Executive Summary

Life Sciences

1 Fostering and Status of Scientists and Technical Experts in Drug Development

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In response to the globalization of the pharmaceutical industry, an agreement at The International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH) has set global standards for the efficacy, safety and quality of drugs. To meet these standards, it is urgently necessary for Japan to strengthen its international competitiveness and improve its drug development environment. Pharmaceuticals can be classified into ethical drugs and over-the-counter drugs (OTC: drugs available at pharmacies and drugstores), the former accounting for about 90% of production[1,2]. Japan has the second largest pharmaceutical market (i.e. development opportunities) in the world, but in terms of sales by country, Japan ranks fourth or fifth among the six countries with drug-development technologies. In response to the ICH agreement, the Pharmaceutical Affairs Law will be revised in April 2005, and after this revision, foreign products are likely to increase their share of the Japanese market. There is great concern that Japan will become an "underdeveloped country" that only manufactures off-patent generic drugs.

Since a long time is needed for drug development (from 10 to 17 years) with a low success rate (one in 11,000) as well as the corporate efforts required, it is important that the government emphasizes drug development research and supports human resource development in this area. Meanwhile, the six-year program for pharmaceutical departments and universities, which will be implemented in 2006, aims to educate pharmacists who specialize in patient compliance instructions, medication history management and risk management for drug-induced suffering. Thus, it is likely that fostering "drug development professionals," which has been the role mainly assumed by pharmaceutical departments and universities, will become even more difficult in Japan.

In the U.S., which is the world-leading drug developing country, NIH research and technology transfer budgets have been organized in an environment where universities, companies and venture capital companies can all participate in drug development. The NIH research budget has actually supported 40% of the pharmaceuticals that have been commercialized. Although the country has no educational institution specializing in human resource development in the drug development area, its flexible curricula and the recruitment of teaching staff beyond departments have fostered human resources interested in drug development. In Japan, companies have individually managed information concerning drug development, from the discovery of pharmaceutical seeds to their commercialization. Human resource development has been conducted alongside pharmacist education in small-scale pharmaceutical departments and universities (about 80 students per grade per department in former national universities). Venture capital companies dedicated to pharmaceutical seed discovery have not been nurtured, and the drug development environment in Japan is in marked contrast with that in the U.S..

Japan has ten original products with annual global sales of 1 billion dollars.

Japan also has certain university-launched products that have been internationally accepted. This suggests that Japan's drug-development technology has the potential to improvement.

Taking advantage of the implementation of the six-year courses for pharmaceutical departments and universities in 2006, we should establish a completely new system (departments) for intensive education in the following five subjects: (1) chemical and biological foundations for developing novel pharmaceutical seeds (compounds); (2) chemical and biological methods for manufacturing novel pharmaceuticals; (3) pharmacology for discovering novel effects and the efficacy of pharmaceuticals; (4) pharmaceutics for exploring novel DDSs (drug delivery systems) suitable for individual drugs; and (5) toxicology for assessing safety and toxicity.

This system would foster human resources who can synthesize organic compounds (Subjects (1) and (2)), can handle not only cells and microorganisms but also animals and are strong in biostatistics" (Subjects (3), (4) and (5)), as is demanded by pharmaceutical manufacturers. This should greatly contribute to the domestic pharmaceutical industry, which would lead to economic revitalization and independence of people's health from foreign pharmaceutical industries.

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2 Trends in Food Allergy Research

p.26

The incidence of allergic diseases continues to increase, mainly in developed countries, and has grown into a serious problem. In particular, food allergy often develops during infancy and can affect a child's growth or trigger an "allergic march," i.e., the progressive development of various allergies. Therefore, early prevention and treatment are recommended for food allergy. The second Science and Technology Basic Plan depicts the "realization of a nation securing a comfortable, safe and high quality of life." Research and development of anti-allergic food can contribute to realizing such a nation and should therefore be promoted.

The development of food allergy involves complex interactions between genetic factors and diet and other environmental factors, which must be considered when conducting research and development in this area.

