Chapter 5

How to Advance R&D, New Product Development, and New Business Development: Requirements That Should Be Taken into Consideration Towards These Ends

Regardless of whether we are talking about R&D, new product development, or new business development, as long as the word "development" is being used, these fields have something in common with each other. Furthermore, they all have the quality of being novel and are resourceful pursuits for humanity; pursuits that can be considered to be activities for realizing potential values.

In such a case, the research that forms the essence of R&D is generally categorized as either fundamental research or applied research or even practical-use research. Whereas fundamental research in particular aims to arrive at new theories, discoveries, and inventions, new product development and new business development primarily aim to create new products and businesses for the market.

Therefore, even though the duration, development scope, and development scale and cost may vary by the development project, as far as their implementation is concerned, they all have a good number of considerations that they share in common. In what follows, I would like to investigate various ways to advance development and the considerations that need to be made towards achieving their ends by looking at them from the viewpoints of such topics as information sources, the integration of development, R&D management, and human resources development and management.

5.1 Considerations for Acquiring and Selecting Data from Sources of Information

5.1.1 *Published and unpublished information*

In general, development-related information sources can be roughly classified into the following two categories:

1) Published information (information made available through trade papers, trade magazines, professional journals, books, research papers (industry-specific, field-specific, country-specific, etc.)), reports, DVDs, videotapes, cassette tapes, databases, various TV, cable, and radio broadcasts, and related information obtainable from search sites.
2) Unpublished information (publicly undisclosed information from academic and non-academic organizations and from information professionals and information non-professionals that are exchanged as electronic, paper, telephone information, and person-to-person word of mouth information, using telecommunication networks, fax machines, telexes, various means of communication using man-made satellites, and encryption to collect, accumulate, access, and evaluate).

Among the published information, an examination of just the types and number of science and technology magazines available today reveals that they have increased exponentially over the past four centuries. Even a survey carried out by King Research at the end of the last century reported that the number of scientific and technical information generated in the world was more than 4.5 million per year and moreover has been increasing at a rate of 4%–7% per year.

Meanwhile, the 1988 science and technology white paper points out the problems researchers of leading edge science and technology fields face when acquiring research information. According to the paper, 68% or approximately seven out of ten researchers said that they believe there are problems faced when attempting to acquire research information.

The reasons stated were mainly "difficult to make time," "budget for travel and purchasing reference materials are insufficient," and "available information systems and databases are insufficient." While the top reason for university researchers was "difficult to make time," the top concern for private enterprise researchers was "available information systems and databases are insufficient." Furthermore, nearly 70% of researchers working at national research and development institutions consider their top reason to be "budget for travel and purchasing reference materials are insufficient."

5.1.2 *Difficulties of acquiring data from sources of information*

The difficulty these researchers face when acquiring information pose major problems for development researchers and since researchers of other representative institutions point out different top reasons, it is believed that such problems need to be eliminated by promoting industrial clusters and intelligent clusters formed through industry-academic-government collaborations, which is currently gaining a groundswell of support.

Furthermore, when comparing the setups of available science and technology databases, the number of Japanese document abstracts (for which this writer has previously contributed) related to science and technology in general found in the Japan Information Center of Science and Technology (JICST) (the current Japan Science and Technology Agency, an independent administrative institution) amounted to 5.6 million as of May 1988. Meanwhile, at this point regarding information in English, in the US, the number of database entries related to mainly chemistry is 8 million, and in the UK, database entries related to the fields of physics, electricity, and computers amount to 3 million. In contrast, the number of

English-language files found in JICST related to science and technology in general amount to 500,000, which is only 1/16th of the amount of the entries found in the US. This clearly indicates the discrepancy between Japanese and English document abstracts and shows that the JICST is extremely limited to Japanese information.

In dealing with this problem, the thinking to rely on overseas databases is certainly there, but when taking into consideration the problems of budgetary and time constraints, which were raised as major issues, the option to just neglect the problem is believed to be inadvisable.

5.1.3 *Four basic considerations for selecting information sources*

Next, pertaining to selecting information sources, the following four considerations must not be forgotten.

The first consideration is that preferably the information source is already established and that it is highly reliable. This is essential. However, it is also a fact that even in the case of information published by the government, relatively speaking, their reliability varies greatly.

If you collect same data from different sources, you will often find that they differ accordingly.

For example, if you decide to research the number of Internet users, you will find that the result according to the report carried out by Access Media International varies from the result according to the one carried out by the Ministry of Public Management, Home Affairs, Posts and Telecommunications, even though they are both reporting for the same year. Specifically, the latter reports about 15 million more users (77.3 million) than the former.

According to the *1985 White Paper on Small and Medium-Sized Businesses*, special-interest magazines and trade journals attract the most interest as sources of information for gathering technical information for product development purposes, regardless of company size. The point can be made that the reason for this is they are the most accessible sources of information while also being the most reliable at the same time. Needless to say, among professional journals, there are old ones and new ones, and in the case of specialists of advanced technology in particular, it can be very well understood that interest in new trade papers and professional journals will run high.

