

Special Feature
R&D Dialogue



First of all, please tell us about your points of contact between Toray and science.

Abe | It really is an honor to be able to talk science with you Dr. Noyori, a recipient of the Nobel Prize in Chemistry. The results of your research into chirally catalyzed hydrogenation reactions became useful technologies that are widely used in the production of compounds, including pharmaceuticals. I have heard that your contacts with Toray date back a very long time.

Noyori | My family has long had a connection with Toray, or Toyo Rayon as it was back then. My grandfather and Asahiko Karashima, the company's future second chairman, were relatives and childhood friends from the same hometown, and I recollect hearing from my grandmother words that Mr. Karashima reportedly said, "If you lick it, rayon melts like glue."

What sparked my interest in science was Dr. Hideki Yukawa becoming the first Japanese Nobel laureate in the impoverished period right after the end of the Second World War. Many young boys held on to aspirations of emulating Dr. Yukawa, and I, at that time, an elementary school pupil, was one of them. Then, just prior to entering junior high school, my father, who was a researcher at a major chemical company, took me to a presentation on Toyo Rayon's nylon product development, where the president back then, Kikuo Sodeyama, introduced nylon as "an epoch-making product that is made from coal, water, and air." Since that was a time when people had nothing, I was impressed to learn even then that "chemistry is just like alchemy in that it can turn something worth nothing into things of value." This "Nylon Incident" gave me added impetus that led me to get enthusiastic about studying science. Added to

We All Dreamed About

which, as I always used to hear my father say at mealtimes, "The companies with money depend on overseas technology, and that is no good. To get back on its feet, Japan should focus on developing domestic technologies." As I grew up in such an environment, I aimed for and entered Kyoto University Faculty of Engineering, which has strengths in chemistry. I had thought that someday I would like to aim to become a researcher at Toyo Rayon. When

Koichi Abe

Executive Vice President and Representative
Member of the Board
Chief Technology Officer (CTO)
Toray Industries, Inc.

Born in 1953

Completed Master's Degree (Physical Chemistry),
Graduate School of Engineering Science, Osaka
University

1977 Joined the Company (Films & Film Products
Research Laboratories)

2005 Vice President and General Manager of
Research & Development Division

Since 2014 Executive Vice President and
Representative Member of the Board

I entered graduate school, however, I was enthusiastic about research and, having been recommended by the professor supervising my work, chose the path of remaining there with the aim of becoming a researcher. But, after having bounced around from one place to the next, I have become deeply involved with Toray as an outside director over the past four years, so my dream came true, and I am finding it very rewarding.

Abe | What led me to have an interest in science was not some lofty motivation like that of Dr. Noyori, but the *Astro Boy* manga series. A child of science, jet propulsion, 100,000 horsepower, a nuclear-powered hero fighting for justice...I received strong messages that science exists for and contributes to society, and vaguely wanted to somehow contribute to society myself through science when I was older. Later, I attended a public high school where I could choose a mathematics and science course from the first grade. The science classes there were not centered on classroom lectures, but a repetitive experience of experimenting by replacing basic principles with macro models. My teacher at that time would give fervent speeches about famous sayings from Nobel Prize winners, and I remember one that seemed to resonate with me in particular was something that Pasteur is supposed to have said: "Chance favors the prepared mind." I interpreted this as "Lady Luck smiles on those who continue to be aware of problems," and that is still my motto. Also, when the teacher gave us a problem of estimating the number of soybeans packed into a plastic case, you run out of time if you try to calculate it properly. I was taken aback by this. In fact, it taught the importance of intuition. Those kinds of unconventional courses aroused my curiosity about science all the more.

In my university days, as a researcher, I had knowledge hammered

Becoming a Scientist

into me, such as "Predict the answer before experimenting. The experiment provides confirmation," "Before conducting an experiment, think carefully about whether the experiment is really necessary," and "If you conduct a two-hour experiment, take at least twice as much thinking time in the laboratory." One day, by changing an experiment's procedure, a phenomenon completely different from the conventional prediction had occurred, and the professor supervising my work told me "We are having a company to file a patent application for your research." That company was Toray.

