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What is the task of the Philippine scientist in the light of the sad state of science and technology (henceforth S & T) in the Philippines and in view of the Philippine context of massive poverty and structural injustice as well as the real needs of the Filipino people and nation?

SCIENCE AND TECHNOLOGY IN THE PHILIPPINES

The present economic and political crisis in the Philippines has overshadowed the serious scientific and technological problems that have been sadly neglected in the last three decades. In January of 1981, fifty-four of the foremost Philippine scientists wrote a petition to President Marcos to express in their own strong words:

> Our grave concern over the backwardness and stagnation of science and technology in our country relative to those in other ASEAN and East Asian countries, our demoralization at the continuing adverse conditions in which we have to do scientific work, and our dissatisfaction with the policies, priorities, and programs of the present NSDB administration.[1]

This sad state of affairs prompted the immediate reorganization of the government's S & T agency, the National Science Development Board (NSDB), into the National Science Technology

1. *Towards the Development of the Natural and Mathematical Sciences in the Philippines.* A Science Policy Study (henceforth, *SPS*) undertaken by the *Kilusan ng mga Siyentipikong Pilipino* under the sponsorship of the President's Center for Special Studies (March 1982). Annex A, pp. 1-7 contains the entire text of the petition and the names of the 54 signatories.

Authority (NSTA). In May 1981 the scientist-petitioners organized themselves into the *Kilusan ng mga Siyentipikong Pilipino* (KSP) (Federation of Filipino Scientists) and, after seven months work, published in March 1982 a Science Policy Study.[2] Hopefully, this in-depth study of science policy by the country's foremost scientists will be taken seriously by the new administration of the NSTA.

Despite these dramatic changes on the S & T scene, S & T remains one of the lowest government priorities not only as far as the national budget is concerned, but also in the kind of scientific research being done in S & T affiliated government institutes and agencies. The 1983 national defense budget (₱8.8 billion) is more than the combined budget allocated to education and health (₱8 billion). The NSTA admits that:

> The task for Philippine science and technology seems enormous in view of the constraints, both financial and institutional, that have plagued its development, forcing the country to lag behind other developing nations. For one thing, Research and Development (R & D) (gets) only about less than 1/2 percent of the total budget, although UNESCO recommends 1 percent as fair investment into R & D.[3]

The 1984 appropriation for the NSTA is ₱303,223 million (current operation expenditures) plus ₱290,714 million (capital outlays), but this amount, a mere 0.6% of the national budget, is relatively a drop in the bucket since S & T and R & D have received no increased financial aid since 1969. The plight of S & T is the result of policies enacted ten to fifteen years ago.

Despite financial constraints, both the NSTA-affiliated National Research Council of the Philippines (NRCP) which was founded in 1933 and the recently established Science and Technology Resource Center (STRC) which is privately funded by the Filipinas Foundation Inc. have on a modest scale provided some institutional support by way of grants-in-aid, funding of seminars and

2. *SPS* is a 93-page study divided into two main parts: Part I: Framework for Policy-Making in Science and Technology; Part II: Recommendations for the Development of the Natural Sciences in the Philippines. Annex A: The 1981 petition of Filipino Research Scientists to President Marcos; Annex B: Draft Parliamentary Bill for the Establishment of Research Chairs in the Basic Natural and Mathematical Sciences; Annex C: The U.P. Natural Science Research Center as an NSDB-Assisted National Research Center for Natural Sciences and Mathematics.

3. *Science and Technology in the Service of the Filipino* (Rizal: National Science and Technology Authority, 1982), p. 50.

symposia and publications.[4] However, there has been no really significant advance by international standards in government-funded S &T R & D that we can be proud of. The International Rice Research Institute (IRRI) is the cooperative venture of many nations which just happens to be located in the Philippines. The Technology Research Center (TRC) seems to be more concerned with impact projects and serves more as the propaganda arm of the Ministry of Human Settlements and the University of Life.

What the Philippines needs, according to the recommendation of the Science Policy Study, is a Philippine research council with a R & D budget of not less than 10 percent of the total R & D budget of NSTA. In 1983, the NSTA aimed to "stimulate productivity" in S & T research by organizing the National Research System (NRS), the Philippine Council for Health Research and Development (PCHRD), and the Philippine Council for Industry and Energy Research and Development (PCIERD) and accredited eight non-NSTA agencies to become part of the NSTA system. Whether quantitative and qualitative R & D will be the real outcome still remains to be seen.

