TECHNOLOGY'S NEW HORIZONS

Conversations with Japanese Scientists

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FOREWORD

Professor Richard L. Gregory, University of Bristol

These interviews with Japanese engineers are a revelation, at least for Western readers. Each interview gives a résumé of the distinguished individual's background interests and working philosophy. There are, also, many suggestive comments on the Japanese view of their culture, and its relations with Europe and America. One senses the growing confidence since the last World War of the Japanese ability to initiate, as well as improve and produce products with technical excellence. It is hard to resist a Japanese car! It just keeps on going and going.

Takanori Okoshi from reading philosophers such as Kant, Schopenhauer, and Nietzsche, turned to seeing the light for optical communication technology. Realizing that existing microwave technology was of the wrong scale, he transferred its technology to fit the wavelengths of light. This was associated with the pioneering work of the Bell Telephone Laboratories in America, but there is no doubt that the Japanese contribution was fundamentally important, and is having incredible impact on human and computer world communication.

Yasuharu Suematsu contributed to the essential source of optotechnology systems—suitable lasers. There is a fascinating account here of matching the laser to fibres and/or matching fibres to available lasers. One senses that these decisions (sometimes made from anticipated but not yet proved discoveries) have immense consequences financially, and for the long term future. It must be a tremendous headache to work with rapid innovation and at the same time produce effective state-of-the-art devices. If only the public appreciated these battles, wrestling with Nature—which are surely more exciting than war games or real wars. Yet, Yasuharu Suematsu says that: 'It may surprise many Westerners that, even in Japan, technology is by no means regarded as the basis of civilization.... Engineers are simply seen as people who beaver away making things. The leading figures in our society are lawyers and economists who see technology as only another way of making money.' This is worth pondering.

Hioroyuki Sakaki leads us to 'the last frontier of electronics'. This is incredibly dramatic, as it leads to an ultimate goal of physics. He describes the restricting of electrons from three dimensions to two, to one—then envisages how a single electron could be captured and imprisoned in a minute box—so far too small even for Japanese fingers to make! This possibility has come from his discovery of quantum effects at room temperature. Here we see fundamental physics and state-of-the-art technology converging, to meet at a point that no one can predict. It may allow computers to read with the smallest possible unit, single electrons; it may reveal new quantal principles when the electron is contained in its box. It is very clear that Hioroyuki Sakaki, and indeed I would think all the subjects of this book, are primarily motivated not by money, but rather by dreams of philosophical and physical understanding, together with how new insights may be applied, hopefully, for human benefit.

Makoto Nagao has developed the most impressive machine translation at present available, between English and Japanese. He started from frankly mystical interests: the seventh-century mythical history of Japan, the *Kojiki*, and the *Manyoshu*, ancient Japanese poetry compiled in the eighth century. The Editor comments: 'It strikes me that language can be approached from the point of view of computers, and at the same time as a cultural, semantic, or philosophical problem.' Again and again the overlap between science and the humanities emerges in this revealing book.

Kazuhiro Fuchi was President of the Institute for New Generation Computer Technology (ICOT). This project for developing the 'Fifth Generation Computer' was terminated in 1993. It might be seen as analogous to the American commitment to land on the moon within ten years—except that the moon landing was achieved within target (1969) and the Fifth Generation Computer has not yet arrived. Is this simply a failure? Kazuhiro Fuchi responds to two levels of criticism. He rejects the media's account that the major problems of artificial intelligence (AI) research would be solved within ten years, saying that no-one at ICOT made such a claim. And it was not expected that, for example, a machine translation system would have the capabilities of humans. Secondly, ICOT was set up to experiment with new ideas, rather than produce practical devices. Clearly there is considerable ambiguity in the history of ICOT—as well, indeed, as in the history of AI in America and Britain. (Perhaps this is typical of human history: it is written after the victory and by the victors; but these hardly exist so far in AI.) The essential plan was to develop parallel inference. This required new hardware and new software. It was influenced by concepts of neural computing of the brain, including neural nets. The performance of AI is compared with the brain, which has been developing for many millions of years. If the brain was understood better there could be more effective transfer of technology from protoplasm to silicon. This is a multidisciplinary, completely international enterprise in which we may see ourselves as marrying the products of our intelligence, so the future may be indissolubly linked brain–machine intelligence.

