SCIENCE POLICY AND NATIONAL DEVELOPMENT: A FILIPINO VIEW*

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INTRODUCTION

Rapid economic development and the improvement of the quality of life and society are goals which developing states have been striving for since the attainment of their political independence. To achieve these goals, they must choose programs and strategies which are deemed appropriate to their available resources and existing level of development. There has been a tendency for these countries to look at the experience of the industrialized states for possible guides in the formulation of their national development plans. It is widely recognized that socio-economic progress among the industrialized states has been propelled by the advance of science and technology. In recent years, however, it has become more apparent that the widespread application of advances in science and technology in these countries can have harmful unforeseen consequences such as, for example, environmental pollution, problems of urbanization, industrial health hazards, and others, which threaten to negate the very achievements of these societies. In the field of technical cooperation between developed and developing states, it has also been observed that the uncritical adoption and diffusion of science and technology from the industrialized states can lead to a waste of valuable resources in the developing states and may even seriously disrupt their existing social systems, thus creating more problems.

> Transferring technologies is not as simple as transferring funds. Innovation requires change but not disruption; the new systems must be congruent with the basic dimensions of the old. The search for congruence between technological and social systems begins with efforts to predict the consequences of innovation.[1]

All states, both developed and developing, thus face the dilemma of how to make optimum use of science and technology while at the same time preventing and controlling their deleterious effects. It is this dilemma which has elevated the formulation of science policy to the forefront of serious deliberation by governments as a vital part of their national plans and policies.

This paper examines the relationship between science policy and national development and looks at the Philippine experience in evolving its own science policy, particularly in regard to the education and training of scientists and engineers. The first part analyses the concept

of science policy and briefly traces its origins as an area of concern in both industrialized and developing countries. The second part focuses on the socioeconomic environment of Philippine science and the goals of government. The third part summarizes the history of the education and training of scientists and engineers in the Philippines and the evolution of science policy and its socioeconomic consequences. The paper concludes with a number of policy recommendations.

THE CONCEPT OF SCIENCE POLICY

Science policy is generally used to refer to:

> The collective measures taken by a government in order to, on the one hand, encourage the development of scientific and technical research and, on the other, exploit the results of this research for general political objectives.[2]

Science policy in this context can be analytically divided into two parts: "policy for (or in) science" designed to foster research and the growth of knowledge, and "policy through science" or "science for (or in) policy" which involves the exploitation or application of the fruits of science and technology in various areas of public concern, e.g. public health, pollution, urban problems, etc.[3] In practice, however, these two aspects of science policy are closely interrelated and can hardly be separated. The formulation of science policy means asking such questions as:

> What percentage of total national resources should science and technology get, in the light of alternative claims on these resources? Within science and technology, how should funds and technical manpower be divided among basic research, applied research and development? And how within science, between physics and oceanography? How many scientists and engineers should the country train? What kinds of research institutions and facilities should it provide them with? What government machinery is required to answer such questions about science and what technical sophistication is needed by the public servants who have to answer them?[4]

It is useful, in this connection, to distinguish between science and technology. Although there are many different ways of defining science, it is commonly regarded as being concerned with the systematic understanding and explanation of the laws of nature. Scientific activity centres on research, the end result of which is the discovery or production of new knowledge. Scientific research is usually categorized as basic (fundamental) or applied in nature depending on whether its results are expected to have long-run or immediate utility. Such a distinction, according to Brooks, is also based on the factors influencing a researcher's choice between alternative courses of action:

> If each choice is influenced almost entirely by the conceptual structure or the subject rather than by the ultimate utility of the results, then research is generally said to be basic or fundamental, even though the general subject may relate to possible applications....The fact that research is basic does not mean that results lack utility, but only that utility is not the primary factor in the choice of direction for each successive step.[6]

Research that is aimed towards immediate use or application is called "applied" or "targeted" research.[7] However, applied or targeted research can also be "highly fundamental in character in that it has an important impact on the conceptual structure or outlook of a field."[8] Technology originally meant "systematic knowledge of the industrial arts."[9] As this knowledge was implemented by means of techniques, technology has become commonly taken to mean both the knowledge and the means of its utilization, that is, "a body of knowledge about techniques."[10]