Research aimed at overcoming food allergy includes the food-oriented approach: the development of hypoallergenic food and antiallergic food. Hypoallergenic food is essential for patients with food allergies to prevent the development of allergic symptoms, to improve their diet and eliminate the risk of nutritional disorders. To date, several hypoallergenic foods have been developed and commercialized, but further research is required for developing foods that are effective against various allergens and preventing any loss of taste, or decline in nutritional and commercial value. Currently, the development of hypoallergenic food is being attempted, using a proteome analysis-based approach, which enables the comprehensive identification of structures commonly found in various allergens. Meanwhile, there have been attempts to develop food that can prevent allergy by utilizing the mucosal immune system in the gut, such as tolerogenic peptides or probiotics. There are great expectations for such foods, as they can interact directly with the body to suppress allergic reactions. Nevertheless, the development of such foods is still in the research phase, and several issues remain to be resolved before their practical application.

Future tasks include characterizing food allergens, establishing allergenicity evaluation systems, understanding the mechanism of food allergy development, and confirming the relationship between food allergy and environmental factors. While these are indeed important tasks to be addressed through research, it is even more important to establish a system for assessing the efficacy and safety of newly developed food products and to find appropriate ways to apply them for patients with food allergy. Future progress in research and development requires not only the resolution of individual research questions, but also discussion of ways to evaluate the efficacy and safety of anti-allergic foods, and their application to allergic diseases. Therefore, cooperation with the medical profession is essential for the research and development of food products.

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Information and Communication Technologies

3 Applying Nanotechnology to Electronics

— Recent Progress in Si-LSIs to Extend Nano-Scale —

p.36

Nano-scale materials for nanotechnology have been prepared using two techniques: top-down and bottom-up methods. The top-down method is applied to process macro-scale materials into a smaller size just as a semiconductor process does, whereas the bottom-up method is applied to integrate molecules or atoms into nano-scale materials just as a living organism synthesizes proteins.

The bottom-up method was recently successfully combined with the top-down method by researchers at universities and companies in the U.S., showing that nanotechnology is being smoothly extended to conventional electronics. The bottom-up method is epitomized by self-assembly, which plays an important role in nanotechnology, together with prospective applications in ionics and electronics. In addition to primitive assemblies of materials, nanotechnology is moving forward to electronic devices and their integration, in which an LSI design is being explored.

Nanotechnology is presented as a realistic, promising technology for the future due to recent progress in this field, where nanotechnology is combined with conventional Si-based electronics.

Long-term investment based on a well-planned strategy is essential for successful materialization of next-generation technologies, such as nanotechnology, where planning should include impressive success in industry, signifying the bright future of the technology.

Although the pros and cons of the top-down and bottom-up methods have been discussed in Japan, new ideas for combining both have not been well studied, except for research in industry (NEC, etc.). The recent progress in the U.S. that tries to combine both methods is suggestive, and is unveiling a new paradigm of nanotechnology indicating realistic applications in industry.

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4 Trends in High-End Computing in United States Government

p.46

The government of the United States of America is engaged in various efforts to maintain its leadership in high-end computing (HEC). Particularly noteworthy are the activities of the HEC Revitalization Task Force, which includes diverse federal agencies. The government formed this Task Force as a special project under the auspices of National Science and Technology Council (NSTC) in March 2003. The Task Force subsequently released the "Federal Plan for High-End Computing," which aims to enable the USA to maintain its leadership in science and technology.

Underlying this action is an awareness that even though high-end computing is essential to science and technology development, national security, and international competitiveness, the high-end computing systems used for federal missions are not always meeting computing requirements. Detailed investigations on high-end computing in Japan were conducted in the course of establishing the plan.

The plan comprises three parts.

(1) Research and development: A roadmap for key technologies over the next 5 to 10 years, emphasizing sustained system performance in practical application and incorporating challenging research and development.

(2) Resources: Relieving the shortage of high-end computing facilities and establishing leadership system facilities with leading-edge computing capability.

(3) Procurement: Efficient procurement by federal agencies, emphasizing total cost of ownership (TCO) and sustained system performance.

The plan was completed in May 2004.

Regarding this plan, the 108th US Congress debated at least three bills with "Revitalization of High-End Computing" in their names during 2004. Of these, the Department of Energy High-End Computing Revitalization Act of 2004 was passed in November. The law specifies the implementation of research on multiple architectures and on system software for high-end computing, the establishment and operation of leadership-system related facilities, the creation of a high-end software development center, and the transfer for technology to the private sector.

To maintain its global leadership in science and technology, the US Government now strongly promotes a strategy centered on high-end computing.