Secondly, there is the issue of the cost efficiency of the information source. This is about whether the use of a particular information source is sufficiently effective or has sufficient benefits *vis-à-vis* the cost incurred over its use. While magazines and newsletters that are restrictively purchased by VIPs all over the world are generally very costly, the decision to purchase them is largely due to the fact that top managers and engineers reason that the purchase of these types of publications are necessary for the survival of the company or for the maintenance of its competitive edge.

Furthermore, regarding institutions that strongly promote publications that claim to offer confidential information, the exercise of caution is necessary, since many of them undervalue confidentiality themselves and are solely motivated by the opportunity to make excessive profits.

Thirdly, the unexpectedness of an information source (a.k.a. serendipity in the sense that you might come across a new source through failures and accidents) cannot be removed from the list of necessary requirements.

To create artificial snow, Dr. Ukichiro Nakaya failed over and over again before finally succeeding in creating an artificial snow crystal through the use of a Japanese hare. While this discovery was truly unexpected, an examination of the hair of the hare through a microscope revealed strands of stinging hair growing in many layers. It then became clear that their structure was exactly right for creating crystals of artificial snow. In this example, the very hair of the hare was the directly sought-after information source, but indirectly, the source was an element of the natural environment found outside of the research facility.

Another famous example is the case of Dr. Alexander Fleming, who had sprinkled a bacteria called staphylococcus on a petridish and left it there without sealing it by mistake. Then by chance, some green mould had fallen into the dish. Consequently, although it was completely unexpected, he ended up observing the staphylococcus melting away, and it is said that it was this very observation that had eventually led him to the discovery of penicillin.

A similar case can be seen in the case of Mr. Koichi Tanaka, who had won the Nobel Prize for Chemistry in 2002. Mr. Tanaka was absorbed in his work on the mass spectrometry of the protein. In this case, it was necessary to vaporize and ionize the protein, but while the protein is a substance that is difficult to vaporize on the one hand, to ionize it, a high level of energy is required. However, since applying a high level of energy fails to vaporize the protein and only leads to its decomposition, it had been extremely difficult to ionize something with a particularly high-molecular weight as protein.

He then accidentally went on to mix glycerol and cobalt by mistake and upon attempting to use the mixture as a thermal energy shock absorber, since he did not wish to see it go to waste, he unexpectedly became the first person in the world to completely succeed in such an attempt. This method was named the "soft laser ion method" and it went on to be awarded the Nobel Prize for Chemistry for its achievements.

The fourth important consideration is to clarify the largest obstacles standing in the way when attempting to efficiently obtain necessary information from required sources. According to the findings of the research carried out by Mr. Hiroaki Okamoto, the largest obstacle was the fact that "necessary articles were too dispersed in various kinds of magazines," which was followed by the fact that researchers "could not obtain translations of dissertations written in a language I cannot read," and "insufficient availability of abstract journals." In addition, while researchers of the Science and Technology Agency (the current Ministry of Education, Culture, Sports, Science and Technology) in particular point out that "the available amount of review magazines is insufficient," the top complaint raised by researchers of research institutes was that "there are too many index journals that are hard to use."

The fifth consideration is that a variety of information resources need to be prepared in such a way so as to be able to provide timely and top-quality information.

And finally the sixth consideration is that information sources need to be raised to a level where they can provide, along with first-hand information, estimations and conjectures as the occasion demands. And, they need to be complex enough to be able to avoid becoming defunct, even in the case of an emergency.

5.2 The Relevance between Information Sources and Basic Research

5.2.1 *The significance of the gene (technical features) map*

To link information sources to fundamental research if it is regarding, for example, materials and processing methods, it is extremely important to develop a gene map (a matrix) of the root effects, phenomena, and rules found among their functions.

This gene (technical function) map systematizes such factors as properties, phenomena, and detected rules that are found in each technology, and makes up for any missing data, while removing any duplicates, and indicates an easy study list of items that need to be created as rules and theories by clarifying the direction of the fundamental research (see Figures 5-1 and 5-2).

For example, in the case of Figure 5-1's materials-technology gene map, a matrix is expressed by listing metal materials, inorganic

Materials \ Functions	Thermal	Electric	Magnetic
Metallic materials	• Seebeck effect • Thomson effect • Pyroelectric effect • High melting • Thermal expansion • Thermoelectric effect • Melting point depression • High heat conductivity • Peltier effect • Shape memory effect • Invar effect	• Magnetocaloric effect • Surface effect • Meissner effect • Barkhausen effect • Ohm's law • Superconductivity • Free electron transfer • Electrode reaction • Metal absorption of hydrogen • Josephson effect	• Metal magnetization • Electromagnetic induction phenomenon • Back electromotive force phenomenon • Noncrystalline phenomenon • Tunnel effect • Pinning effect • Adhesion effect
Inorganic materials	• High melting • Low thermal conductivity • Low melting • Surface reinforcement	• Conductivity • Piezoelectric effect • Insulating properties • Semiconductor effect • Ferroelectricity • Pyroelectric effect • Ionic conductivity	• Strong magnetization • Hall effect
Organic materials (including living things)	• High melting point • Heat insulating effect	• Ohm's law • Semiconductor effect • Isolation effect • Pi-electron effect • Charge-transfer complex	• Magnetization phenomenon • Electron spin resonance
Composite materials	• Fiber reinforcement • High melting • Heat insulating effect	• Electric charge • Insulating properties	• Magnetization phenomenon

Figure 5-1: Materials Technology Gene Matrix

Source: Adapted from Eikichi Ueki's *Text on How to Collect Technical Information,* Keiei Kaihatsu Senta (Management Development Center), 1987.