In the past, the practice of science and technology tended to be unconnected. Scientific knowledge grew mainly as the product of intellectual curiosity about the nature of the world. Technology was developed by craftsmen whose inventions were often the results of intuition, trial and error, in response to human needs. For a long time, science and technology, knowledge and action, were thus pursued separately. By the 19th Century, however, science and technology had become more closely interrelated.[11] Scientific discoveries stimulated many inventions which led to the development of science-based industries. At the same time, technological progress, e.g. the improvements in the manufacture of optics and other scientific instruments, facilitated further testing and discovery of new scientific theories.[12]

This productive wedding of science and technology has given rise to the idea that technology is "applied science." Consequently, there is often considerable ambiguity in the use of the concepts of science and technology, especially because in the contemporary world systematic research has become an important activity in both fields. However, Price makes a practical distinction between science and technology:

> If, when a man labours, the main outcome of his research is knowledge, something that has to be published openly for a claim to be made, then he has done science. If, on the other hand, the product of his labour is primarily a thing, a chemical, a process, something to be bought and sold, then he has done technology.[13]

The close interaction between science and technology accelerated the process of industrialization and economic development among Western states. This has led to the widespread acceptance of the necessity for governments to adopt measures for the advancement of science and technology as means to the achievement of national ends and purposes. These include the creation and support of universities and other training institutes, curiosity-oriented and mission-oriented research establishments, and policies to

encourage industrial research and development in the private sector. These have become part of a nation's science policy.

EVOLUTION OF SCIENCE POLICY IN THE INDUSTRIALIZED COUNTRIES

The widespread concern with national science policy is of recent origin. It is in fact a post-World War II phenomenon. The idea that the state should support and promote science and technology for the benefit of society, however, had been advocated since the 17th Century by philosophers, e.g. Descartes, Bacon, Maupertuis and Condorcet.[14]

Nevertheless, the advancement of science and technology generally proceeded, until the latter part of the 19th Century, with little if any organized government support or intervention. The progress of modern science was, for the most part, due to the work of individuals--amateur scientists working in Europe, particularly in England, France, the Netherlands, Germany, Austria and the Scandinavian countries, during the 17th and 18th Centuries.[15] They were by no means dilettantes. They were amateurs only in the sense that their gainful employment or main occupation were often unconnected with their science.[16]

Communication among these early scientists was initially by social networks and private correspondence. Later, however, they held informal gatherings to exchange scientific information. Such gatherings eventually gave rise to the organization of scientific societies, e.g. the Accademia dei Lincei in Rome (1600-1630), the Accademia del Cimento in Florence (1657-1667), the Royal Society of London (which was given its royal charter in 1662), the Académie des Sciences in Paris (which became a royal institution in 1666), the Societas Ereunetica (1622) and Collegium Naturae Curiosorum (1651) in Germany.[17] Of these, the Royal Society and the (French) Académie des Sciences served as models for the subsequent creation of national scientific societies such as the Berlin Academy in 1700 and the National Academy of Sciences in the United States in 1863.[18] These societies functioned initally with little financial support from the government. They aided early scientific experiments and research by their members and also facilitated the dissemination of scientific knowledge through the publication of their transactions and scientific journals.[19]

The advances in science and technology in the 18th Century provided impetus to the Industrial Revolution. Owing partly to the close social interaction of its amateur scientists and entrepreneurs, Britain led Europe in industrial and economic progress.[20] It was in France, and later Germany, however, where the development of science, primarily in the field of scientific and technical education, found increasing government support. The Ecole Polytechnique, the first college of applied science in the world, and other technical schools were set up in France during the last decade of the 18th Century.[21] In Germany, state-supported universities providing training in scientific research and technical schools had

become well established by the first quarter of the 19th Century.[22] It was this development of professional scientific and technical manpower which enabled Germany to build its science-based industries and catch up with England as the leading industrial state in Europe by the end of the 19th Century.[23]

