HoST
JOURNAL OF HISTORY OF SCIENCE AND TECHNOLOGY

Vol. 3 | Fall 2009

The Fascistization of Science

Journal of History of Science and Technology
ISSN 1646-7752
www.johost.eu

Cover

National Agriculture Experiment Station (Estação Agronómica Nacional), 1948.
The first Portuguese national laboratory was inaugurated in 1936, three years after the fascist constitution of 1933, to make the Portuguese landscape Portuguese.

Journal of History of Science and Technology

Vol.3, Fall 2009

ISSN 1646-7752

www.johost.eu

Published by

Interuniversity Centre for the History of Science and Technology

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The Fascistization of Science

*By Tiago Saraiva**

The current issue of HoST explores the polemical relation between science and fascism. In addition to the traditional aim of revealing the changes in scientific practices following the establishment of fascist regimes, it delves as well into the role of scientists and engineers in conceiving and materializing new political and social designs. By shifting the centre of attention from antiscientific practices to the work of the many scientists involved in the construction of a fascist society, historians started to produce already in the 1980s relevant accounts of the importance of scientific institutions for Nazi Germany.[1] As scientists and engineers adapted their practices to the opening up of opportunities as well as the imposition of restrictions by the new rule, political dreams were enlarged by technological innovations and laboratory work. Such approach proved highly productive as asserted by the copious literature that came out of the research program fostered from 1999 to 2004 by the Max Planck Society on the "History of the Kaiser Wilhelm Society in the National Socialist Era". [2] Although such research offered a complete renewal on the understanding of science and Nazism, a more general comparison with other fascisms was never tried.

In this volume of HoST the Nazi case is placed side by side with Mussolini's regime as well as with Salazar's dictatorship in Portugal. If general historians dealing with fascism find much attraction in comparative perspectives, historians of science and technology have not yet faced the challenge of confronting simultaneously different national experiences with fascism. There is much talk of a new consensus emerging among historians on the meaning of fascism, famously summarized by Roger Griffin as a "palingenetic ultra-nationalism", a force "ideologically driven" to "create a new type of post-liberal national community that will be the vehicle for the comprehensive transformation of political, social and aesthetic culture, with the effect of creating an alternative modernity."[3] This consensus, although unsurprisingly not shared by each and every historian, had the virtue of offering a general framework for dealing with fascist ideology and movements in different contexts and opening up the field for cross country comparisons. A short look at the contents of the journal Totalitarian Movements and Political Religions, the main written vehicle of the referred consensus, is enough to demonstrate its fruitfulness.

Now, strictly following historians of generic fascism, there is an important difference between regimes rising from successful fascist mass movements, as in Italy and Germany, and those authoritarian dictatorships of the inter-war years, such as Salazar's and Franco's regimes. Only the first two should be considered properly as fascist, while the others, in the best case, were to be included in the category of para-fascism for not having the revolutionary ideological vision of proper fascism. As Aristotle Kallis has convincingly argued, such distinction between para-fascist and fascist is very problematic when considering "that the two most developed regimes (in Italy and Germany) resulted from elite co-opting, initial co-habitation with conservative sponsors and consolidation from within the framework of the existing state (rather than a revolutionary break with the past, as fascist ideology would have demanded)".[4] In other words, if one pays closer attention to the actual historical nature of regimes at work, and leaves aside much of the common obsession with fascist movements and their radical ideologies, the sharp distinction between fascist and para-fascist regimes looses most of its relevance. Following Kallis, the process of 'fascistization', either from above directed by traditional elites, or from below demanded by radical fascist movements, is the key phenomenon historians should be looking at.

This demand for greater historical sensitivity to regimes rather than just to ideology resonates nicely with the above mentioned tendencies among historians of science dealing with Nazi Germany. Only by delving in the actual historical dynamics of fascist regimes is one able to grasp the relevance of scientific activities for the experience with fascism. Such trend has a fine example in Thomas Wieland's paper in the present issue, "Autarky and Lebensraum. The political agenda of academic plant breeding in Nazi Germany." Drawing on an analytical framework proposed by Mitchell G. Ash in 2002, Wieland explores the mutual resources exchanges between the realms of academic plant breeding and politics in the Nazi years. He importantly demonstrates how the growing role of state sponsorship of plant breeding can only be understood by taking into consideration the history of the discipline prior to the Nazi seizure of power. The agendas of autarky and lebensraum, or at least colonialism, were already important for plant breeders much before 1933 and they had no problems in seizing the opportunity of putting them into practice under a new regime cherishing both concepts. Plant breeders had of course previous experience of state sponsorship, but drawing on those two key issues the relations between scientists and political regime became much tighter with increasing exchange of resources and with plant breeding achieving a notable status in the eastern expansion of the Reich.

Tiago Saraiva, in his paper "Laboratories and Landscapes: the Fascist New State and the Colonization of Portugal and Mozambique", also underlines the importance of tracing back the genealogy of food and energy autarky projects to properly understand their role in the institutionalization of the fascist regime. The laboratories he deals with are very good examples of the ability of scientists to make their work relevant for the political agenda of Salazar's New State. Saraiva looks at the ways laboratory artifacts such as new strains of wheat and cotton, and models of dams, changed Portuguese and African landscapes according to the regime's colonization policies. He suggests that the contrasting political allegiances of the different scientists didn't hinder their active role in the New State endeavours. Never mind they were enthusiasts, indifferent or opponents, they all forged strong alliances with the corporatist state structure, materializing their new relation in profound changes in the landscape.

This view is somehow divergent from the one offered by Júlia Gaspar, Maria do Mar Gago and Ana Simões in their paper "Scientific Life Under the Portuguese Dictatorial Regime (19129-1954): the Communities of Physicists and Geneticists." By focusing in a different set of scientists the authors illuminate the many difficulties in pursuing scientific activities under a dictatorial regime and the exposure of the scientific community to political persecution. Nevertheless they also identify the constant search of both physicists and geneticists to present themselves as important actors to the State. If the latter seemed to have been quite successful already in the 1930s, the first would have to wait till the 1950s and the nuclear energy project to be granted a research institution they had been claiming for many years before. Instead of making a general claim about fascism and science, the paper stresses the importance of taking seriously the regime's historical dynamics to understand the success or failure of different scientific research agendas. This is only more important in the Portuguese case with its long dictatorial regime inaugurated in 1926 and overthrown in 1974.

Interestingly enough Júlia Gaspar, Maria do Mar Gago and Ana Simões, as well as Tiago Saraiva, also make use of Mitchell Ash's framework of "resources for each other". If general historians strive for a new consensus for the study of fascism, it doesn't seem exaggerate to risk that for historians of science Ash's "resources" have become a very fruitful way to intertwine science and fascism in a dynamic relation. If with the previous mobilization metaphors we had passive scientists limited to answering political powers initiatives, we now have scientists that actively strive for the establishment of stronger ties with the new regimes. And although Roberto Maiocchi in his paper, "Fascist Autarky and the Italian Scientists", doesn´t use Ash, his narrative details the enduring efforts of scientists of the National Research

Council (NRC) to develop lines of research in tune with two major endeavors of Mussolini's regime: autarky and empire. Maiocchi coincides with all other authors in the importance of previous relations between scientists and the state, namely those carved during the First World War. Fascist years ought to be understood as a tightening of such relations with particular support for those projects able to resonate with issues of autarky and empire. Now, Maiocchi's story is one of clear failure, with the NRC never making any serious contribution to the autarky efforts. This is only more striking when thinking that the Italian story is probably the one where scientists were more willing to align their research with the regime's policies. For independently of judgments about failure or success of the NRC it is remarkable the enduring effort of its scientists to make themselves useful for a regime that had many doubts about how to mobilize them for its interests. This is a clear case of auto-mobilization, with NCR scientists not being able to actually offer any significant resources to the fascist regime.

These four papers are of course insufficient to draw any definitive conclusions about the contested relation between science and fascism. Nevertheless this first confrontation of different national experiences with fascism point to at least four important common features: i) continuities between research programs undertaken previously to the fascist seizure of power and afterwards; ii) tighter integration of science and state under fascist rule; iii) strong auto-mobilization of scientists willing to prove useful for the regime iv) autarky and empire as key issues for the 'fascistization' of science.

The volume closes with a paper by Mark Walker on "Ideologically-Correct Science: The French Revolution", based on a thoughtful reading of Charles Gillespie's work on Science and Polity in France.[5] Such closing may look odd for an issue dedicated to fascism. Of course that any historian familiar with the scholarship on science and Nazism will immediately recognize the name of Mark Walker as one of the main experts in the field. Suffice to recall the edited volumes we already referred to or his work on the Nazi nuclear program.[6] And the truth is his contribution to the current volume of HoST is of great value to anyone dealing with science and fascist regimes. This paper is part of a wider project of comparing "ideologically-correct science" (ICS) in the context of the French Revolution, the Russian Revolution and subsequent Stalinist regime, National Socialism in Germany, Imperial Japan during the Second World War, the McCarthy period in the United States, and the Cultural Revolution in Communist China. Walker has no doubts in concluding that the main lesson from ICS is the tighter integration of science and the state in all those different contexts. This of course resonates very well with the rest of the papers in the volume. But maybe more important, by dialoguing in such depth with the work of Charles Gillespie, Walker also challenges all those historians dealing with science and fascism to entail a dialogue with the rest of their discipline. General historians have abandoned long ago the thesis of fascism as an exceptional event of Western history, totally out of context of our experience with modernity. Walker seems to suggest that the time has come to leave behind exceptionalism in the historiography on science and fascism, inscribing it instead in the canon of the history of science.

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[1] See namely, Herbert Mehrtens, "The social system of mathematics and National Socialism: a survey", Sociological Inquiry, 57 (1987): 159-187. Such approach for dealing with science and Nazism is dominant in the influential volume, Monika Renneberg and Mark Walker, eds, Science, Technology and National Socialism (Cambridge University Press, 1994).

[2] For an overview of the results of the research program see, Susanne Heim, Carola Sachse and Mark Walker (eds.), The Kaiser Wilhelm Society under National Socialism (Cambridge University Press, 2009).

[3] Roger Griffin, "Introduction: God's Counterfeiters? Investigating the Triad of Fascism, Totalitarianism and (Political) Religion", Totalitarian Movements and political Religions, 5 (2004): 291-325

[4] Aristotle A. Kallis, "Fascism, Para-Fascism and Fascistization: On the Similarities of Three Conceptual Categories", European History Quarterly 33 (2003): 219–249.

[5] Charles C. Gillispie, Science and Polity in France at the End of the Old Regime (Princeton: Princeton University Press, 1980); Charles C. Gillispie, Science and Polity in France: The Revolutionary and Napoleonic Years (Princeton: Princeton University Press, 2004).

[6] Mark Walker, Nazi Science: Myth, Truth, and the German Atomic Bomb (New York: Perseus Publishing, 1995).

Autarky and Lebensraum. The political agenda of academic plant breeding in Nazi Germany[1]

By Thomas Wieland *

Introduction

In a 1937 booklet entitled Die politischen Aufgaben der deutschen Pflanzenzüchtung (The Political Objectives of German Plant Breeding), academic plant breeder and director of the Kaiser Wilhelm Institute (hereafter KWI) for Breeding Research in Müncheberg near Berlin Wilhelm Rudorf declared: "The task is to breed new crop varieties which guarantee the supply of food and the most important raw materials, fibers, oil, cellulose and so forth from German soils and within German climate regions. Moreover, plant breeding has the particular task of creating and improving crops that allow for a denser population of the whole Nordostraum and Ostraum [i.e., northeastern and eastern territories] as well as other border regions…"[2]

This quote illustrates two important elements of National Socialist ideology: the concept of agricultural autarky and the concept of Lebensraum. The quest for agricultural autarky was a response to the hunger catastrophe of World War I that painfully demonstrated Germany's dependence on agricultural imports and was considered to have significantly contributed to the German defeat in 1918. As Herbert Backe (1896–1947), who became state secretary in 1933 and shortly after de facto head of the German Ministry for Food and Agriculture, put it: "World War 1914–18 was not lost at the front-line but at home because the foodstuff industry of the Second Reich [i.e., the German Empire] had failed."[3] The Nazi regime accordingly wanted to make sure that such a catastrophe would not reoccur in a next war. In addition, reducing agricultural imports should help towards saving foreign currency that was needed for the purchase of military equipment.

The concept of Lebensraum implied the military expansion of Germany towards Eastern Europe that should become the new living space for a genetically improved German master race, whereas the native population was planned to be enslaved, deported, and killed. The vision of Lebensraum was that of a vast, self-sufficient territory based on an autarkic agricultural economy. Hence, the concepts of autarky and Lebensraum were tightly linked together. This linkage is also obvious in another quote from Rudorf's booklet claiming that the German territory was far too small for the feeding of its population.

Rudorf's public support for Nazi policies might not be surprising. As director of the internationally renowned KWI for Breeding Research, he held a highly visible position in the German agricultural research system. Moreover, Rudorf owed his career to the intervention of the Nazi regime that forced the Kaiser Wilhelm Society in 1936 to appoint him director of the institute despite the vote of an expert committee doubting his qualification for the position.[4] Yet, his statement was more than lip service. As we will see in the following, the majority of German academic plant breeders was quite willing to support and implement Nazi policies: academic breeders focused their research on crops that should help towards the closing of the so-called "protein, oil and fiber gap" and the appropriation of Eastern Europe, they established new research institutes to further these objectives, and some of them even collaborated with Hitler's infamous Schutzstaffel, the SS, and the Auschwitz concentration camp.

How can we understand the positive response of academic plant breeders to the Nazi policies of autarky and Lebensraum? My answer draws on an analytical framework proposed by Mitchell G. Ash in 2002.[5] Borrowing from science and technology studies (STS), Ash argues that the relationship between science and politics can best be studied in terms of a mutual exchange of resources which can be financial, cognitive, personal, institutional, rhetoric etc etc. Accordingly, the evolution of the science-politics relationship—and in particular the continuities and discontinuities in the development of science—can be understood as subsequent reconfigurations of "resource ensembles." Informed by this framework, I will argue that while the Nazis' assumption of power brought about some significant changes in the concrete mechanisms and the intensity of resource exchange between the realms of academic plant breeding and politics, the basic patterns of this exchange had already been in place before. As a consequence, it is only by taking the early history of academic plant breeding into account that we can fully comprehend the reasons for the striking willingness of the scientific community to work for the National Socialist sate. As we will see, agricultural self-sufficiency and expansionism or colonialism, respectively, had been on the political agenda of German academic plant breeders long before the Nazis came into power.

Academic plant breeding before 1933

In Germany, the systematic breeding of field crops can be traced back to the middle of the 19th century when market gardeners, beet sugar manufacturers and progressive farmers—most of them based in the Prussian province of Saxony and its adjoining regions—sought to increase yields by the hereditary improvement of sugar beet, potatoes, and cereals. Within a short period of time, a prosperous seed industry came into being that soon sold its products to farmers all over Germany and in many other European countries. Yet it was not before the late 19th century that plant breeding entered academia.[6]

The first series of lectures exclusively devoted to the subject was held at Göttingen University in 1889 by Privatdozent Kurt von Rümker (1859–1940), who worked hard to establish plant breeding as an academic discipline. Thanks to his efforts the breeding of field crops had become a subject of research and teaching at several German universities by the eve of the First World War. Its disciplinary status remained nevertheless uncertain. As a matter of fact, plant breeding stood in the shadow of more traditional agricultural disciplines, above all crop production. Furthermore, academic plant breeders—like other agricultural scientists in Germany—suffered from a low reputation among the largely urban professoriate.[7]

In order to further improve the status of their discipline and to gain material and symbolic support from the state, academic plant breeders were keen to relate their subject to issues beyond the economic interests of farmers and the seed industry. An early issue of concern was the promotion of agricultural development on a regional level that led to the establishment of state-owned breeding institutes in Bavaria, Württemberg, and Baden shortly after the turn of the century. When, under Kaiser Wilhelm II, German nationalism rose to unknown heights and finally erupted into World War I academic plant breeders were able to establish a much broader framework for their scientific activities. Indeed, they presented plant breeding as a way to secure the national interests of the German Empire. Ludwig Kühle, chairman of the Society for the Promotion of German Plant Breeding, announced: "To further plant breeding means to increase the Empire's instruments of power."[8] Consequently, the major political issues taken up by academic plant breeders in late imperial Germany were colonialism and agricultural self-sufficiency.

Germany's transformation into a colonial empire played an important role in the nation's self-perception as a rising military power. In addition to their symbolic importance, the German colonies were considered territories for agricultural exploitation by the motherland.

The initial focus of agronomists and state officials was not on plant breeding but the transfer of new crops to the colonies in order to broaden the spectrum of agricultural production.[9] Because academic plant breeders were relatively late to discover colonial agriculture as an opportunity to develop their discipline, they were all the more eager to promote plant breeding as a means for the implementation of national policies when they entered the field.

For instance, Theodor Roemer (1883–1951), who went in the early 1910s on behalf of the German Colonial Office to East Africa for the establishment of a cotton breeding station, argued after his return that plant breeding has to be considered the most effective tool among the technologies for the development of colonial agriculture.[10] About the same time, academic plant breeder Carl Fruwirth (1862–1930) also thought it was time "to talk on the objectives of plant breeding in the colonies."[11] Fruwirth chose the 1914 meeting of the renowned German Agricultural Society for his talk, ensuring thus a wide audience. Two years before, he had already devoted the fifth volume of his famous handbook of plant breeding to the improvement of colonial crops. In so doing, Fruwirth established a highly visible link between his discipline and the nation's political ambitions.

Germany's colonial history ended with its defeat in World War I. As a consequence, colonial plant breeding lost a great deal of its political and scientific significance. The general idea to appropriate foreign territories by the breeding of new crop plants did not vanish, however. As we will see, the idea experienced a strong revival in the context of Nazi expansionism although its main geographical focus was not Africa but Eastern Europe.

The second major issue of national interest taken up by academic plant breeders even before World War I was Germany's strong dependence on agricultural imports. In 1912, Kurt von Rümker—by then a full professor at Berlin Agricultural College—warned that agricultural dependence would make the nation highly vulnerable in a possible war with its neighbors. Of course, he did not forget to advertise plant breeding that would rank "among the most effective tools" for securing the feeding of the German population from domestic production.[12] Rümker's colleague Theodor Remy (1868–1946) of Bonn-Poppelsdorf Agricultural College argued in a similar way claiming that agricultural self-sufficiency was a "national goal" of plant breeding.[13]

How much Germany actually depended on foreign agricultural products became obvious during the First World War when the British imposed an economic blockade that cut Germany off from important supplies of food and raw materials. The blockade led to a severe food shortage. The situation worsened due to some other factors such as a bad harvest of potatoes in 1916. As a consequence, large parts of the German population suffered hunger—an experience that powerfully shaped the nation's collective memory. The "hunger catastrophe" of World War I provided academic plant breeders with a strong argument in their attempt to mobilize symbolic and material resources for their discipline. This is particularly evident in the various efforts of the noted geneticist and plant breeder Erwin Baur (1875–1933).

In 1917, Baur co-authored a memorandum for a plant breeding institute to be established under the umbrella of the Kaiser Wilhelm Society, Germany's outstanding organization for the advancement of science. The goal of the proposed institute was to help Germany towards agricultural self-sufficiency by applying modern genetics to plant breeding. The memorandum argued that this new approach allowed for a substantial increase in agricultural productivity and for the creation of novel crops. It also considered the foundation of subsidiary institutes in the German colonies in order to promote colonial agriculture in line with the aims and objectives of the motherland.[14]

Due to financial problems, the Kaiser Wilhelm Institute for Breeding Research was only established in 1928. Yet, its political agenda had not changed in the meantime. On the contrary: Baur who became the first director of the institute had developed into an ardent advocate of autarky. He used every opportunity to deplore Germany's dependence on imports and to present plant breeding as a powerful means to overcome it. Baur could provide some evidence for his claims. In 1930, he announced the successful breeding of a novel crop. The so-called "sweet lupin" became the emblem of modern plant breeding in interwar Germany. Since the sweet lupin was rich in proteins and could be cultivated on the sandy soils of East Germany it seemed to be an ideal fodder plant. According to Baur, the novel crop would allow without any problems for the domestic production of all the protein needed for the feeding of the German people.[15] Although this was never realized, in the public perception the sweet lupin proved the omnipotence of modern plant breeding. Furthermore, the problem of autarky now seemed to be a technical rather than a political problem, solvable by the application of modern genetics. It is therefore not surprising that the National Socialist state showed great interest in the sweet lupin that was also called the political lupin.[16]

To summarize: when the Nazis came into power in 1933, expansionism and autarky had already been on the political agenda of academic plant breeders for quite some time. Moreover, academic plant breeders had started to translate this agenda into research programs. This holds especially true for the quest for autarky; the sweet lupin is but one example.

A boost for academic plant breeding

From the very beginning, National Socialist policy aimed at the preparation of domestic agriculture for a future war.[17] Accordingly, agriculture was one of the first sectors subjected to Gleichschaltung (i.e., forced alignment). The development reached its first climax in September 1933 when all people involved in the production and distribution of agricultural products had to join the Reichsnährstand organization. About one year later, the German Minister for Food and Agriculture Richard Walther Darré (1895–1953), who headed the new organization, proclaimed a national food campaign, the so-called Erzeugungsschlacht. Its aim was twofold: (1) maximizing agricultural productivity and (2) shifting agricultural production from surplus commodities to scarce commodities. More specifically, the goals were to increase yield performance, to cultivate crops which allowed livestock farming on a domestic fodder basis, and to provide oils, fats, and fibers for the foodstuff and textile industries.

In order to coordinate the work of German agricultural scientists and to direct their research towards policy goals, in 1934–35, a group of scientists and Nazi officials established the Forschungsdienst (i.e., research service) that comprised all agricultural scientists from universities and research institutes across the country. The prime mover behind this establishment was the consultant of the Prussian Ministry for Education Konrad Meyer (1901–1973), who became chairman of the Forschungsdienst. An agricultural scientist himself and, since 1933, a member of the SS, Meyer became a powerful science organizer during National Socialism. He was director of the Institute for Agriculture and Agricultural Policy at Berlin University, member of the Prussian Academy of Science, and, in 1936, Vice President of the German Research Association to name but a few of his positions. Having an expertise in regional planning, Meyer became head of the Hauptabteilung "Planung und Boden" (i.e., central department for planning and soil) at the main office of the RFK (i.e., the Reich commissioner for the reinforcement of Germandom) where he led the work on the Generalplan Ost.[18]

The Forschungsdienst was subdivided into seven sections, so-called Reichsarbeitsgemeinschaften, each headed by an agricultural scientist. Appointed by Konrad Meyer, the section head was responsible for the planning and coordination of research activities in his respective field. Head of the crop science and plant breeding sectionwas Gießen University's George Sessous (1876–1962), who emphatically declared that German plant breeding was called to join the glorious fight for the nation's self-sufficiency in food.[19] The actual research was handled by working-groups which usually comprised scientists from several universities and research institutes. For instance, the working group for fodder crop breeding was formed by researchers of the universities of Breslau, Danzig, Jena, and Munich, as well as the KWI for Breeding Research in Müncheberg.

