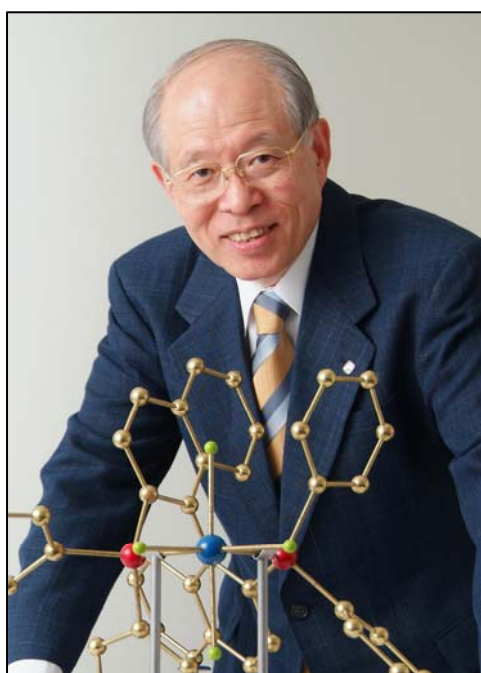


# *An interview with Professor Ryoji Noyori Nobel prize 2001*



Ryoji Noyori is a 2001 Nobel Laureate in Chemistry. Currently, he is President of RIKEN and University Professor of Nagoya University. Born in 1938 in Kobe, Japan, Noyori completed his Bachelor's degree in 1961 and his Master's degree in 1963 at Kyoto University, and immediately became an instructor in Professor Hitosi Nozaki's laboratories at the same university. Noyori received his Ph.D. degree (Dr. Eng.) in 1967 and in the following year he was appointed Associate Professor in the Department of Chemistry at Nagoya University. He spent a postdoctoral period with Professor E. J. Corey (1990 Nobel Laureate in Chemistry) at Harvard University in 1969–1970, and shortly after returning to Nagoya he was promoted to professor in 1972. Noyori served as Dean of the Graduate School of Science of Nagoya University (1997–1999) and Director of the Research Center for Materials Center (2000–2003). He directed the ERATO Molecular Catalysis Project of the Research Development Corporation of Japan in 1991–1996. Noyori was appointed to his current position in 2003.

Noyori is best known for his initiation and development of asymmetric catalysis using organometallic molecular catalysts. The efficiency of the asymmetric catalysts discovered by Noyori rivals—and in certain cases even exceeds—that of enzymes. Applications of his original and versatile chemistry have allowed him and other scientists to achieve truly efficient synthesis of organic molecules of theoretical and practical importance, and technical refinements have led to the industrial production of biologically and physiologically significant substances. His major accomplishments in asymmetric catalysis include the invention of the atropisomeric BINAP ligand; the synthesis of (–)-menthol based on BINAP–Rh catalyzed asymmetric isomerization of geranylamine to citronellal

enamine (with Professors Otsuka and Takaya and Takasago Co.); the discovery of asymmetric hydrogenation of various functionalized olefins catalyzed by BINAP–Ru complexes; its application to the practical asymmetric synthesis of biologically active substances including prostaglandins; the discovery of general asymmetric hydrogenation of functionalized ketones catalyzed by BINAP–Ru complexes; the demonstration of the general utility of dynamic kinetic resolution in asymmetric catalysis; the discovery of a carbonyl-selective hydrogenation method; its extension to asymmetric hydrogenation of simple unfunctionalized aromatic, heteroaromatic, olefinic, and *tert*-alkyl ketones; the invention of chiral Ru catalysts effecting highly selective asymmetric transfer hydrogenation of ketones and imines; the elucidation of mechanistic linkage of asymmetric hydrogenation and asymmetric transfer hydrogenation; the discovery of highly enantioselective addition of dialkylzincs to aldehydes catalyzed by chiral amino alcohols and the elucidation of the molecular mechanism of the chirality amplification phenomenon. In particular, Noyori's BINAP chemistry is being practiced worldwide in research laboratories and in industry. His endeavors are not limited to asymmetric catalysis. Noyori's pioneering study on supercritical carbon dioxide as a reaction media and the discovery of practical hydrogen peroxide oxidations significantly contributed to the promotion of "Green Chemistry". In addition, he devised numerous organometallic methods for chemical synthesis of terpenes, alkaloids, antibiotics, prostaglandins, carbohydrates, nucleosides, nucleotides, etc. Without Noyori's sustained efforts, organic synthesis would not have reached its current high standard.

