Valedictory lecture on March 18, 2016
最終講義
2016年3月18日

Chemistry: A Bridge between Molecular and Real Worlds
化学—分子と社会の架け橋

Eiichi Nakamura
中村栄一

Chemistry Lecture Hall, Chemistry Main Building
化学本館5階講堂

中村教授の還暦に当たってのHoffmann 教授によるご紹介を掲載させていただく.

Introdution by Prof. Road Hoffmann published in a February 2011 special issue of *Chemistry – An Asian Journal* commemorating the 60th Birthday of Prof. Eiichi Nakamura

Chem. Asian J. **6**, 240-241 (2001).

GUEST EDITORIAL

DOI: 10.1002/asia.201000803

For the 60th Birthday of Eiichi Nakamura

This special issue of *Chemistry–An Asian Journal* celebrates the 60th birthday of a great Japanese chemist, Eiichi Nakamura. As I look at Eiichi's career, I see an eye for design, a desire to understand, and a variegated, witty way to engage form and function in molecular matter. I also perceive in his work a modern turn for organic chemistry.

In the beginning, Eiichi was the latest in a striking line of ingenious Japanese organic chemists. In their hands, meticulous attention to detail in the tuning of reagents and conditions has given the community a cornucopia of reliable synthetic procedures of great utility. A substantial segment of the name reactions of the second half of the 20th century are Japanese; the 2010 Nobel Prize in Chemistry is one recognition of this remarkable line of fine chemists. Eiichi Nakamura's stay in the Stork group put him on a like trajectory.

On his return to Japan, and in his first years at the Tokyo Institute of Technology, Eiichi took the first of several turns. He and his able co-workers accompanied their synthetic studies with quantum chemical calculations on their reactions, in particular on the mechanism of organocuprate reactions. The theoretical organometallic chemistry they did, a strand of which continues to this day, was excellent; the advantage the Nakamura group had over other theoreticians then beginning to think about organometallics and their reactions was that Eiichi knew intimately the relevant chemistry. His group's theoretical work, first class as theory, somehow had more than a touch of realism.

Nakamura's reactions were becoming part of the toolkit of organic chemists. At this point, roughly at the time he moved to the University of Tokyo, *Todai,* he took another reasoned turn in his work, to look at the functionalization of buckminsterfullerene and related structures. What caught my attention, after his spectacular synthesis of one and two ferrocene units built on a buckyball, was the following remarkable series of reactions: First one end of C_{60} was functionalized, taking advantage of the specific eclipsing feature of substituents added to the polyhedron around a five-membered ring. And then the process was repeated at the other end of the buckyball. Effectively, two ends of the polyhedron were saturated, leaving behind a belt of conjugation, an entirely new structure, which also could be thought of as the simplest nanotube.

When I saw this synthesis, my mind went through the equivalent of clapping its hands in joy. The product was fascinating, the approach to it as elegant as it was surprising.

I think Eiichi Nakamura's work on fullerenes, nanohorns, carbon shuttlecocks, and nanotubes is witty. It is in no way light, for the concepts he invents for the modification of these structures are highly intellectual, and the chemistry as intricate as it could be. What I mean by witty is the following: The cleverness of Eiichi Nakamura's reactions, the beauty of the way he takes advantage of structure and reactivity, the ingenuity of his molecular constructs, elicits in the chemical observer (unless they are his competitors) a smile. Simply of the joy that it could be done. And done so neatly, so cleverly.

There is fun in the pentapod sprouting buckyballs. And functional fun in a tetrathiolene attached at each end to cobalt atoms, that in turn hold on to two substituted buckyballs. Incredible! And "cool."

Perhaps it is like hearing him play the *flauto traverso*, Bach's flute, in a Telemann trio sonata, likely joined by his wife Yoko on viola da gamba. It looks easy, and, even as we

Eiichi Nakamura with his wife Yoko

know how difficult that passage is, we smile as we hear the satisfying resolution of a complex line of counterpoint.

The same combination of ingenuity, elegance, and chemical wit marks the more-recent collaborations of Eiichi Nakamura with talented electron microscopists. They allow us to see, really see, a long-chain hydrocarbon gyrating inside a nanotube, two buckyballs fusing, a simple hydrocarbon chain passing through a nanopore.

There's a new turn in the making in Nakamura's work. This is the design of electronic function in organic molecules. The transistors, memory devices, gates, and circuits of the future will make use of the flexibility of function and geometry, the fine-tuning that the logic of substituents gives. They will be inorganic and organic. Eiichi Nakamura is making sure organic chemists are there, defining the emergent phenomena of the chemistry of the 21st century.

Roald Hoffmann

Roald Hoffmann
Cornell University
Member of the International Advisory Board,
Chemistry–An Asian Journal

With Prof. Hoffmann in Ithaca, 2003

Roald's favorite Indian art

Chemistry—A Bridge between Molecular and Real Worlds

Eiichi Nakamura

化学—分子と社会の架け橋

中村栄一

My interest in exploring the unknown was probably fostered through the quest of model building. Building wooden 1/1000-scale model battleships of the Japanese Navy was my serious undertaking in the primary school period. During the high school to college years, I made 1/80 brass models of Japan Railways trains and steam locomotives, such as Series 1550 and 1810, using drills, saws and a lathe, day and night. Retrospectively, scratch building from brass sheets and rods was indeed a very creative activity; I made model locomotives following 2-D plans in the catalog of the Imperial Japanese Railways, which gave me the length and height of the engine (8,928 mm and 3,658 mm, respectively, in the case of Series 1550), and 3-D plans reconstructed from several old photographs.

Japan Railways 1550 (1904)

My First Research Paper: “The Israel Railway–Past and Present,” 1972

My interest in formal research started in 1971 when I was 20 years old, working as a summer trainee in the Derech Petah Tikva dairy factory of Tnuva in Tel Aviv. An encounter with excavated 1050-mm gauge rail/crosstie composites at the location of the old Tel Aviv Railway Station stirred up my interest in this peculiar gauge. After a half-year investigation during my stay in Israel and also back in Japan, I published a research paper in *Railway Pictorial* (ISSN0040-4047; NCID: AN0036139X) [Railroad History publications 1 and 2 in Publication List Section] describing how the Hejaz Railways started in the Near East, and how the railroads thrived after the establishment of Israel in 1948. The Hejaz Railways may be best known through the film *Lawrence of Arabia*, in which a steam train is blown up by Lawrence. Although I learned only a few words of Hebrew, including “slihah,” (excuse me) a word of absolute necessity in a crowded bus in Tel Aviv, this extended trip, generously supported by my parents and grandparents, via London–Rheine–Köln–Nürnberg–München–Graz–Rome–Athens–Istanbul–Israel–Ulm–Paris for three months became the most valuable

Prof. Mukaiyama and alumni, ~1990

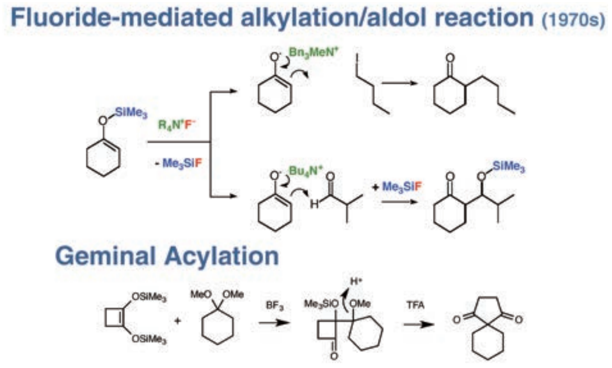
treasure in my life.

The year 1969 was the year of student movement all over the world, and the entrance exam of the University of Tokyo was cancelled with a short notice of 44 days. This changed my destination to Tokyo Institute of Technology (TIT), in which I had never thought of becoming a faculty member. I asked a question to an applied chemistry professor, “Who is the best chemist in TIT?” and he said “It is Mukaiyama,” who was only 42 years old at that time. The year 1972 was the time when the Mukaiyama aldol reaction was being developed by Assistant Professor Koichi Narasaka and when I started my undergraduate work. I worked on the hydrolysis of 1,3-dithiane mediated by $CuCl_2/AuClO_4$, a formidable explosive that put me out of action through injury for nearly half a year. So I did not do too much in the Mukaiyama lab, but still learned much about the Mukaiyama philosophy–“Don’t imitate others.”

The Kuwajima group, ~1990

My First Chemistry Paper: “Fluoride Ion Activation of Enol Silyl Ether,” 1975–1983

When Prof. Mukaiyama moved to the University of Tokyo in April 1973, he asked me to work with a newly appointed associate professor, Dr. Isao Kuwajima. He had studied with Prof. E. J. Corey and asked me to test many of his ideas on a variety of research projects–different subjects every few months. Watching how chemistry research was done in the top laboratories, I thought that being a player in the Chemistry World Series was more interesting than being an amateur historian studying British colonial railways in his spare time–it was my planned life’s work when I was a sophomore student.



Fluoride-mediated alkylation/aldol reaction (1970s)

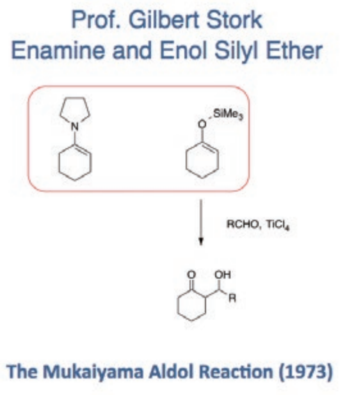
Geminal Acylation

(1) I. Kuwajima and E. Nakamura, *J. Am. Chem. Soc.*, 97, 3257 (1975); E. Nakamura, T. Murofushi, M. Shimizu, and I. Kuwajima, *J. Am. Chem. Soc.*, 98, 2346-2348 (1976).

(7) E. Nakamura and I. Kuwajima, *J. Am. Chem. Soc.*, 99, 961-963 (1977).

(8) R. Noyori, K. Yokoyama, J. Sakata, I. Kuwajima, E. Nakamura, and M. Shimizu, *J. Am. Chem. Soc.*, 99, 1265 (1977).

Two lectures during my master’s studies left a great impression on me. Prof. Akio Yamamoto hosted Prof. Melvin Calvin, who talked about the importance of sunlight harvesting–a subject of my research now. I remember that I asked a question about the connection between light harvesting and the molybdenum chemistry that he mentioned in his lecture. Another lecture in the second year



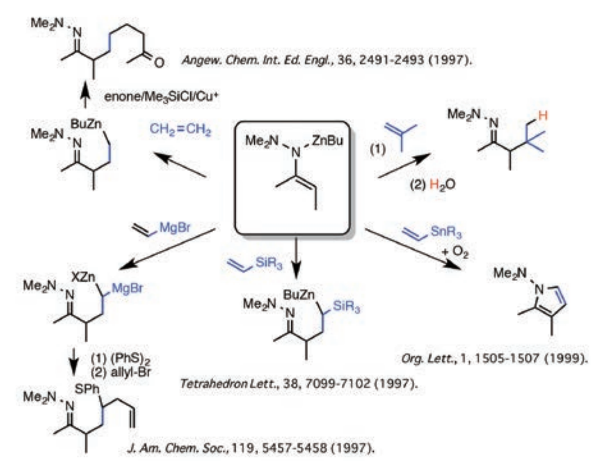
Prof. Gilbert Stork
Enamine and Enol Silyl Ether

The Mukaiyama Aldol Reaction (1973)

Photo Ayako Yamashita

of my graduate study, also hosted by Prof. Yamamoto, literally changed my life. It was a lecture by Prof. Iwao Tabushi on quaternary ammonium phase transfer catalysis in water, and I became curious about the possibility of generating an ammonium enolate–a naked enolate. My idea was to push up energetically a neutral enol silyl ether into an enolate anion through compensation of the energetic penalty by forming a strong Si–F bond. Enol silyl ether was an intermediate developed earlier by Prof. Gilbert Stork and used for the Mukaiyama aldol reaction. I optimized α-alkylation of a ketone by the use of robust benzyltrimethylammonium fluoride and dry molecular sieves. The tetrabutylammonium ion was too unstable. I was struck then by the realization that the best substrate I chose based on the conventional wisdom was in fact the worst substrate, and the worst was the best. Chance favors the prepared mind.

My mother passed away on February 4, 1975 as a result of metastatic cancer. I wrote a one-page *JACS* Communication during the time I was away from the lab for her funeral. The paper was received by the *JACS* office on February 24, my 24th birthday, and appeared in print in May–my first chemistry publication [Original Publication 1]. Prof. Kuwajima then received a letter from Prof. Noyori, a rising star at that time. The letter said that he was working on the same chemistry as applied to the aldol reaction. Collaboration including Mr. Makoto Shimizu, now a Dean in Mie University, started and continued, to produce our joint paper in *JACS* in 1977 [8] followed by another one [21] after I came back from Columbia. Through this collaboration, I learned Prof. Noyori's tenacity to seek for the ultimate truth.



Angew. Chem. Int. Ed. Engl., 36, 2491-2493 (1997).

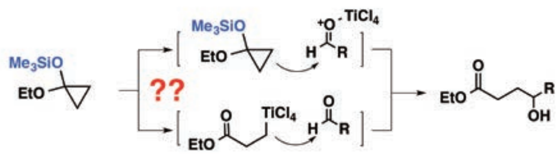
Tetrahedron Lett., 38, 7099-7102 (1997).

Org. Lett., 1, 1505-1507 (1999).

J. Am. Chem. Soc., 119, 5457-5458 (1997).

During my Ph.D. study, I noted a fundamental limitation of enolate chemistry in that the enolate anions do not add to simple olefins because of the large exothermicity of such reactions. It was 20 years later that I solved this problem by using zinc enamide, which allowed me to add a ketone enamine to an olefin and even to a vinyl Grignard reagent to obtain an α-alkylated ketone [199, 225, 296]. You can further trap a γ-zincio intermediate with an electrophile to achieve one-pot three-component coupling. Interestingly, I could add a zincio enamide to gaseous isobutylene to achieve even t-butylation of a ketone.

Homoenolate chemistry: My First Step



(10) E. Nakamura and I. Kuwajima, *J. Am. Chem. Soc.*, 99, 7360-7361 (1977).