The hierarchical structure of the Forschungsdienst seems to have allowed for an efficient coordination of research activities. The most important instrument for the governance of research however was the allocation of funds. Konrad Meyer, who had the ultimate power to decide about the assignment of funds, could draw upon money from various sources including the Ministry for Food and Agriculture, the Reichsnährstand, and the German Research Association. The latter was reorganized in 1937 and supplemented by the German Research Council.[20] Meyer became head of the agronomy and general biology section. The amalgamation of the Forschungsdienst and German Research Council organizations meant a tremendous increase in power for Meyer. This is reflected in the huge amounts of money he was able to distribute. Amounting to 31% of the council's overall funding budget in the period 1935–1943, the agronomy and general biology section had more money at its disposal than any other section of the council. In most years, the amount Meyer distributed even exceeded the amount of all other scientific and technical council sections taken together. Of course, these amounts do not only illustrate Meyer's powerful position within the German research system but also the strategic significance the National Socialist state attached to agricultural research.[21]

Although it is not possible to provide a detailed record of the money poured into the agricultural research system, evidence suggests that academic plant breeders could greatly benefit from funds provided by public and semi-public organizations—ranging from a diversity of ministries to the SS. As far as one can judge from the available sources, most applications for research grants had been successful,[22] and there was also a lot of money for the extension and support of research institutes. The main beneficiary of the financial windfall was undoubtedly the KWI for Breeding Research. In 1937–38, its budget exceeded the amount of RM 1 million and further increased to RM 2.1 million up until 1942–43. Staffed with 48 scientists, 95 technical assistants, and 300 semi-skilled laborers, the institute was by far Germany's biggest research institute for plant breeding in the early 1940s. Thanks to the massive funding, it established a series of branch institutes. Within the university system, in the early 1940s, the biggest institute for plant breeding was that of Theodor Roemer in Halle. Roemer employed twelve scientists, eight technical assistants, and 116 semi-skilled laborers.[23] Regarding its institutional and financial basis, academic plant breeding was certainly on its way up during the Nazi era.

Research for autarky

How did academic plant breeders translate Nazi policies of autarky into research projects?[24] To begin with, academic breeders generally shifted their focus to the development of crop varieties which could be put on the market. The National Socialist state promoted this shift in various ways. For instance, in 1939 a framework was established that regulated the cooperation between private and academic plant breeders.[25] While it was the duty of the private breeders to produce and distribute high-quality seed, academic breeders were to develop new crop varieties. Regarding the latter, the most urgent goal was—as George Sessous unfailingly emphasized—the "increase of yields" and "the closing of the protein, fat and fiber gap."[26] As a consequence, particular importance was given to plant varieties which were rich in these substances.

Sessous himself set a good example and initiated a research project on the soybean. This work was based on a collection of wild and cultivated varieties compiled in the 1920s by a botanist from the I.G. Farben. Due to the quality of its protein that can fully substitute for animal protein, the soybean was considered an ideal crop in the struggle for agricultural autarky. Yet, despite extensive efforts of many researchers and a generous support from state authorities, the soybean project proved largely a failure since it was not possible to adopt the plant to the conditions of cultivation in Germany.[27]

Other legumes than the soybean—for instance, alfalfa and seradella—were successfully developed into high-value fodder crops. Responsible for this line of work was a working group entitled "Breeding and Selection of Fodder Crops" that was coordinated by Friedrich Berkner (1874–1954) of Breslau University. As for oilseeds and fiber plants, academic breeders were mostly interested in rapeseed and closely related varieties, as well as in hemp and flax. The director of the Hamburg Institute for Applied Botanics Gustav Bredemann (1880–1960), for example, worked on a flax variety that was rich in both oil and fiber. He also tried to develop the stinging nettle into a first-class fiber plant. A curiosity of the time was the failed attempt by Max Koernicke (1874–1955) of Bonn University to breed olive trees for the cultivation under the climate conditions of Germany. In his grant application submitted to the German Research Association Koernicke successfully argued that one has to take every chance to overcome the domestic shortage in oils and fats.[28]

There are many more examples of exotic and not-so-exotic plants which academic breeders included into their research programs in order to meet the needs of agricultural self-sufficiency. In view of the striking interest in novel plants, it has to be emphasized that more traditional crops such as cereals and potatoes certainly remained important objects of academic breeding. There was, however, some change in breeding goals. For instance, the breeding of protein rich fodder barley was a sort of novelty in the Nazi era, since academic breeders traditionally tried to develop low protein barley for the brewing industry.

The great variety of oil, protein and fiber plants handled by agricultural scientists at universities and research institutes as well as the shift of breeding goals illustrate well the academic plant breeders' willingness to support and implement Nazi policies of autarky. Still, it would be mistaken to assume that academic plant breeders concentrated their efforts exclusively on the development of crop varieties. As a matter of fact, there was much basic research done at state funded institutes. Despite the general emphasis on yield maximization, breeding goals such as quality and resistance did not vanish. The realization of these goals however asked for basic research on subjects like plant-pest interaction. Furthermore, there was hope that new breeding methods such as species and genus crossings would help towards a more efficient development of new crop varieties, and here again basic research was a necessary prerequisite.

A rising field of basic research entered by academic plant breeders at the time was mutation research. It was generously supported by the German Research Association/German Research Council. About 17 percent of the money the organization spent for botanical work between 1934 and 1945 was poured into mutation research, and more than 80 percent of this amount was given after 1940.[29] Obviously, the National Socialist state considered mutation research important enough to be substantially promoted even during the war. The use of high energy radiation for breeding had been intensively studied at the KWI for Breeding Research and, since 1942, at the newly founded KWI for Research on Cultivated Plants in Vienna, Austria. At both institutions, it was Hans Stubbe (1902–1989), a pioneer in the use of high-energy radiation for breeding, who managed the work. Yet, it was Rudolf Freisleben (1906–1943) of Halle University who succeeded to demonstrate that high-energy radiation could indeed generate valuable mutations in crop plants. In 1941, Freisleben and his colleague Alfred Lein irradiated about 20,000 barley grains with X-rays, thereby achieving a mutant resistant to mildew.[30] The use of high-energy radiation has never become a standard method in plant breeding. Nevertheless, the work of Stubbe, Freisleben and other academic breeders demonstrates that even during the war there was room for basic research on the genetics of plants and on breeding methods.

Academic plant breeding and the expansion towards Eastern Europe

As aforementioned, colonial plant breeding lost a great deal of its scientific and political significance with the German defeat in World War I. But when Nazi expansionism became more and more tangible in the second half of the 1930s, academic plant breeders were keen to revive the discussion about colonialism.[31]

Theodor Roemer, who had already left for the African colonies in the mid-1910s "in order to bring German knowledge and character to bear under the tropical sun," once again turned his interests towards the former dependencies. In 1938, he argued that a German commitment in Africa could improve the domestic food situation, which—sure enough—was everything but problematic at the time.[32] Although Roemer's call for a return of former German colonies met the revisionist aims of National Socialist foreign policy, Hitler envisioned the country's new colonial empire in Eastern Europe rather than in Africa. Considering the quotation in the introduction of this article, the political instinct of Wilhelm Rudorf was certainly better developed than that of his colleague Roemer.

Nazi ideas on Lebensraum in Eastern Europe took shape in the Generalplan Ost commissioned by Heinrich Himmler (1900–1945) at the end of the 1930s. The principal author of the plan was Forschungsdienst chairman Konrad Meyer, who—as we have seen—also worked hard to direct agricultural research towards autarky. The Generalplan Ost aimed for the enslavement, deportation, and killing of Eastern Europe's native population that should be followed by a genetically improved German master race.[33] Since the economy of the envisioned Lebensraum should be based on agriculture, the Nazi regime considered agricultural sciences in general and plant breeding in particular as important instruments for the appropriation and transformation of Eastern Europe. This is evident from the establishment of several research institutes mainly, but not exclusively, operated under the umbrella of the Kaiser Wilhelm Society.[34]

A case in point is the German-Bulgarian Institute for Agricultural Research in Sofia that was the outcome of a 1940 agreement between the two countries to cooperate in the agricultural sciences. It had been initiated by Konrad Meyer and Dontscho Kostoff, director of Sofia's Central Agricultural Experiment and Research Institute. According to the 1941 foundation charter of the institute, Germany and Bulgaria were committed to equally share construction and support costs, as well as the management of the new institution. Kostoff should become "Bulgarian director" whereas the Kaiser Wilhelm Society—representing the German interests—favored Arnold Scheibe (1901–1989) as his German counterpart. Scheibe had just been appointed Professor for Agriculture and Crop Science at Munich Technical College. "In view of the great political, economic and scientific challenges which Germany will be facing in the future in the European southeastern territory," he nevertheless agreed to serve as temporary director during the establishment of the institute—though only in addition to his Munich professorship.[35]

At the laying of the foundation stone for the German-Bulgarian Institute in September 1942, the President of the Kaiser Wilhelm Society Albert Vögler (1877–1945) expressed his belief "that the results obtained here in the continental climate of the European Southeast will have a fundamental importance for the New Europe, too. That is because the main focus of pan-European agricultural production will be shifting to the territories of the European East and Southeast."[36] However, the establishment of the institute proceeded only slowly and stopped in September 1944 when Soviet troops marched into Bulgaria. At the beginning of that year, Scheibe, who considered the new institute a "focal point for German scientific work in the whole Balkans,"[37] had still received two grants from the German Research Council for the breeding of oil and fiber plants. Whether this work had actually been started is yet not known from the available sources.

Two further examples of institutions established in the context of Nazi expansionism are the KWI for Cultivated Plant Research in Vienna and the SS-Institute for Plant Genetics in Lannach near Graz. The scientific background of their establishment was the growing interest of academic plant breeders in wild-type forms of cultivated plants. Wild-types had been identified as carriers of valuable genes that could be transferred to cultivated relatives through cross breeding. In so doing, academic breeders hoped to improve crop traits like resistance to drought and frost. Since the mid-1920s, German academic breeders, such as Erwin Baur, had been making expeditions into the centers of origin of cultivated plants in order to look for and collect wild-types.[38]

Due to the growing interest of breeders in wild-type plants, in 1939, geneticist Fritz von Wettstein (1895–1945) argued for an institute for crop plant research to be established by the Kaiser Wilhelm Society. About the same time, members of Himmler's research and teaching community Das Ahnenerbe also developed the idea of founding an institute. Its objective should be to analyze the wild-type plants compiled during the 1938 expedition of the SS to Tibet. For several reasons, the establishment of both institutes had been delayed for some time. With the German attack on the Soviet Union in June 1941 the situation changed, however. The German troops took possession of parts of the Vavilov institutes network and its large assortments of wild and cultivated plants. In order to "safeguard and exploit"[39] these assortments, the Kaiser Wilhelm Society and the SS decided to speed up the establishment of the institutes. While the two organizations initially agreed on a joint institution, the struggle over its leadership finally let to the foundation of two competing collection and research centers in 1943.

The KWI for Cultivated Plant Research was provisionally housed in the Vivarium, the former Austrian Biological Experiment Institute located in the Vienna Prater. Hans Stubbe of the Baur school became the director. The main goal of the institute was to build up a comprehensive collection of wild-type forms of the cultivated plants of Germany and to use the collection for research in genetics and plant breeding; the assortments from the Vavilov institutes should be integrated into the collection. In addition to this long term goal, Stubbe wanted to perform mutation experiments on barley, peas, and beans. Though he was able to start working, the proceeding war brought an abrupt end to the research activities—just like in the case of the German-Bulgarian Institute in Sofia.

The SS-Institute in Lannach was set up and directed by Heinz Brücher (1915–1991), who, in June 1943, joined a task force established by the SS to rob the assortments of wild and cultivated plants from the Vavilov institutes in the occupied territories.[40] Drawing upon these assortments as well as on those of the 1938 SS Tibet expedition, Brücher wanted to start "breeding cold and drought resistant crop plants for the Eastern territory,"[41] With great fervor he also pursued the breeding of a Chilean composite plant, whose oil was supposed to be used as a fuel additive for aircraft engines. Due to its robustness, the composite was envisaged for the "light low-yield soils of the continental climate of the East." Himmler, who showed great interest in the work of the newly established institute, reserved the right to personally give a name to the novel oil plant. Due to the destruction of the institute by the end of the war, the research and development work did not proceed beyond an early stage in Lannach.

Kok-saghyz—the cooperation between Kaiser Wilhelm Society and SS[42]

How tightly coupled academic plant breeding and Nazi tyranny could be is well illustrated by a large project in which the Kaiser Wilhelm Society and Himmler's SS cooperated. The project was centered on the extraction of natural rubber from Kok-saghyz (Taraxacum bicorne)—a dandelion-like composite plant of the temperate zone. Pioneering Kok-saghyz cultivation, the Soviets had started to develop a large-scale process for the extraction of rubber from the plant roots in the 1930s.

For the German arms industry, rubber was of strategic importance due to its use in the production of military equipment, above all tires for jeeps and trucks. According to Hitler the growing demand for rubber should be met by Buna, the synthetic rubber of the I.G. Farben industry. Yet, in order to secure some material properties of the Buna rubber it was still necessary to add small amounts of natural rubber to its synthetic substitute, and thus German rubber production depended on imports of the natural product. In view of this dependence the Nazi regime welcomed the idea to produce natural rubber within its sphere of control. Kok-saghyz seemed to be an ideal plant for the task.

In order to produce natural rubber the Germans first had to get hold of the sought-after plant. Himmler, who claimed to have been pointed to Kok-saghyz in 1941 by Hitler himself, thus put the machinery of the SS Economic and Administrative Main Office in motion. After the attack on the Soviet Union, SS members were able to take possession of Kok-saghyz seeds which, in the spring of 1942, were planted at Rajsko, the agricultural station of the Auschwitz concentration camp. In charge of the field trials was agricultural scientist and station director Joachim Caesar (1901–1974), who had established the Rajsko facility at Himmler's disposition. To conduct breeding work on Kok-saghyz Caesar ordered the transfer of a group of appropriately skilled women from the Ravensbrück concentration camp to Auschwitz where they were put in a shack located on the Rajsko station's ground. As Caesar pointed out in an internal report this measure allowed for an easy control of the women prisoners because there was "always the possibility of a transfer to the much harsher conditions of the main camp."[43] When Auschwitz was evacuated at the beginning of 1945, the "commando group plant breeding" comprised 150 women prisoners as well as several German civilians, people from the SS, and Soviet scientists. Although the latter were not camp prisoners, they were also not allowed to leave the Auschwitz complex.

The breeding work done at the Rajsko station aimed at the increase of the rubber content of the Kok-saghyz plant. It was based on the method of mass selection. To speed up the selection process, the "commando group" simultaneously handled several thousand plants, the rubber content of which was analyzed in the station's chemical-technical laboratory headed by Caesar's wife. In 1943, the number of tested plants already amounted to 88,000. In addition to the chemical testing of single plants, the "commando group" carried out population research in order to disclose the genetic basis of traits such as growth behavior and flower formation. A significant outcome of this work was the demonstration that rubber content is indeed a hereditary trait of Kok-saghyz. Yet, it is not possible to judge from the available documents whether the breeding work at the Rajsko station actually led to a plant with a significantly improved rubber content.

The agricultural station at the Auschwitz complex was not the only institution interested in the breeding of Kok-saghyz. Since the mid-1930s, scientists of the KWI for Breeding Research in Müncheberg had been searching for rubber plants that could be cultivated in the German climate. It took some time before the academic breeders came across the Kok-saghyz plant of which they were able to obtain a seed sample through the Agricultural Research Institute in Puławy, Poland, in 1938.[44] Wilhelm Rudorf entrusted his assistant Richard Werner Böhme (1903–1945) with the task of analyzing this sample. Although the original seed yielded quite a heterogeneous population of plants, Böhme succeeded to isolate a group of plants that raised hopes for a rubber yield of 200 to 300 kilogram per hectare. In 1941, field trails already covered an area of 4 hectares most of which were part of the "Rotes Luch," a country estate near Müncheberg that offered ideal conditions for the cultivation of Kok-saghyz. Most of the Kok-saghyz research done at the Müncheberg institute focused on the development of suitable breeding and selection techniques. For instance, in a series of experiments Kok-saghyz plants were treated with the mutagenic substance Colchicine to induce polyploidy in hope for plant varieties with increased rubber content. Likewise, inheritance studies should answer the question of whether leaf shape and root seize were correlated—a fact that would have allowed to simplify the procedure of mass selection. Additionally to their breeding research, the institute scientists worked on questions concerning the cultivation of Kok-saghyz (e.g., the question of the most suitable soil conditions).

Böhme pushed the work forward with the utmost diligence, using all means available. This included the use of forced labor and a tight cooperation with the agricultural station at the Auschwitz complex. Wilhelm Rudorf, director of Germany's largest institute for breeding research, supported all of Böhme's activities.

In June 1943, shortly after Himmler had been appointed special representative of plant rubber, a workshop was held in the SS Head Office in Berlin dealing with the breeding and cultivation of Kok-saghyz. Among the participants were numerous renowned agronomists such as the director of the Puławy Agricultural Research Institute Friedrich Christiansen-Weniger (1887–1889), the director of the Berlin Institute for Genetics Hans Kappert (1890–1976), and the head of the East Prussian branch of the KWI for Breeding Research Walther Hertsch (1901–1975). In order to better coordinate Kok-saghyz work Himmler ordered the formation of several working groups, each with a different focus. Wilhelm Rudorf, who introduced the prospected work program to the participants, and Werner Böhme got the responsibility for basic research while Joachim Caesar took over practical breeding work.

Considering the single-mindedness with which Himmler promoted the Kok-saghyz project, Rudorf and Böhme hoped for an increase in their research budget. Böhme developed the idea to turn the Rotes Luch estate into an institute for plant rubber. His plan included a chemical-technical laboratory, 50 to 100 hectares of land for cultivation and breeding, and a staff of about 90 people. As Böhme emphasized, the advantage of the country estate was that neighboring woods would not only protect the location from migrating weeds but also from an over-interested public.[45]

The Böhme plan did not find much approval. Rather than supporting the foundation of a new institute, the SS pushed for an expansion of the Auschwitz capacities. Rudorf, Böhme, and Caesar thus met with Hans Stahl, Himmler's Stabschef (i.e., captain) for plant rubber, in order to negotiate the transfer of basic research on Kok-saghyz from the Müncheberg institute to the Auschwitz concentration camp. From an organizational perspective, this meant the "merging of a division of the KWI for Breeding Research with the station in Auschwitz."[46] Rudorf consequently remained in charge of basic research, while on-site work should be coordinated by Böhme, who—after his appointment as SS-Sturmbannführer—took office in Auschwitz.[47]

When the Germans left Auschwitz in January 1945 because of the advancing Soviet troops, the women prisoners of the "commando group plant breeding" were transferred to the Ravensbrück concentration camp. The Rajsko breeding station moved to Büschdorf near Halle, where the Soviet scientists were also brought. At the end of the war, when the German scientists took flight, the American military government asked academic plant breeder Theodor Roemer of Halle University to carry on the Kogsaghyz work. Roemer, who was perfectly informed about the project, however refused "to take charge for 13 Russian scientists while 80 of my own people have to be laid off." And he continued: "Moreover, I do not intend to burden myself with parts of the SS organization. In our region and in our time, the breeding of Kok-saghyz has no significance; we have to produce potatoes, breadstuff, sugar, and butter."[48]

Like Roemer many other academic breeders quickly tried to adapt their work to the postwar conditions which—regarding the shortage of foodstuff—did not seem to differ too much from the war time. Wilhelm Rudorf, who had moved his institute from Müncheberg towards Western Germany, declared in 1946: "Given the current lack of food and feedstuff the motto is: production, and only production!"[49] With a few exceptions, membership of the German academic plant breeding community did not change. As a mater of fact, most of the scientists remained in their academic positions of the wartime years.

Conclusion

When studying the history of academic plant breeding during the era of National Socialism, one might be struck by the willingness of the majority of scientists to support and implement policies of autarky and Lebensraum. This willingness is well illustrated by the multitude of protein, oil and fiber plants on which academic breeders at universities and other research institutions worked, as well as by a series of new establishments pursuing an accordant agenda. German academic plant breeders were not only keen to fight for the nation's agricultural self-sufficiency; they also took part in the appropriation and transformation of the new Lebensraum in Eastern Europe. In fact, the available sources of that time did not reveal much doubt or critique among academic breeders. The known protest by botanist Elisabeth Schiemann (1881–1971) of the Baur school, who in 1936 complained to a former colleague about his involvement in the nazification of the KWI for Breeding Research, did not disprove this general conclusion.[50]

If we want to understand the reasons for the striking willingness of the German academic plant breeding community to work for the National Socialist state it is necessary to look at the early history of the discipline. As we have seen, autarky and expansionism, or colonialism respectively, have been on the political agenda of academic plant breeders long before the Nazis came into power. The continuity of the concept of agricultural self-sufficiency taken up by academic breeders by the eve of World War I is quite obvious. Erwin Baur's advocacy for autarky—both on a rhetorical and a practical level—is a telling example. In the public perception, the successful breeding of the sweet lupin did not only establish a tight link between modern plant breeding and the quest for autarky but also reduced the latter to a technical problem to be solved with the tools of applied genetics. The link between the concepts of Lebensraum and colonialism is perhaps not as obvious since it is located on a more abstract level. However, both concepts share the idea of appropriating and transforming foreign territories by the means of agriculture, including the tools of plant breeding. Considering these historical continuities, the National Socialist state offered academic plant breeders a welcomed framework for the implementation of already formulated research programs. In this respect, the transition from the Weimar Republic to the "Third Reich" was certainly not as abrupt as one might think.

