VISION 2025

Korea’s Long-term Plan for Science and Technology Development
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VISION 2025:

Korea’s Long-term Plan for S & T Development

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LIST OF ABBREVIATIONS

APEC : Asia-Pacific Economic Cooperation
CASE : computer aided software engineering
DAVIC : Digital Audio Video Council
DBMS : database management system
EPR : Extended Producer Responsibility
EU : European Union
G7 Project : HAN (Highly Advanced National) Project
GPRA : Government Performance and Results Act
GRI : Government–supported Research Institutes
IMD : International Institute for Management Development
IPRs : intellectual property rights
IT : information and telecommunications
ITS : intelligent transportation systems
KDI : Korea Development Institute
KISTEP : Korea Institute of Science and Technology Evaluation and Planning
LCA : life cycle assessment
MBNQA : Malcolm Baldrige National Quality Award
MBO : Management by Objectives
MEMS : Micro Electro Mechanical System
MOST : Ministry of Science and Technology
NAFTA : North American Free Trade Agreement,
NMBY : Not In My Back Yard
NIS : national innovation system
NSTC : National Science and Technology Council
NORC : National Opinion Research Center
PDA : Personal Digital Assistance
PL : Product Liability
RIKEN : Institute of Physical and Chemical Research
S&T : science and technology
SMEs : small and medium-sized enterprises
SOHOs : Small Office Home Offices
TR : Technology Round
VLSI : very large scale integration
WHO : World Health Organization
WTO : World Trade Organization
We are standing at a turning point in history. We have just crossed the threshold into a new millennium. Futurists have given us many different pictures about what the world will be like in the 21st century. They all agree, however, that science and technology (S&T) will be the driving force behind the changes and developments that shape our new world. In fact, even at this very moment, brilliant scientific discovery and technological innovation are providing us with new opportunities and challenges that fill us with new hopes and dreams.

With a view to embracing the future, in March 1999, the Korean government organized a planning committee and subsequently formulated "Vision 2025: Korea’s Long-term Plan for Scientific and Technological Development" (hereinafter 'VISION 2025'). Then, at the third National Science and Technology Council (NSTC) meeting held in December 1999, the government decided to utilize this document as its long-term blueprint for national scientific and technological development. Personally, I believe that the formulation of this vision and the development of this document are very meaningful as other countries — including the United States (US) and Japan, as well as the European Union (EU) and other Asian countries — have also been preparing their own long-term science and technology plans.
In the new millennium, Korea plans to join the ranks of industrially advanced countries by strengthening scientific and technological competitiveness. Consequently, VISION 2025 has been designed to be comprehensive and focused, providing Korea with both a long-range strategy and direction to achieve the goals and enhance Korea’s status in the international community.

Despite the government’s active attempt to formulate science and technology policies for the last three decades, Korea is still lagging far behind other advanced countries. To rectify this situation, nationwide efforts should be taken to increase public awareness of the growing importance of science and technology. As science and technology affects all aspects of life, matters concerning S&T should thereby become a top priority to government policy makers. In this regard, VISION 2025 has been designed to provide a direction for government policies at the national level.

Korea, which has a highly educated workforce, is a nation with a keen interest in education. However, the nation is lacking in natural resources. Therefore, the most effective strategy that Korea can take in order to achieve the status of a small but powerful country is through effectuating scientific discovery and technological innovation.

At this very critical moment of the start of the new millennium, we have to renew our commitment to S&T, reiterate our responsibility toward society as scientists and engineers, and provide new frontiers for our hopes and
dreams. Only in this way can Korea go forward to fully maximize its potential, to earn the respect of the international community, and to earn its place among the ranks of the advanced countries. Only through dedicating ourselves to S&T, can we become a competitive and prosperous nation in the 21st century.

Lastly, let me express my deep appreciation to those who have worked so hard to formulate VISION 2025. Thank you.

June 2000

Jung Uck Seo, Ph. D.
Minister of Science and Technology
SUMMARY

**Evolutionary Direction for the 21st Century Society**

In the twenty-first century, great revolutionary and unprecedented changes are expected to occur. These changes are likely to stem from paradigm shifts, and include structural changes in our lifestyles and value systems, as well as vast transformations in our economic and industrial systems.

More specifically, the paradigm shifts in the 21st century will most likely include:

- The advent of a knowledge-based information society in which national wealth and economic growth will be measured in terms of ideas and technology, and not in terms of materials.

- The attainment of unlimited competition that guarantees free transactions among countries in the world and secures national benefits and competitiveness.

- The creation of a new value system that focuses on personalization, diversification, and improving the quality of life.

In the 21st century, S&T will accelerate innovation and be connected to every facet of society and life.
Roles and Development Patterns of Science and Technology

S&T is the force that will drive the changes in the society of the future. It will be the motivator that reinvents national wealth, improves the quality of life, and heightens the stature of nations by accelerating and widening the scope of development. It will also play an important role in helping society to make sound decisions and prevent potential hazards by minimizing risks.

The characteristic development patterns of S&T that may evolve in the future include: the acceleration of the merging and integrating process of S&T, the attainment of matured stages of systemization and intellectualization, the shortening of the technology life cycle, and the development of extreme technology.

When considering the roles and development patterns of S&T, it becomes readily apparent that advanced countries have devoted the majority of their efforts to developing technologies related to information, life science, medicine, materials, the environment, and energy.

Current Status of S&T in Korea

In the nation’s economic take-off stage, the mainstay of Korea’s S&T policy was the commercialization of R&D through the transfer, assimilation, and improvement of technology from other more advanced countries.
As a result, Korea has maintained competitiveness in several markets, including semiconductors, automobiles, iron, steel, and shipbuilding. However, the nation has failed to secure core and fundamental technologies, so it has been unable to keep pace with more advanced countries in terms of economic development.

According to the study conducted by the International Institute for Management Development (IMD) of Switzerland, Korea does maintain competitiveness to some degree in several quantitative indices such as R&D expenditure, personnel, and patent enrollment. However, there are still some barriers such as insufficient technological cooperation among business entities and insufficient technology transfer between industry and academia.

It is imperative that Korea modify its national development model to be based on physical input factors and the assimilation of foreign technology. Korea needs to explore new avenues for national development based on knowledge and fundamental technology. The nation also has to make the best use of S&T as a source of development by taking the initiative to activate and propel the S&T-based policy on a national level.

**Long-Term Vision of S&T toward 2025**

In preparation for the new millennium, Korea’s long-term S&T vision has been the establishment of an advanced economy and a competitive level of technology. This vision can be attained through the promotion of S&T at the global level. Consequently, Korea’s status in the international community will be enhanced, an advanced system of social welfare will be brought into reality, and national security will be further guaranteed.
Most importantly, the short-term goals essential to the achievement of the long-term vision include becoming 12th in the world-wide ranking for S&T, thereby outpacing all other Asian countries. Therefore, the Korean government needs to change S&T-related infrastructure, laws, and institutions by 2005.

By 2015, Korea will stand out as the major research hub in the Asia-Pacific region, engaging in the activation of the fundamentals of scientific study, promoting globalization, and forging a new atmosphere conducive to the promotion of R&D.

Finally, by 2025, Korea should secure scientific and technological competitiveness in selected areas that are comparable to the level of G-7 countries. The nation will achieve this goal by: creating, utilizing, and proliferating knowledge; heightening scientific literacy; and establishing a national operating system under the purview of S&T.

To attain effectively the above-mentioned, long-term vision and goals, confidence must be acquired first to strategically cope with societal changes in the 21st century. Secondly, Korea has to do its best to develop the fields of information technology, life science, materials, alternative energies, the environment, mechatronics, and basic science by implementing the "selection and concentration" strategy. Third, the government should solidify the national innovation system (NIS) by changing the basic direction of S&T policy.

Future Directions of S&T Development

Issue by issue, the long-term vision in terms of policy and technology is as follows.
First, Korea should become "digitalized" by the year 2005 in order to lead the information revolution in every facet of society. Additionally, by 2010, the nation should achieve the highest obtainable level in the area of information technology. VISION 2025 also includes the achievement of a one-to-one ratio in terms of people and technology, i.e., a one-person-to-one-PC ratio; a one-person-to-one-email ratio; and, a one-person-to-one-homepage ratio. One of the challenges in achieving these objectives will be to actively foster information-related technologies while concurrently minimizing the potential side effects caused by the rapid pace of the informatization.

Second, Korea should make an effort to consolidate industrial competitiveness and contribute to the creation of national wealth. A focused campaign on developing plausible ideas would powerfully affect the 21st century, creating a social environment that: (1) ensures the support of self-reliant technology, (2) respects and encourages entrepreneurship, and (3) returns the fruits of one’s labor to its creator. It is also important to ensure a system of laws that support the establishment of an industry-friendly environment wherein anybody can freely join in the race toward innovation. Over the long term, management skills must be developed and concentrated efforts made to aid in the growth of a qualified workforce-training program conducive to developing and enhancing S&T.

Third, it is essential that there be an actively driven government policy that fulfills the desire for a healthy, safe and convenient lifestyle. The development of core technologies in the disciplines of life and medical sciences can also ensure global competitiveness. By 2010, a strategic plan will be in place to
develop core technologies that assist the elderly, and in this regard, a database dedicated to the silver society industry will be also built. This will in turn be followed by the arrangement of the laws on cloning and ethics and the establishment of respective social values.

To respond to the desire for a healthy life, the government should continue to secure technologies that: prevent air pollution; effectively deal with the management of industrial waste, soil, and underground water; prevent the depletion of the ozone layer; and encourage the development of new and efficient ways to protect our overall environment. Additionally, Korea needs to form an environmental council to solve regional environmental problems pertinent to Northeast Asian countries. Korea’s capabilities to cope more effectively with bad weather and natural disasters should also be enhanced through the advancement of meteorological equipment and emergency preparedness techniques. Along these lines, focus needs to be placed on improving the areas of nuclear safety.

Fourth, S&T development should actively proceed toward ensuring national security and gaining national prestige. Korea is currently developing technologies to ensure that essential resources — such as food production, energy, and water — are maintained. Specific technologies that utilize alternative energies, increase the efficiency of energy consumption, and self-support nuclear energy based on adequate public safety are of priority. In addition, seeking new ways to efficiently manage water resources is of great importance.

The reunification of South and North Korea and international cooperation are two necessary ingredients in the drive to procure a self-reliant national defense policy, thereby
improving Korea's international stature. For this purpose, the government will also develop dual-use technologies, i.e., technologies applicable to both the private and public sectors. Furthermore, Korea proposes to share scientific information between the two Koreas, as well as jointly hold S&T conferences, consolidate mutual cooperation within technical fields, and contribute to the development of the science world by setting a precedent in the area of scientific cooperation. In addition, the challenge of tackling the ocean and the space frontier are prime objectives, along with the planned development of multi-functional satellites and multi-stage rocket launchers. Special resource funding will be available for the production of special equipment for marine research, and the construction of special sea ranches and artificial islands.

Fifth, Korea is actively going forward in carrying out policy to strengthen linkage between rapid advancements in S&T and society. The nation is fostering the development of creative scientists and engineers who have special abilities in S&T. This is being done by encouraging support for strategically developing stable investment and excellent research organizations, for youth who have the spirit to confront challenges and make discoveries, and for gifted scientists and engineers to move closer to achieving a world-class level in basic science by 2010.

By 2005, a comprehensive system of information distribution and management will exist at the national level, including policies that protect intellectual property rights (IPRs). The emergence of a pan-national science campaign will also evoke a new S&T culture and thereby improve overall S&T literacy among the Korean people.
Policy Directions to Reinforce the National Innovation System

To strengthen capabilities in the S&T innovation system, the government should improve the S&T environment and maximize the use of S&T resources by implementing a "selection and concentration" strategy. The national S&T policy directions laid out to establish this system are as follows.

First, S&T should be converted from the existing system of development led by the government to one led by the private sector. It is essential to convert government policy to a bottom-up system in the private sector through an open S&T administration that draws upon national consensus for policy decisions through direct participation. In addition, the role of public research should be shifted from being centered on direct R&D support to a privately supported system using indirect support that can strengthen their innate technological capabilities, such as taxes, finances, and a standardized system.

Second, the investment expansion strategy, which focuses on supply increases, should be converted to an investment distribution plan that focuses on efficiency. In order to increase efficiency of R&D investment, the distribution of resources and investment to all areas is essential. In addition, government R&D budget support needs to be made more efficient and this can be achieved through establishing a Management by Objective (MBO) system. The government should also center its efforts on nurturing a knowledge-based industry, creating core technologies, promoting full-scale fundamental research that supports technology transfer and dissemination of R&D results, as well as planning and evaluating research projects. To increase the efficiency of
R&D investment, the government must also drive R&D toward a long-term market and persuade end-users to participate in target selection, management, and evaluation. The government intends to increase its R&D budget to 5% of the total government budget by 2002. Therefore, government policies must lead to increases in private investment, and private businesses should be urged to step up their mid-to-long range joint research plans in cooperation with academia.

Third, Korea needs to learn how to: circumvent the nation's natural resource limits; utilize global technology, human resources, and information; and cooperate with the international community. When these objectives are achieved, the nation can then play a pivotal role as a bona fide member of the global economic society. To effectively achieve these objectives, the government needs to: convert the domestically completed S&T system into one that is globally networked; establish a system that examines technological disciplines from a single, international perspective; and promote an attractive environment for foreign R&D activities. As an end result, Korea will become a hub of excellence for research. The nation also needs to promote mutual understanding with foreign countries in order to both overcome the limitations of R&D resources and acquire advanced S&T information. This requires using Korea's own initiative to participate in formulating the international rules and standards as well as adapting to national norms and new trends.

Fourth, in order to secure self-reliance pertaining to S&T innovation systems, policies that limit the imitation or copying of advanced technologies should be developed and systematically enforced. In this regard, the nation should focus
its efforts toward developing core technologies and creating new knowledge bases that support new industries. Therefore, the government needs to change its technological development strategy from one that is oriented toward meeting short-term consumer demand, to one that is oriented toward creating the market in the long-term. That is, S&T should drive consumer demand — not the other way around. Currently, in Korea, consumer demand is driving S&T. Toward this endeavor, the government should prepare for the future by allocating a more consistent portion of its resources to future programs. Additionally, it is essential that a new research culture is created — one that will provide Korea with challenges and opportunities and enable Korea to attain the nation’s hopes and dreams. Finally, a new social atmosphere is needed wherein scientists and technicians are respected.

**Korea’s Resolution to S&T Development**

Expanding R&D and innovating the S&T system are, by themselves, insufficient factors to adequately develop the nation’s future. S&T should be a role player that propels the economy and society in a forward direction. Therefore, the government should build a national management system whereby all people will recognize the importance that S&T has in their daily lives as well as the relationship S&T has with other factors in society.

As we are standing at the beginning of the new millennium, we have to renew our commitment to S&T development. By doing so, Korea will move one step closer to attaining a knowledge-based society that is actually based on S&T, and one step closer to achieving the nation’s hopes and dreams.
Preparing for New Challenges
1. Significance of the Year 2025

The new millennium is very meaningful for Korea as it represents both a new beginning and the turning point for changes in paradigms, thought processes, and value systems. The new millennium marks not only the lapse of physical time but also a new landmark of hope. The 21st century will undoubtedly be a time of enormous and prominent scientific discoveries and technological breakthroughs. Now, as we stand at this critical juncture in time, it is crucially important that we properly prepare and plan for our future by assessing future S&T requirements.

According to "The Long-term World Business Cycle Theory," the year 2025 is critical in that it is expected to be the extension phase of the fifth business cycle. The fifth business cycle is based on an economic theory that asserts that economic cycles last fifty years, fueled by specific technologies. It will only be possible for Korea to join the leading countries of the world if it properly and effectively prepares for this phase.
Moreover, according to professors at George Washington University in the US, now, on the threshold of the 21st century, a great innovation is occurring to S&T, and major accomplishments of technological development will pour out during the next fifty years to come.

Becoming a renowned country in S&T will enable Korea to achieve the status of an advanced country. As an advanced country, Korea will be able to more effectively and efficiently manage the great waves of S&T innovation. As Korea is concurrently striving for further economic development, cultural prosperity, the opportunity to benefit mankind, and national reunification. The year 2025 is targeted as the year that Korea joins the world’s advanced countries, and to reach that goal, the government must prepare for it.
2. Aim and Structure of VISION 2025

VISION 2025 is an extensive and comprehensive plan designed to set a national-level vision and directions for science and technology, which will surely drive remarkable changes in the future. It is not actually a fixed or conclusive plan, since we can hardly come up with concrete measures envisaging the future 25 years at the moment. It is rather intended to set up a long-term vision at a national level, and then accordingly establish a new guideline for the government’s policy making. To make this plan more reliable, it can be revised every 3-5 years, reflecting changing environments and the progress of S&T implementation.

VISION 2025 was developed with the following four objectives in mind.

First, it prepares for the future by establishing a new epochal mission that anticipates future changes and developments in society.

Second, it establishes a policy that takes into consideration effective utilization of energy and the nation’s limited natural resources.

Third, it clarifies the responsibilities and duties of employees in the S&T fields and promotes the stature that S&T policy occupies in the national policy.
Fourth, it reveals new dreams and hopes made possible by S&T breakthroughs. Subsequently, VISION 2025 will expand the support base for S&T and encourage people to join the challenge to improve the future.

VISION 2025 was established to fully reflect the views and opinions of the private sector — the end-user of technological development. From the beginning, the Planning Committee, which consisted of civil experts, laid the cornerstone of the plan. Renowned scholars from the Korean Academy of S&T (KAST) and the Korean Academy of Engineering (KAE) participated in writing the draft.

The structure of VISION 2025 is as follows:

First, the direction of our future society was forecasted. Next, the long-term vision for S&T development was established, taking into consideration the strengths and weaknesses of the realities surrounding Korea’s S&T environment. Then, to prepare for this, an actual action plan was drawn up. This plan prepares for the future direction of S&T, and classified and specific tasks were designed and issued. Finally, new policy directions geared toward strengthening the capability of national innovation system based on Korea’s unique situation and changing environment were drawn up and documented.

VISION 2025 specifies a detailed action plan for the next five years, general direction for the next ten years, and a rough outline depicting the overall direction for the ten years extending from 2015 through 2025.
21st Century Society
1. Forecast of the Future Society

The 21st century is expected to be earmarked as the era of great societal renovation that will embody unprecedented, large-scale changes affecting every aspect related to mankind. Society as we know it today will undoubtedly be vastly different when the first quarter century of the new millennium ends. New paradigms will emerge, develop and grow while old ones will undergo significant metamorphoses, adapting to changes in societal institutions, values, and mores. The scope of these revisions will be widespread and all-encompassing, extending from economic and industrial reforms to lifestyle, value system, and social changes.

It is expected that future society will develop in the following directions.

First, the source of national wealth and growth will be focused on knowledge, information, and S&T instead of on physical or material resources. It is certain that individuals, organizations, and countries that effectively utilize knowledge and information in this age will become the leaders. Others will fall behind, unable to compete in the new knowledge-based, digitalized and globalized world.
Box 1. Transition to the Knowledge-based Information Society

- Electronic information is structured, industry is operated based on a knowledge management system, and informatization spreads across all sectors of politics, economy, and society, including such things as voting via the Internet, cyber transactions, networking of consumer activities, and citizen gatherings.
- The mature application of information covering all aspects of individual lives, such as the residence, work, learning, leisure activities, interests, and so on, becomes routine, and the cyber society based on the Internet takes form.
- Changes take place from a system that places importance on wealth based on quantitative production to one that places importance on qualitative production based on knowledge and information and such things as knowledge labor and high-tech service prevails.
- There is an explosive increase in the desire and need for an information infrastructure, like a super-fast information telecommunications network and the Internet, and such issues arise as improving the education system to raise information consciousness, improve information literacy, and nurture people with gifted intellects.
- There is also increased concern over such issues as protecting the value of creative knowledge, like computer programs and intellectual property; the invasion of privacy; and the abuse and misuse of information.

Technologies and ideas are the products of the knowledge-based information society, and discriminative added-value will be created by adapting to the services that technology and ideas provide. Through harnessing the power of computers, telecommunications and information technology, a human being’s ability to produce will make a quantum leap. A new knowledge-based revolution is being born, a revolution that will go forth propelled by the fusion of digitalized technology coupled with an individual’s ability to utilize information. The industrial structure of the twentieth century has become the backbone supporting the knowledge-based information society of the 21st century. In this regard, the manufacturing processes for 21st century
products such as semiconductors and software have been refined and more-or-less perfected. Additionally, the service industries, including the entertainment and advertising industries, are becoming more clearly defined.

Because of the proliferation of the Internet, new service-oriented cyber-businesses will emerge in the form of home-based businesses, or Small Office Home Offices (SOHOs). The industries affected will include, but not be limited to, medicine, education, and entertainment. Additionally, the concept of what constitutes a distribution industry is changing from one based on the flow of physical goods to one that is based on the flow of information. In this respect, the Internet broadcasting and telecommunications industries will predominate in the 21st century.

Second, due to the relaxation and liberalization of laws related to international trade, the transaction of goods, services, capital, and even human resources will flow freely across international borders. Concurrently, the concept of a global village will take hold, the existing borders will become almost meaningless, and exchanges of information and culture will transact on a real-time basis.

So, an age of full-scale, unlimited competition will be staged, and the phenomena of globalization and bloc formation will intensify to promote both national competitiveness and interest. All of these will occur amidst the backdrop of one super-power and several powerful countries, whereby national boundaries will increasingly lose their significance and competition will intensify. These trends are expected to prevail over the long term.
[Fig. 2] Structural Change of Industry based on Knowledge and Information Progress

(Before)  (After)
Box 2. Globalization and Unlimited World Competition

- Industries, finance, and production systems will be globalized.
- The globalization of management seeking production sites and markets with the best conditions and acceleration of borderless economies.
- A high value-added production system and industrial structure will be pursued. Also, a sales system that is able to sensitively respond to worldwide consumer demands, as well as to facilitate the involved technology will take form.
- In international trade, new technologies, and intellectual property rights, the necessity of international rules intensification and international cooperation will increase by accelerating the flow of publications and new technology among nations according to active international trade in information, art, science, and culture.
- The aspect of competition and cooperation between international blocs such as the EU, NAFTA, APEC, etc. will complicately emerge according to regional interests.

Note: EU: European Union, NAFTA: North American Free Trade Agreement, APEC: Asia-Pacific Economic Cooperation

Third, a group-oriented society based on social consensus under common social norms and values will be transformed to a more individual-oriented society based on independence and selective ideals. All this becomes possible because of S&T, and the government will take the steps deemed necessary to ensure that this objective becomes a reality.
Box 3. Improvement of Life Quality and the Advent of New Value System

- Most of the incurable, immortal diseases will be overcome and life expectancy lengthened.
  (e.g.: A project realizing a 100-year-old generation)*
- By escaping from absolute poverty and greatly extending life, the human being’s desire for the quality of life will change from physical wealth to quality value.
- According to the advancement of personalization and diversification, society is expected to ensure a healthy, pleasant, safe and comfortable lifestyle, along with freedom of choice.
- The development of artificial intelligence and information communicative devices will make it possible to lead to a comfortable and automated home and society.
- Destructive and resource-exhausting economic development will no longer be supported. Furthermore, human-natured, environment-friendly development will be permanently developed, while the possibility of disputes around this increases.
- New lifestyles such as new forms of art, broadcasting, education, working, and dilettante activities will emerge and satisfy various desires.
- Lifestyle will rapidly be transferred to an individual-oriented society more focused on logic, rationality, and efficiency than the existing social roles and group principles.
- The viewpoint of value will be confused by high generation-to-generation conflicts due to their different ways of thinking, the change of family relationship due to the social participation of womanpower, the increase in the unmarried population and the advent of the cyber-society using cyberspace.
- Social problems will be escalated according to the increase in the old age population, celibacy, and childless people, and the threat to human dignity such as S&T, life, ethics, and security increased.

*Note: Project for 100 year-old life In 1998, the US government started the governmental welfare programs for the elderly, which includes Medicare and employment in years of old age.

On a universal basis, government involvement in setting social values will no longer be involved to the extent that it is today, and participation by the private sector in determining the solutions for national and social agenda will increase significantly. However, this does not mean that
governments will operate detached from all social responsibility. Instead, the basic responsibilities and duties of government will focus on ensuring national security and protecting lives, properties, and human rights. With regard to social changes, the entire world will increase its demand for comfort, convenience, and a healthy lifestyle. There will be increasing concern pertaining to global environmental issues involving the depletion of national resources, as well as food, water and energy shortages.

Fourth, S&T in the 21st century will be remarkably developed to an extent unequaled in any other century; as such, S&T will also play a pivotal role in economic and social development. Therefore, the overall social system will actually be rearranged on the S&T axis, and dependence on S&T will be gradually but steadily intensified. S&T will be the baseline for developing sound judgement which, in turn, will facilitate the rational decision-making process. On the other hand, concern for problems related to the restoration of contra-functional by-products, ethics, and the environment will be quite serious, and the verification of social receptivity to new technology, more difficult.
Box 4. S&T Progress and its Relationship with Society

- Create new products and industries and remarkably change our lives and way of thinking by influencing our lives directly and indirectly.
- According to the increasing utilization of sophisticated informative machinery and tools, social acceptance of rapid progress of S&T and verification of its security devices, involving ethics and human dignity, problems of relative feelings of alienation, human reproduction, and others, will emerge as important problems.
- The escalation of human alienation or over individualization resulting from S&T development and effective contra-functions from a technique-omnipotent basis will lead to social issues.
- Monopolization by youth or experts will be based on people’s interest, and participation in S&T will increase.

