

# The International Workshop on the History of Chemistry “Transformation of Chemistry from the 1920s to the 1960s” (IWHC 2015)



*March 2-4, 2015, Tokyo Institute of Technology, Japan*

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**The International Workshop on the History of Chemistry**  
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## **Introduction**

The years between the 1920s and the 1960s saw a transformation of chemistry in several aspects. These included the development of biochemistry, polymer chemistry, quantum chemistry, and computational chemistry, as well as the instrumental revolution. New methods, theories, and technologies opened up new fields of chemical sciences, and the chemical industry grew to be one of the most important branches of industry that supported national economies. Chemistry was greatly influenced by World War II and the Cold War, when it was directed especially to military and security needs, while the public image of chemistry also changed, due largely to the environmental problems caused by synthetic chemical materials.

These years also saw developments in Japanese chemistry. The first generation of Japanese chemists started their research in the early 20th century. Born and educated after the Meiji Restoration, the starting point of Japan's full-fledged modernization, some of them founded a research strategy that aimed to study the structure of components of Japan's local natural products using methods newly developed in Europe, in order to compete with chemists in the West. However, after several decades, the accomplishments of seven Japanese Nobel laureates in chemistry became not fundamentally different from those of their Western counterparts. Their researches, performed mostly from the 1950s to the 1970s, developed new methods and theories and opened new fields. Clearly, there must have been a transformation of chemistry research in Japan between the 1920s and the 1960s as well.

The aim of **the workshop “Transformation of Chemistry from the 1920s to the 1960s”** is to stimulate a discussion of the transformation of chemistry in Japan and/or in the world during the period with comparative perspectives. The workshop may take an interdisciplinary approach and pay special attention to the social dimension of chemistry.

This subject has only recently started to be discussed and even then it has only been considered intermittently. This workshop attempts to bring those interested in the history of chemistry in the 20th century together for dialogue and debate from various perspectives. It will comprise thematic three keynote lectures and eight sessions with papers.

**Keynote speakers:**

**Professor Jeffrey Johnson**, Villanova University, USA

**Professor Mary Jo Nye**, Oregon State University, USA

**Professor Ernst Homburg**, University of Maastricht, The Netherlands

With an introductory lecture on the theme and on the Japanese Society for the History of Chemistry by its president, Professor **Yasu Furukawa**, Nihon University, Japan.

The registration fee will be 10,000 JPY, conference dinner 10,000 JPY, and optional excursion 10,000 JPY.

**Workshop venue: the West Building no. 9 at the Tokyo Institute of Technology** (2-12-1 Ookayama, Meguro-ku, Tokyo 152-8552).

The workshop language will be English.

**Selected papers from the workshop will be considered for publication.**

The workshop is organized by the group of historians of chemistry under “Grants-in-Aid for Scientific Research (KAKENHI)” Grant Number 24300295 to study the transformation of Japanese Chemistry in the 20th century.

It is also supported by the Japanese Society for the History of Chemistry (JSHC), the Commission on the History of Modern Chemistry (CHMC), the Society for the History of Alchemy and Chemistry (SHAC), the History of Science Society of Japan and the Chemical Society of Japan. The workshop will be held to commemorate the 40th anniversary of the foundation of JSHC.

**Welcome!**

### **Organizing Committee:**

**Masanori Kaji (chair)**, Tokyo Institute of Technology, Japan

**Keiko Kawashima**, Nagoya Institute of Technology, Japan

**Yoshiyuki Kikuchi**, The Graduate University for Advanced Studies (SOKENDAI), Japan

**Toshiya Kohno**, The University of Tokyo, Japan

**Yasu Furukawa**, Nihon University, Japan

**Makoto Ohno**, Aichi Prefectural University, Japan

**Hiroaki Tanaka**, Tokyo Denki University, Japan

**Togo Tsukahara**, Kobe University, Japan

**Masao Uchida**, Wako University, Japan

**Toshifumi Yatsumimi**, Aoyama Gakuin Women's Junior College, Japan

**Hideyuki Yoshimoto**, Tokyo University of Foreign Studies, Japan

**Jeffrey Johnson (*ex officio*)**, Villanova University, USA

### **Program Committee:**

**Yasu Furukawa (chair)**, Nihon University, Japan

**Jeremiah James**, Ludwig-Maximilians-Universität München, Germany

**Jeffrey Johnson**, Villanova University, USA

**Masanori Kaji**, Tokyo Institute of Technology, Japan

**Yoshiyuki Kikuchi**, The Graduate University for Advanced Studies (SOKENDAI), Japan

**Peter Morris**, Science Museum, UK

**Carsten Reinhardt**, Chemical Heritage Foundation, USA

**Brigitte Van Tiggelen**, Mémosciences, Belgium

**Program IWHC 2015 Tokyo**  
**The International Workshop on the History of Chemistry**  
**“Transformation of Chemistry from the 1920s to the 1960s”**

March 2-4, 2015, Tokyo Institute of Technology, Japan  
West Building No.9

**March 2, Monday**

12:30 – Registration

14:00-15:30 **Opening Ceremony (Chair: Masanori Kaji)**

14:00 – 14:30 Opening Address: Yasu Furukawa (Nihon University, Japan)

14:30 – 15:30 **Keynote Lecture (1): Jeffrey Johnson** (Villanova University, USA)

“From Bio-organic Chemistry to Molecular and Synthetic Biology: Fulfilling Emil Fischer’s Dream.”

15:30 – 15:45 Coffee Break

15:45 – 16:45 **Session 1: From Local Products to Global Chemistry (Chair: Hiroaki Tanaka)**

Masanori Kaji (Tokyo Institute of Technology, Japan), “The Transformation of Organic Chemistry in Japan: Majima Riko and His Research School of Natural Products Chemistry in the First Half of the 20th Century.” (résumé p.10)

Victoria Lee (Max-Planck Institute for the History of Science, Germany), “Screening for Gifts: Japanese Glutamic Acid Fermentation.” (p.11)

16:45 – 17:00 Coffee Break

17:00 – 18:00 **Session 2: Preserving the Chemical Heritage (Chair: Masao Uchida)**

Susanne Rehn-Taube (Deutsches Museum, Germany), “The Nuclear Fission Table in the Deutsches Museum: Heritage of a Science Story on the Eve of World War II.” (p.11)

Ronald Brashear (Chemical Heritage Foundation, USA), “Preserving the Heritage of Modern Chemistry.” (p.13)

18:15 – Reception (the First Co-op Cafeteria)

**March 3, Tuesday**

8:30 – Registration

9:00 – 10:00 **Session 3 (1): Internationalizing Chemistry and the Chemical Community (Chair: Brigitte Van Tiggelen)**

Masanori Wada (Tokyo Institute of Technology, Japan), “The Two International Congresses Held in Tokyo in the 1920s: The Rise of the First Generation of Japanese Scientists.” (p.15)

Danielle M. Fauque (University of Paris Sud, France), “Jean Gérard, Secretary General and Driving Force of the International Chemical Conferences between the Wars.” (p.16)

10:00-10:15 Coffee Break

10:15-11:45 **Session 3 (2): Internationalizing Chemistry and the Chemical Community (Chair: Jeffrey Johnson)**

Yoshiyuki Kikuchi (The Graduate University for Advanced Studies, Japan), “San-ichiro Mizushima and the Reconfiguration of the International Relations of Japanese Chemistry.” (p.17)

Keiko Kawashima (Nagoya Institute of Technology, Japan), “Female Scientists Whom Nobuo Yamada Encountered: Early Radio Chemistry and the Radium Institute.” (p.19)

Evan Hepler-Smith (Princeton University, USA), “Changing Names and Naming Change: Transformations in the ‘International Machinery’ of Chemical Information.” (p.20)

11:45 – 13:00 Lunch (the First Co-op Cafeteria)

13:00 – 14:00 **Keynote Lecture (2): (Chair: Yasu Furukawa)**

**Mary Jo Nye** (Oregon State University, USA) “A Career at the Center: Linus Pauling and the Transformation of Chemical Science in the Twentieth Century.”

