

K. C. Abercrombie ("Population Growth and Agricultural Development," *Monthly Bulletin of Agricultural Economics and Statistics* [April 1969], pp. 1-9). These issues would likely play a greater role in a contemporary work.

But most of the points discussed in this book remain of basic importance and will be relevant for a long time to come. Thus the book has enough timeless qualities to earn its place easily on the shelf of anyone seriously interested in the economic aspects of agricultural development.

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Un clima para la ciencia. By Manuel Lora Tamayo. Madrid: Editorial Gredos, 1969. Pp. 150. Pts. 70.

El Opus Dei en España. By Daniel Artigues. Vol. I. Paris: Ruedo Ibérico, 1968. Pp. 169.

National Reports of the Pilot Teams, Science and Development, Spain. Paris: Organisation for Economic Co-operation and Development, 1968. Pp. 279; statistical appendix. \$3.80.

La educación en España: Bases para una política educativa. Madrid: Ministerio de Educación y Ciencia, 1969. Pp. 244. Tables. Pts. 100.

The retardation of scientific and technological development in modern Spain has been the subject of anxious and troubled discussion among Spanish intellectuals since the 18th century. Liberal thinkers such as the enlightened monk Benito Feijóo (1676-1764) and the histologist Santiago Ramón y Cajal (1852-1934) traced the roots of backwardness to the isolation of Spain from the rest of Europe and, equally, to the orthodox establishment's fear of new ideas. But recent studies of the censorship policies of the Inquisition, for example, have shown that it failed to erect a barrier totally impermeable to alien ideas. Modern ideas have been received in Spain; the problem lies in their scant diffusion.

The 19th-century conservative historian, Marcelino Menéndez y Pelayo (1856-1912), rejecting the notion that traditional Catholicism had been incompatible with modern science, sought to explain decadence by examining the internal structure of scientific research in Spain. In his view, Spanish scientific production since the 16th century has been mostly utilitarian in nature. Concentration on applied sciences such as metallurgy and the neglect of pure sciences such as mathematics and physics were at the heart of Spain's failure to produce any viable scientific tradition. Moreover, a faulty and incohesive university structure prevented individual scientific geniuses, which Spain has somehow been able to produce, from being able to pass

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along a tradition of pure scientific research to their successors.

Menéndez y Pelayo's critique forms the basis of Manuel Lora Tamayo's analysis of the problems involved in creating a "climate for science" in Spain. In Lora's view, that climate is to be created through the double process of state financial backing and promoting a high value for science in society, through education. The articles comprising the book are mainly public addresses given during Lora's tenure as education minister and concern themselves, on the one hand, with the formal institutionalization of science and the creation of a public science policy in Spain and, on the other, with problems of scientific education and the diffusion of scientific knowledge. In addition there are some chapters of general interest on the vocation of the researcher, the nature of research, and the nature of scientific truth. The most significant essays, however, are the two which deal with the progress and status of science in Spain at two distinct points in time, 1949 and 1969. In his introduction he states: "I consider that the rupture of the classical unity of knowledge, creating among its parts a mutual posture of indifference, is one of the signs of the crisis of the moment, and I firmly hold the belief in the necessity of a harmonic growth of all the sciences" (p. 10). The instrument for achieving a new unity of the sciences was the Higher Council for Scientific Research (*Consejo Superior de Investigaciones Científicas* [CSIC]) founded in 1939 at the conclusion of the Spanish Civil War. In the 1969 survey Lora gives a tally sheet of the CSIC's accomplishments as evidence of the progress of institutionalization of scientific activity in Spain (number of institutes affiliated with the CSIC, journals published under the CSIC's auspices, publications by Spanish scientists in foreign journals, membership of Spaniards in international scientific organizations and committees, etc.); it is an impressive catalog in scope but yields rather low absolute figures.

Asking whether the CSIC has been successful in promoting pure, as opposed to applied, science, Lora finds mixed results. In the 1949 survey, he noted that the private sector had been too dependent on imported patents and was not placing enough emphasis on domestic innovative research. He cited an absolute lack of technical research in Spain and stated that pure science must be linked to those sectors of the national economy which could benefit from its results. The lack of technical research, moreover, meant that the present generation of Spaniards did not have the clearly defined mentality which would permit the separation of the concept of technological research from that of immediate economic utility, a mentality which affected not only the industrialists but also the technologists of each industry. "From this," Lora writes, "it results that, in the immediate contact between our men of science and our businessmen a dialogue arises which, not through ill will, but through different interpretations of

the same words, understanding is made difficult, and the matter is frequently resolved by affirming the inutility of science, which today, naturally, is an authentic heresy in any half-civilized nation" (p. 130). Twenty years later, he notes that progress in the drawing together of the men of science and industry and an effective mixture of pure and applied research has been achieved in selected fields (e.g., metallurgy and nuclear energy).