It was with that kind of relationship that I joined Toray and was initially assigned to the Films & Film Products Research Laboratories. Here too, little things I became aware of and an awareness of problems when conducting one research theme provided hints for setting the next theme. At Toray, key phrases like "The deeper, the newer" and "Pursuit of the ultimate limits" have been handed down over the years, but the result of having instilled them in me was that we developed the thin film lamination technology for magnetic tape, New Surface Topography (NEST), for which we won an Okochi Memorial Production Prize.



VALUE CREATION

Ryoji Noyori

Outside Director, Toray Industries, Inc.

Born in 1938

Graduated from Kyoto University

Doctor of Engineering, Distinguished Professor, Nagoya University

2000 Received Order of Culture from Japanese Government

2001 Received Nobel Prize in Chemistry for the development of chirally catalyzed hydrogenation reactions

Since 2015 Outside Director, Toray Industries, Inc.



Intense tenacity is a strength based on a typically Japanese trait, and this the biggest barrier to entry for new market entrants.



In what areas do Toray's R&D fortes lie?

Abe | First of all, Toray doesn't express research and technological development as the one combined term in Japanese, unlike such as R&D in English, and always puts a break in between, research and technological development. Research is like creating one from zero, in other words akin to digging a well, whereas technological development is recognizing that you will fabricate a target quality product in a fixed time for a fixed cost. Having made the distinction between research and technological development in this way, we build one-package systems in which these elements are not divided into two and that I manage in my capacity as general manager of the Technology Center or CTO.

Secondly, at Toray, we identify the value of materials with a broad vision of the times and have that culture of persistently pursuing the ultimate limits with a focus on basic research attitude. In global competition, this intense tenacity is a strength based on a typically Japanese trait, and I consider this the biggest barrier to entry for potential new market entrants. As exemplified by carbon fiber, which became the main structural material for aircrafts more than half a century after the start of research, the culture of commitment to the "Pursuit of the ultimate limits" has built up a host of successful experiences and we continue to reap the benefits to this day.

Finally, the reason why we have a Technology Center is to integrate Toray's research and technological development functions and bring together experts from a variety of fields. The existence of this organization enables the development of advanced materials created in one field to be deployed in other fields. Occurrences of fusions of technologies are also facilitated. One example is the "DNA Chip," which is expected to detect various types of cancer from a small amount of blood and was created by the shared knowledge of biotechnology and nanotechnology experts. Also, to solve the problems associated with carbon fiber and water treatment membranes, we are demonstrating our

comprehensive strengths by utilizing technologies and knowledge from different fields to solve issues in one business field, such as the medical-field researchers who are lending their support to organic synthetic chemistry technologies.

Noyori | Toray has earned a very high level of trust from society by having each of its businesses provide products based on proprietary technologies. It might well be that Toray's comprehensive strengths, in which a wide range of knowledge and technology can bring about innovation across businesses, are a feature unrivaled by other companies. However, in unforgiving competition with European and U.S. companies, which always follow bold selection and concentration policies, and Asian companies with their low-cost production capabilities, Toray must be careful not to expand its business domain too far so that its relative competitiveness is not lost.

Abe | I agree with you. If researchers were to be given a free rein in the setting and management of research themes, management resources would be scattered and research efficiency would decline, making it impossible to win against fierce competition. Having said that, in maintaining technology-based management having an environment that draws out the free ideas of researchers is of absolute necessity. This we thus call "underground research," and at Toray, researchers are encouraged to spend about 20% of their working hours conducting discretionary preliminary experiments and investigations without reporting them to their supervisors. Carbon fiber and my development of NEST arose from underground research.