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5 R&D Trends of LSI Design Technology
— Bottleneck at Development of System LSIs that rule Value-Added Electronic Devices —

p.61

The value of electronic appliances is becoming governed by system LSIs that are incorporated with increasingly more elements and functions. In contrast, the technology to design sophisticated LSIs in a short turn around time is becoming essential to keep pace with the shorter life-cycle of appliances. LSI development is thus more heavily dependent on design technology than manufacturing, and is facing a bottle-neck in the former domain.

LSI design technology is comprised of technology used to design and to support, of which the latter is called LSI design methodology. Thanks to the contribution of electronic design automation, LSI design methodology has displayed considerable progress every decade, abstracting the design description method: in the 1970s, layout diagram of elements; in the 1980s, circuit diagrams using symbols; and in the 1990s, text-style language. Design technology has therefore progressed alongside software technology development.

However, design technology in Japan, where highly abstracted description first took root, shows little progress, since the description is becoming more highly abstracted. Moreover, the extent of design research presented by companies, universities, and institutions in Japan, is seen to be on a downward trend at Design Automation Conference (DAC), a prestigious conference in this field. Currently, the number of accepted presentations from Japan represents 2% of the whole, although the total number of presentations from Japan (mainly in the shape of company contributions) was 10%.

The share of DAC presentations from universities is 70%, representing their important role in developing design technology. Universities have a competitive edge in the development of design technology, which is heavily dependent on ideas rather than huge investment in equipment. U.S. universities began to increase the number of accepted presentations at DAC after beginning the LSI test-production service and industry-academy collaboration. Taiwan, meanwhile, following success in semiconductor manufacturing, has been rapidly developing their own LSI design technology, with the backing of the government. Other countries and areas are also developing similar technology, leaving Japan trailing behind them.

More researchers in this field, where a shortage has been detrimental to R&D, are necessary in Japan. In the short run, it may be possible to employ researchers from industry or foreign countries. In the longer term, university education related to computer science or engineering should be reinforced to produce engineers and researchers capable of developing design technology.

A new LSI design methodology is developed, powered by competitive design technology, and should progress through the development of essential LSIs within a country. For example, the development of original technologies used in security-related LSIs, one of the basic technologies in the ubiquitous network, is involved in a proposed development to construct a secure network environment, made possible by electronic money, identity recognition, and encryption.

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Environmental Sciences

6 Science and Technology Trends in Fire Protection and Disaster Management
— A Consideration of Characteristics and Directions in Science and Technology for Safety and Peace of Mind—

p.75

The White Paper on Fire and Disaster Management compiled annually by the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications brings together information on a truly wide variety of disasters and accidents, including fires, accidents at hazardous materials facilities and complexes, windstorms and floods, wildfires, earthquakes, and accidents related to gases, toxins, deleterious substances, and nuclear power. In the FY 2005 policy on the allocation of resources such as budgets and personnel for science and technology (Council for Science and Technology Policy, May 26, 2004), strategic and comprehensive promotion of science and technology for new efforts concerning national and social problems was established as a new area of strategic emphasis. The comprehensive and cross-sectional promotion of science and technology to build a safe society that provides peace of mind is one example of this policy. To build a safe society that provides peace of mind, the causes of accidents and disasters must be understood, and full discussion on prevention and response after occurrence must take place. Science and technology is necessary for this to happen. Fire protection and disaster management S&T is interdisciplinary research that spans all the priority fields designated in the second Science and Technology Basic Plan. A PDCA cycle connected with the prevention of disasters before they occur through prior response, after-the-fact response, and causal analysis should be formed.

In the near future, concern for safety and peace of mind will include fire protection and disaster management in an aging society, contradictions between environmental protection and a safe society that provides peace of mind, damage from crimes such as arson and from terrorism, accidents accompanying aging infrastructure, and natural disasters such as major earthquakes. In addition, with advances in fuel-cell vehicles and other technologies in recent years, conventional firefighting methods may no longer be sufficient. Research on special combustion behavior and firefighting is therefore essential, as are prevention technologies.