14:00 – 14:15 Coffee Break

14:15 – 15:15 **Session 4: Interface between Chemistry and Biology (Chair: Togo Tsukahara)**

Kevin Fujitani (Ohio State University, USA), “A Child of Many Fathers: The Question of Credit for the Discovery of Thiamine, 1884-1936.” (p.21)

Pnina G. Abir-Am (Brandeis University, USA), “Pauling’s ‘Boys’ and the Mystery of DNA Structure: On Mentorship in Structural Chemistry and Molecular Biology.” (p.22)

15:15 – 16:00 Coffee Break

16:00 – 17:30 **Session 5: Instruments and Measurements (Chair: Carsten Reinhardt)**

Pierre Laszlo (École polytechnique, France & Université de Liège, Belgium), “Why Had NMR Such an Impact?” (p.23)

Mari Yamaguchi (University of Tokyo, Japan), “Pursuit of Accurate Measurements: Gas Electron Diffraction from the 1930s to the 1960s.” (p.24)

Makoto Yamaguchi (Japan), “Development of Vibrational Spectroscopy of Polyatomic Molecules in the 1930s and Its Implication to the Emergence of ‘Molecular Science’.” (p.25)

18:00 – Reception (the Second Co-op Cafeteria)

**March 4, Wednesday**

8:30 – Registration

9:00 – 10:30 **Session 6 (1): Making Theories and Making Methods (Chair: Mary Jo Nye)**

Yasu Furukawa (Nihon University, Japan), “From Fuel Chemistry to Quantum Chemistry: Kenichi Fukui and the Rise of the Kyoto School.” (p.27)

Buhm Soon Park (Korea Advanced Institute of Science and Technology, Korea), “A ‘Marriage of Poor Theory and Good Experiment’?: The Origins of the Woodward-Hoffmann Rules.” (p.28)

Carsten Reinhardt (Chemical Heritage Foundation, USA), “Physical Methods in the Twentieth Century between Disciplines and Cultures.” (p.29)

11:30-10:45 Coffee Break



10:45 – 11:45 **Keynote Lecture (3): (Chair: Yoshiyuki Kikuchi)**

**Ernst Homburg** (Maastricht University, The Netherlands) “On Molecules, Men, and Mirrors: Different Ways to Write a History of the Chemical Industry.”

11:45 – 12:45 Lunch (the First Co-op Cafeteria)

12:45-14:15 **Session 7: Synthesis and Production (Chair: Masanori Wada)**

Takashi Mine (Japan), “Small-Scale Ammonia Production in China in the Time of Mao Ze Dong.” (p.29)

Ian D. Rae (Australia), “ ‘Ideal’ Gases: Anaesthetics in the Heart of the Twentieth Century.” (p.31)

Galina Shyndriayeva (King’s College, UK), “Perfume at the Forefront of Macrocyclic Compound Research: From Switzerland to Du Pont.” (p.32)

14:15-15:15 Coffee Break

**14:20 – 15:00 A Visit to the University Museum**

15:15–16:45 **Session 8: Interface between Chemistry and Physics (Chair: Yoshiyuki Kikuchi)**

Shintaro Furuya (Tokyo Institute of Technology, Japan), “Polanyi’s Physical Adsorption: One of the Early Theories of Quantum Chemistry.” (p.34)

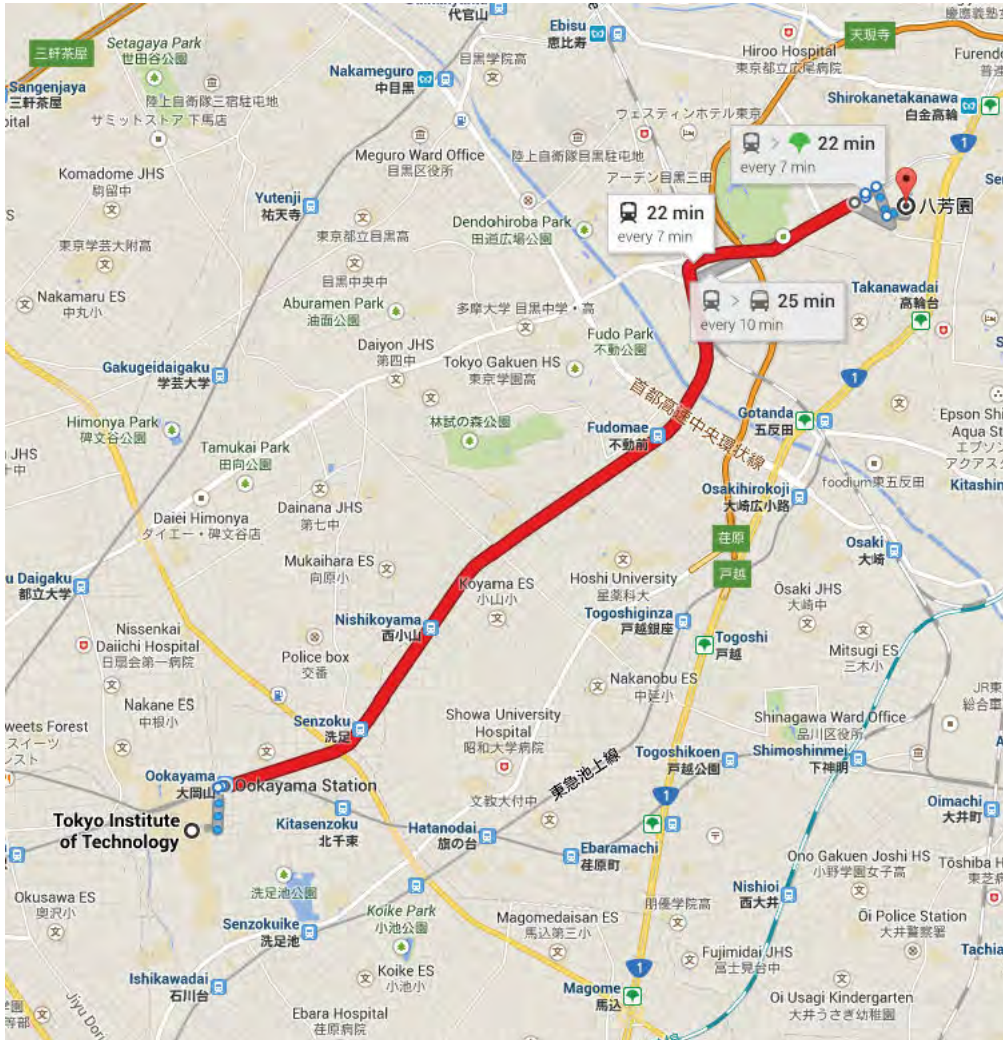
Jeremiah James (Ludwig-Maximilian University, Germany), “From Physical Chemistry to Chemical Physics, 1913-1931.” (p.35)

Noboru Hirota (Kyoto University, Japan), “Robert Mulliken and His Influence on Japanese Physical Chemistry.” (p.36)

16:45–17:00 **Closing Remarks: Makoto Ohno** (Aichi Prefectural University, Japan)

18:45 – 21:00 Banquet (Happo-en, 1-1-1 Shirokanedai, Minato-ku, Tokyo)

<http://www.happo-en.com/english/index.html>



## Résumé IWHC 2015 Tokyo

March 2, Monday

Session 1: From Local Products to Global Chemistry

**Masanori Kaji**

Tokyo Institute of Technology, Group of History of Science and Technology

**“The Transformation of Organic Chemistry in Japan: Majima Riko and His Research School of Natural Products Chemistry in the First Half of the 20th Century.”**

Born in Kyoto, Riko (Toshiyuki) Majima (1874-1962) graduated from the Department of Chemistry of the College of Science at the Tokyo Imperial University in 1899. After a four-year, from 1907 to early 1911 stay in Europe, where he studied under Carl Dietrich Harries (1866-1923) in Kiel and under Richard Willstätter (1872-1942) in Zurich, he became a professor of organic chemistry at the newly established Tohoku Imperial University in March 1911. He became famous especially for his study of urushiol (a catechol (o-dihydrobenzene) derivative), the main components of the sap of the Japanese lacquer tree (*Rhus verniciflua* Stokes, *urushi-no-ki* in Japanese). His research strategy was to study the structure of components of Japan's local natural products using newly developed methods in Europe to compete with chemists in the West. This Majima's approach became major research method of research chemists after Majima in Japan until 1950s. This method was that of developing country to catch up and compete under unfavorable conditions with researchers in advanced countries.