(Ex: ‘Project 2061’ in America, ‘Copus’ in England)

Note: 1) Project 2061: Project to improve science literacy of the people, driving juvenile science, mathematics, technology, and education reform
2) COPUS (Committee on the Public Understanding of Science) Established in 1985, it has constantly proceeded the popularization policy of science.
2. Role and Development
Patterns of S&T

S&T is a core factor in leading the renovation of our future society. It will be motivated by perpetually linking economic development with social development. By facilitating the knowledge-based information society, it will play a pivotal role in creating national wealth through improving efficiency in politics, economy, society, and public administration. In the end, it will function decisively by consolidating industrial competitiveness, the source of national wealth. It will also ensure a healthy, safe, and convenient lifestyle by solving problems pertaining to medicine and healthcare, as well as those problems related to public welfare and the environment. Ultimately, S&T will become the source of creating a truly desirable, humanistic society by protecting various lifestyles and philosophies. One salient feature of S&T will be to provide the means to defend freedom and security; thereby, decisively promoting national stature.

In other words, S&T development facilitates the advent of a knowledge-based information society, while providing the foundation for survival and industrial competitiveness in the 21st century. And, in the age of unlimited competition, S&T guarantees both a high quality of life and national security, while enabling a nation to engender a community of highly creative individuals.
The distinctive aspects of S&T development in the future are summarized by the following four points.

First, the integration effects between S&T, various disciplines of science, and various aspects of technology are expected to come together. There is, in fact, a cycle. Scientific discovery escalates technological innovation, resulting, in turn, in the acceleration of scientific study. The fusion and compound phenomena, in creating a new kind of technology, also will be significantly expanded by a wide range of combinations or fusion with the technology in other fields centered around practical uses.

Second, due to mankind’s sustainable drive to seek out a convenient life, the systemization and intellectualization of technology will lead to a matured stage of development. The products coming to the markets in the future will be of an intellectual type. These products will be characterized by their ability to both self-regulate and adjust quickly and automatically to changing situations.
Box 5. Linkage between Science and Technology

- Invention of the superconductor (science) $\rightarrow$ application to organism measuring machinery and tools (technology) $\rightarrow$ explanation of organism structure (science) $\rightarrow$ application to bio-computer (technology)

Technology Fusion and Integration

- Information + bio-technology $\rightarrow$ utilizing the technology to organize data processing $\rightarrow$ application to the development of artificial intelligence, electronic machinery and tools
- Life + materials technology $\rightarrow$ organizing friendly material technology $\rightarrow$ application to the development of artificial skin
- Materials + information technology $\rightarrow$ optical computer technology $\rightarrow$ application for the development of a super-speed computer
- Information + life + materials technology $\rightarrow$ intellectual MEMS* technology $\rightarrow$ application for the development of highly efficient machinery and tools for human body experimentation.

Note: MEMS: Micro Electro Mechanical System

[Fig. 4] Illustration of Technology-intellectualization

- self-perceptive ability
  - sensor technology
  - self-study
- judgement ability
  - intellectual-type agent technology
  - CASE*
  - parallel-treatment nerve circuit net
- user-friendly environment
  - document/voice perceptive technology
  - brain-wave perceptive technology

Note: CASE: computer aided software engineering
These new products may include sensor technology, which can independently perceive a human being's intentions; self-perceptive technology, which can bring out pre-stored information by self-study; voice-recognition technology, which can interface with various systems; and a user-friendly environment comprising technology that is connected to the applicable system via brain waves. Advanced technologies that have been developed will be merged and extended into a systemic technology.

Third, while technological innovation will be increasingly accelerated, its cycle will be shortened. That is, the time span required to turn a new scientific discovery into a commercialized product will be significantly reduced. The speed at which technological innovation is occurring continues to accelerate, while concurrently the new product transfer time and the speed of product improvement is steadily decreasing.

**Box 6. Accelerating Technological Innovation**

- neon-size computer → desktop (35 years) → laptop (10 years) → palmtop (several years)*

**Shortening Technology Life cycle**

- vacuum tube 33 years → transistor 9 years → VLSI 1 year*
- Bio science was connected to utilization at the same time of its research and development.

Note: 1) desktop: personal computer for desk, laptop: portable personal computer which can be placed on one's lap, palmtop: palm-size personal computer
2) VLSI (very large scale integration): extra large sized, integrated circuit

Fourth, the pursuit and application of extreme technologies will be expanded. These technological developments involve new ways of sustaining life in ultra-low and super-high temperatures, super-high pressures, underwater cities, and space stations. These extreme technologies will create the need for new types of power sources that are portable, light-weight, small-sized, and economical.
Additionally, with regard to computer-related products, the consumer’s desire for high speed and massive storage capability are continuously growing, spurring investment and interest in high technology as well as the development of new technology.

[Fig. 5] Supply/Demand and Speed of Technology Development

In accordance with the aforementioned characteristics of technological innovation, within the next twenty-five to thirty years, certain specific and promising technological trends are expected, as follows.1)

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1) Difficulty in technology forecasting: It was pointed out in 1971 from an announcement made by the Office of Science and Technology in Japan, that the accuracy rate was nearly 25%. The reasons for such technological deficiencies were due to the technological difficulty of 30% and of 70% and other problems unrelated to technology such as social, economic weak impulses, etc. (Science and Technology Policy Institute translated: "The Assessment of Technology Advances" written by Miriam Masarone)

“64KB is enough memory capacity for all users.” (Bill Gates, 1981)
(KIST, "R&D of Korea in the year 2000," 1971)
Box 7. Technology Forecast

[Year 2001~2010]

- In the first decade of the 21st century, the informatization will mature, including important developments in every field. It is likely that these fields could have interactive relationships with various types of media beyond their own borders. Through virtual reality and large display screens, meetings in cyber space will take place at the same time.
- In the medical circle, synthetic remedies and computerized self-diagnosis as well as food and agriculture control through the development of transgenic animal and food products will be possible.
- An ultraviolet blue-green semiconductor laser will be put into practice and engineering technology, to control the silicon microstructure (freely controlling the array of atoms and molecules) will begin to influence every production machinery field.
- A global wide computer network will spread, which monitors worldwide environmental changes in real time. Those data can be synthesized, analyzed, and then distributed to the rest of the world.
- Electronic transactions on networks using electronic payment, electronic cash systems, and network systems that protect privacy from hacker attacks will grow, and systems that make multimedia communications available in every place in the world by using pocketbook-size computers put to practical use.
- Computers with almost no need for a keyboard, portable computers using solar panels, panic-computers that perceive Korean, Chinese, and English written letters above 99% within 1 second and computer that automatically perceives and responds to a person’s voice and expression will be developed.
- Technology to create a reproductive factory system that makes goods by recycling, re-manufacturing and reusing wastes will be developed. Robots that carry out tasks in extremely hard environment (seabed buried site, volcanoes etc.) will be also used.
- Through the use of new materials and the increase of engine efficiency, automobiles will be manufactured with a 30% decrease in fuel consumption compared to current vehicles. Hybrid cars, using both gasoline and electricity will be commercialized. A road transportation control system that monitors the flow of transportation by detecting speed and model of a vehicle and density of traffic will also come about.
- Supersonic fighters and 30m or shorter micro-unmanned aircraft and low and medium altitude satellites, along with ultraviolet X-ray observation satellites and ultra-mini, artificial satellites that are lighter than 5kg will be developed.
• High efficient technology for sewage and livestock waste water treatment, faster utilization of food waste and resources in forming and utilizing animal wastes, along with the retrieval of valuable metals and material from industrial waste will be used.

• A nuclear industrial standard will be applied to the design and construction of nuclear power plants. Robots for the monitoring and maintenance of nuclear power plants will be put to practical use. The technology for the decontamination and decommissioning of nuclear power plants will be secured.

• A long-term thermal storage technology using underground space and energy recovery technology from wastes using biotechnology will be developed. Technology to produce energy from waste by using biotechnology will also be created. Geothermal resources will also be used in creating smaller scaled energy systems.

• Technology for testing the earthquake protection systems for super-high buildings, including tremor deterrents will be manufactured, and disaster prevention and public relief programs will be formed. Noise and tremor reduction systems will also be developed.

• The production of single crystallized diamonds on Si-substrate and plastic working technology, complex-type drives that take advantage of good points of magnetic and optical drives and semi-conductors, as well as ceramic technology will be developed.

• Environment-friendly pesticides, synthetic purifiers and weedicides, will be developed and distributed. Novel-organic synthetic processing using photocatalysts and gold purity plating processes will be developed.

• Medicines to cure hepatitis, arterial-sclerosis non-narcotic chemical synthetics, systemic analgesics and medicines from computer design models will be used along with more efficient medication delivery systems.

• Using genetic technology, certain cancer causing genes that frequently occur in Koreans, and pathogenesis of hepatitis will be classified. Tuberculosis preventives with twice the preventive rate as C-type hepatitis-preventative vaccines and BCG-preventive vaccines will be developed.

• The development of technology to control Kimchi’s fermentation will make organic preservation possible. Earlier fetal death and abortion prevention techniques will be sponsored. The protective proliferation of animal modeling in experiments will be also forged to produce transgenic animals as well.
[Year 2011~2020]

- Work, education, and e-shopping through the computer will be common place. Through the designing of super computers with sensory perception, inferring processes equivalent to the human brain are being discovered.

- All known substances, through the use of compound materials and nano technology, will be available for use while maglev electric automobiles, intelligent transportation systems (ITS), etc. will increase capacity.

- The 5 year survival rate of cancer patient will be above 70% (presently the current rate is 40% for stomach cancer). An efficient way to prevent the transfer of cancer and cures for Alzheimer’s type imbecility will be developed.

- Room temperature control devices for ultra-conductive materials will be applied to industrial products and alternative energy sources (wind power, subterranean heat, solar heat and waste heat) will be widely distributed to every area, such as homes, industries and traffic services.

- The development of highly sensitive sensors and computer (auditory, taste, tactile) technologies equivalent to the human brain will be developed.

- An ultra conductive magnetic levitation train, reaching speeds of 500 km/h that will be used for telecommunications and remote sensing. Low altitude, orbiting (300m) airships for communication service and an electricity boosting system for positioning control of artificial satellites will be realized.

- By using ultra-conductors, high capacity condensers for energy storage will be created. Power transmission line transformers, wireless electronic power transmitting technology will be developed and used, along with ultra-conductive magnets, plasma heating technology and reaction road materials for the development of nuclear fusion will also materialize.

- Factory technology to construct super high rise buildings of upwards of 200 to 500 stories and technology that enables a building to rotate 360 degrees are in the planning stages.

- Three dimensional information stockpiling material that adapts to external environments with self-diagnosing restoring functions, bio-analog polymers, self-perceptive judgment functions and ultra-conductive materials with a transition point at room temperature will be developed.
- Cancer, AIDS, Alzheimer’s disease, bacterial and viral cures will be developed, along with methods of overcoming the drug tolerance ability of malignant tumors that prevents its spreading.
- An aging mechanism, memory molecule mechanism and molecule mechanism explaining the segmenting term of higher animals (men and mice) and the generating growth process will be classified, and biological remedies for diseases of the nervous system by the understanding of growth segmentation genes will be possible.
- All DNA base sequence of major crops, like paddy, will be clarified; major farming quality and livestock genetic maps developed and industrialized; and for high food production, new breeding crops with landmark photo-synthesis efficiency will be developed.
- 30% of human brain functions will be understandable. Life as well could be extended if an aging deterrent gene can be discovered. Neuro-computers with logical thinking patterns modeling high-dimensional brain function can be developed as well.

[Year 2021~2030]
- During the third decade of the 21st century, new achievements in technology such as usable goods and space travel and transportation systems will be visible throughout the society.
- Artificial intelligence chips, which enable computers to understand human feelings, will also be available. It’s possible at this time for computers to read information stored in the human brain by using electronic magnetic information.
- The logical inferring mechanism of the brain will be clarified and man’s cognitive mechanisms will be unveiled and adapted to computer science.
- A space factory for commercial production of semi-conductor and medicines can be established. In addition, a 200 seat plane with the speed of mach 3 that can cross the Pacific Ocean within 3 hours will be available and research of the planet’s underground geology will also be attempted.
- A gene controlling human sensitivity in the brain will be clarified and interfaced directly to a computer.

2) The 6th "S&T Foresight Research toward the Year 2025" by the Office of S&T in Japan.
3) "The 2nd S&T Foresight(2000-2025) - S&T of Korea" in 1999 by KISTEP and STEPI.
Based on S&T forecasting, some advanced countries are making positive and strategic endeavors to secure core technologies, which are essential for ensuring national competitiveness. They are as follows: (1) Information technology to establish the basis for the information age, (2) Life science and medical technology to secure a better life, (3) Environmental technology to respond to pollution and sustain growth, (4) Energy technology to solve potential energy shortages, (5) Material technology to pave the way for technological breakthrough in other areas, and (6) Mechatronics and systems technology, to enhance industrial competitiveness.

The US\(^2\) selected some promising key technologies to facilitate its economic growth for the long term and keep its status as a leader. These areas are energy, environment, agriculture and food, information technology in telecommunications, computer hardware, software and services, robots for manufacturing, medicine, space exploration and transportation.

By 2025, Japan\(^3\) is to establish itself as a creative S&T nation focusing on materials and processing, electronics, information, bioscience, space, transportation, oceanography, natural resources and energy, environment, agriculture, forestry, production machinery, healthcare, medicine, urban design and architecture, civil engineering and social welfare.

France\(^4\), considering basic industrial strategy, is improving industrial competitiveness and coping with social changes by 2010, and has decided its key technology fields to be in healthcare,

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3) Japan: "S&T in 2025(summary)" the 6th Technology Foresight Research by the Office of S&T.
environment, communications, transportation, consumer goods, housing and infrastructure, bio-science, information, energy software, materials, etc.

The UK\(^5\), aiming at establishing a knowledge-based economy by 2020, has set its technological focus on the environment, traffic and transportation, chemistry, defense, space, energy and environment, financial services, food, healthcare, information and communications, materials, etc.

Germany\(^6\), based on the 2020 forecast, concentrates its policies in such areas as materials and processing, information and electronics, bio-science, elementary particles, oceans and the earth, minerals and water resources, energy, environment, agriculture and forestry, manufacturing, urban design, city architecture and civil engineering, communications, space, transportation, medicine, healthcare, and social welfare.

Australia\(^7\) focuses its policies on core technologies that will be strategically needed by 2010. They are environment (energy), transportation, information and telecommunications (IT), electronics, genetic and bio-technology, precision manufacturing, new materials, etc.

Taiwan\(^8\), which is working to be a technologically advanced nation by 2010, supports intensely some core technologies of the future such as multi-media (communications), bio-engineering, space,

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precision machinery, new materials, and electronic automobiles, etc.

Long-term Vision of S&T in Korea
1. Current Status of S&T in Korea

Historically, the Korean people have shown remarkable potential in the area of S&T. However, in the nation’s earlier history, the social status of scholars was valued and the status of farmers, artisans and merchants was considered inferior; consequently, those involved in S&T were looked upon with contempt. The S&T field grew stagnant and remained so during the late nineteenth century. Actually, Korea did not avail itself to staying abreast of S&T until the 1960s, remaining 200 years behind the West and 100 years behind Japan. One could say that the modern history of S&T development in Korea has occurred in a very short period of time.

[Table.1] Major S&T Accomplishments in Korea

<table>
<thead>
<tr>
<th>Age</th>
<th>S&amp;T Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Bronze</td>
<td><em>Daneumomoonyung</em> (Bronze mirror with fine linear design and knobs on the back): Delicate pattern difficult to receive even by CAD program</td>
</tr>
<tr>
<td>The Three Kingdoms &amp; The United Shilla</td>
<td><em>Absolute influence on the ancient culture of Japan</em>&lt;br&gt; <em>Sokkuram Grotto, Chumsungdae, Bongdall Temple Miew Bell</em>&lt;br&gt; - Superiority of geometry, astronomy and founding technology</td>
</tr>
<tr>
<td>Koryo Dynasty</td>
<td><em>Tripitaka Koreana, Metal Type, Blue Celadon, etc</em>&lt;br&gt; - Superiority of type technology, ceramics etc.</td>
</tr>
<tr>
<td>Chosun Dynasty</td>
<td><em>Phluimeter, Anbulig (sundial), Astrolabe, Turtle Boat, White Porcelain, Donggubogam, etc</em>&lt;br&gt; - Superiority of astronomy, sea, weather, medicine, etc.</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td><em>TDX, semiconductor, CDMA</em></td>
</tr>
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</table>

Note: CAD (Computer aided design) / TDX (Time division exchange) / CDMA (Code division multiple Access)
During the 1960s and 1970s, Korea contained its R&D efforts to induce, assimilate, and improve technologies from more advanced countries. The nation recognized the importance of R&D to its industrial development and thereby linked its R&D efforts to the five-year plans for economic development. During the 1980s, Korea strived to raise the level of industrial technology and that of its diffusion by developing certain advanced technologies, absorbing and improving upon them in parallel. Then, in the 1990s, Korea tried to catch up with the technology levels of more advanced countries. Accordingly, today’s shipbuilding, semiconductor, iron, steel, and automobile industries have managed to keep their industrial competitiveness in the world market.

As Korea has to some degree traditionally been dependent on the S&T of other countries, the nation has achieved a substantial portion of its economic growth through the development of process and production technologies. However, the nation is currently facing economic, social, and structural dilemmas, resulting, in part, from neglecting to actively prepare for the future, thereby disturbing the potential for sustainable growth in the 21st century.

This negligence has resulted from the improper handling of ongoing across-the-board environmental changes including rapid changes in the field of knowledge and information. In the meantime, the nation’s economic policy was driven in terms of quantitative growth that delayed structural
adjustment. However, a more fundamental problem was that the level of S&T in Korea did not offer a lasting source of economic growth, since even today it still remains only at the level of commercialization. Even with applied technology induced from foreign countries, with several notable exceptions, the nation has not yet truly established a core technological presence at the world level. KISTEP’s research project, published on August 14, 1999, shows that Korea’s S&T level is only at fifty-to-eighty percent of other advanced countries.

On the other hand, the result of annual research conducted by the IMD in Switzerland suggests several policy implications pertaining to S&T in Korea. The S&T competitiveness of Korea in 1999 was ranked 28th in the world. Korea measures its competitiveness, to some degree, in terms of quantitative indicators, such as R&D investments, human resources, and patents, etc. The study, however, shows that Korea has a weak S&T innovation system and an unfavorable environment for S&T development, resulting from the insufficient technological cooperation between companies, academia, and industry.

9) Korea Institute of Science and Technology Evaluation and Planning
Box 8. Input/Output Compared with Advanced Countries (1997)

- Size of investment: 1/16 of the US, 1/10 of Japan
- Size of workforce: 1/10 of the US, 1/16 of Japan
- Patent enrollment: 1/13 of Japan, 1/7 of the U.S.

Comparison of the Accumulated Investment over the 30 years (1968–1997)

- Size of investment: 1/31 of the US, 1/16 of Japan.

10) [Fig 6] compared some of the meaningful facts among the 26 items researched by IMD. The fields on the outside have higher rankings than the inner ones.
As shown above, the strength of S&T in Korea lies in the relatively high position of S&T resources, including R&D investment, human resources, patents, etc. However, the amount of investment is far from being sufficient when compared with that of major advanced countries — Korea’s accumulated R&D investment over the past thirty years is still lower.
Korea’s strengths include the world’s lowest illiteracy rate (2 percent), a passion for higher education, an abundant source of highly educated workers, and the existence of numerous research groups with the potential for advanced study. When these factors positively interact, they will generate a synergy effect that contributes to the improvement of overall S&T competitiveness.

Korea’s weaknesses lie in the poorly organized S&T management system and institutional environment, and these weaknesses are reflected in both insufficient technology transfer and level of technical cooperation among various institutions — especially between industry and academia. The nation also has an unfavorable legal environment whereby political, economic, and social settings are unsuitable for the promotion of S&T. S&T is not yet recognized as a key element that leads the nation; rather, S&T is still regarded as a peripheral factor to national development. Consequently, S&T is not considered or valued in terms of the national decision-making process. Under these circumstances, coupled with the high burden of defense expenditures incurred as a result of the divided Koreas, it is easy to understand why the nation will have to play catch up in terms of competitiveness with other more advanced countries. Korea’s competitive position amongst its Asian neighbors becomes more noticeable when taking into consideration China’s low wage rate and Japan’s high rate of technological development.
During the 20th century, as Korea was a relative latecomer in the procurement of S&T, the nation failed to secure basic and core technologies. As a result, the competitiveness of industrial technology remained inadequate. The nation, therefore, made very few contributions to the international community. In the global village, a new source of growth is needed before S&T can make a significant contribution to society at large. Before Korea can become a genuinely advanced country, the nation will need a new source of growth. Consequently, Korea’s national growth model, which depends heavily on physical input factors, should taper off, and the reliance on foreign technology must be phased out. Thus, a search for national growth based on knowledge and core technology is needed. It is time for Korea to focus its efforts in the direction of S&T and push forward the implementation of S&T-based policies.
VISION 2025 is designed to improve Korean creativity to reach the world-class level during the first quarter of this century. By promoting excellence in the production of quality products and unique technology, Korea will join the ranks of the advanced welfare countries in matters pertaining to fundamental technology, the economy, public welfare systems, and national security. The first twenty-five years of the 21st century will determine Korea’s potential for joining the list of advanced countries. This period will be critical for Korea. It is the period in which the nation will reshape its future - a future that envisions a re-unified and industrialized economy.

Therefore, the Korean government should concentrate its efforts on bringing about epochal S&T development. In the short-term, the government should prepare for the upcoming knowledge-based society. In the long-term, the government needs to play a more definitive role in global community. The Korea Development Institute (KDI) projects that Korea will see a relatively stable GDP growth rate of about 6 percent over the next two years. If technological innovation and reform are successful, the GDP growth rate will stabilize at about 5.1 percent until 2010 and 4.1 percent until 2020. KDI also projected Korea to attain the global rank of 7th country by 2025, with the GDP totaling over US$ 2 trillion, and GNP per capita income of US$ 38,000 or more.

In order to achieve the goal of joining the advanced industrialized countries by 2025, Korea should invest in each sector of society, paying particular attention to education and S&T. The nation should also ensure that it implements its long-term policy consistently throughout all sectors of society.
A strategy involving intense S&T resource investment needs to be selective and carried out in stages to achieve the S&T development objectives and the vision toward 2025.

By 2005, the aim is to join the top twelve countries in S&T competitiveness, keeping well ahead of the other Asian countries. Toward this end, Korea must significantly expand investment and improve efficiency in R&D, as well as refurbish the R&D infrastructure and legal system in line with privately led innovation trends. Education programs for S&T must be reformed to induce creativity and produce creative human resources. R&D programs must be propelled in the same manner as "Frontier Research Projects" with the overall objective of creating the basis for future growth. Also, to maintain global competitiveness in key sectors such as memory chips, computers, communications, and automobiles, etc., efforts to develop related technologies must be made. The nation needs to develop a diversified technological base capable of dealing with a variety of lifestyles and industries.

In 2015, Korea will emerge as the hub of scientific research in the Asia-Pacific region. To realize this objective, Korea must first become an information "mecca" using current knowledge-based and communication-related ideas. Then, the nation needs to set up a global network that allows smooth technology transfers and more comprehensive R&D programs. Korea also needs to settle the social atmosphere so that creative minds can more freely pursue their hopes and dreams, thereby promoting new knowledge-based industries. Through enhanced creativity, Korea's own technologies can be developed to stimulate its own basic research activities with the goal of producing Nobel Prize winners. In addition, in order to accelerate the development of an information-based
society, intensive efforts are needed to create or improve information infra-technology, such as the next-generation of semiconductors, computers and the Internet. Concurrently, the Korean government should focus its efforts on advanced, ground-breaking technology for stimulating basic research activities and creating new industries. By focusing the energies and efforts in this manner, the goal of becoming the technological hub of the Asia-Pacific region can be realized.

In 2025, Korea will be equal to the top seven countries in technological competitiveness. The nation will accelerate ahead of all other competing countries in selected, specified areas. Korea will create new paradigm designs that develop, utilize, and spread advanced and accessible information. To achieve this goal, the government needs to immediately upgrade the level of public awareness and recognition of S&T.

Furthermore, in preparing for the possibility of unification of the two Koreas, a plan should be set up to integrate the two scientific systems. To promote a more equitable regional and global level of technology pertaining to quality of life and humanitarian issues, Korea needs to employ a national management system in which S&T is recognized as an integral part of all aspects of society. In addition, technologies related to life science, health, medicine, and the environment, are essential to ensuring a more comfortable, convenient, and secure life. Technology that is closely linked to national security, i.e., water, food, energy, and outer space-related projects, will help promote Korea’s national stature in the international community. This technology will also be at the top of the science-policy lists along with Korea-led global research projects.
[Fig. 7] Long-term Plan for S&T Development toward 2025

### Goals of 2025
- Ranking 7th in S&T competitiveness
- Ranking 5th in the informatization index
- 30% in S&T’s contribution to economic growth
- Over 1 in Technology balance of payments
- $80 billion for R&D expenditure
- 34,000 for R&D personnel

### Present
- Ranking 20th in S&T competitiveness
- Ranking 22nd in the informatization index
- 19% in S&T’s contribution to economic growth
- 0.01 in technology balance of payments
- $12.8 billion for R&D expenditure
- 130,000 in the R&D personnel

11) They are phased in first (~2005) second (~2015) and third (~2025) for convenience.
12) Related indices are as follows: “S&T Competitiveness Competition” from the IMD Annual Report. “Informationization Index” from “Cyber Korea 21” issued by the Ministry of Information & Communication. “S&T Contribution to Economic Growth” from “The Cause and Potential Prospect of the Korean Economy” published by Kim Kyung Sik. Variations depend on research institute and researchers. In addition, R&D Investment has factored in 4% of the GDP and R&D personnel was calculated, researchers per 10 thousand population targeting on 60.
VISION 2025 can only be realized with the complete support of both the public and the government. When we all share in the challenges and opportunities brought on by the possibilities that can be achieved through globalization and S&T, then our spirits will be lifted with a sense of renewed hope.

The specific prerequisites for realizing VISION 2025 are as follows.

First, Korea should prepare, both technologically and politically, for potential changes in the 21st century. The emerging knowledge-based information society needs pioneering leadership in the domain of S&T. S&T should take the leading role in strengthening competitiveness, creating national wealth, and meeting the demand for improving the quality of life in an ever-diversifying value system. It will also improve national security and international reputation. In addition to coping with the rapid progress in S&T and its strong influence on society, the government must stimulate the creation of knowledge and induce technological innovation.