Metal Homoenolate and Cyclopropanone Acetal, 1977–1987

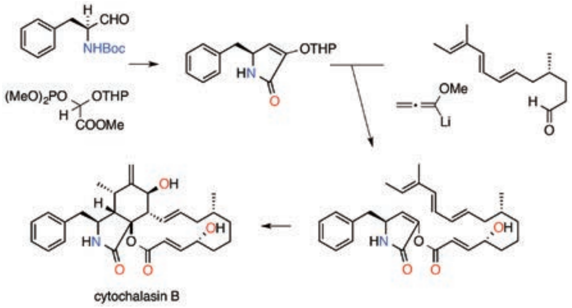
The homoenolate ion is a β-anion of a carbonyl compound, and is an intermediate proposed in the 1960s as a putative transient species in carbanionic rearrangements. During a study on the reactivity of 1,2-siloxycyclobutene, I noticed that a silylated hemiacetal of cyclopropanone was available on a large scale by reductive cyclization of a 3-chloropropionate ester. I thought that the fluoride ion could induce ring opening to generate a homoenolate anion, but this idea failed. Instead, I found that the Mukaiyama conditions worked perfectly–"electrophilic activation of an aldehyde partner with TiCl4." My fifth *JACS* paper [10], on the homoenolate reaction, was published in 1977. Sounds wonderful! However, very deep coloration of the reaction mixture made me suspicious about the Mukaiyama-type mechanisms… I consulted Prof. Akio Yamamoto about the possible involvement of titanium homoenolate, but my organometallic background then was too weak to study such a brand new organometallic in a professional manner.

Westbound trip to New York City, March 20–April 19, 1978

With Prof. Seebach in ETH, April 4, 1978

After consultation with Profs. Mukaiyama, Kuwajima, Noyori, the late Tabushi and Takashi Takahashi in 1976, I decided to work with Prof. Gilbert Stork for my postdoctoral study. I skipped the commencement ceremony of my Ph.D. study, and left Tokyo westbound for New York City on March 20, 1978 with my wife, Yoko. We traveled through Istanbul, Athens, Crete, Florence and Zurich. Prof. Dieter Seebach was kind enough to provide me an opportunity to give a seminar at ETH Zurich, then in the city center, and put us up in the Hotel Poly nearby. An honorarium of 40 Swiss francs in an ETH envelope was kept so carefully that we never saw it again. It was my second research seminar, after the first one during my Ph.D. study kindly organized by Dr. Iwao Ojima, then at the Sagami Chemistry Research Center. We left Europe from Milano Malpensa Airport to arrive at NYC on April 20.

Total Synthesis of Cytochalasins, 1978–1980



My project in Prof. Stork's laboratory was the total synthesis of cytochalasin families via a macrocyclic Diels–Alder reaction. On the first day at Columbia, Gilbert took me to the library, quickly looked through many issues of Chemical Abstracts and suggested a few synthetic routes and synthetic intermediates to me. I wished to contribute to the Stork lab with my expertise in synthetic methodology, and incorporated two new reagents in the total synthesis of cytochalasin B and F [28]. I recall that I did 750 experiments/year then, my most productive period as a bench chemist.

Organic chemistry at Columbia was extremely strong in research and education. Every Thursday evening after dinner, we had an organic seminar/problem session where all organic professors, Stork, Breslow, Nakanishi, Katz, Turro and Still, sat in the front row of a classroom in the Havemeyer Hall, and gave insightful comments for students and postdocs. I met Prof. Amos Smith in a graduate classroom one day. Amos was on his sabbatical. The weekly Thursday Departmental Seminar in the main lecture theater invited eminent speakers such as Prof. Stork, reporting on a new DNA sequencing method. I was therefore greatly thrilled when I was later invited to give a Gilbert Stork Lecture there in 2006. In that year, I was nominated by Gilbert to the

American Academy of Arts and Sciences, and inducted in 2008. I received an e-mail from Gilbert on July 29, 2008:

Dear Eiichi, getting together with Yoko and you for dinner Thursday, October 9 sounds great! But, there is a condition: we will take you out–after all, how often does one of my former associates get inducted as a Foreign Honorary Member of the American Academy of Arts and Sciences?
All the best to you and Yoko, Gilbert

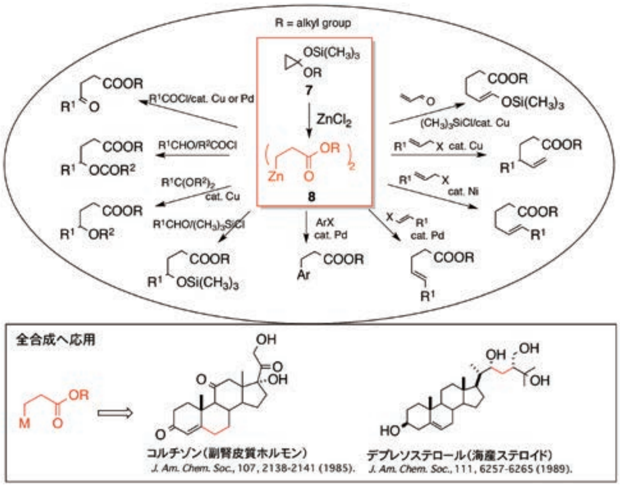

Rrof. Stork, 1979

The Xmas party was another entertainment at Columbia Chemistry, which always featured Koji's famous magic and, in 1979, a rare B-class movie "The Big Drop" filmed by Carl Djerassi. Gilbert tried in vain to sell this movie in NYC. I later benefitted very much from being a member of the Stork Mafia, a Columbia alumnus and a member of the natural product chemistry family in the US and in Japan, where people from chemical, pharmaceutical and biological communities gather. Of the Stork members then, George Majetich, Phil Parsons, Ian Paterson, Dave Sherman, Jeff Stryker, John Taylor, Jeff Winker are active in academia. Clark Still left academia, though.

From Gilbert, I learned another style of mentorship, different from the Mukaiyama/Kuwajima style. It helped me greatly in my career development. I also learned that "A research seminar must be entertaining for the audience. Details can be learned from publications."

Metal Homoenolates, 1980–1988

When I came back to the Kuwajima lab as Assistant Professor, I managed to identify the putative titanium homoenolate [24] involved in the $TiCl_4$-mediated reaction after considerable detours. I then synthesized a number of 3-metallated propionate esters [30] and transient palladium homoenolates from 1-alkoxy-1-siloxycyclopropane [35], and applied this chemistry to the synthesis of adrenal hormone [39, 57] and marine sterols originally isolated in the Red Sea near Israel [33]. This cyclopropane ring-opening reaction is, retrospectively, remarkable in two respects: as a demonstration of the utility of functionalized organometallics, and as a rare example of efficient catalytic C–C bond cleavage. I did not have then a clear vision of the significance of these subjects.



During the study of zinc homoenolate, I found that Me_3SiCl vastly accelerates the conjugate addition of organocopper reagents [37, 38]. Circumstantial evidence suggested intermediacy of a triorganocopper(III), which led me later to perform systematic theoretical studies on the mechanism of organocuprate(I) reactions.

Yoko, Eiichi, K. and M. Nakanishi, N. Nakano, J. Meinwald

The work on metal homoenolates brought me the Young Chemists Award from the Chemical Society of Japan in March 1984, and, on December 16, promotion to Associate Professor at TIT, where I started my independent career at the age of 33. Profs. Mukaiyama and Noyori kindly nominated me to this position. A memorable event then was a face-to-face discussion with Prof. Roald Hoffmann of Cornell for 30 min on the occasion of his TIT visit just after his Nobel Prize. I owe very much to Prof. Hiroshi Kobayashi, who kindly arranged this discussion. Friendship with Prof. Jerry Meinwald of Cornell and his wife Charlotte through music also started at this time.

By the year 1988, I rarely worked in the lab myself, and I realized that management of people is the single most important key issue for running a productive and self-motivated research group. As I realized that some excellent knowledge and know-how cannot be transmitted through generations, I wrote “The Nakamura Laboratory Manual,” where I summarized our best laboratory techniques so that good traditions could be maintained. We read through the entirety of this 130-page manual every April 1. The front page reads as follows:

Actual Planning of the Experiment (a daily, weekly and monthly plan is essential)

In planning the experiments for a day or week, consider such combinations as the following:
Difficult experiment vs. Simple experiment
Experiment likely to succeed vs. Experiment likely to fail
Time-consuming experiment vs. Quick experiment

**Prioritize all issues and then address the important ones first.*
Often, the issues you are willing to address are typically not the important ones.
**Learn not only the knowledge and information but also the methods to acquire such knowledge and information.*
**Protect yourself. Wearing protective goggles is mandatory. Awareness as a researcher is demonstrated by assuming responsibility for personal health and the wearing of protective clothing.*

To facilitate communication within the group, I set up six “official” laboratory parties as a part of our regular routine: We now have O-hanami-Cherry Blossom Party on April 1, spring Group Seminar at Tateshina in May, Pep rally in June for undergrads, fall Group Seminar in October, Year-end Party in December and Celebration of Ph.D., M.S. and B.S. degrees in February. We also have annual sports days for our own group and the Chemistry Department. Apart from these fun activities, we have a Sub-Groups Seminar and Journal Club every week and Research Report every month. Dr. Satoshi Aoki, the first assistant professor in my group, played important roles in establishing these traditions.

My First Lecture Tour in the USA, 1988

At the 1987 Taniguchi Conference on catalysis held in Kobe, I shared a room with Prof. Peter Vollhardt of Berkeley in the Japanese Inn at Kurashiki, and he strongly recommended me to do a US lecture tour. Prof. Rick Danheiser of MIT, another member of the Stork Mafia, kindly arranged a terrific two-week tour through MIT–Harvard–Yale–Columbia–Merck–Cornell–UCLA–Caltech–Stanford–Berkeley and the ACS LA meeting. At Harvard, I had dinner with Profs. E. J. Corey, Yoshito Kishi, David Evans and Stuart Schreiber, who had just returned from Yale. At dinner at Yale with Prof. Fred Ziegler, a dozen fried oysters came as a starter, which made me completely full! At Cornell, I gave a seminar on Friday and a concert on Sunday in the A.D. White House for Friends of Music with Prof. Jerry Meinwald and Charlotte, and professors from the Cornell Music School.

The most gorgeous concert, by the way, that I gave with Jerry, Charlotte and Yoko was the one in *La Basilique Sainte-Clotilde* in Paris in 2004. This Gothic church located behind the Palais Bourbon has the famous César Franck organ. The concert was on the occasion of the 70th Anniversary of *La Fondation de la Maison de la Chimie* hosted by Profs. Pierre Potier and Jean-Marie Lehn. I have no visual record because the pictures taken by Prof. K. C. Nicolaou were completely blurred!

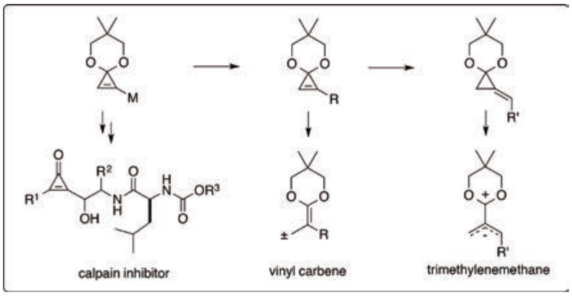

With Prof. Danheiser, MIT


Prof. Evans and Schreiber, Harvard


With Prof. Stork, Columbia

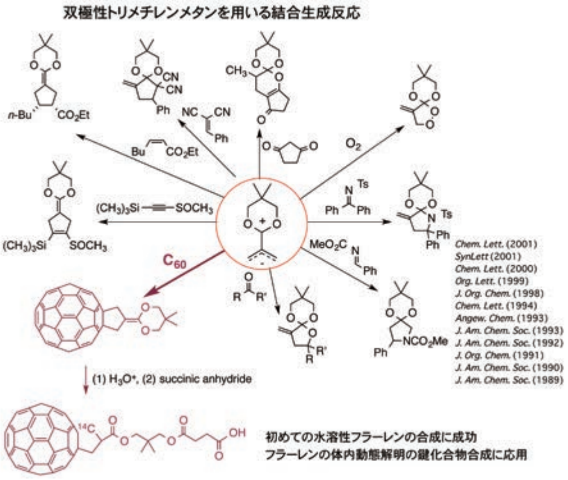
Cyclopropenone Acetal and Enzyme Inhibitor, 1985–95

During the study of homoenolate chemistry, I became fascinated by cyclopropenone, for which Prof. Ron Breslow had published an *Org. Synth.* prep. Extending Ron's methodology, I developed a new method for the synthesis of substituted cyclopropenones [58, 65, Accounts and Review 28]. With these cyclopropenones in hand, I imagined intercalating them among DNA base pairs. During discussion with Dr. Ryoichi Ando of Mitsubishi Chemicals, however, this idea underwent complete metamorphosis in the design of enzyme inhibitors.



Through coupling of a metallated cyclopropenone acetal and an amino aldehyde, we synthesized a variety of peptidyl cyclopropenones with a hope that this hydroxy cyclopropenone moiety would act as a carboxylic acid mimic. As first reported in 1993, some compounds inhibited cysteine proteases very well [84], and were further developed by the Mitsubishi Chemical people, but died during an animal toxicity test. However, this work on cyclopropenones provided me the first opportunity to learn about the connection of my own molecular world and the real world of business.

Methylenecyclopropane and Trimethylenemethane, 1989–1995



We made the small discovery that a methylcyclopropenone acetal (R = Me) that Dr. Shigeru Yamago synthesized often contains a more stable isomer, a methylenecyclopropane (MCP, R' = H). Careful optimization allowed us to obtained MCP as an exclusive product. We soon discovered a thermal [3 + 2]cycloaddition reaction to an electron-deficient olefin [56, 66, 79, 87] and C=X bonds–a thermal endo-selective 6-π cycloaddition of a trimethylenemethane biradical to form five-membered rings [Accounts and Review 26, 27].

I have kept my eyes on buckminsterfullerene (C_{60}) as a strained olefin since 1985, when my high-school classmate, Prof. Hideo Aoki, studying physics in Tsukuba University, challenged me about its total synthesis. When C_{60} became commercially available in 1992, therefore, we were eager to examine C_{60} as a cycloaddition partner of MCP. To our pleasant surprise, the reaction went very well [81, 95]. The product was a ketene acetal that gave an ester upon hydrolysis. My interest in DNA reared its head again: Can we bind this 1-nm-sized molecule to the major groove of DNA?

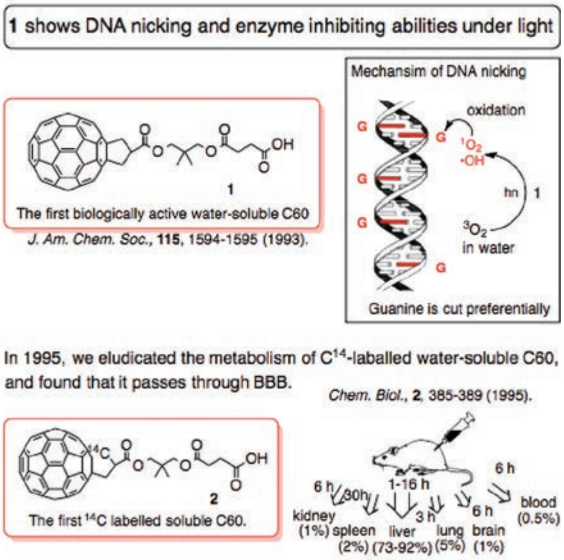
In 1990, after several years running a research group, my interests and research focus were changing rapidly. This is a picture taken at a Banyu Symposium in Tokyo, August 27th, 1990. From left: myself, Profs. Katsuhiko Inomata, Tsujiaki Hata, Teruaki Mukaiyama and his wife, Isao Kuwajima and Kuniaki Tatsuta.