However, after 1981, when Ken-ichi Fukui received Nobel prize in chemistry first in Japan, six Japanese chemists had received Nobel prize in chemistry. Most of them, except Osamu Shimomura, who studied chemistry of marine natural products (basically Majima's approach), discovered and developed new methods or theories in 1950s-1970s. This paper has considered the Third IUPAC Symposium on the Chemistry of Natural Products in Kyoto in 1964, two years after Majima's death as a turning point in the development of organic chemistry in Japan. By analyzing the circumstances behind this symposium and the contents of the symposium itself and its consequences in 1960s, the paper will elucidate major factors for transformation of organic chemistry research in Japan.

## **Victoria Lee**

Max-Planck Institute for the History of Science, Germany

### **“Screening for Gifts: Japanese Glutamic Acid Fermentation.”**

In the late 1950s, scientists at Kyōwa Hakkō developed a process for manufacturing glutamic acid – the amino acid that forms the basis of monosodium glutamate, which the company Ajinomoto had previously made by expensive extraction from hydrolyzed protein – by a microbe. Amid the ensuing excitement across the fermentation science community in Tokyo and Osaka, the application of microbial technology revolutionized MSG production by making the process vastly cheaper. Similarly, the invention of amino and nucleic acid fermentation, which went beyond the technologies of the antibiotics industry by engineering a microbial cell to accumulate a primary metabolite, placed Japan in a leading position in biotechnology. This paper looks at how the new microbial process came to transform a local commercial product in postwar Japan. The set of problems that Japan confronted were half a century old. Ajinomoto was an export product to Asia since the 1910s with origins in local marine goods. Japanese scientists had nurtured a vision of microbes as the solution to industrial and nutritional problems in their “resource-poor” and “overpopulated” island country since the early twentieth century. The new scientific process drew on the skills of agricultural chemistry graduates moving into newly-opened company laboratories in the food, chemical and pharmaceutical industries, who applied state-of-the-art screening techniques and scientific information from the United States. This case of technological innovation opens a window onto how local and global trends interacted in the era of increasing scientific flows as Japan stood on the brink of high-speed economic growth. In the 1950s when the country was slowly recovering from the hunger and devastation of the early post-World War Two years, the invention of glutamic acid fermentation reveals what forms indigenous scientific developments came to take as Japan emerged as a major technological and economic power.

## **Session 2: Preserving the Chemical Heritage**

### **Susanne Rehn-Taube**

Deutsches Museum, Germany

### **“The Nuclear Fission Table in the Deutsches Museum: Heritage of a Science Story on the Eve of World War II.”**



The Hahn-Meitner-Straßmann table shows an arrangement of devices used 75 years ago in experiments which led to the splitting of atomic nuclei for the first time.

Since the 1890s, the scientific community had formed an increasingly accurate idea of the atom. In the early 20th century, various groups of scientists around the world examined the transformations of radioactive atomic nuclei, trying to achieve the conversion of chemical elements in the laboratory. Following an experimental set-up designed by Enrico Fermi, Otto Hahn, Lise Meitner, and Fritz Straßmann analyzed the behavior of uranium and thorium atoms under neutron bombardment in Berlin in the 1930ies. They hoped to find chemical elements that were heavier than uranium. The team with the physicist Meitner and the two chemists Hahn and Straßmann worked together very successfully. A number of papers about the so-called transuranium elements were published. In the summer of 1938, Lise Meitner was forced to flee Germany. Following the “Anschluss” of Austria, as an Austrian Jew she was no longer protected from persecution by the Nazis. This was a shock for everyone involved. Hahn and Straßmann continued their experiments. In December 1938, they found barium among the products of their nuclear reaction. This discovery was based on an amazing performance of analytical chemistry. Lise Meitner, in exile, provided the explanation: By splitting the atomic nucleus, chemical elements much lighter than uranium were formed. The scientific community and the political world immediately showed great interest in the discovery. In the U.S., the Manhattan Project was started with the goal to construct a nuclear reactor. A project with results that still shape our world today in many ways: without the discovery of nuclear energy, our modern life certainly would look different. On the other hand, this development in times of war had terrible

consequences for the people of Japan due to the dropping of the atomic bombs on Hiroshima and Nagasaki.

In the Deutsches Museum in Munich, parts of the original equipment are kept and tell the story of this discovery. In the past, this was not always done in a balanced way. Meitner's contribution remained unappreciated for a long time, an omission Otto Hahn was posthumously blamed for. Recent studies show that this was rather the museum's fault.

This paper tells a story about chemical research under difficult circumstances, the personal stories of the participants on the eve of the war and the post-war presentation of laboratory devices as an example of German scientific heritage in the Deutsches Museum.

### **References (selection)**

1. S. Rehn, 75 Jahre Kernspaltung. Kultur und Technik 3/2013, S. 18-25.
2. J. Lemmerich, Die Geschichte der Entdeckung der Kernspaltung. Ausstellung veranstaltet vom Deutschen Museum München und dem Hahn-Meitner-Institut der Technischen Universität Berlin 1988-1989.
3. M. Poloni, A very wobble unstable drop. Publikation zur Ausstellung „Das Majorana-Experiment“, Kunsthalle Bern, 20.8. – 10.10.2010.
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6. O. Hahn, F. Straßmann, Naturwiss. 27, 1939, 89 – 95.
7. L. Meitner, O. R. Frisch, Nature 143, 1939, 239.
8. O. R. Frisch, Nature 143, 1939, 276.
9. L. Meitner, O. R. Frisch, Nature 143, 1939, 471.
10. J. Lemmerich, Lise Meitner - Max von Laue Briefwechsel 1938 – 1948. ERS-Verlag, Berlin 1998, S. 411.
11. R. L. Sime, Phys. Perspect, 12 (2010), S. 190 – 218.

### **Ronald Brashear**

Chemical Heritage Foundation, USA

**“Preserving the Heritage of Modern Chemistry.”**



Since its inception in 1982, the Chemical Heritage Foundation (originally the Center for the History of Chemistry) has been adapting to find its position in the area of historic preservation of the scientific and technological enterprise, especially in the post-1900 period. From an initial plan to preserve oral histories of chemists, chemical engineers, and entrepreneurs, CHF has evolved to collect and provide access to books, artworks, historical artifacts, and archival collections at its home in Philadelphia. The collecting subject areas have also grown to acknowledge the expansion of chemistry into fields such as biochemistry, material science, environmental science, medicine, and quantum chemistry, among many others.

While CHF has continued to build its infrastructure to create a significant critical mass of primary textual sources and material culture collections, it is clear that CHF cannot and should not continue these activities in isolation. The ability to build a collegial and possibly formal international network of collection and preservation activities will be important as we move ahead into the twenty-first century and CHF can and should play an important role in this development.

This paper intends to build on previous discussions<sup>1)</sup> and present some scenarios that could enhance the international effort at preserving all aspects of the history and heritage of the modern chemical sciences and technologies, from laboratory notebooks and born-digital files to large scientific artifacts and industrial sites. By looking at earlier attempts at historic preservation in science and technology, and seeing what worked and what did not; by looking at issues of international relations and constraints; and by understanding the opportunities that a virtual environment can provide, I hope to create the framework of what could be an international collaborative to enhance the preservation of our chemical heritage.

## References

1. Such as the papers found in *Chemical Sciences in the Modern World*, ed. Seymour Mauskopf (Philadelphia: University of Pennsylvania Press, 1993).

**March 3, Tuesday**

**Session 3 (1): Internationalizing Chemistry and the Chemical Community**

**Masanori Wada**

Tokyo Institute of Technology, Japan

**“The Two International Congresses Held in Tokyo in the 1920s: The Rise of the First Generation of Japanese Scientists.”**

This paper examines the meaning for the state of science and engineering in Japan of two international congresses held in Tokyo in the 1920s: the Third Pan-Pacific Science Congress (PPSC) in 1926, and World Engineering Congress (WEC) in 1929. It argues that these congresses highlight the rise of the first generation of Japanese scientists.

Since the Meiji Restoration in 1868, Japan aggressively absorbed science and engineering from the West. Japanese modernizers had a big goal to emulate the Western powers since the Japanese government made disadvantageous treaties with those nations in late the 1850s and the 60s. New higher educational institutions, such as the old University of Tokyo and the Imperial College of Engineering, invited teachers from Europe and the US. Around 1882, those Japanese who studied under foreign teachers became qualified to be faculty members in those colleges to substitute for foreigners. The author call these students the “first generation” of Japanese scientists. Typical figures were the chemist Jōji Sakurai (1858–1939) and the civil engineer Kōi Furuichi (1854–1934). Sakurai and Fruichi served as leaders of PPSC and WEC respectively.