The same applies to the general role of the state for the promotion of plant breeding that I have only briefly addressed for the pre-Nazi era. The growing influence of state authorities on plant breeding can be traced back to the establishment of state-owned breeding institutes, the objective of which was to substitute for the lack of private initiatives in South Germany. Yet, also, where private initiatives were well developed at the turn of the century as in the Prussian province of Saxony and its adjoining regions, the federal and state governments had to compensate for a growing research load after World War I. This was due to the lack of a plant variety protection act and the financial crisis of the agricultural sector that troubled the breeding research of private seed firms in the 1920s. Since an increasing number of public and publicly financed research institutions took charge of the development of new breeding methods and new crop varieties, the main locus of innovation had shifted from the private to the state sector by the end of the Weimar Republic. The close cooperation between academic plant breeders and state authorities—the orientation of research towards public goals on the one hand and the promotion of academic plant breeding through the state on the other—was thus an established model of interaction when the Nazis assumed power in 1933.

Conceptualizing the science/politics relationship in terms of a mutual exchange of resources—as proposed by Ash—it becomes evident that the National Socialist state could draw upon established exchange patterns in academic plant breeding. Nevertheless, the Nazi era also brought some significant changes to the work done at universities and other research institutions. In general, emphasis shifted to practical breeding work—i.e., the development of crop varieties to be put on the market by the practical breeders. Moreover, new crop plants, in particular those rich in proteins, oils, and fibers, were included into the work of academic breeders. And last but not least, there were some new breeding goals such as the adoption of plants to the climatic conditions of Eastern Europe.

Considering the re-orientation of academic plant breeding, the Forschungsdienst has to be considered an efficient instrument of science policy. It is not possible to judge the contribution of academic research to the securing of foodstuff during World War II—which of course was also based on the plundering of occupied territories. The orientation of academic research towards policy goals and the effective coordination of work forces is undisputed, however. If we look in addition at the development of basic research as done in fields such as mutation genetics we are confronted with quite a complex picture of academic plant breeding in National Socialist Germany. It has certainly nothing to do with the kind of agrarian romanticism that is often associated with Nazi ideology.

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[1] An earlier version of this article has been published as Thomas Wieland, "'Die politischen Aufgaben der deutschen Pflanzenzüchtung'. NS-Ideologie und die Forschungsarbeiten der akademischen Pflanzenzüchter," in Autarkie und Ostexpansion. Pflanzenzucht und Agrarforschung im Nationalsozialismus, ed. Susanne Heim (Göttingen: Wallstein, 2002), pp. 35–56. See also Thomas Wieland, "Wir beherrschen den pflanzlichen Organismus besser,...". Wissenschaftliche Pflanzenzüchtung in Deutschland, 1889–1945 (München: Deutsches Museum, 2004) for detailed references.

[2] Wilhelm Rudorf, Die politischen Aufgaben der deutschen Pflanzenzüchtung (Goslar: Blut-und-Boden-Verlag, 1937), pp. 4–5. All translations from German are mine.

[3] Herbert Backe, Um die Nahrungsfreiheit Europas. Weltwirtschaft und Großraum (Leipzig: Wilhelm Goldmann Verlag, 1942), p. 10.

[4] For the nazification of the KWI for Breeding Research see also Jonathan Harwood, Styles of Scientific Thought. The German Genetics Community, 1900–1933 (Chicago: University of Chicago Press, 1993), pp. 218–225.

[5] Mitchell G. Ash, "Wissenschaft und Politik als Ressourcen für einander," in Wissenschaften und Wissenschaftspolitik. Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts, ed. Rüdiger vom Bruch and Brigitte Kaderas (Stuttgart: Franz Steiner Verlag, 2002), pp. 32–51. For an application of Ash's framework see also Sheila Faith Weiss, "Human Genetics and Politics as Mutually Beneficial Resources. The Case of the Kaiser Wilhelm Institute for Anthropology, Human Heredity and Eugenics During the Third Reich," Journal of the History of Biology, 2006, 39:41–88.

[6] For the early history of plant breeding, both practical and academic, in Germany see Wieland, Wissenschaftliche Pflanzenzüchtung, chap. 1; and Thomas Wieland, "Scientific Theory and Agricultural Practice. Plant Breeding in Germany from the Late 19th to the Early 20th Century," Journal of the History of Biology, 2006, 39:309–343. Scholarly interest in the history of plant breeding has significantly increased over the last years and so did the literature on the subject. For a general introduction see Noel Kingsbury, Hybrid. The History and Science of Plant Breeding (Chicago & London: University of Chicago Press, 2009).

[7] Cf. Jonathan Harwood, Technology's Dilemma. Agricultural Colleges between Science and Practice in Germany, 1860–1934 (Bern: Peter Lang, 2005).

[8] Ludwig Kühle, "Eröffnungsansprache," Beiträge zur Pflanzenzucht, 1914, 4:1–4, quote p. 4.

[9] Michael Flitner, Sammler, Räuber und Gelehrte. Die politischen Interessen an pflanzengenetischen Ressourcen 1895–1995 (Frankfurt/M.: Campus Verlag, 1995), pp. 24–36.

[10] Theodor Roemer, "Die Pflanzenzüchtung als Entwicklungsfaktor kolonialer Landwirtschaft," Beiträge zur Pflanzenzucht, 1914, 4:94–107; Theodor Roemer, "Bedeutung, Durchführung und Aufgaben der Baumwollzüchtung," Jahrbuch der Deutschen Landwirtschaftsgesellschaft, 1914, 29:395–407.

[11] Carl Fruwirth, "Aufgaben der Pflanzenzüchtung in den Kolonien," Jahrbuch der Deutschen Landwirtschaftsgesellschaft, 1914, 29:204–212, quote p. 204.

[12] Kurt von Rümker, Die Ernährung unseres Volkes aus eigener Produktion (Berlin: Parey, 1912).

[13] Theodor Remy, "Neue Ziele der Pflanzenzucht," Beiträge zur Pflanzenzucht, 1914, 4:5–17.

[14] Baur to Harnack, Dec. 21st, 1917; and Denkschrift über die Gründung eines Forschungsinstituts für Pflanzenzüchtung, Dec. 1917, in Archives of the Max Planck Society, Abt I, Rep 1A, no. 2589.

[15] Erwin Baur, "Nationalwirtschaftliche Aufgaben und Möglichkeiten der Pflanzenzüchtung," Archiv des Deutschen Landwirtschaftsrates, 1933, 51:24–37.

[16] For an elaboration of this point see Thomas Wieland, "Die Süßlupine. Natürlicher Organismus, technisches Artefakt oder politisches Manifest?," Technikgeschichte, 1999, 66:295–309.

[17] Martin Kutz, "Kriegserfahrung und Kriegsvorbereitung. Die agrarwirtschaftliche Vorbereitung des Zweiten Weltkrieges in Deutschland vor dem Hintergrund der Weltkrieg I-Erfahrung," Zeitschrift für Agrargeschichte und Agrarsoziologie, 1984, 32:59–82 and 135–164; see also Horst Gies, "Die nationalsozialistische Machtergreifung auf dem agrarpolitischen Sektor," Zeitschrift für Agrargeschichte und Agrarsoziologie, 1968, 16:210–232; Horst Gies, "Aufgaben und Probleme der nationalsozialistischen Ernährungswirtschaft," Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte, 1979, 66:466–499; and especially Gustavo Corni and Horst Gies, Brot, Butter, Kanonen. Die Ernährungswirtschaft in Deutschland unter der Diktatur Hitlers (Berlin: Akademie Verlag, 1997).

[18] For Konrad Meyer and the Forschungsdienst see Willi Oberkrome, Ordnung und Autarkie. Die Geschichte der deutschen Landbauforschung, Agrarökonomie und ländlichen Sozialwissenschaften im Spiegel von Forschungsdienst und DFG (1920–1970) (Stuttgart: Franz Steiner Verlag, 2009); Volker Klemm, Agrarwissenschaften im "Dritten Reich". Aufstieg oder Sturz? (1933–1945) (Berlin: mimeo, 1994), pp. 46–53; and Irene Stoehr, "Von Max Sering zu Konrad Meyer – ein 'machtergeifender' Generationenwechsel in der Agrar- und Siedlungswissenschaft," in Autarkie und Ostexpansion, ed. Heim, pp. 57–90.

[19] See, for instance, George Sessous, "Die Aufgaben der Pflanzenzüchtung in der Erzeugungsschlacht," reprint from Deutsche Landwirtschaftliche Presse, 1937, in Bundesarchiv Berlin, R 3602/412.

[20] For the history of the German Research Council see Sören Flachowsky, Von der Notgemeinschaft zum Reichsforschungsrat. Wissenschaftspolitik im Kontext von Autarkie, Aufrüstung und Krieg (Stuttgart: Franz Steiner Verlag, 2008).

[21] Cf. Ute Deichmann, Biologen unter Hitler. Porträt einer Wissenschaft im NS-Staat (Frankfurt/M.: Fischer Taschenbuch Verlag, 1995), pp. 59–63; Oberkrome, Ordnung und Autarkie; Kurt Zierold, Forschungsförderung in drei Epochen (Wiesbaden: Steiner, 1968), figures pp. 233–234.

[22] See, for example, Reichsarbeitgemeinschafts-Referate in Bundesarchiv Berlin, R73/13128.

[23] A detailed overview of German agricultural research institutes and their staff gives Hanns Piegler, Deutsche Forschungsstätten im Dienste der Nahrungsfreiheit. Ein Handbuch (Neudamm: Neumann, 1940), for plant breeding see pp. 152–171.

[24] For an overview see Klemm, Agrarwissenschaften im "Dritten Reich," pp. 78–84; see also the special issues no. 8 and 16 of the journal Der Forschungsdienst: Forschung für Volk und Nahrungsfreiheit (Neudamm: Neumann, 1938 and 1942).

[25] Richtlinien über die Abgabe von Pflanzenzuchtmaterial, Aug. 5th, 1939, LwRMBL 1939, no. 33, p. 842; and reponse of the academic plant breeders in Bundesarchiv Berlin, R 4901/975.

[26] George Sessous, "Arbeiten und Aufgaben der Reichsarbeitsgemeinschaft 'Pflanzenbau und Pflanzenzüchtung,'" in Forschung für Volk und Nahrungsfreiheit (Neudamm: Neumann, 1938), pp. 181–184.

[27] For a book length study of Nazi interest in the soybean see Joachim Drews, Die 'Nazi-Bohne'. Anbau, Verwendung und Auswirkung der Sojabohne im Deutschen Reich und Südosteuropa (1933–1945) (Münster: LIT Verlag, 2004).

[28] Koernicke, grant proposal, Anzucht winterharter Oliven, March 19th, 1942; German Research Association to Koernicke, March 20th, 1942, in Bundesarchiv Koblenz R73/122279.

[29] Figures are taken from Deichmann, Biologen unter Hitler, p. 78.

[30] Cf. D. Mettin and W. D. Blüthner, "The Development of Cytogenetic Research at the Plant Breeding Institute Halle/Hohenthurm with Special Reference to Aneuploidy in Cereals," Euphytica, 1996, 89:125–141.

[31] For colonial sciences in the era of National Socialism see, for instance, Heinrich Becker, "Von der Nahrungssicherung zu Kolonialträumen. Die landwirtschaftlichen Institute im Dritten Reich," in Die Universität Göttingen unter dem Nationalsozialismus. Das verdrängte Kapitel ihrer 250jährigen Geschichte, ed. Heinrich Becker, Hans-Joachim Dahms and Cornelia Wegeler (München: Saur, 1987), pp. 410–436; and Karsten Linne, "Aufstieg und Fall der Kolonialwissenschaften im Nationalsozialismus," Berichte zur Wissenschaftsgeschichte, 2003, 26:275–284.

[32]Theodor Roemer, "Ueber die Möglichkeit der Verbesserung der Ernährungslage Deutschlands aus den unter Mandatsverwaltung stehenden deutschen Schutzgebieten," Kühn-Archiv, 1938, 50:103–138, quote p. 104.

[33] See Götz Aly and Susanne Heim, Vordenker der Vernichtung. Auschwitz und die deutschen Pläne für eine neue europäische Ordnung (Frankfurt/M.: Fischer Taschenbuch Verlag, 1993), in particular pp. 394–440; Isabel Heinemann and Patrick Wagner, eds., Wissenschaft – Planung – Vertreibung. Neuordnungskonzepte und Umsiedlungspolitik im 20. Jahrhundert (Stuttgart: Franz Steiner Verlag, 2006); and Mechthild Rössler and Sabine Schleiermacher, eds., Der "Generalplan Ost". Hauptlinien der nationalsozialistischen Planungs- und Vernichtungspolitik (Berlin: Akademie Verlag, 1993).

[34] Cf. also Susanne Heim, Kalorien, Kautschuk, Karrieren. Pflanzenzüchtung und landwirtschaftliche Forschung in Kaiser-Wilhelm-Instituten 1933 bis 1945 (Göttingen: Wallstein Verlag, 2003).

[35] Scheibe to REM, Oct. 30th, 1941, in Historic Archives of the TU München, Personalakte 1256 (Arnold Scheibe), p. 20.

[36] Vögler's talk, Sept. 12th, 1942, in Archives of the Max Planck Society, Abt I, Rep 1A, no. 2925.

[37] Scheibe to Telschow, Feb. 27th, 1943, ibid.

[38] See Flitner, Räuber, Sammler und Gelehrte.

[39] Wettstein to President of the Kaiser Wilhelm Society, Oct. 13th, 1941, in Archives of the Max Planck Society, Abt I, Rep 1A, no. 2963, quote p. 6.

[40] Cf. Uwe Hoßfeld and Carl-Gustaf Thornström, "'Rasches Zupacken'. Heinz Brücher und das botanische Sammelkommando der SS nach Rußland 1943," in Autarkie und Ostexpansion, ed. Heim, pp. 119–144; see also Daniel W. Gade, "Converging Ethnobiology and Ethnobiography. Cultivated Plants, Heinz Brücher, and Nazi Ideology," Journal of Ethnobiology, 2006, 26:82–106.

[41] Bericht über das SS-Sammelkommando 1943 zur Sicherstellung von Saatgut der geräumten russischen Gebiete von Leutnant Dr. Brücher, not dated, in Bundesarchiv Berlin, NS 19/2583, pp. 3–15.

[42] See also Heim, Kalorien, Kautschuk, Karrieren, pp. 125–198.

[43] Jahresbericht (1942/43) der Gruppe Züchtung, Jan. 22nd, 1944, in Bundesarchiv Berlin, NS 19/3919, pp. 16–69, quote p. 60. For the actual living conditions of the Rajsko prisoners see Anna Zieba, "Das Nebenlager Rajsko," Hefte von Auschwitz, 1966, 9:75–108.

[44] For the Agricultural Research Institute in Puławy cf. Stanisłav Meducki, "Agrarwissenschaftliche Forschungen in Polen während der deutschen Okkupation. Die Landwirtschaftliche Forschungsanstalt des Generalgouvernements in Puławy," in Autarkie und Ostexpansion, ed. Heim, pp. 233–249.

[45] Vogel to Brandt, April 6th, 1943; Umgestaltung des Provinzialgutes Rotes Luch in eine reichseigene Anlage zwecks Ausbaues zu einer Versuchsanstalt für Kautschukpflanzen, Böhme, March 29th, 1943, in Bundsarchiv Berlin, NS 19/3920, pp. 100–109.

[46] Note, Rudorf, Stahl, Caesar, Böhme, Feb. 18th, 1944, in Bundesarchiv Berlin, NS 19/3919, pp. 91–93.

[47] Zieba, “Das Nebenlager Rajsko,” p. 87.

[48] Roemer to university trustee, June 1st, 1945; Roemer to head of district authority, Saalkreis, May 17th, 1945 in University Archives Halle, Rep 6/2757.

[49] Wilhelm Rudorf, Wie kann die Pflanzenzüchtung helfen? (Hannover: Landbuch Verlag, not dated), p. 3.

[50] Cf. Elvira Scheich, "Elisabeth Schiemann (1881–1972). Patriotin im Zwiespalt," in Autarkie und Ostexpansion, ed. Heim, pp. 250–279.

Laboratories and Landscapes: the Fascist New State and the Colonization of Portugal and Mozambique

By Tiago Saraiva[*]

In recent years, by shifting attention from antiscientific practices to interactions between scientific research and the building of a fascist society, historians of science have given new relevance to the role of laboratories in fascist regimes, namely in Nazi Germany.[1] As scientists and engineers adapted their practices to the opening up of opportunities by the new rule, as well as to the imposition of restrictions, political dreams were also enlarged by technological innovations and laboratory work. The Kaiser Wilhelm institutes, for example, are now commonly perceived as crucial sites for understanding autarky policies and the eastern ambitions of the Third Reich in its quest for Lebensraum.[2] In spite of the many differences between the regimes of Hitler and Salazar, this paper contends that the stories of the Third Reich laboratories may help to shed new light into the research undertaken at Portuguese laboratories during the years of the fascist New State (Estado Novo).

The present paper deals with the creation of three Portuguese scientific institutions: the National Agriculture Experiment Station (Estação Agronómica Nacional), the National Laboratory of Civil Engineering (Laboratório Nacional de Engenharia Civil), and the Center for Cotton Research (Centro de Investigação Científica Algodoeira). The narrative delves into the relations between research undertaken at those laboratories and the colonization efforts of the New State both at home and in the colonies. The use of the concept "resources for each other", developed by Mitchell Ash to deal with science and Nazism, seems very useful to explore the ways science and politics interacted in the Portuguese experience with fascism.[3] By following the importance of scientific artifacts such as new strains of wheat or models of dams for changing landscapes according to the regime's colonization policies, it is possible to grasp how science contributed with its resources for the institutionalization of the New State. In the opposite direction, it would be hard to understand the kind of science undertaken inside those institutions' walls without referring to State support and the political economy of the New State.

The Colonization of the Portuguese Far-West

The frontier narrative is not an American exclusive and there are many examples of the significance of settlement of new territories in the history of the Twentieth Century. The Amazon Jungle in Brazil, the Soviets' Siberia or the Jewish Colonization of Palestine, are well known historical cases.[4] But maybe no one would expect to find similar tales in a country like Portugal for which the rhetoric of conquest and colonization is normally associated with the imperial saga of the navigators of the fifteenth century. Nevertheless, at the beginning of the twentieth century, Portuguese elites were not looking only for Africa or Asia when designing civilizing missions. The very same national territory was to be transformed into an object of internal colonization.[5]

Ezequiel de Campos (1874-1965) is probably the best example of those engineers that started to look obsessively to the map of Portugal in order to produce a scientific plan for the development of the country as a coherent whole.[6] Not being able to find an attractive job after finishing his training as Mining Engineer, he joined the colonial administration of the African island of São Tomé, located in the Gulf of Guinea, where he stayed from 1899 to 1911.[7] Relegated to such a faraway post he was soon confronted with the conservation problems faced by the tropical island, where the clearing of the rain forest by cacao growers was having profound effects in the landscape. Following the direct correlations established by desiccation theory between deforestation and rainfall decrease, he urged the creation of forest reservation areas to moderate severe droughts so the island could keep its rank as first world producer of cacao.[8]

Campos' arguments for the merits of forest reservations were directly taken from his readings of North-American conservationist literature which he abundantly quotes in his books. And if one recalls the large ambitions of American conservation movement of transforming every natural resource into a manageable unit, it can come as no surprise that it didn't take long for São Tomé to become too small for Campos plans.[9] He had no problems in shifting Africa for Europe for, as he stated, the "biggest problem of Portugal… is the colonization of Portugal itself".[10] The overthrow of the Portuguese Monarchy by the Republican coup of 1910 was the perfect moment to present his project of refunding the nation on a scientific basis. His return from Africa as national deputy was followed by intense political activity combining the American conservationist proposals of Gifford Pinchot and Theodore Roosevelt with the Portuguese tradition of internal colonization projects such as those of Oliveira Martins.[11]

In 1911 he proposed to the new National Assembly a law on unreclaimed land which explicitly recognized as guiding principles the conclusions approved in the National Conservation Congresses of 1909 in Seattle (Washington) and of 1910 in Saint Paul (Minnesota).[12] The wealth of the Nation was a direct consequence of the proper conservation of natural resources: to properly manage soil, water, forests and minerals was to properly manage Portuguese society. In his widely quoted The Conservation of National Wealth (A Conservação da Riqueza Nacional), a thick volume of more than 700 pages published in 1913, Campos presented his program to save Portugal from the path of decadence.[13] Social problems were depicted as a series of maps of Portugal accounting for the density of population, the numbers of emigration and rainfall distribution.[14] The maps measured the deficit of national resources and showed the irrationality of Portuguese population distribution. People were emigrating mainly from the highly dense regions of the rainy northwest to Brazil and the United States, while the dry lands of the South, the Alentejo region, could be considered as a no man's land. The central issue of Campos program was almost self-evident: to colonize the south with people from the north.

Such a gigantic move would only be possible through a drastic change of the landscape. The semiarid southern lands were to be irrigated by major hydraulic structures that would allow settlers from the north to practice a profitable agriculture. American reclamation heroes like Powell, Mead or Newell would be proud of the Portuguese engineer who clearly stated that "the problem of the national destiny is intrinsically dependent of the farming of our land, and this is only possible by large scale irrigation of our semiarid region."[15] The large and unproductive properties of the South should be divided in order to sustain a virtuous community of small farmers: "The Republic was born for every Portuguese, offering a homestead to anyone willing to cooperate with the strengthening of the Nation. There is no Republic while a single large landowner subsists." Campos considered that "there is almost no difference between the social condition of the Far West and our Alentejo: both are lands to colonize, the only difference being that the free lands from the Rockies… to the Pacific shores are mainly Public Domain while among us the Alentejo is private property".[16] The analogy went even further: "May tomorrow the Alentejo be a promise land, a new California."[17]

The greening of Alentejo by hydraulic works would be complemented by other typical conservation measures. Forestation by pine trees, eucalyptus, oaks or nut trees would transform unfarmed land into profitable properties providing also a defense against erosion, protecting river banks and, more ambitiously, changing the Portuguese climate. The concluding data that Campos claimed to have gathered from São Tomé were translated to the Portuguese experience, with the entire climate of the country registering a steady increase in precipitation by the effect of planted forests.[18] The technological garden dreamt by Campos also included the exploration of coal, iron and copper mines and an expanded transportation network. But, above all, it would be crossed by an electrical grid transporting the energy produced by Portuguese rivers.[19]

The historical interest of Campos rests as much on his role as distinguished conservation ideologue and politician, as on the fact that his writings and laws were in direct relation to his engineering activities. His claims for a national electrical grid presented in conferences, newspapers and parliamentary sessions, went hand in hand with explorations of the main Portuguese rivers. He traveled along the Douro, Cávado, Mondego, Guadiana and Tagus rivers in search for the hydroelectric power to support the industrialization of the country. And although his narratives are not as exciting as John Wesley Powell's exploration of the Colorado, he confessed nevertheless to have suffered more than in his African experience in São Tomé.[20] After six years of wandering through indigenous Portuguese territory, sleeping among local villagers and carrying his own surveying instruments, Campos' efforts were recognized by the central government who appointed him head of the Hydraulic Studies Brigade created in 1918.