Eiichi, K. Inomata, T. Hata, T. and H. Mukaiyama, I. Kuwajima, and K. Tatsuta

Discovery of Biological Activity of Fullerenes, 1989–2015

Prof. Yukio Sugiura came to lecture at TIT hosted by Prof. Takashi Takahashi. In the evening drinking session, I talked about my idea of the DNA binding of C_{60}, and his response was, “I tried the same idea without success, because C_{60} doesn’t dissolve in water at all.” My collaborator Dr. Yamago and Shigetoshi Tokuyama prepared a succinate derivative of our C_{60} derivative, and it was immediately tested in Kyoto. After two weeks, they found that our water-soluble fullerene cuts DNA, and, as studied at Mitsubishi Chemical, it also inhibits enzyme activities. Our paper was first submitted to Nature, where it was rejected with an appalling reviewer comment, “too weak activity to be useful as an anticancer drug,” and then published as a *JACS* Communication [89]. Alas, while our work was in press, a paper by Prof. Fred Wudl reporting on AIDS protease inhibition also appeared in print in *JACS*, and received worldwide publicity. We studied the metabolism of a 14C-labeled derivative in mice showing that this compact and hydrophobic compound passes through the blood–brain barrier [111]. Regioselective DNA cleavage was made possible by triple-helix formation by tailor-designed fullerene–DNA conjugate molecules made through collaboration with the late Prof. Claude Helene in Paris [101].

The work on the biradical chemistry and some early works on fullerene science brought me the Japan IBM Science Prize, as recommended by Prof. Hisashi Yamamoto, in the summer of 1993.


1 shows DNA nicking and enzyme inhibiting abilities under light

The first biologically active water-soluble C60

J. Am. Chem. Soc., **115**, 1594-1595 (1993).

Mechansim of DNA nicking

Guanine is cut preferentially

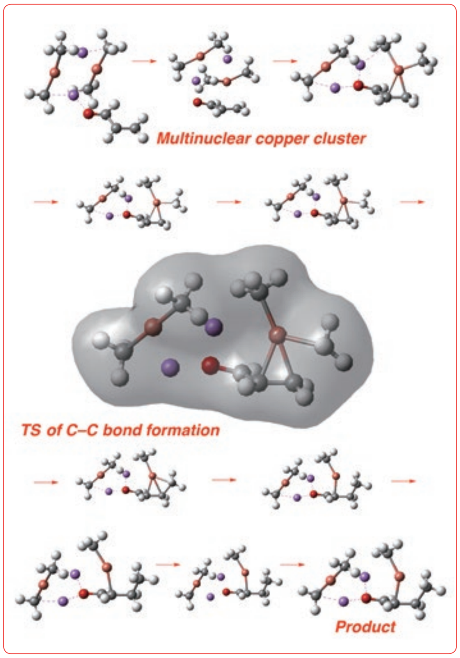
In 1995, we eludicated the metabolism of C^{14}-laballed water-soluble C60, and found that it passes through BBB.

Chem. Biol., **2**, 385-389 (1995).

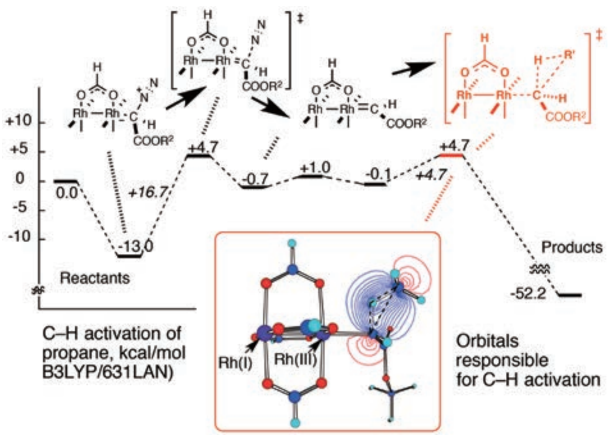
The first ^{14}C labelled soluble C60.

Mechanism of Organocuprate Reactions, 1990–2012

As soon as I became an Associate Professor in 1984, I started to work on computational chemistry, in which I had had a long-standing interest. I obtained a magnetic tape copy of the MNDO/C program from Prof. Eiji Osawa, and compiled the program on the university mainframe computer. After playing around for six months, I found it useless to study the subject of my interest. This fruitless attempt in 1985 however produced fruit later. Upon my appointment in 1989 as Adjunct Associate Professor at the Institute of Molecular Science, Prof. Keiji Morokuma offered me an opportunity to work with his postdoc Andrea Dorigo on a subject of my choice. The IMS Hitachi computer was the same as the TIT computer, and therefore I could immediately start my work. I first taught Masaharu Nakamura how to input data and to analyze the output, and the theory tradition in my group continued through Seiji Mori, Masahiro Yamanaka and Naohiko Yoshikai. I spent the next 25 years on computational research and answered many of my questions on the mechanism of organocuprate reactions and other metal-catalyzed reactions.



Computers then were very slow, only allowing us to study the Hartree–Fock potential surface of the reaction of a MeLi dimer with formaldehyde [94]. Computers became faster, as Moore's law predicted, and by 1994 I could study cases as complex as conjugate addition of solvated Me_2CuLi dimers with methylvinylketone. Although we received serious opposition from a JACS referee, we eventually published a new mechanism of conjugation in JACS in 1997 [128, 129], and this mechanism is now widely accepted [142, Accounts and Reviews 46]. We also studied a variety of bimetallic systems, such as Li–Li, Zn–Li [144], Zn–Zn [140]and Mg–



Zn, as well as Co–Co, Rh–Rh, Ru–Rh and Co–Rh. The mechanism of Cu- [218] and Rh-catalyzed C–H activation of diazoacetate [190] that I studied with Dr. Naohiko Yoshikai stimulated my interest in C–H bond activation.

By the time I turned 40, I was receiving some recognition from the chemistry community. I was invited by Prof. Scott Denmark as the inaugural R. C. Fuson Visiting Professor at the Chemistry Department of the University of Illinois (1990). On my way to Illinois, I paid a visit to Prof. E. J. Corey, who used to be in Illinois before moving to Harvard. E. J. gave me strong encouragement, and escorted me from his office to the Harvard Square Station! Scott and his colleagues thought that Yoko and I would do pretty well at Illinois. Kyoto then suggested to me that I join, and I submitted a plan for research and education to the Department Head on October 2, 1993. Here are the introductory parts of my plan on research and education.

今後の研究について 東京工業大学　中村栄一

有機化学は21世紀における飛躍に向けて，大きな変化をとげつつある．この変化の時期にあたって「ものを創りだす有機化学」の力を活用した，力強く新しいスタイルを確立することが必要である．（Chemistry for the 21st century）

第一にこれまで偶然と試行錯誤に頼ることの多かった有機合成を，科学的原理に基づく合理的予測をもとにして実行できることを明確に示したい．（Rational design）

次に，こうして確立した合理的有機合成を武器に，これまで有機化学の範疇とは思われていなかった分野に踏み込み，自然科学一般に普遍的な価値を持つ有機化学研究の展開を試みたい．（Beyond organic chemistry）

教育に対する抱負

研究生活上で幅広い経験を学生に積ませることによって，専門の有機化学を積極的かつゆとりをもって追及する態度を養って欲しいと念願してきた．具体的には授業でのトピックスの選択，研究テーマの選択に注意を払うと同時に，学生の学会参加，海外で研究経験を持つことを積極的に推奨してきた．これまでに，博士後期課程に進学した学生8人全員を夏期の3ヶ月間，アメリカ，イギリス，スイスなど海外での研究体験に送り出した．（Broaden the interest of students）

日本国内での教育活動の重要性に加え，今後，日本が国際社会での指導的立場を担っていくためには海外からの人材受け入れも重要な課題となろう．これまでにケンブリッジ大学，マサチューセッツ工科大学の学生の短期日本訪問を企画すると同時に，韓国人博士研究員，スイス人大学院生の1年間受け入れを行った．また現在，中国人学部学生も指導している．外国人の受け入れには制約や問題もおおいが，研究室学生の意識の国際化にも役立つことから積極的に続けたい．（Acceptance of foreign culture）（1993年10月2日）

大学院在学中の短期留学 (Sending Ph.D. Students Abroad)

1988 UC, Berkeley, USA (Prof. Peter Vollhardt)	山子 茂
1989 University of Cambridge, UK (Prof. Ian Paterson)	伊坂雅彦
1990 Sandoz Co., Basel, Switzerland	徳山英利
1990 UC Santa Barbara, USA (Prof. Bruce Lipshutz)	荒井雅之
1991 Sandoz Co., Basel, Switzerland	中村正治
1991 Scripps Institute, San Diego, USA (Prof. Dale Boger)	江尻 聡
1992 Sandoz Co., Basel, Switzerland	久保田克巳
1994 Emory University, Atlanta, USA (Prof. Keiji Morokuma)	森 聖治
1995 Princeton University, USA (Prof. Daniel Kahne)	磯部寛之
1997 Emory University, USA (Prof. Lanny S. Liebeskind)	平井 敦
1997 SUNY, Stony Brook, USA (Prof. Iwao Ojima)	坂田 剛
1999 Emory University, Atlanta, USA (Prof. Keiji Morokuma)	山中正浩
2000 SUNY, Stony Brook, USA (Prof. Iwao Ojima)	原 賢二
2000 Emory University, USA (Prof. Frank McDonald)	戸叶基樹
2001 SIOC, Shanghai, China (Prof. L. Wu)	冨田直輝
2002 University of Madrid, Autonoma (Prof. A. Echavarren)	國信洋一郎
2002 University of Munich, Germany (Prof. Paul Knochel)	松尾敬子
2002 Stockholm University, Sweden (Prof. Jan Bäckvall)	吉戒直彦
2002 Hong Kong University, PRC (Prof. Dan Yang)	畠山琢次
2003 University of Geneva, Switzerland (Profs. S. /N. Matile)	Ai-jan Chen
2003 SUNY, Stony Brook, USA (Prof. Benjamin Chu)	中西和嘉
2003 University of Dortmund, Germany (Prof. Norbert Krause)	田原一邦
2003 University of Alberta, Canada (Prof. Jeffrey Stryker)	佐藤宗太
2003 National Taiwan University, Taiwan (Prof. Tien-Yau Luh)	遠藤恒平
2003 Peking University, PRC (Prof. Zhenfeng Xi)	村松彩子
2004 Caltech, USA (Prof. Brian M. Stoltz)	岩下暁彦
2005 University of Geneva, Switzerland (Prof. Stefan Matile)	田中隆嗣
2005 RWTH Aachen University, Germany (Prof. C. Bolm)	藤本泰典
2005 University of Illinois, USA (Prof. Scott E. Denmark)	伊藤慎庫
2006 Merck Research Laboratories, USA	真島紘子
2006 University of Chicago, USA (Prof. Rustem F. Ismagilov)	Laur Ilies
2007 University of Cambridge, UK (Prof. Ian Paterson)	藤田健志
2007 University of Munich, Germany (Prof. Paul Knochel)	山形憲一
2008 MPI, Polymer Research, Germany (Prof. K. Müllen)	三津井親彦
2008 University of Groningen, Netherland (Prof. B.L. Feringa)	本間達也
2008 Weizmann Institute, Israel (Prof. Milko E. van der Boom)	一木孝彦
2009 MIT, USA (Prof. Mohammad Movassaghi)	中村優希
2009 University of Ulm, Germany (Prof. Peter Bäuerle)	Ying Zhang
2009 University of Michigan, USA (Prof. Melanie Sanford)	松本有正
2010 Philipps-University Marburg, Germany (Prof. E. Meggers)	南 皓輔
2011 Northwestern University, USA (Prof. M. R. Wasielewski)	助川潤平
2011 UPMC, France (Prof. Max Malacria)	浅子壮美
2011 University of Groningen, Netherland (Prof. B.L. Feringa)	小島達央
2011 University of Madrid, Spain (Prof. A. Echavarren)	関根真樹
2012 Eindhoven Univ of Technology (Prof. E. W. Meijer)	新田寛久
2012 University of Melbourne (Prof. A. Holmes)	Ricardo M. Gorgoll
2012 ETH Zürich, Switzerland (Prof. Jeffery W. Bode)	上田祥之
2013 RWTH Aachen University, Germany (Prof. Jun Okud	松原立明
2013 University of Würzburg, Germany (Prof. F. Würthner)	庄山和隆
2013 University of Münster, Germany (Prof. B. Jan Ravoo)	山田純也
2013 ESPCI ParisTech, France (Prof. Ludwik Leibler)	岡田 賢
2016 University of Münster (Prof. Frank Glorius)	Junfei Xing
2016 Evonik Industries	西岡拓紀

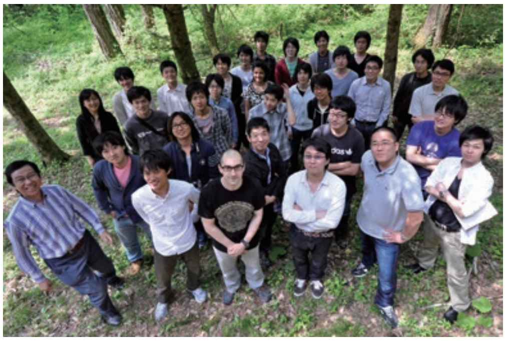
It seems that I was pretty progressive at that time, sending all of my Ph.D. students for a summer internship at foreign universities. I recall, however, that until the mid-1990s, our government did not allow us to pay for the overseas travel expenses of graduate students. Therefore, each student and I personally paid for the travel and living expenses during this summer research internship. I thank here all of my overseas friends who have willingly accepted my students in the past 30 years.