The main and purpose of two congresses were, of course, to exchange academic work internationally. However, for the first generation of Japanese scientists saw these congresses as a chance to enhance the prestige of Japan in the international academic world. There are two distinct features of those congresses. (i) Japanese participants had to use English. Sakurai repeatedly insisted at PPSC that Japanese scientists should use English in publishing papers to get attention from Western scientists.<sup>1</sup> At WEC, they received 813 papers, 371 of which were by Japanese scientists. Most of papers by Japanese scientists were written in English with some exceptions. (ii) Japanese organizers tried excessively to attract the attention of participants from foreign countries. Sakurai and Furuichi themselves were not necessarily very successful academically in their lifetime, but they showed their administrative ability, for example, in organizing those congresses. Japanese organizers of WEC offered 100 reception parties. A



participant joked that “We Eat Constantly!,” after the abbreviation of the congress.<sup>2</sup> In addition, they prepared 52 excursions, including those to Yokohama, Aichi, Kyoto, Osaka, and Kōbe.

As a country trying to catch up, those international congresses in the 1920s were symbolic events to show to the outside world Japan’s rise in the field of science and engineering.

### References

1. Sakurai, Jōji, “Honpo Kagaku no Kokusaika” *Tokyo Gakugei Zasshi* (520) (1926): 467–469; Sakurai, Jōji, “Dai 3kai Han-taiheiyō Gakujutsu-kaigi no Kekka ni tsuite no Kansō” *Tokyo Gakugei Zasshi* (525) (1927): 1–4.
2. Nakamura, Gentoku, *Nihon Kogyo Kurabu 25 Nenshi, Jō* (Tokyo: Nihon Kogyo Kurabu, 1943), p. 652.

### Danielle M. Fauque

University of Paris Sud, France

### “Jean Gérard, Secretary General and Driving Force of the International Chemical Conferences between the Wars.”

Historical accounts preserve effectively enough the names of the presidents of leading scientific bodies. But they tend to overshadow the work of other officers, secretary generals in particular, who were often the people who got things done. This is conspicuously the case with Jean Gérard, secretary general of IUPAC between the wars and a man with an extraordinary capacity for organization that kept the Union at the forefront of international chemistry.

Gérard fully deserved contemporary descriptions of him as the Union’s «cheville ouvrière». In his secretarial capacity, he had played an active role in preparatory meetings, notably in discussions of the IUPAC statutes that the International Research Council finally adopted on 28 July 1919. The statutes specified that an international conference was to be held every year and that a congress should take place every four years. Making that provision a reality called for an effective administrative structure, and Gérard was the man for the job. As a chemical engineer, secretary general and co-founder with Paul Kestner of the Société de chimie industrielle, and editor of the respected journal *Chimie et industrie*, he was eminently qualified. He quickly

transformed the SCI's congresses of industrial chemistry into international events, attended by foreign delegations and members of IUPAC especially during the 1920s.

With his powerful personality and unswerving commitment to the principles of Taylorism, Gérard administered IUPAC and the other bodies of which he was either president or secretary general with resolution. His career and reputation reached their peak with the creation of the Maison de la Chimie in 1927 and the inauguration of the MC's premises in 1934. But he chose the wrong side during the Nazi occupation of France and, after the Liberation, was excluded from both the national and the international community of chemistry.

Much can be learned about the international dimensions of chemistry from the exchanges between Gérard, as secretary general, and the members of the IUPAC council. The exchanges point to Gérard as a corner-stone of chemistry on the world stage between the wars. My aim in this paper is to analyse his role within IUPAC, drawing on administrative correspondence that tellingly illuminates many of the leading preoccupations of the chemical community in the period.

### **References**

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2. VAN TIGGELEN, B. and FAUQUE, D.: The Formation of the International Association of Chemical Societies, *Chemistry International*, 34/1 (January-February 2012), 8-11.
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### **Session 3 (2): Internationalizing Chemistry and the Chemical Community**

**Yoshiyuki Kikuchi**

The Graduate University for Advanced Studies, Japan

**“San-ichiro Mizushima and the Reconfiguration of the International Relations of Japanese Chemistry.”**

The period between 1920s and 1960s was transformative for both the history of chemistry in Japan and the history of chemistry worldwide. One promising way to understand the relationship between these two concurrent developments is to analyze how Japanese chemistry got connected to chemistry at large by focusing on the international connections of key players in this process. The overall aim of this presentation is to scrutinize the reconfiguration of the international relations of Japanese chemistry around the Second World War by using this micro-focusing method.

San-ichiro Mizushima is an ideal choice for this purpose. The notable physical organic chemist who did pioneering studies in quantum chemistry and conformational analysis (he coined the “gauche” form of rotational isomers around 1940), he had extensive personal connections with top chemists and physicists around the world. After trained at Tokyo, Mizushima did an overseas study with Peter Debye at the University of Leipzig between 1929 and 1931 and had immersed himself in the German-speaking scientific world ever since. However, after the end of the Second World War, he quickly established himself as one of the leading scholar in conformational analysis especially in the United States. He was offered the prestigious G. F. Baker lectureship of Cornell University and the P.C. Reilly lectureship of the University of Notre Dame, both in 1951. Mizushima’s international relations evolved from predominantly German connections into truly global ones centered on, but not dominated by, the United States, as is exemplified by his bureau membership of the International Union of Pure and Applied Chemistry between 1955 and 1967.

I would argue three points here. First, this reconfiguration started in the 1930s and was well underway by the time Japan entered the Second World War in 1941. For example, Mizushima had opened correspondence with American physical chemist Linus Pauling by 1936 and discussed their research outcomes, most notably Mizushima’s on rotational isomers. Second, Debye’s immigration to the United States and his appointment at Cornell in 1940 beneficially affected Mizushima’s reputation there. Third, based on his catholic faith, Mizushima cultivated friendship with chemists in catholic universities such as Notre Dame and catholic countries like Vatican City and Spain. Thus, one has to go beyond the familiar narrative of the impact of the United States and the Second World War to understand the reconfiguration of Japanese chemistry’s international relations between 1920s and 1960s.

## **Keiko Kawashima**

Nagoya Institute of Technology, Japan

### **“Female Scientists Whom Nobuo Yamada Encountered: Early Radio Chemistry and the Radium Institute.”**

Nobuo Yamada (1898-1927) was the first Japanese scientist to join the Radium Institute and the first Japanese disciple of Marie Curie (1867-1933). Between 1923 and 1925, Yamada wrote five articles on collaborative research, three of which he co-wrote with Irène Curie (1897-1956), Marie's eldest daughter. Around that time, Frédéric Joliot (1900-1958), who would later win the Nobel Prize for chemistry with Irène, also began working as Marie's laboratory assistant.

Yamada was one of the few Japanese scientists working in early radiochemistry research. However, his experience was even more unique as the first Japanese male scientist with a female teacher and female colleagues. In 1920's, female scientists including Catherine Chamié (1888-1950) and Sonia Cotelle (1896-1945) were in the Radium Institute. Unfortunately, Yamada suffered radiation injury caused by the research in Paris and died just a few years after his return to Japan. Little was known about radiation injury in Japan then; Yamada's bereaved family thought that he had caught a strange disease. Few of his writings about his experience in Paris exist, as his family discarded books and manuscripts that he had brought back from Paris.

Shocked by the news of death of this young and talented Asian disciple, Marie and Irène respectively wrote condolatory letters to Yamada's supervisor and his wife. The Curie Museum in Paris houses copies of those letters. These were the first such letters sent to Japanese from female scientists, rather than the wives or daughters of male scientists.

I would like to discuss the female scientists of the Radium Institute, with a focus on the period of Yamada's time there (1923-1925). It was only place in the world in which male and female scientists worked together under a female leader. This evinces that the fame of Madame Curie, the first person to win the Nobel Prize twice (1903 in physics; 1911 in chemistry), attracted disciples from across the world and stimulated a dramatic increase in the number of women conducting scientific research, especially in the field of radio chemistry. How did their work contribute to the future development of radiochemistry? I would like also analyse the reality of radio chemistry from the gender perspective by comparing the situation of female scientists in modern Japan with that of

Yamada's female colleagues at the Radium Institute.

**Evan Hepler-Smith**

Princeton University, USA

**“Changing Names and Naming Change: Transformations in the ‘International Machinery’ of Chemical Information.”**

A crucial part of the foundation of the chemical sciences transformed between the 1920s and the 1960s. This transformation reshaped chemical practice according to new understandings of the structure and behaviour of molecules – but it was not a theory. Its course of development was intimately related to the emergence of electronic computing – but it was not an instrument. The transformation was funded by chemical firms and took place largely within their walls – but it was not an industrial product or process.