For the country to thrive national resources were to be scientifically managed. This was the answer Campos offered to the Portuguese crisis in the aftermath of First World War and the break of international commercial fluxes. The riots and lootings in the capital city in search for provisions and the unwillingness of the countryside to contribute to Lisbon's hungry relief seemed to confirm Campos' diagnosis of a poorly organized country, excessively dependent of foreign trade with little knowledge of its own potential resources. Soon he would join all those other intellectuals willing to replace traditional liberal politics by the rule of the learned elite. Together with his left leaning companions of the Seara Nova (New Harvest) movement, he claimed for a national government of experts immune to parties' rivalries, a revolution from above to save Portugal from chaos and decadence.[21] For order to be restored the ignorant mobs that dominated the streets of Lisbon just had to trust New Harvest clerks who in the pages of their journal demonstrated their proficiency in economics, hydroelectricity, aviation, literature, irrigation and philosophy. Soon, the illusions of the first years of the Republic were definitely lost and in 1923 Campos overtly embraced an authoritarian solution to "heal the sick body of Portugal". Making no case of the republican constitution, he pleaded for a "national ministry of public salvation… invested with exceptional powers… to launch the bases of the national reorganization."[22]

Campos and his friends were not alone in their distrust of democratic values and they didn't feel uncomfortable to share reform projects with all different sorts of allies. In the Revista dos Homens Livres (Free Men Magazine) they joined forces with anarchists, conservative monarchists and even with radical right wing integralists (the Portuguese version of the French Action Française of Charles Maurras). All that mattered was to gather forces against traditional party politics, for the only authentic dividing line was not "between left and right… but between men of the XXth century and men of the XIXth century."[23] So it is no surprise to find the name of our engineer in the list of ministers of the first government formed after the military coup d'état of May 1926 that overthrew the Republic and inaugurated the authoritarian regime that would last till April 1974. A dictatorship seemed the fastest and the only feasible way to accomplish the task of reorganizing national life through conservationist reforms. Nevertheless, Campos would decline his nomination as Minister of Agriculture, considering the situation too unstable to present his proposals.[24]

His fears revealed unsound and in the following years engineers would become crucial players of the fascist Estado Novo (New State).[25] In 1933 the New Corporatist State was to be officially institutionalized trough the approval of the new Constitution. The new regime replaced any form of liberal mechanisms of representation by ideological nationalism, the one-party state, systematic repression and a social and economic corporatism formed by organic social unities, a combination that definitely placed it among other European fascist regimes.[26] In an ironic resemblance to communist ideology, Portuguese society was considered not yet ready for pure corporatism, the State having to assume the responsibility to build a new social structure based on the harmony of its different organs.[27]

The task of empowering the State to actively intervene in the coordination of national economy demanded an active support from engineers. The prevailing image of Portuguese fascism dominated by a traditionalist establishment, reduced to the trinity "God, Fatherland and Family", doesn't pay justice to the relevance of technoscientific elites in the building of the New State. The very same dictator, Oliveira Salazar, seems to support the traditionalist interpretation with his proverbial suspicion of urban life and praise of pastoral modest virtues. But if Salazar doesn't bring to mind the futurist visions of other dictators, namely those of Mussolini, it is also true that his public image was cautiously designed around the myth of the University Full Professor of Financial Sciences that finally put an order to Portuguese state finances. In 1933, the year of the new constitution, he proudly declared: "When everyone thought that the Dictatorship would crash everything in an adventure of military violence, one sees the government from, almost exclusively, superior professors; strength serving justice; improvisation giving its way to scientific training".[28]

The National Agriculture Experiment Station and the Wheat Campaign

In 1929, three years after the coup d'état, the dictatorship launched a national mobilization for bread self-sufficiency justified by the enormous weight of wheat in Portugal's commercial deficit.[29] The campaign was the final result of several initiatives since the mid 1920s to promote wheat production and support wheat protectionism against the menaces of cheap foreign grain. As for many other western countries, the years of autarky had arrived. The Wheat Campaign came to epitomize the new trend with its motto "Our land's wheat is the border that best defends us". Based on the example of fascist Italy and the Battaglia del Grano, this mobilization for the production of the most basic need – bread - brought together big landowners of the south selling cereal at prices guaranteed by the State; agriculture machine builders; chemical industries producing fertilizers; masses of reapers reclaiming land. There was no contradiction between modernizers looking forward to convert the Portuguese territory into a productive machine and traditionalists relying on the cultivation of the land as the source of national virtue. The Wheat Campaign worked as the first material basis of the new organic social formation dreamt by the corporatist New State. After the campaign a new set of corporatist institutions was created around wheat production with the National Federation of Wheat Producers controlling production and commercialization, the Houses of the People gathering farm laborers or the Farmers' Gilds bringing together landowners. All these institutions were promoted by the State trying to bring his new order to the Portuguese fields through idealized organic unities.

Agriculture engineers and scientists were no secondary actors in this battle for production. The Secretary of Agriculture and future president of the National Federation of Wheat Producers stated that the outcome of the campaign went way beyond the record productions of the years 1934 and 1935, for it settled a new union between farmers and the State technical services.[30] The best proof that his words were not empty rhetoric was the fact that the Army colonel responsible for launching the campaign appointed the young and promising professor of the Agriculture Institute, António Sousa da Câmara, as its field Marshall. The campaign, in tune with the militarist tone, was divided in six divisions - Propaganda; Technical Assistance; Financial Assistance; Transportation; Fertilizers; Seeds –

which were under the control of a triangular command formed by a politician named by the Minister of Agriculture, a large landowner and an agriculture scientist. Technical brigades were launched to the fields of the South of Portugal to promote selected seeds, proper fertilization and mechanized farming. In three years the Alentejo wheat fields had an increment of area of 50% occupying a total of one million and a half acres. Maybe it now resembled more the Great Plains than the desired California, but the old problem of the abandoned fields of the South had finally come to an end. In the following decades all sorts of problems would surface deriving from a monocrop system extended over the thin soils of Alentejo. [31] But by then the Wheat campaign had already put agriculture scientists at the heart of the State administration, and they would be the ones called to solve the problems they had helped to create in the beginning of the 1930s.

For Câmara, the young agriculture scientist head of the campaign, there was no doubt about the importance of this first mobilization of scientists for the fascist new state. Let us follow some of his emphatic words when remembering those glorious days: "The wheat campaign had come. The dawn had arrived! Happy those like us, who started our professional lives under the light of the dawn and were able from the very first moment to follow a Great Leader and the flame of a new Mystique."[32]

In 1936 new legislation would reorganize the Agriculture Department with research being granted a central role. The law founded both the Board for Internal Colonization, created to plan the settlement of the southern lands with people from overpopulated areas of the Northwest, and the National Agriculture Experiment Station (EAN), the scientific arm of the Department. Câmara was selected as the head of this new laboratory, for he was not only a distinguished participant of the wheat campaign, and of all other production battles that followed, but he also had previous experience in renowned international institutions such as the Plant Breeding Institute in Cambridge or the Kaiser Wilhelm Institut for Breeding Research in Berlin.[33]

When he returned to Portugal, Câmara organized his EAN around Genetics which after his international experience he considered to be "the central science of an institute of agriculture research."[34] But besides Genetics, and following the example of most experiment stations that spread all over the world on the first half of the twentieth century, each economically relevant species was scrutinized by a battery of techniques.[35] The departments just sprawled, with wheat, corn, rice or apples put under the scrutiny of genetics, physiology, botany, phytopathology, entomology, chemistry, soil science, economics or sociology. If the botanical gardens of the previous centuries were able to bring together thousands of species under one unique discipline – botany - , the experiment stations limited the number of species but multiplied the number of approaches. One of the distinctive features of experiment stations is this accumulation of departments sometimes organized around their object, like the rice department, others around their discipline, like the phytopathology department.

In 1943, only seven years after its foundation, the EAN counted already 62 researchers. There was no previous case of a research institution in Portugal with so much manpower, and Câmara believed that Taylorism was the tool he needed to organize it: "the organizer of a company tries to elaborate its rules as precisely as he can, by establishing the number of organs needed, the way they relate to each other, the hierarchies between them, the performance expected from each of them... The modern leader is the one who knows how to distribute his power by a system of intelligently divided responsibilities."[36] Câmara's obsession with the organization of scientific work was the main subject of his book On the Way. Guiding a Scientific Enterprise, published in 1943, the XVIIth year of the national revolution as stated in the cover. The book had a preface by Marcelo Caetano, commissioner from 1940 to 1944 of the Portuguese Youth—the regime youth organization tightly connected with the experiences of the Opera Nazionale Balilla in Italy and the Hitlerjugend in Germany -, and future prime minister of the authoritarian regime after Salazar's death. Caetano recommended the book to all Portuguese who have been called "for a mission of leadership, of orientating, of directing national life".[37] Câmara intended to offer a guide to the researcher serving the New State, with science as the best weapon to defend the Fatherland. Every young man mobilized to the EAN should have "faith, patriotism, character, intelligence, knowledge and working capacities. The lack of faith leads to the sad petit bourgeois mentality of some supposedly said scientists... petit bourgeois lack the needed enthusiasm... The religion of the fatherland is the eternal source of energies from where the researcher will get the courage to overcome all difficulties."[38]

Câmara's intentions were translated into stone in the new facilities of the EAN built in 1941 in the Lisbon outskirts. The design of the building and the adjacent experimental fields followed the rules of the Portuguese House movement as established by the regime architects. Câmara bluntly asserted that he wanted to avoid "the modern style and its juxtaposition of containers, with no character, poorly adapted to our climate and being in all its manifestations an outrage to the beauty of the Portuguese landscape."[39] And the fact is that the historicist outcome was singled out as one of the best examples of the public buildings that were remaking the Portuguese landscape following the rules of Portuguese good taste.[40] In the pages of

Panorama, the official magazine of the National Propaganda Board responsible for making Portugal Portuguese, the EAN building was considered to be one of the best expressions of the revival of national architecture.[41]

More practical considerations were of course also taken into account such as the dimensions of the laboratories, their location and illumination. And once again one understands better Câmara's intentions by noting his decision of having only one building instead of several isolated pavilions as was for example the case of the Beltsville Research Center of the American Department of Agriculture near Washington. Câmara made his case by stating that one building "not only promotes a more intimate collaboration between the different departments, but the role of the director also becomes easier and more efficient. In such an establishment the authority of a director can't be dismissed, and it should be felt at every moment and in each activity."[42]

The architecture of the National Agriculture Experiment Station was undoubtedly appropriated for a state laboratory conceived as a tool for colonizing the national soil. Much of the research conducted at the Station had the direct support of the corporate organs of the New State which were trying to penetrate into the Portuguese fields. The National Board of Olive Oil, for example, directly supported in 1939 the research undertaken at the phytopatology department on the Daccus oleae fly, a major plague in Portuguese olive trees, hiring scientists for the study of its biology, ecological relations, natural enemies and ways of controlling it. The National Federation of Wheat Producers built the greenhouses of the plant breeding department, while at the same time and on the opposite direction the Station delivered to the Federation 22 new wheats distributed mainly among Alentejo farmers.

The National Laboratory of Civil Engineering and hydroelectricity

The 1930s, as already stated, were golden years for engineers willing to collaborate in the autarky policies of the regime.[43] Salazar himself sustained that for the State to drive national economy towards corporatism, "the constitution should provide the building of great works such as communications, sources of power, transportation networks and electrical grids…whose plans ought to be designed and enforced by the State."[44] In 1935 the Law for Economical Reconstitution materialized the visions of the development of the economy on a nationalist basis under the direction of the State. Its main investments went to roads, harbors, irrigation dams, public buildings and defense.[45] The combination of defense and infrastructures, typical for many state policies of the Depression years, would materialize the presence of the New State in the territory. Once again, the dictator sermon offers little doubt: "The dominant thought in the Administration is to do nothing without a plan."[46] That same year, 1935, a Plan for Agriculture Hydraulics was set in motion. In 1936 the government launched the Board for National Electrification and the Board for Internal Colonization, founded the National Agriculture Experimental Station and inaugurated the monumental premises of the Superior Technical Institute in Lisbon, the main engineering school of the country. Two years later, in 1938, a new ambitious plan was set in motion: the Forestation Plan. The paradox is striking. Big state plans and big technology were fundamental to materialize Salazar's visions of Portugal as a well kept garden planted by modest catholic farmers.

Of course such paradox is not a Portuguese exclusive. It is good to remind that the program for the rationalization of the national territory through Forests, Internal Colonization, Irrigation and Electricity owed a lot to the American experience with the West. And it is now commonplace for historiography to denounce the distance between the rhetoric of independent yeoman farmers reclaiming the West and the reality of a powerful State bureaucracy - the Bureau of Reclamation – colonizing the western landscape through large dams.[47] If to propose a national electric grid Ezequiel de Campos just had to combine his conservationist readings with expeditions around the country with his unsophisticated topographical and hydrographical instruments, to design and build large dams a totally different kind of instruments was needed.

In 1939 it was started the building of the first Portuguese concrete arch dam, the Santa Luzia dam which inaugurated a new era for the rivers of the country.[48] The irregular behavior of Portuguese rivers with its torrential flows during the rainy winter reduced to scant streams in the dry summer, demanded high structures damming big artificial lakes.[49] By using only conservative heavy and expensive gravity structures most watercourses would remain unexplored. Thinner and cheaper concrete arch dams were needed to materialize the visions of Portuguese rivers supplying energy for an industrial surge based on the country's own resources. And for national resources to support national development, for rivers to support industry, engineering researchers were to be mobilized to study arch dam behavior. This was the rationale sustaining the collaboration between the State hydraulic services and the Center for Studies of Civil Engineering (Centro de Estudos de Engenharia Civil).[50]

The Center, operating in the premises of the Superior Technical Institute, was directed by Manuel Rocha, a young engineer recently returned from the Massachusetts Institute of

Technology (MIT) who was interested in materials resistance.[51] His American experience was made possible through a scholarship of the Institute for High Culture, a government department created to support the formation of a new scientific elite.[52] In addition to offering to young talented scientists the opportunity of attending renowned international universities, the Institute also funded local centers of excellence. The Center for Studies of Civil Engineering, one of the Institute's centers, was founded in 1942. No more than two years later it was already building the first model of the Santa Luzia dam, inspired by the American Bureau of Reclamation work on models for the world famous Hoover dam on the Colorado River. In a tiny laboratory six young and enthusiastic engineers were starting a research program that would become the most successful Portuguese experience with Big Science.

The shortage of coal supplies experienced by Portugal during the Second World War was the ultimate argument for hydroelectric production to free the country from external sources.[53] In 1944 a National Electrification Law was passed relying on large dams as the first energy source of the country and in 1945 the State promoted the creation of two large companies to develop the basins of the Cávado and Zêzere rivers.[54] The big investments of the companies were justified with the creation of new key industries such as electrochemical plants and steel mills, in a typical import substitution industrialization policy.[55] Electrification and the reorganization of Portuguese industry were, not surprisingly, two interwoven topics. Cheap large arch dams, designed following laboratory recommendations, were key elements of the postwar ambitious plans of industrializing the country through the use of the territory's own resources. In 1946 construction started for the large dams of Castelo de Bode and Venda Nova, and one year after the small Center for Studies of Civil Engineering was converted into the flamboyant National Laboratory of Civil Engineering (LNEC).

Contrary to the practice of most countries, the laboratory centralized all experimental activity connected with civil engineering problems, responsible not only for the study of structures and materials, but also for defining standards and developing construction methods.[56] But Manuel Rocha himself was the first to recognize that the impressive growth of LNEC and its relevance on the national scale were first and foremost connected to the research carried in arch dams' behavior. From the beginning most of its researchers were involved with dams, testing different qualities of concrete; observing deformations, stresses and temperatures during and after construction; examining rock foundations; or carrying model studies of the shapes of the structures to be adopted.[57] In fact, model studies became the most distinguishing feature of the research undertaken at LNEC, proving to be an effective tool both to actively participate in the national electrification effort as well as to its international recognition.

Starting from the United States Bureau of Reclamation experience with models of Hoover Dam a research program was launched to systematically use small models in arch dam design.[58] The aim was to overcome the high manpower and time requirements of numerical methods by developing techniques of model building that would at the same time improve accuracy in establishing the stress state of the dam.[59] To reproduce the dam and its foundations at a laboratory scale different model materials were tested, several methods of reproducing the load on the structure were tried, and new instruments for the measurement of deflections were developed. In those model tests the accurate measurement of small deformations was a crucial issue which explains why Manuel Rocha insisted on the importance of counting with an active Instrumentation Section in the laboratory. Electrical extensometers were developed to replace traditional vibrating chords which demanded improved facilities to control experiments' conditions. The measurements made inside LNEC's walls in Lisbon were then compared with field data from the real dams which were equipped with a set of instruments following an observation plan also designed by LNEC in tight collaboration with the building companies.[60]

The engineers of the Structures department of LNEC, directed by Manuel Rocha himself, claimed in several papers presented to the International Congresses of Large Dams and published, for example, in the Proceedings of the American Society of Civil Engineers to have demonstrated the superiority of models when compared to analytic tools in offering a fairer account of the complexities inherent to arch dam structures.[61] The use of models was mandatory if safe thin structures were to be built, especially in sites of irregular profile, in dams with singularities (such as spillway openings) or in the case of heterogeneous foundations. Or, more bluntly, models were mandatory for any important structure. All Portuguese large dams then started to be previously tested in LNEC premises before laying the first stone. In contrast to the U. S Bureau of Reclamation practice which only used models to confirm the designs coming out of numerical methods' computations, the Lisbon laboratory put all its efforts in developing cheap and flexible model techniques that earned its international reputation. In the beginning of the 1960s the very same U. S Bureau of Reclamation was hiring LNEC to make the model studies of the complex Morrow Point Dam structure in the Gunnison River in the Colorado basin.

In 1955, only eleven years after the beginning of the first model of the Santa Luzia dam, Manuel Rocha could already argue that the experimental technique developed in the lab, through its direct savings in structure costs, had already compensated for the entire investment made by the State in the National Laboratory.[62] Such cost-benefit analysis was not an innocent claim for we are dealing with a laboratory that started in the 1940s with six young engineers and improvised research facilities, and that grew up in the 1950s to an institution with 279 people. Four years later the total number of employees was already 490 from which 90 were research engineers. The workforce numbers, as in the case of the Agriculture Experiment Station, demanded a new organization of research. Let us follow Rocha's account of his own institution: "the laboratory has an industrial type organization which enables it to determine the real cost of each service after its conclusion. Each member of the staff has a card in which he records daily the time spent in the different jobs, discriminating even the time spent in studies, in consultations, in receiving visitors, …"[63] These bureaucratic procedures were in agreement with the cautious planning of research activities, avoiding "doing research for the sake of research. The criterion for the choice of a problem is the service it renders to the country."[64]

The building of the laboratory, inaugurated in 1952, reveals Rocha´s idea of what a national research institution ought to be. Its monumental character was in no contradiction with the simplicity of the concrete façade, an obvious homage to the work being carried behind the gray walls. A quick look is enough to realize the modular nature of the building, with no differentiation of the several sections of the laboratory.[65] Each modulus of 7*3.5m was limited by glass walls easily removable in case of necessity. The laboratory was perceived as a research machine easily adoptable to new objects of inquiry requiring different space distributions for teams and instruments. Nevertheless the clear hierarchy of the institution was not forgotten in this egalitarian modular structure. Each section was distributed in a single zone of the building in a cascade occupying its three floors, in order for the engineer director of the section to supervise the subordinates' work.

It is evident that Rocha worked closely with the architect Pardal Monteiro who designed a building to be located in the northern outskirts of the city, between Lisbon new neighborhoods and the recently planned ring road and airport. The building may be seen as part of a coherent whole that was changing Lisbon image. Monteiro's Lisbon was not Speer's Berlin, but it included several monumental buildings, among them those of the High Technical Institute and the National Laboratory of Civil Engineering, new urban landmarks of the fascist New State Capital. Once again, LNEC is not only a fundamental site to understand how during the second half of the twentieth century Portuguese rivers had been dammed according to the internal colonization dreams first expressed by Ezequiel de Campos. The very same laboratory building is an important part of the new urban landscape of Lisbon.

The Center for Cotton Research and the Nationalization of the Empire

The characters we have been following suggest different possible relations between science and fascist regimes. Câmara was a full enthusiast of the New State and he didn't shy in urging the researchers at the EAN to directly contribute to the building of the new regime. Campos, a former minister in the Republican period, was happy to actively participate as deputy in the New State's Corporatist Chamber, as long as the regime implemented his proposals for the rationalization of the territory through conservationist policies. Rocha kept his technocratic pose without apparently mingling with politics until he became minister of Public Works in the first government formed after the overthrow of the dictatorship in 1974. Nevertheless, as we just saw, it is hard to isolate the work undertaken at LNEC from the political economy of the Portuguese authoritarian regime in the postwar years. Actually, as celebrated by the regime's propaganda, there was no stronger material presence of the New State in the landscape than those massive concrete dams tested and calculated at Rocha's laboratory.

In contrast, the biography of Aurélio Quintanilha (1892-1987) seems to confirm the traditional narrative about the difficulties of conducting scientific research under authoritarian fascist type regimes. His dismissal and compulsive retirement in 1935 from his position as Full Professor of the Botanical Institute of the University of Coimbra, when his scientific reputation in the field of cytology and genetics was indisputable,[66] is in accordance with the well known purges of scientists under the dictatorial regime that ruled Portugal from 1926 till 1974. Although the numbers of scientists which fled Portuguese fascism are less impressive than those of Nazi Germany or even Franco's Spain, historians have already explored in detail the research lines, namely in Physics, that were abandoned due to political repression.[67] The decision by the Minister of Education, a physical anthropologist at the same University of Coimbra and local leader of the radical right wind movement – the blue shirts –, to shut down Quintanilha's laboratory, not even allowing him to finish a paper to be presented at the 1935 Congress of Botany in Amsterdam, has been perceived as proof of the antiscientific nature of Salazar's dictatorship. By denying Quintanilha access to his laboratory, the results of seven years of research on cytology and genetics of fungi were totally lost.