Second, R&D resources will be focused on several specific sectors of S&T, and these sectors are predicted to predominate in developed countries in the 21st century. These specific S&T sectors will be very important when analyzing future scientific advances and technological possibilities. It was postulated that
the development of these specific S&T sectors would advance in accordance with costs and efficiencies. These specific sectors include: information, life sciences, new materials, the environment, energy, mechatronics, computer systems, and basic ground-breaking resources. Four of these sectors — i.e., information, life science, energy, mechatronics/systems, are driving forces in advanced countries. Material technology and basic fundamental technology provide the basis for these driving forces. The environmental engineering will provide guidelines for technological development.

Third, the vision of the 21st century will not be achievable without a revolutionary change in policy direction in S&T renovation. In this respect, the policy directions are as follows.

- The government will first change the current S&T system from a government-initiated and development-oriented system to a private sector-driven and diffusion-oriented system.

- The R&D system must convert a domestically-completed S&T system to a globally-networked system.

- More priority will be given to efficient utilization of resources rather than to supply expansion in R&D investment.

- Focus will be greater on creating new markets from a long-term perspective rather than on responding to short-term demands. Finally, the move will be toward a S&T-initiated national management system.
Fig. 8] Framework for S&T Development

- Transition from a government-initiated and development-focused system to a privately-led and distribution-oriented system.
- Transition from a domestically-determined R&D system to a globally-networked system.
- Strategic change in investment promotion from supply expansion to efficient utilization.
- Strategic change in technology development from meeting short-term demand to creating new markets from the long-term perspective.
- Establishment of S&T-initiated national management system.

Ups
- Abundant resources for R&D
- World's lowest illiteracy rate
- High aspiration for education & quality human resources
- High-level R&D & Development workforce with lots of potential

Downs
- Weak S&T management system
- Lack of general awareness of S&T as a major factor for national development
- Heavy burden of national security due to division between the North and South
- Immature political, economical, and social environment
IV

Direction of S&T Development
A mature information society will materialize in the 21st century. Sharp increases in the stream of information have already led the "mega-trends" in our society as information technologies, including expanded Internet communications and networking, have been developing rapidly. The information society will have matured and advanced in all fields by the early 21st century because this period, or "information wave," is flowing at a faster-than-expected speed than what Alvin Toffler predicted in "The Third Wave."

The social environment and structure as well as the lifestyles of individuals, enterprises, and the nation will change. Therefore, we should recognize the need to prepare for the information society now. These are not options -- one must "go digital or die." The government needs to make maximum efforts to upgrade its level of technology as soon as possible and to focus on developing and implementing key information technologies. The realization of an electronic government, including electronic voting and Internet polling, will be among the many challenges that lie ahead. Other technological challenges in the realm of a digitalized government include, but are not limited to: informatizing all social fields of employment, welfare, medical care, distribution, banking, education, and national security; using remote services to include distance education and medical clinics; and fostering a new industrial base in cyber space.
Box 9. Policy Recommendations by the US President’s Information Technology Advisory Committee (Summary) (February 24, 1999)

- Presenting goals in 10 fields to be changed through information technology as key elements spearheading social development in the 21st century.
  1. Internet: One billion customers connected to the Internet doing banking, and communicating regardless of distance/language.
  2. Electronic Library: All people search books, newspapers, and video through Internet regardless of language.
  4. Remote Medical Care: Making computer-diagnosed treatment common, utilizing video-conferencing.
  5. Electronic Commerce: Customers can buy goods and services at cheap prices regardless of region, and enterprises promptly respond to customers' reactions.
  6. Working at home: Fifteen million US workers will telecommute from their homes in the next 10 years.
  7. Design Drawing: Drawing complex structures using the Internet with the manufacturers and final users participating in the process of designing.
  8. Virtual Experimentation: Studying through virtual labs regardless of physical space.
  10. Electronic Government: Citizens access governmental service and information regardless of location or proficiency in using the Internet.
- This is done through the intensive investment of software industry, information infrastructure, super computer systems, and research on social/economic impact of information education and information technology.

[Task 1] Sustain momentum to advance information technology so that world leadership is attained and supported in core technology fields by 2010.

Everyone is aware that IT is directly connected to efficiency and effectiveness of all social sectors as well as the development of equipment and devices necessary to
actualize the exchange of knowledge and information. This phenomenon is expected to clearly appear, considering the wide-spread ripple effect of IT and its ability to fuse with other fields.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Development Direction of Information Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classification</strong></td>
<td><strong>Direction of Development</strong></td>
</tr>
<tr>
<td>Fusing and mixing of technology, product and service</td>
<td>- advent of information-related home appliances combined with computer, broadcasting, communications and recreational functions.标准ize functions, specifications, and parts. - multimedia network integrating voice, data and image.</td>
</tr>
<tr>
<td>Networks such as the Internet</td>
<td>- faster speed of transmission, wider band of transmission scope, and high capacity data processing.</td>
</tr>
<tr>
<td>Integrated software</td>
<td>- system software, application software</td>
</tr>
<tr>
<td>Smarter information-related home appliances</td>
<td>- data processing, interface, integration through international standard institution</td>
</tr>
<tr>
<td>Information service</td>
<td>- application systems for industrial and home use, and contents industry</td>
</tr>
<tr>
<td>Special semi-conductor</td>
<td>- special semi-conductor combined with machine, chemistry, optics, biology, and medical technology</td>
</tr>
<tr>
<td>Auto-sensing, auto-judging and decentralized control</td>
<td>- monitor/control technology, automatic diagnosis, pursuit of &quot;smarter&quot; for correction of errors</td>
</tr>
</tbody>
</table>

Some analysts claim that they will not be able to predict the extent of technological development in 2010, because of the vast potential of the unknown in technological innovation corresponding to the shortening life-span of technology in general. Consequently, the development of core IT must take place as soon as possible. Korea needs to capitalize on its current technologies, including semi-conductors, home
appliances and telecommunications equipment, by maximizing their usefulness, and making the most of the "infra-strengths." In this connection, the nation needs to take into account the fact that it has limited resources and must compete with advanced countries, despite its limitations. Maximizing current technologies will, in the end, be beneficial to enhancing its competitive edge.

In this regard, the government should continue establishing short-, mid-, and long-term technology development plans like "The Five-year Plan for Information and Telecommunications Technology Development" announced in September 1999, in order to present the direction for technology development in industry. Korea will also have to secure core technology that can do "cross-licensing" with the advanced countries and the technologies that can counteract profit-seeking moves made by the advanced countries (e.g., Charges for the exchange of information through the Internet).

To do this by 2005, a base for informatization that includes the selection and development of strategically important infra-technology will be constructed, fostering a professional workforce, completing the super highway information network, localizing core electronic parts, and strengthening cooperation with the world's technology leaders. By 2015, Korea will develop world-class technology and products like telecommunications terminals based on infra technology. New technologies with high degrees of sophistication will be developed that spearhead world markets, including technology related to communications equipment, and increased competitiveness centering on core sectors by actively participating in international telecommunications and service markets. By 2025, Korea will develop products that lead the world market by fusing source technology with multi-media technology, and by developing a terminal with communication concepts having the embedded technology for the next-generation equipment.
To achieve these goals, Korea will have to continuously work hard under an intensive strategy at the national level to develop succeeding technologies in the following fields.

First, strive to attain leadership in home appliances, memory semi-conductors, TDX (time division exchange), ATM (asynchronous transfer mode) switching machine, CDMA (code division multiple access) cellular phones, optical fiber, etc., fields that already have secured international competitiveness thanks to the heretofore intensive strategy fostered by the government. Second, follow-up technology must also be developed in the fields of multimedia, information-related home appliances, and information service and such, that are beneficial to fusion and mixing technology commercialization. The infrastructure of the telecommunications sector, such as super highway information networks and Internet technology, is essential in an information society. Their prompt construction and completion in both quantity and quality on a world wide level are required. So, toward this end, intensive investment in the following promising technologies must be fostered and completed in a speedy manner: (1) VLSI (very large scale integrated) semi-conductor technology including 4/16/64/100 gigabytes; (2) Future-orientated computer technologies, such as the development of portable multi-media terminals, terabytes, $10^3$ flops computers, optics/bio-computer, portable multi-media computers, etc.; and (3) A three-dimensional video processing system. Korea will also have to develop core technology that is attuned to develop relevant technologies, viewed as faster, connected and smarter.

As to "faster," efforts must be directed at developing core devices and parts for telecommunications, including system-on-chips, smart micro systems, optics/high frequency devices and faster wireless
data communications technology along with the next generation of VLSI semi-conductors, future-oriented computers, and portable multi-media terminals. As to "connected," the development of the next generation communications network technology is necessary. It materializes network infrastructure, which is a base for realizing cyber-space. Also necessary is the development of technology for home networking and mobile networking. Technological development to support cyber life is essential, including cyber intelligence, which can do work in place of human beings, and applied technology. Regarding "smarter," development of human-friendly information-processing technology and digital contents should be done — such as three dimensional images, virtual reality, voice recognition, etc., and smarter multi-media contents technology that includes a real-typed, multi-media DBMS (database management system).

Box 10. Key Information Technology for the Future

- Next-generation telecommunications network technology
  - In order to establish a network infrastructure that serves as the backbone for cyberspace, the next-generation infra-technology of telecommunications needs to be secured, such as high-speed networks that include wider band wireless telecommunications in the U-NII band, Internet-related technology, and networking.

- Technology to support cyber life
  - Next generation cooperative system for three-dimensional image processing technology will enable people to process information while at home and on the move. The development and application of cyber intelligence will increase the convenience of daily lives, making possible inter-active tele-education, ultimately creating an environment suitable for education and training in cyber space.
• Intelligent multimedia contents technology
  - Realistic multimedia database systems with digital contents will be
    produced. Its application will enhance language education systems,
    interpretation telephone with automatic simultaneous interpretation,
    and large-scale retrieval. Cyberspace will be harnessed for more
    efficient and multi-party on-line communication using information
    technology.
• Human-friendly information processing technology
  - Bio-human computer inter-face technology, virtual reality technology,
    natural language processing technology, three-dimensional image processing
    technology, etc., will lead to the development of human-friendly
    easy-to-use information production and transmission technology such
    as multimedia agents, chirological interpretation systems, and
    image-to-voice transformation systems.
• Info-protection and security
  - To safely share information around the world, security-related technology
    such as next-generation authentication access controlling and
    encryption will be developed. In addition, next-generation information
    restoration systems (e.g., virus detection and automatic vaccine
    application system) and Internet service quality verification systems will
    also be developed.
• Future computer technology
  - Next-generation computer-related equipment and devices, including
    10-tera flops computer, fiber-optic and nerve network and bio
    computer and the portable multimedia high-tech computer, will be
    developed.
• Portable multimedia terminal
  - Parts integration and miniaturization and a low-voltage circuit system
    will contribute to the development of the portable multimedia terminal
    with other functions of telecommunications with computers and the
    development of multimedia information retrieval systems.
• High-speed wireless data communication system
  - The development of high-speed wireless network access technology,
    multimedia processing and transmission technology, and wireless
    multimedia mobile-ware set-up technology will open the window for
    the development of high-speed wireless multimedia data (text, voice,
    motion picture, image, and graphic) processing and transmission
    technology and the information system on the Internet as well as in
    the mobile computing environment.
• Next-generation ultra-large-scale IC technology
  - Through the development of 416/64/100 Giga DRAM and key
    semiconductor components, Korea will keep the leading edge in the
    global semiconductor market.
- Core parts of Telecommunications device
  - An integrated circuit will be developed in which many circuits are integrated on a nano-meter scale: smart microsystems, flexible fiber-optic materials that send out information at speeds of 10 trillion bits per second, ultra-high frequency passive devices and core modules, wireless sensor network systems (smart dust), millimeter wave transmission and reception modules, millimeter wave antenna, and high-speed switch.

- Three-dimensional image processing system
  - High-definition flat display technology is required. Optical transmission technology will be developed to make a screen with a three-dimensional image, high resolution that bends, and is non-toxic to humans.

- Core software technology
  - Software technology and automatic programming systems will be developed to support the creation, storage, distribution and utilization of information.

- Future informatization base technology
  - Nano-technology that serves as a basis for future informatization, optical Internet technology, and telepathic signal processing will be developed.

[Task 2] Improve the efficiency of public service through computerizing in data processing, and establishing the “Electronic Government” by 2005.

To lead informatization in every sector of the society, the government should first make efforts to improve the efficiency of administrative work, enhance transparency of the government and, thereby, improve service. The “electronic government” will make all of these possible. The electronic government that links the people with the government over fiber-optic cable will be able to provide people with one-stop administrative services and better access to information. The government needs to increase its service productivity and implement policies in a transparent manner, thus generating more efficient leadership.
To achieve administrative informatization for higher government productivity, the current paper document management system must be changed to an electronic document system in which electronic settlements and electronic document distribution methods are used and all of the information and data are digitalized. Furthermore, information networks that are currently decentralized, depending on the ministries and the nature of work, will be integrated by stages from a single centralized information and telecommunication infrastructure to a central management system under the government.

Informatization efforts, which will dramatically improve public service, include linking and integrating the home-pages of government ministries to provide comprehensive services to the public over the Internet. Also necessary is establishing integrated digital information services to citizens of every city, county and district, and developing an integrated information service terminal through which public documentation can be issued anywhere, anytime. Along with these technological advances, a security system that protects privacy is also important.

[Task 3] Promote public access to information.

In the informatization age, no one should be excluded from technology, and everyone should be encouraged to adapt to the new environment. To this end, individual capability to process and use information will be enhanced. A positive mentality toward the digital society is required.
It is necessary for all of the Korean people to get connected to a website in less than a second. This entails minimizing the time to access information and attaining the urgently needed information within electronic systems. Therefore, the nation must modernize its IT infrastructure, which also includes the information super-highway. The government also must provide one PC, one e-mail, and one homepage to each person to materialize the creation of the “cyber house.” All Koreans will be able to easily become accustomed to the IT environment by themselves.

Early schooling and home education for children will also be provided to create an information-oriented mindset and place top priority on training skills essential to informatizing. For this, primary and secondary schools will need to reinforce info-tech-related subjects, publish related textbooks, and hire more competent teachers. As English is the language of the Internet, education reform is needed to ensure that Koreans have sufficient English background to master the Internet. Information-related education must be fully provided at an early age, said US President Bill Clinton, and by the time Korean students graduate from primary school, they should be able to use the Internet in English without much difficulty. New education systems, such as the cyber college and life-long education on the network, will expand cyber education to even include the underprivileged, i.e.: the handicapped, housewives, blue-collar workers, farmers and fishermen.

The IT industry in Korea, which includes computer hardware and software, as well as telecommunications industries, grew quickly, as high as 18.2% in 1996, 25.9% in 1997, and 18.1% in 1998. However, unfortunately, the Korean IT industry, with the exception of telecommunications, has yet to develop a leading edge in the global market.

To expand the market in the mid- to long-term future, the next-generation of promising export products, such as PDA (Personal Digital Assistance) and digital contents must be developed. Leading telecommunications technologies too must be developed, and support provided to the knowledge-based industry, both require the talent of Koreans. Promising industries that also need nurturing are financial engineering industries based on use of the computer and telecommunications networks; E-businesses that include electronic commerce and information providers (IP); and advanced software industries that support high-tech animation, games, culture and the broadcasting industry.

The government needs to improve the educational environment such as regular education organizations to secure skilled workers in these emerging IT industries. In addition, overseas education programs for talented students to acquire advanced skills using technology should be promoted, and the reeducation of information technology professionals should also be considered. Opening of the telecommunications market in line with globalization calls for Korea to develop internationally compatible devices and distribute them. Deregulation in the telecommunications sector will encourage telecommunications businesses to compete more fiercely in the market.
### Table 4: Prospects for IT Industries in Global Market

<table>
<thead>
<tr>
<th>Technology</th>
<th>Market size</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile data telecommunication service</td>
<td>151.5</td>
<td>153.8</td>
</tr>
<tr>
<td>Personal computer</td>
<td>289.5</td>
<td>272.7</td>
</tr>
<tr>
<td>Mobile phone service</td>
<td>161.5</td>
<td>161.8</td>
</tr>
<tr>
<td>Digital contents production</td>
<td>23.5</td>
<td>32.5</td>
</tr>
<tr>
<td>Information provider (IP)</td>
<td>10.2</td>
<td>17.0</td>
</tr>
<tr>
<td>System LSI</td>
<td>11.5</td>
<td>26.2</td>
</tr>
<tr>
<td>Internet electronic sale</td>
<td>23.4</td>
<td>31.0</td>
</tr>
<tr>
<td>Cable TV(CATV)</td>
<td>24.6</td>
<td>31.8</td>
</tr>
<tr>
<td>Software with agent function</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Ultra slim monitor</td>
<td>39.6</td>
<td>47.9</td>
</tr>
<tr>
<td>Digital broadcasting</td>
<td>107.5</td>
<td>127.9</td>
</tr>
<tr>
<td>Semiconductor equipment</td>
<td>24.4</td>
<td>40.0</td>
</tr>
<tr>
<td>Mobile computer</td>
<td>9.60</td>
<td>17.8</td>
</tr>
<tr>
<td>LCD</td>
<td>29.3</td>
<td>46.4</td>
</tr>
<tr>
<td>Next-generation mobile phone</td>
<td>12.2</td>
<td>16.4</td>
</tr>
<tr>
<td>Internet access service</td>
<td>15.9</td>
<td>24.0</td>
</tr>
<tr>
<td>Next-generation memory chip</td>
<td>20.1</td>
<td>20.1</td>
</tr>
<tr>
<td>Fiber-optic cable</td>
<td>11.1</td>
<td>11.1</td>
</tr>
<tr>
<td>Videogame software</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>ATM switch for fiber-optic cable</td>
<td>2.30</td>
<td>3.50</td>
</tr>
</tbody>
</table>

Note: 1) 100 Japanese yen was presumed to be 1,000 Korean won.
[Task 5] Effectively cope with side-effects of rapid informatization.

Technologies for protecting information and ensuring security, encryption technology, for example, must be developed in order to effectively cope with the adverse effects of rapid informatization, such as the violation of privacy, computer hacking, illegal copying of software, and the misuse of information.

Moreover, it is the duty of the government to effectively cope with the adverse effects of informatization. It must create a social environment that protects private information, establishes telecommunications ethics, and regulates inappropriate distribution of information.
The information revolution and deregulation of worldwide economic activities will further globalize the world market and its production system. Therefore, the distinction between domestic and foreign markets will blur and mega competition led by technology and information will also accelerate.

Against this backdrop, in order to join the ranks of advanced countries in the next quarter century, Korea must move out of the conventional quantity-oriented model of growth to the information-based, high value-added creative models of growth. In 1960s, when Korea was experiencing breakneck speed of economic growth, S&T depended heavily on "production by simple assembling", utilizing foreign technology and equipment as well as cheap domestic labor. In 1970s, Korea established a somewhat solid technological base by introducing and imitating foreign technologies. After 1980s, the country digested some of the new foreign technologies, and then started to improve or even develop them. However, the overall S&T level of Korea is still low, relying on the foreign technology, except for a few areas only. The inferior technological level restricts ensuring the growth potential of Korea under the knowledge-based economy.

As the paradigm shifts toward the knowledge-based economy in the 21st century, Korea must fully prepare for the changing environment.
First, in conventional areas such as the automobile, shipbuilding and home electronics, Korea’s energy and efforts must be concentrated, through technology, on areas that have the greatest potential to produce high value-added products so that they can remain flagship industries in the future.

Second, the Korean government needs to forecast what the emerging industries of the future will be and lay the foundation for the growth of those industries. As functionality, accuracy and intelligence become increasingly important, the human demand for convenience, stability and increased mobility in the 21st century is expected to be marked by a rapid growth of new products, such as multimedia devices, portable instruments, medical equipment and bio-related products. Therefore, the related technologies must be developed in advance.

Third, intensive efforts must be made to promote the competitiveness of high value-added future service industries, which include multimedia contents (entertainment, screen and music), e-commerce, education, medical services and tourism, because the industrial paradigm is expected to shift from manufacturing to service. In order to strengthen the above high value-added industries, it is necessary to develop the prospective core technologies in conjunction with establishing IT infrastructure, reforming the distribution system, fostering internet-related industries, building e-commerce systems, and strengthening the protection of intellectual property rights (IPRs).
[Fig. 9] Value-added Industries and Technologies in the Manufacturing Sector (Examples)

- Technology
  - Information technology
  - Material technology
  - Life science
  - Functional Genomics
- Industries
  - Multimedia
  - Network
  - Virtual reality
  - IT home electronics
  - Multimedia devices
  - Wearable devices
  - Cure for diseases
  - Anti-aging & reverse of aging
  - Recovery from disability
- Demand
  - Anywhere/anytime
  - Variety of info. & contents stability
  - Convenience
  - Longevity
  - Recovery from disability

[Fig. 10] Economic Growth and the Role of S&T in Korea

GDP per capita (USD)

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic economy</th>
<th>S&amp;T</th>
</tr>
</thead>
<tbody>
<tr>
<td>'75-00</td>
<td>Sustainable development</td>
<td>fundamental technology</td>
</tr>
<tr>
<td></td>
<td>Global competition</td>
<td>new technology</td>
</tr>
<tr>
<td></td>
<td>Knowledge-based economy</td>
<td>knowledge-based technology</td>
</tr>
<tr>
<td>'00-25</td>
<td>Rapid growth</td>
<td>Industrial technology</td>
</tr>
<tr>
<td></td>
<td>Cheap labor</td>
<td>Applied technology</td>
</tr>
<tr>
<td></td>
<td>Aggressive capital investment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laying the groundwork for growth</td>
<td>Manufacturing and assembly technology</td>
</tr>
<tr>
<td></td>
<td>Diminution of absolute poverty</td>
<td></td>
</tr>
</tbody>
</table>

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The arrival of transnational competition calls for more than just dealing with international competition. It requires Korea to actively respond to new modes of knowledge-based economic and industrial activities; thereby, enhancing the competitive edge in industry at a level above other nations. In the 21st century, knowledge and information will play the most important role. Therefore, industries that involve information, life, environment, energy, mechatronics, and material processing technology will have the greatest impact on technology development and on the market. The significance of this development trend in Korea will be as great as they are in other advanced countries.

Information technology in the 21st century is not only essential in an information society, but also crucial in adding value to S&T. IT’s spillover effects to the economy and overall society carry important implications for industries. According to a survey conducted by a Japanese economic newspaper “Nihon Keizai Shimbun” in 1998, new information technologies will play a dominant role in the world market during the first ten years of the 21st century.

Biotechnology will be able to satisfy the basic human desire to enjoy a healthy long life and to improve the quality of life. Biotechnology will also be a high value-added field in this 21st century. Therefore, it is no exaggeration to say that this is an essential technology for strengthening the competitive edge of industry. Although biotechnology is in its infancy stage, it is expected to grow rapidly by 2010, and by the mid twenty-first century, biotechnology will play a leading role in creating new industries as IT did in the previous century.
Environmental technology makes possible "sustainable development," through which a better quality of life, economic growth and environmental protection can be achieved without compromising each other. It also enables Korea to produce an environment-friendly atmosphere in line with international regulations and standards that will enhance productivity.

Energy technology requires long-term and systematic approaches directly associated with the survival of a country, and serves as an engine for industrial progress. In this field, improving the efficiency and diversifying the sources of energy are considered to be important, which is associated with limited global resources and environmental problems.

Mechatronics and system technologies are advanced technologies creating high value-added. They provide production facilities for the entire industry and offer more area for convenience life for modern people. System technology, in particular, greatly contributes to the growth of other related industries and technologies.

Materials and processing technologies are the basis for the development of various industries, including electronics, energy, environment, and biomedicine, etc. They are the leading technologies that make it possible to develop high value-added, innovative products.

<table>
<thead>
<tr>
<th>Box 11. Goals of Six Major Promising Technologies of the Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Information Technology</td>
</tr>
<tr>
<td>· Phase I (<em>2005</em>)  Strengthen the basis for information industry by establishing infrastructures for information and telecommunications and developing core technologies for strategic information equipment.</td>
</tr>
<tr>
<td>· Phase II (<em>2015</em>)  Establish global competitiveness in core fields by producing various products through the development of world-leading and high-level technologies that are difficult to develop.</td>
</tr>
<tr>
<td>· Phase III (<em>2025</em>)  Lead global markets by developing market-leading products through combining leading technologies with multimedia technologies.</td>
</tr>
</tbody>
</table>
**Biotechnology**
- **Phase I**: Develop core technologies for genome function research. Establish infrastructures and foundations for industry through the domestic production of biomedical equipment.
- **Phase II**: Create specialized fields by combining transgenic technologies for animals and plants with the technologies utilizing genome functions.
- **Phase III**: Establish biotechnologies that are compatible to those of industrially advanced countries by developing Korean-unique technologies for utilizing genome functions.

**Environmental Technology**
- **Phase I**: Found the basis for advancing environmental technologies, as the development of product design technologies based on the life cycle assessment (LCA) concept.
- **Phase II**: Establish environmental technologies for the future as the prevention of environmental pollution and the rehabilitation of the environment, etc.
- **Phase III**: Contribute to the protection of global environment by developing core technologies to control ozone layer, and to monitor the transfer of pollutants from country to country, etc.

**Energy Technology**
- **Phase I**: Develop technologies to save energy, and to improve the efficiency of energy consumption.
- **Phase II**: Develop alternative energy sources and their distribution
- **Phase III**: Establish the ability to independently supply energy by developing new concepts of alternative energy sources.

**Mechatronics and System Technology**
- **Phase I**: Develop fundamental technologies as intelligent integrated control technology by establishing industrial base and infrastructures.
- **Phase II**: Strengthen competitiveness by enhancing application capabilities as electronic system matching technology.
- **Phase III**: Develop products that lead world markets, such as the tele-controlled humanoid.