Inasmuch as the CSIC looms large in recent scientific developments in Spain, Daniel Artigues's book on the Opus Dei is of particular interest. The Opus Dei is a Catholic lay order which has come to prominence since the Civil War, and most of whose members combine religious orthodoxy with political conservatism and economic progressivism. Among the more illustrious members of the group are leading technocrats who, both at the ministerial level and below, have sought to raise the Spanish economy to the Western European level.

The problem facing the victors of the Civil War was to reconstruct the intellectual and social elites of the country on a basis totally distinct from that of the prewar period. Since the end of the 19th century almost the entire intellectual and educational establishment had been secularist and nonobservant (when not outrightly anticlerical). With the Franco victory came a tremendous shakeup in the structure of the academic elite. By 1961 only one-third of the professors in service in 1936 still retained their chairs, and most of the new professors were orthodox Catholics. In this light, Artigues asks whether there might have been a concerted effort by the Opus Dei to appropriate as many professorial chairs as possible and "conquer" the educational establishment (a coup is indicated, really, since until quite recently a cloak of semisecrecy surrounded the membership and activities of the group). Although the Opus was not generally successful in this endeavor, the CSIC was an exception; its secretary general from 1939 until his death in 1966 was José María Albareda, a soil chemist and Opus member, who was ordained a priest in 1959. Other key Opus men like Alfredo Sanchez Bello were likewise involved in the inception of the council. This early infiltration, in Artigues's view, gave the Opus a good springboard from which to influence the Spanish intelligentsia in general and the scientific community in particular.

Personally, I reject Artigues's insinuations of a conscious conspiracy on the part of the Opus. More significant than any supposed political machinations is the common philosophy which Opus members share and the place which science holds therein. The prologue of the decree establishing the CSIC insists upon "the necessary re-establishment of the basic Christian unity of the sciences, destroyed in the eighteenth century. . . . One must impose, in sum, with the aid of education, the essential ideas which have inspired our glorious movement, in which the purest lessons of the universal Catholic tradition

are united with the exigencies of our own epoch." The ideal of the catholicization of science which this quotation suggests and which is echoed in the previously cited passage from Lora Tamayo (not a member of the Opus) suggests that the men who control the scientific establishment in Spain, even those who are scientists themselves, do not accord to pure science the central place in their world view that their counterparts in other Western nations do. Evidence for this assertion can be found, to skip ahead for a moment, in the First Development Plan, largely the work of Alberto Ullastres, former Trade Minister and an Opus man. (The present head of the Development Plan, Laureano López Rodó, is also a member of Opus Dei.) According to the Organisation for Economic Co-operation and Development (OECD) report, scientists were not involved in the preparation of the plan and, moreover, "low priority given to scientific research by the economists is reflected not only in their failure to include scientists when preparing the overall plan but also in the low volume of resources allotted to research" (p. 125).

In this light, it becomes necessary to reexamine Lora's dictum concerning the lack of scientific tradition in Spain and the break in the unity of the sciences. It seems clear that these themes, which have been articulated since the time of Menéndez y Pelayo, are basically a frightened reaction to the rise of secular science and education and all that those concepts entail for conservative and orthodox religious values. The reaction is not to some vague break in tradition sometime in the 18th century but to the secular domination of science and education in Spain prior to 1939. A good case can be made for the growth of a solid, secular, mainstream scientific tradition in modern Spain, culminating in Ramón y Cajal and his school but represented as well by more than a few serious research centers and researchers in a variety of fields. This tradition was totally unpalatable to the victors of 1939, who had then to reach back and breathe life into the views of Menéndez y Pelayo, who in his own time had been fighting a losing rearguard action.

The report of the OECD pilot team is basic to understanding the current problems of science and development in Spain. It was carried out in tandem with the work of Lora's ministry and, not unnaturally, reflects a great many of Lora's preoccupations. It begins with an eloquent, almost passionate, call for a restructuring of Spanish attitudes toward science: "In the case of an ancient society like that of Spain, which has inherited an essentially literary and artistic culture and possesses cultural institutions (universities, academies, etc.) founded at a time when science played a less important part in national life, the need to catch up with the scientifically advanced countries leads more or less directly to the reshaping of all institutions and all ideas" (pp. 9-10).

