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SCIENCE BULLETIN

National Science Council
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Position Paper on the Status of the Natural Sciences and Mathematics

I. Background

During 1985 and 1986, the Division of Natural Sciences and Mathematics of the National Science Council (NSC) carefully drew up plans for major target areas requiring development within the fields of mathematics, physics, chemistry, meteorology, geology, and ocean science. In general, all these major research efforts have since been carried out.

However, feasible suitable administrative strategies have, unfortunately, not yet been formulated to attack certain restrictions presented by the research environment. One of these problems is the lack of monies allocated for research in the science thus driving researchers to lean heavily towards independent projects and shy away from larger, integrated programs. Another problem is the difficulty keeping pace with the rapid development of science and technology worldwide. As a result, although academic organizations and the NSC have been striving hard together towards these developmental targets, desired results have yet to be attained.

In November of 1992, the Division of Natural Sciences and Mathematics expanded its responsibilities and began officially actively promoting the program to increase the proportion of planning and resources allocated to these fields.

On February 10, 1993, representatives from all relevant academic scieties, program evaluators, and other scholars familiar with project planning were assembled to perform general principle planning with respect to the natural sciences. Decisions arrived at during this conference included the three main points:

1. The Division of Natural Sciences and Mathematics would take charge and be assisted by all relevant academic societies and organizations.

2. The period to be covered by current planning measures was set to extend for the coming ten years, with five-year periods designated as mid-term stages.

3. Essentials of planning measures should cover:

a. Detailed descriptions of all major research fields within each individual discipline

b. Designated focus or developmental direction for the future for each field

c. Strategy proposals for the promotion of each of the primary areas of interest

Through careful deliberations, eight directors were chosen to head seven specific academic fields:

– Mathematics: Hwai-chiuan Wang, Professor of Mathematics at the National Tsing Hwa University.

– Statistics: Pe-cheng Wang, Professor of Statistics at the National Central University.

– Physics: Shang-fang Tsai, Professor of Physics at the National Taiwan University.

– Chemistry: King-chuen Lin, Professor of Chemistry at the National Taiwan University, and Biing-jiun Uang, Professor of Chemistry at the National Tsing Hwa University.

– Meteorology: Wen-shung Kau, Professor of Meteorology at the National Taiwan University.

– Earth Science: Yeong-tein Yeh, Professor of Earth Science at the Academia Sinica.

– Oceanography: Wen-ssn Chuang, Professor of Oceanography at the National Taiwan University.

Guiding principles to be used throughout planning have been laid out.

1. The Division of Natural Sciences and Mathematics will assemble a planning task force composed of the Director of the Division and the eight members listed above. This task force will be responsible for deciding the overall content and direction of planning, regulating progress, and interdisciplinary exchanges and for maintaining consistency among different disciplines. Each member of this task force will assemble support groups as needed within his own discipline. (**Figure 1**)

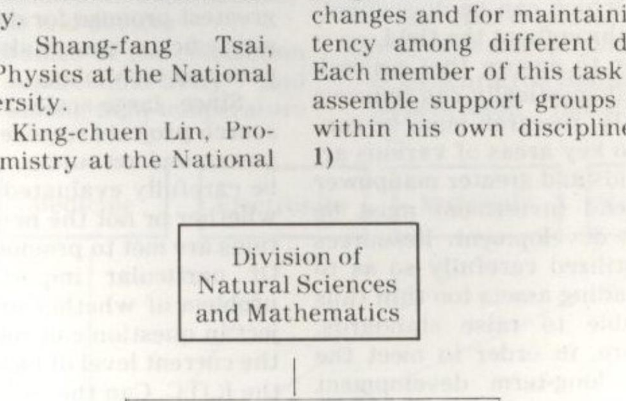

Figure 1: Administrative Structure for Planning in the Natural Sciences and Mathematics

2. Meetings of various types and scales will be held to conduct academic planning and promotional strategy for the next five years based on all relevant available information, survey questionnaires, and designated sci-tech focus and indicators.