**Materials and Processing Technologies**
- **Phase I**: Enhance materials properties and processing technologies and strengthen the competitiveness of current materials.
- **Phase II**: Find materials infrastructures for new-technology demands by establishing independent domestic technologies for information and electronic materials and enhancing the efficiency of the materials related to energy, environment, and biotechnologies.
- **Phase III**: Create high value-added new materials that lead related technologies, as the technology that leads through improved intelligence in core materials fields.
Unlike the advanced countries, Korea has relatively less natural resources and lower technological levels in various fields. Thus, it is necessary to promote technology development by selecting and focusing on a few core technologies with realistic and step-by-step goals.

Among the six promising future technologies, IT-related technologies are addressed in Section One (“Spearheading the Information Society”), while bio-technology and environmental technology are dealt with in Section Three (“Improving the Quality of Life”) under the title "Science and Technology for a Healthy Life" and "Science and Technology for a Comfortable Life," respectively. Energy technology is discussed in Section Four (“Ensuring National Security and Enhancing National Prestige”).

Mechatronics refers to the realization of a high performance system by combining mechanical device technology as tools and equipment with such electronic technologies as electronic circuits and control technologies. These days, more attention is being drawn to intelligent mechatronics, which also embraces communications, networking, and human intelligence. Mechatronics is a technology-intensive, high value-added technology that allows us to concentrate more on creative works by achieving the efficient use of limited resources and the automation of manufacturing facilities. In addition, mechatronics, through the development of MEMS (MicroElectroMechanical System) or robotics, extends the scope of human activities.

Prospective future technologies in the mechatronics-related
systems or areas (general mechanics, aerospace, etc.) include
development of intelligent integrated production systems; intelligent,
high-speed precision processing devices; next-generation aircraft,
multi-functional artificial satellite; multi-phase space rocket; and
so forth.

Materials processing technologies refers to the materials
technologies that develop new materials with outstanding
properties and the process technologies that create new
materials characteristics and applications by the development of
innovative manufacturing processes with conventional materials.
These technologies are highly technologically intensive and
value-added and cover a wide variety of areas. These
technologies also create a lot of economic value both in specific
material markets and in product markets that use the materials.

More recently, rather than simply producing materials (metals,
 Ceramics, semi-conductors, polymers, etc.), rapid developments are
being made in the practical application of complex, functional
materials (information, electronics, mechanics, structure, organism,
medical care, etc.) with specific functions.

To secure the core technologies that are necessary for being
a competitive and profitable country in the 21st century, there
must be various kinds of policy support as well as efforts
made in technology development. In addition, Korea must also
become more responsive and receptive to new R&D, production,
and management methods.
Box 12. Essential Mechatronics and System Technologies for the Future to Establish Industrial Competitiveness

**Intelligent Robots:**
Prepare the future robot-industry by developing such advanced next-generation robot technologies as:

- tele-controlled humanoid that can collect information and work at dangerous places or remote areas
- robots for medical application
- robots for extreme environments
- personal human robot, etc.

through the development of the following core technologies:

- core technologies in moving and working
- next generation robot-controlled system based on artificial intelligence
- sensors and tele-control related technologies
- mutual sensing technology between human beings and robots

**Intelligent Integrated Manufacturing Systems:**

Develop systems that can achieve:

- enhanced productivity and stabilized product quality
- factory automation
- production control

by developing computer integrated manufacturing (CIM), intelligent manufacturing system (IMS), automated factory, innovative integrated product design technology, etc.

**Intelligent, High Speed Precision Machining Devices:**

Develop core technologies for intelligent-machining devices, which include design, fabrication and processing technologies, etc. to develop software and hardware for enhancing the performance of metal-machining devices. The machining device is one of the core-capital goods that becomes a basis for the competitive power in the manufacturing industries.
Next-generation Vehicles:

- Develop the next generation vehicles keeping up with the changes in new market environment, which limits carbon dioxide emission to prevent global warming. The next generation vehicles include:
  - vehicle utilizing alternative or non-petroleum fuels
  - highly efficient zero-emission vehicle
  - computer integrated vehicle with significantly improved safety
  - fully automated vehicle that can drive by itself without human intervention

Next-generation Aircraft:

Develop the next generation aircraft, such as an ultra-small flying object, unmanned aircraft, mid-size aircraft, mid-size helicopter, supersonic and mega-size aircraft, etc., through the development of the following core technologies:

- micro-electromechanical system
- ultralight, multifunctional special materials
- propulsion system as plasma acceleration system

Future Vessel System:

Develop the core technologies for the next generation vessel including:

- super-conductive motor for elevated temperatures
- self-cutoff system
- optimal electronic propulsion system, etc.

to lead the world marine logistics industry through the development of large-capacity, high-speed vessels

Wireless Network Sensors:

Develop the manufacturing technology for sensors and an ultra-small transmitter-receiver equipped with data processing system and ultra-small, high efficiency batteries, and wireless network system.
Box 13. Essential Materials Processing Technologies for the Future to Establish Industrial Competitiveness

Next-generaton High Density Storage Materials:
Develop extra-high density storage materials of 10 terabit, in which one atom becomes a memory unit, to provide a basis for producing devices that are smaller but have higher capacity and improved performance with faster data transfer rate.

Biomaterials:
Develop high performance CO2 absorbing materials and related system to reduce air pollution, and soil-cleaning materials and related system to prevent soil from being polluted.

Nano Materials Technology Utilizing Self-assembly:
Develop synthetic technology for inorganic materials and production technology for bulk materials utilizing self-assembly.

Future Carbon Materials Technology:
Develop next-generation display devices, ultralight high-strength materials for aerospace and automobile applications, and hydrogen storage materials using nano-carbon materials.

High Performance, High Efficiency Structural Materials:
Develop future-oriented high performance structural materials that can be potentially utilized for various special applications with their extra-high strength, hardness, and are corrosion resistance, and apply them to the related industrial fields.

Intelligent Microsensors for Artificial Sensory Systems:
Develop basic and application technologies for sensors that have sensing capability similar to human sensing organs (eyesight, touch, hearing, smell).

Biomimetic Chemical Processing Using Molecular Engineering:
Develop new chemical processes by simulating organism-function using molecular engineering that aims to produce various small-quantity and customized products, which replace mass production processing from the present large plants.

Materials Controlling Biofunction:
Develop new materials that are necessary to control biological functions such as genesis, growth, maintenance, etc. for animals and plants, including the human body.

In the past, Korea’s exports were mainly based on Original Equipment Manufacturing (OEM) or producing cheaper and sometimes second grade products with an ample supply of labor and capital in such industries as textile and footwear. More recently, on the other hand, with increased financial and technical capability, industries such as the automotive, shipbuilding, steel, semi-conductors, and telecommunications industries have been developed as the major industries, driving the economic growth of Korea. However, the problem remains in that Korea’s products are still perceived as being cheap and of low quality. In addition, there is not enough attention throughout society directed at improving overall product quality in society, making it difficult for products to make inroads into high-end markets. Moreover, numerous Korean products are increasingly found in the uncomfortable situation in which there is significant Chinese and Japanese competition.

In order to stay competitive in main industries and to be more competitive in new areas, it is essential to upgrade the quality of products and parts, and to gain the confidence of consumers. Quality-confidence control technology, including precision measurement and monitoring techniques, must be introduced. Active support must be provided to R&D efforts with regard to SMEs. Financial and tax incentives should be extended to firms that take positive action to upgrade the quality of their products and gain customer trust.
In addition, enhancing quality levels and gaining trust require legal and institutional support. Henceforth, the quality assessment industry that covers precision measurements, non-destruction examinations, system assessment design, and advice on provisions of quality control should be fostered as a high-value-added, knowledge industry, while thorough quality testing is carried out. Quality certificates systems and PL (Product Liability) laws should be in place as well. However, what is most important and urgent is to recognize the need for quality innovation as a matter of national survival. For this, the government needs to start concentrating on qualitative, not quantitative growth while companies and each individual reform their perception of quality. For starters, goals should be set to rebuild the national image for quality, and a “quality-first” national campaign needs to be launched.

**[Task 8] Encourage entrepreneurship and technological innovation through a merit-based system.**

Technological innovations can only take place when there are entrepreneurs fighting against the odds to achieve what seems uncertain and unlikely. Therefore, the prerequisite of encouragement must be set. A social environment is required in which people with new ideas, technologies, and know-how can readily start new businesses despite uncertainties.

In particular, special assistance must be offered to instill entrepreneurship, foster and operate technology-intensive venture businesses, and create rich sources of innovation. To do so, it is necessary to prepare and implement policies to cultivate the entrepreneurial spirit that includes policies for science and engineering colleges to reinforce their curriculum so students
foster the spirit and an insurance system for technology development should also be operated. In addition, the policies should include steps to stimulate venture start-ups in universities and research institutions, assist investment attraction, and provide increased funds for R&D activities for innovative technologies. Moreover, to increase investment opportunities for uncertain and untested technologies, the government, as a means to take on a part of the risk, should review commissioning institutions such as "Venture Bond Retail Firms" or "Venture Asset Management Corporations" so that viable technologies from unviable venture companies can be bought, managed and resold. Also, as part of an effort to fully reward technology developers themselves, the ownership of such innovations should go to the individuals themselves rather than the groups they belong to. This is to guarantee high return for the innovators who have taken the risks.

[Task 9] Revise laws and regulations to ensure an “innovation-friendly” environment.

The taxation and financing system should be improved so that capital accumulation and investment in technology innovation are achieved. In addition, laws and regulations that hinder private research activities should be regularly reviewed and removed if considered unnecessary. Moreover, government support is needed to upgrade the technological evaluation process, train qualified evaluators, and forge cooperation among businesses or research institutes. Another area in which government assistance is essential is the dissemination and transfer of technologies through CEDO’s (Consulting Engineering Design Organizations), research personnel dispatch firms, and technical advisory groups.

For this to work smoothly, the government must establish a
special financial institute for technologies by considering organizing a special institution that evaluates the values of technologies, or launch a public "Corporation for Technology Export," or an "Ex-Im Bank for Technology."

The world is now moving toward stronger protection of IPRs. To meet international standards pertaining to IPRs, a special organization is needed to manage, examine, and evaluate patents. Simultaneously, regulations should be improved so that foreigners or corporations can establish their research institutes without difficulties at desired sites in Korea.

The nation must create a more favorable environment than its competitors, in terms of industrial technological support, and the government should make sure that all assistance programs are reliable and continuous. For these support programs to be easily accessible to the users, they must be carefully coordinated, integrated, and streamlined. However, it needs to be noted that each government’s R&D subsidy to its private sector is increasingly being restricted by the TR (Technology Round) under the WTO New Round.

**[Task 10] Cultivate high-caliber S&T personnel.**

As Korea moves into the knowledge-based society and see advancements in industrial structure, the severe shortage of skilled technicians is becoming apparent. An annual labor shortage of 44,000 people is expected in technology-related areas, while at the same time, an oversupply forecasted in other areas. What makes this issue critical is the labor shortage is envisaged in such high-tech industries as information and electronics. Another point that needs to be noted is today’s disconnection between education and business. Young
engineering college students are graduating without the skills needed in the workplace, which aggravates the labor shortage. What’s more, these young graduates prefer to work in industries other than manufacturing. The utilization system for technicians is not well established, there are limitations in the support system for highly-educated technicians for small- or mid-sized companies, and construction and utilization of the information system for the technicians are not well operated.

In order to address such difficulties, therefore, a redoubling of effort is required to nurture more flexible, innovative, and skilled technicians that meet industrial demands. Efficient use of labor through institutional support is essential to gain the competitive edge in technology in the long run. In addition, it is necessary to establish a system to utilize the brains in the R&D area as well as technicians working in foreign countries.

**[Table 5] Prospect for Future S&T Demand**

((unit: 1000 people, %)

<table>
<thead>
<tr>
<th>Classification</th>
<th>1998</th>
<th>2001</th>
<th>2010</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total labor demand</td>
<td>22,145</td>
<td>23,031</td>
<td>24,885</td>
<td>12%</td>
</tr>
<tr>
<td>Professional engineers/technicians (% against total labor demand)</td>
<td>2,189(9.9%)</td>
<td>2,488(10%)</td>
<td>2,935(12%)</td>
<td>3.68%</td>
</tr>
<tr>
<td>S&amp;T related vacations (% against professional engineers/technicians)</td>
<td>570(26.0%)</td>
<td>689(26.4%)</td>
<td>929(31.5%)</td>
<td>5.43%</td>
</tr>
<tr>
<td>Scientists and technicians (% against S&amp;T related vacations)</td>
<td>399(62.5%)</td>
<td>489(87.7%)</td>
<td>639(89.1%)</td>
<td>6.59%</td>
</tr>
</tbody>
</table>

It is essential that the long-term demands of the workforce be surveyed regularly throughout industry to accomplish the above. Based on the results, a rational workforce supply plan...
should be devised. For this to be effective, it is most crucial that a database comprising technicians that are available be compiled and used.

Corporate research centers may also be directly involved in education to train students so that young workers are prepared for the business world and armed with the skills required at the workplace. That is to say, companies should start cooperative programs between colleges and their R&D centers or set up college/graduate school courses within the company to produce the kind of human resources they need. Additionally, along with continuous reform efforts in science and engineering colleges and graduate schools, special-purpose S&T institutions such as the Korea Advanced Institute of Science and Technology (KAIST) and the Kwangju Institute of Science and Technology (K-JIST) should be fostered to become world-class S&T education institutes.


The intensified competition and movement to the knowledge-based economy require innovation in R&D, production, and management methods. Thus, responding effectively to such changes is very important to establish competitiveness.

In terms of R&D methods, new technologies and innovations are making inroads into business more rapidly than ever before, demanding a new and more flexible R&D system that can commercialize innovations promptly. In addition, to make the most out of the locality, the R&D process must be reinvented to be more open and competitive. Strategies are needed to acquire necessary technologies rapidly, efficiently, and as
economically as possible. Compulsory technologies must be obtained at lower cost as soon as possible. Meanwhile, strategically differentiated technologies should be acquired through internal R&D activities or through special strategic alliances. Likewise, in obtaining technologies, a dual-mode strategy is considered to be an effective approach.

In terms of the changes in production and management methods, knowledge- and technology-based management have become commonplace in the business environment. As a result, the following has become more increasingly pronounced: More companies are taking measures to protect and manage their intellectual properties. Product cycles are shortening while competition among high-tech products are becoming fiercer. More importance falls upon being able to own creative ideas and core technologies, being the first to occupy markets and set standards and being able to flexibly respond. At the same time, more businesses are going beyond mass customization and are moving towards producing a variety of products in small quantities and customized production in a bid to meet the different demands of the customers.

All of the above-mentioned changes illustrate the importance of promptness, flexibility, networking, and the shift towards more creative systems in R&D, production and the management process. To achieve this, a Flexible Manufacturing System (FMS), and an expert system must be introduced while efforts are made to overhaul the organizational structure to be more flexible. Moreover, information on labor resources ought to be networked and shared among the parties concerned.
3. Improving the Quality of Life

In the 21st century, rapid development in S&T will bring about a broad range of challenges in all sectors of society. Individuals will become increasingly more economically self-sufficient and attitudes regarding life will also change as the forces will be directed more on pursuit of the quality of life, rather than mere material gain. Longer life spans will usher in an aging society, thus increasing the demand for a healthier life.

![Diagram showing Technologies for a better quality of life]

- Discovery of the cure & treatment for incurable fatal diseases
- Aging prevention and rehabilitation of diseases
- Remote medicine
- Controlling pollution in the air, water, and soil
- Environmental pollution control and restoration
- Predicting natural disasters and improving resource capability
- Improving safety in nuclear power and large structures
- Function controlling devices
- Telecommuting & home office
- Improved social infrastructure
- Transportation network using information & telecommunication
- Genome & new technology for gene application
- Treatment for incurable or fatal diseases
- Technology for a longer life span & research on anti-aging
- Development of artificial organs
- Development of advanced medical devices
- Technology for pollution prevention & environmental restoration
- Technology for waste material treatment & recycling technology
- Cleaning technology
- Technology for environmental preservation
- Technology for weather observation & forecasting
- Technology for monitoring, forecasting, and preparing for natural disasters
- Nuclear safety technology
- Intelligent agribusiness technology
- Human interface
- High speed information network
- ITS (Intelligent Transportation System)
These changes will require the development of health and medical technologies, entailing the expansion and improvement of the welfare-related industries (such as the silver society industry). Homes, and in a broader sense, the whole society will be more comfortable and automated. New types of art, broadcasting, education, occupations, and hobbies will emerge. The whole new world will increase the demand for comfort, convenience, and safety. Interest will grow in environmental pollution, ozone layer depletion, and global warming caused by continuous and resource-draining economic development. This needs scientific and technological advances as well as active participation in resolving the earth’s environmental problems.
3-1. Science and Technology for a Healthy Life

Improvements in medical science and rising standards of living in the twentieth century increased life expectancies from 47.3 years in 1900 to 77 years in 1999. This translates into a thirty year leap within a 100 year span. Given the rapid progress in biotechnology, a dramatic increase in life expectancy is further expected in the 21st century.

Box 14. Experts’ Estimation of the Life Expectancy by 2050

- The US Social Welfare Department estimates that life expectancy will remain about 80 years by the year 2050, which means the figure is not very different from today’s.
- Two demographers, Jay Olshansky of Chicago Univ. and Kenneth Manton of Duke Univ. expected the number to be 85 and 90 respectively and said that it is unrealistic to expect that the lifespan of human beings will reach 100 or more.
- However, Dr. William Schwartz, professor at South California Medical School, argued that “with the development of the medical sciences, we will eventually be able to control the aging process of cells, and the lifespan will expand to 120 years.”
- Meanwhile, Dr. William Heredine, who runs a bio-engineering firm called “Human Genome Science,” expects the number to increase to more than 200 in 2000.

According to statistics, the percentage of population of people aged over 65 is to reach 13% by 2020 in Korea, 23% in the US, 36% in Japan, and 27% in the EU, indicating that lifespans are increasing. Meanwhile, according to the World Health Organization (WHO), the number of cancer patients is on the rise, and the
WHO indicated that the average cancer incidence rate per ten thousand is expected to increase from 44 in 1985 to 50 in 2050. Currently in Korea, the number of cancer patients is 61 per 10,000, which is higher than the world’s average.

All these trends call for advancement in biotechnology and medical science, which contribute to healthy human lives, by slowing down the aging process, restoring damaged body parts, finding the causes of incurable diseases, and extending life expectancy. What is needed at the same time is a social system for the elderly population, such as the silver society industry and a social welfare system.

[Task 12] Develop technologies in life and medical sciences suitable to Korea.

The importance of bio-engineering and health/medical science is well recognized. These core technologies lead to achieving healthier and longer lives, which are basic human desires. These technologies are among the most promising in the 21st century for inducing the creation of new industries. That is why advanced countries formulate national policy to develop bio-engineering, and apply it to healthcare and commercialization. “The 21st Century Bio-engineering Program” of the US, Japan’s “Life Science R&D Basic Plan” and “BioRegio Program” of Germany are examples of such national policies. Korea has “Biotech 2000,” and now is in the process of carrying out this project.

Life, health, and medical sciences are areas where knowledge-intensive technological developments are possible. For Korea with its limited resources, these are promising areas to set
short-term goals to achieve. Therefore, Korea must first set up the infrastructure through systematic technological and human resources development. From the long-term perspective, Korea must develop its own technologies and continue to develop strategically important technologies under the principle of “selection and focus.” If this is done as planned, the highest level of technology can be achieved in certain areas.

To make that happen, a three-phased plans has been devised.

To set up a technological and industrial infrastructure by 2005, the following is being done: securing the data for interpreting the genetic characteristics of Koreans; securing core technologies for research on the function of the genome; mapping out the measures to increase manpower; and building medical equipment with indigenous technologies. By 2015, medical products and treatments will be developed using the data and core technologies. Those products will be combined, for example as functional genomes, and genetic characteristic conversion technologies in plants and animals will be developed. And by 2025, functional genomes will be developed to push Korea to the ranks of the advanced countries.

**Box 15. Human Genome Project**

- This project involves a tremendous amount of work, comparable to the Manhattan project. Elucidation of the whole human genetic code is a huge task under which 3 billion chemical base pairs in human DNA must be defined in a row. Just 1% of them was defined by 1996 and the work is expected to be completed by 2008. EU countries, Japan, and the US, are investing $8.5 billion every year. When it is completed, only a few thousand among more than 30 thousand commonly known genetic diseases will be treated and many people will be free from about 100 to 150 genetic diseases that currently threaten them.
The most important thing to do is to find the causes of diseases, and treat and cure them at the genetic level. This is accomplished by understanding living creatures at the molecular level through interpreting the genetic structure of humans, plants, and microbes. Nevertheless, the infrastructure for genome research now does not exist in Korea, although it is the basic element of life, health, and medical sciences.

Therefore, basics for new genetic technologies must be provided through the development of basic and applied gene technologies and nucleus transplant technology. In addition, the government must provide support for the functional genomes, which make new medicines possible through finding and analyzing functions of disease-related genes and proteins. Once basic core technologies are secured to research the functions of the genome, new challenges will be found in defining the causes of diseases, developing treatment and new medicines for incurable diseases such as cancer, and creating artificial organs through transgenics.

The areas where further development is needed include remote medicine; super-small medical equipment; new procedure technologies using microbes — to compare with the level of advanced countries; biological resources application; and protection technology, and enzyme engineering.
Box 16. Core Life Science and Health and Medical Technologies

- **Functional genomics**
  - Finding disease-related genes and proteins, analyzing their functions, and creating new medicines by developing core technologies such as high-speed targeting techniques of bio-polymer and bio-molecule, genome function analysis technology, and bioinformatics.

- **Incurable disease treatment technology**
  - Developing drugs against cancer, diabetes, liver diseases, immune-related diseases, and cardio-circulatory diseases by seeking major incurable disease treatment methods, prevention, and drugs.

- **Technology to increase life expectancy**
  - Developing and commercializing food and drugs to delay aging and extend life span, and developing technology to replace aging tissues by research on the molecular mechanism of the aging of living organisms, and development of bio-elements for controlling aging.

- **Artificial organ development technology**
  - Developing mass production technology for artificial organs by developing animal transgenic technology, technology to replace organs and organ transplantation methods.

- **Sophisticated medical equipment development technology**
  - Developing ultra-slim and highly efficient biological measurement and non-invasive treatment equipment, which can minimize patients pain and inconvenience through non-invasive technology.

- **Tele-medicine system development**
  - Designing and manufacturing hardware and software from terminals for tele-medicine to medical information servers through micro-size wireless terminal technology, medical information standard protocol and artificial intelligence technology.

- **Bio-resources utilization/conservation technology**
  - Developing useful resources and utilization technology based on diverse domestic natural products bio-resources by developing useful bio-resources exploration and preservation technology, and applied technique of cell and bio-molecule.

- **New biological process technology**
  - Developing eco-friendly biological process technology that can replace and complement existing chemical process technology through low-polluting process technology, resource-thrifty and reusable biological process technology, and highly productive clean bio-reaction technology.

- **Bio-element technology**
  - Preventing diseases by examining nerve unit genetic mechanisms of DNA and cells by developing genetic engineering technologies, including bio-chip technology and biomimetics.
[Task 13] Continue brain research to join the ranks of the world leaders in specific areas.

Brain research includes: understanding functions and information processing of the human brain; applying the intelligent information process, which is similar to the human thinking process of neural networking; and developing brain disease prevention and treatment technologies. A recent survey shows that the number one reason for death in Korea is cerebrovascular disease, and the three main brain diseases are stroke, Alzheimer’s, and Parkinson’s. It is estimated that there are 1.2 million patients with such brain diseases in Korea. These diseases are expected to increase in the 21st century. Brain research, therefore, should be continued in order to meet this challenge in the aging society.

Countries throughout the world are accelerating the pace of brain research recently. The US government already enacted a law called “Decade of the Brain” to support brain research with such programs as the Human Brain Project of the National Institutes of Health (NIH). Japan is also preparing work to name the 21st century “The Century of the Brain,” and is funding brain research amounting to 800 billion won every year for twenty years since 1997. Korea is also carrying out related projects under the “Braintech 21” plan that was set up in 1998.

Brain research is still an interdisciplinary area at the fledgling stage, and needs the cooperation of other areas, like cognitive science and information technology, and has great influence on the economy, society, and other technologies. Moreover, brain research is in the knowledge-intensive sector, which enables the development of new medical treatments and products with modest investment. This area is very appropriate for Korea to develop, as the nation has a highly educated workforce. The government needs continuous
R&D investment and should focus on the brain information processing area, which uses information technology, one of Korea’s strengths. Core research areas on brain research include: research on understanding the brain; application research on brain information processing which includes molecular biological study on neurons; study on cognitive brain functions; and a study on understanding technology to overcome brain diseases, which includes research on checking neural diseases and their causes.

[Task 14] Develop core technologies for the aging population and the "silver society industry" by 2010.

Guaranteeing the quality of life of the aged will be one of the key issues in the 21st century, along with the inescapable aging of the whole society. In this regard, the government will have to deal with larger and larger medical and welfare costs. The demand for silver society products will also grow, with a potential global market size reaching 100 trillion won by 2010. The silver society industry is, therefore, expected to be a new high value-added sector in the future.

For the above reasons, it is only natural that demands for silver society engineering continue to increase. Research is already in full swing in the advanced countries, and Korea needs to make efforts to secure the core silver society technologies, and build a strategic foundation for this industry. To this end, the following must be developed: first, a welfare system covering health information and home automation, which will assure comfortable living conditions together with reliable medical services; second, medical software and hardware that will enable health care workers to identify the
causes of diseases of the elderly, diagnose the early stages of Alzheimer’s disease, in addition to other mental disorders as well as keep these disorders in check, and tackle complications; and third, a tele-medicine system in which patients can be taken care of at home by connecting them to emergency care organizations. At the same time, Korea will attain the competitive edge in silver society products, such as welfare system facilities, aid devices, housings, and etc.

[Task 15] Build the infrastructure for life, health and medical technologies, which cannot be pursued by the private sector alone.