The private industrial sector does not provide a brighter picture of S & T in the Philippines. The general deficiencies of S & T development in underdeveloped countries of the Third World are even more pronounced when applied to the Philippines. There is no incentive to create or develop indigenous appropriate technology or even the capacity to choose wisely which foreign technology to absorb. Indigenous technologies are set aside in favor of foreign technology that only enriches the foreign country. A case in point is the coconut monopoly which, instead of adopting indigenous coconut technologies developed by Filipinos and tested, proven and recommended by the NSTA, opted for hiring an American researcher, and a French consultant and adopted German technology with a total investment of ₱1.1 billion for a plant employing not more than 200 workers and producing acids and detergents for other industries. If this huge amount had been invested in indigenous technology, it would have provided jobs for 10,000 Filipinos and would have brought a gross national

4. The NRCP celebrated its fiftieth anniversary last year (1983). For valuable information on past and on-going grant-in-aid basic research, scientific projects and activities, the NRCP publishes bulletins, newsletters, proceedings and symposia, and, of course, its annual report. The STRC also has similar but fewer publications.

income of not less than ₱2.5 billion and a dollar revenue of not less than $100 million yearly.[5]

There is no link between science development in the Philippines and the kind of technology being imported. Because imported technology is easily accessible, little pressure is exercised on the local community of scientists and technologists to provide technological alternatives, especially in the manufacturing industries. These industries engage in market-type research and can boast of no real R & D. They are heavily dependent on costly and restricted foreign technology which does not fit the technological needs of the country.[6] The twenty-five largest S & T-related corporations in the Philippines depend on foreign technology in the form of imported equipment and supplies, foreign patent licenses, and multinational corporations (MNC) which own or control their subsidiaries here.

Much had been written about the disastrous effects of MNCs from highly developed countries (HDC) on the economies of less developed countries (LDC) and in particular on the Philippine economy.[7] The technology transferred is more suited to the needs of the MNCs than to the needs of the LDCs. Furthermore these capital-intensive technologies which employ cheap labor are not only eliminating more jobs than they are creating, thus aggravating the unemployment problem in LDCs, but also intensifying the class division and disparity of income between the few rich and the majority who are poor.[8]

A few concrete examples of MNCs in the Philippines will suffice

5. Vicente D. Gabriel, Sr., "Coconut Monopoly Exists," *Business Day*, 2 July 1984, p. 5.

6. In 1982 Dr. Emil Q. Javier, director-general of NSTA, lamented the fact that in all the technological changes due to imported foreign technology, neither the local S & T system nor the science community had any input. The new task of NSTA is to "internalize" technological changes by emphasizing R & D work on technologies that meet the identified needs of Philippine society. According to Filipino physicist, Dr. Roger Posadas, the government's over-all economic policy that is dependent on foreign technology has resulted in no effective demand for local S & T *Business Day*, 2 July 1984, pp. 5, 8.

7. The classic study on MNCs is Ronald Muller and Richard Barnet, *Global Reach: Power of the Multinational Corporations* (New York: Simon & Schuster, 1975). See also, Jovito R. Salonga, "Multinational Corporations and their Participation in Philippine Development," *Unitas* 48 (June 1975): 267-89. *Ibon Facts & Figures*, No. 139, 15 May 1984, provides data on transnational corporations in the Philippines.

8. Suzanne C. Toton, *World Hunger.* The Responsibility of Christian Education. (New York: Orbis Books, 1982), has a chapter which is a good primer on MNCs.

to show the dangers and pitfalls of technological dependence on foreign interests. "Technology transfer" which should benefit Filipinos is usually effected thorugh MNCs which are reluctant to share their technological secrets, e.g. "hardware" and/or "software," unless it brings them profits. In 1981 U.S. MNCs in the Philippines made $45 million on fees and royalties alone. In 1983, 164 MNCs accounted for 79 percent of the total net income of the top 1000 corporations. A question that is unasked and therefore unanswered is: How much local income (wages, etc.) did MNCs generate? We have no reliable data but local income generated is most likely very little. From 1961 to 1980 for every $1 invested (84 percent of MNCs' capital was from local sources) $2.87 was remitted abroad. By means of Presidential Decree 1892, MNCs control wide tracts of land in Mindanao beyond constitutional limit through a tie up with the government's National Development Corporation (NDC): Dole–30,000 hectares, Del Monte–24,000 hectares, Guthrie–24,000 hectares, Sime Darby–16,000 hectares. NDC-Guthrie Plantations Inc. (NGPI) evicted 440 families or roughly about 3,000 people to make room for a palm oil plantation employing 2,000 workers earning not more ₱15/day.[9]

Technology transfer can be very harmful as evidenced by the most controversial government–assisted foreign projects in the Philippines– the Kawasaki Sintering Plant in Mindanao and the Westinghouse Nuclear Plant in Bataan. When the people of Ciba, Japan strongly objected to the intense pollution of Kawasaki's proposed Sintering Plant, the Philippine government offered an alternative site in Misamis Oriental at the expense of small farmers who lost their lands and at the great risk of health hazards to future generations of Filipinos. The still unfinished Westinghouse Nuclear Plant in Bataan remains the object of continuing public protest.[10] The capital-intensive industries of MNCs at the BEPZ exploit cheap labor and have not provided more decent human

9. "TNC's Control Wide Tracts of Land Via NDC," *Business Day*, 15 November 1983, p. 11. Roger Bantiles, "Mindanao," in *People's Solidarity for Liberation and Development: Issues and Prospects*, proceedings of the Second Convention of the Philippine Assistance for Rural Development (PARUD), July 19-21, 1983, pp. 19-23, also provides valuable data.