Underlying transformations in such better-known areas of chemistry were changes in chemical information: journals, reference works, databases, nomenclature rules, and classification schemes. Such systems, both material and conceptual, made knowledge about rapid developments in the chemical sciences accessible, between collaborators within an individual institution as well as among an international chemical readership.

My paper will follow the transformations in chemical information during this period along two axes: nomenclature and reference media. One of the signal tasks of the International Union of Pure and Applied Chemistry, founded in 1920 (Japan joined in 1921), was the establishment of an international system of organic chemical nomenclature. Buffeted by organizational challenges, political tensions, and war, the nomenclature commission slowly but steadily extended the compass of its rules, finally publishing definitive guidelines – the "Blue Book" – in 1958.

Meanwhile, new technologies for indexing chemical compounds emerged to rival the enormous print reference works for which the IUPAC rules had been developed. Beginning in the 1940s, chemical firms like Du Pont and state agencies began experimenting with punched card indexes for storing and retrieving information about particular compounds. By the 1950s, many such systems gave way to electronic databases. The material configuration of these new media inspired entirely new means of representing chemical identity, from intricate ciphers that mapped three-dimensional molecular structure to a string of characters to the Chemical Abstracts Registry Number, an arbitrary numerical identifier that cut through the Gordian knot of chemical

relationships that a name or formula might be asked to express. Transformations in nomenclature guidelines and information systems between the 1920s and the 1960s shaped the communication of all of the other transformations in the chemical sciences, and the possibility of preserving still-valuable knowledge from chemistry's past.

#### **Session 4: Interface between Chemistry and Biology**

**Kevin Fujitani**

Ohio State University, USA

##### **“A Child of Many Fathers: The Question of Credit for the Discovery of Thiamine, 1884-1936.”**

The discovery in the early twentieth century that healthy living organisms required more than just water, proteins, fats, carbohydrates, and minerals in their diet transformed the field of nutrition, and scientists were quick to tout the supplementary importance of vitamins. In the case of vitamin B<sub>1</sub>, or thiamine, two researchers' names feature prominently in popular culture. In Japan, Suzuki Umetarō is broadly accorded credit for discovering this curative factor for beriberi and for originating the study of vitamins as a discrete field. In the West, however, Casimir Funk receives widespread recognition for the same. However, there are a number of researchers who have, knowingly or unknowingly, worked on vitamin B<sub>1</sub>, usually while searching for a cure for beriberi. A handful could even be recognized as having advanced the state of knowledge of this essential nutrient. Takaki Kanehiro found that the cure for beriberi in the Imperial Japanese Navy lay somewhere in sailors' rations. Christiaan Eijkman narrowed (one of) its locations to the husks of rice grains. Suzuki and Funk both claimed to first have isolated it chemically. Barent Jansen and Willem Donath isolated it in its pure form, but deduced its chemical formula incorrectly. Robert Runnels Williams ascertained the correct atomic formula, subsequently determined thiamine's molecular structure and synthesized it in 1936. Finally, Frederick Hopkins provided a unifying theme to this practical research, conceiving of “accessory food factors” that are essential for a healthy diet. Through examination of scientific journal articles, memoirs, and popular culture references, this paper will accord these researchers their proper place in this early and somewhat contentious period in the history of nutrition. Williams ultimately deserves credit for the discovery of vitamin B<sub>1</sub>. Hopkins, rightly, was awarded a Nobel for originating vitamin theory, the field which now encompasses

thirteen, for humans, of these essential nutrients. Funk is the source of the very catchy and durable word “vitamin.” As for Suzuki, although he cannot be said to have discovered thiamine, or even to have founded the study of vitamins, it can, however, be said unequivocally that it was he who first brought the study of vitamins from the nutritional level to the chemical.

**Pnina G. Abir-Am**

Brandeis University, USA

**“Pauling’s ‘Boys’ and the Mystery of DNA Structure: On Mentorship in Structural Chemistry and Molecular Biology.”**

Linus Pauling’s involvement with the structure of DNA (1951-53) has remained enigmatic, despite several remarkable biographical studies of his well known career, as one of the greatest structural chemists ever. This talk seeks to shift the focus of inquiry from the biographical to the interactional or mentorship. In particular, I seek to better explain Pauling’s failure with solving the structure of DNA by examining in greater detail his deployment of a group known as “Pauling’s boys”. The group included research assistants and associates, often former graduate or post-graduate students, who remained in Pauling’s lab for an extended time frame, benefited from his mentorship, and could be relied upon to participate in his ventures when needed. I distinguish between those who remained at Pauling’s home institution at the time (Caltech) or elsewhere in the US; and those who were “deployed” from overseas locations. The latter invariably ended up in labs run by Pauling’s main competitors in the protein structure area in UK, e.g. Edward Hughes sent to Leeds; Jack Dunitz to Oxford, Jerry Donohue and Peter Pauling to Cambridge. The former group included those who witnessed Pauling’s presentation of a triple helical DNA model prior to its publication in February 1953. (e.g. Ken Hedberg, Richard Marsh, Alex Rich, Verner Shomaker, among others) The talk explores whether Pauling’s deployment of his “boys” differed from other lab directors implicated in the quest for DNA structure, and whether such a difference played a role in the ultimate location of the discovery of DNA structure. The talk is based on research done at the Ava Helen and Linus Pauling’s Archive at Oregon State University in Corvallis under a fellowship from its Special Collections and Archive Center, held in 2012.

## Session 5: Instruments and Measurements

### **Pierre Laszlo**

École polytechnique, France & Université de Liège, Belgium

#### **“Why Had NMR Such an Impact?”**

I had the luck to participate in the nmr revolution of the 1960s. The very first (1962) “nmr-man” in chemistry at Princeton University. Member of the editorial board of the *Journal of Magnetic Resonance* from its launching (1969). Joint author, with Peter Stang, the present editor of the *Journal of the American Chemical Society*, of a textbook on *Organic Spectroscopy* (New York: Harper and Row, 1971). Pioneered sodium-23 nmr (1970s).

Far from one-upmanship though, this contribution will highlight developments witnessed in the United States and in France. In Japan, I was privileged to know colleagues such as Fujiwara Shizuo, Arata Yoji or Ōki Michinori, Professors at the University of Tokyo.

Some of the points my talk will raise are:

- The actors, *chemists and not physicists*, organized themselves into a restricted group of peers — about two dozens — to devise the new methodology, and its terminology.
- Nmr did not just fit into the existing molecular spectroscopy. Our contributions as nmr-chemists went beyond the technical, they were predominantly conceptual — to stereochemistry, for instance.
- With its roots in the US, nmr-in-chemistry neither occurred top-down (from, say, the Harvard chemistry department), nor bottom-up, as a grassroots movement.
- To acquire expensive spectrometers made the budgets of chemistry departments skyrocket, which was only possible because of the Sputnik-caused growth of American research universities.
- Industrial laboratories, especially Varian Associates and the Experimental Station of DuPont de Nemours, were highly influential. The then Mellon Institute, in Pittsburgh, served as a clearinghouse for the new information.
- Polymer chemists relied on nmr, to determine e.g. tacticity of polymers.
- Workshops set by instrument makers, such as Varian, JEOL and Bruker, educated users. The other, crucial, channel for bringing nmr to the chemical community was books: fewer than half-a-dozen were influential.



- Historical conjunctions played a role, such as the heyday of conformational analysis coinciding with the advent of nmr.
- Nmr allowed real-time observation of chemical processes, e.g., vastly expanding the scale of chemical dynamics.
- Since I have mentioned stereochemistry, nmr had a federating role in the still ongoing re-unification of chemistry and biology.
- Nmr techniques spawned new sub-disciplines of chemistry, e.g., Fourier transform nmr nourished a massive expansion of organometallic chemistry.

### **Mari Yamaguchi**

University of Tokyo, Japan

#### **“Pursuit of Accurate Measurements: Gas Electron Diffraction from the 1930s to the 1960s.”**

In the twentieth century, several physical measuring methods such as NMR and spectroscopy changed the practice of chemists, which is often dubbed “the Instrumental Revolution.” Most methods have been improved continuously since their invention. Such improved methods usually enabled more accurate measurement and the existing data were overwritten with new more precise data. But what kind of problems did the improved accuracy of different methods cause, and what impact did it have on the development of molecular science? To answer this question, this paper will trace the history of Gas Electron Diffraction, GED, mainly after World War II in Japan and compare with those of other methods such as spectroscopy.