Shun-ichi Amari bases his ideas on AI very much on the brain seen as a neural computer. He spent a lot of time considering whether the brain works in the same way as a computer. As he says, 'It's interesting that while the computer can be described perfectly as a Turing machine, the brain, although we live with it and have an intuitive grasp of its workings, has so far revealed nothing about the principles of its own operation.' It could be added that it is current technologies, especially of brain scanning and computer analysis of complex data, that are now revealing brain processes at a rapidly increasing rate. Shun-ichi Amari's approach was to start with random circuits, then look at neurons arranged spatially in layers, and then search for the kinetics of the pattern by which 'the excitement of one neuron is transmitted to others around it. Then, by way of basic research on the learning process, we investigated possible models for memory where the links between neurons change as a result of this action.' This is very much in the spirit of the pioneering Canadian psychologist, Donald Hebb; an approach which went out of fashion with the ascendancy of digital computing, but has now returned. Shun-ichi Amari emphasizes what he calls the 'form' approach: that the brain is not only doing simple processing (like a computer) but perhaps more important, it processes objects in perception 'intuitively and unconsciously as form. Also many items related to but not actually represented in symbols—like the raw material and even the history [of a seen object]—are activated at the same time as the brain grasps [the object] as a form.' Asked whether he sees himself as a leader in the search to unite brain and computer, he replies: 'No, maybe just a cheer-leader—and, I would add, don't follow your leader blindly!'

Hiroaki Yanagida wants to design intelligence into materials. He is especially interested in ceramics. His point is that intelligence can exist outside brains: the immune system copes with all manner of problems adaptively, without bothering the brain and without consciousness. He sees materials capable of self-diagnosis—so warning of corrosion or external threat. He sees humidity sensors, comparable to human skin, and self-adjusting materials such as photochromic glass, but more sophisticated. As an example: 'a "wise" material for the next generation might be traditional Japanese wood. Wood as a structural material adjusts to Japan's very humid environment by its capacity for self-diagnosis and self-recovery mechanisms without any help from micro-chips! I think it would be marvellous to find a new material which not only retains the merit of wood but also overcomes its weaknesses. Such a material, of which I dream, should be considered neither smart nor intelligent but "wise", in the sense that it's full of wisdom.' And he proposes that materials should be breakable for recycling, and as simple as possible to promote techno-democracy.

Hiroyuki Yoshikawa is President of the University of Tokyo, so his interests range from engineering to issues of education. He pioneered the concept of 'general theory of design'. He is one of the few to ask 'What is engineering?' although many have asked 'What is science?' His answer includes the notion that while science deals with infinite possibilities, engineering is always limited to finite solutions from a set of restricted possibilities. A key issue is how human beings classify the world. For example there are three sorts of meat: one fresh, one rotten, the last dry. A primitive man or woman will examine each option, and after experimenting will classify them. 'From a viewpoint of edibility, the fresh meat stands out from the others. However, the human soon notices that the fresh meat will also rot eventually. Thus, from the viewpoint of durability, fresh meat and rotten meat are similar, while dried meat stands apart. It can't be eaten but it won't change in time. So a primitive person begins to wonder if there is a kind of meat which is both edible and durable even though he doesn't have it in front of him.' Isn't pemmican edible dried meat? However this may be, the notion is that creative design follows from existing designs and is limited to generally rather few possibilities. This also applies to biological 'design' in the evolution of species. Professor Yoshikawa is attracted to genetics, as the engineer, also, has to design from what already exists. Again related to biology: 'No one expects a man of seventy to behave as though he was thirty. But we are demanding that the nuclear reactor doesn't age or die.'