Tateshina Group Seminar and Team Work Spirit, 1993–

My long-standing interest in research management continued into my 40s. To cultivate a culture of cooperation in my group, I started the "Tateshina Group Seminar Series" at the Harmony-no-Ie (a house with harmony), held twice a year since the fall of 1993. We just finished the 46th seminar this year. The routine now is the following: We leave Hongo on Friday morning to arrive at Tateshina by noon to start the group seminar

Fall, 2001

Spring, 2004


Spring, 2012


Fall, 2013

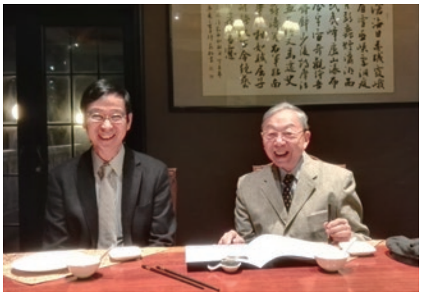
at 1 pm, followed by an Onsen (hot spring) nearby and BBQ from 5 pm. After recessing to the house around 8 pm, we spend a relaxing time till well after midnight. On Saturday morning, we have breakfast at 8 am on the terrace, resume the seminar, have lunch, clean up the rooms and leave Tateshina at 4 pm to come back to the university by 7 pm. This short retreat in the woods has become a part of our lab life, leaving a fond memory among us all.

Visiting Taiwan and China: Profs. Luh and Dai


With Prof. Danheiser and Luh, Honolulu, Dec. 2000

Sometime in 1991, my former student Dr. Masahiko Isaka, now in Thailand, visited Prof. Tien-Yau Luh in Taipei and this was my first connection with TY. Since then, we have been working together in a variety of occasions, including a Pacifichem 2000 symposium that we coorganize with Prof. Rick Danheiser of MIT and the Tateshina Conference from 2000. Then, sometime in 1993, on the occasion of a symposium in Nagoya, Prof. Noyori introduced me to Prof. Li-Xin Dai, who kindly arranged my first visit to China in May 1994–the beginning of my close connection to China. This visit has had a big impact on my academic and personal life. I visited Shanghai Institute of Organic Chemistry, Fudan University and the Institute of Chemistry at the Chinese Academy of Sciences in Beijing. Through the connection established by this first tour, I later became very close to Prof. Li-Jun Wan–the former Director of the Institute of Chemistry, where a number of my former postdocs are now working as faculty members. In 2015, Li-Jun became the President of the University of Science and Technology of China (USTC), where my former collaborator Prof. Yutaka Matsuo is a full professor of Chemistry and Materials Science from April 2016.


1994; Prof. Dai 69, myself 43 and Yoko 42, Shanghai


2015; 90 and 64 years old, Shanghai

Moving to the University of Tokyo, 1995

One day in the November of 1994, I received an offer to take up the Physical Organic Chemistry Chair of the University of Tokyo, to succeed Prof. Hiizu Iwamura, famous for his organic magnets. Being then a pure synthetic organic chemist, I was a little hesitant to take this important position. After 25 years, though, I am more of a physical organic chemist than a synthetic organic chemist. Your work environment creates your career.

QUOTES & PHOTOS OF THE YEAR

Chemical & Engineering News Dec 23, 2013 Quotes

A look at some of the **MOST INTRIGUING** statements and photos that made it onto our pages in 2013

JULY 29

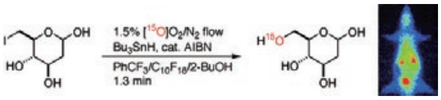
"Scientists should provide solutions to social problems and dreams for people."

EIICHI NAKAMURA, UNIVERSITY OF TOKYO

By the time I moved to the Hongo campus in April 1995, our cyclopropenone peptide mimic was considered seriously by Mitsubishi Chemical, and I was forming a certain view about the role of a university professor in society. This thought was recently summarized in my statement at the 43rd ACS National Organic Chemistry Symposium (June 23 to 27, 2013) as cited by *Chemical & Engineering News* among "Quotes of the Year 2013."

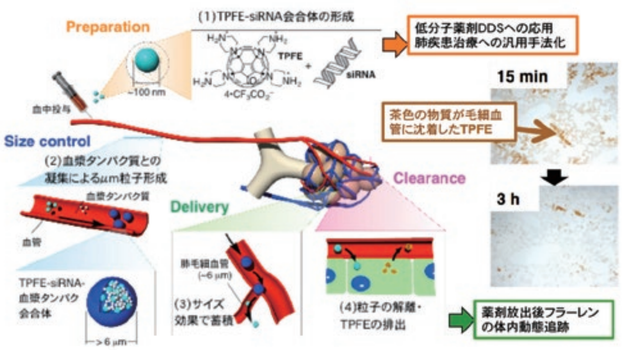
PET imaging with a 122-s Half-life ^{15}O-Glucose, 1995–2007

In my second collaboration with industry, I developed a new PET imaging reagent, ^{15}O-labeled glucose [239, 278]. This short-lived PET imaging agent is useful for multiple labeling studies using ^{18}F- and ^{11}C-labeled drugs. The study was planned and executed together with Dr. Shintaro Nishimura of Fujisawa Pharmaceuticals and Dr. Hideki Yorimitsu, a SPD JSPS post doc from Kyoto, who also contributed to shift my interest into electron microscopic imaging [220]. The idea of this synthesis originated from our own idea of the ultrasound-initiated oxygenation of organic radicals, and the challenge was how to combine rapidly and effectively a glucose molecule and a ^{15}O atom that has a half-life of only 122 s. The whole project took 10 years. In 2005, we published an ultra-rapid synthesis and bio-imaging of ^{15}O-labeled 2-deoxy-D-glucose, synthesized in 1.5 min on an automated synthesis/purification flow system. This compound is still the most complicated ^{15}O-labeled compound ever made.



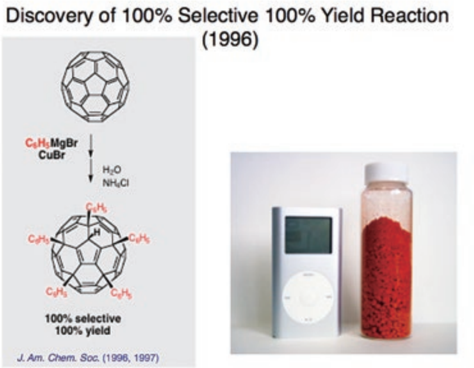
DNA and siRNA Delivery with Aminofullerene, 1997–

Two facts astonished me when I moved to the Hongo campus. First, I found that eight, as I recall, professors, including Prof. Kazuo Tachibana, out of 48 in the Chemistry Department had graduated from my high school, which has been producing only 160 graduates per year. Undoubtedly, science teaching there was enlightening and fruitful. I owe the most to my teachers, Messrs. Hisao Fukuoka, Hiroya Shiroki and Ichiro Tada, who inspired me in a variety of subjects, including chemistry. Second, I found that my office on the fifth floor of the Chemistry West Building overlooks the old part of the University Hospital campus, where I was born on February 24, 1951. Even more astonishing is that our new office and lab from April 2016 are located exactly in this old campus. I have returned to my birthplace!



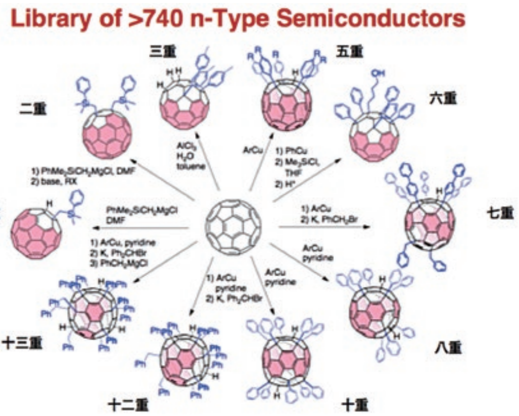
Having the university medical school was an obvious asset of Hongo for me over TIT. When the chair of the Recombinant DNA Committee was assigned to me, I started to work together with Prof. Hiroto Okayama on the use of aminofullerenes for in vitro and in vivo delivery of DNA [169, 259]. Dr. Hiroyuki Isobe pushed this new area forward. He was my fifth assistant professor, later a Tohoku Professor and now my successor in the Physical Organic Chemistry Chair. We still continue to work in this field (siRNA) with Prof. Eisei Noiri of the University Hospital and Dr. Koji Harano, an current associate professor in my group [353].

Bucky Ferrocene, Shuttlecock and Vesicles, 1998–


Discovery of 100% Selective 100% Yield Reaction (1996)

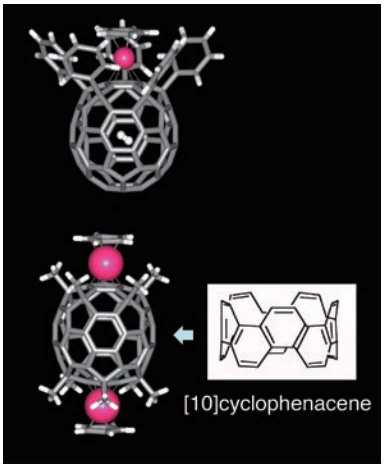
After some success in the biological research on organofullerenes, I decided to explore more seriously the potential of organofullerenes. The fruit of this decision was the discovery of an efficient, scalable synthesis–regioselective and high-yield penta-addition of organocopper reagent to [60]fullerene. This was the most intriguing and productive subject of my research, which illustrates how science starts from a seemingly minor detail and self-propagates into something unexpected–in this case, atomic-resolution electron-microscopic imaging of organic molecules and their reactions.

During our move to Hongo, Dr. Masaya Sawamura, my third assistant professor, and a new student, Mr. Hitoshi Iikura, joined my group, both from Kyoto. They made a huge discovery. I asked Iikura to control Grignard addition to fullerene with a faint hope of creating a cyclopentadienyl anion out of a pentagon in C_{60} [124, 133, 143]. Our lab was then studying organocopper chemistry; it was perhaps natural for him to add a pinch of a copper salt to the reaction mixture of a phenyl Grignard reagent. He found, in his HPLC chart, a trace of a peak with a molecular weight corresponding to $C_{60}(C_6H_5)H$–the unexpected but desired product. In a few months, he improved the yield from a few percent to over 90%. Further pursuit of this reaction later by Dr. Yutaka Matsuo, my sixth assistant professor, produced over 800 multi-addition products of this kind that we published in the literature. He has been extremely productive in my group, and published over 110 papers on the synthesis and solar applications of organofullerene compounds.


Library of >740 n-Type Semiconductors

With Dr. Matsuo's expertise in inorganic chemistry, we could make numerous organometallic complexes highlighted by bucky ferrocenes–a hybrid of fullerene and ferrocene [192]. Among them is a bucky ferrocene containing an endohedral hydrogen molecule. It belongs to a unique class of "hydrocarbons without a C–H bond" created by Profs. Koichi Komatsu and Yasujiro Murata [255].

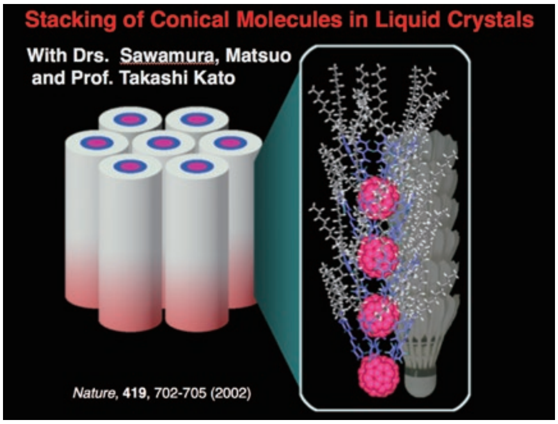
[10]Cyclophenacene is another intriguing system that we reported in 2003 [198, 223]. It is a fully conjugated hoop-shaped aromatic system that had defied synthetic efforts for half a century since the theoretical prediction by Heilbronner in the 1950s. A "double decker" bucky ferrocene is an aesthetically pleasing organometallic compound containing the [10]cyclophenacene ring. The compound caught the eye of Prof. Hoffmann, who made the following remark, and invited me to Cornell as a Bromquist Lecturer in 2006. Yoko and I enjoyed playing for the School of Music Lunch Concert with Jerry and Charlotte again.



"Beauty does not reside in simplicity. Nor in complexity, per se. For a molecule or a song, for a ceramic vase or a play, beauty is created out of the labor of human hands and minds. It is to be found, precarious, at some tense edge where symmetry and asymmetry, simplicity and complexity, order and chaos, contend." (R. Hoffmann, HYLE: International Journal for Philosophy of Chemistry, 9, 7–10 (2003).)

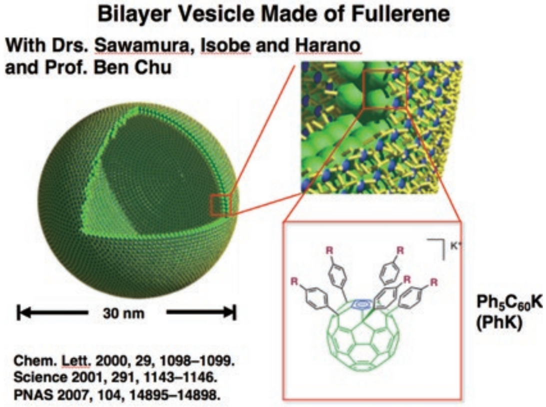

With Prof. J. Hsu, C. Greenspan, J. Meinwald, and R. Hoffmann

Our research activity toward material science was driven by collaboration between Prof. Takashi Kato in the School of Engineering and Dr. Sawamura in my group, who conceived the possibility of one-dimensional stacking of pentaorganofullerenes like badminton shuttles [149, 212, 273]. This molecular packing attracted a lot of attention from the general public throughout the world.


