An E-Conversation with Prof. Tadashi Matsunaga, President of Tokyo University of Agriculture and Technology

Subhas K. Sikdar

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Prof. Tadashi Matsunaga earned his Ph.D. in biotechnology from Tokyo Institute of Technology. After serving as Research Associate in Miami (USA), he joined the Tokyo University of Agriculture and Technology as Associate Professor. He was promoted to Full Professor in 1989, served as Vice President from 2007 to 2011, and now serve as President since 2011. Prof. Matsunaga's main research areas are Marine Biotechnology, Bioelectronics, and Biomagnetics. He published over 350 international scientific papers, authored or has been involved in about 100 books, holds more than 200 domestic patents, and 60 international patents. He received the Carnegie Centenary Professorship, honorary degree of Doctor of Science from Heriot-Watt University in Edinburgh (UK) in recognition of his contribution in the field of Marine Biotechnology, and the several awards including prizes of Chemical Society of Japan and Japanese Society for Bioengineering, and Bioscience.

(Subhas Sikdar) Tadashi, you have spent the years so far in this century in administrative positions at your university of which you are now the President. But through all your professional life you have been known as a prominent biotechnologist. Along with electronics, nanotechnology, particle physics, and cosmology, biotechnology has been enjoying, for quite some time now, an explosion of knowledge creation. Since ours is a journal devoted to clean technologies and sustainability, I would like to know your views on what you see as the emerging areas in biotechnology that can improve our living standards other than the obvious field of pharmaceuticals.

(Tadashi Matsunaga) Biotechnology is the use of living organisms for improvement of human life and environmental protection. There are medical, pharmaceutical, agricultural, environmental, and other industrial applications. The history of biotechnology had started in the ancient time. Human beings have used fermentation for liquor, cheese and yogurt production, and for preservation of foods. Plant culture, domestication of animals, and their breeding are also included in old biotechnology. Biotechnology saw rapid expansion in the late 20th and early 21st century. Recombinant DNA technology, genomics, proteomics, cell culture and fusion, and their industrial applications have emerged in this period. I am interested in environmental and industrial biotechnology. Waste water treatment and bioremediation are included in environmental biotechnology. Industrial biotechnology involves chemical, material and fuel productions, and bioelectronics. Plants and microorganisms are used for environmental and industrial biotechnology. Biotechnology has been applied to not only environmental and industrial fields but also to health care and food production. Human health care consists mainly of the medical application of biotechnology.

S. K. Sikdar (✉)
Cincinnati, USA
e-mail: sikdar.subhas@epa.gov

For example, new biopharmaceuticals have been made by genetically engineered organisms, genetic testing has been used for diagnosis of human diseases and so on. Biotechnology has indeed improved the standard of human life so far.

(SKS) *Just to continue on environmental applications, biological methods indeed have been in use for waste treatment and cleanup for a long time. Thinking of preventing pollution, what are the significant trends that you see where biotechnology shows promise? Also, on sustainable alternatives to current methods, where do you see successes of biotechnology in food (such as synthetic proteins), fuel (such as aliphatic alcohols, diesel etc.), and chemical production (such as polyhydroxy alkanolic acids and their esters etc.)? Are there examples where application of biotechnology has become an unwise decision in this regard?*

(TM) There are many kinds of pollution including air and water pollutions and soil contaminations. Pollutions and contaminations are mainly prevented by regulation. Regulations are very important for control of industries and individuals. Sensing technologies are useful for regulations. Biosensors are one sensing technology that uses living organisms and proteins. Bio-fuel is an important application of biotechnology. Ethanol, biodiesel, and methane are included in bio-fuels. Ethanol is produced from corn, sugar cane, and potato by yeast and bacteria. Biodiesel is produced from palm, coconuts, soybean, and sunflower. One big problem is that their production competes with food. Therefore, bio-fuels are beginning to be produced from agricultural and forestry wastes recently. Micro and macro algae are also used for bio-fuel production. Production of bio-plastics such as polylactides (PLA) and poly(3-hydroxybutyrate) (PHB) has become important area of biotechnology. Production of bio-fuels and bio-plastics may contribute to lowering carbon dioxide emissions, and help us reduce our heavy dependence on petrochemical industry for most things.

(SKS) *You indicated that it is desirable to move away from feedstocks, which are used for food products, toward non-food agricultural outputs or wastes. Brazil so far successfully used sugar from sugar cane for making ethanol. Is it always wrong or are there some overriding rationale for doing so in some circumstances? What are those circumstances? In your judgment, is sugar from corn ALWAYS a bad idea?*

(TM) It depends on timing and place. It is not always a bad idea. However, we have to develop new methods for fuel production. Especially, we should find a new method which is cost-effective.