Chemical	Biochemical	Mechanical	Optical	Radiation particle-like
• Law of the voltaic battery • Deionization phenomenon • Catalytic effect • Ionization tendency difference • Noncrystalline phenomenon • Electrochemical reaction • Ion nitriding • Kirkendall effect	• Low ionization • Organism stability	• Vibration absorption • Shape-memory superelasticity • Superplasticity phenomenon • Law of geostatics • Noncrystalline phenomenon	• Photovoltaic effect • Snell's law • Zeeman effect • Kerr effect • Cotton effect • Stark effect • Doppler effect	• Thermionic emission • Radiation ray absorption • Atomic collapse • Electrothermal radiation • Nuclear fission • Photoelectric effect • Diffraction phenomenon • Auger effect • Compton effect • Mössbauer effect
• Chemical reaction • Low dissolution charge • Low ionization • Semipermeability • Honda Fujishima effect • Ion diffusion • CVD • Cotton effect	• Artificial crystallization • Medical benefit effect • Poor solubility • Organism stability	• Machinability • Durable solidity • Antifriction • Self-lubricating	• Kerr effect • Photochromic phenomenon • Snell's law • Chemical reaction • Photovoltaic effect • Photoconductivity phenomenon • Spectral phenomenon, interference • Diffraction phenomenon • Electrochromic	• Radiation ray absorption • Radiation ray electromotive force • Flicker effect • Kramer effect • Schottky effect
• Chemical inertness • Chemical reaction • Absorption phenomenon • Surface activation • Surface tension • Semipermeability	• Hydrophilic property • Poor solubility • Enzyme • Medical benefit effect • Chemical reaction • Semipermeability	• Machinability • Fiber reinforcement • Molecular force binding • Movability • Vibration absorption • Surface reinforcement • Self-lubricating • Fault tolerance	• Translucency • Liquid crystal phenomenon • Photochemical reaction • Selective reaction • Snell's law • Spectral phenomenon • Diffraction phenomenon • Raman effect	• Photochemical reaction • Radiation ray electromotive force • Radiation absorption
• Chemical inertness • Surface tension	• Organism inertness	• Fiber reinforcement • High solidity • Composite reinforcement • Self-reproducibility	• Snell's law	• Radiation ray absorption

Figure 5-1: (*Continued*)

Processing method \ Function	Thermal energy type	Electromagnetic energy type
Cutting	• Plasma oscillation phenomenon • Arc discharge phenomenon • Combustion behavior • Joule effect • Explosion phenomenon • Fusion phenomenon • Hot shortness phenomenon • Nernst effect	• Discharge phenomenon • Electrolysis phenomenon • Charged particle beam Ion beam • Electrophoresis phenomenon • Attachment phenomenon
Change of shape/Fusion/Solidification response	• Thermoplasticity • Fusible alloy phenomenon • Combustion phenomenon • Explosion phenomenon • Heat transfer phenomenon • Thermosetting property • Solidification • Amorphization • Thermal stress phenomenon • Frictional heat generation • Thermal diffusion • Arc discharge phenomenon • Magnetocaloric effect	• Discharge phenomenon • Joule heating effect Superconductivity • High frequency guidance phenomenon • Plasma oscillation phenomenon • Electro-deposition phenomenon • Magnetothermal effect • Ettingshausen effect • Magnetocaloric effect • Meissner effect
Junction	• Positive adsorption phenomenon • Absorption phenomenon • Capillary phenomenon • Arc discharge phenomenon • Combustion fusion phenomenon • Plasma oscillation phenomenon • High temperature condensation effect • Vapor deposition phenomenon • Heat transfer phenomenon • Thermal diffusion phenomenon • Interface wetting phenomenon • Peltier effect	• Joule heating effect • High frequency induction heating effect • Discharge phenomenon • Electro-deposition phenomenon • Electric heating value effect • Righi-Leduc effect • Charged particle beam

Figure 5-2: Processing Technology Gene Matrix

Source: Adapted from the same source cited in Figure 5-1.

