophet of Solar Energy: A Retrospective View of Giacomo Luigi Ciamician (1857–1922), the Founder of Green Chemistry, on the 150th Anniversary of His Birth

Giorgio Nebbia and George B. Kauffman*

*Professor Emeritus of Merceology, Università di Bari, Italy, nebbia@quipo.it, *Department of Chemistry, California State University, Fresno, Fresno, CA 93740-8034, georgek@csufresno.edu*

Abstract: On the occasion of the 150th anniversary of the birth of Giacomo Luigi Ciamician (1857–1922) this article summarizes the life and career of this Italian-Armenian founder of green chemistry with emphasis on his work on pyrroles, plant chemistry, photochemistry, solar energy, the environment, and politics.

Former U.S. Vice President Al Gore's "An Inconvenient Truth," the Academy Award-winning motion picture of 2006 about global warming earned more than 20 million dollars, making it the fourth largest grossing documentary of all time (For a review see Holt, R. Trying to Get Us to Change Course. *Science* **2007**, *317*, 198–199). Paramount Classics made an unprecedented pledge to donate five percent of the receipts to the Alliance for Climate Protection. Gore and Kevin Wall, an Emmy-winning concert producer, partnered in founding Live Earth, the unparalleled "Concerts for a Climate in Crisis," featuring more than 150 artists, the biggest names in music, playing for a 24-hour period (Saturday, July 7, 2007) across the globe and broadcast on the major television channels, with the aim of triggering a global movement to solve the climate crisis. In addition to concerts in the six continents, North and South America, Europe, Africa, Asia, and Australia, a band of scientists performed in Antarctica. Simultaneously, more than 6,000 parties were held in 119 countries. The event was not intended as an end in itself but as the beginning of a three- to five-year campaign. Concert-goers were asked to sign a 7-point pledge to pressure their governments to sign treaties to reduce global warming and carbon dioxide pollution as well as to plant trees.

Concern with solar and other forms of alternative energy, green chemistry [1], global climate change, greenhouse gas emissions, biomass conversion, and a host of environmental problems has proliferated everywhere in the media. Evangelical groups, taking humankind's stewardship of our planet seriously, have joined the movement. Sales of hybrid vehicles, formerly in only moderate demand, have skyrocketed. In California Governor Arnold Schwarzenegger, jokingly dubbed the "global guru of greenhouse gas reduction" by a journalist, became dissatisfied with efforts of the federal government in combating global warming. He has taken a number of steps to do this on a statewide basis. For example, he created the California hydrogen highways network, the Sierra Nevada Conservancy, intended to provide support for economic sustainability across about 25 million acres within the Governor's suzerainty, and an Ocean Action Plan, which is intended to increase the abundance and the diversity of California's oceans, bays, estuaries, and coastal wetlands. In September, 2006 he enacted landmark legislation to reduce greenhouse gas emissions, and in 2007 he is signing an executive order to establish the world's first low-carbon standard for transportation fuels. In short, concern with the environment, long promoted by most scientists, seems to be reaching a tipping point as citizens and society all over the world are finally paying attention to this long-festering problem.

However, Al Gore, Arnold Schwarzenegger, and other high profile figures are not the first to advocate the adoption of measures to mitigate the adverse effects of human actions on the environment. Priority for this achievement belongs to Giacomo Luigi Ciamician (1857–1922) (Figure 1), the founder of photochemistry and pioneer of solar energy [2–7], who, in an often-quoted address, "The Photochemistry of the Future," delivered before the Eighth International Congress of Applied Chemistry, held in New York City in 1912, stated:

> And if in a distant future the supply of coal [then the most widely used fossil fuel] becomes completely exhausted, civilization will not be checked by that, for life and civilization will continue as long as the sun shines! [8, p 394].

In many ways Ciamician was truly a century ahead of his time.

To commemorate the 150th anniversary of Ciamician's birth a historical-scientific conference, featuring 14 speakers, including one of us (GN) and sponsored by four Italian organizations, was held on September 16-18, 2007 at the Department of Chemistry "Giacomo Ciamician" (the department is named in his honor) (Figure 2) of the Università di Bologna (the oldest continually operating degree-granting university in the world, founded in 1088—only 22 years after the Battle of Hastings in 1066!), where Ciamician, a several-time Nobel prize nominee, spent most of his career, carrying out numerous photochemical experiments and lobbying for solar energy [9].