While these changes in Germany were in progress, there arose a widespread feeling among Englishmen that science was in decline in their country. Charles Babbage, a leading mathematician and inventor writing in 1830, attributed this decline to the lack of recognition of science and scientists in Britain compared to France and Germany (Prussia), the "corrupt" state of the Royal Society and the failure to teach science properly in the universities and schools of Britain.[24] The formation of the British Association for the Advancement of Science in 1831 was a direct consequence of these criticisms on the state of science in England. From 1840, to 1890, there was growing clamour for reforms in science and education. These reform movements led to state support for science education through the creation of a Science and Art Department, a system of examinations and changes in the curricula of the older universities.[25] A movement for the "endowment of research," which gathered in strength from 1860-1875, argued that pure research was basic to the nation's material prosperity and should thus be given more financial support by the state. The goal of this reform subsequently developed into the Endowment of Science in 1876-1880.[26]

The growing demands for reforms in science and education in Britain reflected the changing character of the scientific enterprise during the 19th Century. Scientific research was no longer the preserve of the gentleman amateur with wealthy patrons. It had become a specialized and full-time activity. It had also become more expensive and beyond the means of most individuals. Moreover, the prosperity brought about by the science-based industries in Germany had demonstrated the long-term utilitarian value of scientific research. The net result of these reform movements was the growth of university, government and private research establishments and fellowship schemes towards the end of the 19th Century. In 1900, the National Physical Laboratory was set up.[27] From 1900-1915, state fellowships for research were created.

The turn of the Century thus saw increasing relations between government and science. Science had already been introduced in the British civil service. Government agencies using science had grown in number not only in Britain but also in the United States and Canada.[28] However, there was still no science policy in the sense that present governments are concerned with, i.e. overall planning, support and coordination of scientific and technological activities.

World War I marked the beginning of the extensive entanglement of scientists with government. It was the first time in which scientists on both sides, i.e. England, France and Germany, were mobilized to devote their science to the war effort. The war subsequently gave rise in England to the creation of the Department of Scientific and

Industrial Research (DSIR) in 1916. The DSIR represented the first government attempt to organize and coordinate scientific research on a large scale.[29] National Research Councils were similarly established in the United States and in Canada in 1917, in response to the wartime need to rationalize scientific research.[30]

In the period following World War I, closer relations between science and government developed further. As a consequence of the Russian Revolution and the establishment of the Soviet state, science was mobilized to serve communist ideology and the state. In the Soviet Union, science was not only "recognized as a national capital asset, but it was also proclaimed a public service and integrated in the forces of production."[31] Central government planning and coordination of scientific research for purposes of economic development thus became institutionalized in the Soviet Union.[32] The phenomenal achievement of Russian industrialization within a short period after the Revolution was largely attributed to the policies that the Soviet government had adopted for science. This gave rise to the belief that science could and should be planned for the benefit of society.

In England, this belief inspired the "Social Relations of Science" movement which flourished in the 1930s to the mid-1940s. The SRS movement was spearheaded by influential scientists such as, J.B.S. Haldane, Hyman Levy, Julian Huxley, Lancelot Hogben, P.M.S. Blackett, J. G. Crowther and J.D. Bernal.[33] The economic depression of the 1930s strengthened the belief of these scientists in the relations of science and society. Science, if planned, could improve immeasurably the human condition. Bernal eloquently expounded this idea in his book, *The Social Function of Science*, published in 1939. As he put it:

> Science has ceased to be the occupation of curious gentlemen or of ingenious minds supported by wealthy patrons, and has become an industry supported by large industrial monopolies and by the State. Imperceptibly this has altered the character of science from an individual to a collective basis, and has enhanced the importance of apparatus and administration. But as these developments have proceeded in an uncoordinated and haphazard manner, the result at the present day is a structure of appalling inefficiency both as to its internal organization and as to the means of application to problems of production or of welfare. If science is to be of full use to society, it must first put its own house in order. This is a task of extraordinary difficulty, because of the danger of any organization of science destroying that originality and spontaneity which are essential to its progress. Science can never be administered as part of a civil service, but recent developments here and abroad, particularly in the U.S.S.R., point to the possibility of combining freedom and efficiency in scientific organization.[34]

Bernal examined the existing organization of scientific research in Britain, science in education and the application of science and suggested remedies. His recommendations touched on the training of the scientist, the reorganization of research, scientific

communication and the financing of science. The reorganization of science, in Bernal's view, must be a comprehensive task and "cannot be undertaken alone either by scientific workers themselves or by the state or economic organizations outside science, but only by all working together in an agreed direction." The question of "whether science can be reorganized at all is not simply or even principally one for scientists" but is a "social and political question. Every aspect of any reorganization of science concerns the economic and political structure of society."[35]

The idea of planning science was roundly criticized by many scientists and the anti-planning movement was led by J. R. Baker and Michael Polanyi who saw planning as inimical to the nature of the scientific enterprise. They formed the Society for Freedom in Science in 1941 to counteract the views and activities of Bernal's group and to safeguard the traditional independence of scientific inquiry.[36] The debate over planning versus freedom in science continued until the end of the Second World War, although by that time the differences between the two views had narrowed considerably.