Light energy type	Chemical energy type	Mechanical energy type	Radiation energy type
• Stimulated emission phenomenon • Solid-state laser radiation phenomenon • CO2 laser radiation phenomenon • Liquid laser radiation phenomenon • Photoresist phenomenon • Photoetching phenomenon • Photoelectromagnetic effect • Photochemical reaction	• Combustion behavior • Solvent action • Chemical milling • Ion etching • Plasma etching • Spark etching • Maskant recycling • Absorption phenomenon	• Acoustic wave amplification phenomenon • Plasticity • Distortion hardenability • Internal friction phenomenon • Low-temperature brittleness phenomenon • Friction phenomenon • Diffusion phenomenon • Nitryl effect • Nitro roller dislocation • Notch effect	• Radiation phenomenon • Permeation action
• Stimulated emission phenomenon • Thermal radiation phenomenon	• Explosion phenomenon • Implosion phenomenon • Combustion behavior	• Superplasticity effect • Shape memory effect • Lubricating effect • Cooling effect • Bridgman effect • Distortion speed effect • Consistency effect • Creep phenomenon • Rolling friction • Age hardening • Elastic after-effect	• Hot electron effect • Kramer effect
• Laser stimulated emission phenomenon	• Diffusion phenomenon • Conjugated double bond • Substitution reaction • Condensation dispersion response • Aspell Kanner effect	• Internal friction phenomenon • Supersonic vibration phenomenon • Pressure adhesion effect • Age hardening • Shock wave phenomenon • Diffusion phenomenon	• Radiation polymerization reaction

Figure 5-2: (*Continued*)

materials, organic materials, and compound materials on the vertical axis and the many properties peculiar to them, such as namely thermal characteristics, electrical characteristics, chemical properties, mechanical characteristics, and photocharacterizations on the horizontal axis. In so doing, the matrix enumerates in each element the various effects, properties, detected representative rules and hypotheses that correspond to each material and individual characteristic. These can also be enumerated in chronological order or by the depth of relationships *vis-à-vis* the content of the research project. Therefore, these tables do not simply function as a set of keywords for the purpose of obtaining an output through their input, but in fact, function to filter every material through different perspectives, creating a highly valuable map that in effect becomes a wellspring of expected (and unexpected) outputs.

5.2.2 *Case examples*

In the gene map of Figure 5-1, electron tunneling is an effect that exists where metallic and magnetic properties intersect. The fact that this became the harbinger of the transistor age is an all too famous story. This phenomenon is the apparently improbable appearance of electrons on the base side of a compositional surface in a manner that suggests that they have passed through a tunnel. Dr. Reona Esaki had discovered the phenomenon and had announced it to the domestic Physical Society, but the reaction of the scientists was extremely indifferent, as it was seen to apparently violate the theories of classical physics at the time. However, it is known that the discovery began to attract attention once Dr. Esaki received acclaim from Dr. William Shockley, a pioneer in transistor research, after Dr. Esaki announced the discovery at an international convention in Brussels upon publishing an article on the discovery in an American journal in 1958.

In addition, while this is not indicated in the gene maps shown in Figures 5-1 and 5-2, I would like to show how such a map could point towards the development of such a drug as Aricept. Generically known as donepezil, Aricept is a drug developed for the treatment of Alzheimer's disease. It was developed by a technician at Eisai and had received a special commendation in the 1997 UK Prix Galien Awards (the Prix Galien is considered the equivalent of the Nobel Prize for medical research). In a materials-technology gene map, let us enter the category of neurotransmitter in the vertical axis and the category of enzyme properties in the horizontal axis. At the intersection of these two points, you should find the Choline hypothesis, an idea that was falling into obscurity at the time. Nevertheless, this hypothesis drew the attention of the Eisai technician and eventually paved the way towards its development into a drug whose sales went on to exceed 100 billion yen in Japan alone (as of 2002).

In this way, when linking information sources to fundamental researches, it can be understood that it is extremely important to first of all carry out an exhaustive investigation of rules, hypotheses, and effects that can offer the direction for the discovery and development of fundamental research themes, and secondly, to arrange and display the information sources that make such an investigation possible, and thirdly, to have a person fulfilling the role of an intermediary between these two sides.

5.3 Relevance between Sources of Information and Applied Research

When attempting to deepen the relevance between information sources and applied research in the context of the preceding paragraph, since the key to reinforcing relevance and realizing successful applied research, productization research, and commercialization research is believed to lie in a broad sense in investigating the matching or synchronization of seeds with needs, and in a narrower sense, in the thesaurization of keywords and in the carrying out of technical relation analysis, I would like to touch upon these topics.

5.3.1 *Matching needs with seeds (synchronization)*

When matching and synchronizing needs with seeds, you should begin by enumerating the keywords that correspond to market diversification and dramatic market changes, and then follow up by writing a brief on the changes in technological seeds and their multi-faceted circumstances. And then, as a third step, you should match them according to their relevance to ascertain themes and directions of new products and new businesses. In other words, this is an approach that attempts to figure out what is the best way to express relevancies between inputs and outputs, assuming that you consider an information source as a cause (input) and the result, new product, or new business derived from an applied research as an effect (output). In the end, this approach entails the creation of a checklist of needs and seeds (a matching table) (refer to Figures 5-3 and 5-4).