Life and Career

Giacomo Luigi Ciamician was born on August 25, 1857 in Trieste, at that time part of the Austro-Hungarian empire [10–31]. The Municipality of Trieste placed a bronze medallion with his portrait and an inscription by patriot and scholar, Senator Attilio Hortis on the house in which he was born at 21

* Series Editor contribution

Figure 1. Giacomo Luigi Ciamician (1857–1922). (Nasini, R. *J. Chem. Soc.* **1926**, *129*, Part I, 996–1004).

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CHRONIQUE

GIACOMO CIAMICIAN
CHIMISTE DE GRAND TALENT
ET PIONNIER DE LA PHOTOCHIMIE (*)

Par

MICHEL PFAU
Laboratoire de Chimie de l'Ecole Normale Supérieure, Paris, France
et NED D. HEINDEL
Department of Chemistry, Marshall University, Huntington, West Virginia, U. S. A.

L'Institut de Chimie Giacomo CIAMICIAN *à Bologne.*

L'un des traits du génie humain est sans doute de pouvoir s'intéresser à plusieurs domaines différents tout en approfondissant chacun d'eux. En ce sens, Giacomo Luigi CIAMICIAN, *pionnier de la photochimie, illustre bien cette définition. Au cours d'une carrière scientifique qui dura quarante-cinq années, il apporta une contribu-*

(*) Article complémentaire : Ned D. HEINDEL et Michel PFAU : « A profitable partnership : Giacomo CIAMICIAN (1857-1922) et Paul SILBER (1851-1932) ». *J. Chem. Educ.* (sous presse).

Figure 2. The Istituto di Chimica "Giacomo Ciamician," Università di Bologna. (Courtesy, Margherita Venturi).

Via S. Martiri [20]. Ciamician was very proud of his Armenian origin and heritage. The family claimed descent from Michele Ciamician, the great eighteenth-century historian of the Armenian people [20]. In about 1850 Ciamician's family moved from Istanbul to Trieste, where there was a thriving Armenian community and where they had ties with one of the Mechitarist bishops.

The Mechitarist (or Mekhitarist) congregation of Roman Catholic Armenian monks, widely recognized for their contribution to the Renaissance of Armenian philology, literature, and culture early in the nineteenth century and particularly for the publication of old Armenian-Christian manuscripts, was founded in 1701 in Constantinople (now Istanbul) by their eponymous founder, the priest Mekhitar Petrosian of Sivas (1676–1749) (http://www.mekhitar.org; http://www.mekhitarists.org/mekhitar.html) [32]. Expelled from Constantinople in 1703, the congregation moved to Modon in Morea, Greece (1703–1715) and finally settled in 1717 on the island of San Lazzaro, Venice (http://www.mekhitarists.org/stlazarus.html), which was given to them by the Venetian state. Their community, known as Ordo Mechitaristarum Venetiarum, argued over a revised constitution by Abbot Stephen Melkonian, and in 1772 a group of dissidents left Venice for Trieste and founded a separate branch (Ordo Mechitaristarum Vindobonensis) in Vienna in about 1810. The Ciamician family was indeed fortunate in that by their move to Trieste they avoided extermination during the persecutions of Armenians by the crumbling Ottoman Empire, beginning at the end of the nineteenth century and culminating in the first genocide of the twentieth century [33].

Ciamician attended primary and secondary schools in Trieste and was impressed by the chemistry and natural sciences that were taught there by Augusto Vierthaler, an applied chemist who was one of the founders of the teaching and practice of *Warenkunde* [35]. This explains in part the continuous attention that Ciamician paid, during his long academic and public life, to the practical and economic aspects of chemistry and innovation.

After 1882 Italy's foreign policy, based on an alliance with Germany and Austria, led the educated classes to revere German culture and science. A small but constant stream of Italian science students enrolled in German universities, supported by fellowships offered by the Italian government for studies abroad. Ciamician moved to Vienna in 1874 where he studied at the Polytechnic and the Universität Wien. He devoted himself to chemistry under chemistry professors Ludwig Barth (1848–1890) and Hugo Weidel (1849–1898) and the zoologist Carl Claus (1873–1896). During these years, while still a student, Ciamician published on zoological observations, the nature of schists, and spectroscopy [20].