Salazar, who was also a professor of financial sciences at the University of Coimbra, felt strong personal reluctance towards Quintanilha, a renowned anarcho-syndicalist who embodied all he stood against. In the years they coincided in Coimbra, the would-be dictator would not even shake hands with Quintanilha. Salazar, always in his severe black suit, felt insulted by a figure who dared to show up in public wearing tennis sportswear and exhibited the cosmopolitan character earned in his Berlin and Paris years.

It was to escape the regime's repression that in 1936 Quintanilha left Portugal for Paris to work in the Natural History Museum where he temporarily had to abandon his research on genetics. But fascism, once again, stood on his way. After voluntarily joining the French Army to fight the Nazi invasion of France, he returned to Portugal where his previous scientific connections promised him a warm welcome. Namely, his fellow geneticist Antonio Câmara, assured Quintanilha a position at the EAN. Although Câmara was one of the main figures of the scientific Portuguese fascist establishment and was responsible to develop a new breviary of the scientist serving Salazar's New State, the dictator himself interceded personally to prevent Quintanilha to be hired by the Experiment Station. In the following years Quintanilha could only count with a part-time job at the laboratory canteen to maintain himself and his family.

In 1943 he was finally recruited by the Board of Export of Colonial Cotton Board (Junta de Exportacao do Algodao Colonial – JEAC) which was willing to create a Center for Cotton Research (Centro de Investigacao Cientifica Algodoeira – CICA) in Mozambique, the Portuguese colony in Eastern Africa. Quintanilha was thus sent to a far-away post, isolated from the political intrigues of the metropolis, following the regime's policy of sending opposition members to the African Colonies. He would remain in Mozambique till 1982. The trajectory of Quintanilha doesn't bring any special problem to historians. Nevertheless, I intend to suggest that his Mozambique years shouldn't be seen just through the lens of forced exile.

Despite the formal annexation of Mozambique after the Berlin Conference in 1885 that officially launched the Scramble for Africa, Portugal was never able to really take possession of the territory, ceding large plots of land to chartered companies formed by international capitals that had total control over their concessionary areas. Most of the income of these companies was derived from extracting taxes from African populations living under their domain and exporting conscripted labor to the South African gold mines or the Katanga copper mines. The economy of Mozambique was totally dependent on its neighbors, with railways transporting ores from South Africa and Southern Rhodesia mines to be shipped at the ports of Lourenço Marques and Beira, and returning in the opposite direction carrying conscripted laborers to work at the same mines. Autarky policies demanded more from a territory that was supposed to provide raw materials and markets for metropolitan industries. The fast growing Portuguese textile industry in particular was getting in 1931 only 1% of its ginned cotton from the African colonies, buying huge amounts of North American and Egyptian cotton in the world market and decisively contributing to the negative balance of payments of the State.[68] Charted companies were repeatedly denounced in Portuguese press, not only because of their foreign capital, but mainly because of their inability to transform the Mozambican landscape into a productive territory.

Already in 1926, as first Minister of the Colonies of the dictatorial government, João Belo launched new legislation to bring to an end the domain of the chartered companies which in some areas were to be replaced by cotton zones. The zones should materialize the "nationalization of the Empire", the motto guiding Belo's policies and much of the imperial initiatives of the New State.[69] In such zones concession holders had purchasing exclusivity over native production at prices fixed by the Government. The holders were not only compelled to buy, gin and export to Portugal all the cotton produced in their zones, but they were also entitled to force natives to plant cotton, mobilizing them to the nationalized colonial economy. Through the new labor legislation of 1928, the previous system of forced labor of rounding up natives and displacing them to plantations was now to be replaced by forced crop cultivation requiring workers to remain in their own village and tile their own land. In spite of the joint efforts of concessions' overseers and colonial agents, the main objective of incorporating native population into capitalist production of commodities was hard to achieve, with only 80.000 peasants, out of a total population of more than 4 million, incorporated into the cotton system by 1937.[70]

The colonial authorities were especially concerned with the provinces of Northern Mozambique with its population of two and a half million people occupying an area 4 times the size of the Metropolis and with no visible contribution to the economical welfare of the Portuguese empire. In 1938 the New State created the Board of Export of Colonial Cotton, another economic coordinating organ, part of the corporatist structure institutionalized by the constitution of 1933. The Board not only organized cotton exports from the colonies as it intervened directly in the process of capturing the peasantry for cotton production. Board officials had the power to designate the areas for growing cotton as well as to fix mandatory dates by which peasant communities planted, reseeded, and harvested their cotton crop. In accordance with the standardization tasks of many of the corporatist organisms of economic coordination, the Board also defined the various qualities of cotton and helped to set the price paid to the peasants by concessionary companies and to the concessionary companies by the Portuguese textile industry. In 1940, two years after the Board started its action, there were already, and only for the Northern provinces, about half a million natives incorporated in the cotton regime. For the entire country the numbers reached some 800.000 people. From 1942 to 1946 from a total of 28 million tons of cotton imported by Portugal, 24 million were produced in the African colonies. Cotton had become in a few years the first Mozambican export, with the northern region producing around 60% of all colonial cotton.[71]

These numbers that made the joy of Salazar and strengthened his imperial vision of Portugal were directly related to one of the darkest pages of Portuguese colonialism. Historiography has convincingly documented the brutal character of the Portuguese cotton regime and its systematic use of violence. Allen Isaacman offers a detailed survey of the grim stories, rumors, gossips, and songs depicting the colonial state sanctioned violence spread out through the Mozambican countryside.[72] And it's good to remind that the guerrilla war for independence led by FRELIMO started exactly in those northern cotton districts in 1961 when several thousand cotton growers demonstrated. There are many different versions of what happened in the village of Mueda, but Eduardo Mondlane, the founder of FRELIMO, had no doubts about making the killing of unarmed protesters by the colonial police a founding myth of the would-be postcolonial country, converting the cotton regime into one of the main symbols of Portuguese oppression.[73] In his book Struggle for the Independence of Mozambique, published in 1969, the same year he was murdered by the Portuguese secret police, he recollected various statements of poverty, violence and hunger associated with the cotton regime.[74]

It was in the brutal context of the cotton regime that the anarcho-syndicalist Aurélio Quintanilha was supposed to lead the Center for Cotton Scientific Research. The Center created in 1943 was to be the scientific branch of the Colonial Cotton Board. Following the organization of the National Agriculture Experiment Station, a multiplicity of disciplines was to be gathered around one unique object: cotton. To cover the multiplicity of issues related to cotton were created the departments of genetics, entomology, soil, botany, phytopathology, fiber technology, agriculture engineering and regional experiment stations.[75]

The establishment of a network of experimental fields distributed through the entire Mozambican territory was the first task of the Center. Essays on 39 experimentation sites were to offer basic results about proper sowing timing, strains employed and planting rotations.[76]

These first essays covering the different regions should produce enough information on the fundamental issue of where to plant cotton. The policy of just enrolling through coercion a growing number of natives led to the cultivation of cotton in improper areas with fast erosion of soils in vast areas.[77] Textile factory owners in Portugal also complained about the lack of reliability of colonial cotton with large annual variations of quantity and quality. In 1945 the number of cotton producers started to decrease and would stabilize around some 500.000 for the next two decades, with some of the previous cultivated areas even being interdicted for cotton production. In the opposite direction, cultivation was to be intensified in the most suitable ones.

Together with the scientists responsible for the network of experimental fields, other researchers of the Center were dedicated to translate the landscape of Mozambique in laboratory terms. During the rainy season botanists and soil scientists collected and analyzed data available on climate, geology, vegetation and demography of the colonial province. When dry season arrived brigades of scientists crossed the country collecting samples of soils and plants, making socio-economical inquires to local populations and marking areas for cotton cultivation in the topographical maps. In 1955 all this work would be brought together in the thick volumes of the "Ecological-Agricultural Survey of Mozambique", the first of such surveys to be completed in the Portuguese colonies.[78] The research center was thus able to produce an invaluable tool in the form of maps detailing the areas more suitable for planting cotton.

The Portuguese scientists, led by Quintanilha, were following the example of experiment stations in neighbor regions whose experience they were aware of by constant trips to Egypt, Congo, Sudan, Uganda, Nigeria, Rhodesia or South Africa. Detailed reports of research facilities of the British Empire Cotton Growing Corporation, like the Uganda one were published by Portuguese scientists.[79] The Empire Cotton Growing Corporation (ECGC) and its network of experiment stations in the British colonies was in fact the main international model for the Portuguese Center. But maybe the most direct influence of the ECGC was the import of strains developed by its Barberton station, in the Union of South Africa, which accounted for the vast majority of cultivated cotton in Mozambique. The great advantage of the strains developed at Barberton by F. Parnell in the 1920s, namely the famous U4, was their resistance to Jassid, an insect pest that constituted one of the main obstacles to the success of cotton in Africa, and that in the twenties it was even thought to inhibit any cultivation in the Southern region of the continent.[80]

Much of the initial breeding work held in the Mozambican Center for Cotton Research was thus to adapt the Barberton varieties to local ecological conditions, namely by selections of the U4 strain, aiming to enhance productivity and the technological properties of the fiber. A constant selection effort was also necessary to avoid the degeneration of the cultivated species resulting from crossings with previously planted varieties by insect pollination or poor seed isolation, in order to keep the good properties of yielding, fiber quality and resistance to diseases or plagues. Each of the regional experiment stations, controlled by the Research Center, performed essays testing different selected seeds under different conditions of fertilization, pest control, sowing timing or rotation of cultures. Only after were the cotton seeds ready to be multiplied and distributed among the cultivators. The local experiment station was supposed to work as a model farm whose order was to be transplanted to the entire landscape of cotton fields.

As cotton zones were delimited by the officers of the Board of Export of Colonial Cotton, local people inside those areas were registered by local state and cotton companies' officers as cotton producers. Each grower received a card which he should always carry with, documenting age, residence, size of cotton field, type and qualities of seeds received, number of times the field had been weeded, quantity and quality of the produced crop…[81] Thus, as in many other examples of designed agriculture schemes throughout the African continent, indigenous individual identity was indistinguishable of the condition of crop-grower.[82] Actually, this was the core of the Portuguese civilizing mission, transforming lazy indigenous into proud hardworking farmers, even if for that, as the board officials dully observed, physical coercion had to be employed.[83]

U4 Cotton seeds looked like the perfect tool to attain such objective. In spite of the disadvantages of producing short cotton fibers and small capsules, which meant low productivity levels, the U4 was not only resistant to Jassid (its main characteristic) as it also proliferated under very different climatic and soil conditions.[84] If it were not for the qualities of the U4 it would be hard to explain how Mozambican cultivators, growing the crop entirely manually, in small plots of scarcely more than 2.5 acres, without the aid of any farming implements, and dealing with an unstable climate, were able to produce those quantities of cotton in the 1940s that made the joy of Salazar and the Board technicians.

As it is usually the case in such schemes, its success was also the first cause of problems.[85] To protect cotton from having to compete with other crops for moisture, sunlight and soil, the

Board engineers imposed a system of monocrop in contrast to traditional practices of growing different crops in the same plot of land, mixing maize, sorghum, beans or peas.[86] The concessions' surveyors only had to take a quick look at the field to realize if natives were complying or not to their obligation of growing cotton. The dismissal of the chaotic model of intermixing crops in favor of monothematic fields of cotton caused all sorts of environmental problems, namely soil erosion and the spread of new plant diseases like the red bollworm. Already in 1947 a report to the president of the Board of Export of Colonial Cotton supported the increasing evidence linking plant diseases and pests associated with the monoculture of cotton to the decline in food crops.[87] Nevertheless, such decline was also associated to the short periods of time natives were allowed to dedicate to their own households, occupied as they were with demanding cotton fields. More than that, the quick visual method of surveillance required the demarcation of cotton fields along the few roads crossing the Northern Mozambique landscape, most of the times a long-way from natives villages. Soon, the diet basis of the local population was based on manioc, a less demanding crop but also a less nutritive one. Famines stared to show up in the cotton regions and in 1951 in the Mogovolas some two to three thousand people died from starvation.[88]

Not only such events were denounced by the catholic church as well as the very same General Governor of Mozambique asserted that the obsession with cotton production, separating it from the general issue of food security, was responsible for the spread out of famines in the northern regions.[89] It is no surprise than to find out that already in 1947 the Cotton Board, under the advice of the Center for Cotton Research[90] started promoting the construction of a network of planned cotton communities throughout the north of Mozambique, the so called "cotton concentrations", multi crop agriculture units organized around scientific principles of rotation and crop management and located on the best available land. For native people the main advantage of belonging to such communities was the opportunity to plant other crops along with cotton. In the carefully planned cotton concentrations, land rotation, access to tractors, better seeds and lands, and the opportunity to grow other crops were intended to overcome all previous problems. Each household received a plot with an area between five and seven hectares, half of which would be allowed to lie fallow at any time. On the remainder, peasants would cultivate a hectare of cotton, a hectare of corn or sorghum, and a hectare of manioc. The concentrations contemplated also an integral social structure with a primary school, a sanitary post, a fountain, and houses for the professor, nurse and overseer of the concession holder. [91]

By the end of the 1950s more than 30.000 families had been relocated into the cotton concentrations. Nevertheless, the majority of cotton planters didn't adhere. Women, namely, were very resistant to a new scheme where the transmission of property was now in the hand of men, the family's head in the colonial social model.[92] More, soil quality was now the overarching factor determining the location of concentrations. Soil scientists didn't make much case about complains associated with abandoning the protection of ancestor spirits, guardians of fertility. Also contributing to the unwillingness of natives to resettle was the fact that the translation of the experimental station model into the fields demanded harder and longer work than before. The very same overseers recognized that "within the concentrations we had more or less perfect control over the work of each peasant every day. We could never have exercised such power when their cotton fields were dispersed."[93]

It may be argued that 30.000 families were just a tiny proportion of the total number of cotton planters in Mozambique, roughly 10% of the total number. But the fact is that in spite of the majority of natives not being under the scientific rule of the cotton concentrations the scientists of the Center for Cotton Research still kept a large array of responsibilities: distribution of selected and disinfested seeds produced at the experimental stations; decision about the areas for growing cotton, taking into consideration soil and climate conditions; election of best strains for each region; instructions on how to prepare soil and defend them against erosion and loss of fertility, when and how to seed, when and how to weed, when and how to pick... The connection between the recommendations made in the colony's capital, Lourenço Marques, and the field was assured by a vast corps of agriculture extension distributed by 4 delegations, 22 sectors and 195 agencies. By the mid 1960s, short after the coercive labor system was abolished, 2700 officials of the Cotton Institute, the new name of the Board, were responsible for managing less than half a million cotton growers planting some 350.000 ha of cotton.[94]

But maybe the best example of the tight connections between laboratory work and the changing landscape is the breeding effort undertaken by the center geneticists and phytopatologists. In the 1940s the requisite of selecting strains resistant to Jassid attacks was considered as a necessary condition to the very same future of cotton in Africa. Twenty years later, breeders' aims would change radically. In the 1960s plants resistant to Jassid were perceived as a hindrance to achieve higher productivity. For cotton to be picked up mechanically it is necessary to employ a chemical defoliant, so that leafs won't be picked together with the cotton fiber. Now, Jassid resistance is due to pubescent leafs that after the application of a defoliant stick to the cotton fiber, reducing drastically its value. Jassid resistance is thus a property tightly connected with manual workers, planting in their small plots much less productive strains. In the beginning of the 1970s the new strains that the breeders of the Center were proud to announce presented a poor resistance to Jassid, but were highly recommended for farmers relying on machines and making use of big inputs of insecticides.[95]

The new strains were thus crucial for the new white settlers that started to dominate cotton growing in Northern Mozambique, and that in 1974, just before independence, were responsible for 80% of the region production. The new settlers, with the support of local authorities, occupied the best lands and even took over the previous areas of cotton concentrations. If the new rise in international markets in cotton prices attracted many to the cotton business, the colonial government also contributed to this new strategy of changing the color of cotton from black to white in order to create buffer zones against guerrilla actions in one of the most disputed landscapes of Mozambique.[96]

It is hard to distinguish what allows for what. Was it the policy of the last European empire that offered the resources for the breeders work? Or were the breeders the ones that offered colonial authorities the resources for keeping their policies in spite of the international pressure to put an end to Portuguese imperial ambitions?[97] Better than understanding the history of colonial science as a simple tool of empire, the cotton case suggests instead that we should start considering it simply as colonial history.

Conclusion

The aim of the present paper was to make a similar case for the other two laboratories, the National Agriculture Experiment Station and the National Laboratory of Civil Engineering. Better than just understanding them in the context of internal colonization of Portugal, I suggest that one should take their history as internal colonization history. The argument is that delving into the relation between laboratories and landscapes helps to make history of science narratives more relevant for general history. In this paper I present at least three forms of understanding such relation. First, laboratories can grow up from landscapes, with people and instruments mobilized around the translation of landscapes into laboratory language. The EAN was tightly connected with the new wheat fields of Alentejo; LNEC's main feature was its ability to put rivers and dams at laboratory scale; the Cotton Research

Institute first task was to translate the entire territory of Mozambique into soil and vegetation charts while building an entire regional network of experimental cotton fields.

Second, it pays off to explore how laboratory facilities interact with their surroundings, as suggested by the treatment of LNEC as new urban landmark of fascist Lisbon. But maybe the EAN example was even clearer with its building taken as the best example of the kind of architecture that should make Portugal Portuguese. Actually, paying attention to architecture and the sprawling departments occupied with the same object helps to understand how big state laboratories work, mobilizing instruments and people for the purpose of scrutinizing individual objects, be it dams or wheat.

Finally, and this is the third and more obvious point, landscapes are changed by the work done inside laboratories walls. The way cotton fields are organized or rivers are put in service of electrical production is only understandable passing through interior spaces. Also, landscapes are constantly changing and one need lots of laboratory work to keep them producing good yields of wheat or cotton, to keep dams producing electricity without falling apart or to keep natives working the land for autarky policies. A useful way for historians of science to question a landscape is to ask for the laboratories that produced it. And so it seems proper to end by slightly changing Bruno Latour's famous motto into "Give me a laboratory and I will raise you a landscape".[98]

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[1] See namely the edited volumes, Susanne Heim, Carola Sachse and Mark Walker, eds., The Kaiser Wilhelm Society under National Socialism (Cambridge University press, 2009); Monika Renneberg and Mark Walker, eds., Science, Technology and National Socialism (Cambridge University Press, 1994); Margit Szöllösi-Janze, ed., Science in the Third Reich (Oxford. Berg, 2001); Carola Sachse and Mark Walker, eds., Politics and Science in Wartime: Comparative International Perspectives on the Kaiser Wilhelm Institutes, Osiris 20 (2005).

[2] Susanne Heim, ed., Autarkie und Ostexpansion. Pflanzenzucht und Agrarforschung in Nationalsozialismus (Göttingen: Wallstein, 2002)

[3] Mitchell Ash, "Wissenschaft und Politik als Ressourcen für einander", in Wissenschaften und Wissenschaftspolitik: Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts , eds. Rüdiger vom Bruch and Brigitte Kaderas (Stuttgart: Franz Steiner Verlag, 2002), 32-51.

[4] For a general overview see, Caroline Elkins and Susan Pedersen (eds.), Settler Colonialism in the Twentieth Century: Projects, Practices, Legacies (New York: Routledge, 2005). For an informed discussion between the relation of American and Australian frontier myths see, Sarah Franklin, Dolly mixtures: the Remaking of Genealogy (Durham: Duke University Press, 2007), 118-157. For Brazil and the Soviet Union see, for example, Marianne Schmink and Charles H. Wood, Contested Frontiers in Amazonia (New York: Columbia University Press, 1992); Paul Josephson, Industrialized Nature: Brute Force Technology and the Transformation of the Natural World (Washington DC: Shearwater Press, 2002), 172-192.

[5] For the role of science and technology in the efforts of the Portuguese state to control the national territory in the second half of the nineteenth century see, Tiago Saraiva, Antonio Lafuente, Ana Cardoso de Matos, "Tecnología y Frontera: La Invención Fracasada de Iberia", in Maquinismo Ibérico, eds. Antonio Lafuente, Ana Cardoso de Matos and Tiago Saraiva (Aranjuez: Doce Calles, 2007), 15-32.

[6] For a general overview of Campos' trajectory see Fernando Rosas, "Ezequiel de Campos e a solução neofisiocrática da «crise Portuguesa»", introduction to Textos de Economia e Política Agrária, Ezequiel de Campos (Lisbon: Banco de Portugal, 1998).

[7] Ezequiel de Campos, Pregação no deserto (Porto: Lello & Irmão, 1948).

[8] Ezequiel de Campos, "Modificação do Ambiente das Ilhas de S. Tomé e Príncipe", Boletim da Sociedade de Geografia de Lisboa, 74 (1956): 141-150.

On the formation of an international desiccation discourse see Richard H. Grove, Green Imperialism. Colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1800, (Cambridge University Press, 1995).

[9] David E. Nye, America as Second Creation. Technology and Narratives of New Beginnings (Cambridge, Mass: MIT Press, 2003); Donald J. Pisani, Water and American Government. The Reclamation Bureau, National Water Policy, and the West, 1902-1935 (Berkeley: University of California Press, 2002), 272.

[10] Campos, Pregação no Deserto, 12.

[11] For Martins' proposals see Oliveira Martins, Fomento Rural e Emigração (Lisbon: Guimarães, 3rd ed., 1994). For the Portuguese tradition of internal colonization projects, Fernando Oliveira Baptista, A Política Agrária do Estado Novo (Oporto: Afrontamento, 1993), 19-35.

[12] Ibid., 20-22. For a description of the conservation movement see, Samuel Hays, Conservation and the Gospel of Efficiency. The Progressive Conservation Movement, 1890-1920 (Cambridge, Mass: Harvard University Press, 1959); Donald Worster, Rivers of Empire: Water, Aridity, and the Growth of the American West (Oxford University Press, 1985).

[13] Ezequiel de Campos, A Conservação da Riqueza Nacional: a grei, os minerais, a terra, as matas, os rios (Porto: 1913)

[14] From 16.000 emigrants for the year 1900, the number rose to 31.700 in 1910. From 1900 to 1930 the total flux of emigrants was of some 900.000 people. The total Portuguese population was 5.446.760 in 1900 and 6.802.429 in 1930.