Stacking of Conical Molecules in Liquid Crystals

With Drs. Sawamura, Matsuo and Prof. Takashi Kato

Nature, 419, 702-705 (2002)


Bilayer Vesicle Made of Fullerene

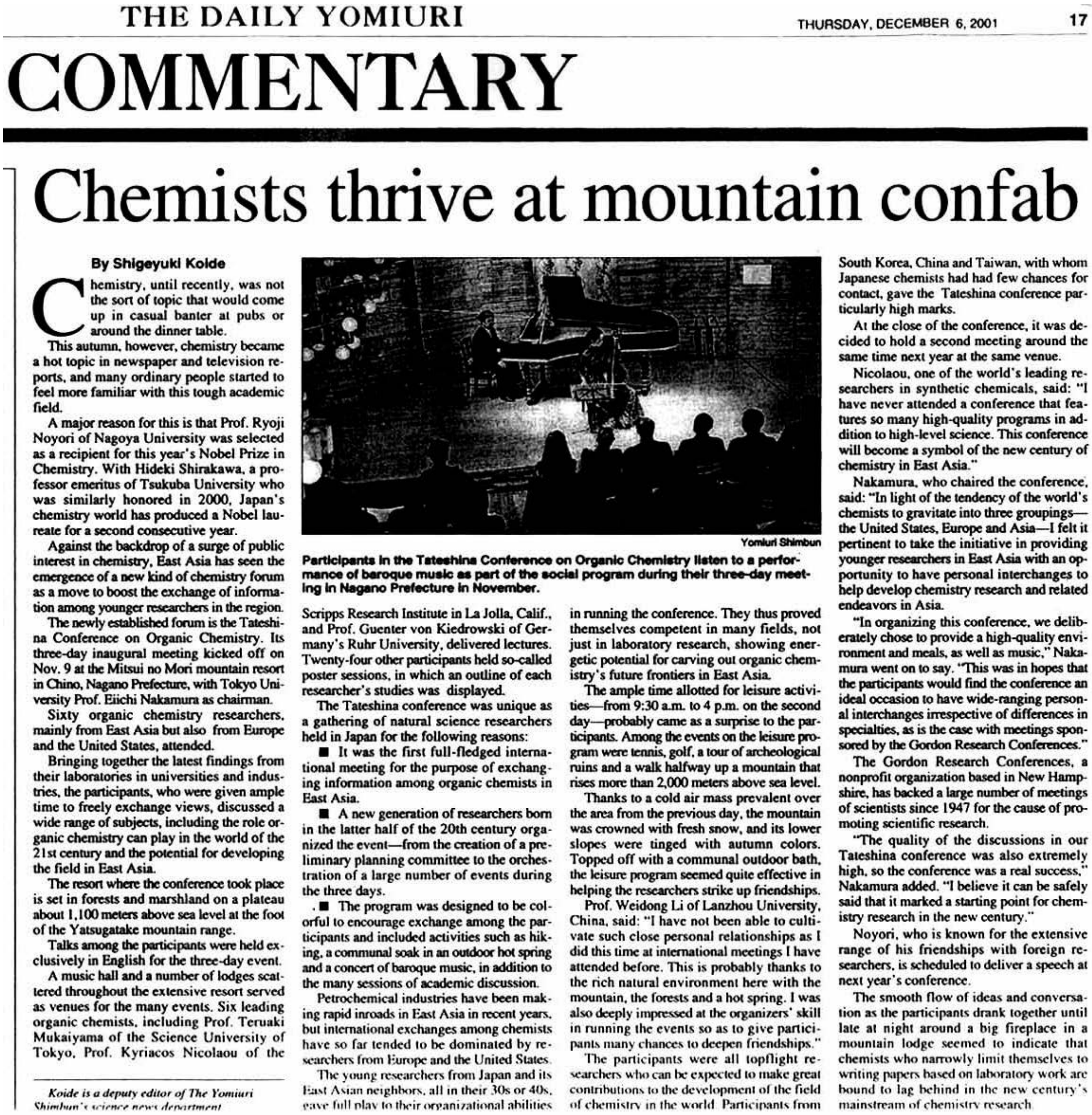
With Drs. Sawamura, Isobe and Harano and Prof. Ben Chu

Chem. Lett. 2000, 29, 1098–1099.
Science 2001, 291, 1143–1146.
PNAS 2007, 104, 14895–14898.

When Dr. Sawamura was entertaining freshmen of the university at a summer school, he discovered that the $(C_6H_5)_5C_{60}^-$ anion forms a homogeneous aqueous solution [171], and I happened to have a chance to discuss this puzzling phenomenon with Prof. Ben Chu. Being the world expert on the analysis of polyelectrolytes in water, Ben found out what was going on. We published a paper together in a 2001 *Science* paper reporting that this anion forms a bilayer vesicle in water [179]. This story also entertained the general public very much and was cited in an annual encyclopedia published in Spain!

Tateshina Conference on Organic Chemistry, 2000–

The Tateshina Conference on Organic Chemistry is an offshoot of my social "Fava-Bean Group," where the families of Mr. Shigeyuki Koide, a journalist, and I invite our friends for a concert and a dinner over a weekend in Tateshina. Through this fava-bean scheme, I conceived a new type of chemistry conference in the woods away from towns. I consulted Profs. Noyori, Murahashi and Otera as well as Profs. Li-xin Dai, Yong



THE DAILY YOMIURI THURSDAY, DECEMBER 6, 2001 17

COMMENTARY

Chemists thrive at mountain confab

By Shigeyuki Koide

Chemistry, until recently, was not the sort of topic that would come up in casual banter at pubs or around the dinner table.

This autumn, however, chemistry became a hot topic in newspaper and television reports, and many ordinary people started to feel more familiar with this tough academic field.

A major reason for this is that Prof. Ryoji Noyori of Nagoya University was selected as a recipient for this year's Nobel Prize in Chemistry. With Hideki Shirakawa, a professor emeritus of Tsukuba University who was similarly honored in 2000, Japan's chemistry world has produced a Nobel laureate for a second consecutive year.

Against the backdrop of a surge of public interest in chemistry, East Asia has seen the emergence of a new kind of chemistry forum as a move to boost the exchange of information among younger researchers in the region.

The newly established forum is the Tateshina Conference on Organic Chemistry. Its three-day inaugural meeting kicked off on Nov. 9 at the Mitsui no Mori mountain resort in Chino, Nagano Prefecture, with Tokyo University Prof. Eiichi Nakamura as chairman.

Sixty organic chemistry researchers, mainly from East Asia but also from Europe and the United States, attended.

Bringing together the latest findings from their laboratories in universities and industries, the participants, who were given ample time to freely exchange views, discussed a wide range of subjects, including the role organic chemistry can play in the world of the 21st century and the potential for developing the field in East Asia.

The resort where the conference took place is set in forests and marshland on a plateau about 1,100 meters above sea level at the foot of the Yatsugatake mountain range.

Talks among the participants were held exclusively in English for the three-day event.

A music hall and a number of lodges scattered throughout the extensive resort served as venues for the many events. Six leading organic chemists, including Prof. Teruaki Mukaiyama of the Science University of Tokyo, Prof. Kyriacos Nicolaou of the Scripps Research Institute in La Jolla, Calif., and Prof. Guenter von Kiedrowski of Germany's Ruhr University, delivered lectures. Twenty-four other participants held so-called poster sessions, in which an outline of each researcher's studies was displayed.

The Tateshina conference was unique as a gathering of natural science researchers held in Japan for the following reasons:

■ It was the first full-fledged international meeting for the purpose of exchanging information among organic chemists in East Asia.

■ A new generation of researchers born in the latter half of the 20th century organized the event—from the creation of a preliminary planning committee to the orchestration of a large number of events during the three days.

■ The program was designed to be colorful to encourage exchange among the participants and included activities such as hiking, a communal soak in an outdoor hot spring and a concert of baroque music, in addition to the many sessions of academic discussion.

Petrochemical industries have been making rapid inroads in East Asia in recent years, but international exchanges among chemists have so far tended to be dominated by researchers from Europe and the United States.

The young researchers from Japan and its East Asian neighbors, all in their 30s or 40s, gave full play to their organizational abilities in running the conference. They thus proved themselves competent in many fields, not just in laboratory research, showing energetic potential for carving out organic chemistry's future frontiers in East Asia.

The ample time allotted for leisure activities—from 9:30 a.m. to 4 p.m. on the second day—probably came as a surprise to the participants. Among the events on the leisure program were tennis, golf, a tour of archeological ruins and a walk halfway up a mountain that rises more than 2,000 meters above sea level.

Thanks to a cold air mass prevalent over the area from the previous day, the mountain was crowned with fresh snow, and its lower slopes were tinged with autumn colors. Topped off with a communal outdoor bath, the leisure program seemed quite effective in helping the researchers strike up friendships.

Prof. Weidong Li of Lanzhou University, China, said: "I have not been able to cultivate such close personal relationships as I did this time at international meetings I have attended before. This is probably thanks to the rich natural environment here with the mountain, the forests and a hot spring. I was also deeply impressed at the organizers' skill in running the events so as to give participants many chances to deepen friendships."

The participants were all topflight researchers who can be expected to make great contributions to the development of the field of chemistry in the world. Participants from South Korea, China and Taiwan, with whom Japanese chemists had had few chances for contact, gave the Tateshina conference particularly high marks.

At the close of the conference, it was decided to hold a second meeting around the same time next year at the same venue.

Nicolaou, one of the world's leading researchers in synthetic chemicals, said: "I have never attended a conference that features so many high-quality programs in addition to high-level science. This conference will become a symbol of the new century of chemistry in East Asia."

Nakamura, who chaired the conference, said: "In light of the tendency of the world's chemists to gravitate into three groupings—the United States, Europe and Asia—I felt it pertinent to take the initiative in providing younger researchers in East Asia with an opportunity to have personal interchanges to help develop chemistry research and related endeavors in Asia.

"In organizing this conference, we deliberately chose to provide a high-quality environment and meals, as well as music," Nakamura went on to say. "This was in hopes that the participants would find the conference an ideal occasion to have wide-ranging personal interchanges irrespective of differences in specialties, as is the case with meetings sponsored by the Gordon Research Conferences."

The Gordon Research Conferences, a nonprofit organization based in New Hampshire, has backed a large number of meetings of scientists since 1947 for the cause of promoting scientific research.

"The quality of the discussions in our Tateshina conference was also extremely high, so the conference was a real success," Nakamura added. "I believe it can be safely said that it marked a starting point for chemistry research in the new century."

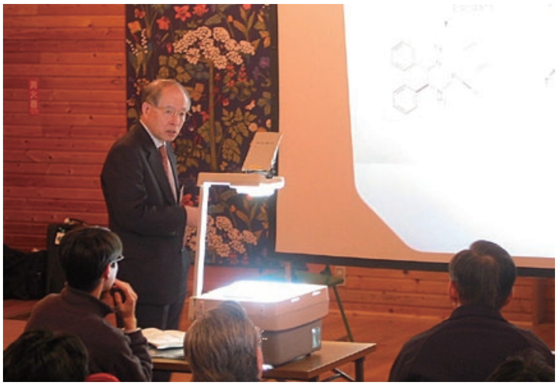
Noyori, who is known for the extensive range of his friendships with foreign researchers, is scheduled to deliver a speech at next year's conference.

The smooth flow of ideas and conversation as the participants drank together until late at night around a big fireplace in a mountain lodge seemed to indicate that chemists who narrowly limit themselves to writing papers based on laboratory work are bound to lag behind in the new century's mainstream of chemistry research.

Yomiuri Shimbun

Participants in the Tateshina Conference on Organic Chemistry listen to a performance of baroque music as part of the social program during their three-day meeting in Nagano Prefecture in November.

Koide is a deputy editor of The Yomiuri Shimbun's science news department.


Prof. Noyori, Harmony House, 2002


Yuki Nakamura and Akemi Maruyama, Tateshina Lodge

Hae Kim of KAIST, Tien-Yau Luh of Taiwan and Henry Wang of Hong Kong, and held a test conference in 2000. The first official one started in 2001, run together with Prof. Keisuke Suzuki till 2010, and now run by Prof. Shu Kobayashi. It is designed as a Far East version of the Bürgenstock Conference and Gordon Conference to foster friendship among industry and academic researchers in this area of the world. Mr. Koide summarized the first conference in the *Daily Yomiuri News*.

Association with Academic Journal Publication, 1992–

My appointment as Associate Editor of *Chemistry Letters* in 1992 was the beginning of my association with journal publishing. I helped Prof. Shunichi Murahashi to remodel and reform *Chem. Lett.* operations. One day in 1999, I received a phone call from Prof. Scott Denmark, who delivered a message from my old friend Prof. Amos Smith soliciting me to work for *Organic Letters. Org. Lett.* was one of the first electronic-communication-based ACS journals, where the data in a host computer located in my office was updated every night via a telephone line! On my travels abroad, I received, every morning at the hotel, tens of pages of manuscripts by fax. By the time I started to serve as Associate Editor of *J. Am. Chem. Soc.* (*JACS*) in 2009, all was done quickly through the Internet. Faster communication increased the burden on editors; I handle one manuscript a day now.

Chemistry–An Asian Journal, Special Issue: In Honor of Professor Eiichi Nakamura for His 60th Birthday

Between Org. Lett. and *JACS*, 2006 and 2009, I worked for *Chemistry–An Asian Journal* (*CAJ*)–an outcome of the Tateshina Conference on Organic Chemistry, where Dr. Peter Gölitz visited with Eva in 2003. In 2005, Profs. Noyori, Murai and Tatsumi, and Drs. Gölitz and Wille and I finalized the details of the organization of the journal over dinner in the Palace Hotel in Tokyo. A photo is attached. Peter was thoughtful enough to publish a special issue on February 2011 celebrating


With Drs. Wille, Noyori, Gölitz, Tatsumi and Murai, Palace Hotel, Tokyo

my 60th birthday, Kan Reki, for which Mr. Shuzaburo Shibi designed a cover page and Prof. Roald Hoffmann wrote a poetic editorial reproduced on pp.14-15. Below, I cite Peter's words.