In addition to this approach, by coming up with the following functional and psychological expressions, it became possible to capture over 120 new product themes and actually create unique proprietary products: "add or subtract," "try to change the shape," "change the product (the material)," "think the opposite," "apply fundamental principles or phenomenon," "think again by returning to the starting point," "attempt unification," "consider instantization," "apply analogies," "use waste matter," "consider in terms of healing and nature," and "capture the changes in the minds of users."[5,7]

5.3.2 *Thesaurization of keywords*

The thesaurization of keywords refers to the adoption of a tool that helps to control terms when converting keywords used by people searching indexes from their vernacular form into more specialized system terms or documentation terms or information terms. As

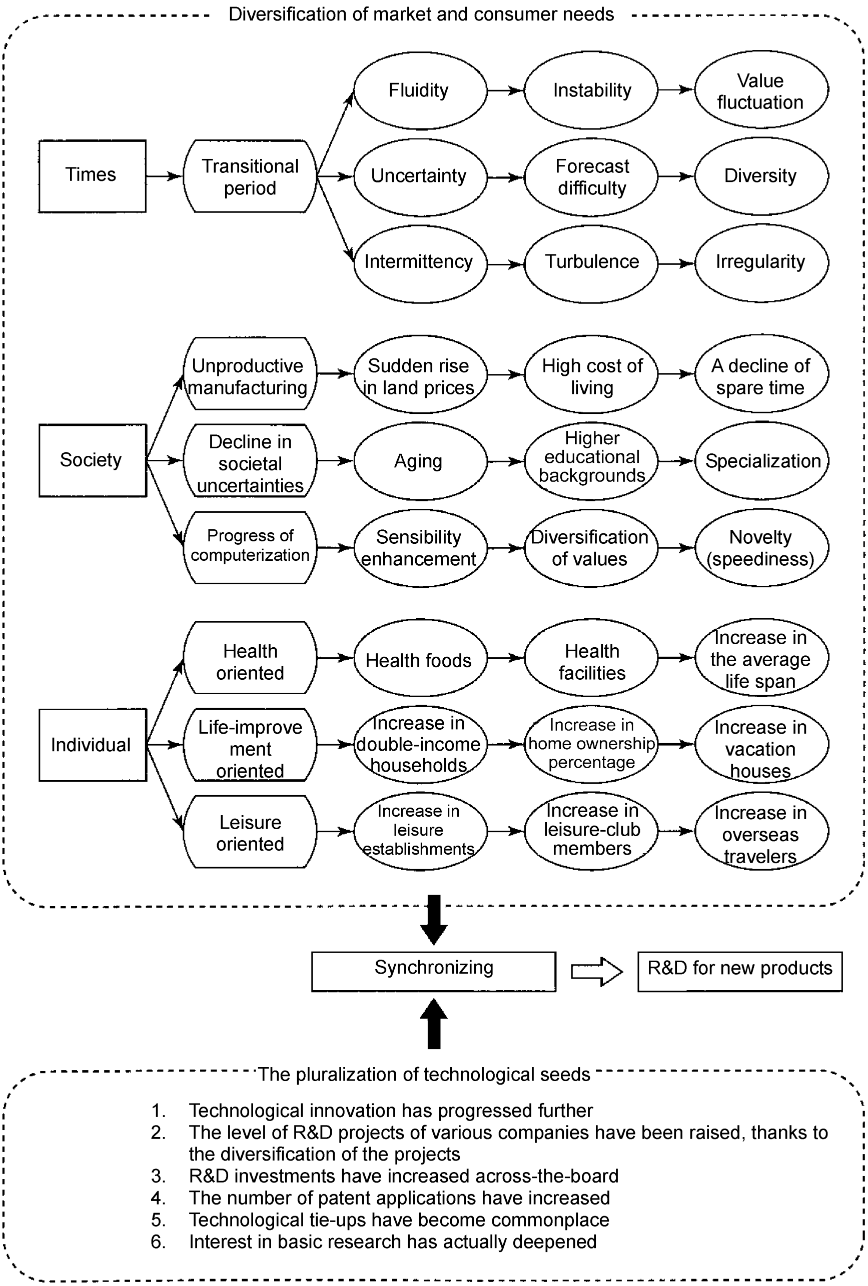

Figure 5-3: Synchronizing Needs with Seeds[1]

Brand	Funding ability	Marketing channel	Mechatronics	Materials technology	Production technology	Product technology	Seeds/Needs
	Complete solar system					An air conditioner for changing moods	**Energy**
			Cultural-exchange conferences using multimedia				**Culture**
		Home delivery information service	PDS for moving				**Information**
Online travel service	Luxury liner cruise		Disposable camera		Multi-variety gigantic labyrinth manufacturin g system		**Leisure**
				Artificial foods			**Food**
	City map using multi-dimensi onal spaces			Inter-city air transport			**Urbanization**
		Courier service for delivering hope			Multi-directional, three-dimensi onal road map		**Traffic**
			Automatic collision avoidance system	Super thermal insulator			**Security**
	A fulfilling home for the elderly					Artificial skin, artificial organ	**Medical care**
		Package-deli very service for health-food products		Pillows for deep sleep			**Health**
							Education

Figure 5-4: A Checklist of Needs and Seeds[1]

a result, it becomes possible to prepare a lexicon that limits keywords, and arranges and regulates synonyms, subsumptions, and related terms when attempting to search specific terms in information sources.