[15] Campos, Pregação no deserto, 17.

[16] Campos, Conservação da Riqueza Nacional, 460.

[17] Campos, Pregação no deserto, 18. Ezequiel de Campos conducted his own colonising test in Alentejo by buying some 42 hectares of land and occupying it with settlers from the northern region. In his memories he narrates all the difficulties that would finally put an end to the experiment. Ibid., 33-36.

[18] The correction of the rain pattern of Portugal by forestation was one of Campos' favourite issues, on which we presented several papers. For example, Ezequiel de Campos, Problemas Fundamentais Portugueses (Lisbon: Edições Ocidente, 1946), 77-81.

[19] On Campos proposals for a national electrical grid see, Campos, Problemas Fundamentais, 150-151.

[20] Campos, Pregação no deserto, 61-63; Campos, Problemas Fundamentais, 151-152.

[21] Manuel Villaverde Cabral, "The Seara Nova group (1921-1926) and the ambiguities of Portuguese liberal elitism", Portuguese Studies, 4 (1988): 181-95.

[22] Fernando Rosas, Salazarismo e Fomento Económico. O primado do político na história económica do Estado Novo (Lisbon: Editorial Notícias, 2000), 179.

[23] Rui Ramos, A Segunda Fundação, in História de Portugal, vol. VI, ed. José Mattoso (Lisbon: Círculo de Leitores, 1994), 552.

[24] Campos, Pregação no Deserto, 136-138.

[25] For an overview of the relation between engineers and the New State see, José M. Brandão de Brito, "Os Engenheiros e o Pensamento Económico do Estado Novo", in Contribuições para a História do Pensamento Económico em Portugal, ed. José Luís Cardoso (Lisbon: Dom Quixote, 1988): 211-234; Nuno Luís Madureira, "Visionários e dirigentes: os engenheiros portugueses na primeira metade do século XX", paper presented at the XXth Annual Meeting of the Associação Portuguesa de História Económica e Social, Oporto, 2000.

[26] This short list of characteristics of Salazar's regime is taken from Manuel Villaverde Cabral, "Portuguese Fascism in Comparative Perspective", working paper presented at the International Political Science Association, XIIth World Congress Rio de Janeiro, 1982. For an informed discussion on the place of the Portuguese authoritarian New State among fascist regimes see, António Costa Pinto, Salazar's Dictatorship and European Fascism. Problems of Interpretation (New York: Columbia University Press, 1995). For a contrasting position see Luís Reis Torgal, Estados Novos, Estado Novo: Ensaios de História Política e Cultural, 2 vols., Vol. I (Coimbra: Imprensa da Universidade de Coimbra, 2009), 289-367; Manuel de Lucena, "Interpretações do Salazarismo" (I), Análise Social 20 (1984): 423-451; Villaverde Cabral, "Portuguese Fascism in Comparative Perspective". These three texts are convincingly critical about the exclusion of the Portuguese regime from the category of Fascism. The historian Fernando Rosas goes a step further and includes it in the family of totalitarian regimes: Fernando Rosas, "O salazarismo e o homem novo: ensaio sobre o Estado Novo e a questão do totalitarismo", Análise Social, 35 (2001): 1031-54. On the deep relation between Portuguese fascism and its European counterparts see also, Manuel Loff, "O nosso século é fascista!" O Mundo visto por Salazar e Franco (1936-1945) (Oporto: Campo das Letras, 2008).

[27] Manuel de Lucena, "Interpretações do Salazarismo: notas de leitura crítica" (I), Análise Social 20 (1984): 423-451

[28] Luís Reis Torgal, A Universidade e o Estado Novo (Coimbra: Minerva, 1999), 46.

[29] In 1928 wheat alone represented 12% of the total Portuguese imports, being responsible for 22% of the external deficit. The best source for the Portuguese Wheat Campaign is still, José Machado Pais, Aida Maria Valadas de Lima, José Ferreira Baptista, Maria Fernanda Marques de Jesus, Maria Margarida Gameiro, "Elementos para a história do fascismo nos campos: A «Campanha do Trigo»: 1928-38 (I)", Análise Social 12(1976): 400-74; and José Machado Pais, Aida Maria Valadas de Lima, José Ferreira Baptista, Maria Fernanda Marques de Jesus, Maria Margarida Gameiro, "Elementos para a história do fascismo nos campos: A "Campanha do Trigo": 1928-38 (II)", Análise Social 14 (1978): 321-89.

[30] António Sousa da Câmara, Os objectivos da Campanha do Trigo (Lisbon: Editorial Império, 1955), 42-43.

[31] Mário de Azevedo Gomes, Henrique de Barros e Eugénio de Castro Caldas, "Traços principais da evolução da agricultura portuguesa entre as duas guerras mundiais", Revista do Centro de Estudos Económicos, 1 (1945): 21-203; Mariano Feio, Le Bas Alentejo et l'Algarve (Lisbon: Congrès International de Gèographie, 1949), 82-87.

[32] Câmara, Os Objectivos da Campanha doTtrigo, 31. This is a quotation by Câmara of the words spoken by Homem de Melo.

[33] For a description of Câmara's experience in berlin see Tiago Saraiva, "Fascist Labscapes: Genetics, Wheat and the Landscapes of Fascism in Italy and Portugal", Historical Studies in the Natural Sciences, 40 (2010), forthcoming.

[34] António Câmara, "Programa de Trabalhos do Departamento de Citologia e Genética", in Planos de Trabalho da Estação Agronómica Nacional, ed. António Câmara (Lisbon: Estação Agronómica Nacional, 1939) 79-89, on 79.

[35] António Câmara, "Horizontes da Estação Agronómica", in Planos de Trabalho da Estação Agronómica Nacional, ed. António Câmara (Lisbon: Estação Agronómica Nacional, 1939), 7-41.

[36] António Câmara, No Caminho. Guiando uma empresa científica. (Alcobaça: Tip. Alcobacense, 1943), 47-48.

[37] Marcelo Caetano , preface to Câmara, No Caminho, X.

[38] Câmara, No Caminho, 68-72.

[39] António Câmara, "Instalações da Estação Agronómica Nacional", in Câmara, Planos de Trabalho da Estação Agronómica Nacional, 42-70, on 54.

[40] On the new old good taste see Margarida Acciaioli, Exposições do Estado Novo, 1934-1940 (Lisbon: Livros Horizonte, 1998).

[41] "Campanha do bom gosto", Panorama, 1941. On the role of the National Propaganda Board see for example, Daniel Melo, Salazarismo e Cultura Popular (1933-1958) (Lisbon: Imprensa de Ciências Sociais, 2001); Luís Trindade, O Estranho Caso do Nacionalismo Português. O salazarismo entre a literatura e a política (Lisbon: Imprensa de Ciências Sociais, 2008).

[42] Câmara, "Instalações da Estação Agronómica Nacional", 54.

[43] The First National Congress of Engineering in 1931, the Great Exhibition of Portuguese Industry in 1932, and the First Congress of the Portuguese Industry in 1933, were historical landmarks expressing the new social role of engineers. See, Brandão de Brito, "Os engenheiros e o pensamento económico…"; Rosas, Salazarismo e fomento económico; Madureira, Visionários e Dirigentes, 8.

[44] Quoted in Rosas, Salazarismo e Fomento Económico, 58.

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[46] Ministério de Obras Públicas, Quinze anos de obras públicas: livro de ouro (Lisbon: Comissão Executiva da Exposição de obras Públicas, 1948), 122.

[47] Worster, Rivers of Empire; Marc Reisner, Cadillac Desert: the American West and its Disappearing Water (New York: Viking, 1986)

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[51] For a biographical account of Manuel Rocha see, Armando Gibert, Manuel Rocha, O Pensamento e a Obra (Lisbon: Imprensa Nacional Casa da Moeda), 1986.

[52] On the activities of the Institute of High Culture see in this same issue the article by Júlia Gaspar, Maria do Mar Gago, Ana Isabel Simões, "Scientific Life under the Portuguese dictatorial regime (1929-1954): the communities of geneticists and physicists."

[53] António José Telo, Portugal na Segunda Grande Guerra (1941-1945) (Lisbon: Vega, 1991).

[54] Direcção Geral dos Serviços Eléctricos, Concessão do aproveitamento hidroeléctrico da energia das águas dos rios Cávado e Rabagão (Lisbon: Imprensa Nacional, 1964); Ilídio Mariz Simões, Pioneiros da electricidade em Portugal e outros estudos (Lisbon: EDP, 1997); Maria Fernanda Rollo and J. M. Brandão de Brito, "Ferreira Dias e a constituição da Companhia Nacional de Electricidade", Análise Social, 31 (1996): 343-354.

[55] Brandão de Brito, "Os Engenheiros e o Pensamento Económico do Estado Novo", 223-225; Madureira, "Visionários e Dirigentes", 16-17.

[56] Manuel Rocha, The Laboratório Nacional de Engenharia Civil. Organization Mangement, and Activity (Lisbon: Laboratório Nacional de Engenharia Civil, 1955), 1-2.

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[59] Manuel Rocha and J. Laginha Serafim, "Analysis of Concrete Dams by Model Tests", Fifth Congress of Large Dams, Paris, 1955.

[60] Manuel Rocha, J. Laginha Serafim, A. Ferreira da Silveira, and O. V. Rodrigues, "The Observation of the Behaviour of the Portuguese Concrete Dams", Fifth Congress of Large Dams, Paris, 1955.

[61] Rocha et al, "Model tests…".

[62] Rocha, The Laboratório Nacional de Engenharia Civil, 2.

[63] Ibid., 3.

[64] Ibid., 2.

[65] I follow here the unpublished architecture project for the laboratory building, Pardal Monteiro, Laboratório Nacional de Engenharia Civil. Programa e Memória Descritiva. Ante-Projecto (Lisbon: Ministerio de Obras Públicas, 1948).

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[69] Valentim Alexandre, Velho Brasil, Novas Áfricas: Portugal e o Império (1808-1975) (Oporto: Afrontamento, 2000), 208-215.

[70] Nelson Saraiva Bravo, A Cultura Algodoeira na Economia do Norte de Mocambique (Lisbon: Junta de Investigações do Ultramar, 1963); Allen Isaacman, Cotton is the Mother of Poverty. Peasants, Work, and Rural Struggle in Colonial Mozambique, 1938-1961 (Porstmouth, NH: Heinemann, 1996).

[71] Pitcher, Politics in the Third Portuguese Empire, 114-136;

[72] Isaacman, Cotton is the Mother of Poverty.

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[74] Eduardo Mondlane, The Struggle for Mozambique (Harmondsworth: Penguin, 1969).

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[79] António Jose da Silva Teixeira, "A Estação Experimental Algodoeira de Namulonge, Uganda", Separata Gazeta do Agricultor, 1955: 1-31.

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[81] Isaacman, Cotton is the mother of poverty, 44.

[82] Cristophe Bonneuil, Osiris

[83] Saraiva Bravo, A Cultura Algodoeira, 233-34,

[84] On the qualities of the U4, see Quintanilha et al, "Variedades de algodão cultivadas", 21.

[85] For a general discussion of State schemes failures with some examples taken out from agriculture projects, see James C. Scott, Seeing like a State: how certain schemes to improve the human condition have failed (New Haven: Yale University Press, 1998).

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[87] Secrete correspondence between Gabriel Teixeira, Governor of Mozambique, and the Minister of Overseas (Ministro do Ultramar) for the year 1951: Arquivo Nacional Torre do Tombo (ANTT), Arquivo Salazar (U/7-a).

[88] The authorities recognized the problem, but only acknowledged the death of 200 Mozambicans. See Fortuna, O Algodão de Moçambique, 152-154.

[89] Secrete correspondence between Gabriel Teixeira, Governor of Mozambique, and the Minister of Overseas (Ministro do Ultramar) for the year 1951: Torre do Tombo, Arquivo Salazar (U/7-a).

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[92] M. Anne Pitcher, "Conflict and Cooperation: Gendered Roles and Responsibilities within Cotton Households in Northern Mozambique", African Studies Review, 39 (1996): 81-112.

[93] Nelson Saraiva Bravo, op. cit., 114-115

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[95] P. Pereira de Carvalho, 25 anos de melhoramento do algodoeiro em Moçambique – 1952-1976. (Maputo: Instituto de Investigação Agronómica de Moçambique, 1976).

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[97] See namely, the UN reports on massacres in Mozambique committed by the Portuguese: UN General Assembly, Report of the Commission of Inquiry on the Reported Massacres in Mozambique, New York: United Nations, 1974.

[98] Bruno Latour, "The Force and the Reason of Experiment", in Experimental Inquiries: Historical, Philosophical and Social Studies of Experimentation in Science, ed. H. E. Le Grand (Dordrecht: Kluwer, 1990), 49-80, on 76.

Fascist Autarky and the Italian Scientists

*By Roberto Maiocchi**

This work examines the history of the National Council for research, the most important Italian scientific institute in Fascist years, until World War II. The focus is on the role of the institute in carrying out the autarky project which involved the whole Italian society from 1935 onwards. The National Council for Research would eventually prove to be unable to reach the goals set by the political power.

The official proclamation of autarky – the fundamental fascist political project – appeared in a speech given by Mussolini at the end of the great manoeuvres in Bolzano on 31st August 1935. On this occasion the Duce announced to the World that Italy "would manage alone"[1]. In fact, the question of economical autonomy of the nation had been discussed in the scientific-technical circles since twenty years, that is, since World War I had revealed the weakness which endangered the foundations of the Italian economy.

The war mercilessly displayed serious lacks in the production sector and the lacks regarding basic raw material – problems which in other countries involved in the war (particularly in Germany) were approached with a decisive help of applied science[2]. During the conflict there was the birth of an ideology, a "technical-scientific nationalism", which, by means of conferences, publications, organisational initiatives and political pressure, made an attempt to obtain concentration of resources (including the founding of large national research institutes) and a greater involvement of Italian scientists in research of applied character (which created the basis for a reasonable use of the national resources)[3]. Those two points of the programme, namely the fight for diffusion and the development of a science that would be useful for the nation, provided cultural background for numerous public and private initiatives, the greatest of which was the creation of a Bureau for Inventions and Research Initiatives by the Ministry of War, initiated in the first place by Vito Volterra, an internationally recognized mathematician[4].

By the end of the war, also thanks to Volterra, a project aiming at the creation of a public institution detached from the university circles was elaborated. Such a step would permit the opening of a large state laboratory (to be eventually divided into three laboratories, separately for physics, chemistry and biology) and push the Italian science towards studying the questions regarding the economical development and the security of the Nation. This institution was the National Council for Research. Although the project was faced with many difficulties caused by the political circles, and many times it seemed that it would collapse, the National Council for Research was eventually founded on 18 November 1923 with Volterra as president[5].

At that moment, however, the cultural atmosphere was changing. The economical post-war crisis was already over and what followed was a period of economical growth which, in spite of a certain slackening, continued until the great crisis of 1929. Such growth resulted from an intensive international exchange which didn't really fit into the idea of decreasing imports, which was so high in precedent years. The scientific-technical debate over the possible economical autonomy of Italy, so intense at the beginning of the 1920s and concentrated particularly onnitrogen fertilizers and combustibles, occupied progressively less and less space[6].

The National Council for Research, based upon a quasi-autarky programme, remained practically fruitless. During the four-year presidency of the anti-fascist Volterra, the government subsidies were enough only to maintain its existence (175.000 lira per year which today would equal about 110.000 euro)[7]. In 1927, after the tenure of Volterra's office had expired, the post was offered to Guglielmo Marconi, who had invented the world-famous radio, a business man who led a sort of multi-national society. Marconi was a complete stranger in the Italian academic circles, chosen by Mussolini only because of the splendor he could add to the institution[8]. During the handing over of the post to Marconi, the Council underwent a restructuring – a work which lasted two years, so that real activity only started in 1929.

Still, the resources at disposal of the NCR remained very small (679.000 lira a year, about 400.000 euro) which excluded the possibility to put into practice even a part of the project regarding the creation of research institutes of national character. Moreover, until 1937 the institution remained without an own head office: it was hence forced to be hosted at some public offices or to rent private apartments, and sometimes it had even to face the necessity to dismiss some of its employees[9].

This little generosity regarding the funding of the NCR resulted undoubtedly from Mussolini's attitude. At least until 1930 Mussolini had serious doubts regarding the utility of the NCR. He saw it, above all, as a propaganda-instrument dedicated to organizing conferences and exhibitions, issuing publications and popularizing a perfect image of the Italian science abroad. As such, to Mussolini the Council seemed a useless copy of the Italian Academy – a representative body created specially in 1926 to glamorize the culture of fascist Italy. Thus, Mussolini thought seriously of an opportunity to liquidate the unit and did not feel any need to offer the NCR directives regarding any strategic research project[10].

With absolutely no hints from the government regarding the course to follow, the direction of the NCR turned on its own initiative towards autarky. In the narrow management group particularly noticeable were, because of their influence, the vice-president, Amedeo Giannini, a professional diplomat involved in science, and Nicola Parravano, Professor of Chemistry at the University of Rome, who had close ties with industry. In their vision, Italy appeared as a country whose economy should be based predominantly on agriculture and which was able to follow an economical development different than the model displayed by states where capitalism was already advanced (England and the United States), that is – which should develop through focusing on industrial production linked to agriculture. Only being aware of this ruralist perspective can one understand the first research projects initiated at the NCR, almost all of which were focused on rational – direct or indirect – use of the Italian agricultural resources. Great attention was granted to the use of wood as fuel, with utilization of gasogene material. Particular attention was paid to the processing of citrus fruit where, in accordance with the Institute for Export, the NCR managed to obtain a patent on a mechanical procedure for extracting lemon essence from lemon paste– the by-product of citric acid production. Among the studied issues there were also glycerine production through fermentation of agricultural by-products, tomato conserves, mineral waters, producing of ethanol from agricultural products and the use of castor oil as "national" lubricant[11].

In 1931, however, the political and economical climate in Italy started to change. Only during this year the seriousness of the international economical crisis was fully evaluated. Italy made efforts to maintain a free trade foreign policy even after such powerful countries as England had adopted protective measures. Nevertheless, the fascist government would soon recognize that the economical problems would not be solved by turning towards international markets and that the situation required regulation of foreign trade and the increase of domestic production. This decision, which anyhow was to be carried within the two following years, was accompanied by the decision to finally put into practice the reorganization of the Italian production sector trough Corporatism which should allow for the government to control effectively the national economy. Corporatism was to be implemented together with the strategic and military resolution to prepare the conquest of Ethiopia[12]. Therefore, in 1933 a clear political line was drawn – a line that aimed at the mobilization of all national resources, searching the possibly largest independence from abroad in view of preparing a conquest war. It was the autarky project, even if the term itself was not yet in use.

In this new context this ideology, which I have defined as "scientific-technical nationalism", and that was at the roots of the initial project of the NCR, regained its power. The Council tried to adapt to the requirements imposed by the historical moment by launching certain initiatives meant to contribute to the economic independence of Italy. Particularly remarkable was the activity of the Committee in charge of the raw materials used in Italian production structures[13]. The president of the Committee was Gian Alberto Blanc, a chemist who was deeply involved in some industrial initiatives. In his speech delivered at the opening of a plenary reunion of the NCR on 7 March 1933, Marconi confirmed that the raw materials issue was the central point of the Council's programme. The following year, talking at the plenary reunion of 8 March 1934, Marconi came up with what could be called an innovation if compared to his previous public appearances, because of the combining of the usual subject of national resources evaluation with that of imperial mobilization of science[14].

Mussolini seemed to have decided on the involvement of the Italian science in military preparations: he ordered a considerable increase of the funds for the NCR – while between 1930 and 1934 the average funding was about 1.500.000 lira (ca. 1.200.000 euro), in 1935 almost 6 million lira (5.300.000 euro) were assigned to the Council[15]. So the assigned money was four times as much as in the previous years! On 18 May 1934 the Duce approved the order which constituted the Co-ordination Committee between the NCR and the army. The Committee's first session, presided by Marconi, took place on 9 July 1934. Trails of this Committee have been lost: most probably its activity didn't last longer than 1934. Its inauguration session, however, had a truly solemn tone[16].

Regardless of numerous official declarations, none of the Government's representatives seemed to consider the NCR as a useful consulting body. The ministers and the Army preferred to address their own technical offices and evidently considered the NCR a rival of which to be jealous, rather than an instrument of technical and scientific information. The NCR, although it did not have necessary strategic information, had to decide alone which problems were urging most to work on. On 6 March 1935 Mussolini sent a letter[17] to Marconi in which he indicated problems which should further be considered fundamental in the final stage of the realization of economical autarky in view of the war. At that time, the preparations for the war in Ethiopia, which was to start in October of the following year, were already in full progress.

The Duce pointed at four fundamental questions and asked the NCR to swiftly resolve them:

"It is an absolute need that the NCR should polarize and concentrate its efforts on the following problems in order to find both a national and an industrial solution to them (that is, not just a simple laboratorial one). A) the problem of national fuel (alcohol, rocks and schists, gasogene material etc.). B) the problem of national textiles. C) the problem of national cellulose. D) the problem of the use of solid national combustibles (coal, brown coal etc.). On some of the listed problems there are studies, experience and industrial applications (in initial stage). It's time to give the Government a ground for large-scale activity".

The problems brought up by the Duce, as well as other issues, had been discussed for a couple of months by the press, but the NCR did not take them into consideration except for the "cottonization" of hemp [mixing cotton with fibres made of hemp]: for this purpose they rented a laboratory in a technical institute in Naples and left it at disposal of the hypothetical "inventors". Those were huge problems to which there seemed to be no quick solutions and which could only be reasonably approached if one had much time and vast resources. Mussolini did not concede either to the NCR; however, his directive could not have been ignored.

The NCR's reacted rapidly and within less than two months the reports expected by the Duce were ready[18]. Of course, as it might have been supposed, the reports were absolutely useless and sank into oblivion. Never again did Mussolini ask the NCR for anything personally.

Also in Spring 1935 another important sign of a modest growth of interest of the Government for the activity of the NCR was given, namely the creation of the "Inter-Ministerial Commission for Insufficient Raw Material and for Substitutes" (further called CISS). This was the unit expected by the Supreme Commission for Defence, the highest governmental body with military prerogatives, whose head was Mussolini himself[19]. The task of the Commission was of great strategic relevance. The Commission was to issue a report in January of the following year; the report, which was to be presented to the Supreme Commission for Defence, was supposed to indicate the needs, effective resources, deficits, and ways to obviate the possibly broad variety of raw materials Italy would need in a hypothetical first year of war. In other words, the report was to serve in the evaluation of whether the Nation was able or not to resist a year of war. The Commission was meant to be of permanent character and to issue such an evaluation every year. The Commission represented the most important form of involvement of the NCR in the war preparations.