Isao Karube develops biological sensors for electronic devices. These started using enzymes (protein molecules) and then using micro-organisms. The BOD (biological oxygen demand) sensor is used for environmental monitoring of polluted rivers. This electronic–biology link up leads to possibilities of introducing electronics circuits into the damaged nervous system. 'My wildest dream is to create a form of biocommunication using sensors that measure energy at a different dimension, such as quantum wave sensors. Of course, if it becomes possible to put sensors easily into the brain, I suppose psychological activities such as memory, thought, and emotion will be sensed electronically.' And: 'If it becomes possible to sense the flow of transmitters in what is regarded as a modern disease such as a manic-depressive psychosis or stress, we could view these diseases using objective data. The day might come when we could decide whether or not to work by observing the dynamic flow of transmitters in the brain! By integrating sensors for different transmitters, a "communication cap" could be made which would enable us to communicate with others without using language!' Isao Karube comments generally: 'The tendency to think of Japanese technology as being without originality is completely outdated. Today, the technology of Japan, the US, and Europe is almost at the same level, and the problems they are facing have many things in common. To put it very simply, I think the essence of these common problems is how to transform the materialistic civilization that is characteristic of the twentieth century to a spiritual civilization in the twenty-first century. Recent research, for example, into the electronic interface with the brain or chemical communication with plants, is a way that we technologists, worldwide, have of changing our materialistic civilization.'

Teruhiko Beppu working in biotechnology, searches among micro-organisms for functions which might work to our advantage. Such secrets of Nature may be applied quite directly, and they may suggest artificially created molecules, or even new organisms. Teruhiko Beppu thinks that it was beyond human technology to have invented penicillin: essentially by chance Fleming discovered something of immediate use which led to 'drug designs' which might never occur in Nature. So here again technology is intimately associated with biology, and can go beyond the solutions of natural selection. For him, research into penicillin is an example of 'the need to go beyond basic research, testing out alternative applications. I think this is a very good example of a discovery in applied research leading to a new theory in pure science.' He goes on: 'The history of science is full of such cases. A famous example occurred in the Sony Laboratories, where the tunnel effect was discovered by chance when they were trying to develop new transistors.'

Science is the most international of all human activities; yet there are limits. Teruhiko Beppu says: 'I graduated in 1956, just when Watson and Crick's model [of DNA and its significance] was presented, but I knew nothing about it. In Japan, for a while, this model was not even taught in postgraduate lectures.' Do we, in the West, know enough of Japanese discoveries? This book may help to open our eyes.

These conversations with Japanese engineers are rich in the usually unstated wisdom of technology, which in fact is shaping our world. It is very strange that the methodology and aims of science are extensively discussed—especially by philosophers—but the same is not so for technology. Yet, as Teruhiko Beppu says: 'These are good examples of technology leading science. It is a myth that we always move from pure to applied science. A true investigation begins only when we confront an unexpected situation. It is only half true that science always precedes technology.'

It is not clear what prestige engineers have in Japan. I suspect it is higher than in the UK. But wouldn't it be a huge advance in our social, scientific, and technological wisdom, if engineers and technologists realized to the full their enormous contribution to the great adventure of discovering the nature of the universe and ourselves? Wouldn't this appreciation give Western industry the meaning and indeed glamour it sadly lacks? For pure science is utterly dependent on the devices and techniques of technology. Indeed they push back the frontiers of metaphysics, as new experiments become possible. Where would we be without giant telescopes and microchips? Pure mathematicians look to computers for proof—even preferring the computer's machinations to their own intuitive 'Aha!' feeling that they are right. In ancient Egypt, the weighing of the soul upon death for judgement leading to their heaven or hell, was not trusted to man or god. Thoth, the God of Wisdom, merely ensured that the scales of justice were kept calibrated. It was the machine that made the moral decision. It isn't only that machines decide moral issues (such as who should receive hospital treatment) but as technology advances so new moral dilemmas are created: for as it becomes possible to achieve more it must be decided what *should* be done from what *can* be done. Will these be future machine decisions?

It is impossible to read this book without sensing the importance of these issues, and realizing that it is the countries with industrial wealth who are now leading the world of ideas—as indeed was so in the seventeenth century, when England and Holland, together with the special imagination of Italy, introduced the enlightenment of post-Aristotelian physics.

As our bodies and brains were designed by blind trial-and-error of natural selection, the sole goal at each step being survival, so the technology determining our future proceeds by blind processes to unknown unforeseeable futures. Listening to these philosopher–engineers living at the edge, indeed creating the edge, of present possibilities, is perhaps the nearest we can come to seeing the future. Whether this understanding makes it possible to choose what to invent and control what lies ahead is another question.