To link the results of fire protection and disaster management science and technology with achieving a safe society that provides peace of mind, the public must be able to understand and use these results. The utilization of science and technology to prevent accidents before they happen is a matter of course, but at the same time, people must be educated so that they can properly understand, manage, and use them. Various budgets are allocated for research directly linked to technology, but funds should be allocated for preventative education and so on in the same way. As with pure scientific research, the results may not be tangible, but this education is essential in constructing a safe society that provides peace of mind. One can easily imagine that when an earthquake occurs, damage will vary widely by location. Therefore, providing all residents in a given area with disaster drills through virtual reality and other simulations can be effective from the perspective of damage mitigation.

Currently, the evaluation of researchers by their results is increasingly widespread and becoming more important. In most such researcher evaluations, changing research fields may not be advantageous because it can cause a temporary drop in publications and presentations. To foster interdisciplinary researchers, it is therefore desirable to devise evaluation methods that integrate contributions over time into building a safe society that provides peace of mind.

In addition, the market scale is small, so there is little incentive to develop equipment in accordance with the frontline needs of fire protection, and it is difficult to adopt the most advanced results of research in science and technology to combat disasters. This would contribute to an effective and efficient research system with full-fledged cooperation among industry, academia, and government, as well as intra-governmental cooperation. Such a system of intra-governmental cooperation could enable the fruits of fire protection and disaster management science and technology to enter the general market, expanding the target market for research and development. Because the environmental resistance and performance required for frontline fire protection activities is equivalent to or greater than that required by military technology, the scientific and technical issues to be solved are advanced. At the same time, however, the cost effectiveness required is closer to that of the civil sector.

Compared with the United States of America, the world's policeman that leads in science and technology through its military technology, Japan may be able lead the world in fire protection through breakthroughs in the science and technology of disaster prevention and mitigation, contributing to the global community. To effectively utilize fire protection and disaster management S&T and contribute its achievements to society, the creation of such visions and systems is vital.

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Frontier

7 Effectiveness of the Quasi-Zenith Satellite System in Ubiquitous Positioning

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In our future information society, accurate positional information at any time and at any place will be available as a matter of course. For this purpose, a variety of research targeted at “ubiquitous positioning” has already begun in many countries. Here in Japan, the Ministry of Internal Affairs and Communications has launched a policy, scheduled to be completed by April of 2007, to build a high-performance infrastructure, providing police and fire fighting agencies with enhanced emergency communication capability for improved safety and freedom from care. Considering that mobile phones are used in more than half of police notifications, high-precision positioning of the transmitter using Global Positioning System (GPS) will greatly streamline the handling of accidents and crimes. The lack of means for the accurate and speedy locating of the transmitter has long been a bottleneck in mobile phone usage in this area. Mobile terminals with automatic positional information transmission capability using GPS will enable security agencies including police to reach the spot much more quickly.

The GPS that will play a fundamental role in this policy uses time-base signals from four or more GPS satellites (NAVSTAR satellites launched by U.S.). However, acquisition of the required number of GPS signals for accurate positioning can be severely hindered where mountainous terrain and densely populated urban canyons block signal propagation. This has been often pointed out as major blind side in GPS utilization.

The Quasi-Zenith Satellites System (QZSS) is a constellation of three satellites that orbit the earth on different geosynchronous orbital planes, with at least one satellite positioned near the zenith at all times in low to middle latitude on the same line of longitude. The three satellites round the earth reciprocating northern and southern hemisphere with their orbits cutting a figure of “8” when projected on the earth's surface centered on a certain longitude. QZSS is a multi-functional satellite system that can function as a communication, broadcasting and observation system, as well as providing positioning information.

Near-zenith satellites will compensate for the blind sides of GPS satellites, enabling GPS positioning to concentrate on enhanced emergency communication, as well as providing a variety of applications such as human navigation, railway traffic control, and land survey. The total system will be a major component that constitutes the basic infrastructure of a country. It will also provide substantial business opportunities to the aerospace industry in Japan. However, the simultaneous implementation of communication and broadcasting capability in addition to positioning may hinder the timely completion of the system, as it will entail vast development efforts in satellite technology and the establishment of a development framework. Compared to these additional functions, the positioning capability has higher priority in terms of urgency and social importance as basic infrastructure for Japan, and it will be a major driving force in renovating the structure of society and producing new values. I propose that the first QZSS complements and augments the GPS to enable secure, rapid development and the early start of operation. As part of this effort, establishment of a governmental organization that will preside over all positional information utilization in Japan, as the Interagency GPS Executive Board does in U.S.A., is essential for the promotion of the QZSS.

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