Because he had not attended courses in "classical" studies, Ciamician was not permitted to graduate from the Universität Wien. Instead, he attended the Universität Giessen, from which he received his Ph.D in 1880 (Figure 3). Because we were unable to find the title of his dissertation or the name of the professor under whom he had worked, we called on the skills of Vera V. Mainz of the University of Illinois. She called on Claudia Alcala Iniguez, who learned from Eva-Marie Felschow that she was unable to find any reference to Ciamician's doctorate or dissertation at the Universität Giessen. He probably received his degree only as a "Promotion in absentia," which was customary at small German universities like Giessen until the end of the 19th century. For this practice the recipient would not actually attend the university and would not publish his or her dissertation.

Ciamician was then appointed *assistent* (assistant) to the eminent Italian chemist Stanislao Cannizzaro (1826–1910), of Karlsruhe Conference fame, at the Università di Roma. In Italian universities this academic position was offered to young graduates who demonstrated proficiency and interest in

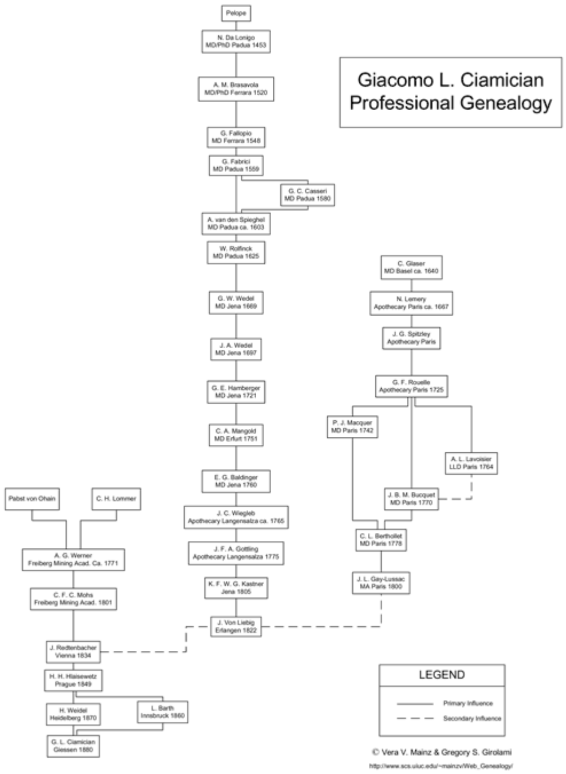

Figure 3. Giacomo L. Ciamician, Professional Genealogy. (Courtesy, Vera V. Mainz and Gregory S. Girolami).

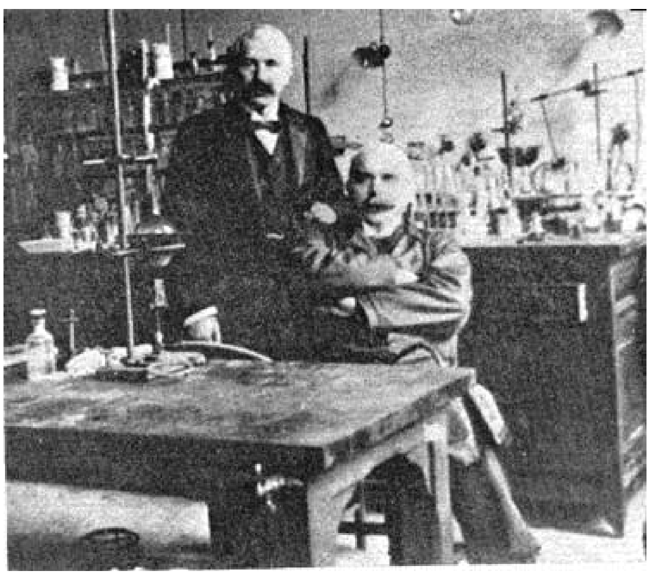

Figure 4. Giacomo Ciamician (left, standing) and Paul Silber (right) in Their Bologna Laboratory. (Courtesy, Margherita Venturi).

research and teaching and was generally followed by an appointment as professor at one of the universities. During the years of service as assistant the salary was usually low, but the experience gained in this position was very extensive, and most assistants became professors. In chemistry, in particular, an assistant followed “his” professor in the research work and in the preparation of lectures and experiments, and the assistantship was often a stimulating job. In Italy the position of *assistente* was abolished in 1980.