Noyori's scientific contributions have been recognized with, among others, the Chemical Society of Japan Award (1985), the Asahi Prize (1993), the Tetrahedron Prize (1993), the Japan Academy Prize (1995), the Arthur C. Cope Award (1997), and the King Faisal International Prize for Science (1999), the Wolf Prize in Chemistry (2001), the Roger Adams Award (2001), and the Nobel Prize in Chemistry (2001). He was honored as a Person of Cultural Merit in 1998 and conferred the Order of Culture in 2000.

Noyori is a Member of the Pontifical Academy of Sciences and the Japan Academy, and a Foreign Member of the National Academy of Sciences in the USA and Korea, the American Academy of Arts and Sciences, the Russian Academy of Sciences, the Polish Academy of Sciences, and the Royal Society. He holds 10 honorary degrees and eight honorary professorships from universities around the world.

Recently, Noyori has been deeply involved in administrative tasks related to his responsibilities as President of the Chemical Society of Japan (2002), Chair of National University Corporation Evaluation Committee (2003–), Chair of the Science and Technology Council, Ministry of Education, Culture, Sports, Science and Technology (2005–), Member of the Science Council of Japan (2005–), and Chair of Education Rebuilding Council of Japanese government (2006–2008).

## *The Interview by Professor Pietro Tundo – “Green” Director*

### **1. In the last two years the nobel price has been awarded to scientists involved with catalysis (2007 Prof. Gerhard Ertl, 2006 Prof. Grubb) Why do you think catalysis is so appealing for the scientific community?**

My naive curiosity guided me to catalysis chemistry. In the 1960s, I was an instructor of Professor Hitosi Nozaki's group in Kyoto. In 1966, during a study of the mechanism of carbene reactions, we discovered the first example of “asymmetric catalysis” with a chiral transition metal complex, albeit in a low selectivity. In those days, most organic chemists, except for synthetic polymer chemists, remained indifferent to organometallic chemistry. However, at the start of my independent research at Nagoya in 1968, I decided to pursue what was then a new research field, organometallic chemistry directed toward organic synthesis. The future looked very bright. And my decision proved to be correct.

I recommend that young students tackle a very important, fundamental subject rather than fashionable themes. However, finding an important problem is most difficult; it is much more difficult than finding a good answer to a question. “Serendipity”, namely, good luck, is needed for researchers. Scientific discovery cannot be planned, but neither is it a simple accident. Science originates in the intelligence and sensitivity of individuals. Remember the wise saying of Louis Pasteur, “Fortune favors the prepared mind”.

I am very proud of being a chemist. Chemistry is more than the mere observation and understanding of Nature. By utilizing our accumulated knowledge we can create high-value substances from abundant natural resources such as oil, coal, and biomass. In fact, looking at human history, man-made substances and materials have enormously enhanced our quality of life. In this regard, catalysis is extremely important, because it is the only rational means to produce useful substances and materials in an economical, energy-saving, and environmentally benign way.

### **2. What do you think will be the next big thing in catalysis?**

A measure of the importance of catalysis chemistry is the fact that more than ten Nobel Prizes, including three in this century, have been awarded in catalysis and related fields.