If Korea is to honor its commitment to international agreements, e.g., the Biodiversity Convention, the government must actively support the construction of infrastructure and efficient operational systems. In order to join the ranks of the advanced countries in terms of the safety and toxicity assessment of the genetically engineered products, new drugs, and pesticides, it will first be necessary to build internationally certified facilities in accordance with the OECD guidelines, for safety testing. It is also necessary to set up as soon as possible a comprehensive clinical evaluation system that encompasses the whole process, ranging from animal to human experiments.

A nationwide gene bank is also a must so that the information on genetic resources, which is one of the key components of developing genetic engineering capabilities, can be actively searched, managed, exchanged, and disseminated. A number of Korean firms have already secured a substantial amount of genetic resources by themselves. In this vein, it is now necessary to link these resources for common progress among
related private, academic, and government organizations. It is also important to set up a national cooperative network so that the country can actively respond to the rapid global changes resulting from the Convention on Biological Diversity and international patents on microbes.

A “Biodiversity Conservation Center” needs to be set up as the headquarters for coordinating activities of the relevant government agencies working to uphold international commitments as well as to support systematic research on biodiversity in Korea. “Advanced Medical Research Centers” should be also established in universities or hospitals focusing on hard-to-cure diseases, incurable diseases, cancer, the brain or other aspects of medical science so that the fundamental technologies in sophisticated medical care can be secured. At the same time, related infrastructure including the medical information network and medical insurance system should be reinforced and improved to assure good healthcare for all citizens.

Korea still has a long way to go as far as life and health-related industries are concerned. So, the government must continue to invest in these fields so that relevant technologies can make progress and industries can grow.

[Task 16] Establish ethical norms on newly emerging cloning technology.

Bioethics became a hot issue worldwide when “Dolly” was born in February 1996, because of the implications for human dignity. Cloning has a great potential in terms of industrial uses such as helping to solve food shortages, or improving
medical services. So, it is natural for many countries to invest manpower and money in this field. However, it is necessary to build a legal control mechanism soon because haphazard development in this field can trigger ethical disasters with the growing likelihood of cloning human body cells. Countries like the US, the UK, and Japan have relevant laws and guidelines for DNA recombination experiments, and these laws and guidelines do not impede research.

Korea has to do the same. As a start, Korea should set up a Committee on Bioethics. Citizens must also keep a watchful eye on cloning and other bioethics-related issues because of their potential threat to human dignity. It is for this reason that Korea needs periodic technological impact assessments involving the participation of its citizens.
Citizens in an advanced society call for clean air, water, and green forests. The environmental demand for a better life will increase along with the rising awareness among the public. Korea is now suffering from serious environmental problems as a result of its decades-long, development-oriented economic policy. The past forty years in which environmental issues were completely disregarded deserves contemplation. It is also time to pledge to set up and implement developmental strategies that harmonize economic development and preservation; thereby, guaranteeing prosperity and comfortable lives for all Koreans in the 21st century.

Conditions surrounding the environment are rapidly changing in and outside Korea due to fluctuations in the Korean economy and the growing international concern about the global ecosystem. Domestically, environmental protection appears more challenging in the face of deregulation trends in environmental management. However, once the environment is polluted as a result of this setback, it will take years, even decades to recover the original state in the case of soil or groundwater. For example, chemical treatment takes three years, biological treatment using microorganisms takes five years, and it may take as long as ten years if the affected area is large. Emerging problems involve the environmental conflicts between regions and between the development-oriented people and their ecological counterparts.

Local autonomy also plays an important role in this complicated picture. Cases in point are the ubiquitous "Not In My Back Yard (NIMBY)" phenomena and the conflicts surrounding
the "Wichon Industrial Complex". At the same time, it is necessary to cooperate with North Korea to protect its natural environment since development projects in the North Korea are being sometimes planned according to the result of inter-Korean economic exchanges.

Externally, Korean industries would be affected by the country’s subscription to the international norms of greenhouse gas emissions because a large number of Korean firms still have low energy efficiency, while the consumption is steeply rising. Furthermore, the competitive edge of Korean products could decline as the result of environment-related industrial and trade controls, which are popping up, like ISO’s introduction of environmental standards in 1996, and the EU’s initiative of the Extended Producer Responsibility (EPR). The transboundary movement of pollutants from Korea’s neighbors, such as China, Mongolia, and Russia, all of which are eager to develop their economies, poses a threat. For example, heavy acid rain is observed in the Western coastal region of Korea, which is seemingly the result of the air pollutants coming from China. No less serious is the pollution of the Yellow Sea.

[Task 17] Develop environmental technologies to attain advanced levels and prepare for the Green Round and other future demands.

Demand for environmental technologies has been increasing not only in developed countries, but also in developing countries, resulting in the development of environmental technologies designated by the world’s leading research institutes as key technologies of the 21st century. Environmental technologies are expected to rapidly develop in the future. Furthermore, in order to come up with common solutions to the environmental problems of the world, the Green Round is expected to be convened in the near future.
Korea’s environmental technologies are in their infancy. However, people now have more interest in a clean environment than ever before and environmental problems are becoming stumbling blocks to the technological development of Korea’s industry. Nowadays, environmental technologies are being more widely used in many fields. For example, the automobile industry is pursuing low emissions and high efficiency. The chemical industry is required to use the concept of Life Cycle Assessment (LCA) in which the effects of products on the environment are thoroughly evaluated when they are designed. Regulation of greenhouse gases will have so many effects on production technologies of the whole industry, that the development of clean technology will be accelerated. Therefore, Korea should enhance its environmental technologies, which are relatively lagging behind, by investing substantially more into research and development.

To achieve this goal, Korea should develop environmental core technologies through active investment, improve the competitiveness of the environmental industry, and establish the basic framework for the development of environmental technologies. Furthermore, Korea needs to upgrade its environmental technologies to the level of advanced countries through strategies that identify and secure technologies for future environmental demands, such as the protection of human beings, the natural ecosystem and the global environment.

First, by the year 2005, in order to set up a framework for the development of more advanced environmental technologies, Korea must secure technologies to prevent and manage the contamination of air, water, soil, and underground water. Furthermore, technologies to treat and recycle a variety of
household, industrial, and city wastes need to be developed as well. Second, in order to secure future environmental technologies related to prevention and restoration by 2015, Korea needs to develop technologies that restore the environment of the soil, rivers, and oceans. Additionally, technologies need to be developed that prevent contamination and predict and evaluate the effects of pollution on the environment. By 2025, Korea will have the core technologies that observe and forecast the environment, control the environment-destructive materials such as greenhouse gases, and predict and evaluate climate changes.

**Box 17. Development of Key Environment Technologies**

- **Technologies to prevent air pollution**
  - By developing technologies for highly efficient dust collection, pollutant measurement, and car emission control, Korea should secure technologies to treat, measure, and analyze pollutants according to their sources in order to reduce air pollution. This should be done with technological know-how to biologically treat non-biodegradable materials such as sulfur and nitrogen.

- **Technologies to manage underground water and soil**
  - By studying the decomposition of pollutants and their movement characteristics, and developing technologies for soil and underground water restoration, highly efficient water purification for hi-tech industries, and the evaluation of the hazardousness of soil contamination, Korea should develop technologies to stop pollutants from flowing into soil and underground water, as well as those for soil and underground water purification, a comfortable environment in restored areas and a safe water processing system.

- **Technologies to treat and reuse wastes**
  - By developing technologies for waste management monitoring, treatment and reuse of hazardous wastes, and household and industrial wastes, Korea should secure technologies for the incineration and landfill of wastes, as well as those for reuse of wastes such as producing chemical products by using reusable resources.
- Technologies to watch the global environment and predict climate changes
  - Korea should develop techniques to monitor and predict global environmental changes, and technologies to watch, predict, and evaluate climate changes in a unified manner.
- Technologies to prevent pollution in advance (clean technology)
  - By developing clean technology, Korea should minimize pollutants from production and use of products in advance.
- Technologies to reduce noise pollution
  - By developing technologies to predict, reduce, and control noise, Korea should minimize noise from machines, equipment and vehicles.
- Technologies to keep the maritime environment clean
  - In order to solve the pollution of adjacent seas that are getting worse due to increasing population and industrial activities, Korea should establish a management system to protect the marine environment and conserve the renewable marine resources by creating regional seas environmental program and develop clean technology to protect the marine environment.

[Task 18] Advance projects that expedite the use of new environmental technologies.

Active interest and support from users are the prerequisites for the application of new technologies. However, a system that adequately supports the application of new technologies has not been established yet, and the general public is not quite aware of the need for it.

As a result, newly developed technologies are not widely used and people are not eager to further develop any new technologies. Since the public sector has been the main consumer of environmental technologies, it fails to offer sufficient incentives to the private sector for inducing new technologies. Therefore, in order to accelerate the distribution of new technologies, systems should be refurbished as soon as possible. In response, the Korean government (the Ministry of Environment) formulated, and is now implementing, ten projects for the development of environmental technologies.
The government must expedite the distribution of new technologies based on evaluation and certain guarantees. At the same time, it needs to implement a new result-based compensation system under which a technology developer establishes a facility using the technology that he/she has developed; then, financial assistance from the government is made available to the developer when the technology turns out to be successful. The system can be used for technology that is not easily evaluated. If a business saves money by using this new technology, the government needs to reimburse part of the money saved as a subsidy. The government should also implement a "two-envelopment system" in which businesses compete with one another in price, technology and in strengthening public relations (PR) activities. Then, various incentives for small- and medium-sized enterprises(SMEs) should be provided in the forms of preferential treatment in project awarding and such. Above all, by shifting the consumers of environmental technologies from the public sector to the private sector, the government needs to increasingly emphasize the need for applying new technologies, which is very important.

Task 19 Implement model projects to raise environmental awareness

The general public must recognize the importance of environmental protection in order to improve the quality of life in a comfortable environment. To this end, the public has to be educated from childhood about the fact that the environment is an important part of their life. Furthermore, citizens should be taught to actively participate in establishing environment-related standards. Ash-colored cities should be reborn as green cities where humans and other living creatures can coexist, and whose natural environment is protected. Dredging and land filling coastal
areas should also create eco-islands, where environment-friendly cities are developed. Finally, the government should construct green buildings that are not only environmentally friendly but also energy efficient. These are the prospective model projects that merit priority. Through these various projects, people can realize the importance of environmental protection.

**Task 20** Form a Northeast Asian body on environment, to address environmental issues.

As Northeast Asia comprises a major economic community of the world, environmental problems in the region are emerging as hot issues among South-North Korea, China, Japan, and Russia. In particular, Northeast Asia is so subtle a region politically that environmental problems are closely linked to regional security.

The concerned parties have sharply divided their opinions on this issue. Because the effects of serious environmental pollution in China are surfacing as an important issue, regional cooperation surrounding the Korean peninsula is becoming more important. In China, where economic development is recently being accelerated, more emphasis is being placed on economic growth rather than on environmental protection. Therefore, the air and ocean pollution in the Gulf of Bohai, the Yellow Sea and the East China Sea are expected to exacerbate. Furthermore, because China has been passive in regional cooperation to reduce air and ocean pollution, friction is apt to occur between China and its neighboring nations. In this respect, the parties concerned should come up with common solutions to these problems by holding regular meetings, setting up a joint research team, and studying continuously the routes and effects of pollution.
The exponential population increases are resulting in indiscriminate destruction of the environment, producing a continuous rise in global temperature due to greenhouse effect – such as carbon dioxide in the air, and causing deforestation in the tropics. A number of people throughout the world have suffered a lot from abnormal weather caused by climate changes. Recently, an unprecedented amount of torrential rain did great damage to Korea, China and Japan.

It is also noteworthy that the number of natural disasters caused by typhoons are increasing every year. In addition, earthquakes hitting Turkey, Greece, and Taiwan made people aware of the earthquake itself. As a result, more people are demanding a safe life through improvement of the ability to respond to natural disasters.

The increasing number of nuclear power plants, radioactive leakage accidents, and the collapse of the Sung-Soo Bridge and the Sampoong Department Store have caused people here to become more concerned about safety. They now urged the government to come up with proper measures to solve these problems. The government must establish a more advanced national emergency management system as soon as possible that enables people to prevent natural and man-made calamities, and restore damaged properties.
[Task 21] Build national emergency system.

Recently, a number of people have been suffering from abnormal climate changes throughout the world. For example, in 1995, the people in the UK suffered from the worst drought in 200 years. Scorching heat of over 45 degrees Celsius killed forty-one people in Spain. The Yangtze River in China floods tens of thousands of hectares of farmland every year causing the death of thousands of people.

Korea also experienced torrential rainfalls in the summer of 1998 and 1999. Rainfall is becoming heavier every year and breaking weather records. A variety of natural disasters claim an average of 164 lives every year, destroying more than 600 billion won worth of properties. This implies that Korea is not immune to natural disasters. However, even though property damage is rising every year, the death toll is decreasing. This reflects that Korea's ability to predict weather changes has been improving gradually. However, this improvement still does not yet meet the expectations of the public.

Nations over the world are now staging "A War against Abnormal Climate Changes" in this new millennium. For example, the US has operated the National Climate Management Committee over the past twenty years to effectively respond to unusual weather conditions that may threaten the whole world. In the 1990s, Australia set up an agricultural system against weather disasters, regarding them as 'normal phenomena' that are apt to happen at any time. Korea, however, has just introduced the super computer for use in weather forecasting, not having any meteorological satellite yet. Korea's ability to forecast weather disasters is far from satisfactory.
Therefore, Korea needs to establish a comprehensive climate prediction system that is not only able to improve the ability to forecast mid- and long-term weather changes, but also to produce high quality weather information. By doing so, the reduction of damage caused by meteorological disasters will be possible. Korea should also develop a modern weather information transmission system, with quantitative weather prediction technology reflecting the geographical features of the Korean peninsula. Such weather observation technology will make it possible to observe the atmosphere around the Korean peninsula in real time and in three dimensions.

By 2004, Korea will establish an optimal radar observation network and introduce new observation technologies such as the vertical wind profiler. A multi-purpose satellite that will be launched in polar orbit in 2004 according to the mid- to long- term plan for national space development will mount weather observation sensors, and it is expected to improve the weather observation capability from outer space. It is also important that a prediction model suitable for the Korean peninsula be developed to enhance weather forecast accuracy. By 2006, weather forecasting accuracy should be improved to the level of the advanced countries through the advanced weather interactive system. Using the multi-purpose satellite in stationary orbit being launched in 2007, a precise and comprehensive space observation system will be set up: adding a variety of uses, such as for information on weather, the environment, in communication, defense, and broadcasting. This is in connection with the mid-to long-term plan for national space development. Furthermore, the personal video device for weather forecasting will be developed and distributed by 2015. Global modelling with a horizontal resolution of one kilometer will be used operationally by 2025. Weather modification technology will be also developed for practical use.
[Task 22] Develop observation and forecast technologies to detect natural disasters.

From January to September 1999, Korea experienced a total of 34 earthquakes, compared with the yearly average of 19. In particular, tremors having a magnitude of more than 3.0 units occurred fifteen times. From 1978 until 1998, when Korea started observing earthquakes by using the seismograph, tremors that having a magnitude of more than 3.0 units occurred 186 times. This means that such quakes occurred an average of nine times a year, which is 67% lower than that of 1999. Korea is no longer safe from earthquakes.

Therefore, by developing technology to predict, control and overcome natural disasters such as earthquakes, damage can be reduced. In other words, Korea needs to develop technologies that observe and predict tremors so there can be effective responses to coastal disasters such as the tsunami caused by earthquakes, and effective earthquake-proof building designs. By 2005, Korea will establish combined observation devices, disaster prevention and warning systems, such as a modern early-warning systems to forecast earthquakes and tsunamies, and a national earthquake prevention management system. By 2015, a comprehensive disaster prevention network will be set up, and earthquake observation devices distributed across the nation. By 2025, Korea will continue efforts to develop technology that makes it possible to predict strong earthquakes several days before they occur.
[Task 23] Guarantee nuclear safety through safety inspection and continuous technology development.

Nuclear energy has played a dominant role in generating electricity as a major source of power in Korea. This trend is expected to continue in the future. As of October 1999, sixteen nuclear reactors are in operation, and the capacity factor has been more than 80% for seven years in a row since 1991. Furthermore, in preparation for future demand for electricity, the Korean government plans to construct twelve additional nuclear power plants, thus operating a total of 27(Kori-1 unit will be planned to shut down) nuclear reactors by 2015.

However, nuclear safety should be given priority to protect lives and properties of people from radioactivity, which is a major government task. Therefore, the government must guarantee the safety of nuclear power plants through thorough safety inspection and the development of nuclear safety technology, and actively inform the general public about nuclear safety in order to dissolve their suspicions.

The government will initiate various activities to inform people of the safety of nuclear energy through various organizations, such as the Organization for Korea Atomic Energy Awareness and others. The government needs to brief the public on a regular basis on nuclear safety issues. Systems for nuclear power plant on-line monitoring and periodic nuclear safety evaluation system are needed. Furthermore, a life cycle management system covering the design, manufacturing, construction, operation, and decommissioning is required. The government must also continuously develop nuclear safety-related technology in such areas as the safe NPPs (nuclear power plants) operation, life extension, decontamination and decommissioning, and safety regulation standards.
[Task 24] Strengthen safety checks for large-scale structures and improve safety standards.

Collapses of the Sung-Soo Bridge and the Sampoong Department Store are attributed to lack of concern for and negligence with regard to safety throughout the Korean society. These tragedies were both physically and mentally damaging to Korea and Koreans. As a result, Koreans have had more interest in the safety of bridges and large-sized buildings, such as skyscrapers and apartments. As the society becomes more attuned to safety concerns, and as the economy continues to grow, demands for safe bridges and large buildings are expected to increase.

Therefore, standards for the maintenance of large facilities will be enhanced to extend their life spans, and technologies concerned with repair and reinforcement secured. Moreover, the government is putting more emphasis on the safety of structures at the stages of design and implementation than ever before, when large-sized structures are constructed. Responsible government agencies and private experts are also advised to assess the safety of the structures regularly in order to further strengthen safety standards.
Human beings have intrinsically pursued convenience in their lives. In the 21st century, that tendency will likely increase because of economic growth and S&T progress. People will prefer products that are convenient to use, stable, and portable. Businesses will have to develop open-ended products and production technologies that can satisfy a variety of consumer needs. The government will support a convenient life for individuals by expanding related infrastructures, including the information infrastructure.

In order to achieve a more convenient life, the existing traffic congestion problem should be solved as well as the related information and communication infrastructure. To this end, the government needs to develop an intelligent transportation system, such as an advanced road traffic control network; high-tech traffic sensing techniques; and the next-generation railroad transportation system, including the maglev, new city railroad and an unmanned train operation system. By distributing intelligent electric household appliances and constructing smart houses, the government should encourage the development of telecommuting and remote communication. The concept of an informationized future-city can be introduced through the development of emotion sensibility ergonomics, intelligent agent technology, voice recognition, 3D image processing, and advanced housing technology, including the “intelligent” building.
Box 18. Development of Key Technologies for Construction and Transportation for a Convenient Life Style

- **Intelligent transportation system**
  - The government needs to develop an advanced traffic management system, that controls the flow of traffic in real time, through real-time traffic data and offers traffic information, and advanced vehicle identification technology that makes it possible to automatically identify the number of vehicles on the road per hour, types of vehicles, occupation rate, and speed.

- **New urban railroads to increase the volume of traffic in railroad networks of metropolitan cities**
  - The government must devise measures to develop two-story trains, integrating the railroad system in metropolitan areas, and operate express and two-story trains in order to increase the transport capacity of railroad networks of metropolitan cities.

- **Transport system that integrates roads and railways, and complex logistics system throughout Northeast Asia**
  - The government should present measures to secure the competitiveness of the physical distribution system through a railroad system and check design, vehicle development and facilities for a conversion transportation system between railroads and roads.

- **A Unmanned train control system using satellites and a highly efficient unmanned train operating system that uses alternative energy**
  - The government should set up an unmanned railroad system by developing remote control technology and control system technology through satellites.

- **Development of smart housing**
  - The government should construct advanced future houses by developing the key technologies that are energy efficient, aid informatization, and are health-oriented and contribute to comfort, and finalize a basic model and a comprehensive design for advanced future houses.
The future society of the 21st century will face a world that is short of food, energy, and water due to the rapid increase of population and economic growth. Accordingly, disputes between advanced countries and less-developed countries over resource possession could increase and the possibility of armed conflict arises.

The geometric increase in the world’s population is a major factor in the depletion of resources, such as food, energy, etc. According to a UN report (1998), by the turn of the year 2025, the rate of population increase in advanced countries will remain at around zero%; however, in less-developed countries there will be a dramatic increase. The world population of 6 billion in 1999 will approach 8.5 billion by 2025. In Korea, the increase rate being 0.77% in 2000 and 0.01% in 2021. The population will hit 50,386,000 in 2021, and thereafter it is expected to gradually decrease. An estimated population report by the UN shows that the population of North Korea will be over 32 million by 2020.

On the contrary, as the rate of food production continues to decline, and food shortages become a reality, starving populations are expected to reach about 0.6 billion throughout the world by 2010. Our self-sufficiency in food (about 30%) is the lowest of all the world’s major countries. Korea will have difficulty in correcting
this problem due to Korea’s heavy dependency on imported food and limited arable land utilization. According to UN statistics, more than eighty countries — about 40% of the world population — will suffer from water and food shortages. Korea will also face a water shortage of 0.4 billion tons in 2006 and 2 billion tons in 2011. Currently, fossil fuels account for 85% of commercial energy worldwide and are expected to be exhausted within the next forty years. Coal and natural gases are expected to deplete within 100 ~ 200 years. As the rate of fuel use in Korea is running at a higher level than the rate of economic growth, there will be difficulty in securing a stable energy resource in the near future.

Therefore, before Korea experiences shortages of food, energy, and water, systematic preparations are needed to eliminate those possibilities. Resources must be defined as the basic means for survival to guarantee national continuity. Development of resources-related technology as an area of responsibility pertinent to the nation is essential.

Meanwhile, the special circumstances such as territorial division and the geopolitical importance of the Korean peninsula require Korea to secure an independent defense capability for its national security. The prevailing assumptions are that the factors of instability will likely continue, as the confrontational circumstances among the four major powers over the Korean peninsula continue. While the political, military and diplomatic influence of China and Japan grows within the Northeast Asian region, Russia and China at the same time tend to check the expanding role of the US. Therefore, the mandatory task is to make a master plan to systematize the
management of national defense resources for securing strategic weapons. Also, after attaining an inter-Korea system of cooperation as soon as possible and solidifying a base for balanced economic development and stable growth, preparation for the reunification of the Korean peninsula must be commenced.


In terms of national security or bracing for reunification, securing food is very important for Korea. As bio-technology in resolving food problems becomes recognized worldwide as the most effective alternative, the nation will develop good quality livestock breeds, secure a variety of plant genetic resources, and actively develop technology for mass production of food resources through bio-engineering. The government also has to push ahead in the development of production photo-synthesis technologies and systems of artificial functional food materials.
### Table 6: Core Technologies for Mass Production of Food Resources by Phase

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<td>Molecular breeding</td>
<td>Detecting useful genes &amp; verifying functions</td>
<td>Introduction of useful genes &amp; stabilization technology</td>
<td>Evaluation of breeding &amp; stability</td>
</tr>
<tr>
<td>Transgenic technology</td>
<td>Establishing a transgenic system</td>
<td>Next generation test</td>
<td>Evaluation of stability for transgenic crops &amp; animals</td>
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<tr>
<td>Animal cloning</td>
<td>Establishing somatic cell cloning technology</td>
<td>Useful animal production by somatic cell cloning technology</td>
<td>Mass production of cloned animals</td>
</tr>
<tr>
<td>Safety assessment of transgenic seed</td>
<td>Safety &amp; hazard assessment of transgenic seed to both human bodies &amp; environment</td>
<td>System development of Assessment &amp; Management of transgenic seed</td>
<td>Safety &amp; hazard assessment for bio-engineering products involving transgenic seed</td>
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### Task 26: Develop core technologies for alternative energy sources and energy efficiency.

To improve Korea’s ability to be self-sufficient, it is essential to increase energy efficiency and develop alternative energies in the future as well. Priorities in energy technology development should be set considering feasibility, urgency and eco-friendliness, while engaging in intensive investment and resources. In addition, by activating a system using this new technology, which is grafted element technology, the nation will have to renovate its energy-saving system. To maximize the effects of saving energy, the government plans to develop the appropriate technology by 2005. A retrieval program that runs from unused energy and improves the fuel consumption efficiency of power systems will also be built.
In addition, the government will secure fundamental technology for saving electricity and will also have acquired the basic technology for a fuel cell and fuel cell vehicles by 2010. This new system will operate efficiently, and save power. Also included will be a waste-energy retrieval system. The development and distribution of alternative energy such as creating and operating field model centers that use alternative energy will be expanded, and by 2025, a high efficiency power system that expands nature-friendly energy distribution, a new source of power for the next-generation will exist. There will also be secure high efficient electric equipment and tools used to create this technology base. New fuel production technology will be generated that aims at solving the problems of energy and environment.

These goals can be achieved when the efficiency of using the existing energy is increased by building a system of recycling energy resources. By advancing energy-saving technology, along with making the energy equipment more efficient, the government will increase the ability to substitute fossil energy through developing alternative energy sources, such as wind power, biomass, and small hydropower. The government will also enhance the efficiency of existing energy sources through use of technologies that make fossil fuel highly efficient, improve the functions of electric equipment and tools and extend life expectancy, and the development of highly efficient power transmission systems. Korea will especially seek a landmark achievement in energy use through development and application of super conductivity electric equipment and tools. A broad range of next-generation alternative energy sources must be produced by substituting fossil fuel with developing hydrogen-generating and storage technology and by using low-priced, highly efficient, super-thin-film solar batteries.

Within the next two decades, Korea will develop a module for commercialization having more than a 15% solar battery transforming rate, and also develop a hydrogen-producing pilot plant.
Box 19. Core Technologies in Energy Fields

• Efficient fossil fuel technology
  – Combining Coal gasification technology, gas refinement and conversion technology and high temperature fuel cell technology, new energy generation, with more than a 60% generating efficiency, and new fuel production systems will be developed.