10. Walden Bello, John Harris & Lyuba Zarsky, "Nuclear Power in the Philippines: The Plague that Poisons Morong," *Third World Studies Papers*, Series No. 37 (Quezon City: U.P. Third World Studies Center, 1983).

working and living conditions for the workers.

"Appropriate technology" means the development of technologies which a country can sustain and which fit available resources and local expertise and meet the basic and real needs of the people. In the past the World Bank (WB) and the International Monetary Fund (IMF) have funded many so-called "appropriate technologies" even at the grassroots level. However, a closer analysis clearly shows that these technologies are not always for the benefit of Filipinos and trap us into being more dependent on foreign technology. The Philippines borrowed high-interest foreign loans to finance expensive technologies which we do not need such as the $2.2 billion nuclear plant, the multi-million nickle refinery of Marinduque Mining and Industrial Corporation (MMIC) financed largely by American and Japanese loans. For every 1 percent increase on the interest of the country's $25 billion external debt, $5 billion is added every year. We have fallen into an absurd "technological" and "debt trap."[11] The larger issue is not whether to allow foreign involvement in our local industries but whether we, Filipinos, exercise real control of our own industries that have become so dependent on foreign science and technology.

Along with the government and the private industrial sector, the Filipino people are also partly to be blamed. The NSTA observed that "the pervasive socio-cultural conditioning of the Filipino, the so-called 'colonial mentality' stands in the way of the development of national self-reliance."[12] A striking illustration of the neocolonial mentality is a study showing how the Filipino male/female has become captive to the consumer products of over a hundred MNCs.[13]

SCIENCE EDUCATION IN THE PHILIPPINES

The state of S & T in the Philippines is only a reflection of the state of science education and S & T manpower development in the country. If on the whole, public and private education on all levels has slowly deteriorated in the last two decades, so has science education. Due to the lack of competent science teachers,

11. *Ibon Facts & Figures,* No. 141, 30 June 1984 provides data on the Philippines' debt addiction.
12. *Science and Technology in the Service of the Filipino,* p. 50.
13. *Forum* 3, No. 1 (April-May 1980).

most of whom are undertrained, overworked, and underpaid, lack of adequate laboratories and equipment, and lack of textbooks and teaching materials which are mostly foreign and outdated, science education in the Philippines is inadequate and poorly taught.[14]

In a society and in a culture which gives a very low priority to the development of S & T, science education does not offer much career opportunity. Philippine schools continue to develop teachers and students in business and commerce, humanities and communication arts, law and medicine, but only a few take mathematics, physical sciences, and engineering. A scientific career is not very attractive because social, institutional and financial support for S & T is negligible. In the evaluation of a life career, S & T rank the lowest. Although Philippine society is one of the most literate among Asian countries, it is among the poorest in S & T.

Philippine manpower development in S & T is also very discouraging. Although the 1970 UNESCO figures indicate a fairly large number (29,420 per million of the population) of professional scientists and engineers in the Philippines, Philippine scientists and engineers in R & D are only 80 per million, compared to USA (2,760/million), Japan (3,560/million), Singapore (4,760/million), and Thailand (480/million). UNESCO prescribed a midterm goal to 200 scientists and engineers in R & D per million in 1976. This target has already been achieved by Korea (320/million), and Singapore (270/million) and almost reached by Thailand (10/million). In 1982 the Philippines had not gone much beyond the 1970 figure of 80 per million. Just to reach the 1976 goal, the number of Philippine scientists in R & D has to be multiplied four or five times the present number.[15] In a country of about 53 million, NSTA's 1982 statistics show a total of 580 scientists with Ph.D's in the Philippines: Engineering–66;

14. The miserable plight of Filipino teachers is backed up by data in *Ibon Facts & Figures*, No. 137, 30 April 1984. Only those who teach in Manila's public schools and in state colleges and universities are paid above the legislated effective minimum wage of ₱1,262 a month in Metro Manila and ₱1,230 in other areas. Their salaries compare dismally with the monthly cost of living, which in 1983 amounted to ₱2,250 in Metro Manila and ₱2,133 elsewhere in the country. The salary of private elementary and secondary school teachers ranges from ₱350 to ₱650 a month. Take home pay of an elementary teacher with a salary of ₱1,039, after all official and unofficial deductions, is ₱546.41.

15. *SPS*, pp. 65-66.