The GED is the method of measuring the interatomic distances and valence angles of molecules by electron diffraction. It started in 1930 in Germany, but the US and Norwegian groups led the GED studies worldwide before and after the war. In Japan, Yonezo Morino was the most active among Japanese GED researchers. In the early 1930s, although attracted to GED, he had to perform Raman spectroscopy at the University of Tokyo. Morino started GED with the help of practitioners of electron diffraction at Nagoya University in 1943. He continued GED studies and trained successors after returning to the University of Tokyo in 1948.

Before the war, the Norwegian group adapted extensively a new method which led to more accurate measurements without trained human eyes. After the war, this method

was widely adopted by GED researchers. In 1949, Isabella Karle and Jerome Karle in the United States demonstrated that the method had the ability to evaluate vibrations between pairs of atoms in a molecule. This work encouraged Morino. Along with GED, his group introduced microwave spectroscopy for investigating molecular structure in the late 1950s.

The accumulation of more accurate data, however, revealed discrepancies between GED results and those from microwave spectroscopy. This situation generated a pessimistic view concerning the future of GED. Nevertheless, Morino insisted that the results of both methods should be combined to understand dynamic molecular structure. He and his co-workers tackled several problems through interaction with researchers overseas. One of their achievements was the Bastiansen-Morino shrinkage effect, where the vibrational motion of the atoms in a molecule have an effect on the structure. Pursuing accurate measurements with not only one measuring technique was one of his strategies to better understand the true nature of molecules.

### **Makoto Yamaguchi**

Japan

#### **“Development of Vibrational Spectroscopy of Polyatomic Molecules in the 1930s and Its Implication to the Emergence of ‘Molecular Science’.”**

In 1920s most of the basic concepts on the molecular systems were formulated immediately after the emergence of the quantum mechanics. Covalent bonding of molecular hydrogen was successfully explained and development of valence bond and molecular orbital theories followed. Born and Oppenheimer derived separation of motions of electrons and nuclei in molecular Hamiltonian and wavefunction. Dirac gave his famous statement in 1929 and the quantum mechanics of the molecular systems seemed to be the issue of theoretical physicists no longer. However, practical applications of such basic concepts in 1920s were mostly limited to diatomic molecules. It was in 1930s when theory and experiment of polyatomic molecules were greatly advanced.

In contrast to the diatomic molecules with only one vibrational mode, polyatomic molecules with  $N$  atoms have  $3N-6$  vibrations and assignment of the vibrational structure in the measured spectra has to be made. Thus the group theory in quantum

mechanics by Wigner became indispensable tool to explain selection rules in molecular vibrations, Discovery of Raman effect in 1929 was very timely as they show vibrational bands different from the infrared spectra. Placzek explained the selection rule of the Raman band by symmetry changes of the molecular polarizability. Teller developed theories on the vibrational structure of electronic spectra of polyatomic molecules beyond Born-Oppenheimer approximation. They initiated these works in Germany and moved to the United States in 1930s and continued research on chemical reactions and molecular spectra there until the World War.

In the United States young scientists who had a chance to study in Germany in 1920s and became familiar with the newly born quantum mechanics made great contribution in development of the valence bond and the molecular orbital theories. Physical optics and spectroscopy were also the subjects American physicists were strong. The close relationship of these studies resulted in the leading role of the United States in this field. It is interesting to note that some scientists describe their fascination by the molecules they were working with. This may be a consequence of the studies on the molecular structure and spectra of polyatomic molecules 1930s which made the images of molecules more lively. This feeling might be implicitly shared among the scientists practicing molecular spectroscopy but not by the chemists who still regarded molecules as rather hypothetical entities to explain experimental results.

**March 4, Wednesday**

**Session 6 (1): Making Theories and Making Methods**

**Yasu Furukawa**

Nihon University, Japan

**“From Fuel Chemistry to Quantum Chemistry: Kenichi Fukui and the Rise of the Kyoto School.”**

Kenichi Fukui (1918–1998) is one of the ten quantum chemists who have received Nobel Prizes in Chemistry. Throughout his long career, Fukui belonged to the Faculty of Engineering at Kyoto University. His initial major was in the practical field of fuel chemistry. This paper attempts to answer the question of why he moved to quantum chemistry from fuel chemistry, and explores how he established a world-renowned school of theoretical chemistry in Kyoto’s Engineering Faculty. Since the 1920s, Gen-itsu Kita had built up a tradition that stressed the importance of basic research in the Department of Industrial Chemistry, Faculty of Engineering at Kyoto. When Fukui enrolled in Kita’s department in 1938, Kita suggested that Fukui study basic science in order to major in applied chemistry. Fukui chose to study physics as a basic science and began reading through German papers and books on newly emerging quantum mechanics. He considered quantum mechanics to be a powerful means of mathematizing chemistry. As a graduate student, he studied under Shinjiro Kodama in the newly founded Department of Fuel Chemistry in Kyoto’s Engineering Faculty. While in Berlin, Kodama had been greatly influenced by Michael Polanyi who asked Kodama to learn quantum mechanics in order to conduct chemical research. Kita and Kodama then created a departmental environment that encouraged Fukui’s research in quantum chemistry. During the war, Fukui carried out research on the synthesis of gasoline additives, which aroused his interest in the reactions of hydrocarbon compounds. Promoted to professor of fuel chemistry at Kyoto after the war, he concentrated on a quantum-mechanical interpretation of chemical reactions of hydrocarbon compounds, while recognizing the limits of the existing electronic theories of organic reactions. In the early 1950s he began publishing a series of papers on the “frontier orbital theory” of reactions in the *Journal of Chemical Physics*, the work that would lead to the 1981 Nobel Prize in Chemistry. Fukui was tactful enough to maintain his circle of quantum chemistry in the Department of Fuel Chemistry within the Faculty of Engineering. He managed a laboratory where his associate professor and assistants

worked on conventional experimental studies on fuel-related subjects, whereas a select group of theoretical chemists focused on the expansion of his frontier orbital theory. From this group of theoretical chemists, a large number of quantum chemists and computational chemists emerged. Thus, Kyoto's Engineering Faculty became Japan's leading center for theoretical chemistry during the latter half of the twentieth century.

### **Buhm Soon Park**

Korea Advanced Institute of Science and Technology, Korea

#### **“A ‘Marriage of Poor Theory and Good Experiment’?: The Origins of the Woodward-Hoffmann Rules.”**

It is well known that the “Woodward-Hoffmann rules” demonstrated the usefulness of quantum mechanics in organic chemistry by predicting, for the first time, the outcome of certain chemical reactions. The rules were published in a series of papers in 1965, explained in a few review articles, and then presented as a fundamental theoretical construct in the 1970 monograph, *The Conservation of Orbital Symmetry*. The book's opening page gave a law-like statement that “orbital symmetry is conserved in concerted reactions,” along with a caveat that no exception would be allowed.

This paper explores the origins of the Woodward-Hoffmann rules by drawing on archival sources, published papers, and various recollections. The fruitful collaboration between Robert B. Woodward, a famed organic chemist at Harvard, and Roald Hoffmann, a Junior Fellow at Harvard's Society of Fellows, both of whom would receive Nobel Prizes respectively in 1965 and 1981, is important part of the story. Yet the main focus is on the changing epistemological status of the Woodward-Hoffmann rules as chemical theory. When, and on what basis did they recognize the possibility of generalizing the rules? What were the sources of their confidence—the accumulation of empirical information, the sophistication of quantum mechanical maneuvering, or something else? Why did they describe their rules as a product of the “marriage between poor theory and good experiment”? This study aims to explicate their attitudes toward theoretical model-building in the context of mounting challenges from competitors like H. C. Longuet-Higgins of Cambridge University, Kenichi Fukui of Kyoto University, and Michael J. S. Dewar of University of Texas at Austin. Woodward and Hoffmann, it shows, needed to characterize their rules as a qualitative yet highly generalizable theory geared for the chemical audience, and so did they. This

paper thus offers a contextual account for what the philosopher of science Michael Weisberg has recently called the tradeoff between precision and generality in chemical modeling.