INTRODUCTION

HIROAKI YANAGIDA

For this book, leading technologists working in a variety of specialities were asked to talk about their work. They were also asked about their own lives, the background to their research, their views about society and education, religion and philosophy, and even about their personal hobbies. These discussions are as diverse as can be imagined and it seems impossible to draw any systematic conclusions from them. The book can be seen as a preliminary step to deeper and broader discussions in the future. An attempt was made to discuss the current status of their research for the non-specialist reader. As a result, this book contains the most advanced discussion about several technologies which can be viewed as being of the utmost importance to contemporary civilization such as optical communications, computers, new materials, and biotechnology. In addition, this book will be a good introduction to the fascinating fields of advanced technology for students on engineering courses.

It may be a surprise for Western readers that much of this research was initiated in Japan, because, according to the familiar stereotype, Japanese technology has always been practical rather than theoretical. Technological products from Japan have dominated the world because the Japanese people have a completely pragmatic caste of mind. This stereotype is not completely wrong; indeed it is almost true. In fact, after reading these interviews, Western readers may be surprised that so little of the discussion is theoretical. Japanese technologists are usually down-to-earth even when they are asked to be philosophical; they seem ashamed to speculate. For this reason we were obliged to offer them alcohol to loosen their tongues! It should be emphasized also that the scientists interviewed here are not stereotypically Japanese. They are pioneers with highly original minds, who have sometimes suffered from the resistance which is rooted in a Japanese culture hostile to change. Japan can be seen as the last industrialized country in which a call for a philosophy of technology is heard.

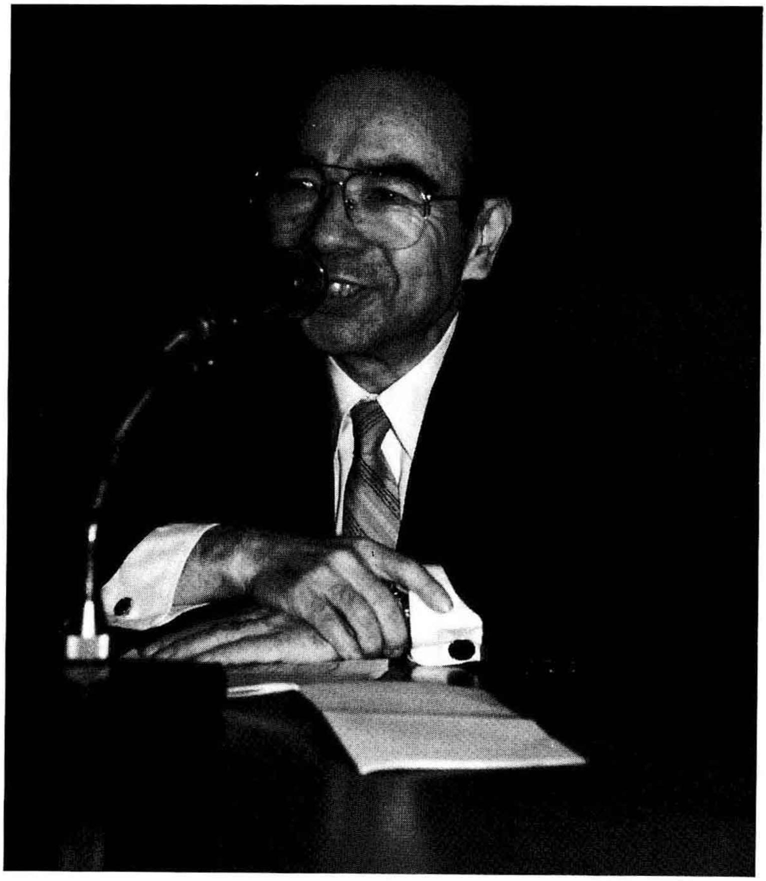
However, this is not the true picture. Apart from the fact that there has been a very strong tradition of philosophical thought in Japan, there are very strong cultural reasons why we Japanese people have had to pose questions about technology. It should be remembered that modern technology is the twin brother of modern science, which is rooted deeply in Western civilization. Modern technology is, it could be said, a purely Western phenomenon. In fact, it has matured in the West over several centuries beginning with giants like Leonard da Vinci. It is a natural outcome of the growth of Western civilization. It cannot be denied that there is a Western flavour in every aspect of contemporary technology, from computers and robots to rocket missiles and space shuttles. To the Japanese, technology seems like an unnatural transplant. Though there were strong craft traditions before the Meiji Restoration, technologies based on the science of Gallileo, Descartes, and Newton were alien to Japan's cultural identity. We have been forced to adapt quickly to something quite foreign to our traditions in order to survive in the cruel competitive world of the modern superpowers. After a hundred and thirty years of restless endeavour, we have now apparently assimilated Western technology. It is aptly stated by one interviewee that we are now 'more Western than the West'. Because it is somewhat unreal for us, however, technology in Japan sometimes goes too far. This situation is exemplified in the Japanese landscape with its labyrinthine network of electricity cables, so different from the country of Hokusai and Hiroshige, and this is the target of severe criticism by Professor Okoshi, the renowned leader in optical communications and the first interviewee in this book. Also Japan is one of those advanced countries in which environmental pollution is particularly high. Technologists have struggled with environmental problems in this country for years. I would maintain therefore that Japan is the country where we should enquire most seriously into the status of technology as a cultural phenomenon. I hope we can stimulate the Western reader with the unexpectedness of our ideas.