Physics and Chemistry–144; Mathematics–44; Biological Sciences –230; Agricultural Sciences–96. Estimates of how many are actually doing R & D vary from one third to one fifth.[16]

This country urgently needs both quantitative and qualitative S & T manpower development. To get some idea of the quality of our present scientific manpower, let us take as examples chemistry, mathematics and physics. In chemistry, the 1970 NSDB survey lists 250 chemists (about 10 percent of the total) active R & D, 80 of whom had advanced degrees (less than a third, Ph.D.'s; the rest, master's degrees). In mathematics, the 1978 survey of the first Southeast Asian Conference on Mathematical Education showed that all the Philippine mathematicians with degrees were either teachers (638) or administrators (130), with hardly any mathematicians doing R & D. In physics, according to the 1982 data gathered by the Samahang Pisika ng Pilipinas, there are in the Philippines 21 Ph.D.'s and 15 M.S.'s. The situation is probably better for the biological sciences but there are no up-to-date data available.

The universities are the training ground for future scientists. Yet only about five out of a total of fifty universities have a sufficient number of properly trained research-active faculty members in the mathematical and natural sciences. The need for scientific manpower in universities is much more apparent in chemistry, mathematics, and physics. In chemistry, which is our most developed physical science, only 7 percent of the teachers have Ph.D.'s and only 26 percent have master's degrees. In universities in Singapore, Taiwan, Hong Kong, and Korea, practically 100 percent of the teachers have advanced degrees. The local situation for mathematics and physics is worse with less than 1 percent of teachers with Ph.D.'s. Moreover, those with master's degrees are more likely to have M.A.'s and M.A.T.'s rather than research degrees.[17]

To aggravate matters, there is the phenomenon of external "brain drain" whereby Philippine scientists, for whatever reasons, economic or otherwise, migrate permanently to the U.S. or other countries and are lost to the country for good. The U.S. National Science Foundation revealed that from 1966 to 1976, 12,382

16. *Science and Technology in the Service of the Filipino*, p. 50, also *Daily Express*, 24 January 1982.
17. *SPS*, pp. 66-68.

Philippine scientists and engineers migrated permanently to the U.S. This number does not include thousands of doctors and nurses and S & T students who obtained advanced degrees abroad and have not returned. The NSTA tried to reverse this "brain drain" by instituting the "balik-scientist" program in 1973. From 1975-1982, 77 Philippine scientists with Ph.D.'s returned, but this is a very low number for the S & T manpower development needs of the country.[18]

But there are signs of hope for the future. Although an enlightened, comprehensive, long-term and effective government S & T program has still to come, there are a few significant starting points. In Metro Manila, universities like the University of the Philippines System, Ateneo de Manila University, and De La Salle University have given impetus to the following movements.[19] First, higher level training, both local and foreign, in mathematics, physics, and chemistry is now made possible through a consortium of schools and financial grants. This consortium has created a center for dialogue, discussion and implementation of higher manpower training and research in mathematics and the natural sciences. Secondly, the KSP has published a Science Policy Study and recommendations which include a five-year program for scientific manpower training. The KSP will continue to provide a stronger voice for the local scientific community in the formulation and implementation of S & T policy in the country. Thirdly, directions and plans continue to be worked out in dialogue with the NSTA on manpower development, management of S & T, career paths for scientists and technologists, development of scientific institutions and universities.

CHALLENGE TO PHILIPPINE SCIENCE AND TECHNOLOGY

The twofold challenge of S & T in the Philippines is first, that of creating and developing a scientific tradition or culture rooted or inculturated in the historical, socio-economic, political, and cultural situation of the people; and, secondly, that of the con-

18. *Daily Express*, 24 January 1982.

19. Bienvenido F. Nebres, S.J. "Science and Technology in Philippine Jesuit Schools," in *Proceedings of the Jesuit Educational Congress* (Manila: Salesian Press, 1981), pp. 115-18. See also Amando F. Kapauan, "Mathematics and Natural Sciences: Three Possibilities," ibid. pp. 127-28.

textualization of S & T in the Philippine context of massive poverty due to structural injustice.

TOWARDS A SCIENTIFIC TRADITION AND CULTURE

With regard to the first challenge, science must precede technology. Unless a country is good in science, it will never be good in technology. Unlike Japan, Korea, Taiwan, Singapore, and Malaysia, there exists no scientific tradition or culture in the Philippines. In building up this tradition a few guiding principles must be kept in mind.[20]

First, the development of a scientific culture in a third world country requires the identification and development of necessary supporting infrastructures. The internal infrastructure is native scientific talent or genius. The external infrastructure is society's support for scientists in terms of career opportunities and sufficient rewards and of the value society gives to the development of S & T. In the Philippines rewards for a scientific career are poor and S & T as a life career does not have much visibility or appeal. This cultural mentality which is a block must be reversed.

Secondly, while a scientific discipline cannot be developed in isolation and there is need of cooperation and assistance from the outside, it is imperative that the local scientific community be organized and other requisite conditions be first developed so that outside assistance can be properly assimilated. Programs for visiting scientists and technologists and for scholarships to S & T students abroad have in the past simply gone down the drain because other local conditions essential for the absorption of such aid were neglected, in particular, an organized local community of scientists.