However, when moving from the research stage to the development stage, because we will create a pilot plant and need a lot of raw materials and people, it is impossible to do everything. Deciding what to invest in is the real thrill of management, but since it is a very hard decision to make, I make a point of making a judgment after trying as much as possible to quantify the extent of its value. Moreover, since this is an age in which our integral technologies are being caught up in the blink of an eye, we carefully examine whether it is a theme that would enable us to demonstrate Toray's strengths in the years to come, not just transiently. Priority is also given to those themes that have a high affinity with Toray's business and technological foundations and that cannot be built overnight. I call this "appropriateness for the Company" and is something to which I attach great importance. We are advancing to development stages when we can build up an exact picture of where to get value for money from the technology, where we could earn income in the value chain and how to build a business model that minimizes risk and maximizes return.



It is said that it is difficult for innovation to happen in Japan. What are your thoughts on this issue?

Noyori | Japanese companies are often said to "win in technology and lose in business." Since projects do not advance to the development stage despite their high potential and are poorly converted into value, Japanese R&D expenses tend to be perceived as costs rather than investments. Just because a project did not reach the commercialization stage, however, does not necessarily mean that the technological level was inferior, and there are many "premature inventions"

that the times have not caught up with. If, a few years later, an idea were to undergo huge transformation outside the company that had first thought of it, that would be a story of extreme wasted effort.

We should not be passive with regards to markets, but instead gather information, look out across the world and proactively make proposals that make use of our inventions and technologies. Japanese companies have keen “insect eyes” to view one thing intensely and precisely, but I think we have more of a need to develop “bird’s eyes” to have a panoramic, bird’s-eye view of things and “fish eyes” to sense as yet unrevealed phenomena and signs.

Then, as we enter the age of “value co-creation” on a worldwide basis, there is another problem in that Japanese people are not aware of the differences between groups and teams. A group has the meaning of a “flock” that occurs spontaneously based on homogeneity, whereas a team is an “organization” that has an artificially defined purpose. Since the traditional Japanese spirit of “doing something while maintaining precious harmony” has its origins in flocks, this exerts great influence in social stability and in the execution of routine tasks. However, the power of multiplication to create new value does not emerge from a homogeneous group. Solo musicians and vocalists are good in music, but in an orchestra format you have to bring together virtuosos for performances on a variety of musical instruments. And it will take an excellent conductor to hold them together. Unlike tug-of-war competitions, baseball and rugby games need players with different roles in order to win, and team lineups that are rich in diversity are essential. To speed up innovation, Japanese companies in particular should be aware that selecting different people, not closed groups, forms winning teams. Because Silicon Valley is able to do that, startups succeed. They benefit from investing in innovative ideas, bring together diverse talent from around the world with that capital, and create the strongest teams.

Another thing I would like to add is that I think science and technology also requires art, or perhaps I should say, an element of sensitivity. At advanced technology universities, not only in Europe and the United States but also in Asia, there is an increasing number of art departments that inspire sensitivity. There are many Toray researchers with excellent STEM (Science, Technology, Engineering, Mathematics), but having added Art, the people who possess a sense of STEAM will become indispensable for future business development.

Naturally, company research should be conducted not for solving immediate problems but for creating new value for the future. Society is vast. Researchers and engineers tend to attack a research theme with established logic, but unless they possess the “creativity” to provide “imagination,” they will not be able to create things the world wants. In that sense, the approach that says an expert will realize something with the ideas from an amateur is also important. Isn’t it also important, however, to adopt various sensibilities and think about innovation with soft ideas, such as from sales and marketing departments that are in contact with customers on a daily basis, people who are sensitive to life or employees who attended art schools who possess more keenly developed intuition and “feel”?

Abe | To respond to Dr. Noyori’s suggestions, Toray is now in the process of building the R&D Innovation Center for the Future and is aiming for its completion in December 2019. The Center



To win in business, Japanese companies should be aware of forming winning teams rather than closed groups.

will consist of an integrated research building, which will fulfill an ideas creation function, and an experimental research building that will promote the prototype production, assessment and demonstration of products developed on the basis of those ideas. The plan is for the Advisory Board to also welcome people from the areas of humanities and social sciences. Instead of the Center serving just as a technological development base for *monozukuri* (manufacturing), we are exploring the functions and mechanisms necessary for the future society and trying to conduct *kotozukuri* (the creation of added value) using the strengths of materials. The Center will also fulfill an innovation hub function, such as an international conference hall, exhibition/demonstration area, and open lab, and accelerate strategic open innovation through exchange, fusion, and collaboration with academia and important partners in various fields.