In Cannizzaro’s laboratory Ciamician met and became a close friend of Paul (in Italian, Paolo) Silber (1851–1932) [23, 24] (Figure 4), a young and promising chemist who had come to Italy for reasons of health. Silber followed Ciamician to the Università di Bologna, when Ciamician, after a short tenure at the Università di Padova (1887–1889), became in 1889 Professor at Bologna, where he remained for the rest of his life. Silber, who was appointed an Honorary Colleague of Bologna’s Faculty of Science, was a coauthor on most of Ciamician’s papers—at least 378—from the 1880s until World War I, when Silber returned to Germany, his native land. At the conclusion of the conflict he returned to Bologna as Scientific Director of the Istituto Neoterapico Italiano.

The two friends complemented each other with their own characteristic talents. Ciamician, acting as a genial but critical research director, applied his theoretical and practical insights to organizing the direction of the program and interpreting its results. Silber, the skilled, patient experimentalist, provided the abundant results on which the two established their joint careers. Together they raised the stature of Italian chemistry to world renown and joined the ranks of the most famous, productive, and intimate collaborators in chemistry such as Joseph Louis Gay-Lussac and Louis Jacques Thenard, Cato Maximilian Guldberg and Peter Waage, Justus von Liebig and Friedrich Wöhler, Pierre and Marie Curie, Irène and Frédéric Joliot-Curie, and more recently, Fred Basolo and Ralph G. Pearson.

Exhausted by his labors for Italy during the war, Ciamician suffered from a fever in the autumn of 1921. Contrary to the advice of both students and friends, he tried to begin his lectures on general chemistry and organic chemistry, but he was unable to continue. He died on January 2, 1922 at the age of 65. Information on his life and an extended bibliography are contained in a little-known paper by Gino Secchi [22]. Ciamician’s work at Bologna, from its inception as a modest laboratory to its development into a great institute, is described in detail in an issue of *Chimica per la Scuola* (*Chemistry for the Schools*, *CnS*) [26].

Chemical Work

Ciamician’s contributions to chemistry are as outstanding as they are varied. He made significant discoveries in physical and theoretical chemistry; the chemistry of natural substances; essences of plants such as aniseed, saxifrage, parsley, and celery; and organic photochemistry, a field of which he is recognized as the founder. A bibliography of Ciamician’s articles is preserved in the library of the Università di Bologna’s Istituto Chimico [22].

Spectroscopy. A master of both theoretical and experimental chemistry, Ciamician, in Vienna, even before earning his doctorate, had already published a series of important articles on spectroscopy, vapor density, animal resins, and air pressure in tubes [25]. At the early age of 20 he made an important discovery—elements in the same family of the periodic table have remarkably similar emission spectra—that would later have led to the concept of energy levels of atoms. Since quantum theory had not yet been developed, the young scientist formulated a theory that attributed spectral similarities to the fact that elements in the same group share certain components. His article was widely discussed, and Ira Remsen thought that it was so important that he translated it

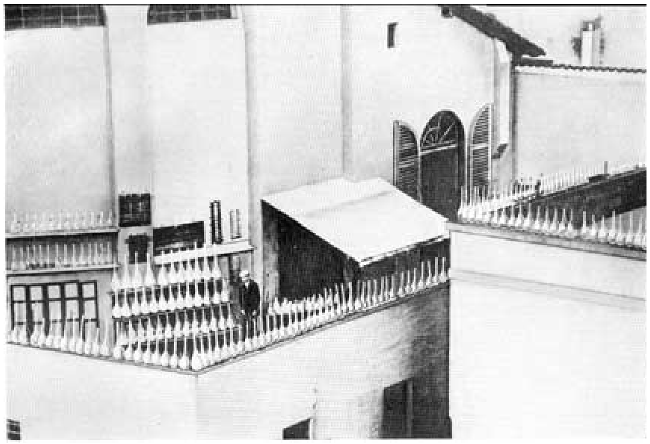

Figure 5. Giacomo Ciamician Surveying His Collection of Tubes and Flasks Being Exposed to the Sun on the Roof of His Laboratory. (Courtesy, Margherita Venturi).