Thirdly, the development of a scientific tradition is not simply the transplanting of an imported body of knowledge. It is an organic growth of scholarship as an integral part of national society and culture. What is desirable and good for HDCs may not necessarily be so for LDCs. It seems that local scientists who have been educated abroad have often been trained for emigration.

20. Not only for these guiding principles but for this article the authors are heavily indebted to Bienvenido F. Nebres, S.J., "The Task of a Jesuit University in the Philippines," *Philippine Studies* 27 (1979): 82-92.

Fourthly, leadership is an absolute prerequisite for the development of a scientific tradition. This leadership must come from our own Filipino scientists whether they are trained here or abroad. But Philippine society must also provide better conditions than those which now prevail to attract and motivate Filipino scientists to remain here and be of service to their people.

A mature scientific culture, national self-reliance with respect to basic material needs, self-determination to develop in the way we choose, a responsible conservation of our natural resources, are all indispensable for national development. It is essential that science develop *pari passu* with technology. We must use wisely the kind of technology we import; it may not be good for us in the long run. Only by doing science and applying technology ourselves can we begin to build our own scientific tradition and culture.[21]

SCIENCE AND TECHNOLOGY IN THE CONTEXT OF POVERTY AND INJUSTICE

The contextualization of S & T in the Philippine situation of massive poverty and structural injustice is the second challenge to the Philippine scientist. Poverty in Philippine society is not a problem of scarcity of natural and human resources but a problem of the maldistribution of wealth. Data on Philippine income distribution show that about 5 percent of the population are very well off, with another 15 percent in the "middle class," leaving the great majority, or about 80 percent, in the low income bracket. The richest 20 percent of the population receive incomes 15 times greater than the poorest 20 percent and 3 times higher than the national average (₱5,536) which represents the condition of the second richest group. During the last quarter of 1983, government figures show that families earning ₱10,000 and above, which comprise 6.9 percent of households, absorbed 45.5 percent of total family income. From only 22.1 percent in 1980, the share of families belonging to this bracket grew to 36.3 percent in 1981 and 39.2 percent in 1982. At the other end of the scale, in 1980 the share of the lowest 29.7 percent of families earning under

21. The authors are also indebted to an unpublished paper entitled "Reflections on the Role of Science and Technology in National Development," (1983) by Fabian M. Dayrit, Ph. D. of the Chemistry Department of the Ateneo de Manila University, 1983.

₱1,999 received 16.6 percent of total family income. The share decreased to 11.4 percent in 1981 and further to 9.4 percent in 1982. The richest 2 percent of families got 16.5 percent of total income in 1983 or ₱8,570 million, compared to the poorest 2.9 percent who had a share of 0.2 percent or ₱104 million. Take away ₱8 billion from the rich and they are still 5 times richer.[22]

There are two norms for measuring the extent of poverty—the *food* threshold and the total *poverty* threshold. As of the last quarter of 1983 the food threshold was estimated to cost ₱39/day or ₱14,000/year for the average Filipino family. More than half, or 51.18 percent or 4.80 million families subsisted below the food threshold. In Metro Manila families living below the food threshold are 21.14 percent against 57.16 in the rural areas. The barest minimum subsistence budget for the average Filipino family of six as of the year end 1983 amounted to ₱23,268 a year, ₱1,939 a month, and ₱64.63 a day. In the last quarter of 1983 close to three fourths, or 70.62 percent or 6.63 million families lived below the poverty threshold.[23] In Metro Manila the 1983 cost of living for the average family was ₱74.95 and yet the effective minimum wage was only ₱42 a day.

The root cause of poverty and inequality in the Philippines is institutionalized or structural injustice, both on the national and international level. A historical and structural social analysis of Philippine society shows both external neocolonialism and internal colonialism—through domestic capitalism and "feudalism"—both of which have been supported by a government which uses measures that keep the vast majority of the people in a state of poverty and oppression.[24] On the national level, Philippine society is characterized by structural injustice[25]: structures that

22. *Ibon Facts & Figures*, No. 139, 31 May 1984.

23. The results and conclusions of a research made by Alejandro V. Almazan and Carol B. Ibañez, "Determining Poverty Thresholds," are published in *Business Day*, 25 May 1984, pp. 10-11.

24. This is the conclusion of a social analysis by Romeo J. Intengan, S.J., *A Survey of the Theology of Liberation in a Philippine Context*, 3rd ed. (Quezon City: Ateneo de Manila University, 1980), pp. 3-14.