The history of the thesaurus began when Dupont introduced one in the 1950s. Since then, a large number of them have been created to respond to various needs of organizations, such as governmental institutions, various academic societies, the International Organization for Standardization, United Nations Educational, Scientific and Cultural Organization (UNESCO), and newspapers. The thesauri created in Japanese include the "JICST Thesaurus" for use in exploring science and technology in general, and the specialized "News Thesaurus" (Chunichi Shinbunsha) and the "Textile Thesaurus" (Textile Machinery Society of Japan) for use in exploring specific fields.

To create a thesaurus, you need to follow the following steps:

1) Confirm whether it is possible to use other thesauri covering specific areas and adjacent areas related to information sources.
2) Determine the selection of descriptors (as terms or symbols that have been officially approved and formulated throughout the thesaurus) in accordance with the thesaurus' structure, usage objectives (whether the thesaurus is designed for manual use or mechanical retrieval), and planned scope.
3) Evaluate the effectiveness of descriptor candidates with the following key considerations:
    - (Expected) frequency of appearing in documents
    - The high probability that the candidate will be posed as a question during search
    - Relevance with descriptors that have already been approved
    - Validity as a term that can be used generally
    - Degree of usability and comprehension when alluding to or clarifying specific ideas.

5.3.3 *Technical relation analysis*

Thirdly, I will explain technical relation analysis. One aim of this type of analysis is to attempt the linking of information sources with appropriate themes and keywords of applied researches by incorporating tabulation and patternization into the systematization of keywords mentioned above.

It is possible to depict charts and patterns through various structures and processes such as tree structures, network structures, and their hybrid structures, and technical relation analysis is also a method that applies these structures.

In technical relation analysis charts, it is common to show various cutting-edge innovatory technology fields on the left-hand side, and to show the results of mixing different technologies on the right-hand side.

For example, when citing the fields of fine chemicals and specialty chemicals as cutting-edge innovatory fields in the area of chemistry and combining them with the field of new materials, you get the hybrid technology of engineering plastics; when linking natural resources to energy, you get the development of the fuel cell; and when you link life science to biotechnology, you give rise to the possibility of fields such as artificial organs, artificial skins, and artificial blood.

These combinations of different technologies can be completed with just two types in the simplest cases, but in most cases, such as in the case of artificial organs, the combination is the result of various attributes, including at least mechanical, material, bioengineering, and medical. Additionally, if you attempt to express their relational analysis little more closely, it will become necessary to portray their interrelationships through multidimensional charts and diagrams.

Furthermore, if you aim to successfully realize the development of a certain undeveloped or insufficiently developed artificial organ, a new product development management map that includes elements such as the management strategy, product strategy, product development, and experimental design will become essential, and without the cooperation of an entire organization that strongly shares values in common with you, you will not be able to realize anything successfully.

Regarding this point, I would like to touch upon several topics, including market analysis, R&D budgetary control and human resources development/management. It is often the case that the research environment and the personal-property motivation of researchers exert a definitive influence over the development and realization of new products and new businesses. I will elaborate with concrete examples.

5.4 Effective R&D and Personnel Training Management

5.4.1 *Effective criteria for evaluating R&D projects*

As a means to lead R&D management to success, effective criteria for evaluating an R&D project and the timeliness of its evaluation are indispensable. Thus, I present to you the following points adapted from a research study carried out by the Massachusetts Institute of Technology (MIT):

1) *Sales figure or sales revenue*

Increase in transactions, additional amount of production that does not accompany additional investment, market share, percentage of R&D products, ratio of new product sales to old product sales, growth rate of new customers, etc.

2) *Costs for materials, personnel expenses, and overhead costs*

Amount saved in patent fee payments, amount saved in costs for materials, reduction in personnel expenses, improvement in the utilization of surplus equipment, decline in indirect costs, increase in the productivity of unit processes, etc.

3) *Profit*

Differences in the profits of new and old R&D products, R&D expenses per profit unit, changes in the rate of return, etc.

4) *R&D stage of completion*

Differences in the completion stages of new and old R&D projects, differences between actual completion stages and forecasted completion stages, differences in per-unit cost completion stages, relationships between completion stages and anticipated results, etc.

5) *Customer satisfaction and receptivity*

Growth rate of sales volume, types and amounts of returned products, rate of defective products, number of customer complaints and their seriousness, etc.

6) *Level of contribution toward technological development*

Number of new ideas, advanced materials, extent of introducing new processes, level of preparation and development of the specification sheet, extent of technology mix and collaboration, responsiveness to technical requirements, etc.

