Epilogue

I wonder what kind of impression you had after reading this book. Many of you might have thought, "Is it true?" or "I have never heard of this; besides, it sounds like it is fake," or "How come other countries are not doing this?" or "Why does the government not pay attention to this if it is that good?" and so on.

Strangely, we have a habit of labeling things that nobody did before "fishy." A famous Japanese scholar once grieved that "in our country there are excellent horses but no horse dealers." A horse dealer is a person who raises horses. In terms of science, it means that there are advanced researchers who have the potential to be scientific leaders in the world, but there is no environment available for nurturing them.

A new idea does not look so good at first. Therefore new research is an easy target if someone is trying to criticize it because it might have many weak points. However, incremental research looks fine because the base research has already been improved by many people.

When a young scholar gives a research talk, influential figures, who brag about being scientific leaders in Japan, ask trick questions that the young scholar cannot answer, so that they can show what great scholars they are. For the influential scholar things are over at that point and nothing is left behind from this experience, but the shock the young scholar experiences is great and spoils his or her potential.

In that respect I have a strong and rare nature; no matter how I am criticized, I can forget it in a few days. What I experienced 30 years ago is a good example. I developed a new computational technique, but the response was exactly the same as what I wrote at the beginning of this epilogue. I heard from a scholar overseas that

when he asked a Japanese scholar, "What do you think about Yabe's method?" the answer was, "I do not have a particular reason, but I just do not like it."

After that kind of response continued for more than 10 years, in 1999, I was asked to deliver the commemorative invited lecture of the British Royal Institution at its 200th anniversary. The response in Japan has changed completely since then. Gradually people critical of the method disappeared, and now my technique can always be found in numerical computation books.

The response I received when I announced in public the idea of a "magnesium society" is very similar to the one I had 30 years ago, and I feel as if I went back in time. At the same time I feel that recognition from foreign countries is indispensable for the realization of this vision.

However, things are different from how they were 30 years ago, and the time for change seems to have come unexpectedly early. One of the reasons is that I was introduced by magazines known globally, such as *Nature* and *Time*, with very good comments. But even more significantly, the completion of the device came true and we were able to show it in a visible form.

In my mind, the magnesium society is a society that has already been established, anyway. There will still be some problems with small technical issues or production methods. But they will not amount to much. The machine for practical use has already been completed as a desalination/water purification device. It has exactly the performance we estimated, and if this spreads, it could change the world dramatically.

The solar-energy-pumped laser and magnesium smelting are closer to completion. In addition, magnesium smelting has reached as high as 70% purity. This should be enough for fuel.

Because of the patent protection, I allow students to talk, at the university or outside, only about the results that do not look so good. As easily expected, the other instructors criticize the students: "Is

the cycle possible with such low efficiency?" meaning, "I told you so." In the current Japanese environment, this is a typical example of denying an idea of a student in the middle of research.

That reminds me of an example from more than 20 years ago—the opinion of a group of professors from a famous university: "The solar battery will never work because the large amount of energy needed to make it cannot be collected from the sun during the lifetime of the battery." I remember that I said at that time, "We do not need to be that pessimistic, because the technology will advance." This became true; they say that in three years a solar battery can collect the energy that was needed to make it. This is a good example that we should keep in mind. Unless a technological problem is related to an absolute limitation, such as solar light not being able to generate more than 1 kW/m^2, it will one day be solved.

Furthermore, we are receiving domestic and international business proposals and support, and the funding is becoming abundant. Some pieces of the whole system have already become part of the business world, and the disagreeable comments are becoming meaningless.

In this case, the encounter with Tatsuya Yamaji, a writer/editor, was good fortune. I found the perfect partner who can describe our technology to the world from the viewpoint of liberal arts. In addition, Shoichiro Kishi, of PHP Publisher, offering to publish the book just at the right time is something more than a coincidence.

Besides I felt a mysterious connection when I found out later that the logo of PHP Publisher is Pegasus, the same as the symbol of our desalination device (*Pegasos* in Greek).

I had many such lucky encounters in the past. This is greatly related to the career path I had chosen.

I graduated from Tokyo Institute of Technology and became an assistant. If I had stayed there, I might not have had any hardship in my career. At that time, I was attracted to the laser fusion research performed at Osaka University, and during a conference I said to

Professor Chiyoe Yamanaka, director of the Laser Fusion Research Center, "I would like to be your assistant". I left Tokyo Institute of Technology and went to Osaka University. The research at this center built the foundation of the magnesium cycle research that I conduct today.

In addition, after the director Yamanaka retired I applied, at age 38, for a professor's position at Gunma University. It is common to wait for a professor position until around age 45. A colleague at Osaka University wondered why I was leaving an imperial university for a local university. I was trying to be free from being one of the gears in a huge project, laser fusion, because I wanted to concentrate on the computational method that I had devised.