### **Carsten Reinhardt**

Chemical Heritage Foundation, USA

#### **“Physical Methods in the Twentieth Century between Disciplines and Cultures.”**

This talk aims at contributing to the historical sociology of a type of science that focuses on the development and dissemination of research methods. "Method making" differs from the problem-oriented approach in science and technology in important respects, partially because the epistemic status of the research methods has to be re-negotiated each time when they are transferred across disciplinary boundaries and national cultures. I argue that in the middle of the twentieth century, based on the effects of governmental research funding and supported by industrial instrument manufacturers, some research scientists made the making of methods their most important task. In analyzing high-tech instruments used for the isolation, identification, and interpretation of materials and data, I investigate the social positioning of the "method makers" in terms of their roles as experts and their functions in innovation processes.

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### **Session 7 (1): Synthesis and Production**

#### **Takashi Mine**

Japan

#### **“Small-Scale Ammonia Production in China in the Time of Mao Ze Dong.”**

The war promotes the technical progress development generally speaking. In the early time of People’s Republic of China, however, small scale production was preferred and pursued under the Chairman Mao Ze Dong’s self-reliance policy. The

ammonia production was the typical case of such small-scale production under the self-reliance policy.

In the pre-war China 50,000t/y ammonia plant was constructed in Dalian and 33,000t/y ammonia plant in Nanjing. These two plants were reconstructed in the early 1950's and newly three more ammonia plants with 50,000t/y production capacity each were constructed owing to the USSR aid in the late 1950's. Thus during 1950's China already established the middle-scale (namely 50,000 t/y) ammonia plant construction and operation technology.

But Mao Ze Dong considered that USA and/or USSR will attack and invade into China, and aimed to construct the geographically dispersed production structure since the concentration of production will cause a serious damage on the Chinese economy in case USA and /or USSR attack China. Therefore despite the established middle-scale ammonia technology, China newly developed the technology of small-scale ammonia plants, namely 800t/y or 2,000t/y which was the pre-war initial level technology. And around 1,500 small-scaled ammonia plants were constructed in the rural area of all over China during end of 1960's - early 1970's.

In the postwar world there is a tendency in the ammonia production technology toward the large-scale (330,000t/y) from the pre-war middle-scale. But China shifted from the middle-scale to the small-scale, resulting 55% of national ammonia production from the small-scale plants in 1973, though 94% in 1962. In other words China's ammonia production development pattern is from the middle-scale to the small-scale plants, while the general development pattern was from the middle-scale to the large-scale.

This reversion to the pre-war initial technology in China was caused by the Mao Ze Dong's self-reliance policy. Under the self-reliance policy China denied the division of labor and aimed to construct the self-sufficient economy in each rural area. The denial of the division of labor prevented the technical progress development and ammonia production technology reversed to the pre-war small-scale level.

Needless to say ammonia is the raw material of nitrogen fertilizer. In the post-war world the urea production increased dramatically combined with the large-scale ammonia production. In China, however, technology utilizing ammonium bicarbonate ( $\text{NH}_4\text{HCO}_3$ ) as nitrogen fertilizer was newly developed combined with small-scale ammonia plants. Ammonium bicarbonate is not an effective fertilizer since it is easy to

deteriorate during transportation and storage. But ammonium bicarbonate plant is easy to construct and operate. And the price is very cheap. China constructed the ammonium bicarbonate plants all over the rural areas together with small-scale plants to supply nitrogen fertilizer to the poor Chinese farmers. The geographically dispersed production reduced the loss during transportation and storage and covered the defects of ammonium bicarbonate. China is the only nation in the world which utilized ammonium bicarbonate as the fertilizer.

In 1972 Mao Ze Dong and Nixon of the United States met together and shake hands. Since that time China's strategy changed. Namely the self-reliance policy and self-sufficient economy of China began to change gradually since that time. It is noteworthy that in 1973 China began to negotiate the importation of 13 large-scale ammonia plants from Japan, the United States and European countries. The first large-scale plant started operation in 1976. Since then China has also begun to aim the large-scale production and ammonium bicarbonate were gradually replaced by urea.

### **Ian D. Rae**

Australia

#### **“ ‘Ideal’ Gases: Anaesthetics in the Heart of the Twentieth Century.”**

We can divide the development of chemistry in the twentieth century, and especially in the period 1920-1960, into three categories. These are, respectively, theoretical or intrinsic chemistry; chemical instrumentation; and the one that interests me most, applications of chemistry for societal purposes. These include the development of biocides, drugs and medical devices, as well as a host of industrial and specialty chemicals.

Roald Hoffmann claims that ‘Synthesis, the making of molecules, is at the heart of chemistry’ and that ‘without chemical synthesis, there would be no aspirin, no cortisone, no birth-control pills, no anesthetics, no dynamite’. As a case study, I examine the development of anaesthetic substances through the middle of the twentieth century. Only a few anaesthetic gases were known by 1920, and they were supposed to act by dissolving in fatty membranes in key organs of the body, thereby changing permeability and disrupting consciousness. Assessment of likely candidate anaesthetics was based on their lipid solubility (Meyer-Overton theory) rather than an Ehrlich-like specific interaction.



The poverty of the lipid explanation was soon exposed, and new anaesthetics were sought in close analogues of existing anaesthetic substances. Cyclopropane was found to be much more effective than other small-molecule hydrocarbons. It came into clinical use in the mid-1930s and for several decades was a mainstay of clinical anaesthesia. Variations on the molecule of diethyl ether included ethyl vinyl ether and divinyl ether, but trifluoroethyl vinyl ether (Fluroxane) was found to be especially effective. It became a model for further investigation of fluorinated aliphatic ethers, one of which, halothane (2-bromo-2-chloro-1,1,1-trifluoroethane), became a major anaesthetic in the 1950s.

The field of anaesthesia is marked by unexpected discoveries, and one that stands out as arising not from a systematic search but from serendipity is the noble gas, xenon. Its anaesthetic properties were also revealed in mid-century following mild activity attributed earlier to argon. Although new models of anaesthetic action have been developed, and binding sites identified for most of the known anaesthetic substances, none has passed the ultimate test – being the basis for rational design of a new active substance.

### **Session 7 (2): Synthesis and Production**

**Galina Shyndriayeva**

King's College, UK

#### **“Perfume at the Forefront of Macrocyclic Compound Research: From Switzerland to Du Pont.”**

The history of the twentieth-century perfume industry can provide an unusual entry into analyzing chemistry in the context of global history, linking luxury commodities, chemistry and fashion. A number of recent studies and papers demonstrate that histories of the beauty industry, of luxury commodities and chemistry, and of the senses are attracting careful attention and analysis. Work such as business historian Geoffrey Jones on the beauty industries and sociologist and historian Steven Shapin's exploration of expertise and the sciences of subjectivity provide rich ground for my research.<sup>1)</sup> Jones indeed set perfume as the pioneer capitalist industry in the beauty market, one which had the greatest influence on the development of the modern cosmetics business.<sup>2)</sup> However, recent historiography of cosmetics and perfumery has focused heavily on marketing and consumption and the French case, without deeply engaging with

production and the history of chemistry.<sup>3)</sup> Additionally, the historiography of organic chemistry as well as of chemical industries has tended to disregard perfumery.<sup>4)</sup>

I propose to place the perfume industry as a driver for organic chemistry research and as an important multinational business, with centres in Switzerland and the United States, amongst others. Here I would like to focus on the story of research into macrocyclic compounds driven by perfume companies, a story linking Leopold Ruzicka and Wallace Carothers. Ruzicka, 1939 Nobel Prize winner for his work on terpenes, asserted that “perfumes have substantially contributed to the development of organic chemistry as regards methods, systematic classification, and theory”.<sup>5)</sup> He collaborated closely from 1921 onwards with a Swiss fragrance materials company, Chuit and Naef, later to become Firmenich, now one of the five largest such companies in the world. Ruzicka’s research on macrocyclic compounds was taken forward by Wallace Carothers of Du Pont, who was interested in what these compounds could reveal about polymerisation; one result of this research was the synthesis and production of a synthetic musk, Astrotone. This story will demonstrate how the perfume industry gives new insights into the global distribution of chemical activity, as the industry was concentrated in places which are not, and were not, regarded as especially important within studies of organic chemistry in particular.