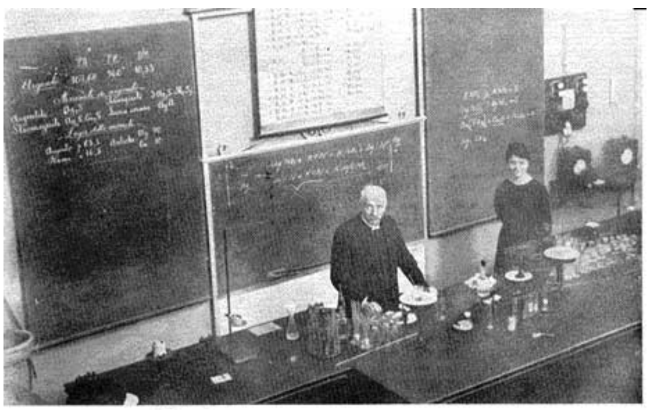

Figure 6. Giacomo Ciamician Lecturing in Bologna. (Courtesy, Ned D. Heindel).

for publication in the first volume of his new journal (*Am. Chem. J.* **1979**, *1*, 301).

Organic Chemistry. Ciamician's first organic research dealt with the components of natural resins. At age 24, when he was still in Rome, he began his study of pyrroles ($(CH{=}CH)_2NH$, bone oil or Dippel oil), the colorless, toxic, five-membered ring compounds that are components of chlorophyll, hemin, and many other naturally occurring substances, in an article published in the *Berichte der Deutschen Chemischen Gesellschaft* in 1881. He established the nature of pyrrole as a secondary amine and elucidated its ring structure by synthesizing it from succinimide. He prepared numerous derivatives of pyrrole, pyrroline, and pyrrolidine [25]. In 1885 he and Silber reported their preparation of tetraiodopyrrole, $(C{=}I)_4NH$, a new powerful antiseptic, which they christened "iodol" and patented [35]. Decades later it was still used as a substitute for iodoform (iodomethane, HCI_3), and its discovery was considered one of the most important contributions to pharmacology [36]. In 1887 Ciamician summarized in Italian his and Silber's research on pyrroles [37], and he reviewed their work in German in a classic lecture that he delivered before the Deutsche Chemische Gesellschaft [38]. For his work on pyrroles [37] Ciamician was awarded a prize by the Accademia dei Lincei, the world's oldest scientific society, founded in 1603 [21, 30].

Plant Chemistry. Ciamician determined the constitution of a number of essential oils, for example, eugenol, saffrole, and apiole from the oils of cloves, sassafras, and parsley and celery, respectively (1888–1889) [39]. During his photochemical studies, he decided that the future of organic chemistry was involved in its application to biology [25]. From 1908 to the end of his life he collaborated with Ciro Ravenna (1878–1994), Professor of Agricultural Chemistry at the Università di Pisa, on the origin and function of organic substances in plants, resulting in 21 articles, most published in the *Gazzetta chimica italiana*. The two synthesized glycosides in plants by inoculating them with different substances. For example, injection of plants with amino acids stimulated the production of alkaloids [25, 40]. They studied the influence of organic substances on plant development. They found that inoculation of plants with alkaloids like caffeine and theobromine increased the activity of chlorophyll and led to the overproduction of starch, and they concluded that alkaloids were not excretory products of plants but that they possessed a function similar to that of hormones in animals.

Natural Products. In Padova and later in Bologna Ciamician and Silber turned their attention to the structure and chemistry of the organic components of vegetable substances. In their studies of terpenes and essential oils they published more than 70 articles on the isolation and characterization of apiole, safrole, eugenol, isosasafrole, isoeugenol, pseudopelletierine, and numerous other naturally occurring phenolic compounds, many of whose rearrangements and isomerizations they studied. Their base-catalyzed isomerization of eugenol to isoeugenol was useful in the synthesis of vanillin. Ciamician also continued his studies in theoretical and physical chemistry, including the structures of naphthalene, pyrrole, and other five-membered ring compounds. He also tried to correlate the similarities of compounds that form solid solutions and to relate the physical properties and structures of benzene and thiophene systems [25].

Organic Photochemistry. Ciamician and Silber's work on natural products led them to investigate the chemical effects of light. The experimental work was carried out by exposing various vessels, such as tubes and Erlenmeyer flasks, containing the chemical compounds to sunlight on a terrace of the Istituto Chimico of the University of Bologna [4, 24] (Figure 5).

These studies, the results of which were reported in 85 papers [41], published in the series, "Azioni chimiche della luce" (in Italian) and "Chemisches Lichtwirkungen" (in *Berichte der Deutschen Chemischen Gesellschaft*, in German) from 1899 to 1913, led to the discovery of many new reactions, including the photoreduction of aldehydes, ketones, quinones and nitro compounds; the photodimerization and the photochemical cycloaddition of olefins; the phytohydrolytic fragmentation of ketones; and the intramoleular photochemical disproportionation of *o*-nitrobenzaldehyde. These researches opened a new field of chemistry and placed Ciamician among the leading scientists of his time, thus bringing world renown to Italian chemical research.