II. Determine indicators relevant to planning emphasis and declare the plan spirit

A. Indicators to be used as reference

The most basic matter in planning an academic discipline is in selecting the major focus and priorities and in designating relevant indicators by which to measure performance in these areas. Given the differences between various academic disciplines, indicators must be adjusted appropriately. However, each discipline must develop guidelines for each of the following areas.

1. Research within the discipline,
2. Personnel training and utilization,
3. Integration of existing resources and facilities,
4. Special characteristics of the discipline and the effects on future development, and
5. Possibilities for integration.

These five areas of guidelines will be discussed in greater detail here below:

1. Research to be given priority includes pure or applied research which is basic to the specific discipline or research which has broad implications for the future and the results of which can be disseminated widely throughout the field.

In order to ensure that sci-tech standards domestically can improve significantly, research must be conducted into key areas of various academic fields and greater manpower and financial investment must be devoted to development. Resources must be utilized carefully so as to avoid spreading assets too thin thus being unable to raise standards. Furthermore, in order to meet the needs for long-term development and to keep pace with international development trends, emphasis must be placed on selecting research which will have great significance in the future.

2. Sufficient quality research leaders and professional personnel must be trained in order to meet R&D needs in every sci-tech discipline.

Research personnel can be cultivated through actual research projects; however, the extent of exposure any given individual receives through a specific project is limited. Therefore, this cannot be relied on as the sole method of cultivating necessary research manpower. In addition, individual research projects, generally run on a smaller scale and having a less well developed structural organization, are not well suited to effectively training the sci-tech research leaders needed domestically. These deficiencies can be alleviated through careful planning of research projects to integrate larger groups of sci-tech personnel.

3. More competitive research teams must be organized which will integrate a wider range of equipment and a greater diversity of researchers who can work together, complementing each other working towards modern goals.

The limited manpower, facilities, and financial resources available in the R.O.C. must be planned carefully to establish independent national sci-tech research capabilities which can keep pace with those in advanced nations. All resources must be united in order to set up larger research teams which, in turn, will be able to achieve faster and greater research results raising the research standards. This will lead to greater competitive ability and a stronger nation.

4. Domestic research must be evaluated and basic research must be focused in the areas which show greatest promise for development of strategic or essential areas of science and technology.

Since large-scale integrated research projects require greater manpower and resources, projects must be carefully evaluated to determine whether or not the necessary conditions are met to promote the project. Of particular importance is the problem of whether or not the project in question can coordinate with the current level of basic research in the R.O.C. Can the existing research resources be reasonably used in support without seriously adversely affecting other ongoing research projects?

Strategic areas of research in the R.O.C. must be well planned and utilized to integrate significant personnel, equipment, and financial resources to help improve research ability and standards in these areas. Certain fields requiring research in the R.O.C. often lack resources and research foundation. Careful consideration should be given to including these fields in the sphere of a broader academic discipline and carrying out necessary planning and conducting appropriate research projects in this manner so that a proper research base can be built as soon as possible.

5. Researchers in the natural sciences and mathematics should participate frequently and willingly.

In order to effectively promote research that has been so painstakingly planned, all research personnel must actively participate; otherwise, without the necessary manpower, desired results cannot be attained and the entire intention of the overall plan has been lost.

B. The plan spirit

1. Understand the conditions both at home and abroad.
2. Choose objectives which are suited to long-term domestic development. Support the establishment of individual character within each academic discipline.
3. Balance strategic research projects and individual research projects to a pre-determined ratio. Encourage the integration of research topics and projects and the establishment of research teams.
4. Cultivate research leaders. Promote mid- and large-scale research projects.
5. Promote sci-tech development in all areas throughout the nation. Plan the careful utilization of national resources.

III. Strategic direction for research and development

Although the natural sciences are all similar in that they investigate problems using theoretical exploratory methods, they are not otherwise closely linked. In fact, however, they do affect each other; individual disciplines cannot deny their own academic reliance on other disciplines. If the natural sciences were to be separated from each other, we would be like the blind men describing the elephant from their own particular vantage point. Basic science research does not have a character all its own and cannot be separated from the sciences in general.