25. Richard P. McBrien, *Catholicism*, vol. 2 (Minneapolis: Winston Press, 1980), p. 983, defines social sin as "a situation in which the very organization of some level of society systematically functions to the detriment of groups or individuals in society. The sinfulness consists in the way social relationships are contrived or allowed to exist. Sometimes people of good will administer those systems. They are caught up in them. Although they may bear no personal guilt, the *situation* is sinful nonetheless." Peter J. Henriot, S.J., "The Concept of Social Sin," *Catholic Mind* 71 (October 1973): 38-53,

systematically oppress human dignity, violate basic human rights and impose gross inequality; situations which promote and facilitate individual selfishness; and complicity and silent acquiescence to social injustice. The present economic and political crisis, in the words of businessman Jaime V. Ongpin, is not only a crisis of complicity but credibility in:

> A system of one man rule that is not only virtually uncontrolled, but is in fact actively abetted by a legislature which is inutile, a judiciary which is subservient, a military which has been perverted, and a press that is intimidated– not to mention a central bank which does not know how to count.[26]

In a country where the principal problem is the concentration of wealth and power and access to the benefits of S & T is limited to one small segment of the population, there is urgent need for radical moral and social reform as well as for education towards social justice.[27]

SOCIAL RESPONSIBILITY OF PHILIPPINE SCIENTISTS

In view of the sad state of S & T and science education in the Philippines and in the Philippine context of poverty and injustice, what is the social responsibility of Philippine scientists? The biggest challenge to Philippine scientists is a double commitment– to science and to the Filipino people especially the poor and powerless. The first commitment demands scientific competence and excellence; the second, requires a new social awareness and social responsibility. Commitment to science means that the Philippine scientist as a scientist is professionally competent and will continue to grow professionally in his own area of specialization in cooperation with the local scientific community and, if the opportunity offers itself, in continuing contact with the scientists throughout the world. A commitment to make S & T serve

gives an excellent summary of the development of the concept of social sin in Catholic social thought.

26. Jaime V. Ongpin, "A Report on the Political Situation," paper presented at the Makati Business Club Plenary Session, 29 February 1984, Metro Manila, p. 4.

27. One of the three main points stressed by the Catholic Bishops Conference of the Philippines in their July 22 pastoral letter, "Let There be Life," is precisely the "need to revamp our entire economic and political structure to make it more responsive than it presently is to the ends of life." *Philippine Concerns*, special issue (July 1984), pp. 3-8.

the needs of the Filipino poor and oppressed requires more of the Philippine scientist as a Filipino and as a Christian.

It is no longer enough for Philippine scientists to merely teach science. They must begin to *do* science, discover new scientific knowledge, and apply this science to indigenous and appropriate technologies. The poor working conditions and low compensation of scientists in the Philippines is a situation that must be drastically remedied but should not be a convenient excuse for intellectual sloth, mediocrity, or neglect of R & D. There is no lack of native genius in our country and it is possible to think and create under adverse circumstances. There is more than ample evidence of Filipino scientific genius and technological talent both in the past and in the present.[28] Philippine scientists should strive to advance and become as competent as the best in the First World. To be satisfied with second rate or mediocre scientific knowledge is to remain dependent and oppressed. The men of science in a developing country are a precious asset. They should be given opportunities for advanced training but they have the corresponding responsibility to strive for scientific competence and excellence.

Essential to that competence is the nature of scientific investigation itself as a humanistic endeavor. Doing science as a dialogue with nature in order to arrive at the truth about oneself and the other is one of the most human endeavors. In science the partner of this dialogue is the natural world and the truth so learned is called scientific knowledge. The secret of such knowledge is precisely how to dialogue: how to ask the right question of nature and understand the answer. The first step in this process is experimentation or establishing of the experimental facts. The second step– the interpretation of the answer–is called building the theory. Finally, having thus addressed a question to nature and listened to hear the answer, the scientist continues the dialogue by asking further questions. This third step is called verification of the theory or confirmation by experimentation. These three steps, though

28. *Scientists in the Philippines* (Manila: National Science Development Board, 1975) provides the bio-data and scientific accomplishments of the following Philippine scientists: Jose Algue, S.J., Fernando Calderon, Isabelo Concepcion, Paul C. Freer, Leon Ma. Guerrero, Richard Crittendon McGregor, Anacleto del Rosario Y Sales, Otto Schobl, and Marcos A. Tubangui. A brochure of the *Science Technology Research Center* of the Filipinas Foundation, Inc. mentions the scientific discoveries of the more recent and famous Philippine scientists.

they are not independent, are the essence of the scientific method.[29] Asking the initial question already implies some idea, some hypothesis, some theory which then leads the scientist in what he asks of nature; the theory also predicts just what would happen in further experimentation and so finally leads the scientist in the verification process.

It can be seen that these three steps: observation of data, theory construction, and verification by experiment, have their own values and way of proceeding. Observation requires patience, intellectual curiosity and perseverance. Forming the theory implies humility before the facts and submission to objective truth as a given, not something one can manipulate or change. Verification implies the desire to learn and teaches the excitement of the method of discovery, of learning by experience. The science student who sees before him the experiment he has done, proving to him what he set out to find, does not easily forget the beauty of discovery. Even the null experiment, the verification of which turns out to prove the opposite, is a valuable experience in learning that truth is objective and must be respected in its own right.