I have long been involved in “asymmetric catalysis”. In fact, we devised a series of chiral molecular catalysts consisting of a transition metal and chiral organic ligand, which allow asymmetric hydrogenation of various carbon-carbon and carbon-oxygen double bonds. Our chemical methods are able to selectively produce a wide range of chiral compounds, either left-handed or right-handed, called enantiomers. Asymmetric

catalysis is important, because the difference in enantiomers is subtle but significant when they are involved in biological or physiological phenomena. Very often, enantiomeric compounds smell and taste differently. In certain cases, a right-handed compound is an excellent drug to cure painful illness, while its left-handed counterpart is highly toxic. Therefore, selective access to single-handed compounds, eliminating “evil twins”, is extremely important. Our method is very practical and widely used worldwide in research and industry for the production of pharmaceuticals, agrochemicals, flavors, and fragrances. We were able to chemically synthesize single-handed antibiotic or anti-bacterial agents very efficiently.

Thus asymmetric catalysis, in its infancy in the 1960s, has dramatically changed the procedures used for chemical synthesis. This approach has resulted in an impressive progression of chemical synthesis to a level that technically approximates or sometimes even exceeds that of natural biological processes.

**3. You have always been involved in sustainable chemistry? Which contribution do you reckon catalysis can give to green chemistry nowadays?**

All of us are asked to not only solve current arduous scientific/technical problems but also foresee the worldwide social trends of our grand- and great-grandchildren. The sustainable society requires permanent and stable forms of energy and radically reduced consumption of precious resources. Although chemical synthesis has reached an extraordinary level of sophistication, there is still room for improvement. We want to synthesize the target compound with 100% yield and 100% selectivity without unwanted wastes. We need the rational program of material saving and recycling that can be made possible through Green Chemistry (GC).

**4. Do you think green chemist can help improve the opinion that people have of chemistry and of chemists?**

Yes, GC is the key to our future, though it is not a new concept. I personally have consistently focused on GC, including catalytic hydrogenation and oxidation, long before this idea received proper appreciation. In view of the inherent significance of man-made substances and materials in civilized society, chemical synthesis will remain important forever. Chemistry must further contribute to the creation of the technologies that will be required in the new society. Therefore, GC is not a mere catchphrase, but an indispensable principle that will sustain humankind. Most importantly, GC needs to be promoted and supported not only by the scientific community but also by industry and all other sectors of society. In particular, governments must exert powerful guidance and provide substantial financial support for research in GC.



**5. According to you what is the most appealing aspect of chemistry? What would you say to a young student to convince him/her to start a career as a chemist?**

RIKEN is Japan's flagship comprehensive research institution for natural sciences. Our research activity is very wide-ranging, including physics, chemistry, life sciences, and a number of technologies. Our missions are to: (1) Pioneer new research areas by carrying out research of the highest quality and integrating the knowledge of various scientific fields; (2) Establish infrastructures of the highest standard for the research community and provide opportunities for their use; (3) Initiate and establish new systems for promoting research in science and technology and nurturing young researchers; (4) Contribute to the improvement of people's daily lives, culture, and education by returning research outcomes to society at large.

**6. Do you think ethical issues should be addressed by science? Do you reckon they should be included in a student curriculum?**

Ethics is extremely important in the scientific community. While science (creation of knowledge) is neutral, science-based technologies have both bright and dark sides. Students of science must have an ethical view and integrity. Academic education alone is not enough for this. In addition, ordinary citizens worldwide must enhance their scientific literacy in this knowledge-based society. Global society is sustainable only if all nations respect one another and avoid unnecessary conflicts. All nations and peoples need to work toward a more comprehensive goal by integrating all possible knowledge essential to our planet Earth.

**7. One last and easy question. Which is the most exciting synthesis you performed in your laboratory as a researcher?**

Our work on molecular catalysis, particularly asymmetric hydrogenation, has allowed synthesis of various theoretically and practically important chiral compounds. I am very pleased to develop our original science to a technological level through collaboration with industry. However, what I am most proud of is that many talented students in my research group have gone on to play an active part in various sectors of society. I sincerely hope that some of them will make significant contribution to the advancement of GC and the realization of a sustainable society. If we can dream today, we can live tomorrow.