This type of planning must be adhered to simply because of these influences among disciplines. Great care was exercised during the planning procedures. Major areas of emphasis for each discipline are outlined below. The seven fields have been divided into a total of 29 strategic directions of focus.

A. Mathematics

There are five major directions for the future:

1. Research on Algebraic Tools Related to Number Theory:

The theory of algebra, number theory, and arithmetic geometry and their applications and computation; theories related to algebra and number theory

2. Research on Algebraic Geometry and Differential Geometry

3. Theory and Applications of Linear and Nonlinear Analysis:

Research on analysis, geometry, differential equations, and numerical computation

4. Research on Discrete and Computational Methods:

Computational theory and applications using the tools of discrete mathematics and numerical computation

5. Stochastics Methods and Applications:

Research on stochastic analysis and statistics with emphasis on statistical computation

B. Statistics

There are two major courses for the future:

1. Theoretical Statistics

a. Mathematical statistics

Decision theory (including Bays and empirical Bays theory), nonparametric methods and semiparametric modelling, regression and generalized linear modelling

b. Probability

Stochastic process and influence

2. Applied Statistics

a. Industrial statistics

Research on reliability analysis, experimental design, and other statistical methods in industrial applications

b. Biostatistics

Research on survival analysis, sequential analysis and other biometric methods

c. Other applied statistics

Time series and spatial statistics, multivariate analysis and discrete data analysis, environmental and ecological statistics, and statistical computing

C. Physics

There are six major areas of focus:

1. Particles and Field Theory and Experimentation

2. Surface Physics

a. Electrons and electron structures on the surface and at interfaces

b. Dynamic behavior of atoms and dynamics on the surface

c. Manufacture of new materials and research on their properties

d. Improvement of surface analysis techniques

e. Establishment of a national surface preparation laboratory

3. Superconductivity and Magnetism and Magnetic Materials

a. Superconductivity

a1. Studies of superconductors under extreme conditions

a2. Studies of the vortex dynamics of superconductors

a3. Studies of superconducting thin films and devices

a4. Studies of the connection between superconductivity and magnetism among high-temperature superconducting oxides

a5. Studies of anomalous state propertise of high-temperature superconducting oxides

b. Magnetism and magnetic materials

b1. Thin film, multilayers, and superlattices

b2. Granular particles / film and mesoscopic / ultra-fine particles

4. Physics of Optoelectronic Materials

a. Semiconductor physics

a1. II-VI semiconductor compounds

a2. III-V semiconductor compounds

a3. Establishment of a crystal-growth center open for public use

b. Quantum optics

b1. Applications of fast lasers and studies of frequency and time-resolved high-resolution spectrometry

b2. Quantum behavior and studies on electron-optical mechanisms of semi-conductor lasers

b3. Electro-optical studies of quantum wells, dots, wires, and clusters

b4. Nonlinear optical properties; research on and applications of frontier materials