Commitment to science, scientific competence and excellence, the training of more competent mathematics and science teachers are all necessary but not enough to meet the challenges of S & T in the Philippines. There is need for a heightened sense of social awareness and social responsibility among Philippine scientists. There is need for commitment to the Filipino people and nation. The scientist as a Filipino has a social responsibility to his people and for him to make S & T serve the needs of the poor and oppressed is genuine nationalism.

THE CREATIVE AND REDEMPTIVE ROLE OF THE PHILIPPINE SCIENTIST

The scientist in the Philippines, like his fellow scientists in the world, participates in the creative mind and creative work of God.[30] He is fascinated by the fact of the natural world and is

29. Werner Heisenburg, "Understanding," in *Physics and Beyond* (New York: Harper & Row, 1972), pp. 27-42.

30. For the relevance of the Christian doctrine of creation to justice and liberation

challenged to understand the "how" of nature's unending, eternal changing which never changes–the dance of matter and energy. Understanding the "how" of this dance intrigues because the creative mind of the scientist can achieve this understanding through the scientific method of experiment and theory based on mathematics.[31] It is as if mathematics and experiment are able to guide the mind of the scientist through the maze which nature's ways so often seem to be, but once through the maze, the scientist can contemplate the beauty of the perfectly orchestrated dance, the inner meaning of nature.

For the Christian scientist, the contemplation of nature achieved by the scientific method is more than the admiration of the dance of nature. It is a participation in the creative mind of God, in the intelligibility of the master plan, and indeed in the full meaning of Christ's creative and redemptive role in the universe (1 Cor. 8:6; 2 Cor. 5:19; Col. 1:15-18; Eph. 1:3-10). Since the world was made *through* Christ, *in* Christ, and *for* Christ, one may go a step further and say that the contemplation of nature's meaning is already the contemplation of the fuller meaning of man himself. As the universe is made in the image of Christ, then man is the measure of the universe and this full measure of man is what the dance of nature reveals to the Christian scientist. The poet Tennyson wrote that if man knew all that there was to know about a flower, he would know God and man.

The creative act of the scientist as the contemplation of "how" nature works is only one side of the picture, the bright side. The other, dark side of this contemplation, from the Christian point of view, is sin. The Christian scientist, as he further penetrates the maze of nature by his application of the scientific method and learns the "how" of nature's dance, finds the constant temp-

theology, see *Maturing in Christian Faith*, National Catechetical Direotory of the Philippines (Manila: Catholic Bishops Conference of the Philippines, 1982), pp. 57-59. See also, Roger L. Shinn, ed., *Faith and Science in an Unjust World*, vol. 1 (Philadelphia: Fortress Press, 1980) and Paul Abrecht,ed., *Faith, Science and the Future*, vol. 2 (Geneva: World Council of Churches, 1980).

31. Stanley L. Jaki, *The Road of Science and the Ways to God* (Chicago: University of Chicago Press, 1978), pp. 248-50. See Dorothy L. Sayers, *The Mind of the Maker* (San Francisco: Harper & Row, 1979), pp. 21-31, 35-45, 49-59.

tation to use this knowledge as power. His scientific contemporaries and technological culture pressure him to use his knowledge to master the forces of nature and harness these forces for "practical" purposes. Yet the Christian scientist knows that such objectives are often motivated by the will to control and manipulate, first, nature and then, other persons, the will to power leading man to exploit man. This is sin for the scientist and it shows itself most fully in the technological world whose structures of power so often tend to grind on the powerless, in disregard of the "least" of our fellowmen.

Given this power of the scientist and the temptation to exploit such power for its own sake, God's plan of redemption from sin, of course, arises. For the Christian scientist the act of redemption is precisely the act of rejection of the exploiting of power, of the use of power for the benefit of the powerful, and the acceptance of the role of the powerless servant, even the suffering servant. To use power in the service of all implies for the Christian scientist that the way to go even deeper into the maze of matter and arrive at an ever more comprehensive contemplation of the dance of matter is to follow the law of the cross, the law of the seed that dies, the servant who gives up power for the sake of service (Mt. 16:25; Mk. 8:35; Lk. 9:24; Jn. 12:24-25).

What does this all mean to the Philippine scientist today? The Philippine scientist has the choice of using his scientific expertise in his own land for his own people, or going abroad permanently where there are better opportunities for scientific R & D and a much higher pay, or the option of working for a multinational corporation, or for one of the government's S & T institutes at great sacrifice to his own future career and at a much lower salary. Given these options, his decision can be dictated by practicality or it can be inspired by his Christian commitment. A commitment to science and a commitment to the Filipino people involves the choice of the cross. Science education is expensive and entails intellectual discipline and hard work. If one ambitions wealth, prestige, and power, the future prospects of a scientist or a science teacher in this country is not very promising. From his Christian faith, the Philippine scientist knows that his science education, his scientific talent and success, are not a stepping stone to prestige and power but a social responsibility for the service of the people especially the poor and victims of injustice.