> *"Professor Eiichi Nakamura celebrates his 60th (Kan Reki) birthday this month. Professor Nakamura has had a far-reaching influence in multiple areas of chemistry through his outstanding contributions and is highly respected the world over. He was also extremely active in the founding of Chemistry–An Asian Journal, first serving on our Editorial Board and currently on our International Advisory Board. His enthusiasm and hard work were instrumental in the journal's success, and he has continued to set a high standard with his own publications in the journal. As a part of his birthday celebration, and as a tribute to Professor Nakamura's illustrious career, this special issue is in honor of this occasion."*

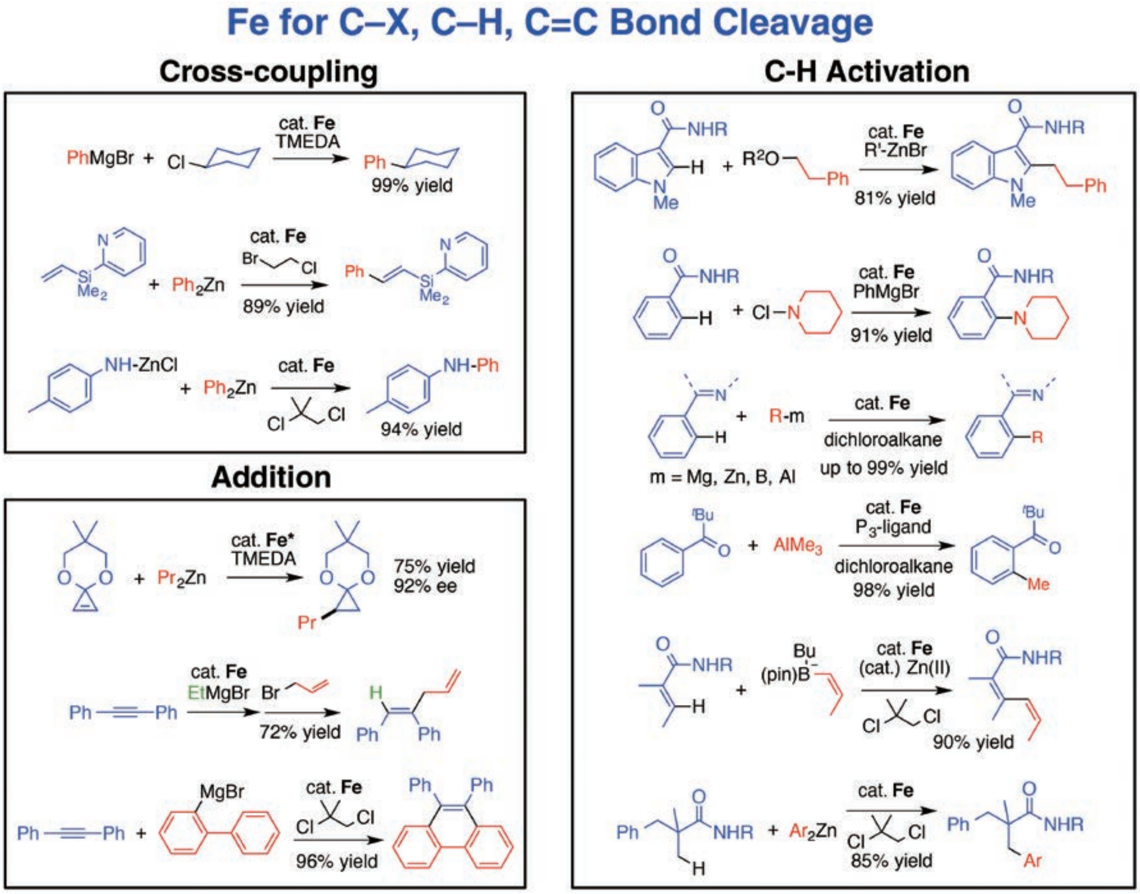
This issue contained the editorial by Roald and as many as 56 papers by the authors listed below, for which I thank again all of my friends. The title page was designed by my friend, designer Mr. Shibi, who also designed the cover of this book and the attached CD:

Professors and doctors Roald Hoffmann, Seiji Shinkai, Terunori Fujita, T. S. Andy Hor, Valentine P. Ananikov, Irina P. Beletskaya, Jin-Ho Choy, Martin Pumera, Tsukasa Matsuo, Kohei Tamao, Keisuke Suzuki, Takashi Matsumoto, Naohiko Yoshikai, Insung S. Choi, Klaus Müllen, Varinder K. Aggarwal, Younan Xia, Hisashi Yamamoto, Teck-Peng Loh, Jun Okuda, Zhenfeng Xi, François Diederich, Guy Bertrand, Alakananda Hajra, Masaya Sawamura, Takeshi Akasaka, Shigeru Nagase, Jian Pei, Li-Jun Wan, Ayyappanpillai Ajayaghosh, Andreas Hirsch, Hiroshi Watanabe, Shigeru Yamago, Kimoon Kim, Yong-beom Lim, Myongsoo Lee, Ian Paterson, Gernot Frenking, Eric Meggers, Diego J. Cárdenas, Antonio M. Echavarren, Won Jong Kim, Byeang Hyean Kim, Wonwoo Nam, Erhard Kemnitz, Sergey I. Troyanov, Masahiro Yamanaka, Paul Knochel, Tien-Yau Luh, Hiroyuki Arai, Makoto Arita, Masayuki Inoue, Chi-Ming Che, Waka Nakanishi, Hiroyuki Isobe, Hidetoshi Tokuyama, Tohru Fukuyama, Dawei Ma, Wei-Zheng Weng, Hui-Lin Wan, Atsushi Wakamiya, Kenichiro Itami, Andreas Pfaltz, Keiji Maruoka, Jeffrey W. Bode, Shū Kobayashi, Zuowei Xie, Chul-Ho Jun, Hee-Yoon Lee, Young Ho Ko, Mikiko Sodeoka, Hideki Yorimitsu, Koichiro Oshima, Iwao Ojima, Stefan Matile, Shingo Ito and Kyoko Nozaki.

Iron-catalysis for Organic Synthesis and the "Element Strategy Initiative," 1997–

For reasons entirely unclear to myself, I have tried to do something different from others since my childhood. Therefore, I have always stayed away from popular palladium catalysis. Instead, I worked on zinc, titanium and copper. Because ^{56}Fe is the final stable product of element synthesis in the universe, it must be abundant, nontoxic and suitable for organic synthesis. It took me, however, a long time to decide to study iron because reactive iron species are often too active, and die quickly before doing anything good in a flask.

We started to focus on iron catalysis in the late 1990s with Dr. Masaharu Nakamura, my fourth assistant professor and now Kyoto Professor. We published our first paper on an iron-catalyzed asymmetric carbometallation reaction–the first example of organoiron-catalyzed asymmetric synthesis [160]. Working on iron-catalyzed substitution reactions for some time [215, 323], we made a serendipitous discovery of C–H



functionalization in 2006 together with Dr. Naohiko Yoshikai, my seventh assistant professor and now at Nanyang Technological University [306, 326, 356, 372]. In the panel below, I summarized the work in this field, a large part of which was developed together with Dr. Laurean Ilies, the 13th staff member in our group [337, 386, 466].

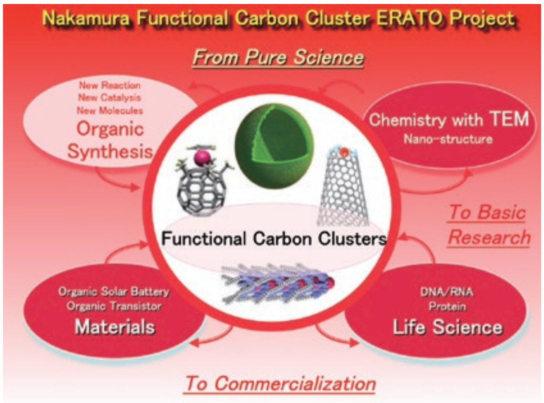
Organized by Profs. Shinji Murai and Kohei Tamao, the Japan Science and Technology Agency (JST) held a workshop on “Dream Materials in the 21st Century,” where many interesting futuristic ideas were proposed. To fit all these ideas into one single scheme for policy makers, I summarized the discussion by coining a term, 元素戦略, “Element Strategy Initiative.” This project was implemented in 2007 as two government projects in MEXT and METI. This initiative provided a model for similar projects in the EU, USA and China. The concept of the Element Strategy Initiative is detailed in my Commentary in *Nature Materials* reproduced in this book [Accounts and Reviews 44], pp.104-107 in this book.

JSPS Program Officer and JST Program Director, 2003–2015

A sudden intrusion in 2003 to my calm academic life was a new job as senior Program Officer of a newly established KAKENHI funding center at the Japan Society for the Promotion of Science (JSPS), where Profs. Ryoji Noyori, Tasuku Honjo and the late Yoji Totsuka served as directors. Though it was an entirely unwanted job, I did it with my characteristic perseverance and eventually learned thoroughly about the governmental research support system. I commuted every Thursday and Friday to my office at the JSPS office for three and half years, and we set up new rules and protocols for funding for basic research in Japan. Working together with the General Manager of JSPS, Ms. Maki Kubo, Profs. Hideo Utsumi and Hiroaki Aihara, a KAKENHI reform committee that I chaired proposed a future plan for funding reform, which has been mostly implemented in the funding system in the past 10 years (http://www.jsps.go.jp/j-center/data/08_seika/hokoku.pdf).

At the university, I led the MEXT Global COE Program for graduate school reform and worked closely with professors in the Faculties of Science and Engineering. After that, I was recruited by JST as Chair of the Board of Program Directors for their funding (ERATO/CREST/PESTO), and worked together with the JST staff members and the MEXT officers to draft future plans for needs-oriented research in our country.

Nakamura Functional Carbon Cluster ERATO Project, 2004–2010

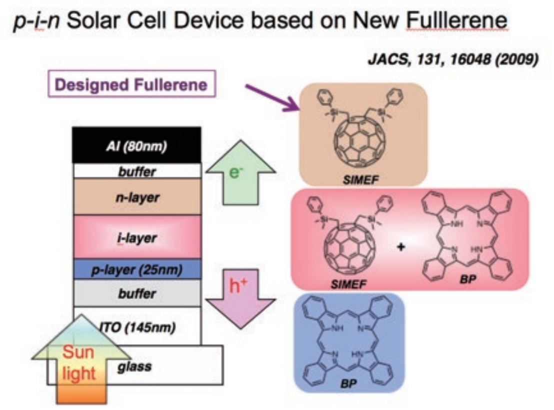


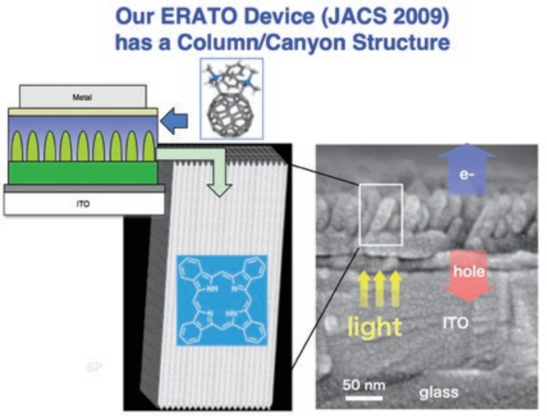
A five-year ERATO project literally changed my research life in a way I had never dreamt of. It was a top-down project, and one day in the summer of 2004, I had 1.8 billion Yen (1.5 million dollars) at my disposal. The aim of the project was to extend my synthetic expertise to a new world of organofullerenes and nanotubes (with Dr. Yutaka Matsuo as group leader), to printable organic electronics (Dr. Yoshiharu Sato) and to molecular imaging at atomic resolution with transmission electron microscopy (TEM) (Dr. Kazu Suenaga and later Dr. Masanobu Koshino). I must admit that I was an entire amateur in these areas. No results were obtained in the first 1.5 years, but significant progress was made by 2006 in both organic solar cells and microscopic imaging. Now, my former student and successor to the Physical Organic Chemistry Chair, Dr. Hiroyuki Isobe, is also running an ERATO program, “Degenerate π-Integration.”

Organofullerenes and Printable Solar Cells, 2009–

Prof. Katsumi Yoshino of Osaka University is a pioneer of photocharge separation using fullerene as an acceptor. A casual conversation with him in the late 1990s led us to work together to use my organofullerene repertoire for solar-cell applications. By the time Dr. Sato joined the ERATO project, I was quite confident that our repertoire, then counting over 200 in number, gave us a chance to be a winner in this competitive field of solar cell research. Serendipitously, we found in 2006 a method to induce phase separation between benzoporphyrin and silylmethylfullerene (SIMEF), which formed a nm-scale “column/canyon structure,” 剣山構造 [345]. This nanostructure was perfectly suited for charge separation at the donor–acceptor interface, and the device recorded 7% in our lab. The technology was immediately transferred to Mitsubishi Chemicals, who quickly recorded the world’s highest efficiency of >11% for their single-cell solar cells in 2011, and have put it on the market this year. The long collaboration with Dr. Hiroaki Yamaoka of Mitsubishi Chemical Co. on the R&D of solar cell business has been a very rewarding experience for me.

The work on our side was pushed forward by a device specialist, Dr. Hideyuki Tanaka, my 14th staff

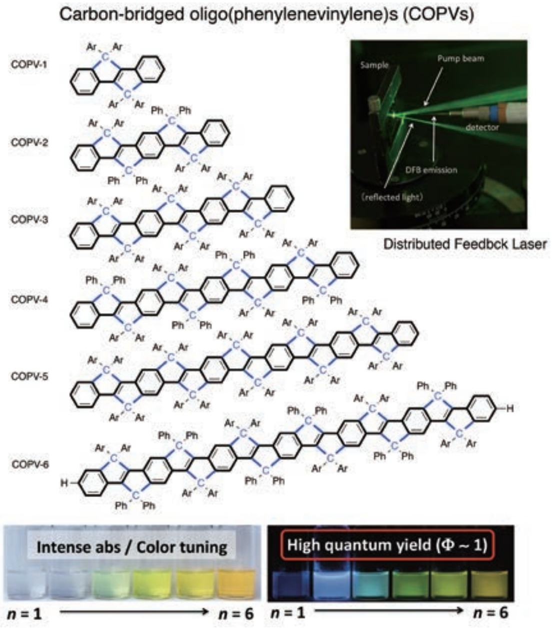




member. We are currently working on lead perovskite solar cells, and thus far have achieved 16% efficiency working together with Dr. Yunlong Guo, the most recently appointed associate professor in my group [469].

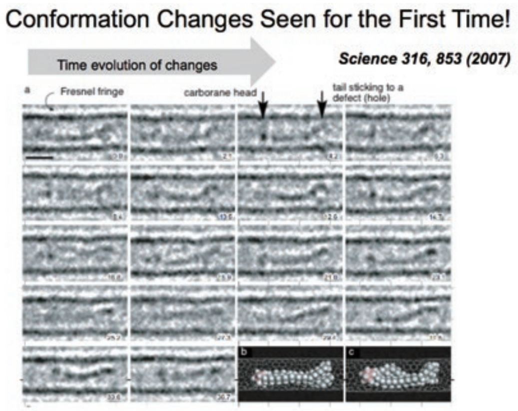
New π-Systems, a Solid-state Laser and Molecular Wire, 2006–

Dr. Masaharu Nakamura left our group to succeed Prof. Tamao in Kyoto in 2006. I then hired as my fourth associate professor Dr. Hayato Tsuji from the Tamao Group, and later also Dr. Shunsuke Furukawa, my 15th staff member, to explore the potential of new heteroaromatics for organic electronic research. We first synthesized a variety of benzodifurans and their nitrogen, phosphorus and silicon congeners [293, 302, 303, Accounts and Review 50], and finally came up with a carbon version, carbon-bridged oligo(phenylenevinylene)s (COPVs) with Dr. Xiaozhang Zhu now in Beijing [343, 387, 415]. This last class of compounds features an entirely flat and rigid conjugated system, exhibiting 100% quantum yield of fluorescence and hosting highly stable negative and positive polarons. Thus, they show excellent photostability and serve as a highly efficient dye for a solid-state laser [467]. An electron tunnels through the COPV framework, rendering these compounds effective single-molecule molecular wires [452].