• Next-generation alternative energy technology (hydrogen, solar cell, etc)
  – Through development of photovoltaic and solar thermal technology and hydrogen technology, hydrogen generation and storage technology and low cost highly efficient ultra thin film solar cells will be developed, which will substitute fossil fuel. Also, a commercialized module with a more than 15% solar cell conversion rate will be developed.

• Efficient energy improvement technology
  – Through development of a highly efficient gas turbine, hydrogen turbine, the next-generation highly efficient energy storage batteries and micro-battery and securing energy storage and transforming material technology and energy saving technology using underground space and establishment of energy use network to conserve energy and improve energy efficiency.

• Natural gas conversion technology by using plasma
  – Complete process of converting natural gas into high value added chemicals like ethylene or methanol using plasma through development of core technologies such as room temperature plasma technology, and reactor design technology and scale-up activity.

• Electric equipment and appliances performance improvement and life span extension technology.
  – Design and manufacturing technology for next-generation electric devices, 500kv class DC (direct current) electric device, and 1200kv class electric device development

• Super conductivity energy technology
  – Producing environment-friendly devices and systems for the next generation super conductive energy, through development of key technologies like super conductivity energy storage system, super conductivity cable, generator, transformer, limiter etc.,

• New technology for resource exploration and development.
  – Development of technology for thematic map compilation for the entire country and computational standardization and development of technology for enhancement of exploration depth and degree.

• Resource value-added enhancement technology
  – Enhancement of retrieval rate of mineral energy resources and enhancement of value added for metal and non-metal mineral resources.
[Task 27] Join nuclear technology exporting countries by developing nuclear core technology.

Presently, nuclear power is relied upon to such an extent that it accounts for 41.7% of the total generation of electric power in Korea. Nuclear energy could be more useful if the improvement of technology continues to be made on the basis of safety improvement.

Box 20. Key Nuclear Technology Development Tasks

- **Radioactive waste management technology**
  - Development and commercialization of waste reduction technologies and Korean-type waste disposal technologies centering on key technologies such as waste treatment technology, low and medium level waste disposal technology, and high-level waste disposal technology, etc.

- **Life extension technology for nuclear power plants**
  - Development of technologies necessary to extend the current life span of 30 years to 40–60 years, such as the life span evaluation, management and replacement of nuclear facilities.

- **Decontamination and decommissioning of nuclear power plants**
  - Development of technology to decommission and decontaminate nuclear power plants in operation

- **Advanced nuclear fuel**
  - Development of nuclear fuel in which in-core irradiation stability, heat conductivity and retention ability of nuclear fission gas are innovatively improved compared to current fuel.

- **Technology to secure inherent nuclear safety**
  - Development of a new-concept reactor with more passive safety features to enhance nuclear safety through mitigation of accident caused by human error and component malfunction.

- **Radioisotope production and utilization technology**
  - Improving the localization rate of high value-added isotope products for industrial and medical use, through the development of core technologies in the areas such as isotope production and utilization technology, food radiation technology, industrial use of radiation, etc.

- **Liquid metal reactor**
  - Development of liquid metal reactor to maximize the utilization rate of uranium resources and reduce the disposal amount of spent fuel waste by 2025.
Therefore, Korea will pursue the use of nuclear energy as the main alternative energy source, which now supplies more than 50% of the total domestic electricity output. By developing nuclear core technology and improving nuclear R&D ability such as advanced reactor and fuel technology, radioactive waste management technology, life extension and decontamination and decommissioning technology of NPPs, and radioisotope production and utilization technology, the nation has to stand independently and join the exporting countries in the nuclear field.

To this end, the government needs to develop technology unique to nuclear power for security and stability by fully automating NPPs whereby, only one worker is able to operate the entire plant. This requires the elimination of artificial operating technology and active-type use of equipment and tools when an accident happens, and to promote passiveness so as to secure nuclear safety. Korea also has to enhance fundamental technology to the level of the advanced countries in preparation for the practical use of future nuclear technology, such as the liquid metal reactor and the nuclear fusion reactor.

[Task 28] Seek new water resources and develop water resource management technology.

To secure water resources, Korea will have to learn how to use existing resources more efficiently and develop new resources. As part of these efforts, technologies should be developed to understand the characteristics of surface water and underground water, which are substantial supply sources. Korea also needs to develop technology that can predict the usage of available water resources and explore other supply
sources. Considering the quality and amount of available surface water and underground water, rivers, dams, etc., the government needs to develop core technologies for efficient integrated management, and future-oriented systems of water supply and drainage.

[Table 7] Core technologies for Water Resources and Management Techniques by Phase

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<td>Technology for securing surface water</td>
<td>Hydrologic characteristic analysis basic model development</td>
<td>Hydrologic cycle model development</td>
<td>Technology for securing surface water</td>
</tr>
<tr>
<td>Technology for securing underground water</td>
<td>Determination of characteristics of hydrologic structure by unit</td>
<td>Fractured rocksess integration, flexibility model development</td>
<td>Water environment integrated information system buildup</td>
</tr>
<tr>
<td>Management technique for integrated water resources</td>
<td>Optimizing real time river management</td>
<td>Development of integrated management system considering quality of surface water, underground water, etc.</td>
<td>Development of corresponding technology for water resources affected by climate change</td>
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(Task 29) Secure technologies for national defense and pursue civilian and military dual-use technology programs.

As the Korean peninsula is still in the state of division and antagonistic relations despite the end of the Cold War era between the East and West, national defense is still the first priority for the country. The military potential of the surrounding countries continues to remind Korea of the need for a self-reliant defense capability. As the modern warfare tends to increasingly depend on advanced S&T information,
securing S&T capability for high-tech weaponry and command systems that use advanced technologies play a decisive role in self-reliant defense. Therefore, Korea has to secure an independent defense capability by developing S&T relevant to national defense, which needs to select core technologies to brace for the future wars of information and science and then leap to the level of the advanced countries in the area of self-defense.

Box 21. Civilian and Military Dual-use Technology Development Task

- **ATM (asynchronous transfer mode) with small capacity.**
  - Development of ATM switching that integrates and transmits voice and data necessary to construct a long distance communication network, multiplexing equipment and exchanger.

- **Observation satellite image analysis technology for quick sensing.**
  - Topographical information and material transforming software development for basic materials and topographical information for regional development planning.

- **Intelligent automotive tracking with multiple targets and sensing techniques.**
  - Using multiple sensors for a traffic control system, early warning system, system development for target acquisition and providing information.

- **System for quick detection of explosives and chemical weapons using radiation.**
  - Development of technology for detecting chemicals using radiation that can detect illegal products, such as chemical weapons, drugs, etc.

- **Navigation and control systems for autonomic unmanned submersible marine equipment.**
  - Development of navigation propulsion, control systems for autonomous unmanned submersibles with high reliability and high performance for use in gathering seabed minerals and drifting mine removal, etc.
- **Remote-controlled robot for dangerous work.**  
  - Development of a robot for remote-controlled work, guarding, and anti-terrorism, use in rescue and salvage, unmanned reconnaissance, removal of explosives, etc.

- **Technology for processing toxic chemicals.**  
  - Development of a processing technology for innocuous biochemicals used for air purification, processing hospital waste, processing chemical weapons, etc.

- **Small and mid surface-effect ships.**  
  - Contributing to strengthening marine defense capability by possessing super high-speed guard and landing ships through development of a surface-effect ship for 20 man capacity.

- **Multi-purpose helicopter.**  
  - Realizing technology self-reliance through development of multi-purpose helicopters by technology innovation and the localization of technology of core parts.

- **Non-active gas generator.**  
  - Development of gas turbine engine technology for aero and industrial use through the development of non-active gas generators for fire extinguishing and military operations.

As Korea’s R&D investment in the defense area is now very satisfactory, compared with advanced countries, and about 3% of the total national defense budget is invested in R&D, national concern is needed for increasing the R&D budget investment or the overall national defense budget itself until the base is built for Korea’s own development of high-tech weaponry. Korea also needs to aggressively pursue dual-use technology while strengthening self-reliance based on advanced S&T on a mid- and long-term basis. Korea’s development of its own technologies is needed for supersonic fighting equipment and tools, artificial satellites for reconnaissance defense, unmanned planes for long-range reconnoitering at high altitudes.
Nations of the world are making an all-out effort to develop advanced S&T as a key to their national defense and are aggressively pursuing dual-use technology programs as an effective strategy. The US has been actively pursuing a dual-use technology application program "to graft" national defense technology with civilian technology since 1988. Japan is accelerating expansion of its military power using intensive technology, high-tech civilian technology on the basis of world-class technology in the private sector. Based on the subjects and characteristics of technological development, the dual-use technology idea is classified into three areas: spin-off, which transfers and utilizes national defense technology within the private sector industry; spin-on, which transfers and utilizes privately developed technology within the military industry; and finally spin-up, which jointly develops military and civilian technology.

Dual-use technology is a low cost and highly efficient technological development strategy that can most effectively obtain and utilize advanced technologies by mobilizing R&D resources both in the military and private sectors. Understanding the need for the dual use of technology, Korea has enacted the "Dual-use Technology Project Promotion Law", and this law has been in effect since 1998. Dual usage projects, however, are still in initial stages, their further expansion should be continued in the future.

[Task 30] Continuously promote South-North Korea S&T cooperation to prepare for reunification.

The Cold War system between the East and the West has come to an end and a new international order is being set. The
reunification of South and North, being manifested as a historic and national belief, will become the base for stability and security both on the Korean peninsula and in Northeast Asia. It also makes the realization of a collective community of an economic and culturally homogeneous race possible, and offers the opportunity to improve Korea’s stature and caliber on the world stage. As it will provide the footing for the second leap of the Han Nationality (Korean People), Korea should make systematic preparations for unification at the national level. S&T, which focuses on areas of mutual benefit, could be the important means for accelerating reunification at the national level. In this context, the government should build an inter-Korea integrated S&T innovation system in the long run.

Korea must strive for achieving contacts and openness among inter-Korea S&T circles by initiating exchanges of scientists and holding joint S&T events, such as inter-Korea S&T festivals, S&T conferences, joint S&T Olympiads, etc. The government also has to pursue inter-Korea joint R&D projects regarding the joint survey and development of the DMZ (demilitarized zone) and Yellow Sea that set the stage for the way to unification by transferring necessary resources to North Korea free of charge, such as super corn, potato microtuber, and other things. In addition, an inter-Korea weather forecast cooperation project will be pursued stage-by-stage, that is mutually beneficial to both sides, such as the exchange of information and experts and joint-study. At the same time, from the humanitarian viewpoint, Korea will also have to pursue collaborative projects that contribute to the reduction of damage due to weather disasters in the North Korea.
[Task 3] Participate in international mega-science programs, and contribute to the world S&T community.

With the advent of the age of the global village, active participation in various activities in the field of S&T are needed to resolve the global issues. Korea is preparing itself to enter the ranks of the advanced countries, which can heighten its prestige through participating in the global S&T fields. Therefore, participating in resolving S&T tasks at the global level by jointly responding to the problems of environment, weather, virus contagion, etc is essential. To do this, the government will employ multiple channels, such as sending more scientists to international organizations, institutions, and conferences, and aggressively participate in international forums that deal with global issues. In addition, through the transfer and support of technologies for developing and less-developed countries, S&T cooperation and partnership with those countries needs to be should be strengthened.

A great deal can come from participating in the ongoing mega-science programs, which heightens the stature, enables Korea to learn about important advanced technologies, and further cultivates systematic technological abilities. Therefore, the prestige of Korea on the world stage will be enhanced by actively participating in international mega-science programs that deal with nuclear fusion, earthquakes, destruction of the ozone layer, space development, and astronomical observation, etc.
Box 22. Ongoing International Mega Science Programs

► Particle accelerator development program by CERN
  - Background of the program
    - After World War II, 12 countries participated and established (1954) with the view of studying the nucleus and particle physics.
  - Special notes
    - Completion of the world’s largest particle accelerator LEP (Large Electron Positron Collider) (1989), five Nobel laureates, approval of ground-breaking (1988) for the world’s largest particle accelerator LHC (Large Hadron Collider) in the 21st century and completion scheduled (2007)
  - Operating budget (1997)
    - 870 million Swiss Francs. (About 540 billion won)
  - Users
    - 308 members organizations and 213 non-member institutes or universities and a total of 6,895 scientists participated (about 50% of particle physicists worldwide)
  - Participation
    - Since 1980, six universities including Kyungpook University, KAIST, Chonnam University, etc., have participated in LEP experimentation. Since 1997, thirteen institutes including Kyungpook University, Korea University, etc., have been in the CMS (Compact Muon Solenoid) project.

► ITER (International Thermonuclear Experimental Reactor, 1989)
  - Objective: Presenting scientific and technological possibilities for development of nuclear fusion energy that can be used for peaceful purpose through international cooperation.
  - Participating Countries: the US, Japan, Russia, Europe
  - State of Progress: Completed engineering design project that commenced in July 1988. Attained technical data that will decide detailed, complete, and perfectly unified ITER design and construction direction
[Task 32] Prepare for the space challenge.

The landmark development of S&T is bringing the other space frontier closer to reality — and not just an object of yearning. Advanced countries, including the US, are preparing to take the initiative in the upcoming space age. Korea is also preparing for systematic space development through the “National Space Program (1996–2015).”

Satellite technology capabilities are being developed by designing low orbiting satellites and launching a total of nineteen artificial satellites by 2015. Indigenous technology to build a delivery system for putting micro satellites into low earth orbit be realized by 2005. Korea is also pursuing independent satellite use and core space-probing technology that integrates satellite information, such as earth observation, and building a base for their use. Technologies are being developed based on space science and the space environment. By 2005, the government will develop and launch indigenous launch.
vehicles using domestic facilities. Korea will also have to strengthen its position in the upcoming space age by quickly securing the ability to develop ultra mini communication satellites for low earth orbit: multi-purpose artificial satellites, such as artificial satellites for earth and weather observation and artificial satellites in geo-stationary orbit, as well as multi-stage launch vehicles to launch satellites for commercial and military use into a geo-stationary orbits.

**Box 23. Development of Core Technologies in the Space Field**

- **Ultraminature multi-purpose satellite**
  - By 2005, develop and launch a micro satellite for low earth orbit through the development of core technologies as position/attitude control, telemetry/command, electric system using solar panel, etc. By 2015, develop an ultra miniature communications satellite and satellites for global observation, environmental monitoring and weather observation. By 2025, develop a satellite to operate in a geostationary orbits.

- **KSLV (Korea Space Launch Vehicle)**
  - By 2002, develop KSR-III, three-stage, liquid-propellant sounding rocket, ultimately aiming for space launch vehicle to deliver domestic satellites into low earth orbit (LEO) after 2005. According to the "National Space Program 2015," Korea is planning to launch 7 satellites by indigenous launch vehicle, KSLV (Korea Space Launch Vehicle) by 2015. Launch micro satellites into LEO by KSLV-I in 2005, KSLV-II shall have capability to deliver 1-ton satellite into LEO by 2010. Construct the Korea Space Center at the south coast of Korean Peninsula by 2005 to accommodate the planned satellite launch.

[Task 33] Promote oceanic exploration.

S&T development is also translating the oceans into additional space for human activities. The huge amount of resources lying at the bottom of the sea are expected to help resolve the current problems of resource shortages and create
new space involving artificial islands, sea ranches, etc. Surrounded on three sides by the sea, Korea has many advantages in developing the oceans. The nation will have to build a service system for composite ocean information through the developmental technology for ocean observation and an operational data base.

Development of technology will enable Korea to harness resources of the ocean and probe the deep seabed for resources. This will require improved technology to secure fishery resources, just one of the many food resources. Developing marine space for use as new, diverse land, and technology development for use in airports using marine space, military bases, storage bases, undersea parks, undersea ranches, etc. are important, useful and necessary.

**Box 24. Development of Core Technologies in the Marine Field**

- **Deep sea resource technology**
  - Construct a long-term stable base for the supply of manganese, nickel, copper, cobalt, etc., which are the major strategic metals of the national infrastructure in the 21st century through developing core technology such as mining of seabed minerals, such as manganese nodules and cobalt-rich manganese crust, refining technology, and offshore hydrothermal deposits.

- **Marine life resource technology**
  - Develop new technologies for searching novel and useful marine natural products and develop sea ranching technologies such as recolonizing and nursing high-values target organisms in the model sea area in order to nurture the marine bio-industry to brace for exploration of the bio-engineering market in the 21st century.

- **Construction and utilization technology of marine space**
  - Develop airports, military bases, storage bases, undersea parks, undersea tunnels, undersea ranches, etc., using marine space through development of core technologies such as large marine structures, construction of seabed space and ranching technologies.
Shifting away from the age when tangible materials created value-added, knowledge will increasingly be applied to create value-added in this new century, as society becomes more knowledge-based. As a result, explosion of the creation and expansion of knowledge is likely to take place. The ability to achieve innovation comes from creativity and the efficient use of the knowledge acquired. This is not only a decisive factor in obtaining wealth, but is also a basis for inciting competition among nations.

Due to the lack of endowed material resources, a strong intellect-base must be established for Korea to prepare for the advent of the knowledge-based society. Therefore, in order to foster workers with creative knowledge and to build mechanisms for creating, utilizing, and spreading S&T-based knowledge, the continued acquisition of new knowledge and experience is required both through strengthening education and training, and through improving the contents of education and training.

Future S&T policy direction toward constructing a knowledge-based economy should be based on the systematic management of intellectual resources throughout life, wherein knowledge is produced, utilized, expanded and abandoned. The total amount and quality demanded by the knowledge society should be managed systematically. Comprehensive administration is needed in order to advance basic science, the basis of obtaining knowledge; produce talented people with creativity by reforming science education; developing public systems that spread and distribute the knowledge; protect the value of knowledge; and provide scientific literacy to all citizens.
[Task 34] Advance the level of basic science by 2010, and foster world-class scientists.

The study of basic science requires a great deal of time and effort because of the high possibility of trial and error. Science has the characteristic of common ownership. The performance and results of research are available for ordinary people who need them. It should be intensively developed through the support of the government and the public sector rather than through the market system. Universities, leading players in basic scientific study, possess 73.7% of all Ph. D’s, representing the highest quality of intellect, but their overall research activities are poor due to their education-oriented work, insufficient research funds, insufficient research facilities, and lack of basic research and incentives.

Therefore, the government’s future task is to activate the potential power of the university research program to improve the quality of studies, establish an efficient system of carrying out research at universities, and strengthen productive links between research institutions and businesses. To deal with these problems, a program is needed that expands and supports investments in universities for basic scientific research. These investments will create a jointly used database that supports use of the infrastructure, such as the large-scale equipment and materials needed to improve the level of basic science. Meanwhile, the Science Research Centers (SRCs) program must be maintained to foster excellent researchers within universities by 2010. Additionally, a support policy must be formulated for prompt globalization, while increasing the quantity and the quality of excellent research.
It is also time to transform the policy of Korean companies from quality-oriented management into dignity-oriented management. Korean companies are being undervalued because of the lack of dignity, even though their goods and services nearly match the quality of advanced countries. Technology can improve quality, but the high quality of products and services ultimately comes from the development of science. From a broader perspective, this implies that science and art are important. In this context, when the dignity of goods and services become a priority in producing scientists, Nobel prize winners can emerge from Korea. Therefore, Korea has to produce many more world-class scientists as well. Addressing this issue, there must be focused on developing programs that can virtually boost and strongly support the education of young scientists, encouraging a spirit of tenacity for challenge and research both at home and abroad.

In the 21st century, an area of science that actively transforms itself based on rapidly changing social demands, will be in the limelight instead of one that has simply explored the ultimate principles. In this area, which includes mathematics, statistics, computer science, physics, chemistry, biology, geometric science, astronomy and space science, basic creative research will be promoted and studies on future sources of technology boosted to meet the social demands of the 21st century. Studies are now targeting the free electron laser and X-Ray laser, basic nuclear fusion research and ultra technologies for super high vacuum, super high pressure, super clean technology, super high temperature, weightlessness, cryogenics, super magnetic property research, basic study on accelerator, and high temperature super conductivity, as well as others.
Box 25. Development of Nonbiological Science

- Physical science designates non-biological science and it includes chemistry and engineering sectors of materials, electronics, chemical engineering, etc. excluding physics and biochemistry.
- Unlike in the early 20th century when a uniform system was pursued, physical science will develop into a diversified, and very dispersive types as well as in a way that theory and practice are combined and basic science and applied science are closely connected in the 21st century.
- New signs of change: anti-restoration, concern for complex system, physicochemical understanding of life phenomenon, and new concern for the nano world.
- Connected with development of technologies such as carbon-related materials (high temperature, super conductor, nano technology, carbon nano tube, optical technology, and laser cooling).
- 21st century’s science industrial complex can be called “carbon valley” if the major term of the 20th century’s is silicon valley.

Note: This information has been obtained by extracting and summarizing the relevant part from the report “S&T Development toward the New Millennium” published in a grand forum of “National Vision & Strategy for the New Millennium” held in Nov 8, 1999.

Box 26. Basic/Future Source R&D Tasks

- Particle/Nucleus/Astro-Physics
  - Research on theories that deviate from the application of standard models
- Concentrated material physics
  - Development and properties of electronic, optical, and magnetic materials, new quantum phenomenon, and complex configuration, in addition to non-parallel, ductile cohesive, phase transitional, and critical phenomenon and research of chaos, etc.
- Optics and nuclear physics
  - Physics for optical communications, optical measurement, precise optical instruments and processing, atomic optics and quantum engineering, medical optical fields and others.
• Materials science
  - Development of potential medicines using a combination of new styles and techniques. Development of candidate materials for pharmaceuticals that use complimentary chemical techniques. Analysis and control of synthetic structures concerning new inorganic material, study of super conductor catalysts in high temperature, micro and minute porous material, core material with new functions for industrial use, and automation of organic synthesis.

• Chemical life and health care
  - Develop treatment medicine for incurable diseases and study of protein in cell-assembly. Polymer-separation membrane having a function based on molecular sensing, more special bio-cell hair catalyst than the bio-cell enzyme function, development of actuator polymer, which is identical with artificial muscle.

• Computational chemistry
  - Nano second and femto second time high-resolution with excessive spectroscopy, development of expensive medicines using casual control of chemical reactions, and study concentrated on material stereo selectivity and regio selectivity of catalytic reactions.

• Molecular dynamics
  - Research on high resolution transient spectroscopy with nanosecond and femtosecond
  - Development of highly value-added medicine using random control in chemical reaction
  - Research on coagulants and condensed matters
  - Research on catalytic reaction with high stereo selectivity and region selectivity

• Biology
  - Analysis of structure and function of protein, study of functional genome, medicine genome, animal genome, and microbe genome, etc.

[Task 35] Cultivate creative minds through reform in S&T education system.

To teach students how to creative using science, the ideas of student volunteers need to be reflected in a part of the
science curricula. That will also add more time for experiments and practical exercise classes. In addition, local facilities equipped with adequate science labs and materials must officially be promoted so that science students can pursue their studies more efficiently. Classes should not be confined just to the classrooms. Visits to science labs or companies and lots of field trips should be available to students, who will later present the results of their experiences in assignment reports. Furthermore, interactive science education through the Internet, Cable TV and digital broadcast networks must also be actively utilized as tools for presenting assignments and later assessing the results. Science textbooks for primary and secondary students should be revised into more stimulating and interesting form, while texts, which now focus on assessing simple memorization, should be changed to encourage "participation" and "practice" of students. For example, field reports or science contests would prove to be more stimulating for students.

For this purpose, the science curriculum for primary, secondary and tertiary students should be subject to immediate and comprehensive revision. As for the primary and secondary curricula, students should memorize and focus on simple questions and answers. Particularly, high school science textbooks should be more based on learning for learning sake than preparing for college admission. Along with that, universities should expand experimentation hours and make them more "intensive" as well. In the US, for example, high school science textbooks are so profound and extensive that students become easily accustomed to learning pure science at higher institutions. Even though Korean students get relatively higher scores during their high school years, they face difficulties afterwards. American undergraduate students get an average of eight intensive lab practical exercise classes per week, compared to two hours for Korean counterparts.
Besides, to improve the quality of the faculty science department, a variety of programs can be included among the options, such as giving opportunities for under-qualified science teachers to improve themselves through the Internet, so that they can be reassessed or reinstated. Another option would be to invite prominent scientists, either at home or abroad, to present special lectures on the Internet, and employing excellent professionals as temporary teachers.

Intensive support is absolutely and immediately needed for earlier detection and educating creative and talented students so that their current education programs can be expanded to include education at an even earlier age. Programs to make the system much more effective include development of intensive courses and materials, improvement of selection procedures, implementation of foreign exchange programs, and field study programs for students and faculty members. In addition, excellent students under the programs should be able to choose from any higher institution, either domestic or overseas, after finishing high school. Furthermore, the related authorities should provide counseling for students and parents to help them decide their future course.

Given its future inter-linkage and integration with other parts of science, such as liberal arts and social studies, business-minded scientists and engineers are also needed. Therefore, engineering undergraduate students need to widen and deepen their scope of knowledge about the economy and other parts of society. For this purpose, it is necessary to make it mandatory to have a double major, or select several arts or social science areas as a minor, or include business administration, economics, S&T policy, R&D administration—management, and history of S&T as required courses.
Meanwhile, 21st century science education cannot emphasize the creativity and scholarly ethics enough. Talented students who will be the leaders of their fields in the 21st century should be creative and ethical so that they can learn that knowledge of science comes from time-consuming effort and diligence. In addition, to answer the questions that will be raised in the 21st century involving human genome and living modified organisms (LMOs), the scientists of the next generation must be truly humanitarian and respect traditional values. The importance of sustainable development and environmental conservation must not be ignored as well. So, the earlier the reforms are made, the better the education will be. To achieve this goal, extensive political support and investments are necessary to promote the ethical qualities of faculty members.

Finally, Government has to establish institutions to disseminate newly found information and knowledge to people who have already graduated from schools or retired from offices.