(SKS) *Some efforts have been seen in developing technologies for capturing carbon dioxide from coal-fired power plants emissions. Is this a promising application?*

(TM) Many efforts have been done for lowering carbon dioxide emission. Carbon dioxide from coal-fired plants emissions can be directly removed by microalgae. But huge land space is needed for complete removal of carbon dioxide by microalgae. Further research is required for practical application.

(SKS) *Has CO₂ capture by microalgae been tested at a large pilot scale in Japan? Suppose the capture can be efficiently conducted at a coal-fired power plant, and further suppose we have also succeeded in separating the fat (triglycerides) from the cells. What do you see are the challenges to make it commercially viable? In other words, what bottlenecks must be removed, and what do you see happening in research in this area?*

(TM) Small pilot scale experiments of CO₂ capture by microalgae have been done in Japan. But huge pond or bioreactor is needed in order to capture most of CO₂ from electric power plant. This experiment has not been conducted in Japan. We may use sea for this purpose and many regulations prevent pilot scale experiment in sea.

(SKS) *How do you think biotechnology is creating synergy with other scientific and technological fields for newer solutions to environmental and societal problems?*

(TM) Biotechnology has created new fields with information technology (IT), robotics, and device technology. Bioinformatics has become an interdisciplinary area which addresses biological problems with IT. Bioinformatics plays an important role in genomics, proteomics, and structural biology. Medical and nursing robots have been developed. Various medical devices have been used for diagnosis of diseases.

(SKS) *Can you please give some examples of these advances, keeping in mind we are focusing on environmental applications and sustainability?*

(TM) One typical example of these advances is automated genetic analysis. This is accomplished with combination of biotechnology, IT, and mechanical engineering. Human cells are collected, and DNA is extracted from cells automatically with DNA extraction apparatus. Then, DNA is analyzed by DNA sequencer and gene sequence is determined. Gene sequence is compared with DNA data base and analyzed. Medical diagnosis is made based on individual genetic analysis. This information is useful for human health care. This technology will be applied to environmental analysis. Animals, plants, and

microorganisms will be genetically analyzed and compared with data base. Environmental diagnosis will be made in the near future.

(SKS) *Is it too early to speculate some environmental applications in specific terms? Can you give us some concrete examples for environmental protection?*

(TM) Metagenome analysis is one of examples for environmental application of biotechnology. It is the analysis of genetic materials directly collected from environmental samples. Genetic materials from environmental samples mainly consist of DNAs from various microorganisms. Especially, rDNA sequences show diversity of microorganisms in the environmental samples. This analysis indicates how water and soil samples are contaminated and polluted with various chemicals. This will lead to prevention of environmental pollution through regulation.

(SKS) *Now a question about environmental impacts of agriculture. Agricultural as the primary source of food materials is a must for all nations, especially Japan. Generally the known environmental concerns here are loss of biodiversity, nutrients in runoffs contaminating rivers or groundwater, spread of pesticide, and herbicides in the environment. Do you foresee any dramatically improved methods of agriculture that can in the future may rid agriculture from many of the adverse effects on the environment? What are some of these potential approaches?*

(TM) In Japan, appropriate amount of nutrients, pesticides, and herbicides has been used and heavy

contamination of rivers and groundwater has not happened. We have faced environmental pollutions by industrial chemicals rather than nutrients and agrochemicals in 1970s. Since that time, strict regulations have been adopted, and water qualities of rivers and ponds have improved very much. Air pollution has also been prevented by regulation of automobile and industrial exhaust gasses.

(SKS) *One last question. It has been three and half years since the great east Japan earthquake and tsunami, which resulted in the loss of many human lives, although no one has died because of radiation exposure from the Fukushima Daiichi accident. Has the investigation into the effects of radiation release on the food chain been completed yet? What about the overall environmental impact?*

(TM) The great east Japan earthquake was a big disaster for Japan. The earthquake and tsunami caused severe damage including damage to buildings, roads and railway, and fires in many areas. More than 15,000 people died. The tsunami caused nuclear accidents in the Fukushima Daiichi Nuclear Power Plant complex. Nuclear reactors suffered from explosions due to hydrogen gas after cooling system failure resulting from the loss of electric power. The evacuation zone has affected hundred thousands of residents. The investigation into the effects of radiation release has continued and many people cannot come back to their home yet.

(SKS) *Thank you, Tadashi, for agreeing to this e-conversation. This is most appreciated.*