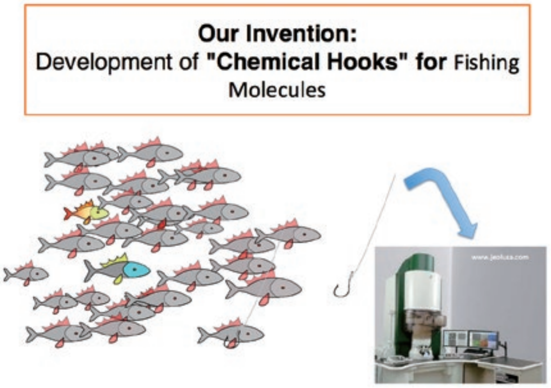


TEM Imaging of Single Organic Molecules in Action, 2006–

The world-first filming of the motions and reactions of single organic molecules was the most



memorable discovery in my research life. My interest started with an unanticipated encounter with Prof. Sumio Iijima at a hot spring in Nagano, and the whole story was made possible by the ERATO project with the aid of his lieutenant, Dr. Kazu Suenaga, as well as Dr. Isobe. Since 2006 together with Dr. Koshino, we have developed a protocol for atomic-resolution imaging of single organic molecules in action [283, 348, 384], which we named "single-molecule atomic real-time TEM imaging" (SMART-TEM) [Accounts and Reviews 48]. One referee of our *Science* paper called our work the "Holy Grail of microscopy."

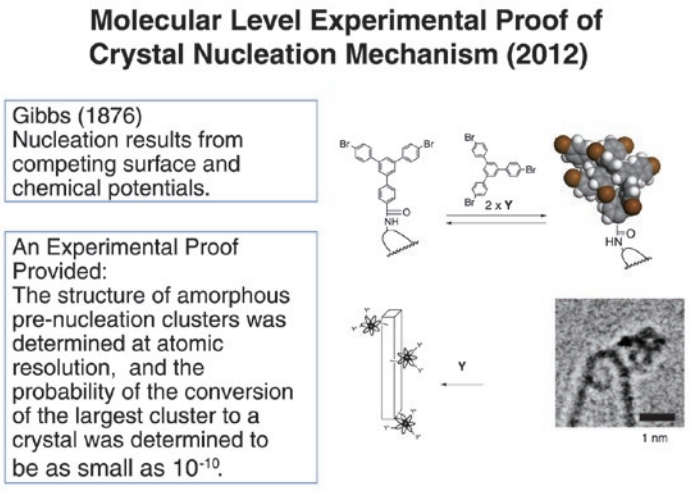

Our Invention:
Development of "Chemical Hooks" for Fishing Molecules

The development of "chemical hooks" was the key for the successful imaging of single molecules. To visualize single organic molecules by TEM, you put the specimen molecules in the nm-scale imaging field of the TEM by use of a functionalized carbon nanotube. To capture molecules on the surface of a carbon nanotube, we developed a method to synthesize aminated carbon nanotubes, and then formed an amide bond with the specimen molecules.

Mechanism of Crystal Formation, 2010–

The nm-scale "column/canyon structure," 剣山構造, stimulated my interest not only in charge separation induced by photons but also in the mechanism of phase separation. Phase separation, and the closely related crystal formation, is one of the most ubiquitous yet least understood phenomena in chemistry. During our study on the imaging of C–C bond rotation, I serendipitously found a TEM movie image of a termolecular aggregate of molecules under study. While this image was about to fall into oblivion, I thought that it may well be a "prenucleation molecular cluster" that people have long tried to identify [410]. With Dr. Koji Harano, my 11th staff member, we redesigned the experimental system and succeeded in identifying the structures of long-sought molecular clusters that precede the formation of crystals. We are currently studying the control of the crystal nucleation processing, targeting on the drug formulation. I am learning very much this field through collaboration with Dr. Shun Inokuma of Towa Pharmaceutical Co. We thus came across by chance a new field of research on crystal nucleation–one of the most enigmatic processes in nature:

> *"It is common experience that the evaporation of carbon dioxide in a freshly poured glass of a carbonated soft drink proceeds slowly through the formation of discrete bubbles at a few spots on the glass. This is because the formation of the*

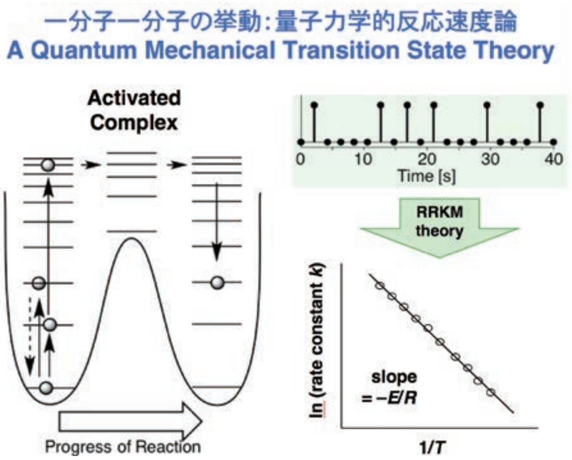

Molecular Level Experimental Proof of Crystal Nucleation Mechanism (2012)

Gibbs (1876)
Nucleation results from competing surface and chemical potentials.

An Experimental Proof Provided:
The structure of amorphous pre-nucleation clusters was determined at atomic resolution, and the probability of the conversion of the largest cluster to a crystal was determined to be as small as 10^{-10}.

new phase (gas) from the old phase (supersaturated liquid) is hindered by the free-energy penalty associated with the creation of the interface separating the two phases (heterogeneous nucleation). Although the nucleation of new phases has long been studied, to this day it remains one of the most enigmatic processes in nature." (News and Views by P. G. Vekilov, *Nat. Mater.*, 11, 838 (2012).)

Single Molecules Kinetics Follow Quantum Mechanical Model



The conventional mechanistic study of a chemical reaction is performed using the time and molecular averaged data. Even the so-called single-molecule studies utilize ensemble average data. In addition, all existing methods utilize certain physical properties (typically spectral properties) of the reactants and/or products as the data from which the kinetics of the reaction is deduced rather than directly studying the structural change of the molecules. The SMART TEM technology now for the first time enables us to study the reaction mechanism by directly observing reacting molecules, and by directly measuring the probability of reaction event at various temperatures. This capacity provides us an exciting new opportunity to study chemical reactions within the framework of a quantum mechanical transition state theory as show on the figure. We are currently studying the mechanism of fullerene dimerization and have just found it to occur through previously unknown mechanisms.

Robert Hooke, Micrographia 350

I often cite in my TEM lectures the following remarks on the use of optical microscopy in biology by Robert Hooke, a contemporary of Isaac Newton. What he says about *the Science of Nature* applies to *Chemistry* in modern times.

"The truth is, the Science of Nature has been already too long made only a work of the Brain and the Fancy: It is now high time that it should return to the plainness and soundness of Observations on material and obvious things." (Robert Hooke, *Micrographia*, 1665.)


With Prof. Alan Chapman (left) and the original Micrographia in Oxford

On the occasion of the 350th anniversary of the publication of *Micrographia*, I was invited to Christ Church, Oxford, to give a public lecture on the advances of electron microscopy in chemistry (Oxford Podcast: https://podcasts.ox.ac.uk/series/micrographia-350), and was so pleased to take a close look at one of the 17 original prints of *Micrographia*. Our university owns one copy but I haven't had a chance to see it, though.

Pacifichem 2010 and 2015

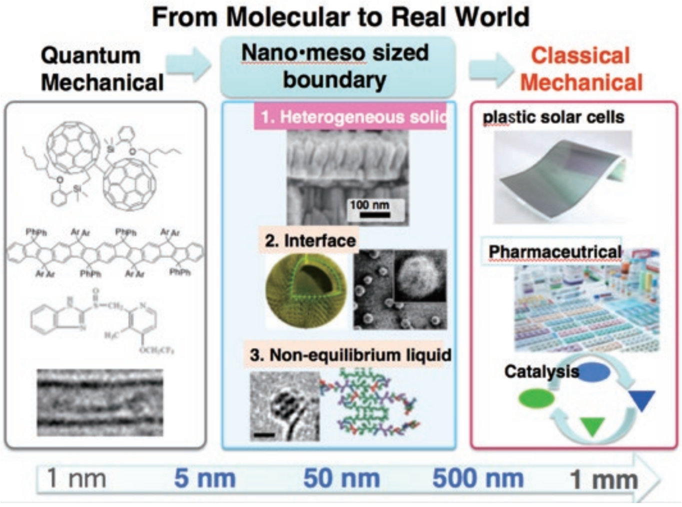
In 2005, I joined an international team for Pacifichem 2010 and 2015 headed by Profs. Howard Alper and Peter Stang, respectively. Peter is also my boss at *JACS*. The Japanese committee included Profs. Mitsuo Sawamoto, Kazu Tatsumi, Kaoru Yamanouchi, Hiroshi Kitagawa and Atsushi Takahara, assisted by Mr. Nobu Kawashima, Ms. Hiroko Ihida and Emiko Inada–a wonderful team working together and roaming around the Pacific Rim countries. A signing ceremony for the 2015 meeting in Prince Ville, Kauai Island, was a memorable event, overlooking the dramatic view of Hanalei Bay featured in the film *South Pacific* (1958).


The Signing Ceremony in Kauai, Hawaii, 2011

The Pacifichem 2015 meeting hosted a record-breaking 16,000 participants from all over the world. As Chair of the Protocol Committee, I helped organize concerts for Orchestra Chimica, Japan, and played a Mozart flute quartet on a one-key classical flute.

"Molecular Technology Innovation" Endowed Chair, 2015–2022

Although the expression "molecular technology" sounds all right, it has not been as popular as "molecular science" and "molecular engineering." Prof. Shinji Murai proposed the former expression in 2009 as a key new concept for synthetic chemistry in the 21st century. Borrowing this concept, I formulated a research scheme for industry–academia collaboration for the Faculties of Science, Engineering and Medicine, for which the university built a new building, "Molecular and Life Innovation Building," on the campus of the university hospital. A generous endowment from four companies allowed me also to establish, in this new building, the "Molecular Technology Innovation" Endowed Chair laboratory for seven years from 2015. This way, I am planning to explore "Chemistry Connecting the Molecular World and Real World."



Acknowledgments

The research, educational and social activities summarized above were possible only through collaboration with the dedicated members of our group, who roughly number 250. The group activities have been headed by the 16 junior faculty members and six staff members listed here. I express my sincere appreciation to the alumni of the Nakamura Group for their contributions in every aspect of our group activities.

Past and Current Members of the Nakamura Lab

Junior Faculty Members
- Satoshi Aoki (1989-91)
- Shigeru Yamago (1991-95)
- Masaya Sawamura (1995-2001)
- Masaharu Nakamura (1996-2005)
- Hiroyuki Isobe (1998-2007)
- Yutaka Matsuo (2001-10, 2015-16)
- Yoshiharu Sato (2004-10)
- Kazu Suenaga (2004-07)
- Naohiko Yoshikai (2005-09)
- Hayato Tsuji (2006-16)
- Koji Harano (2007-)
- Laurean Ilies (2009-)
- Masanobu Koshino (2007-10)
- Hideyuki Tanaka (2010-15)
- Shunsuke Furukawa (2012-14)
- Yunlong Guo (2016-)

Administrative Staff
- Saeko Okada (1996-2001)
- Haruko Yoshimura (2001-02)
- Akemi Maruyama (2002-)
- Takao Kaneko (2004-)
- Suehiro Aburaya (2004-10)
- Sachiko Aso (2005-10)

As a university professor, there is nothing more satisfying than seeing students, postdocs and staff members develop their talent further after leaving the group. Among 250 current and former associates, there are 18 full professors, 23 associate professors and 15 assistant professors at universities over the world, as well as a number of managers and directors of companies. Among them, over 30 university professors received awards from our government (MEXT), the Chemical Society of Japan, the Pharmaceutical Society of Japan, or the Society of Synthetic Organic Chemistry and various other awards in their own countries.

My association with Prof. Teruaki Mukaiyama started just as pure luck, originating from the historic event of the cancellation of the entrance exam of the University of Tokyo in 1969. He had a profound influence on my life because his and my ways of life somehow resonated with each other to create a new synergistic outcome. Prof. Koichi Narasaka, then assistant professor in the Mukaiyama Group, helped me to form a solid background of research. My affiliation to the group of Prof. Isao Kuwajima was also accidental, but turned out to be extremely rewarding because I learned about the most advanced research style of the 1970s.

Collaboration with Prof. Ryoji Noyori during my Ph.D. was another unexpected encounter that deeply influenced my research style. Kind words given by the late Prof. Iwao Tabushi during my Ph.D. years encouraged me to maintain my interest in a broad area of chemistry beyond synthesis. Consultation on my future career with these eminent professors in my fourth year of Ph.D. study brought me to New York City to study with Prof. Gilbert Stork, from whom I learned about mentorship.

In my 40s, I obtained my “second Ph.D.” through close collaboration with Prof. Keiji Morokuma, from whom I learned about the theoretical perspective of organic chemistry. The vision gained through my theoretical/computational studies allowed me to explore, in my 50s, the new world of electron microscopy, working with the group of Prof. Sumio Iijima. Profs. Shinji Murai, Hisashi Yamamoto, Yoshinori Yamamato and Iwao Ojima gave me continuous support over many years on various occasions. I also thank Mr. Shigeyuki Koide, a former Editor of *Yomiuri Shimbun News*, for his interest in our research and for teaching me how scientists should communicate with the general public and policy makers. He also made this book rather special, as you see, by telling me that any publication is useless unless it has a message to the readers. Messrs. Mitsuya Goto and Shuzaburo Shibi helped me to actualize this advice. Mr. Kiminori Mochizuki conceived the rather unusual idea of having the photos of me and Yoko taken by Mr. Kishin Shinoyama, the most famous photographer in Japan. Here I wear my farther's cufflinks.

Warm support from my colleagues at TIT and the University of Tokyo as well as from my friends has been and will be the key element of my research, educational and social activity. I express my appreciation to the JSPS and the Japan Agency for Science and Technology for provision of continuous support of our research. They also provided me with a rare opportunity to learn about funding policy.

I express my appreciation to my grandparents and parents, Kuniharu, Masa, Goro, Yoshiko, and Fumi for guiding me to develop my own philosophy of life. Last but not least, I deeply appreciate my 40-year partnership with Yoko, who has inspired me immensely all the time in the past and hopefully will continue to do so in the future.