b5. Generation and applications of optical sources in quantum states

5. Astrophysics

a. Recruiting and topical training

b. Establishment of major observational facilities and technical capabilities

c. Development of other branches of astrophysics

6. Synchrotron Radiation

Synchrotron radiation demon-

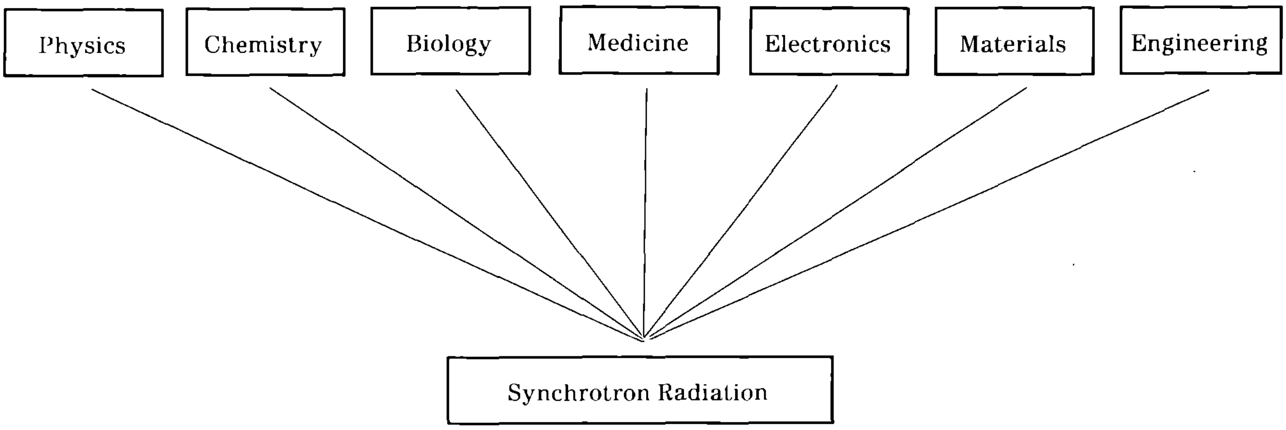

Figure 2: Interdisciplinary Integration

strates continuous spectra, linear polarizability, extreme beam-parallelism, and pulsed time-structure. As such, it is most suited for probing the structure of matter, which is a topic of common interest in many areas of research, such as physics, chemistry, biology, material science. This unique characteristic not only bridges interdisciplinary research fields but provides, in turn, a means of consolidating research manpower and experimental facilities in the related sciences. (**Figure 2**)

Some of the major areas of research in the field of physics, for example, which use synchrotron radiation include the following:

a. Related condensed matter surface, interface, and atomic and molecular spectroscopy

b. Related condensed matter surface, interface, and atomic and molecular spectroscopy

c. Related optics and imaging

d. Related machine physics instrumentation, and development of other electromagnetic sources

D. Chemistry

There are six major areas for concentration:

1. Molecular Simulation and Computational Chemistry
2. Methodology Development of Ultratrace Analysis
3. Synthesis and Characterization of New Materials
4. Biomedicinal Chemistry
5. Synthetic Chemistry
6. Laser Chemistry and Applications of Synchrotron Radiation

E. Earth Science

There are four major directions for the future:

1. Subduction and Collision near Taiwan
   a. Geological evolution of the Ryukyu arc / coastal range / Luzon arc
      a1. Paleogeographic reconstruction and basin analysis of the coastal range
      a2. Time-spatial characters of andesite geochemistry
      a3. Paleomagnetic study of the Luzon Island
   b. Deformation mechanism of mountain belts
   c. Stress analysis in seismogenic zones and simulation and inversion of source processes
2. Environmental change in the Coastal Area around Taiwan
   a. Sedimentation and stratigraphy
   b. Geomorphology
   c. Ground water and pollution
   d. Human activity and archaeology
3. 3-D Crustal Structure in Taiwan and Surrounding Regions
   a. Velocity structure
   b. Q structure
   c. Density, magnetic, and electric structures
4. Evaluation of the Lithosphere of Southeastern China
   a. Tectonics and basin evolution
   b. Magmatism
   c. Metamorphism and deformation

F. Meteorology

There are two major focuses:

1. Climatic Change
   a. East Asian short-term climatic change
   b. Atmospheric chemistry and radiation
2. Meso-scale meteorology
   a. Studies of heavy rainfall over the Taiwan area
   b. Local circulations around the Taiwan area
   c. Typhoon studies
   d. Observation and numerical simulation of severe weather over the Taiwan area
   e. Coupling studies of the mesosphere and ionosphere

G. Oceanography

There are four major areas:

1. East China Sea Study: KEEP II (Kuroshio and East China Sea Shelf Exchange Processes)
   a. Circulation and hydrology
   b. Chemical fluxes
   c. Sedimentation processes
   d. Biology and trophic dynamics
   e. Other related studies
2. South China Sea Study
   a. Establish a data bank on the South China Sea
   b. Establish an exchange model of the South China Sea and the western Pacific Ocean.
   c. Compile marine charts
3. Plate Tectonics and Geodynamic Study East of Taiwan
4. Other Research
   a. WOCE (World Ocean Circulation Experiment) and TOGA (Tropical Ocean and Global Atmosphere Studies)
   b. Land-ocean interaction study in the coastal zone