Please tell us more about the importance of open innovation.

Noyori | The days when a company could singlehandedly undertake everything, from research to technological development, have passed. In the pharmaceutical industry collaboration with external research institutes and startups has become commonplace. Innovation has a difficult birth from the traditional large companies with entrenched organizations. What is effective instead is an “ecosystem” in which various structural elements function cyclically and efficiently, like the ecosystems in the natural world. In other words, as a strategy, it is important for Toray to regard its own technologies as the core, to create high value-added products while utilizing external technologies and capital, and build the mechanisms to continuously generate revenue. The Toray Technology Center is not a place to lock up the accumulated knowledge and technology in a safe. To bring about innovation, Toray should actively promote not only internal use but also the integration of technologies with the outside, and I think that Executive Vice President and CTO Abe’s role, in the control tower overseeing operations, is of great importance.

Abe | I think Toray originally had an ethos of what we now call open innovation, but around the year 2000, the Company was particularly concerned about self-sufficiency. However, in the fiscal year ended March 2002, when Toray (unconsolidated) recorded a loss in operating profit, we earnestly reflected on that particular commitment and established the New Frontiers Research Laboratories in 2003. However, looking back, the basic invention of carbon fiber was that of Dr. Akio Shindo of the Osaka Technical Research Institute (now the National Institute of Advanced Industrial Science and Technology (AIST) Kansai). Toray quickly realized its value, received a patent license, and has persistently continued research and technological development. I think this is exactly what open innovation is all about. I would like to reaffirm that kind of activity and thereby bestow a meaningful function on the R&D Innovation Center for the Future.



In the sense of science for solving social issues, the marine plastics pollution issue is coming under intense scrutiny. Please tell us about the efforts that Toray is making in this regard.

Abe | Resolving the marine plastic pollution issue is positioned as a priority theme at Toray. However, just because something is made from biodegradable plastic, it does not mean that it will easily biodegrade when thrown away into seawater. The misunderstanding that plastic immediately biodegrades may conversely encourage more dumping. Giving consideration to such possibility, Toray is focusing on recyclability. For example, most packaging bags commonly used in supermarkets are plastic films but they are made in combination with multiple materials. By reducing the material to one type of film, we believe that recycling would be greatly encouraged.

Noyori | There is an increasing demand for materials that contribute not only to innovative functions, but also to a recycling economy. This is because the more useful the product, the more its negative impact, such as in the form of environmental problems, tends to increase. Research to efficiently produce oil-derived structures that realize breakthrough functionality will continue to be important. On the other hand, since Toray is a company that provides materials to all industries around the world, I think that it has a social obligation to make effective proposals for environmental problems, including marine plastic pollution, by the power of materials. In addition, because Toray advocates that “materials can change our lives,” as a Toray supporter, I would like the Company to formulate and address “what should be done,” not at the level of doing “what can be done,” but in a leading role in solving these global issues.



What are your thoughts on human resource development that contributes to the world with the power of science?

Abe | Researchers and engineers who have made great achievements at Toray are not passive, have a high sense of purpose and mission, and are able to actively think and work, but they also are “people with extensive expertise backed by basic scientific capabilities.” However, the recent trend

at universities is that specialized fields have become limited and more extensive, but even after completing a master’s program in polymer chemistry, it seems that the basic scientific ability to see the entire picture, including the surroundings—the “bird’s eyes” that Dr. Noyori mentioned—seems to have declined. In the meantime, it has become no longer possible to create major new products from a single technology, and it remains difficult to produce significant results from research conducted in isolation. Moreover, the major subjects at universities and research themes at companies do not always coincide. Thus, people who can see things with “bird’s eyes,” who possess multiple areas of expertise, even if they are not the same depth, and who know the key points to look for when approaching unknown fields, are producing great results. These are the types of human resources on which we are focusing development.