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### **Pankaj Kalita**

Arya Vidyapeeth College, India

#### **“Polymer Synthesis from the 1920s to the 1960s.”**

The first truly man-made polymer came in 1909 when Leo Hendrick Baerlan developed phenol-formaldehyde polymer. Other polymers — cellulose acetate, urea-formaldehyde, poly(vinyl chloride), nylon followed in the 1920s. It is obvious that the pace of development of polymer picked up considerable momentum in the 1930s and the 1940s. In the 1930s, acrylic resins polystyrene and melamine resins were introduced. The search for materials to aid in the defense effort during World War II resulted in some important polymers, for example, polyethylene was developed (1933, E.W. Fawcett) because of the wartime need for better-quality insulating materials for such applications as radar cable. The years following World War II (1950s) witnessed great strides in the growth of established polymer and the development of new ones. This period saw the development of acetal, polycarbonates, nylon, phenoxy, polyimide, poly(phenylene oxide), polysulfone; they belong to the group of plastics known as the engineering thermoplastics having outstanding impact strength and thermal and dimensional stability — properties that place them in direct competition with more conventional materials like metals.

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### **Session 8: Interface between Chemistry and Physics**

#### **Shintaro Furuya**

Tokyo Institute of Technology, Japan

#### **“Polanyi’s Physical Adsorption: One of the Early Theories of Quantum Chemistry.”**

In this presentation, I will explain how and why Michael Polanyi was able to propose physical adsorption, although the ‘paradigm’ of the time was a chemical one. It is apparent that quantum chemistry started from the time Heitler and London applied quantum mechanics to the bonding properties of the hydrogen molecule in 1927. This was the first theory, which explains the mechanism of chemical bond satisfactory. Then in 1930, London explained the interaction between nonpolar molecules as inverse the third of the distance, which had already appeared in Polanyi’s paper in 1916. But where did the inverse third theory come from? Neither physics nor chemistry. I would extend the idea proposed by Gavroglu and Simões to the early history of quantum theory and reframe it with the context of thermodynamics, physical atomic theory and low-temperature experiment. The significance of Polanyi’s theory must be reconsidered in the process.

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### **Jeremiah James**

Ludwig-Maximilian University, Germany

#### **“From Physical Chemistry to Chemical Physics, 1913-1931.”**

Though Wilhelm Ostwald in Riga chose to officially promote the new discipline he envisioned as “physical chemistry,” he frequently used two other terms for the field “general chemistry” and “theoretical chemistry.” He never abandoned the conviction that this new discipline would uncover the general principles that underlay all chemical experiments and phenomena. Moreover, he and most of his fellow first-generation physical chemists shared certain common assumptions concerning the form these general principles would take. They set out to find succinct mathematical expressions generalizing the results of numerous experiments on chemical compounds and reactions, often using apparatus borrowed from physics laboratories. They avoided, in general, speculating on the “underlying mechanisms” that might explain the regularities they observed.

In the first decades of the 20<sup>th</sup>-century, the modern atomic theory was firmly established, and the quantum hypothesis was refashioned to apply to a range of phenomena far beyond its origins in radiation theory. With only a slight delay, methods

and theories relying upon atomistic thinking entered into physical chemistry, and reshaped the discipline. By the late 1920s, the cutting-edge of research into the general principles of chemistry looked quite different from what Ostwald had envisioned. No small part of this change was the development of quantum mechanics and its appropriation by those interested in chemical theory. However, as the philosophers Brian Sutcliffe and Guy Woolley have pointed out, changes in key aspects of chemical theory most likely have their roots in “a far reaching reinterpretation [that] has been made for reasons that are largely independent of any requirements of physics.”<sup>1)</sup>

Moreover, this disciplinary shift extended beyond the development of new theories. By the late 1930s, the center of gravity of research into chemical theory was clearly moving away from the German-speaking universities, as research centers in Britain, the US, and Japan developed ever more prominent roles in promoting new research methods. Particularly in the US, this led to tension between an older generation of physical chemists and those using the new methods, and new journals were founded and new research positions were established to help ease this tension. A new label also developed for this new kind of research “chemical physics.” This new term included not only quantum chemistry, but also modern reaction kinetics, diffraction techniques (both x-ray and electron diffraction), and molecular spectroscopy, as well as several related fields.

### **References**

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### **Noboru Hirota**

Kyoto University, Japan

#### **“Robert Mulliken and His Influence on Japanese Physical Chemistry.”**

Physical chemistry underwent a transformation from the science based on thermodynamics to the one based on quantum mechanics in the late 1920s and the early 1930s, creating a new field of quantum chemistry. Two young American physical chemists, Linus Pauling and Robert Mulliken, played the most important roles in this transformation. Both of them started as experimental chemists, but they went to Europe to learn quantum mechanics in the institutes of theoretical physics. Initially Pauling’s

valence bond theory was more influential among chemists of those days because of its appeal to chemical intuition. However, in the long run Hund-Mulliken molecular orbital theory has made a far-reaching influence on chemistry, while the valence bond theory eclipsed. In addition to the work on the molecular orbital theory, Mulliken presented a theory on the charge transfer interaction in 1952 that had become very important in a variety of areas of chemistry. Mulliken also had a close tie with Japanese physical chemists, including S. Nagakura of the University of Tokyo and K. Fukui of Kyoto University. Here I mainly discuss Mulliken's charge transfer theory and its influence on Japanese chemistry.

Mulliken visited Japan on the occasion of the international conference of theoretical physics held in Kyoto in 1953. He presented a paper on electronic spectra and structures of molecules at the satellite meeting in Nikko organized by M. Kotani. Since then his theories on molecular orbitals and charge transfer interactions have made great impacts on the work of Japanese chemists. When Fukui reported his frontier electron theory of chemical reactions in 1952, his theory was initially criticized by theoretical chemists abroad. Fukui found a support to his theory in Mulliken's work on the charge transfer interaction. In the early 1950s Nagakura's group studied electronic spectra of organic molecules that involve intra- and inter-molecular charge transfer interactions. They were inspired by Mulliken's work on the molecular orbitals and the charge transfer interactions. Nagakura and some of his associates worked in Mulliken's laboratory in Chicago in the late 1950s and the early 1960s. In 1954 H. Akamatsu, H. Inokuti and Y. Matsunaga of the University of Tokyo discovered a high electric conductance in a charge transfer complex composed of perylene and iodine. Studies of charge transfer complexes have become very active areas of research in Japan.

## **Optional Tour (Excursion) in Tokyo to Central Tokyo: Past and Present**

*\* English-speaking guide service is included.*

*\* The tour contents are subject to change without notice.*

### **March 5, Thursday**

Departure: around 8:40 AM (hotels)

Time Required: 9 hours

Fee: 10,000 JPY per person (lunch included)

#### **Hamarikyu Gardens (60 minutes)**

A former seashore garden of Tokugawa Shoguns with a tidal pond and duck hunting sites, built in the 17th century.

[Hama Rikyu \(http://www.japan-guide.com/e/e3025.html\)](http://www.japan-guide.com/e/e3025.html)



#### **Meiji Shrine (40 minutes)**

One of the largest Shinto shrines in central Tokyo, dedicated to Emperor Meiji and Empress.

[Meiji Jingu Official Website \(http://www.meijijingu.or.jp/english/\)](http://www.meijijingu.or.jp/english/)



#### **A Lunch at the Japanese-style restaurant “Gonpachi” (90 minutes)**

<http://www.gonpachi.jp/nishiazabu/?lang=en>

### **Tokyo Waterworks Historical Museum (60 minutes)**

A museum of unique history of water supply system, back to 17th century in Edo (former Tokyo).

Tokyo Waterworks Historical Museum

(<http://www.suidorekishi.jp/images/index/generalinformation.pdf>)



### **Asakusa (70 minutes)**

One of the oldest traditional downtown areas of commoners with Buddhist temples and shrines.

Asakusa ([http://en.wikipedia.org/wiki/Asakusa,\\_Tokyo](http://en.wikipedia.org/wiki/Asakusa,_Tokyo))

### **Tokyo Station**

A main station in Tokyo first built in 1914, recently restored to the original pre-war condition.

Tokyo Station ([http://en.wikipedia.org/wiki/Tokyo\\_Station](http://en.wikipedia.org/wiki/Tokyo_Station))

The tour will end upon arrival at Tokyo Station.





# Campus Map (Venue)



## Public Transportation Map

- The Ookayama Campus is a 1-minute walk from Ookayama Station
- The Suzukakedai Campus is a 5-minute walk from Suzukakedai Station
- The Tamachi Campus is a 2-minute walk from Tamachi Station