With Kishin Shinoyama, Roppongi, Tokyo, Feb. 4, 2016

鉄道ピクトリアル, 22, 57-63 (1972)

イスラエル国有鉄道

ISRAEL RAILWAYS

—その歴史と現状〔前〕—

中村　栄一
なか むら　えい いち

DL と客車群　　ダイモナにて　　'71.8　筆者 写

Gold on dark blue background

国鉄紋章

イスラエルは，ユダヤ問題・パレスチナ問題と世界の注目を集めている反面，この国の実状，ましてその鉄道については日本では殆んど知られていない．しかし，この地域の複雑性ゆえにその歴史は変化に富み，周囲から切り離された戦後のイスラエルの鉄道は，小国の国鉄の興味深い一例となっている．また，独特の 1050 mm 軌間，市営の地下ケーブルカー（正真正銘の都市交通機関である，次号グラフ参照）など，趣味的にも興味深いものをもっている．

1.　イスラエルの地勢

イスラエルは地中海東岸，緯度ではほぼ九州から奄美諸島にあたる地域に位置し，東はヨルダン川・アカバ湾を境に，ヨルダン・サウジアラビアに面し，西はスエズ運河でエジプトに接している[1]．

国土の中央を南北に走る山地は高度 500 m から 1,000 m 程度であり，南のネゲブ・シナイ半島に向かって高原状となっている．山地の西側は緩い傾斜で地中海に面し，東は一部では 500 m ほどの断崖となって地溝帯に落ち込んでいる．東の国境となっている地溝帯は，2つの海面下の湖，ガリリー海・死海（海面下 392 m，塩湖），そしてキリスト洗礼の川，ヨルダン川を含み，南北 300 km にわたって地球上で最も低い地帯を形作っている．

イスラエルは普通，ゴラン (Golan)・ガリリー (Galilee)・サマリア (Samaria)・シャロン (Sharon)・ユダ (Judah)・ネゲブ (Negev)・シナイ (Sinai) の 7 州に分けられる．ネゲブ・シナイを除く 5 州は，年間降雨量も 500 ミリ前後と比較的多く生活に適しているが，南に行くに従って急激に乾燥し，アカバ湾付近では降雨量も 25 ミリ（1969 年は 6 ミリ）で完全な砂漠気候となっている．

2.　パレスチナ百年の歴史とイスラエル

戦後のパレスチナ分離独立以来続くイスラエル・アラブ諸国間の敵対関係のため，現在のところイスラエル国有鉄道（Israel Railways）の活動は国内のみに限定され，周囲との関係は全く存在しない．しかし，独立に先立つ半世紀では鉄道はこの地の地理の良さ，宗教性を軸に発達し，近東の南北連結という重要な役割を果たしていたのである．

19 世紀後半，地中海東岸はまだオスマントルコの支配下にあった．しかし，500 年もの間東欧・西アジアを支配したトルコ帝国も当時「ヨーロッパの病人」と呼ばれるほど衰微し，崩壊は時間の問題とみられていた．そして，この東西交通の要衝の地をめぐり西欧列強は盛んな活動を展開していた．パレスチナ付近に興味を示したのはフランス・イギリスで，前者はレバント[2]，後者はエジプトを拠点とした．ドイツは他より遅れて 1880 年代にトルコに進出してくるのだが，20 年後にはすでに大きな脅威となり，トルコに重大な影響を与えるようになる．

ところで，オスマントルコは多くのアジア諸国と同様に鉄道建設に際し，西欧列強に特許を与えこれを建設する方法を採った[3]．こうしてパレスチナ・レバントにもフランスの会社によるいくつかの軌道・鉄道が現われる．その1つとして建設されたのがパレスチナ最初の鉄道，ジャファ[4]—エルサレム[5]鉄道（Jaffa—Jerusalem Railway）[6] であった．1892 年の開通である．聖地へ通ずる鉄道であり，教会筋からもいくらか出資されていたという．

その頃，ヨルダン川西岸ではドイツの技術援助によってヘジャズ鉄道（Hedjaz Railways）の建設が始まっていた．シリアのダマスカス（Damascus）からイスラムの聖地メジナ（Medina）まで狭軌で約 1,500 km，聖地巡礼を目的に，純粋に宗教的な鉄道として他に例を見ないものであった．

1900 年代に入ると，3B政策によるドイツのバグダード鉄道（Bagdad Railway）建設も進み，先のレバントの鉄道等を通じパレスチナ—ヨーロッパ間も一応鉄道連絡がなされたのである．

第1次大戦中トルコは同盟国として参戦し，エジプトへ侵攻するが，反撃に移ったイギリス軍により，戦争終

[1] 1967年休戦ラインによる領土である．六日戦争により奪回・獲得した地域を含むがシリア・ゴランは基本的な領土には含まれないと考えられる．

結時にはレバンァ以南を失っていた．戦時中にエジプトからパレスチナに向かって建設された標軌軍用鉄道はその後，この地域の幹線鉄道の役割を果たす．

大戦後のベルサイユ体制により，オスマントルコは解体し，レバントはフランスの，パレスチナ・トランスヨルダンはイギリスの委任統治領となった．パレスチナ政府のもとに組織されたパレスチナ鉄道（Palestine Railways）は，パレスチナとその周辺の鉄道，つまり標軌軍用鉄道，ヘジャズ鉄道等を一括管理することとなったが，複雑な所有権，資金不足，劣悪な設備に悩まされ経営は苦しかった．ユダヤ人植民の進む中で，路線の変更，新設の要求が出され，一部ユダヤ人による建設も行なわれたが，多くは未着手のままのこされ，後のイスラエル国鉄が尻拭いさせられる形となった．

第2次大戦前後，周囲のアラブ諸国は次々と独立し，1947年の国連決議によりイスラエルも独立を得たが，パレスチナ分離独立に反対するアラブ国家との対立は，独立の日から現在まで断え間なく続いている．パレスチナ戦争（1948），中東戦争（1956），六日戦争（1967）の3つの戦争を経験し，現在，六日戦争の結果としてシナイ・パレスチナ全土，ゴランを統治している．

イスラエル国鉄は，旧パレスチナ鉄道の一部を受け継ぎ，再興ユダヤ人国家の発展のため新線の建設，車両・施設の近代化に努力を傾注した．だがその後は鉄道側に積極策は見られず，「大過ない」経営を行なっている．自動車攻勢による地盤沈下に対し最近，「鉄道会計の正常化」を導入して政府の援助を引き出す努力を行なっている．

2) レバノン・シリアとその周辺の呼称．
3) 公共的サービスを特許によって経営する，いわゆる特許企業は投資が極めて安全で西欧列強の経済侵略の手段であった．
4) エルサレムへの入口に当る3000年来の自然港．現在はテルアヴィヴと共に，テルアヴィヴージャファア．
5) ダビデの王国以来の首府であり，ユダヤ・キリスト・イスラムの宗教の聖地として宗教的・政治的なパレスチナの中心地．
6) 正式名称と推測される．

3. パレスチナにおける鉄道の歴史

パレスチナの鉄道史は次の4期に分けることができる．

○トルコ時代（1914まで）—フランスによる最初の鉄道とヘジャズ鉄道建設．軌間1000 mm及び1050 mm．

○第1次大戦（1914～20）—ドイツの援助による軍用狭軌鉄道とイギリスの軍用標軌鉄道建設，軌間1050 mm及び1435 mm．

○委任統治時代（1920～48）—パレスチナ鉄道による鉄道の充実．

○イスラエル独立以後（1948より現在）—イスラエル国鉄による鉄道近代化．

以下この分類に従って，記述を進めることとする．

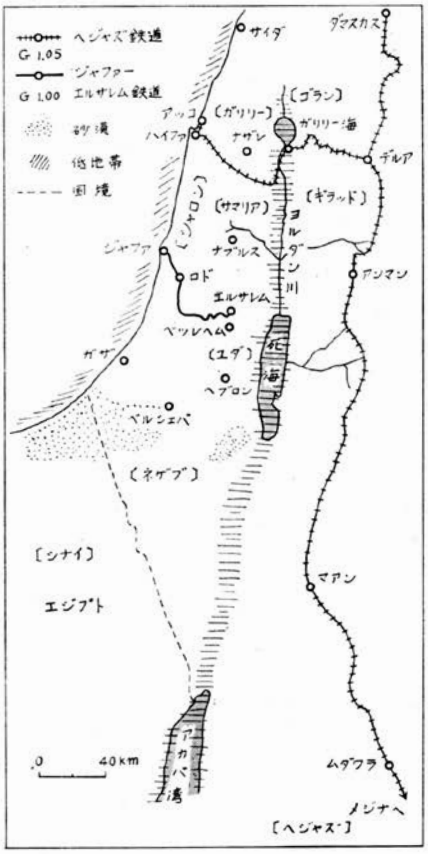
3-1 トルコ時代

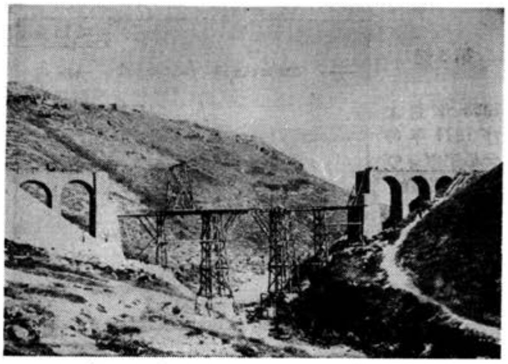
パレスチナのユダヤ人帰還が始まるのは1870年後半であっが，1880年の書物 "The Land of Gilead" には，移住者のコロニー計画と共にエジプトのイスマリア（Ismalia）への支線を含め，ダマスカス—死海—アカバを結ぶ鉄道が提案されている．最初の具体的な提案であったが，裏付けを欠き単なる提案に終った[7]．

1888年10月28日，トルコ皇帝はジャファーエルサレム間，そしてナブルス（Nablus, Sichem）・ガザ(Gaza)への2支線について特許を，ユダヤ人ナボン（Navon）に与えた．4年以内の建設を条件に71年有効の特許であった．しかし彼は，すぐにその特許を代価100
フランス
万フランでフランスの会社，ジャファーエルサレム鉄道会社（Societe de chemin de fer de Jaffa a Jerusalem）に売り渡している[8]．

特許下付後の手続きの遅さから，実際の着工を危ぶむ向きもあったが，2年後の1890年3月21日，ジャファ
31

第1図　1910年頃のパレスチナの鉄道





パレスチナにおけるヘジャズ鉄道の建設
Railway Conquest of the World

で定礎式が催され着工された[9]．軌間1000 mm，路線長87 km，この地方独特の石灰岩の山地を登る鉄道は難工事であったという．主任技師はフランス人エチエンヌ(Etienne)であった．1892年初頭，会社は払い込み済みの株式，社債80万ドルに加え，68年間償還で180万ドル5%の社債を発行している[10]．同年半ば，鉄道は開通をみたが他の2支線は遂に建設されることはなかった．鉄道開通は古代の雰囲気の残る当時のエルサレムに〝西洋化の波〟をもたらしたという．

一方，この頃シリアのダマスからアンマン(Amman)・マアン(Ma'an)を経て聖地メジナ(Medina)へ至るヘジャズ鉄道が建設されていた．工事はドイツの援助でイスラム系労働者とトルコ軍によって行なわれ，橋りょう・築堤用の石材は，この地域の至る所に産するものをそのまま用いた．聖地巡礼者のための鉄道としてイスラム教徒の献金を主たる資金源としていた．沿線は未開であり，巡礼者に交通手段を提供していたベドウィン族等土着民の鉄道への反感はしばしば叛乱にまで発展し，厳しい地形，自然条件と相俟って困難な工事とした．全線約1,500 km の開通までおよそ15年，一番列車が聖地メジナに入ったのは1908年8月であった．鉄道は急曲線と急こう配が連続し，マアン南方では最小半径100 m を持つ大規模なループ線も用いられたという[11]．

ヘジャズに至る本線に加え，この本線と地中海との直接連絡のため，シリアのデルア(Der'a)からガリリー地方の港，ハイファ(Haifa)，アッコ(Akko)へ抜ける支線も同時に計画された．デルアから一旦ガリリー海・ヨルダン川まで下り，ジェズリール(Jezreel, Esdraelon)の谷を海へ上るという路線設定となっており，1892年頃着工[12]，1905年の開通であった．先のメーターゲージの鉄道，ジャファーエルサレム鉄道に続く，パレスチナ第2の鉄道であり，軌間はヘジャズ鉄道独特の1050 mmであった．

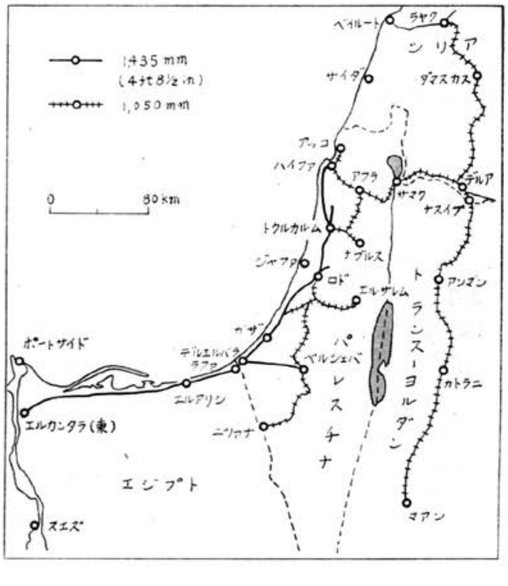
3-2 第1次大戦

トルコ帝国時代にパレスチナに勢力を持っていたのはフランスであり，また次第に勢力を伸ばしていたドイツであった．そして，これを一転イギリス領としたのが第1次大戦とトルコ崩壊であった．

オスマントルコはこの戦争に同盟国として参戦し，地中海東岸では，エジプトのイギリス[13]と対立していた．

ところで，1912年の国鉄組織後，トルコは鉄道の買収を行なうなど，次第に鉄道に対して真剣になっていた．開戦後の1915年夏，トルコ政府はレバントにあるフランスの4鉄道と共にジャファーエルサレム鉄道の買収を発表[14]，更に同年中にこれを軌間1050 mm へ改軌する．ヘジャズ鉄道の延長と車両転用のためとされる．なお，軍用道路建設のため，1915年初頭にはドイツ人の手により同鉄道の一部，ジャファーロド(Lod)間は撤去されていた[15]．北のヘジャズ鉄道では輸送の便宜のため，サマリアのナブルス・トウルカルム(Tulkarm)・アフラ(Afula)を結ぶ2支線，南ではジャファーエルサレム鉄

第2図　　1918年の路線図



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7) イスラエル国鉄編「鉄道70年の歴史」ヘブライ語版 p. 5

8) 前掲書によるが，鉄道建設の真の立案者，その意図等，特許発行の細かい事情は明らかでない．宗教的ないしは戦略的に大きな価値が認められていたと思われる．なお19紀世末の為替相場ではおよそ1ポンド≒5ドル≒5円であった．

9) 〝The Jerusalem—Jaffa Railroad〟 The Railroad Gazette, May 23, 1890, p. 365.
以後書名は RR. Gaz. とし，不要の場合タイトルも省略する．

10) RR. Gaz., January 8, 1892, p. 29.

11) F. A. Talbot, 〝The Railway Conquest of the World〟 (London: William Heinemann, 1911), pp. 117-27.

12) RR. Gaz., September 23, 1892, p. 711.

中流砥柱映高膽
村鄰鄉舍譽非凡
榮歸故里留懋績
一代名師樹典範

陸天堯 敬撰

丙申春于台大

A poem by Prof. Tien-Yau Luh (2016)