The outbreak of the war saw the mobilization of scientists and engineers by governments on an unprecendented scale. They were engaged in weapons research and development as well as research to produce synthetic substitutes for many raw materials that had been made scarce by the war. This wartime experience demonstrated that scientific and technological progress can be greatly accelerated by organized government support and coordination of research.[37] The fruits of such scientific and technological enterprise can, moreover, be geared towards priorities of national policy. Thus after the war, the formulation of a national science policy became an important objective of policy-making among the industrialized states. This can be seen in the formation in Britain of the Advisory Council on Scientific Policy in 1947, with its subsequent science policy debates and the reorganization of the scientific establishment,[38] the revitalization of the National Center for Scientific Research (CNRS) and establishment of the Atomic Energy Commission in France in 1946,[39] the formation of the civilian Atomic Energy Commission (1946) and organization of the National Science Foundation (1950) in the United States,[40] and the subsequent preoccupation of governments (in general) in reviewing their national science policies.[41]

The expanding role of science and technology in government, as shown by the preceding historical survey, has been motivated largely by the desire among states to maintain economic development and military superiority. With the emergence of the Cold War and space exploration, national prestige has been added to these two goals of science policy among the industrial states.[42] The continuing importance attached to science policy among the industrialized states can be seen from the periodic ministerial discussions, conferences on science policy and surveys of national government organization and resources devoted to scientific research and development undertaken by the member states of the Organization for Economic Cooperation and Development (OECD) since the 1960s.[43]

SCIENCE POLICY AND DEVELOPING COUNTRIES

Concern with science policy has also spread to the less developed countries, largely as a result of the efforts of the United Nations and its specialized agency, UNESCO. In 1963 the UN sponsored a Conference on Science and Technology for Development which discussed ways by which science and technology could be utilized for the benefit of less developed countries without unduly disrupting these societies.[44] UNESCO, since 1965, has published reports on the organization of scientific research and policies of its member states.[45] These country surveys are designed to assist member states in determining their scientific and technological potential and priorities for development.[46]

In 1968, UNESCO convened a conference in New Delhi, India on the application of science and technology to the development of Asia. The goal of scientific autonomy among the new nations was considered at the conference as vital to their independent development:

> The progress of a country depends on its capacity to identify, resolve and decide upon the scientific and technical problems which confront it at the successive stages of economic and social development. This is particularly relevant to the change-over from the traditional industries to the new forms of production, and to the integration of modern techniques into the national production system. This process cannot take place in a country that has not attained a certain degree of advancement in science, which must hence be regarded as an essential prerequisite for any genuine national independence.
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> From this viewpoint, the aim of the government policy in science and technology will be to procure an endogenous social and economic development supported by the nation's own scientific and technological community and to reach this goal, international and regional cooperation in science is a vital element.[47]

The foregoing view on the role of science and technology policy in the development of new states has also been expressed by Edward Shils, thus:

> For underdeveloped countries, many or most of the problems of scientific policy are the same as those of the advanced countries. There is one very important exception. This is the establishment of scientific tradition, that is, the establishment of beliefs and orientations that heighten and maintain sensibilities and motivations that prompt the selection of important and appropriate problems for investigation and suggest the approach toward them in ways that permit their fruitful solution. Countries in which science is well established may take this for granted....it is an obvious task of science policy in these (underdeveloped) countries to make the arrangements that will foster the establishment of such a tradition.[48]

In a similar vein, Stevan Dedijer emphasized that:

> National development requires a large and continuous production of scientific results; the importation of foreign specialists to produce them is politically and economically intolerable as a long-term arrangement. The development of a national research potential, i.e. qualified scientists, scientific institutions and equipment, and a scientific culture within those circles must be created in order to carry out other national policies with any degree of effectiveness. The development of this potential must be regarded from the first not as a luxury but as an inseparable part of the general program of development. Hence, a policy for the development and the use of science must be from the start an integral part of the national policy. Science policy must be an important part of the national development policy as economic and educational policy...to neglect a planned and vigorous development of indigenous research in the physical, life and social sciences endangers the whole process of development.[49]

The preceding views emphasize that developing countries must build up their own scientific and technological capability as tools for socioeconomic development and genuine national independence. Elsewhere in the literature on science policy it has been pointed out that scientific and technological capability is particularly needed by a developing country, in the first place, to be able to survey and assess its own natural resources and undertake their exploitation and development in the light of the conditions and needs of the society, and, secondly, to effectively acquire, absorb and adapt existing science and technology from other countries for its own purposes.[50] Thus it has been argued that a developing country's national science policy "should be a reflection of long-term national goals and objectives, and the overall economic and social development plan designed to achieve these aims."[51] Science planning, therefore, needs to become an integral part of overall development planning.[52]

Behind the arguments linking scientific and technological capability with the independence of developing states is the recognition that modern science and technology developed within certain social, economic and political milieux. It is, therefore, unwise for developing countries to rely completely on industrialized states for their scientific and technical needs. As Waldo pointed out:

> The developed nations are *nations*, and while nations (and certainly persons and groups therein) are sometimes capable of acts of disinterested altruism towards other nations and nationals, this is not their distinguishing feature; and the truth is that much of the aid that is given, scientific and technical included, is given in an atmosphere of competition, rivalry and potential hostility. Science...is presumed to have important international characterisitics and even supra-national potentials and tendencies. But even the most abstract and theoretical sciences are also embedded in particular languages and cultures, from which they cannot wholly be divorced: there is a giver as well as a gift and gifts notoriously create relationships. (That the gift was purchased may be important but does not necessarily nullify the point.) Technology is even less divorced from particular cultures and national interests.[53]

The problem of dependence or autonomy in science and technology for developing countries is closely tied up with the question of political and economic dependence or autonomy of the new states. There is a continuing imbalance between scientific and technological development among contemporary states. Available information indicates that 98 percent of all research and development facilities are located in developed countries and are almost wholly concerned with the problems of these countries. The remaining two percent is carried out in developing countries on problems related to their needs.[54] The issue of dependence or autonomy in science and technology has thus continued to be a salient issue in the 1979 United Nations Conference on Science and Technology for Development which was held in Vienna, Austria.[55]

From the scientist's point of view, developing countries need to build up their own scientific and technological capability since they "have as much to *give* to science as they have to take from it."[56] This argument is based on the recognition that scientists in developing countries, by virtue of their being in different locations in the world and working in different environments, are in a better position than scientists in developed countries to study certain problems in science, for example, tropical diseases, agriculture, and the like. The fund of scientific and technological knowledge can thus be enriched for the benefit of mankind through international scientific cooperation and exchange.

SUMMARY

It can be seen from the above discussion that science policy is a broad concept. On the other hand, it encompasses measures to foster scientific and technological research and development. These include policies to ensure an adequate supply of qualified scientists and engineers. On the other hand, science policy pertains to the utilization of research results for general policitical objectives. As such it cuts across many government programs and involves various agencies.

The widespread concern among industrial states with the need for national science policy is quite recent and is largely a post-World War II development. The beginnings of state support for the advancement of science and technology, however, can be traced to the latter part of the 18th Century. This was initially directed at reforming universities and establishing technical colleges to promote scientific and technological education and stimulate research and development. France and Germany led in this respect. Great Britain followed during the 19th Century. These reforms were considered vital for industrial modernization and economic progress. Russia's rapid industrialization after the 1917 Revolution demonstrated further the extent to which central planning and direction of scientific research and technological development can be geared towards the achievement of socioeconomic and political purposes. As a consequence of the large-scale mobilization of scientists and engineers during World Wars I and II and the ensuing Cold War, military superiority and national prestige have become important goals of national science policy. Western industrial states have thus established various institutions to plan and implement their science policies.