I intended to keep on living in Gunma, but I received an offer to return as a professor to Tokyo Institute of Technology, my alma mater, and this is how I reached where I am today.

Let me mention some names here, even though the list is long, because the relationship with these people is significant in my history.

I have friendship for 30 years, both officially and privately, with Professor Kunio Yoshida, who was a colleague during my time at Osaka University. I feel the wonder of the encounter that Professor Yoshida was the one who prepared the laser medium for solar-energy-pumped laser and nonreflective coating technology.

At Tokyo Institute of Technology, the CIP method was completed with the collaboration of my former students, Associate Professor Xiao Feng, Tokyo Institute of Technology; Associate Professor Yoichi Ogata, Hiroshima University; Associate Professor Takashi Nakamura, Tokyo Institute of Technology; and Dr. Kenji Takizawa (now a key research scientist at Rice University, Houston, Texas). Because of the completion of the CIP method, I could have a productive relationship with industry and was able to get advanced information and brush up my business sense. In recent years, Shigeaki Uchida, special appointment professor, and Eiichi Matsunaga, Tomomasa Okubo, Choijil Baasandash, Yuji Sato, and Yasutaka Sakurai,

postdoctoral researchers, stayed at the university to complete the basic technology for the magnesium cycle. In addition, the secretary, Mamiko Shinohara, dealt with the university office work swiftly so that we could concentrate on our research. I should not forget that many students willingly participated in difficult experiments.

I received great fiscal and technical support from collaborators in the business world, Takayuki Okamoto, president of Okamoto Optics Work, Inc., and Yoshiaki Okamoto, managing director of Okamoto Optics Work, Inc. We have known one another since my days at Osaka University. Without their world-eminent technology, the improvement of the laser would have been impossible.

Toyota Tsusho Corporation gave us generous funding, and there was much support from those, including Akitoshi Morita (currently at Toyotsu Material), who served as a bridge in obtaining a large amount of funding.

For the experiments, I received great cooperation from chief director at Chitose Institute of Technology, Takaaki Koyatsu, President Hiroyuki Sasabe, Professor Kiyoshi Kato, and Chitose City Hall and from people at Takenaka Corporation. For the next plan, the Kochi prefecture harbor section, citizens of Miyako-jima Island, and city hall workers offered a warm invitation to us, and we are examining that now.

Media reporters, *Sankei Shimbun* (newspaper), *Nikkei Shimbun*, *Nikkan Kogyo Shimbun*, *Tokyo Shimbun*, Kyodo News Enterprise and NHK, TV Tokyo, and others covered our research. Especially Shigehiko Nakajima had a good relationship with us for 20 years through *Nikkei Shimbun* and *Nikkei Science*.

The companies that set desalination as their main business are strongly promoting the magnesium-related business and are growing now. The top runner is President Motohiro Yoshikawa of Pegasos Electra Co. Ltd., Hozumi Yagioka, Michikazu Kumada, and Yutaka Koide are supporting him, and great helper Toshihiro Hirosaki, president of Ask Planning Center Inc. is supporting the construction business in foreign countries.

Like a speech at an Oscar ceremony, I listed the people who took care of us, and without their support the magnesium cycle business might not have been realized and we could not have expected the development for the next 20 years.

Finally, I should not forget Setsuko, my wife, who always looked after me gently and gave me the driving force to rebuff the criticism in the world; my two daughters, Kyoko and Eriko; my granddaughter Hinako, whose lovely smile makes my heart warm; Kotaro, our dog, who is always next to me; and our first dog, the late Rintaro. This family support nurtured the new idea that is unique in the world and helped me establish an enterprise. Thank you all.

Afterword

After the original Japanese book was published, various changes took place.

The development of the magnesium–ion battery is now growing in various places over the world, and a new type of magnesium air battery has appeared demonstrating 90–96% efficiency. The magnesium air battery was abandoned because the surface of the magnesium is soon oxidized and only a thin surface layer can be used. This prevented a high-efficiency battery from coming into effect. Then appeared the technology to automatically get rid of the oxidized layer, and a long-time obstacle was removed.

The efficiency of the solar-energy-pumped laser is greatly improved, and we are able to get 100 W class output even with a size that is 4 mm in diameter and 5 cm in length, which is one-tenth of what was used in 2008. The output is transported through an optical fiber for a long distance from the laser device, and the laser from the fiber cuts the steel plate. A very high-quality Fresnel lens of large size is now ready for experiment in collaboration with Dr. Hitoshi Oomori at the Physico-Chemical Laboratory, and we expect a two times larger solar input to the laser medium.

The project is now strongly supported by Recep Ozkan (president of JIG Corporation) and Muratbek Rustambekov (representative in Uzbekistan of Technopian Corporation) toward the construction of large-scale pilot plants in both Turkey and Uzbekistan.

Takashi Yabe

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