**[Task 36] Foster female scientists and engineers**

One of the priorities in joining the advanced nations in the 21st century is to produce the highest quality of scientists and engineers as possible. One of the most feasible options to meet this demand is to educate and utilize the present female workforce. The role of women is expected to increase in the future. As the population increases with a decrease in workforce and the information and knowledge–based society begins to gain momentum, the interest in utilizing and producing female scientists and engineers will grow, which thus far has not entailed any realistic measures.
In recent years, the number of female majors in natural science has been increasing at an annual rate of 10% reaching a total of 12,500 in 1997, of which, 9% of the total workforce is in S&T. This shows that there is a growing number of women going into the field of science as an occupation. Nevertheless, invisible barriers against women still remain high and the rate of women entering the world of natural science and engineering is relatively low compared to that of men. Most women choose bio-technology, environmental or textile engineering over mechanics or electronics. Furthermore, the number of female participants in government-sponsored science projects is so low that it is almost negligible. For instance, the rate of basic research projects of women scientists against total projects during the recent 5 years was only 5.4%.

The expansion and utilization of a pool of women scientists should also be backed by the efforts of women, in parallel with political support that includes coming up with related policy measures and placing as many women as possible in the process of deliberating and assessing national R&D projects. In addition, programs that can fully utilize the strengths of women need to be developed to upgrade technological prowess. Those programs should be accompanied by new plans to discover and educate young talented females at an earlier age. The upcoming generation is likely to center around the information services and software industries, while the demand for a female workforce that is well-equipped with comparable features of sensivity, intellectuality and aesthetic delicacy, is expected to skyrocket. Therefore, new areas of industry that can utilize talented females need to be found and developed.
[Task 37] Establish a nationwide, comprehensive knowledge management system by 2005.

A national knowledge inventory management system will systematically monitor and manage the whole process of knowledge: its creation, distribution, dispersion, and demise. This system is a prerequisite to help knowledge spread across the society and add value to the follow-on processes.

As part of the plan, it is necessary to set up a technology information distribution site on the Internet that will provide information technology and knowledge from suppliers at a low cost, and with just one touch. In this process, we need to integrate separate information-related agencies and organizations into one network, and expand the related databases. Additionally, a way to compensate the suppliers of knowledge and information by changing the users has to be created.

Another requirement in helping to spread knowledge and information at a rapid rate is to facilitate the exchange of human resources among academia, business and government. To make this happen, they must be linked into integrated networks and a variety of exchange programs establish while recognizing that good programs take into consideration and include individuals with less experience to avoid any disadvantages.

[Task 38] Take appropriate measures to protect IPRs.

As acquired knowledge is sure to emerge as one of the most important assets in the future, efficient ways to institutionally protect intellectual property rights should be built so that the creation and spread of knowledge may continue to be facilitated. For this purpose, laws need to be enacted strongly to regulate illegal acts of plagiarism, stealing and pirating, and, at the same time, encourage the legal use of products.

The government has to create an active Supreme Court,
which makes the final judgement for protecting the value of knowledge and institutional conflicts. The Supreme Court needs to assure professional judgement, and make legal decisions in the shortest period of time involving court cases so that the expense of clients are minimal. Public knowledge tanks and universities need to take charge of applying for and managing their own patents. Meanwhile, as an active response to the growing international trend of protecting intellectual property rights, public awareness about intellectual property rights must be strengthened over the long-term.

[Task 39] Create national science culture through nationwide campaigns and establish network for a science museum.

Even though Korea does time-tested and prominent scientific traditions and legacies, it has failed to sustain developing and improving them. Rather, there has been too much dependence on foreign ideas in which the build-up of S&T came relatively short and quantitatively high. That is why Korea’s scientific base is so weak and lacks public awareness compared to other industrialized nations. Therefore, the Korean government will endeavor to help its citizens to understand and keep up with other unique scientific traditions so they will have confidence and pride in their own heritage. Such a mind-set will promote public awareness in S&T. In addition, a nation-wide science campaign should materialize so that useful scientific ideas can be explored and utilized in daily life. Various programs promoting public interest in S&T must be put in place. For example, a national campaign encouraging participation in science events should take place at least once a month. This campaign could help people gather and spread daily ideas and applications to all members of society, including
housewives and those who have jobs. Town hall meetings between young scientific hopefuls and prominent scientists as well as a variety of science contests will be sponsored.

Korea needs to establish as many high quality science centers as possible so that “meeting places” between the general public and scientists are provided. In the plan, science exhibition centers, which are now scattered around throughout the regions, will be linked to each other to offer better service to the ordinary people. While local centers should be managed autonomously, the capital will have a world-class exhibition center, fully accessible by the general public and linked to other prominent institutions around the world.

Media groups also have to play a major role in awakening the public to the importance of S&T. Programs, including news, special forums, dramas, documentaries, and entertainment, can be fully used to promote public interest in S&T, while science correspondents, program directors, commentators, PR managers for science labs, entertainers, and politicians can help narrow the gap between the society and science. Meanwhile, it is necessary to push to establish a broadcasting system that specializes in science programs.

To broaden public awareness in science, it is necessary to promote publications and papers in S&T-related materials, by raising support for professional scientific writers who would politically nurture famous journals in Korea to compete with renowned journals as Science or Nature and Internet web sites. In addition, special programs should be developed to assist scientists, engineers and professionals to publish their work so that it is easily accessible and understood by the public.
Recommendations for the National S&T Innovation System
An innovation-friendly society is a prerequisite to strengthening the national innovation system. Innovation is the only way to survive in the rapidly changing world. An "innovation-friendly society" means a society that encourages debates and challenges, incites risk-taking, and promotes information exchange.

This innovation-oriented society will lay the groundwork for developing S&T. Prior to this, however, it is necessary to detect problems and find cures, and at the same time, predict and prepare for the future. As mentioned earlier in Chapter 3, Korea has relatively abundant R&D resources, such as high-quality human potential — a population with a great desire for education. On the other hand, Korea’s weak points are S&T management system, and a public perception problem that is not favorable to S&T being the main engine for driving national development. In addition, an immature political, economic and social atmosphere impedes S&T development. By further improving and linking the strong points and patiently persevering and overcoming the drawbacks, it is believed that scientific strategies can be phased-in. If successful, Korea could stand on a par with other scientifically developed countries in the first quarter of the 21st century. Building the knowledge-based society could well result in Korea becoming a major state in the international community.

The task of strengthening the National Innovation System (NIS) requires a new strategy, which aims to improve the necessary social and economic infrastructure in stages, and concentrates R&D resources in specific areas. First, investment in strategic R&D should be expanded. There must be more efficient, relevant laws refurbished, institutions upgraded, and
infrastructures built by 2005 to move into the knowledge-based society. Next, there is a need to upgrade the level of S&T to that of other advanced countries by 2015, linking our system to a global R&D network, and putting in place a new set of R&D patterns. These efforts will help lead to the competitive knowledge-based society. Finally, new mechanisms need to take root to create, utilize, and spread sophisticated and open-style knowledge and information by 2025. Korea should then emerge as a central power in the world community by establishing S&T-initiated management systems.

The specific guidelines under this strategy are:

First, establish an NIS that is flexible in satisfying social demands and rapidly changing scientific and technological situations. In this sense, the system dominated by the government should be converted to one led by the private sector.

Second, to promote the efficiency of R&D, increased investment and more effective ways to distribute it are needed. That means there must be focus on effective utilization of the investment rather than the simple increase.

Third, state-of-the-art technology needs to be fully utilized, as well as use of information and human resources from overseas to overcome the domestic limitations in R&D resources. For this, Korea’s R&D system needs to be transformed from being domestically determined to being globally networked.

Fourth, in order to achieve both S&T independence and competitiveness, imitation and copying should be stopped. S&T
capacity needs to be increased to develop indigenous technologies. Therefore, technological development strategy should be changed from the short-term, demand-meeting type to that of the long-term market-creating type.

Finally, increasing R&D investment and reforming the NIS to maintain continuous progress in S&T are not enough. The most important thing is that S&T take its place as a major factor in every facet of society, and that every member of society be aware of its importance. S&T needs to be transformed into a system driven by a national management strategy.
Since the 1960s the Korean government has actively framed strategic plans to invest resources and create standard policies regarding S&T development. Accordingly, some industrial technologies, such as shipbuilding, semiconductors, electronic products, telecommunications, automobiles, and so on, have forged ahead to gain a certain level of competitiveness in the world market.

With economic growth, the role of the private sector has been carrying more and more weight. Since the late 1980s, the market system has made great strides through privatization. NGOs (Non-governmental Organizations) have been actively involved in current social welfare issues, such as environment, population, women, children and the elderly. Moreover, with the advent of the knowledge-based economy, the role of government is expected to change radically – becoming increasingly involved in the enhancement of the social infrastructure.

[Fig. 12] Government’s role in the New Paradigm

- Vertical structured authority
- Direct intervention in market

- Horizontal decentralisation
- Indirect condition creation

= Knowledge Government

- Infra buildup to create and distribute knowledge
Previously, the Ministry of Science and Technology (MOST) played a major role in national S&T policy making. However, since the early 1990s, circumstances drastically changed. Other ministries began to carry out their own R&D projects. And, with the advent of the World Trade Organization (WTO), government support has been confined to spheres that the private sector alone cannot implement. The planning and management of research projects have also been changing from a government-initiated system to a private-sector driven.

Compared to the speed of transition in the socio-economic field, S&T lags behind because it requires high-level expertise, sustainable investment, and the support of government. Korea’s weakness in S&T has not allowed it to keep up with the ever-changing economy. One reason for this is that despite redirecting policy toward privatization, structural reforms of Government–supported Research Institutes (GRIIs), which played a pivotal role under the government’s supervision, were largely made against the wishes of the institutes themselves, so they remain unfinished. However, Japan and China show methods and results that differ from Korea’s. Through drastic reforms, Japan made public research institutes independent corporations, improving flexibility. This allowed the formation of a different, less restrictive environment, supported by relatively young scientists in their thirties. China, under the supervision of the Prime Minister, has also implemented radical structural reforms of GRIIs and affiliated departments. By doing this, the government is cutting off direct financial investment and replacing it with indirect private support.

Unfortunately, research jointly sponsored by the Korean government and private enterprises has yielded only minor results. Laws and regulations that could utilize and expand the performance and results of research have not been systematically
organized. In addition, the support system of taxes, banking, the workforce and so on are too complex and diverse for private businesses, especially SMEs, to handle. In response to the WTO, Technology Round (TR) and other international regimes that represent international standards, the government should change policy direction from direct involvement to indirect support, allowing more flexibility. The fact of the matter is that the majority of S&T projects are still planned and enforced by the central government.

In the 21st century, however, when innovative technology rapidly changes and diversity and individuality are highly esteemed, centralized government involvement will only impede the development of the entire industry. Therefore, Korea should cope with the rapidly evolving S&T environment and play the part of a responsible member of the global community through transforming from the practice of direct government—initiated development to a private-driven innovation system.

For privatization and expansion to materialize, the decision-making process must originate from the private sector, not the government. Second, the participation of private experts should be expanded from diversified fields, including NGOs, in the S&T policy-making process. Third, the centralized government support for R&D should also be privatized. Fourth, in response to the privatization of S&T policy, public research institutions should reorganize and renovate their current systems.

[Recommendation 1] Transform the current S&T policy development system from government-initiated to private sector-driven.

To foster this privately initiated bottom-up policy proposal, an evaluation system will be implemented, incorporating the
participation of research councils, academicians and NGOs in decisions regarding S&T policy and R&D projects. For instance, a "Policy Notice System" should be implemented to collect the opinions from scientists and other experts. And, the deliberation of a private committee can be required in the policy-making process.

All parties involved — i.e. a diverse group of private experts, including consulting firms, patent attorneys, as well as other lawyers, both at home and from abroad, are determined to initiate input concerning policy planning and decision-making. In addition, the participation of S&T consultants should be expanded in the decision making process of non-S&T fields, such as politics, economy, society, culture, and etc.

[Recommendation 2] Promote public awareness of S&T policy.

A "Response Monitoring System" will be set up when developing S&T policy or planning R&D programs. Social welfare experts, the general public and the scientific community will periodically participate in the evaluations of these programs. In addition, by implementing a Technology Assessment Program, a national consensus can be reached in advance whenever pursuing high risk projects such as nuclear power, and those projects related to the environment or bio-engineering, which could affect people’s safety or involve national ethics. To support this policy, a "National S&T Report Convention" will be initiated to inform the president of such scientific results and gather public opinion.

[Recommendation 3] Reform support system from direct to indirect system.

A healthy environment will be created so that private enterprise can increase their technology innovation efforts. The
government’s support of industrial R&D activities has been restricted since the establishment of the WTO. However, the government support system will transform from direct to indirect means involving taxes, financing, patents, standardization and technology markets. Emphasis will be on S&T personnel, R&D experiments, information dissemination and support for SMEs.

The complex and diverse tax and financial system for technological innovation, which is supported by taxes will be streamlined, simplified and clarified for greater efficiency by the government. Through the application of a sunset system of taxation management, the current inefficient taxation system will be abolished. Support procedures for other enterprises, especially SMEs, will also be streamlined for maximum efficiency while integrating similar systems. There will be increased tax deductions on a yearly basis by means of the "Technology Development Investment Tax Deduction System" to encourage R&D investment of private enterprises. R&D funds will also be more efficiently allocated in stages as "risk burden" and "budget demand" differ, depending on each stage of scientific development. That is, in the R&D stage the government’s financial support cannot be ignored; however, during the production and industrialization stages, support through a technology financing fund should be systemized and intensively fostered.

The government will play the role of being the lynchpin, catalyzing collaboration within the private sector, such as technology evaluation, nurturing the technology market and easing restrictions that hamper the R&D activities of private enterprise. Through this measure, businesses will be able to access loans on technology credit, loans on technology securities, technology royalties, or enterprise values.

Public research institutes need an evolving process since their mission and function require them to incessantly respond to social demands. When the capability of private R&D was lacking, the government-initiated R&D system greatly contributed to the development of the national R&D capability through public R&D institutes. However, there has been criticism that the level and contents of public R&D institutes are not meeting private demands as the research caliber of private enterprises and universities have strengthened. Therefore, responding to private-initiated innovation systems, reorganizing the role of public research institutes, and renovating the public R&D system are required. This is very important because the role of national/public research institutes cannot help but be relatively small due to their dependency on GRIIs. Therefore, in the long run, the role of the national/public R&D institutes should be reorganized along with the restructuring of GRIIs.

As noted in “The Results of Management Checking on GRIIs” study conducted by McKinsey & Company, the fundamental problem facing Korea’s GRIIs is that most research institutes, whether in either the industrial sector or the public sector, lack a customer-service orientation. Therefore, the extent of concentration on customers at the institutional level needs to be increased. Recent pursuit of clarifying the mission and management goal in the restructuring process of management systems for GRIIs will result in a turning point by making GRIIs directly attuned to their customer’s expectations.
GRIs will serve the role of “middle man” by connecting university research with R&D activities of private enterprises. They will be in charge of both the strategic technology development that is necessary for the nation and the R&D fields where the legitimacy of government support is recognized, due to the difficulty of private participation and vulnerability of high caliber technological advancement. Furthermore, GRIs will operate technology transfer and marketing. This mechanism will strengthen the demand for the industrial sector in the process of job performance for the institute, such as task selection, and in the long run, eventually switch over to being a profit center. Besides, GRIs that are basically public oriented in nature, such as the Institute of Physical and Chemical Research (RIKEN) in Japan, will be a special incorporation or have a management system carrying out functions only for public purpose (like the national/public institutes of Korea). On the other hand, the national/public research institutes whose functions are weak will have to make efforts to strengthen their functions and roles by adopting the merits of GRIs.
Over the last three decades Korea’s S&T potential has expanded through R&D investment in S&T. This strategy was initiated by the central government, and as of 1997, the investment level ranked sixth globally, and reached third in the world in proportion to GDP. R&D investment, only $8.18 million (0.38% of GDP) in 1967, increased to $40.3 billion (0.81% of GDP) in 1977, $2.5 billion (1.81% of GDP) in 1987, and sharply increased to $12.8 billion (2.68% of GDP) in 1997. However, comparing the absolute size with advanced countries, R&D investment was only 1/16 of the US and 1/10 of Japan. As the accumulated stock of R&D investment over the past thirty years (1969–1997) is only 1/31 of the US and 1/16 of Japan, there is urgent need for expanding overall R&D investment. The size of the government research budget too, only $2.9 billion, falls short of that of just one single company such as General Motors ($8.9 billion), Ford ($6.8 billion), IBM ($3.9 billion), etc. Accordingly, we find that the government’s share of the total research budget, which is only 23.4%, is close to Japan’s 26.5%, but our government’s share is very small compared with such major countries as the US (35.4%), France (43.1%), and Taiwan (40.8%). Therefore, efforts to expand R&D investment in the government sector is needed.

However, the problem is that Korea’s R&D system is
relatively poor in the allocation of investment resources and utilization/expansion of results. According to an IMD report, the competitiveness of Korea’s overall S&T ranked twenty-eighth in 1990 among the forty-four countries. Therefore, key investment allocation strategy needs to be changed, giving more weight to the efficient utilization of investment resources. This goes along with the continued expansion of R&D investment, taking into consideration the efficiency of resource injection in R&D allocation. To improve the overall efficiency of R&D investment, it is necessary for resources to be put in the optimal place. The government should expand the opportunity for additional subjects to participate in the process of resource allocation, and steer key policy in the direction of supporting private R&D activities by building a research base.

[Recommendation 5] Define clearly the boundaries of the government R&D budget.

As the concept and scope of R&D are not clearly defined, there are items or contents included in the R&D budget that are not practical. Because of this, there is redundant criticism that a bubble exists in the nation’s R&D budget. According to the Frascati Manual of the OECD, in 1990, the scope and specific projects of R&D were redefined to determine the basic data for pre-tuning the budget, but they have not properly taken root since the budget was first implemented.

Once the concept and scope of the government’s R&D budget is defined, continuing management and budget increases for practical R&D is possible through examining, analyzing, and evaluating the R&D projects for the preceding year, along with pre-tuning the R&D budget for the next year. In addition, as the National Assembly and general public come to understand the content and flow of the R&D budget, the monitoring function will
be enhanced. Korea can also compare its projects with R&D projects of other countries by establishing an R&D concept that corresponds to international practices; thus, a precise understanding and further improvement of current situations and problems can be achieved in Korea’s R&D programs.

[Recommendation 6] Pre-coordinate the R&D budget and manage R&D projects by using an MBO system.

There is a need to improve budget allocation and management to efficiently allocate and enforce the secured R&D budget. The advanced countries in S&T are implementing a diverse budget allocation system to improve the efficiency and reasonableness of their R&D budgets. In the US, the budget is being allocated by strict evaluation based on the Government Performance and Results Act (GPRA). In Japan, the basic direction of the S&T budget is determined by holding an S&T conference along with identifying mid- and long-term planning objectives. Therefore, the Management by Objectives (MBO) system needs to be applied to all national R&D projects as soon as possible and a specialized institution should be fostered professionally and strictly evaluate output against input for R&D projects.

The National S&T Council (NSTC), recently established in Korea is tuning the R&D budget for the next year in advance. However, this budget adjustment involves too many conflicting interests. Therefore, it is especially important at this time that a strategic budget system be put in place. An impartial, but objective budget coordination system needs to be established based on understanding and cooperation among the concerned parties. This budget coordination should be done through strict evaluation and the introduction of the GPRA concept in the evaluation of GRI.

[Recommendation 7] Promote basic/large-scale research through
disseminating R&D results, planning, evaluating, and etc.

The government should give more weight to efficiency for base buildup, expand the dissemination of R&D results, support private research activities such as basic research and fostering R&D personnel who are difficult for private enterprises to employ.

The 1998 R&D budget allocation shows that the bulk of government financial support went into short-term industrial projects. In the future, however, the government should focus on long-term, high-risk projects such as fundamental technology, mega-science, and basic science, areas that are difficult for the private sector to take on.


- R&D budget: 2,441 trillion won
- Technology development budget: 1,825 trillion won (74.8%)
- Short-term industry technology: 678 billion won (27.8%)
- Basic core technology: 433.6 billion won (18.8%)
- Mid- and long-term core technology: 410.2 billion won (16.8%)
- Public welfare/large-scale technology: 203.8 billion won (8.9%)
- Transfer & expansion of technology: 35.5 billion won (1.5%)
  - Infrastructure: 38.2 billion won (15.7%)
  - Fostering basic science workforce: 215.2 billion won (8.8%)
  - S&T inspection/policy: 16.9 billion won (0.7%)
- Excluding R&D budget for defense, foundation fund included.

Note: Data: Ministry of S&T, the Result of Survey, Analysis, and Evaluation of National R&D Programs, March 1999.

Support for technology transfer needs to be strengthened. Disseminating R&D results to make best use of research planning and performance evaluation is also essential and will surely improve the efficiency of R&D projects.
[Recommendation 8] Meet R&D demand of the private sector.

The power to allocate resources has so far resided in the central government and the bulk of R&D resources have been centered on GRIs. However, the R&D caliber of private enterprises has been growing and has reached 3/4 of the total national R&D activities. The role of the government has been changed from direct to indirect support. Accordingly, from now on there should be a balanced R&D resource allocation where enterprises are highly valued.

[Fig. 13] Government R&D Allocation System

Korea should induce the streamlining of substantial collaboration among industries, universities, and research institutes. This can be done by strengthening the participation of enterprises in the process of R&D planning, selection, management, and evaluation of the projects. This makes it possible for end-user-oriented resource allocations, such as contract research, and outsourcing to be awarded to universities and research institutes.

Korea has to rapidly establish a well-built S&T base and system to reach the goal of becoming a major world power by securing competitiveness in S&T and matching the level of the seven advanced countries by 2025. The level of R&D needs to improve for the whole country up to 4.0% by 2025 from 2.69% of GDP of 1997. This is essential to raise the R&D share of government and R&D amount that involves R&D personnel, infrastructure support for SMEs and support for basic research. The government’s portion of the overall national R&D investment needs to be raised from the 23.4% level in 1997 to 27% by 2005, to more than 30% by 2015, and the R&D budget, which is only 3.7% of the government’s budget needs to increase to more than 5% in 2002.

However, above all, for landmark expansion of R&D investment, Korea has to expand R&D investment in the private sector, which will play a pivotal role in the 21st century. For this purpose, the government will improve the technology support system for private enterprises through streamlining the incentive policy, such as a technology development–related system and enticements to sharply increase their R&D investment.

[Recommendation 10] Tighten cooperation between private and academic sectors in mid- and long-term fundamental technology.

Currently, the R&D activities of our enterprises are mostly being carried out on their own. A little support from industry for universities and GRI is means that the industry is focusing on short-term industrial
development and research density in mid- and long-term key base technology is too low.

As basic research and mid- and long- term key base technology are needed for the creation of new technology and industries in the 21st century, the concern of enterprises is further needed. Considering that S&T and the industrial competitiveness of the US are based on improvements in the research caliber of universities and collaboration with enterprises, enterprise support for universities should be strengthened. However, as key base technology requires high costs and time, and there is a high risk of failure, it is hard for private enterprises to carry it out alone. Thus, the government’s active support is essential.


- Total Industrial R&D 8,829 trillion won
  - Internal use: 8,322 trillion won (94.9%)
  - University: 189.5 billion won (2.1%)
  - Donation to the public institutes: 189.8 billion won (2.2%)
  - Others: 68 billion won (0.8%)


[Recommendation 11] Establish a local government-initiated S&T promotion system.

The role of central government will be to sponsor and support the local governments in terms of S&T development. Local governments will independently map out and implement S&T promotion plans suitable for their respective regions. As time passes, the central government will gradually hand over
project management responsibility to the local affiliates. Moreover, as a portion of the central government’s budget is spent to support local S&T in the form of matching funds, the local government will gradually share more costs as a certain period of time passes. Responding to the era of local autonomy, organizations will be established and expanded to be exclusively responsible for the S&T work on the basis of each local government building its own base of S&T development.
3. R&D System: From a Domestically Completed to a Globally Networked

As severe competition develops throughout the world in parallel with the trends toward openness and globalization, an age of competition and cooperation is at hand. Strategic collaboration among enterprises will also increase and high-tech source technology will maintain the technological edge. However, in general, Korea has acquired and developed technology by imitating, absorbing, and digesting advanced technologies from abroad. Accordingly, the development of technology and products has been domestically restricted throughout the life cycle. Our people traditionally have had a conservative disposition; thus, thought and practice that lives up to internationalization have not yet taken root. Legal and systematic obstacles to globalization in S&T still remain. As a result, Korea has fallen behind both its Asian competitors and the advanced countries when it comes to participating in world bodies of S&T and international joint programs.

To keep abreast with and globalize the whole area of the socio-economic sector in this age of growing competition, Korea has to more actively utilize both international R&D resources and high-tech S&T information. This is done by changing the R&D system from the current “domestically determined type” to the “globally networked type” in parallel with S&T internationalization. The reason is that first class S&T can be achieved earlier by overcoming the limitations of locally available R&D resources and strengthening research competitiveness through utilizing world-class advanced technology, our workforce, and
information. At the same time, in a similar manner as the WTO, Korea can also play a role as a responsible member of the global village.

In this age of openness and globalization, the international sector is no longer an environmental variable, but is an important actor in R&D activities. Moreover, since only 2.3% of the entire world’s R&D investment is done in Korea, the efficient utilization of R&D resources and actors in overseas countries is very important. Since there is no distinction between local R&D and overseas R&D actors, the distinction among industry, academia, and the institutes is becoming extinct. The controversy in the country over the role of industry, academia, and the institutes and the classification is no longer meaningful.

In order to transform to a new innovative system from the "domestically determined type" to the "globally networked type," the government needs to take the following factors into account.

First, to avoid the traditional viewpoints that are understood as the overseas sectors, as an environmental factor, or the 4th factor following the industrial, academia, and institution sectors, it is necessary to build a new S&T innovative system and view it without any discrimination.

Second, by amplifying Korea’s base to make it fit for R&D activities — that is, the R&D workforce, facilities, taxes, and banking — Korea and its institutes should attract research institutes of foreign enterprises.