Concern with national science policy subsequently spread to developing countries, largely through the activities of the United Nations. It has been pointed out in UN-sponsored and other international conferences that dependence or autonomy in science and technology is closely tied up with the political and economic dependence or autonomy of the new states. Modern science developed in the Western cultural, socioeconomic and political milieux and gradually spread to developing states with differing environments, goals and priorities. Thus developing states have been exhorted to strengthen their scientific and technological institutions and formulate relevant science policies to support national development plans.

NOTES

This monograph is based on the author's Ph.D. thesis, "Science Policy in the Philippines: The Education and Training of Scientists and Engineers", Queen's University (Kingston, Canada: 1980); Chs. I and X.

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2 Jean-Jacques Salomon, "Science Policy Studies and the Development of Science Policy," in Ina Spiegel-Rosing and Derek de Solla Price, eds., *Science, Technology and Society, A Cross-Disciplinary Perspective* (London and Beverly Hills: Sage Publications, 1977), pp. 45-46.

3· OECD, *Science, Growth and Society; A New Perspective* (Paris: OECD, 1971), p. 37; Jacques Spaey *et al.*, *Science for Development; An Essay on the Origin and*

Organization of Science Policies (Paris: UNESCO, 1971), p. 35; G. Bruce Doern, *Science and Politics in Canada* (Montreal: McGill-Queen's University Press, 1972), pp. 167-168.

4. Emmanuel Mesthene, "The Impact of Science on Public Policy" *Public Administration Review,* Vol. XXVII, No. 2 (June, 1967), p. 103.

5. Jerome R. Ravetz, *Scientific Knowledge and Its Social Problems* (Oxford: Clarendon Press, 1971), Ch. 1; James B. Conant, *Science and Common Sense* (New Haven and London: Yale University Press, 1974), Ch. 2; Bernard Dixon, *What is Science For?* (New York: Harper and Row, 1973), Ch. 2; David Knight, *The Nature of Science; The History of Science in Western Culture Since 1600* (London: Andre Deutsch, 1976), Chs. 1-2.

6. Harvey Brooks, *The Government of Science* (Cambridge, Mass.: The M.I.T. Press, 1968), pp. 283-286.

7. Targeted research is "the application of existing knowledge to a specific target" See Salvador E. Luria, "Goals of Science" *Bulletin of the Atomic Scientists,* Vol. 33, No. 5 (May 1977), pp. 29-30.

8. Brooks, *op. cit.*, pp. 285-286.

9. E. Layton, *"Conditions of Technological Development"* in Rosing and Price, *op. cit.*, p. 199.

10. C. Freeman, "Economics of Research and Development" in Rosing and Price, *ibid.*, p. 235.

11. Peter Mathias, "Who Unbound Prometheus? Science and Technical Change, 1600-1800" in *Science and Society 1600-1800,* ed. by Peter Mathias (Cambridge: Cambridge University Press, 1972), pp. 54-80.

12. Brooks, *op. cit.,* pp. 293-296, 303-307.

13. Derek de Solla Price, *Science Since Babylon,* (Enlarged edition; New Haven: Yale University Press, 1975), p. 125. Maurice Korach argues that the term "science of industry" is more appropriate to use for applied science or technology. See Korach's "The Science of Industry" in Maurice Goldsmith and Alan Mackay, eds., *Society and Science* (New York: Simon and Schuster, 1964), pp. 179-194.

14. Jean-Jacques Salomon, *Science and Politics;* translated by Noel Lindsay (London and Basingstoke: Macmillan, 1973), pp. 6-20; J. R. Ravetz, "*...et augebitur scientia*" in

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15. Martha Ornstein,*The Role of Scientific Societies in the Seventeenth Century* (published by the University of Chicago, 1928, reprinted in London: Archon Books, 1963), Ch. 2.

16. D.S.L. Cardwell, *The Organization of Science in England: A Retrospect* (Melbourne: Heinemann, 1957), pp. 12-14.

17. Ornstein, *op. cit.*, Chs. 3-6.

18. *Ibid.*, pp. 177-197; A. Hunter Dupree, *Science in the Federal Government; A History of Policies and Activities to 1940* (Cambridge, Mass.: Harvard University Press, 1957), p. 138.