Apart from this general intention, this book has one specific purpose. We have often been told by Westerners that the Japanese are 'faceless'. This could be because the Western people exhibit their faces too much, while there has been little effort on the part of the Japanese to display their individual thoughts to the West. This has been especially true of the technologists who were responsible for the world-renowned technology of Japan. Therefore, the specific purpose of this book is to present for the first time the real individual voices of some of the leading Japanese technologists. In saying that, I do not mean that these technologists are speaking as the representatives of Japan. They have been selected because they are original and interesting people. Their thinking is by no means conventionally Japanese. Their work has universal merit. Although their subject matter is not specifically Japanese, many of their views, sometimes expressed unconsciously, do have a Japanese orientation. Many of the interviewees express critical views, for example about research in the USA. It cannot be denied that we are nationalistic to a degree but it should be pointed out that many interviewees are critical of the Japanese system itself. None of the technologists interviewed are chauvinists.

As this book is the first of its kind, I have tried to make it a valuable record of the history of technology. Care was taken, in this respect, in the interviews concerning optical communications. It is not generally acknowledged that twentieth-century civilization would not have been what it is without telecommunication technology. The replacement of electrical by optical communication is one of the most significant changes to have occurred in modern civilization. For example, the recent passion in the United States for the 'Information Superhighway' and for multimedia was only made possible by optical communications technology. Japan's highly significant contribution to this revolution might become the subject for research in the history of technology. One interview deals with a subject which has had much coverage in the media: the New Generation Computer Project of Japan. An institution called ICOT was created purely for this project. Although interesting in many other respects, the project gained historical significance because it was the first national technological project in Japan which could be described as truly adventurous. I have no difficulty with the stereotypical criticism from abroad that the Japanese are much better at refining the ideas of others than creating their own. It must be stated, however, that this is changing. ICOT is the first venture to meet this criticism. As any adventurous undertaking is likely to fail, it was reasonable that many foreign newspapers pictured it as a failure. The reader can decide whether this was really the case after reading the interview with Professor Fuchi, the former President of ICOT.