7) *Level of success of technological solutions*

Success rate of R&D issues, application patents, number of new industrial designs, details of unresolved technologies and the impact they have on failures.

8) *Cost/effect (effectiveness)*

Profit per unit cost, effectiveness of up-to-date information, difference in the cost-benefit ratios of new and old projects, and the variance in the differences.

9) *Environmental management and CSR*

Recycling rate, environmental sustainability, level of societal contribution on a cost per unit basis, risk aversion ratio, etc.

According to a survey conducted by A.H. Rubenstein,[1] the top five evaluation criteria used by 37 US research institutes are as follows:

- Time and cost required in technology solutions
- Sales figure or sales revenue
- Amount saved in materials costs, personnel expenses, or overhead costs
- Output of R&D information
- The level of success of a technology solution.

5.4.2 *Effective evaluation organizations for projects*

Next, ideally, the formation of the following five organizations or organizations with the following five functions are considered to be necessary for evaluating projects:

- Organizations that inquire closely into the very details of an R&D project and evaluate whether such details are truly in alignment with the aims of medium to long-term management plans, strategic plans, and R&D plans.
- An organization that considers the operations management method for R&D projects and evaluates whether human, material, and information resources are being fully utilized.[4]
- An organization that carries out cost-utility analysis for R&D projects and evaluates whether sufficient benefits are being obtained or whether sufficient effectiveness is being achieved or is in the process of being achieved *vis-à-vis* investment efforts (including cost-effectiveness analysis of project risks).
- An organization that evaluates the extent of an R&D project's contribution toward environmental protection.

- An organization that evaluates the extent of an R&D project's contribution toward achieving a company's Corporate Social Responsibility (CSR) targets.

For example, the central laboratory of company T is made up of a special mobile unit, which is set up as a temporary organization to deal with new projects, and mobile room units to which general researchers belong. The laboratory does not have permanent setups and general researchers formed into A, B, C groups in accordance with themes, but instead it acts as a permanent organization that forms future kernels in accordance with research studies of long-term projects and themes, while also performing activities as a special mobile organization in some cases. In effect, the laboratory is a complex organization prepared to assume contingent roles.[1]

In this way, the company is believed to be increasing its chances of being able to deal with unexpected situations (such as new discoveries, acts of God, and man-made calamities) in an agile manner.

Next, I would like to point out that the relation between new product development and marketing research is particularly indispensable during the planning and trial manufacturing stages. Figure 5-5 shows what types of product concepts are appropriate for elucidating the demand structure of labor-economizing equipment, and what types of marketing research need to be carried out for planning new product development strategies.

5.4.3 *Personnel training management*

Lastly, I would like to touch on the matter of developing and training human resources.

Mr. Masamichi Ishii, in his book *The Conditions of Originality* (NTT Publishing, 2005),[2] analyzes successful cases of original product development such as the lens-equipped film "Utsurndesu," the entertainment robot "AIBO," and Quartz wristwatches, and states that the four abilities the developers of these products shared in