The Commission comprised technicians representing various ministries, the Armed Forces and the NCR. The latter was also supposed to provide the head office and contribute to the organizational needs. Since the NCR did not possess any unit for publishing statistical data (the data included in Blanc's report regarding raw material would later turn out unreliable), basic numbers for the report on the necessity and availability of raw material were requested from the Committee for Civil Mobilization, a military structure created during World War I to manage the production of economical goods in case of war. The head of the Committee was General Alfredo Dallolio, an elderly officer of a very tough character, who would always make it evident that he considered the CISS a useless and annoying, if not harmful, rival. Still, regardless of these difficulties, the CISS pursued its activity in the following years and would issue its annual report on time. The Commission was gradually broadened: outstanding scientists and technicians from the private industry sector were employed, the work was divided and articulated efficiently, and so the scale, precision and concreteness of the final reports increased noticeably.

It seems that Mussolini paid great attention to the CISS reports, but – unfortunately – also the CISS paid much attention to Mussolini's opinion. In the final discussion about the preliminary works, one can feel agrowing worry not to provide an excessively negative picture of the situation in Italy, smoothing the available data in order not to delude too much the expectations of the Duce. In the execution of this preventive censorship Amedeo Giannini, the vice-president of the NCR, was particularly active. What seems to be the most glamorous example of "mending" of data to support Mussolini's strategic choices instead of confronting them with the reality is the case of the evaluation of pit coal included in the report from January 1940[20].

January 1940 was a particularly dramatic period: several months before Europe had fallen prey to the advancing Wehrmacht and Italy had to decide whether it should enter the war as Hitler's ally or not. The CISS-report was to serve as a reference point for an epochal decision in the Italian history. The report contains disconcerting data on pit coal. It represented the most important import item, reaching about 13 %, in value, of Italian imports. The amount of imported coal gradually increased and in the years 1938-1939 it exceeded 12 million tonnes. The CISS report from 1940 provided a both clear and surprising hint: if, in case of peace, the need of combustibles to import was expected to be of 12.750.000 tonnes, in case of war the estimation was reduced to 8.900.000 tonnes, that is, the amount guaranteed by the secret agreements with Germany. Thus, it meant that, in case of entering the war, Italy's needs for coal consumption would be reduced! The miracle of reducing the consumption by almost 4 million tonnes of combustibles would have been put into practice by means of a drastic decrease in industrial production: for the industries working in Italy during peacetime there was a reserve of 9,5 million tonnes, but in case of war the industries would have to do with less than 6,5 million tonnes, about 4 million of which were destined to the war industries. It seems more than evident that such a solution, based upon the almost complete paralysis of industry could only be seriously considered in case the war wouldn't last long; indeed, only for a few months could the country survive and fight with its industrial structures barely working or even out of work to avoid consuming coal. As far as the combustibles are concerned, the decision to enter the war seemed to be a bet, a great risk that could only be taken into consideration if one had forgotten all that was written and said on the principal conclusion that should have been drawn from the experience of the Great War during the two precedent decades: modern war was no longer a war of armies but a war of nations which required the complete involvement of all productive forces, the maximization of industrial activity, and certainly not its slackening; to take this risk with trust in a swift solution of the conflict was a dramatic step. Mussolini, though, chose to risk and the CISS report provided data which were mostly welcomed by the Duce. Immediately after Italy had entered the war, the CISS was dissolved: because of the fact that the war was in progress, a body dedicated to predict a future which had become the present seemed to be superfluous.

Let us go back to the period of the Ethiopian war. The already mentioned increase in funds in 1935 was followed by an even greater augmentation in 1936, which raised the disposable financial resources to 10 million lira (more than 8 million euro). The increase grew and immediately before World War II the funding eventually reached more than 25 million lira (almost 17 million euro) per annum. Thus, within five years the real value of the funds of the NCR was multiplied by more than 17[21]. Mussolini's initiative was fundamental for such large increase. This sudden wealth brought new perspectives to the NCR. It was finally possible to put the original programme into practice, at least partially. If nothing else, the NCR was able to build its own headquarters which were opened in 1937, also thanks to the contribution of many companies which were asked by Mussolini to intervene directly.

The increase of funds didn't come with any new governmental directive regarding scientific research aimed at contributing for Italian autonomy. Mussolini offered generous funding but he did not say how to use it. The NCR thus invented for itself a role as key player in the process of construction of imperial Italy, often provoking jealousy of various ministries, above all of the Ministry of Education headed by Giuseppe Bottai.

In early 1936, when the victory of the Italian army in Africa seemed already imminent, similarly to many Italian public bodies, the NCR launched an evaluation of the resources that could be found in the conquered lands. The Council wanted to demonstrate with its own diligence that it was worth the fund increase. It proposed, therefore, to co-operate with ministries and bodies like the Italian Academy; the answers, however, were either negative or none at all[22]. The only thing the NCR managed to do was the organization of a commission of chemists which in 1936 explored Ethiopia in search for industrial structures that later might be further developed. After its return to Italy, the commission painted a depressing panorama which lacked any interesting perspective, and so the final report was absolutely useless. It is worth to underline the fact that the head of the mentioned mission was Henry Molinari, a recognized expert on plant design and installation who, however, was well-known also by the Italian police as a militant anarchist. Because of his political ideas, Molinari was forced to quit university and couldn't obtain a permit to leave the country. It was only due to a personal intervention of Mussolini that Molinari was given a passport so that he could leave for Africa[23]. Also in the following years Molinari occupied important posts in the NCR. It seems that Mussolini accorded more importance to technical competences than to political fidelity. As for Molinari, not once did he show, regardless of his political anti-fascist position, resistance to the idea of autarky: in his view, from the perspective of scientific research the autarky-project was the most rational solution. This is only one example of the approach that characterized many of the Italian technicians: the autarky-project, interpreted as an evaluation plan of the national resources by means of scientific research seemed to many an absolutely reasonable idea.

The NCR's will to appear as being involved in the realization of imperial autarky met various obstacles. Those were, among others, the determined opposition of the Ministry of Education against conceding to the NCR the legal possibility to realize its own and autonomous research institutes, and Marconi's death in July 1937. In fact, NCR activities in the second half of 1936 and till the end of 1937 remained limited to its basic functions, without any major contribution to the realization of the autarky project, which in this period should have become the axle of all the political activity of the government[24].

In the years 1938-1939, after the reorganization and the nomination for president of Pietro Badoglio, the conqueror of Addis Abeba and protagonist of military operations that had given Italy an empire, the NCR started to work at full blast. According to the official declarations, the NCR would have to direct all its forces towards autarky, but in reality things followed a different way[25].

First of all, a decree stated that the NCR was to use a large part of the funds at its disposal to constitute a national geophysical service and to reconstruct the National Thalassographic Committee – two institutions which were not linked to the autarky-project. Moreover, no political or military body consulted with the NCR about strategies to be followed while formulating scientific research projects of autarkic interest. Mussolini said nothing more, no ministry asked for assistance – on the contrary, the animosities of the precedent years continued and the armed forces, regardless of Badoglio's presence, did not seem to regard it useful to involve the NCR in its own activities. Thus, once again the Institute had to invent itself a role to play. The management of the NCR, however, was formed mostly of people whose background was not scientific and who did not have qualifications (as it had explicitly been recognized) to formulate plans regarding the Italian scientific research. Therefore, since nobody ever created any plan regarding autarky-orientated research, no-one ever indicated the priorities on the endless list of problems brought up into discussion every day by the autarky-construction issue.

All remained entrusted to the initiative of individuals who managed to obtain funding for their own studies due to their personal contacts rather than because of the objective importance of the researched questions. Many of those researchers who now appeared as autarky-constructors put forward the same issues that they had already dealt with in the precedent years and that had previously not gained attention, but that became extremely up-to-date in the new autarkic atmosphere.[26] These researchers represented the already mentioned scientific-technical nationalism which appeared during the Great War: to them autarky meant the realization of an ideal they had pursued for a long time without success.

Among names that could be enumerated here the most significant is that of Mario Giacomo Levi. Levi, lecturer at the Technical University of Milan, for almost two decades had studied the features and the possible use of Italian coal to replace imported anthracites. With the appearance of autarky, Italy's lack of coal seemed to be the fundamental problem of the production structures and Levi's studies suddenly became famous. In a speech delivered in Autumn of 1937 on the change that came about Levi said:

"In 1931, at the 20th meeting of our Society in Milan I was to speak about a part of the problem, that is, about the technical and economical aspects of the fuel issue. My faith, my enthusiasm and our work did not slacken /.../ but the atmosphere in Italy was sceptical and fearful: what prevailed were strictly economical considerations /.../ I admit that I suffered during this Congress. I left the meeting discouraged and bothered by the doubt whether it was true that I was obsessed and fanatical about my insistence upon studying problems which to our Country meant neither possibility, nor benefit /.../ And how different is the atmosphere today! /.../ The land cultivated with conscientious faith germinates vigorously, the indifferent have become enthusiastic, the incompetent rushed to study and have become scholars, the industrialists, the technicians, the capitalists are fully mobilized, our 130 publications are being searched, read and sold everywhere. The reasons for such a change are known to everybody: for the third time in twenty years the problem of fuel has recently reappeared in Italy, displaying all its violent gravity – maybe more violent than ever because the whole World has united or has tried to unite against us, when 50.000 Italians were abroad in another continent, conquering the Empire. A brilliant victory or suffocation and humiliation depended on transport, production and weapons; the only really national and really available raw material [is] the heroism of our soldiers of all units and in all ranks, the prophetic clairvoyance and the super-human courage of the Duce"[27].

In Autumn 1938 Levi was expelled from the University and persecuted by racial laws.

Just like Levi, many other scientists offered their scientific credibility in favour of autarky, even when the latter became a plan of preparing Italy to an exceptionally important war. The public support of scientists for the autarky project was of great propagandistic importance and served to add a touch of "being scientific" to programmes which were all but reasonable.

I will finish my paper with a brief overview of the research conducted in the political-institutional climate I have sketched before.

The produced research was of various levels and of diversified results. First of all I should certainly recall the research which could be conducted only because of autarky and which led to a failure. The group usually referred to in order to describe the particular scientific climate of the period must be divided into two sub-groups. One group is constituted by typically Italian researches like that regarding some substitute textile fibres (Lanital, "cottonized" hemp) or the use of plants like broom as sources of cellulose, while the second group consists of researches which, due to the technologies applied, were to be forgotten but which, in a given moment, could be considered as in line with the international scientific community: such were the studies of gasogene material, to which the NCR dedicated its largest research institute, the Engine Institute (Istituto Motori) in Naples. Reference models for this kind of research were France, Germany, Switzerland, Austria and the research on reinforced concrete with bamboo cane instead of iron (along the lines of what was being done in Germany) conducted with great intensity in the centre for studies on construction material in Turin led by Gustavo Colonnetti, who at the same time was working also on an avant-garde issue, namely the pre-compressed concrete. Still, along with the efforts which could only be justified by the climate of those days (and they were not limited to Italy only), which were doomed to be instantly forgotten and to which one used to emblematically reduce the whole science of the second half of 1930's, also other typologies were present. Research lines which had already been followed autonomously in the past were resumed by scholars who finally found a way to make their names known and became the centre of general attention in the autarkic climate. This recuperated researches included for example studies regarding the use of national combustibles, the production of aluminium and light alloys, and the extraction of cellulose from annuals. Also new researches, stimulated and made possible by the autarkic conjuncture, were initiated. These studies, which would later be significantly developed, included above all Giulio Natta's research on the production of synthetic rubber supported by Iri and Pirelli. The mentioned research constituted a prelude to Montecatini's achievements in the field of plastic material in the post-war period, as well as to Natta's personal success in the field of polymerization. There were also industrial researches based upon foreign patents without contribution of the University circles, which gave birth to great production realizations such as the hydrogenation of combustibles by the Anic or the production of national magnesium in Bolzano. Also without the contribution of the University original industrial research which brought important results, such as the perfecting of the T4 explosive by Nobel, was undertaken.

This mobilization, rather operational than ideological, of scientists and technicians was not and could never have become sufficient to give any plausibility to the autarky project. The shortages of raw material and of production capacity were too large, too disastrous to achieve the scopes of autarky, even in such a limited and partial shape as it was sketched in fascist plans.

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[1] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, Roma, Carocci, 2003, p.125.

[2] R,Maiocchi, L'organizzazione degli scienziati italiani, in V.Calì, G.Corni, G.Ferrandi (eds.), Gli intellettuali e la Grande guerra, Bologna, Il Mulino 2000, pp.209-244.

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[5] R.Simili, G.Paoloni (eds.), Per una storia del Consiglio nazionale delle Ricerche, Roma-Bari, Laterza 2001, vol. I, p.15.

[6] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, quot., cap.1.

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[8]R.Simili, G.Paoloni (eds.), Per una storia del Consiglio nazionale delle Ricerche, quot., vol. I, cap.2.

[9] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, quot., cap.1

[10] Ivi, p.26 and ss.

[11] R.Maiocchi, La ricerca agraria, in R.Simili, G.Paoloni (eds.), Per una storia del Consiglio nazionale delle Ricerche, quot., vol. I, pp.448-64;

[12] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, quot., p.37.

[13] Ibid., p. 35.

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[18] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, quot., p.50.

[19] R.Maiocchi, Gli scienziati del Duce. Il ruolo dei ricercatori e del Cnr nella politica autarchica del fascismo, quot., cap.4.

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[21] R.Maiocchi, Le istituzioni di ricerca in Italia tra le due guerre, quot.; Id., Gli scienziati del Duce, quot., p.264.

[22] R.Maiocchi, Gli scienziati del Duce, quot. p.115.

[23] Ibid., p.122.

[24] Ibid., p.115.

[25] R.Maiocchi, Il CNR da Badoglio a Giordani, in R.Simili, G.Paoloni (eds.), Per una storia del Consiglio nazionale delle Ricerche, quot.,vol. I, pp.173-200.

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Scientific life under the Portuguese dictatorial regime (1929-1954): the communities of geneticists and physicists

*By Júlia Gaspar, Maria do Mar Gago, Ana Simões**

Introduction

This paper aims at analyzing the scientific agenda of the Portuguese dictatorial regime and how it interacted with the emergence and development of two distinct communities, the community of physicists and the community of geneticists. With the word "interaction", we mean to approach the relationship between science and politics from a dynamic point of view, considering each one as a resource for the other.

The analysis of different political regimes – democratic, fascist, and communist – led Carola Sachse and Mark Walker to conclude "that no one political ideology or system is best, or for that matter worst, for supporting science."[1] Likewise our concern is to show how science developed in Portugal under a dictatorial regime whenever its officials deemed it desirable to fund scientists and scientific institutions in order to implement their policies. We question how and in what ways specific scientific contents and practices co-evolved within a particular political context.

In this paper we use the comparative method to contrast two different groups of scientists which due to their more noticeable dissimilarities and loosely connections offer the opportunity to illustrate in more dramatic ways different instances of co-evolution of science and politics. The group of geneticists reveals a more loosely nature, the group of physicists gave way to what genuinely may be named as a research school. One emerged concurrently in the university context (University of Coimbra) and in one experimental station designed to respond to the international and political context of autarky; the other was grounded solely in the university context (University of Lisbon). Both were the result of events which took place around 1929.

In the context of peripheral countries, scientific groups were often heavily dependent on charismatic leaders, and in the same way political agendas were often dependent on the stamina and ideas of individual politicians. In the Portuguese case, the role of two scientists turned politicians, the agronomist and geneticist Sousa Câmara, and the geneticist and advocate of eugenics Tamagnini, proved crucial. Our narrative ends in 1954 when the relationships between the regime and physics changed noticeably, pushedforward by external events and the ideas of another individual, Leite Pinto.[2]

The Scientific Agenda of the Regime: education, autarky and institution building

After 16 years of a Republican regime, a military coup which took place on 28 May 1926 put an end to a situation that was deteriorating in social and economic terms. A military dictatorship emerged and led to the recruitment of António de Oliveira Salazar (1889-1970) as Finance minister in March 1928. In about one year the economic situation was under control and projects from previous governments were to be implemented. Among them we highlight the Board for National Education (Junta de Educação Nacional), an institution created to support research, dependent on the Ministry of Public Instruction (Ministério de Instrução Pública), headed by the physicians Augusto Celestino da Costa (1884-1956) and Luís Robertes Simões Raposo (1898-1934). Out of a very limited budget, the leading team of the Board for National Education granted funds to laboratories and libraries, and individual scholarships from which members of the scientific community, including the two groups under study in this paper, profited.

In 1932 Salazar was in full power as prime minister and dictator for the next 37 years. The next year a "Constitution" was established to legitimate the new political regime called Estado Novo. In 1936, Salazar took the opportunity provided by the civil war, which started in Spain opposing fascists and supporters of the Popular Front's government, to strengthen the country's social structure with organizations of a fascist character[3]. The new legislation also introduced alterations into the statute of the Board for National Education signaled by its change of name to Institute for High Culture (Instituto para a Alta Cultura)[4]. It became more limited in its autonomy from the regime and the majority of its leaders were appointed among those loyal to it. Some years later, in 1940, the Institute for High Culture took the decision to create "Centres for Studies" in some faculties, granting researchers means, albeit limited, to conduct research and training. Among the first to be installed was the Center for Studies in Physics (Centro de Estudos de Física) at the Laboratory of Physics of the University of Lisbon (Laboratório de Física da Universidade de Lisboa), and a year later the Centre for Natural Science Studies (Centro de Estudos de Ciências Naturais) was installed at the Faculty of Sciences of the University of Coimbra.

The 1930's and the 1940's were times of autarky all over Europe. Following World War I and the great 1929 depression, countries sought in agriculture a new way for self sufficiency in food supplies. It was in this context of autarky that a new policy for supporting agrarian research was adopted in Portugal, creating the right conditions for the development of Portuguese genetics. In 1936, the National Agronomics Station (Estação Agronómica Nacional) was created under the tutelage of the Ministry of Agriculture and in accordance with the regime's priority to support the great landowners' claims. To head this institution the regime chose António da Sousa Câmara, the holder of the chair of agriculture at the Institute of Agronomy (Instituto Superior de Agronomia). Câmara had not only been an enthusiastic participant in the Wheat Campaign (1929-1933), a campaign mirrored on the Italian Bataglia del Grano, but he had received training abroad, at the Plant Breeding Institute in Cambridge and at the Kaiser Wilhelm Institut for Breeding Research in Berlin. [5]His 3-month stay at the Kaiser Wilhelm Institut was determinant for the idea Câmara formed of the role of scientific institutions. Câmara was struck by "the connections between genetics research and the political economy of fascism," the common worship of political leaders, Hitler or Salazar, and, above all, the importance of sustaining autarky dreams by fundamental scientific research.[6] In 1943, after seven years of activity, the National Agronomics Station had turned into a prolific research institution with 62 researchers, a quite unique situation in Portugal, resulting from its consonance with the regime's agrarian policy.[7]The successful organization and financial support bestowed on the National Agronomics Station was to be followed in other domains. This occurred in engineering and in physics, with the foundation of the National Laboratory of Civil Engineering (Laboratório Nacional de Engenharia Civil), in 1946, and Nuclear Physics and Engineering Laboratory (Laboratório de Física e Engenharia Nucleares) in 1961, respectively.

But the scientific agenda of the Portuguese fascist regime cannot be reduced to the foundation of big laboratories exclusively dedicated to applied science. A less obvious interface between the state and the scientific elite emerged from the 1933 Constitution. Indeed, this Constitution not only served to legitimize the political regime imposed in May 1926, but to re-organize Portugal into a "corporative" state. In 1936, under the regime's corporative ideal "national boards" were conceived as "organisms of economic coordination" whose mission was to "develop, improve and coordinate" production activities.[8] Autarkic sentiments were therefore translated into a corporative language, and from 1936 onwards various National Boards came into existence: the National Board of Fruits (Junta Nacional das Frutas), the

National Board of Olive Oil (Junta Nacional do Azeite) and the National Board of Wine (Junta Nacional do Vinho). As recently stressed, the role of techno-scientific elites was crucial for the regular activities of these state organisms.[9] A paradigmatic example is discussed in this paper – the collaboration from 1946 onwards between the National Board of Husbandry (created in 1939) and the University of Coimbra.

The regime's autarkic program came to incorporate the power production domain after the war's end. In 1946 the National Laboratory of Civil Engineering was launched for the purpose of damn building, and hydro power production. In 1954, the Nuclear Energy Board (Junta de Energia Nuclear) paved the way for nuclear power production using the nation's uranium resources. Unlike the National Boards, conceived as "organisms of economic coordination" and run on a business-like logic, the Nuclear Energy Board, also discussed in the paper, held a specific goal of engaging in scientific and technological research.

Important events taking place in 1945 impacted on the lives of scientists and scientific institutions. The allied victory in May was followed by the dissolution of Parliament (Assembleia Nacional) in October and the call for elections in November. Normally, newspapers, all sorts of magazines, and books were subjected to formal censorship. No freedom of speech and of assembly existed, and the political police was eager to enforce this state of things. Political opposition was illegal but, in fact, it managed to work clandestinely. The ten days given to the opposition for presenting lists of candidates and about one month for preparing for election were clearly a simulacrum of democracy, although freedom of speech and assembly were granted by the government during this short period. In spite of these difficulties there was a massive participation in electoral meetings organized by the opposition. In October, at the first of these meetings, a declaration was issued and signed afterwards by fifty thousand citizens from all sectors of activities, labourers and university teachers included, considering the election period a farce, and calling for an enlarged period of six months to prepare for elections. The Movement for Democratic Union (Movimento de Unidade Democrática) came into existence aiming at maintaining the pressure for democratic rule. These events marked dramatically the life of several university teachers and researchers including members of the genetics and physics community under study in this paper.