THE PROPHETIC ROLE OF THE PHILIPPINE SCIENTIST

S & T are not value free and independent from moral and religious considerations; their uses are either pro-life or anti-life, human or inhuman, moral or immoral. To be concerned only with the objectivity of science and freedom of research for the sake of universal science is to fail as a human being and as a Christian. True, the Christian faith does not offer ready-made answers to the most complex problems of food, population, and energy crisis, external and internal pollution, and of new information/communication as well as biological technologies; but the Christian gospel challenges the immediate goals and values of those who control the uses of S & T. More than ever scientists must restate with conviction that "science and technology find their justification in the service that they render to man and to humanity" and must exercise serious responsibility of studying more deeply "the ethical problems of the technological society."[32]

The Philippine scientist has no excuse for not being well informed about the religious and ethical issues arising from S & T development. No one individual or group of individuals can keep up with the rapid advance of S & T and at the same time be cognizant of the emerging religious and ethical dilemmas, unless in each country, a structure of forum for a continuing dialogue between scientists and theologians and other scholars is set up and organized. Such a center for the theological encounter with S & T on a local and regional level can exercise a powerful prophetic voice that is morally credible to decision makers who control S & T.

The Western powers have used S & T for their own economic, political, the military interests, to the detriment of the peoples of the Third World. If these neocolonial powers make use of S & T to keep the people oppressed, it is imperative that Third World scientists make effective use of S & T to advance the liberation of their oppressed peoples.[33] But in order to be morally cre-

32. "Science, Technology and Peace," address of Pope John Paul II to scientists at the United Nations University in Hiroshima, February 1981. See *Catholic Mind* 79 (June 1981): 57-64 Quote is on p. 62.

33. Guillermo Ponce de Leon, "The Perversion of Science," *The Diliman Review*, 28 (March-April 1980):16-18. See "A Critical Statement by Participants from Africa, Asia, Latin America, the Middle East and the Pacific," in *Faith and Science in an Unjust World*, vol. 2, pp. 171-72.

dible and exercise a prophetic voice in a country characterized by poverty and injustice, the scientist must lead a life that is characterized by service, sharing, simplicity of life-style, solidarity with the poor, and "subversion" in the sense of becoming an agent of social change by cooperating in community to change unjust structures or at least not profiting from or conniving with these unjust structures. It is a fact that only multi-million enterprises backed by western-dominated S & T can afford high-paying scientific R & D and hire the best scientists, engineers, and technicians. These scientists, including our own, must re-examine their ties with multinational corporations, government, military, and private business projects, even if these ties are not immediately evident. Even if they have accepted jobs and contracts for purely economic reasons, they may unwittingly be serving foreign interests rather than those of their people. They may be guilty of complicity or silent acquiescence to social injustice. Too often scientists and engineers who serve foreign interests rather than those of the people become alienated and eventually join the "brain drain." By a life of dedication and self-sacrifice, the Christian scientist can do more for the education toward justice and may help remedy the defective education through mass media in a consumer society that caters only to the rich elite, encourages greed and the worship of mammon, and fosters blind conformism to the image of consumer-man. All this may sound idealistic and impractical unless the Christian scientist lives his faith.

Since S & T are capable of exploiting peoples and the earth's natural resources and environment, endangering human survival, it is the social responsibility of the scientist in cooperation with the local scientific community to exercise a prophetic voice to inform his people of the risks, dangers and social repercussions of modern S & T in the wrong hands. The local scientific community, from a global perspective, must with courage denounce and protest the current use of S & T as instruments of militarization and total annihilation. In the Philippine context, the local scientist must denounce massive deforestation and pollution caused by logging, mining, fishing, fruit-export operations owned or controlled by multinational corporations. The Japanese economy has advanced by leaps and bounds but only at the expense of other Asian countries. Vulnerable industries have been relocated outside Japan and overseas investments and trade have grown at Asia's

costly sacrifice.[34] The U.S. military bases in the Philippines pose a continual threat to nuclear attack.[35] If socially responsible Philippine scientists did their homework, they would have been more credible than politicians and activists in alerting the public to the risks and social impact of the Kawasaki Sintering Plant in Mindanao, the controversial and still unfinished nuclear plant of Westinghouse in Bataan, and other questionable government projects that do not redown to the good of the people.

In a country characterized by poverty and injustice there is a crying need not only for competent science teachers and highly trained scientists but for men and women of science who are deeply committed towards the liberation of the people from poverty and injustice.

34. Tazawa Yoko, "The Japanese Economy and the Third World," paper given at the Asian Conference on "The Future: Science, Faith and Justice in Asia," attended by 45 Asian scientists and held at the University of the Philippines, 18-22 December 1983. This article is a revised edition of a paper given by V.R. Gorospe, S.J. at this same conference.

35. "The Consequences of a Nuclear Attack on the Philippines," *Philippine Concerns* 3 No. 31-34 (November 1983): 1, 3-6.