Teaching and Mentoring Activities

Ciamician was a captivating lecturer (Figure 6), as described by American chemist and later (1930) President of the

American Chemical Society, William McPherson, who attended one of his lectures in 1913:

Figure 7. Autographed Portrait that Giacomo Ciamician Presented to Students Who Submitted Perfect Examination Papers. (Courtesy, Margherita Venturi).

Figure 8. Giacomo Ciamician (left) and Riccardo Ciusa (right) performing a lecture demonstration, 1908. (Courtesy, Ned D. Heindel).

> These lectures were ideal—exceedingly clear and logical. They were illustrated with numerous experiments skilfully performed. For one and one-half hours (the length of the lecture period) he poured his whole energy into this subject. At the end of his lecture he was received by an assistant with a heavy wrap—much as our modern football players who retire exhausted from the game [14, p 105–106].

During his long and fruitful career, Ciamician acted as an inspiring teacher, research supervisor, and mentor to a large number of scientists, many of whom subsequently came to occupy prominent and important positions in Italian universities and public laboratories in their own right (Figure 7). His colleague in Rome and brother-in-law (husband of his sister, Carolina), although not strictly an "academic son," was Raffaello Nasini (1854–1931), Professor of General Chemistry at the Università di Padova and author of a compassionate obituary of his friend [20].

Ciro Ravenna, who collaborated with Ciamician on research on alkaloids, became Professor of Agricultural Chemistry and Director of the Agricultural Experimental Institute of Pisa. Since he was Jewish, he was dismissed from his post because of the fascist racial laws, was captured by the Nazis, and was killed at the Auschwitz concentration camp in 1944. Maurizio Leone Padoa (1881–1944), who coauthored an important article on affinity and valence [42], was also Jewish and was killed at Auschwitz. Other assistants of Ciamician's were Giuseppe Bruni (1873–1946) [10, 16], Giuseppe Plancher (1870–1929) [17, 18], Luigi Mascarelli (1877–1941) [11], Giovanni Boeris (1867–1946), and Angelo Angeli (1864–1931).

One of us (GN) personally knew Riccardo Ciusa (1877–1965), another of Ciamician's assistants (Figure 8), who was appointed in 1924 to the Chair of Pharmaceutical Chemistry at the Università di Bari, where he, in turn, had many assistants, including Angelo Mangini (1905–1988), who was to become the leader of a school of chemists at the Università di Bologna; and Luigi Musajo (1904–1974), Professor of Pharmaceutical Chemistry at the Università di Padova.

Another of Ciamician's assistants was Giuseppe Testoni (1877–1957), who became Professor of Merceology [34] at the Università di Bari. One of Testoni's assistants was Walter Ciusa (1906–1989), Riccardo Ciusa's son, and one of us (GN, b. 1926, Professor of Merceology at the University of Bari, 1953–1995), was Walter Ciusa's assistant and so considers himself, somewhat presumptously, Ciamician's great-great-grandson.

Ciamician was the author of two critically acclaimed books [43, 44]. His laboratory work and teaching was imbued with a profound, middle-European seriousness, which was transmitted to everyone who worked with him as well as to his assistants and co-workers of their own assistants. His seriousness permeated a large number of chemists in academe, public laboratories, and industry for many decades until late in the twentieth century.

Prophet of Solar Energy

It was quite natural that a scientist who had devoted his life to photochemistry, the chemical transformations induced by light, would consider the possibility of using solar radiation as a source of energy as an alternative to the coal that was the primary fossil source of energy during the last decades of the nineteenth century.

How long would coal be sufficient for human needs? The English economist and logician (William) Stanley Jevons (1835–1882), several years before Ciamician did so, had suggested that the English coal mines would one day be exhausted. At the same time, in 1899, future (1903) Nobel chemistry laureate, Svante August Arrhenius (1859–1927), a Swedish forerunner of today's environmentalists, had suggested that the increase in the atmospheric concentration of carbon dioxide caused by the combustion of fossil fuels could cause an increase in the earth's temperature. The use of solar heat to produce electricity with thermoelectric devices had also been advocated by Antonio Pacinotti (1841–1912), Professor of Physics at the Università di Pisa.