It might be helpful to give the reader some background information about the system which sustains Japanese technology. Roughly speaking, the healthy state of technology in Japan is due to the efforts of a vast number of engineers working in numerous industries. The technological strength of Japan is based upon an infinite number of inventions, improvements, and innovations which have taken place in industry, especially since the Second World War. As has often been pointed out, these achievements have been characteristic of Japanese perfectionism and collectivism, thus typifying our 'superb mediocrity'. Research in industry has been orientated very strongly towards application; it is only recently that the need for 'basic' research in industry has been recognized. There were no research institutes like Bell or IBM in Japan, though this situation is changing. Thus, basic technological research has been mostly carried out in our universities. British and American readers may not be fully aware that in Japan most of our national universities have the capacity for advanced research. These universities were originally created by the Meiji government to import ideas in order to catch up with Western civilization. Therefore, the basic tendency has been for Japanese national universities to refine and disseminate imported knowledge. This forms the basis of the notorious 'copy-cat' image of modern Japanese culture. Nevertheless, although this tendency was quite strong in our culture, the originality of Japanese research bloomed unexpectedly early in science and technology. It should be remembered that the first official department of engineering in a university was established in Tokyo. After only thirty years of the study of Western physics, Nagaoka's solar model of atomic structure was first conceived in Japan. The quiet invention of antennae by Yagi, ignored in Japan, revolutionized the war and led to the defeat of Yagi's mother country. Since the Second World War, the imperial universities in Japan have gradually changed, the most important aspect being the influence of the USA. Readers will find evidence of this influence throughout these interviews. Almost all of the technologists interviewed have had the experience of staying in America when they were young. The reader might be interested to compare the interviews with Professor Okoshi and Professor Sakaki, who were in the USA at almost the same time but at different ages. Therefore, it can be said that the leaders in Japanese technology have been deeply affected by American thinking and attitudes. It is a point of great interest to see how Western thought interacts with the Japanese mind. On the other hand, it is ironic that the spirit of higher education in Japan has not changed very much since the war. Although academic freedom is encouraged, our national universities are constrained financially by the Ministry of Education. Because its main aim has been the wide dissemination of standard education, the Ministry of Education has not had a coherent policy concerning research in universities. Out of the total expenditure on research and development, which is estimated at 3.5 per cent of the gross national product, only one-fifth comes from the public sector and is mainly directed at the universities, the rest being investment by industry aimed primarily at the development of its own commercial products. Foreign visitors are astonished to see poorly equipped laboratories in the most prestigious universities in Japan. This situation is discussed by two Presidents of leading universities, Professor Yoshikawa of the University of Tokyo and Professor Suematsu of the Tokyo Institute of Technology. There have been efforts by the Ministry of International Trade and Industries (MITI) to support research in advanced technology, of which ICOT is an example. Recently transnational and international research groups have been formed using government support. Therefore the financial restraints on the growth of original research seem to be disappearing gradually. There are, however, still many problems in achieving originality in Japanese technological research. For example, we have been criticized by foreign researchers for having little tradition of peer review, without which the sensible allocation of the research budget cannot be attained. This can be boiled down to the characteristic social position in Japan: the emphasis on consensus and the repression of divergent opinions. Many of the technologists interviewed have views on this subject.

Finally, I would like to explain how this book came about. Originally, a series of books called *Steering* were published in Japanese by Mita Press in 1989. This series was made up of interviews with thirty leading technologists of Japan. Its main aim was to present to engineers, managers, and students the real thoughts of cutting-edge technologists in Japan. Also it was intended to explain the current state of advanced technologies. After this series had been welcomed by the Japanese public, we were approached by Oxford University Press about the possible publication of an English version. As the Japanese version was not aimed at a foreign audience, extensive reorganization and editing were required. Because these subjects are rapidly changing, a substantial update was necessary. For this purpose, we first selected ten interviews out of thirty, and then conducted a series of back-up interviews, assisted by the editorial staff in the Tokyo office of Oxford University Press. After this new series of interviews was completed, we reorganized the material, integrating old and new interviews. Thus, the present book is not a translation of the Japanese edition, but a new book based on it. I would like to express my gratitude to those original interviewers whose questions have been somewhat 'transformed'. These are as follows: Chapter 1, Mr Etori of Mita Press; Chapter 2, H. Yanagida of the University of Tokyo; Chapter 3, Mr Etori; Chapter 4, Professor Murakami of the University of Tokyo; Chapter 5, Professor Karube of the University of Tokyo; Chapter 6, Mr Moritani, a journalist; Chapter 7, Professor Nakamura of Waseda University; Chapter 8, Mr Etori; Chapter 9, Professor Nakamura; Chapter 10, Mr Nano, a journalist. Also I appreciate the efforts of the translators and the staff of Oxford University Press for carrying out this difficult project.



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