As a comment on Lora's call for the institutionalization of science, the first part of the report ("Existing institutional structure and R&D activity") makes fascinating reading. The research institutes, particularly those affiliated with the CSIC, are described in detail, as are the governmental bodies in charge of research policy. The team's conclusion is that, although "from the formal standpoint at least, Spain possesses an entirely adequate number of executive or advisory institutions to provide . . . for the preparation of an overall science policy. . . . This institutional set-up is not operating as efficiently as might be desired" (pp. 21-22). The CSIC, for example, functions wholly within the Education Ministry, and therefore coordination with research institutes in other ministries has been difficult or impossible. When figures are given, the conclusion that scientific planning has been inadequate turns out to be quite an understatement: "Were it not for the fact that there is abundant scientific output of high quality, the above data and those given below for expenditure per researcher would seem to indicate the impossibility of carrying out any effective research at all. It is impossible to see how one could organise any systematical scientific activity with such resources" (p. 30).

Here indeed is the paradox of modern Spanish science, which has been able to produce, for example, a school of first-rate histologists, on the basis of minimal resources. The OECD team remarks on having observed ingenious makeshift instruments in Spanish laboratories which the scientists have devised from sheer desperation and lack of funds, a description hauntingly reminiscent of Cajal's description of the meagerly equipped laboratories of his own student days in the middle of the last century.

The second part of the OECD report ("Towards a methodology for the planning of research expenditures") concentrates in large part on the agricultural sector but stresses—as did Lora—the problem of foreign patents as a central symptom of Spain's developmental problems. The introduction of foreign techniques in the form of patents, contracts, etc., has enabled Spain to make substantial strides toward industrial modernization, especially in the last fifteen years. Today, however, the need to develop competitive exports drastically changes the situation. "In the medium and long term, only manufactures based on Spanish scientific and technical research and patented by Spanish research centres or firms can contribute to export expansion." Here, from another angle, the need for substantial increases in government R&D expenditures appears again. Research has not made a tangible contribution to Spain's recent substantial economic growth. The First Development Plan did little to rectify the situation, and the educational structure, especially in engineering research, is notably weak.

Lora Tamayo's successor, José Luis Villar Palasi, has undertaken

the first necessary step in educational reform, outlined in the ambitious White Book, *La educación en España*. The White Book envisions a general restructuring of the entire educational system, the major ends being the modernization and democratization of education in Spain. This is entirely laudable, in fact revolutionary. But in the light of the OECD report, the comparative lack of emphasis on science (technical education comes off somewhat better) in the White Book is significant. The sections of the plan devoted to science education (pt. 1, secs. 56, 205–213; pt. 2, secs. 71–74) do no more than reiterate some of the conclusions and suggestions of the OECD report.

The Spanish establishment, both educational and governmental, retains, in my opinion, a world view in which science and scientific research are not highly enough valued. Possibly judgment must be withheld on this score, for at the present juncture in Spanish history there may justifiably be higher priorities. In any case, the debate has been joined.

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The Sciences of the Artificial. By Herbert A. Simon. Cambridge, Mass.: M.I.T. Press, 1969. Pp. xii + 123. \$5.95.

This is a slightly revised version of the Karl Taylor Compton Lectures given in the spring of 1968 at the Massachusetts Institute of Technology by Professor Simon. The final chapter, "The Architecture of Complexity," originally appeared in the *Proceedings of the American Philosophical Society* (December 1962). The general purposes of the treatise are "to explain how a science of the artificial is possible and to illustrate its nature" (p. xi). Both tasks are suggestively and briefly, but nonetheless quite persuasively, accomplished.

The artifacts of primary interest to Simon are digital computers. Because a number of kinds of computers have been developed, it is possible to write a "natural history" of them, to "build a general—but empirical—theory of them" (p. 20). Such a theory would be concerned with their "broad functional characteristics" rather than their hardware. These "characteristics" seem to be their problem-solving behavior more than anything else. By codifying such behavior in the form of various sorts of strategies for satisfactorily solving various types of problems, we obtain the content of a "science of design" which is a fundamental part of the content of the "science of the artificial."

Simon hypothesizes that, "*A man, viewed as a behaving system, is quite simple. The apparent complexity of his behavior over time is largely a reflection of the complexity of the environment in which he finds himself.*" Insofar as man is regarded as a problem-solving behaving

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