19. Ornstein, *op. cit.*, ch. 7.

20. For examples of these fruitful interactions, see Sir Solly Zuckerman, *Beyond the Ivory Tower: the Frontiers of Public and Private Science* (London: Weidenfeld and Nicolson, 1970), ch. 13; Desmond King-Hele, *Doctor of Revolution; the Life and Genius of Erasmus Darwin* (London: Faber and Faber, 1977), Chs. 4-5.

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23. Hilary Rose and Steven Rose, *Science and Society* (London: The Penguin Press, 1969), pp. 28-36.

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27. Russell Moseley, "Origins and Early Years of the National Physical Laboratory: A Chapter in the Pre-history of British Science Policy" *Minerva*, Vol. XVI, No. 2 (Summer 1978), pp. 222-250.

28. These were in the areas of geological surveys and exploration, agriculture, medicine, and public health. Dupree, *op. cit.*, chs. 5, 8, 10, 13-14; Doern, *op. cit.*, pp. 2-3, 17.

29. Rose and Rose, *op. cit.*, ch. 3; Ian Varcoe, *Organizing for Science in Britain; A Case Study* (London: Oxford University Press, 1974).

30. Dupree, *op. cit.*, ch. 16; Doern, *op. cit.*, pp. 3-5, 22-37.

31. Salomon, *Science and Politics, op. cit.*, pp. 30-42; the quotation is from pp. 33-34.

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34. J. D. Bernal, *The Social Function of Science* (London: Routledge and Kegan Paul, 1939, re-issued in Cambridge, Mass.: The M.I.T. Press, 1967), p. xiii.

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36. Filner, *Science and Politics in England, op. cit.*, chs. 5-6; William McGucken, "On Freedom and Planning in Science: The Society for Freedom in Science, 1940-46" *Minerva*, Vol. XVI, No. 1 (Spring 1978), pp.42-72.

37. Rose and Rose, *op. cit.*, ch. 4; Dupree, *op. cit.*, pp. 369-375; J. Stephan Dupre and Sanford A. Lakoff, *Science and the Nation; Policy and Politics* (Englewood Cliffs, N.J.: Prentice-Hall, 1962), pp. 9-11, 91-103; Robert Gilpin, "Introduction: Natural Scientists in Policy-making" in Robert Gilpin and Christopher Wright, eds., *Scientists and National Policy-Making* (New York: Columbia University Press, 1964), pp. 3-6.

38. Philip J. Gummett and Geoffrey L. Price, "An Approach to the Central Planning of British Science: The Formation of the Advisory Council on Scientific Policy" *Minerva,* Vol. XV, No. 2 (Summer 1977), pp.120-143; Norman J. Vig, *Science and Technology in British Politics* (Oxford: Pergamon Press, 1968); and his "Policies for Science and Technology in Great Britain; Post-war Development and Reassessment" in Long and Wright, *op. cit.*, pp. 59-109.

39. Robert G. Gilpin, Jr., "Science, Technology, and French Independence" in Long and Wright, *op. cit.*, pp. 113-132; and his *France in the Age of the Scientific State*, *op. cit.*, chs. 6-7.

40. The creation of the National Science Foundation was recommended by Vannevar Bush in his report to President Harry S. Truman, entitled *Science: The Endless Frontier*. For a personal account of his role in the establishment of the NSF, see Vannevar Bush, *Pieces of the Action* (New York: William Morrow & Co., Inc., 1970), pp. 63-66. On the NSF, see Dorothy Schaffter, *The National Science Foundation* (New York: Frederick A. Praeger, 1969), pp. 7-13.

41. In Canada, a Special Senate Committee headed by Senator Maurice Lamontagne undertook an examination of past and present science policies in 1967. The Committee's findings and recommendations are embodied in its report, *A Science Policy for Canada* : Vols. 1 & 2 (Ottawa: Queen's Printer 1970 and 1972). Reactions to Vol. 1 of the Report showed that the question of planning versus freedom in science remained an important issue in Canada. See, for example, Harry E. Gunning, "The Lamontagne Report: A Simplistic Approach to the Complex Problem" *Science Forum*, Vol. 4, No. 2 (April 1971), pp. 7-8; "Senator Lamontagne replies to the critics of the Senate Science Report" *Science Forum*, Vol. 4, No. 3 (June 1971), pp. 9-13.