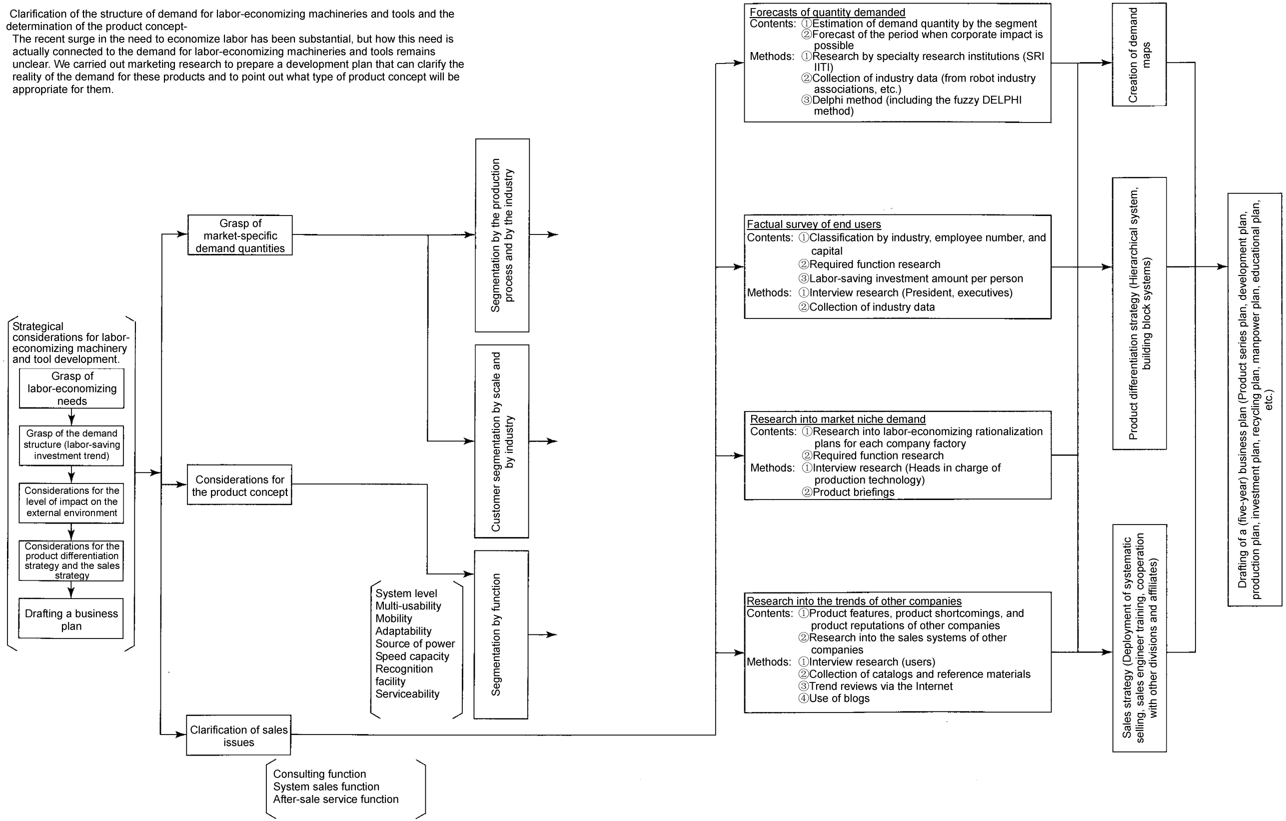

Figure 5-5: For Drafting a New Product Development Strategy[3]

Source: Adapted from R&D Guidebook Editorial Committee's *R&D Guidebook (Seventh Impression)*, Union of Japanese Scientists and Engineers, 1984, p. 298.

common were the ability to perform specialized tasks, the ability to motivate themselves, the ability to engage in creative thinking,[6] and the ability to engage in strategic thinking.

The ability to engage in creative thinking in particular is a new approach and it comprises the following five attributes, which advocate the importance of motivation:

1) Ability to collect research data such as theses, academic society information, and university/laboratory research information;
2) Ability to bring your own specialized knowledge and experience into new fields;
3) Ability to introduce new specialties into existing research fields;
4) Ability to conceive ideas from the perspectives of different industries and viewpoints;
5) Ability to draw out new knowledge and new discoveries from unexpected experimental results (serendipity).

Where motivational human resources training is concerned, it is being asserted that it is indispensable to carry out such training under free circumstances in an independent and active manner, and that serious consideration should be made in determining how to go about cultivating motivated individuals from the time they undergo compulsory education. Additionally, it is necessary to have proposals and research studies that can contribute toward enhancing "national creativity," such as the country's systems and structures that help to boost creativity.

From the viewpoint of the structure and environment of the organization, when taking the analysis of the same work into consideration, the following points can be raised as requirements for effectively cultivating talent:

1) Allow the maximum degree of freedom in the selection of themes and issues to be dealt with.

2) This should be allowed even when continual support from the top or your superiors proves difficult.
3) Provide as many measures as possible that will promote separation and independence from day-to-day business affairs and from the supervision of headquarters.
4) For the purposes of carrying out research, give the opportunity to freely participate at domestic or overseas universities, laboratories, and academic societies as occasion demands.

I would like to end, however, by emphasizing that the foundation of successful R&D projects, new product developments and new business developments goes beyond the scope of individual capability. The foundation, in fact, lies in the securing and sustainment of boundless passion and motivation and in the environment and structure of an organization that makes maintaining and increasing such zeal possible.[8,9,10]

Akira Ishikawa

References

1. Akira Ishikawa, *The Q&A Primer to Information Searching for Developing New Products and New Businesses,* Dobunkan, 1988, pp. 54–55, 66–67, 82–83, 85–87, 106–109.
2. Masamichi Ishii, *The Conditions of Originality — How Epoch-Making Products were Born,* NTT Publishing, 2005, pp. 142, 150–151.
3. R&D Guidebook Editorial Committee, *R&D Guidebook*, Union of Japanese Scientists and Engineers, 1984, p. 298.
4. Masatsugu Kawai, *The Manual for Developing Hit Products with CD-ROM Attached*, ASUKA Publishing, 2001.
5. Nikkei Business Daily, *Ultra-Tech — Japan's Underlying Strength*, Nihon Keizai Shimbun, 2003.
6. Takahiro Kawashima, *How to Create a Genius*, Kodansha International, 2004.
7. Makoto Takahashi (editor), *Encyclopedia of Creativity*, Mode Gakuen Publishing Bureau (Incorporated Educational Institution), 1993.
8. Akira Ishikawa, *Theory of Strategic Budgetary Control*, Dobunkan, 1993, pp. 333–376.
9. Akira Ishikawa, Makiko Okuyama, Toshitaka Kobayashi (editors), *The Cybernetic Renaissance,* Kogyo Chosakai Publishing, 1999.
10. Akira Ishikawa (editor), *Global Information Network*, The Nikkon Kogyo Shimbun, 1992.