In this international, intellectual *milieu* Ciamician was invited to give a lecture at the inauguration of the 1903–1904 academic year of the Università di Bologna. He chose as its title "The Chemical Problems of the New Century":

> The problem of the use of the energy irradiated from the Sun is assuming and will assume increasing importance. When such a dream will be realized, the industries would be carried again to a perfect cycle, to engines that produce work with the force of the daylight that is free and does not pay taxes [43].

When Ciamician delivered this lecture, the world energy consumption was slightly less than one billion tons of oil equivalent (toe); it was 2 billion toe in 1950 and became 10 billion toe this year (2007).

Less than a decade later, on September 11, 1912, Ciamician gave a lecture at the Eighth International Congress of Applied Chemistry in New York. In the earlier mentioned, "The Photochemistry of the Future" [8], he suggested that the radiant energy of the sun could one day replace coal with benefits to the environment:

> Solar energy is not evenly distributed over the surface of the earth; there are privileged regions, and others that are less favored by the climate. The former ones would be the prosperous ones if we should become able to utilize the energy of the sun in the way which I have described. The tropical countries would thus be conquered by civilization, which would in this manner return to its birthplace. Even now the strongest nations rival each other in the conquest of the lands of the sun, as though unconsciously foreseeing the future….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 [8, p 394].

Ciamician concluded by stating that the photochemistry of the future should not be postponed to distant times; he was correct, but it has been only recently that some modest steps are finally being taken.

In a prophetic anticipation of the current attention to so–called renewable or "green" resources and energies Ciamician presented a unified view of all the aspects in which solar energy and radiation may satisfy humankind's needs for energy and commodities. He judged all known sources of energy to be inferior to natural sunlight, and he predicted solar home heating, photoelectric batteries, increased agricultural utilization of light, and industrial and synthetic applications of solar fuel [7, 24]. He considered the radiant energy for photosynthesis a "manufacturer" of biomass that, in its enormous variety, could offer "renewable" energy sources and raw materials for industrial products, besides food. He correctly considered as solar energy the hydropower, derived by the water cycle kept in motion by the sea, as well as the commercial energy that could be obtained by wind and ocean waves, kept in motion by the difference of temperature that solar radiation generates in various parts of the oceans and continents. He correctly evaluated the "energy content" of the waters flowing on the continents at about 1,500 EJ (one exajoule = 10^{18} joules) per year, an enormous quantity, although only a fraction of the 5,000,000 EJ per year that he correctly calculated as the total solar energy received by the earth.

Furthermore, Ciamician recognized that the effects of phototropism could be used in the dyeing of commercial textiles as a new fashion. In short, he considered chemical research as a source of industrial activities in the service of humankind, especially of those living in the underdeveloped countries that we call the "South of the World," currently underdeveloped but in fact "privileged regions" from the viewpoint of the sun's richness.

Nobel Nominations

Among the numerous honors that Ciamician received during the course of his long career, was his membership in the Accademia dei Lincei and the Italian National Academy of XL as well as corresponding memberships in almost all the Italian academies. He was made Cavaliere dell'Ordine del Merito civile di Savoia, and he held foreign memberships in the scientific academies of France, Prussia, Bavaria, and Sweden and in the scientific societies of Göttingen and Uppsala. He was an honorary member of the American Chemical Society and the chemical societies of Germany, France, and London. He was awarded an honorary degree of Doctor of Laws (LL.D.) from Glasgow University, and after the Italian Association of General and Applied Chemistry was reorganized, he was elected its President [4]. He was especially proud of being named Chevalier de la Légion d'Honneur, bestowed on him by the French government. In fact, he was considered to be one of the most faithful friends of France in Italy [21].

According to Robert Marc Friedman, during the early years of the 20th century the Nobel Chemistry Committee did not have to face the problem of deciding among the elderly chemists, many of whom were dying off, but they had to deal with the next generation of chemists,

> who were some twenty years younger but who earned their reputations in the 1880s and 1890s. These included Wilhelm Ostwald, Giacomo Ciamician, and Theodor Curtius, all of whom received persistent and respectable international support. But the real problem was the lack of overwhelming outside support for any one candidate [45].