To create a climate where one could concentrate on research and technological development for a long time, and in which young researchers could work hard to become “research professionals,” Toray established a Research Fellow System in 1992, and an Engineering Fellow System in 1998. We bestow the titles of Research Fellow or Engineering Fellow on research and technological development engineers who have achieved breakthroughs that have contributed to the Company or have demonstrated their professional leadership in either of those fields. As an effect of this, there are people with proficient skills at Toray. We have also compiled a collection of successful cases called “How I Proceeded with My Research,” about how breakthroughs have come about, and are making efforts to pass them on.

Noyori | People are drawn to people. Rather than learning what kind of a product was made, people are more interested in the routes taken to bring about success. I think it’s very good to pass on the efforts of successful people.

In my experience, the owner of an original idea is not necessarily an excellent student who can do anything, or a student with high academic grades. Rather, the ideas and behavior of honors students are said to be similar. It is a problem if everyone is outside the norm, but in making something that does not yet exist, you cannot ignore the ideas of eccentrics and stubborn researchers. I think that non-standard ideas will arise from those who have been self-taught since they were young and are in the habit of self-study. For that reason, it is not easy for them to abandon pet theories and they tend to be isolated in an organization, but regardless of that I think that it should be Toray that trains the non-conformists of this world.

In addition, it is clear that we are heading to an era in which data will be known as the second oil resource, and AI and big data will exert their influence. In that respect, it has become important to secure and train human resources who are strong in mathematics and statistics. As far as researchers are concerned, there was an awareness that digital technology is a means to do things efficiently, and that digitalization and systemization are somehow alien to a world of steady manual labor like chemistry. But this belief should be revised. The evolution of IT has enabled exploration with orders of magnitude and speed. In 10 years’ time, the chemical industry map will be filled with the colors of the



If you want to become a researcher, you will need the spirit to make a big hit.

Koichi Abe

companies that are data driven. Throughout the Company, Toray should aim to be the market leader in the new information-oriented society.



Finally, as a message to the researchers and engineers who will be leading the coming era, please tell us what kind of human resources Toray is seeking.

Abe | In the words of our late honorary chairman, Katsunosuke Maeda, Toray is seeking for human resources who “have a discerning eye for change and possess the power to see through the essence of the matter” and are capable of “independently tackling their own issues head-on.” This has not changed and will not change. On top of that, I think that even a company with sales exceeding ¥3 trillion will start to decline if it loses its spirit as a collective of startups. To be honest, in the past, I was researching films with the spirit of “making a big hit.” I still feel that pioneer in me saying, “I will change Toray with my own strength. I will change the world with my own strength.” I would like everyone to possess that degree of fearlessness.

Noyori | I would like young people who are full of intelligence and sensibility to fully recognize the current trends in a world where the way things are in modern civilization are being questioned, to fully utilize their talents upon coming to Toray. Toray is aiming for global recognition as an excellent company. Based on Toray’s philosophy that is similar

I would like scientists to live in a world they themselves have created.

Ryoji Noyori

to CSV (Creating shared value), which balances economic profit activities and the creation of social value, the company is staking its future on the Green Innovation Business Expansion Project and Life Innovation Business Expansion Project. What is meant by life here?

Toray should aim not only for innovation for life but also for innovation of livelihoods and lifestyles. These will become possible only after reflecting the will of society. There is a host of opportunities for Toray to do that.

I know from personal experience that science makes great contributions to society and is a truly rewarding life occupation. I would like young scientists who are breaking new ground toward the future, to live in a world they themselves have created, not one given to them by others. Possessing that spirit, I hope that they can depict the future society the way it should be, by cooperating with a variety of people.

As one of the Company’s directors myself, I am aware of my responsibility to those who will be responsible for the future of Toray. Yoshikazu Ito, who himself developed a nylon manufacturing method utilizing photosynthesis, and changed the company name from Toyo Rayon to Toray after taking office as president, and focused on developing business in the non-textile sector, said, “It is easy to just improve business results over the short term. The president’s job is to sow the seeds for the generation after next.” This spirit of management has been passed down to Toray’s current president, Akihiro Nikkaku. I, too, would like to support management with that kind of spirit.