42. As Congressman Emilio Q. Daddario put it: "Science policy as defined by Congress has two distinct aspects. First, there is the body of *policy for science*. This policy is to assure the continuing health of science in the United States in terms of trained manpower, facilities, management and organizations, funding channels, information exchange, etc. The objective is to establish United States science as preeminent throughout the world and to enable the exploration of areas of promise as they are

perceived." See Emilio Q. Daddario, "Congress and Science Policy" in Arthur B. Bronwell, ed., *Science and Technology in the World of the Future* (New York: John Wiley & Sons, 1970), p. 226.

43. See, for example, OECD, *Ministers Talk About Science;* A report on the Ministerial Meeting on Science held at OECD, Paris, October 1963 (Paris: OECD, 1965); *Government and Allocation of Resources to Science and Fundamental Research and the Policies of Governments;* Background Reports for the Ministerial Meeting on Science, January 1966 (Paris: OECD, 1966); OECD, *Problems of Science Policy*; Report of a Seminar held at Jouy-en-Josas in February 1967 (Paris: OECD, 1968); OECD, *Science, Growth and Society: A New Perspective* (Paris, OECD, 1971); OECD, *Science and Technology in the People's Republic of China;* a Study based on a Seminar held in Paris in September 1976 (Paris: OECD, 1977); and OECD, *Reviews of National Science Policy: Belgium*, 1966; *France*, 1967; *United Kingdom-Germany*, 1967; *Japan*, 1967; *United States*, 1968; *Canada*, 1969; *Italy*, 1969; *Norway*, 1971; *Austria*, 1971: and others.

44. Among the topics discussed were "Education and Training" and "Science and Planning" See *Science and Technology for Development*; Report on the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas (New York: United Nations, 1963), Vols. VI and VII.

45. These reports form part of the UNESCO series, "Science Policy Studies and Documents" (SPSD) which has now reached report No. 41. The first report was *Science Policy and Organization of Research in Belgium*, SPSD, No. 1 (Paris: UNESCO, 1965).

46. As a guide to these surveys, UNESCO has issued a *Manual for Surveying National Scientific and Technological Potential; Collection and Processing of Data, Management and "R & D" System*; Science Policy Studies and Documents, No. 15 (Paris: UNESCO, 1970); and *Method for Priority Determination in Science and Technology*; UNESCO/UNACAST Surveys of Institutional Needs of Developing Countries in the Field of Science and Technology; Science Policy Studies and Documents, No. 40 (Paris: UNESCO, 1978).

47. UNESCO, *Science and Technology in Asian Development*; Conference on the Application of Science and Technology to the Development of Asia, New Delhi, August 1968 (Paris: UNESCO, 1970), pp. 103-104.

48. Edward Shils, ed., *Criteria for Scientific Development: Public Policy and National Goals* (Cambridge, Mass.: The M.I.T. Press, 1968), pp. xiii-xiv.

49. Stevan Dedijer, "Underdeveloped Science in Underdeveloped Countries" in Shils, *Ibid.*, p. 146.

50. Charles Cooper, "Science and Underdeveloped Countries", in OECD, *Problems of Science Policy, op. cit.*, pp. 155-162; Claire Nader and A. B. Zahlan, eds., *Science and Technology in Developing Countries*; Proceedings of a Conference held at the American University of Beirut, Lebanon, 27 November to 2 December 1967 (Cambridge University Press, 1969), p. xvi.

51. Graham Jones, *The Role of Science and Technology in Developing Countries* (Oxford: Oxford University Press, 1971), p. 36.

52. Dwight Waldo, "Planning and Administration for Viable Policies: The Perspective of Official Responsibility" in Nader and Zahlan, *op. cit.*, pp. 402-405.

53. *Ibid.*, p. 401.

54. Guy B. Gresford and Bertrand H. Chatel, "Science and Technology in the United Nations" *World Development*, Vo. 2, No. 1 (January 1974), p. 44.

55. "Dependence or Autonomy: UNCSTD's Hidden Agenda" *Nature*, Vol 280 (16 August 1979), pp. 525-526; "UNCSTD: What's to be Done? 14 Experts Comment", *Nature, Ibid.*, pp. 527-532.

56. Bernal, *op. cit.*, p. xxix.