Third, the government has to actively induce the advancement of research organizations, workforce, and activities in other countries, and boldly open Korea’s R&D system.
Fourth, active participation in world bodies like the WTO and OECD is needed. Such participation is pivotal to instituting S&T-related international regulations and improving and complementing related systems to meet international standards and norms.

[Recommendation 12] Incorporate the overseas sector in the national S&T innovation system

The viewpoint discriminating domestic from foreign sector should be abandoned. In this regard, the nation should consider the overseas sector as a key player within the S&T innovation system. To escape from the concept that competition and collaboration are among local R&D actors, expansion of the area of R&D activities to those of the international R&D community of overseas research institutes, enterprises, and universities is needed. In the pursuit of development, utilization and expansion of fundamental technology, completing the life cycle of R&D within the country is no longer necessary. Now, objectives need to be achieved through international joint research, technological alliances with foreign countries, and bold outsourcing.

The scope of the strategic technological alliance is not only the formation of mutually dependent networks in simple development, but also expands into technological alliances for manufacturing, marketing, and integrated technological development. A management form of technical alliance should also be developed into a variety of forms ranging from a simple license contract to cross-licensing, exchange of workforce, parts specifications, test agreements, purchases, sales and service contracts. Furthermore, since even formal arrangements like joint investment for technology acquisition is established in various forms, regulatory responses are required for them to be successful.
[Recommendation 13] Create an attractive environment for R&D activities in Korea to emerge as a center of excellence.

In this age of growing competition accompanied by remarkable openness and globalization, the overseas R&D organization for businesses is being localized, as technology and merchandise development becomes suitable for the domestic market and local demand becomes the essential ingredient for competitiveness. Therefore, since there are a number of companies with advanced technology seeking to utilize Korea as a center of excellence for R&D to access Asian markets, blue chip businesses and their high-tech research facilities fully equipped with a sound research base should be attracted to Korea.

An example of this would be the creation of a research center exclusively for foreign scientists at a conveniently located area, such as Young Jong Island behind the new airport. In doing so, not only the support system and culture related to R&D, but also the improvement of the tele-communications network and distribution system should be facilitated, and all the conditions associated with foreign capital investment, including banking, taxes, etc., should be streamlined. Additionally, accommodations for the scientists and their families should be fully equipped with all of the modern conveniences. A multi-purpose center needs to be built to provide a place where their children can be educated, and shopping, sporting, leisure, and cultural facilities designed and built for their comfort.

[Recommendation 14] Simultaneously push liberalization and overseas participation.
By encouraging the establishment of overseas research centers and research branches at major scientific centers and sourcing areas of advanced technology worldwide, Korea should strengthen its overseas R&D activities, and directly learn about and utilize the most advanced technology, human resources, and information. Mutually cooperative partnerships need to be found by establishing a research fund (e.g., a basic research funding program) to support basic research for teams of prestigious universities or eminent researchers abroad. To initiate this, the government needs to implement a program to provide support in the first ten years of the 21st century. The programs should foster such projects as ERC/SRC to overseas. However, as an operating method, the existing RRC (Regional Research Center) would be more appropriate. Also, as in post-doctorate training, field training or joint-research will be expanded by sending the local research workforce to foreign countries. In the near future, the government will expand the relevant policies for local Ph. Ds to be trained overseas, if they want to, and actively encourage students or graduates to get credits and training in their fields. By participating in international joint-research programs, such as the mega-science forum initiated by OECD, IMS, information/communications, bio-engineering, etc., which will emerge as key issues in the 21st century and contribute to S&T development in the world, Korea’s prestige will grow as it plays a leading role in international joint programs.

Advanced technology will be induced, and a workforce will come to Korea as the result of improving R&D-related systems and environments and by actively attracting excellent foreign research institutions and enterprising institutes to Korea. Korea will open the door to its R&D, implement outsourcing, and
promote attracting an excellent foreign research workforce. These measures will make up for the weak points by overcoming the limitations of local R&D resources with allowing the nation to quickly learn and make use of advanced foreign technology. Based on the characteristics of each research institute, a certain percentage of foreign researchers will be employed among the local workers. Excellent foreign researchers will be utilized by improving laws and support systems so they can work as chief scientists, researchers, and etc. To do this, a favorable research environment for the foreign workforce must be created – one that is comparable to the environments of advanced countries. If needed, the government will implement planning and evaluation of R&D projects by foreign experts and specialized institutions, and open our R&D projects to a certain degree to foreign institutions and foreign researchers.


In the new high-tech industry of the 21st century, which will be based on information and bio-engineering technology, advanced enterprises will exclude the participation of new enterprises and pursue international monopolization of technologies through technological alliances. Accordingly, in the case of an advanced industry that has the competitive edge in the development process, it is essential that industry institutes standards that are discussed during the technology development stage. Because production is directly linked to the growing share of the world market, it is very important to participate in instituting the process of international standards and specifications.

However, in the case of Korea, there is a lack of understanding of the importance of international standards and specifications, and the relevant experts. As of this writing, there are only two
versions of the Romanized Korean alphabet deemed as acceptable to international specifications. Also, in the globalized age that transcends borders, Korea has to comply with international standards, such as intellectual property systems. However, there is a lack of understanding pertaining to intellectual property on our part. Illegal copying still remains prevalent and patent examinations are being delayed due to lack of experts in that area. In 1999, a survey conducted by the Committee on Software Property Protection shows the rate of Korea’s illegal copying reached 67.4%, much higher compared with 27% in the US, and 32% in Japan.

Therefore, it is necessary to cope with technological monopolies by the advanced countries and streamline local standards and norms. This is to be done after considering in-depth discussion among global participants about international rules and regulations, such as new advanced technology, IPRs, and a property knowledge rating system where international specifications, standards, norms, and practices are not yet established. The government has to arrange a discussion forum to increase awareness and concern among businesses about international specifications. The government must also support international standardization of local specifications by actively supporting its enterprises in order to participate in industrial forums, such as DAVIC (Digital Audio Video Council)\(^3\), which is leading in industrial standards in instituting new technology. Korea will also push ahead with employment and deployment of Korean experts to the WTO, OECD, ISO, and etc., which have been playing pivotal roles in instituting international standards and norms. Advancing to head or manage global organizations and the affiliated committees will push forward to internationally standardize local norms.

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13) DAVIC (Digital Audio Video Council): It is a non-profit standardization body based in Geneva, Switzerland, and was established to institute a variety of service-related standards in Aug. 1994, sponsored by the world’s famous computer/communications-related companies.
Korea will strengthen government support to crack down on illegal copying and to use genuine products. The nation will also foster a specialized workforce involving intellectual property rights, and actively participate in international flow of the WIPO (World Intellectual Property Organization) to internationally standardize application procedures for IPRs of each country by May 2000.

[Recommendation 16] Establish an institute specialized in international collaboration.

With the growing globalization and liberalization in the 21st century, when the international exchanges of goods and services are universalized, the internationalization of S&T, such as technology/information exchange, international joint-research, and the exchanges of scientists will be increasingly important. Currently, KOSEF, KISTEP, and KOICA are implementing periodic and limited international cooperative businesses, but they have little relevance to S&T.

Therefore, the establishment of a specialized institution of international S&T collaboration is needed. This specialized institution will not only attract foreign scientists and research institutes, but also support local/overseas information and technology exchange, the participation of local scientists and research institutes in foreign countries, and international joint-study pursued at home and abroad. However, in accordance with the characteristics of a specific institution, Korea has to avoid duplicating work pursued by other institutions and work that is overlapping. This will be helpful to the SMEs that cannot afford to run their own overseas branch offices as well as to large enterprises.
The new high-tech industry of the 21st century cannot be created without world-class cutting-edge technologies. Based on this, Korea cannot survive the growing competition without a new industry in which the nation is strong. In the high economic growth stage of Korea’s development, the nation was able to sustain competitiveness through imitation and improvement of advanced technology. However, in the future, forging the competitive edge in technology will occur at the industry standard stage, not the production stage, and is directly linked to pre-occupying the world market. Therefore, the government must try to change the R&D paradigm from the short-term R&D strategy that is of a demand-meeting type to a long-term innovative strategy that leads to new market creation. That is, instead of a demand-pull to satisfy the desire of customers, there should be a harmony between the two by continuing to expand support for technology-push creating new markets.

To address this issue, the government needs to give more weight to the recently increasing creative research by expanding investment resources and restructuring government R&D projects for the efficient pursuit of basic research study being performed in each specific technological field. To make this creative research possible, the government not only has to support long-term investment, but also pick out creative research leaders who have originality and creative minds. The nation also needs an R&D system to guarantee a self-regulating system of R&D management that will allow leaders to work to the best of their abilities in an excellent research environment. Furthermore, the nation has to provide them with sufficient compensation and incentive for excellent performance and results.
Box 29. Development of Fluorescence from the Study of Firefly Light

- Iman, a researcher at GE, researched a study based on the idea that a light bulb would not be hot if an electric light was made out of just a pure theoretical ray that does not include infrared rays. This was concluded after the study of the firefly’s light, which is not hot when held in the hand. Through this study, Iman developed fluorescence by discovering the fact that the infrared rays coming out of a discharge changed to a thorny ray as the short-wave length gets longer where they contact materials such as oxidized zinc or oxidized cadmium.

A New Superconductivity Study

- Are there no dream materials without electrical resistance? Since the phenomenon of superconductivity where electrical resistance disappears was discovered for the first time in 1981, advanced countries have been investing huge workforce and research expenditure to study superconductivity and to apply it to industry. There are now more than a thousand kinds of materials where the phenomenon of superconductivity was discovered. However, this phenomenon mainly occurs under very low temperatures. The full-scale study of superconductivity at high temperatures has been going on since a material was found showing superconductivity at more than 77K. This is the temperature that makes cooling possible with cheap liquid nitrogen. The successful development of high temperature superconductivity, having endless application like maglev as well as electronics, information, communications, and such, will not only contribute to innovative development for the S&T side, but also will have an enormous influence on industrial development.

[Recommendation 17] Prepare for the future through constant allocation of investment.

It is expected that a number of new industries will be
created through technological innovation, like the emergence of brand-new technology by integrating technologies that used to be considered independent. Therefore, the government should place more emphasis on creative research as part of the entire R&D project by sharply increasing the size of creative research.

Therefore, in the future, more emphasis must be put on improving the degree and scope of creative research. The government should always be prepared for the future by allocating a certain percentage of investment to future programs. Inter-ministerial coordination has jointly been conducted with the G7 Project\(^4\) since 1992 to improve some core technologies to the level of the advanced countries early in the 21st century. In this respect, Korea has to push ahead with the plan, and pursue joint frontier R&D projects through inter-ministerial coordination for at least ten years to prepare for the future. For systematic pursuit, the nation must further strengthen the function of R&D by planning and continuing to operate as a pool of experts to see this through.

[Recommendation 18] Cultivate a new R&D culture to foster creativity.

Korea will make overall improvements in R&D systems and respective cultures, specific to organizations and management techniques in order to encourage creativity.

Korea will seek out researchers with creativity, high caliber research and leadership from industries, universities, and

\(^4\) G7 Project: It is called HAN (Highly Advanced National) Project and is a giant national R&D project that is jointly being pursued by pan-department, 1992 to 2001, to improve some core technologies to the level of advanced countries by early in the 21st century.
institutes. In the selection process, local and overseas Korean scientists will be included on the basis of selections using strict and objective evaluation criteria. The government will support sufficient research funds, the best research facilities, and give much flexibility to providing funds for researchers so that they can make the most of their ideas. To escape the imitation-oriented research culture and management system of institutions, independence has to exist in research organizations, personnel and finance, and the discretion of the principal researcher must be strengthened to allow research organizations to take the lead and pursue task-oriented research.

To achieve great research performance and results, such as the creation of a new industry, R&D funds should be steadily supported. In the long-run, an atmosphere that attaches importance to quality of study is needed, and a culture accepting failure (free-to-fail) should be created. As failure can be the opportunity to produce and accumulate new knowledge, we can accumulate new intellectual property through failure. Also, in order for creative research performance and results to be promoted through competition, a system of carrying out multiple studies and fair competition in selection of research teams should be established. Korea will give full authority to the principal researcher to form a group to carry out research. The nation will also operate the sunset type organization research, which is supposed to disband once the study is completed. All these measures will serve to facilitate the flow of knowledge and activate technological innovation by fusing together knowledge and technology.
Box 30. Exemplary Principles of a New Creative Research Culture

- **Creativity of research leaders:**
  - Choose and support research leaders with creativity, challenge and motivation.

- **Originality of research themes:**
  - Support research themes characterized as creative ideas.

- **Generic domain of research area:**
  - Linked to a fundamental technology development by supporting a basic area rather than development area.

- **Mobility of research workforce:**
  - Have up-to-date ideas flow in through a continued cycle of young research workforce like post-doctorates.

- **Creative research environment:**
  - Create research environments where creative researchers stretch their wings, give full authority to the research leader (instituting research goals, instituting and modifying research direction, composing the research team and strategy of research performance.)

- **Competitiveness of research performance:**
  - Intensive support to the research team having the highest potential for success after picking out and supporting multiple excellent teams through fair competition.

- **Sunset approach of research organization:**
  - Prevent the new formation of a bureaucratic research organization by terminating support for research on a unit-by-unit basis after research has been completed.

- **World-class research performance:**
  - Produce world-class performance and results through evaluations based on the world-class standard.

For a creative study to be initiated and excellent scientists to continually be produced, Korea has to create a social atmosphere where scientists who made the greatest contribution to bolstering the status of the nation and creating wealth are respected. For this social atmosphere to be created, a culture where S&T plays a leading role should take root, and S&T should become popular as an S&T mind-set develops among the public.

To this end, media will be used, which will promote active communication between scientists and the public.

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<tr>
<th>Box 31. S&amp;T Awards by Major Countries</th>
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<tr>
<td><strong>[ the US ]</strong></td>
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<tr>
<td>· The Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring by the NSTC.</td>
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<tr>
<td>· The Presidential Early Career Awards for Scientists and Engineers by the NSTC</td>
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<tr>
<td>· National Medal of Science by the NSF.</td>
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<td>· National Medal of Technology by the Department of Commerce</td>
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<td><strong>[ Germany ]</strong></td>
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<tr>
<td>· Deutscher Zukunftspreis by the German President; so-called The Presidential Award for Technological Innovation, Gottfried Wilhelm-Leibniz-Pries by the German Research Council.</td>
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<tr>
<td><strong>[ France ]</strong></td>
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<td>· Les Grandes Prix by the French Science Academy</td>
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</table>

By pursuing a tentatively named "Science Hero Program," several successful venture scientists will be selected. Those scientists who make the greatest contributions will be chosen
to give young students dreams and hopes through media publicity, visits to elementary schools, and public lectures, etc., and create visions among the people that wealth and honor can be created through S&T. Through monetary and social compensation, a diverse award system will be put in effect to boost the morale of those scientists who make the greatest contributions to S&T. Major countries operate many award systems in which the country’s president awards the person.

In the US, especially, the MBNQA (Malcolm Baldrige National Quality Award)\(^{15}\) is presented to public institutions and private enterprises. "Les Prix de Culture Scientifique et Technique" is awarded to the lab of a specific research institute in France, and S&T related awards are even given to publishers. Also, Japan is instituting and awarding the "Japan Prize"\(^{16}\) that transcends a scientist’s nationality.

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15) Malcolm Baldrige served as Commerce Secretary of the U.S. (1982-1987). As a key man for national prosperity he proposed qualitative management. Shortly after his death in 1987, the U.S. Congress instituted an award after his name. Public agencies or private enterprises whose qualitative management and company management performance and results are excellent have received this award. Currently, the NIST of the US is implementing this.

16) Since the first awarding in 1985, till 1998, Japan won only five out of a total of thirty-eight awards. Americans totaled twenty awards, Europeans eleven awards, and the other Asians only two awards.
Expanding R&D and innovating the S&T system are not enough for S&T to really develop the nation’s future. S&T should be a role player that leads the economy and society. The nation with a well-equipped S&T mindset can produce new value as its S&T becomes the environmental background leading innovation and eventually improving the innovation ability of individual enterprises and all social sectors. Therefore, in order to substantially build the S&T innovation system, all people should come to recognize the importance of S&T, and to breathe S&T in their daily lives. Additionally, it will be necessary to enable S&T to emerge as a key factor in all corners of society, including such fields as politics, economics, and culture. Furthermore, a national management system, in which S&T is acknowledged as being the leader in all fields, encompassing society, politics, economy and culture, needs to be built.

In the case of the major countries, S&T is a key element that leads the nation. The US Congress asserts that the additional role of S&T in the 21st century is to help the American society make sound decisions. It is noted that not only R&D programs aimed at analyzing and solving the current issues, but also close cooperation between scientists and policy makers are important. In Japan, which has emerged as an economic power in the world, increasingly weight is being given to S&T in national management. The influence of a scientist becomes strong, and some Japanese Prime Ministers came from the S&T circle. In China, scientists that have
become ministers, including the current leader of China, hold many positions in the government, and as a result, running a country becomes heavily dependent upon its S&T capability.

In Korea, when making an important decision on the nation’s management, S&T is still not highly valued. Its importance is understood only from an ideological perspective, and firm recognition that technology is a national power is lacking, so national competitiveness is weak. There is no substantially high value placed on S&T, and not much is thought of scientists. As a consequence, the priority of S&T tends to be on the backburner in the decision-making process of the government, enterprise, and the individual. Fortunately, the number of CEO’s who were former researchers or engineers is gradually rising, and S&T-oriented management is gradually being introduced into industry.

For S&T to lead the national management system, it should be a role player in all fields of politics, economy, society, and culture. S&T should be put a high priority in decision-making process. This will allow heightened social recognition for S&T and the national management system. Above all, the president’s continued expression of concern about the importance of S&T is vital, and it is necessary to encourage developing the S&T mind-set of opinion leaders and policy makers. In Sweden, the king not only participates in the Nobel Prize awards ceremony, but in the annual gatherings of S&T expert groups as well. By fostering S&T-related NGOs and having them participate in the government’s various policy-making processes, people must be made to recognize the importance of S&T, and NGOs must influence raising the priority of S&T to a higher level. A decision-making system should be socially built where the scientists that participate in this process play an important role.
As S&T will be linked and fused with the human and social sciences, its role and responsibility to society will grow bigger and bigger. Consequently, S&T will be responsible for society by increasing, in a sense, the reform of consciousness among scientists. Korea needs to produce high-caliber scientists with management mind, and help them fulfill their duties, improving the public’s confidence in them. In this regard, Korea also needs to broaden the overall knowledge and awareness of scientists in other areas, including economics, societal issues, and management. Korea should also encourage scientists to fulfill social responsibilities, and in turn, the public and society should grant them corresponding respect. An annual survey performed by the National Opinion Research Center (NORC) at Chicago University on public confidence, covering thirteen sectors, including medical care, S&T, education, etc., found that the S&T sector ranks second, following medical care.

Korea will also be able to predict and find alternatives through scientific data and method, and based on this, shape the reasonable practice of looking for the best, which leads to the practice of finding feasible solutions. The S&T initiated decision-making climate should be applied not only to the processes at the national level, but also to the private sector and the general public as well. Also, by using the scientific process there will come the improvement of dignity across the nation.

Korea needs to strengthen the S&T-related functions of the
National Assembly and improve the S&T mindset to a higher level. This is especially so in establishing an S&T evaluation institution that deals with bioethics, atomic matter, economics, and the technicalities of a large-scale national project. In addition, Korea should institutionalize an annual and periodic report to the National Assembly on policy-making and performance/results of the national S&T. Korea will also regularly hold S&T-related National Assembly hearings and, like the advanced countries, encourage scientists to explain and justify the R&D budget to the National Assembly at the research planning stage.

Korea will also pay attention to the utilization of writing, educational activity, and the mass media in order to enable the general public to more easily understand S&T. In doing so, arranging for a mechanism for free communications between scientists and the media/public is needed. A program that strengthens the S&T mindset of the public persuasion, professionals like journalists, politicians, and so on, is also needed. Korea must also spread the pan-national S&T mindset by encouraging diverse advancements of scientists in the press and in political circles.

Korea’s future depends on the youth. The nation cannot overemphasize that the nation’s youth should be familiar with science, and have interest in it. They’ll become tomorrow’s Nobel Prize winners, creative scientists, engineers, entrepreneurs, etc. Further, they will take charge of the nation’s healthy development. Through youth, Korea will join the advanced countries in the world by 2025.
### 1. VISION 2025 Indicators

#### Key National Indicators

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<td>50,400,000</td>
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#### Key S&T Indicators

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<td>S&amp;T’s Contribution to Economic Growth (%)</td>
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<td>Technology Management</td>
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<td>Scientific Environment</td>
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</table>
2. List of VISION 2025 Tasks

1. Sustain momentum to advance information technology so that world leadership is attained and supported in core technology fields by 2010.

2. Improve the efficiency of public service through computerizing, in data processing, and establishing the “Electronic Government” by 2006.

3. Promote public access to information.


5. Effectively cope with side-effects of rapid informatization.

6. Promote self-reliance through intensive support for future technologies.

7. Raise status of existing industries through quality and value-addedness of products.

8. Encourage entrepreneurship and technological innovation through a merit-based system.

9. Revise laws and regulations to ensure an “innovation-friendly” environment.

10. Cultivate high-caliber S&T personnel.


12. Develop technologies in the life and medical sciences suitable to Korea.
13. Continue brain research to join the ranks of the world leaders in specific areas.


15. Build the infrastructure for life, health and medical technologies, which cannot be pursued by the private sector alone.

16. Establish ethical norms on newly emerging cloning technology.

17. Develop environmental technologies to attain advanced levels and prepare for the Green Round and other future demands.

18. Advance projects that expedite the use of new environmental technologies.

19. Implement model projects to raise environmental awareness.

20. Form a Northeast Asia body on environment, to address environmental issues.


22. Develop observation and forecast technologies to detect natural disasters.

23. Guarantee nuclear safety through safety inspection and continuous technology development.

24. Strengthen safety checks for large-scale structures and improve safety standards.

25. Pursue R&D for mass production of food using biotechnology.

26. Develop core technologies for alternative energy sources and energy efficiency.
27. Join nuclear technology exporting countries by developing nuclear core technology.

28. Seek new water resources and develop water resource management technology.

29. Secure technologies for national defense and pursue civilian and military dual-use technology programs.

30. Continuously promote South-North Korea S&T cooperation to prepare for reunification.

31. Participate in international mega-science programs, and contribute to the world S&T community.

32. Prepare for the space challenge.

33. Promote oceanic exploration.

34. Advance the level of basic science by 2010, and foster world-class scientists.

35. Cultivate creative minds through reform in S&T education system.

36. Foster female scientists and engineers

37. Establish a nationwide, comprehensive, knowledge management system by 2005.

38. Take appropriate measures to protect IPRs.

39. Create national science culture through nationwide campaigns and establish network for a science museum.
3. List of Recommendations

[Recommendation 1] Transform the current S&T policy development system from government-initiated to private sector-driven.

[Recommendation 2] Promote public awareness of S&T policy.

[Recommendation 3] Reform support system from direct to indirect system.


[Recommendation 5] Define clearly the boundaries of the government R&D Budget.

[Recommendation 6] Pre-coordinate the R&D budget and manage R&D projects by using an MBO system.

[Recommendation 7] Promote basic/large-scale research through disseminating R&D results, planning, evaluating, and etc.

[Recommendation 8] Meet R&D demands of the private sector.


[Recommendation 10] Tighten cooperation between private and academic sectors in mid- and long-term fundamental technology.
[Recommendation 11] Establish a local government-initiated S&T promotion system.

[Recommendation 12] Incorporate the overseas sector in the national S&T innovation system.

[Recommendation 13] Create an ideal environment for R&D activities for Korea to emerge as a center of excellence.

[Recommendation 14] Simultaneously push liberalization and overseas participation.

[Recommendation 15] Comply with international norms and standards.

[Recommendation 16] Establish an institution specialized in international collaboration.

[Recommendation 17] Prepare for the future through constant allocation of investment.

[Recommendation 18] Cultivate a new R&D culture to foster creativity.

### 4. VISION 2025 Taskforce Participants

#### 1. 2025 S&T Development

**Long-term Planning Committee**

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<th>Position</th>
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<tr>
<td>Chairman</td>
<td>Kim K</td>
<td>Samsung Advanced Institute of Technology</td>
</tr>
<tr>
<td>Member</td>
<td>Xi YF</td>
<td>Samsung Advanced Institute of Technology</td>
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<tr>
<td>Member</td>
<td>Lee BK (Hyundai Motors)</td>
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<tr>
<td>Member</td>
<td>Lee EY (Korea Institute Technology Association)</td>
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<td>Cho YH (Korea Institute of S &amp; T Evaluation and Planning)</td>
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<td>Member</td>
<td>Han HS (Institute for Advanced Engineering)</td>
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**Life & Medical Sciences Sub Committee**

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#### Sub Committees

**I & T Sub Committee**

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**Material Subcommittee**

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</table>
### 3. Korean Academy of Engineering

**Advisor:** Kim JW (Korea Institute for Advanced Study)
- Kim JS (Korea Institute for Advanced Study)
- You YJ (Korea Institute for Advanced Study)
- Park KH (Korea Institute for Advanced Study)

**Researcher:**
- Kim TY (Seoul National University)
- You YJ (Seoul National University)
- Lee YH (Seoul National University)
- Cho YK (Seoul National University)
- Kim EJ (Seoul National University)
- Bang JG (Seoul National University)
- Song JH (Seoul National University)

**Assistant Researcher:**
- Kim BI (Seoul National University)
- Ryu JY (Seoul National University)
- Shin HC (Korea University)
- Lee HS (Seoul National University)

**Advisor:** Kwon JH (Seoul National University)
- Oh MJ (Seoul National University)
- Chung EJ (Korea Advanced Institute of Science and Technology)
- Choi JH (Korea University)

### 4. Forums & Advisors

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<td>IT &amp; Science Evaluation and Planning</td>
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**Note:** The table lists key personnel and their affiliations within the Korean Academy of Engineering and related forums.
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