Ciamician was nominated for the Nobel Prize in Chemistry for nine different years: by fellow Italian Icilio Guareschi (1847–1918) in 1905 [46, pp 204–205]; by 1902 Nobel laureate Emil Fischer (1852–1919), the greatest organic chemist of his time, and by 1906 Nobel laureate Henri Moissan (1852–1907) in 1907 [46, pp 210–211]; by Fischer again in 1908 [46, pp 214–215]; by the German Ludwig Wolff (1857–1919) in 1911 [46, pp 222–223]; by the German Ludwig Knorr (1859–1921) in 1912 [46, pp 224–225]; by four Austrians, Max Bamberger (1861–1927), Joseph Maria Eder (1855–1944), Wilhelm Suida (1887–1959), and Georg Vortmann (1854–1932), and the German Carl Dietrich Harries (1856–1923), in 1914 (For this year Theodore William Richards (1868–1928), the first American Nobel chemistry laureate received six nominations to Ciamician's five [46, pp 230–231]; by Italian Leone Pesci (1852–1917) in 1916 [46, pp 234–235]; by the Italian Giorgio Errera (1860–1933) in 1919 [46, pp 240–241]; and by the Italians Camillo Golgi (1843–1926) and Vito Volterra (1860–1940), as well as Georg Vortmann again in 1921 [46, pp 244, 245, 247].

Ciamician nominated others for the Nobel Prize in Chemistry for ten different years: for William Ramsay (1852–1916), who received that year's prize, in 1904 [46, pp 202–203]; for [Hermann] Walther Nernst (1864–1941), who received the prize in 1920, in 1909 [46, pp 218–219] and in 1912 [46, pp 224–225]; for Paul Walden (1863–1957) in 1914 [46, pp 2230–231]; for Theodore William Richards, who received the previous year's prize, which was not awarded until the following year, in 1915 [46, pp 232–233]; and for Philippe Auguste Guye (1862–1922) in 1917 [46, pp 236–237], 1918 [46, pp 238–239], 1919 [46, pp 240–241], 1920 [46, pp 242–243], and 1921 [46, pp 244–245].

Ciamician also submitted nominations for the Nobel Prize in Physics for ten different years: for Augusto Righi (1850–1920) in 1912 [46, pp 50–51], 1913 [46, pp 54–55], 1914 [46, pp 59–60], 1915 [46, pp 62–63], 1916 [46, pp 65–66], 1917 [46, pp 68–69], 1918 [46, pp 73–74], 1919 [46, pp 76–77], and 1920 [46, pp 80–81]; and for Peter J. W. Debye (1884–1966), who won the 1936 Nobel chemistry prize, in 1921 [46, pp 82–83].

Ciamician's Political Activities

Ciamician was named a member of the Italian Senate on January 26, 1910. In Italy at that time the members of the Senate were not elected but were named by the King on the basis of their authority as scientists or as entrepreneurs or politicians. Senator Ciamician gave his first speech on May 11, 1910 to commemorate the death of his mentor, Stanislao Cannizzaro, also a Senator. Ciamician's contributions to discussions in the Senate are described by Keheyan [47, 48].

In the Senate Ciamician intervened in various important problems on the organization of university studies and on technical questions. In the months following his nomination the Senate was discussing the problem of eliminating the poisonous white phosphorus that was largely used in the manufacture of matches, being cheaper than the innocuous red phosphorus. In 1905 the Bern convention had requested the nations to prohibit the use of white phosphorus; in 1909 the convention had been ratified by the Italian Camera dei Deputati (House of Representatives), and in June, 1910 the ratification was to be discussed at the Senate. Ciamician spoke, recounting the role of phosphorus in agriculture and industry. A detailed account of the chemical and industrial controversy in the manufacture of matches and of Ciamician's role in this dispute is reported by Nicolini [49]. Ciamician was also elected a member of the Consiglio Comunale of Bologna in 1912 and served in this position from 1912 to 1914.

The outbreak of World War I found Italian cultural and political circles sharply divided. In a letter of August 6, 1914 to Vito Volterra, Ciamician invited this mathematician and scientist to join with scientists from many nations in a declaration against Italian involvement in the war. Ciamician, who chose to be neutral, believed that science and scientists should ignore national differences, proclaim their aversion to "exacerbated nationalism," and condemn war as a "crime against civilisation" [50, pp 32–33]. During the war many other Italian scientists, like Ciamician, continued to view German science and education as a model to be emulated. A review of Ciamician's political activities is discussed in a recent dissertation [28].

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References and Notes

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