Aurélio Quintanilha: shaping a group of geneticists at the University of Coimbra

In 1929, genetics began to be taught at the University of Coimbra in the context of a "biology" course created in the November 1926 Reform of the Teaching System. The council of the Faculty opted to teach the science of heredity, granting "the importance genetics was acquiring" instead of teaching generalities in biology.[10] A practical course was organized which included the breeding of Drosophila melanogaster. The cultures of Drosophila were offered by the German biologist Erwin Baur who was in Coimbra for a conference in 1929 by invitation of the local German Institute.[11]

This movement towards genetics was certainly related with the scientific activity of Aurélio Quintanilha (1892–1987), full professor of botany since 1926 and the only person of this university working on genetics prior to 1929. Quintanilha was a medical student in Lisbon from 1913 to 1915,[12] where he met the physicians Celestino da Costa and Marck Athias (1875–1946) who were not only at the forefront of the struggle for university research, but tried to implement new modes of experimental practice in the biological sciences, arousing Quintanilha's interest in cytology.[13] In 1915, influenced by Ruy Telles Palhinha, a teacher of botany, and a native of the Island of Azores like him, Quintanilha changed from medicine to the course of historical-natural sciences at the Faculty of Sciences of Lisbon. He began his histological studies in 1917, as an assistant at the Botanical Laboratory of the Faculty of Sciences, while he continued to do research in cytology, physiology and microbiology at the laboratories of the Faculty of Medicine. In 1919 he moved to Coimbra to become a teacher of botany at the Faculty of Sciences.

In 1928, one year before the creation of the Board for National Education, Quintanilha was awarded a scholarship granted by the University of Coimbra to pursue cytological studies with the German botanist Hans Kniep at the Pflanzenphysiologisches Institutof Dahlem, Berlin, and work on "morphological and physiological problems of fungus and application of this knowledge to questions of plant pathology".[14] After one year, and following Kniep's death in 1929, Quintanilha was invited to work under the supervision of Max Hartmann at the Kaiser Wilhelm Institut for Biology. He interacted with those he called the "grosse Kanonen" of genetics – Carl Correns, Richard Goldschmidt and his supervisor Hartmann. From 1929 to the end of 1931, the Board for National Education granted him another scholarship, to pursue work started in 1928, but in the meantime he had turned already to sex hereditary problem on fungus, one of his old interests, and a topic in between genetics and cytology[15].During his stay in Germany, including the holidays of 1929/30 spent at the Biology Station in Helgoland, he improved important techniques useful for his genetic work.[16] Despite his genetic work conducted in Germany, it is interesting to note that Quintanilha did not use the word "genetics" in his first reports to the Board for National Education."[17] The anti-Mendelian positions shared by the Portuguese biomedical community, to which belonged the heads of the Board for National Education, probably inspired Quintanilha to be careful in reporting his activities.[18]

Returning to Portugal in 1931,[19] Quintanilha was granted yet another scholarship to continue his research at the Botany Institute of the University of Coimbra.[20] Together with Tamagnini, professor of the Deparment of Zoology and Anthropology, Quintanilha ensured the teaching of genetics. Conditions for the emergence of genetics in the university context were being created.His experimental skills in biology, learned with the Lisbon circle of physicians, were now upgraded with technical and theoretical background on genetics acquired while in Germany.[21] Several of his students were influenced by him to such an extent that they became interested in genetics and later pursued academic careers as geneticists. Such was the case of Abílio Fernandes (1906-1994), Flávio Resende (1907-1967) and José Antunes Serra (1914-1990).

In the mid-1930s, following the economic crash of 1929 in the United States of America, Portugal faced economic difficulties. The leaders of the Board for National Education claimed for increased budgets and some researchers, ideologically out of tune with the government's political ideas, participated with critical articles in the newspaper O Século (The Century) in 1933. They publicly criticized university's "retrograde role" in society, and the lack of government's support to scientific research. In the article "The role of scientific research and its needs in Portugal,"Quintanilha declared that the university neither educated nor showed any capacity for fostering scientific research. Furthermore, poor salaries of university teachers accounted for their disinterest for university's affairs and for the accumulation of jobs. There was no real scientific collaboration between masters and disciples, the young students being chosen by old professors for mirroring them, for not being troublesome elements, not for their scientific capabilities.[22] Following these criticisms, in 1935 Quintanilha was dismissed from his post and faced exile in France where he continued his research on genetics.[23] Coimbra lost its greatest professor of experimental biology and genetics.

More than a scientific leader, Quintanilha fits better the category of "mentor," "awakening" his students to the new science of heredity. In our view, lack of time was the main constraint which accounts for his inability to consolidate a research school on genetics with a coherent agenda. Quintanilha's group of disciples was formed between 1926 and 1935, each approaching genetics in a different way. One of them was José Antunes Serra (1914-1990), who decided to abandon the medicine course and to co-opt for biological sciences after attending Quintanilha's lectures on medical botany in 1931. Serra is remembered as one of Quintanilha's disciples because he received laboratorial training in experimental biology in his laboratory and was then awaken to the problem of heredity. However, he did not pursue his studies with Quintanilha. In fact, he opted for a career opportunity at the neighboring department of zoology and anthropology, where he concluded a Ph.D. on human pigmentation under the supervision of Tamagnini.

As stated before, Tamagnini was also in charge of teaching genetics in the University of Coimbra. His interests on genetics can be understood in the international context of eugenics and in the particular political context of Portuguese colonialism. Known as "Salazar's scientific ideologue" for the Portuguese colonial empire, Tamagnini had become responsible in the mid 1930's for the implementation of eugenic programs in the Portuguese colonies.[24]Genetics was therefore seen as a crucial tool to scientifically legitimize the "problems" of racial mixtures. Both Tamagnini and Serra took advantage of this political context to implement research on heredity in the anthropological and zoological department.[25]In 1940, in a congress on the science of population held in Porto, Serra argued that pigmentation constitutes the "indispensable basis" for human racial classifications.[26] One year after he was awarded a Ph.D. for his work on melanic pigmentation in human populations (1939), he turned to phenogenetics, developing a research line under the influence of the German school of eugenics led by Eugene Fischer at the Kaiser Wilhem Institut for Anthropology.[27]

But while during his early career Serra took advantage of the political context of eugenics, after the war it was the other way around: by 1946 he was invited by a member of the Wool Division of the National Board of Husbandry to participate in a project of wool's improvement and sheep's genetics.[28] This collaboration lasted almost four decades. Serra's contribution was of two kinds: first, to scientifically supervise the design of sheep breeding experiments, which took place at the Alter Stud, and which aimed at the reduction of defects through a proper selective methodology; and second, to investigate ways to eliminate wool defects through chemical reactions performed in his laboratory in Coimbra.[29]Unlike the National Agronomics Station, no specific institution was built for Serra to conduct research on animal breeding and genetics. Instead the National Board of Husbandry opted to support his research at the Zoological and Anthropological Laboratory of the University of Coimbra, a situation which constrained his basic research in terms of material organization and scientific practices.[30] At the same time, Serra took advantage of the publications of the National Board of Husbandry to disseminate original theoretical ideas about heredity and evolution. In the National Board of Husbandry his collaboration was remembered as a "striking instance of the fertility of the link University-Corporation."[31] In July 1950 he was promoted to a full professorship at the Faculty of Sciences of the University of Coimbra and, in 1953, he moved to the Faculty of Sciences of the University of Lisbon.[32]

Like Quintanilha, his university teacher, Serra condemned the social and political regime, but in contrast with Quintanilha, Serra did not appreciate to be involved in social and political activities. A major exception happened when he joined the group of university teachers who endorsed the petition for free elections in October 1945. Following the defeat of Hitler and Mussolini, many intellectuals hoped that Portugal would soon have its deserved democracy. Serra was among them and his scientific career was to pay for his involvement. His scholarship from the Institute for High Culture was suspended in 1946, and from 1947 to 1963 he was forbidden to participate in any scientific meetings abroad. We give some examples. In 1947 he had to decline his first invitation from Milislav Demerec, the director of Cold Spring Harbour Laboratory in Long Island, USA, to participate in the XII Cold Spring Harbour Symposium. Besides, after the Symposium he was granted a fellowship by the Carnegie Institution of Washington to stay with his family and work at the Laboratory for as long as he liked. Unable to accept this offer he sent a paper which was published in the Cold Spring Harbour Symposia on Quantitative Biology.[33] In 1959, he was one the few geneticists invited internationally to participate in the "Erwin Baur-Gedächtnisvorlesungen" in Gatersleben Berlin, organized by Hans Stübbe for the Deutsche Akademie der Wissenschaften zu Berlin (DDR) and once again he was not allowed to attend the conference.[34]

Cyrillo Soares and Valadares: shaping a research school in physics at the University of Lisbon

The physicist Manuel José Nogueira Valadares (1904-1982) was an assistant at the Faculty of Sciences of the University of Lisbon (Faculdade de Ciências da Universidade de Lisboa) and worked also in an institution for cancer therapy. In 1929 the Board for National Education granted him a scholarship to go to Geneva to specialize in radon treatment and to qualify for a physics job at the Cancer Institute. After nine months Valadares considered his training complete and applied for another scholarship at the Marie Curie's Laboratory in Paris to work on experimental physics, and specifically on radioactivity. This second training lasted from 1930 to 1933, the year he was awarded a Ph.D. and returned to Portugal, to the Laboratory of Physics of the University of Lisbon. In order to implement research on radioactivity and X-ray spectrography, he was forced to improvise and re-use old equipment, encouraged by the support of the Laboratory's director, Armando Cyrillo Soares (1883-1950). Finally, in 1936, the Board for National Education granted the Laboratory of Physics some funding and Valadares concentrated on X-ray spectrography, abandoning temporarily research on radioactivity due to the high cost of radioactive materials. His first paper reporting results of this research was published in 1938.[35]

Valadares was not only a stubborn physicist able to work under unfavourable conditions but someone eager to create a group around him. Aurélio Marques da Silva (1905-1965) was the first to join him. As Valadares, he was also trained in nuclear physics at the Laboratoire Curie in Paris, for a period of almost five years ending in 1938. His doctoral dissertation was supervised by Frédéric Joliot (1867-1934) and dealt with pair production. After his Ph.D., Marques da Silva was ready to collaborate with Valadares' project of installing a research centre at the Laboratory of Physics.

Armando Gibert (1914-1985), a mathematics student who became physics assistant in 1938, was another member of this team. In 1940 he published a note about cosmic rays in Nature,[36] and later he held a scholarship for training at the Physikalisches Institut of the Eidgenössische Technischen Hochschule in Zurich. His work, supervised by Paul Scherrer (1890-1969), concerned the effect of temperature on slow neutrons scattered by hydrogen, and lasted for four years ending in 1946.

Facing an obsolete university system after a rich scientific experience in European research centres, a group of former scholarship holders and young university teachers of mathematics, physics and chemistry, which included members of the Laboratory of Physics, decided to join forces and create an informal association – the Nucleus for Mathematics, Physics and Chemistry (Núcleo de Matemática, Física e Química) – offering scientific courses outside the academic establishment for all interested.[37] They were encouraged by Celestino da Costa, head of the Institute for High Culture, who continued to defend that the government should support research institutions and university laboratories in which teaching and research duties would not conflict with each other. They were also encouraged by Bento de Jesus Caraça (1901–1948), a mathematics teacher at the Lisbon Technical University with a long experience of this type of association as a member of the board of the Popular University, since the time of its foundation in 1919 till its end in 1944. Created during the First Republic (1910–1926), this independent university was part of a project of Education for All, which advocated the instruction of Portuguese workers as a step towards their political and social emancipation.

The Nucleus' program was mainly dedicated to modern physics and their sessions, which spanned three years, from November 1936 to November 1939, took place in university premises. Lecturers were both mathematicians and physicists. Dismantled for still unknown reasons, their legacy remains: four books funded by the Institute for High Culture covering some of the courses delivered.[38]

In 1940, the installation of the Center for Studies in Physics supported by the Institute for High Culture was a very important event for the Laboratory of Physics. Funding was more generous and the awarding of scholarships for conducting research and training assistants was reinforced. Research activity centered on Valadares' topics: X-ray spectrography, radioactivity and nuclear physics. During the period 1942–1946 four assistants were trained for their doctor's degree and others, including one from Spain, used the laboratory's instruments and know-how for their specialization.

A research school emerged under the joint leadership of Valadares and Soares.[39] The characteristics of this dual leadership are worth discussing. Soares, the director of the Laboratory of Physics, was not a researcher but the success of research in his laboratory was strongly dependent on his material control and moral support. He was remembered affectionately as the "Master" for his continuous stimulus to research, the establishment of good working conditions, and his firm character.[40] Complementing these virtues, Valadares' outstanding qualities as a researcher and his ability to attract candidates to the Laboratory, train and grant them autonomy within a coherent structure accounted for the construction of the group's scientific identity as a research school. The access to research instruments was secured by the funding of the Institute for High Culture and scholarships awarded to its researchers. In fact, Soares was keen in securing the acquisition and the maintenance of equipment for his Laboratory and sensitive to the intellectual and material well-being of its researchers. In Valadares's opinion, Soares understood that success depended on building a group of specialists trained in the same research domain, able and eager to help each other and to evaluate critically on-going experimentation. Valadares impressed his leadership to many young researchers – a significant number of which was recruited by 1942 – through example and the experimental methods he robustly commanded. Finally, the international journal Portugaliae Physica,created in 1943, offered the means to both trainees and senior researchers, for access and control of publication, and was an extra step towards the successful internationalization of the group.[41]

Mirrored on Portugaliae Mathematica created in 1940 by mathematicians who belonged to the Nucleus, the editor of Portugaliae Physica was Soares who was also member of its drafting committee, which included Marques da Silva and Valadares as well. During the war this journal was an important outlet for the experimental research conducted at the Center for Studies in Physics, and profited from the collaboration of Portuguese mathematicians and foreign physicists.Its success was confirmed by Robert Beyer's book Foundations of Nuclear Physics (1949). A compilation of facsimile articles which played a foundational role in the emergence of nuclear physics,[42] it housed an extensive bibliography on different areas of nuclear physics updated as of 1947, including many articles from Portugaliae Physica.[43]

Portugaliae Physica was complemented by another journal Physics Gazette (Gazeta de Física) founded in 1946. The Physics Gazetteaimed at consolidating physics as a profession in Portugal by discussing the role of physics, inform about the contribution of physicists and physical-technicians to the industrial progress of the country, and help training students and high-school teachers. Purposely addressed to the general public, it was created by Gibert with the support of his research fellows from the Laboratory of Physics, and it mirrored the Mathematics Gazette, created in 1940 by the mathematicians Aniceto Monteiro and Hugo Ribeiro. A former mathematics student, Gibert held intimate relations with them, especially after Gibert's and Ribeiro's stays in Zurich, with grants by the Institute for High Culture to obtain their doctoral degrees.

In October/November 1945, during the short election period for parliament, scholars from different areas expressed their opinions in newspapers. Valadares was among those who criticized the institutional system built to support research and advocated new teaching programs. His interview for the newspaper República, was entitled "The Faculties of Sciences must be reformed because, just as they are operating now they are, at most, first grade high schools."[44] He insisted on an idea which he had put forward as early as he returned to Portugal in 1934, defending stoutly the creation of Research Institutes. Physicists trained abroad in experimental physics should be dedicated full time to research, a practice already consolidated in developed countries. For him, this was the only way for the country to profit from its investment in training specialists eager to participate in the development of Portugal.

Following the 1945 elections and the emergence of a movement of political opposition to the political regime, the situation degenerated and Salazar took measures to control it. University professors were punished for their intervention during election time. At first scholarships were suspended and, in 1947, twenty one faculty members from various universities were dismissed. Valadares, Marques da Silva, Gibert and Resende were among them.[45] Reacting to these dramatic events, Soares handed in his resignation. The research school at the Laboratory of Physics abruptly came to an end.

Valadares left the country for exile in Paris never to return. He became a Maître de Recherches at the Centre de Spéctrométrie Nucléaire et de Spéctrométrie de Masse, Orsay, in 1948. After 1959 he became director of the Centre until he resigned in 1966. Marques da Silva changed his profession and became a civil engineer. Gibert stayed in Portugal and was involved in the implementation of the nuclear energy program. In 1958, among various initiatives, he joined a group of men from the finance sector and the industrial world to promote an enterprise aiming at building a nuclear energy plant. Their efforts, however, were not successful and their company was shut down in 1964.[46] Following the dissolution of the Laboratory of Physics, the Institute for High Culture chose as new director of its Center for Studies in Physics, the Spanish right-wing physicist and researcher Julio Palacios (1891-1970), formerly at the Madrid Cosejo Superior de Investigaciones Científicas. Palacios also directed the Centre for Studies in Nuclear Physics installed at the Portuguese Cancer Institute (Instituto Português de Oncologia), in Lisbon, far away from the Faculty of Sciences. This location determined a new orientation for nuclear physics at the University of Lisbon, which became centered on medical applications of radioisotopes.

In the 1950s the applications of nuclear energy to economic development were on the agenda of many European powers and the USA. Salazar and his government seemed to have no plans for investments in this area, with the exception of Leite Pinto (1902-2000), an official of the Institute for High Culture, who was conscious of its importance. Like Câmara, Leite Pinto was loyal to the regime, being a member of regime's party (União Nacional). In the early 1950s he actively defended the implementation of a nuclear energy program in Portugal. His efforts paid off in 1952, when the budget of the Institute for High Culture was increased to establish Centres for Nuclear Energy Studies in various domains, including physics, at the universities of Oporto, Coimbra and Lisbon with the special purpose of preparing scientific and technical personnel for the Nuclear Energy Board. Created by a Decree in 1954, this Board fulfilled three main objectives: the prospect, exploit, and commercialization of uranium ores, the promotion of activities in the domain of pacific uses of atomic energy; and nuclear research. The latter was assigned to the Institute for High Culture but was to be organized jointly with the Nuclear Energy Board. A research reactor was acquired and installed at the Nuclear Physics and Engineering Laboratory, in 1961. Expectations that the scientific and technical training provided could be applied in nuclear power plants built with the uranium possessed by the nation never fully materialized.

Concluding remarks

Since late 19th century, the biomedical sector of the Portuguese university system was seriously engaged in research to such an extent that its leaders played a leading role in campaigning for research. This led to the creation of the Board for National Education, in 1929, headed by doctors such as Celestino da Costa and Simões Raposo. One of its outcomes materialized in the government's investment in university research institutions in tune with its policy of filling in the educational system with adequate personnel. This was the case of mathematics, physics and the natural sciences. Both Quintanilha and Valadares profited from these measures. But contrary to Quintanilha who partook of a solid tradition of experimental biology such was not the case of Valadares and the Laboratory of Physics he helped to build. While neither Quintanilha nor Valadares partook of the scientific agenda of the regime, both came public in their criticisms to aspects of its educational and political options. If Quintanilha did not have the conditions to form a research school around him, Valadares, with the support of Soares, built the first successful research school in physics in Portugal. Indeed, social and political choices were able to influence scientific developments and their outcomes.

After 1936, and spreading a 30 year-period, institutions of applied sciences, such as the National Agronomics Station or the National Laboratory of Civil Engineering, together with organisms of economic coordination such as the National Board of Husbandry, or still later, organisms of another type such as the Nuclear Energy Board, were set up whenever the pressure for economic and social development was strongly felt. From start, genetics was decisive for the government in the context of economic autarky, and the National Agronomics Station became a model for the future organization of the country's applied research. Therefore, the regime supported enthusiastically genetics while it did not support physics until after the end of WWII, when nuclear energy was a promising source for electric power production, and valuable uranium mines in Portugal offered the raw materials for the implementation of the nuclear program. By following the winding course of a number of practitioners from the genetics' and physics' communities, including Quintanilha, Serra, Valadares and Gibert, different instances of co-evolution of scientific practices and facilities, and the autocratic regime's scientific agenda, were discussed.

Members of both communities suffered political persecution for publicly disagreeing with the regime's policy for research organization, claiming for more resources and political freedom. Ideologically situated on a broad political spectrum, ranging from Marxism to fascism, a true commitment to research was shared by all members of both communities. By contrast, scientists or engineers such as Tamagnini, Câmara and Leite Pinto were admirers of the dictator Salazar and were deeply committed to the politico-scientific agenda of the regime. But this did not mean they could not, at times, be critical of the regime's decisions. Câmara, for example, fought for the importance of scientific research, and worried that after the physicists' dismissal, in 1947, there was no one left from the physical and the chemical sciences able to take advantage of the progress in nuclear energy.

In fact, only some years later an investment on scientific and technical training in nuclear physics was deemed to be an asset for the country's modernization, and the university benefited the most from it. But nuclear power plants never came into being, a negative outcome which turns the claim that the regime's autarky agenda was also being applied to the Nuclear Energy Board less straightforward than the successful cases of the National Laboratory of Civil Engineering and the National Agronomics Station.

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[1] Carola Sachse, and Mark Walker, "Introduction: A Comparative Perspective" in Politics and Science in Wartime. Comparative International Perspectives on the Kaiser Wilhelm Institute, Carola Sachse, and Mark Walker, eds. Osiris 20 (2005) 1-20.

[2] For other research studies in the European periphery see Josep Simon, Néstor Herran, with Tayra Lanuza-Navarro, Pedro Ruiz-Castell, Ximo Guilllen-LLobat, Beyond Borders. Fresh Perspectives in History of Science, (Newcastle: Cambridge Scholars Publishing, 2008).

[3] The Portuguese Legion (Legião Portuguesa) was organized as a militia depending on two ministries, Internal Affairs and War. Portuguese Youth (Mocidade Portuguesa), dependent on the Ministry of National Education, was intended for the young, both students and non-students, to develop their whole physical capacities, to strengthen their character, and to foster their love for the fatherland in a climate of order, delight in discipline, and culture of military duty. The purpose of Mother´s Work for National Education (Obra das Mães para a Educação Nacional) was to stimulate the collaboration between school and family and to prepare the female generation for its future maternal, domestic, and social role.

[4] Law 1941, 11 Apr 1936.

[5] Tiago Saraiva, "Campos de Laboratório: O Centro de Investigação Científica Algodoeira (CICA) e a Paisagem Moçambicana (1943-1974)," (forthcoming); Tiago Saraiva, "Fascist Labscapes: Geneticists, Wheat and thelandscapes of Fascism in Italy and Portugal," Historical Studies in the Natural Sciences,(forthcoming); Tiago Saraiva, "Laboratories and Landscapes: The Fascist New State and the colonization of Portugal and Mozambique", HoST (forthcoming);

[6]Saraiva, "Campos de Laboratório" (ref 5).

[7]Saraiva, "Campos de Laboratório" (ref 5).

[8] Manuel Lucena, A evolução do sistema corporativo português. O Salazarismo (vol. 1) (Lisboa: Perspectivas e Realidades, 1976), p. 307

[9] Saraiva, "Laboratories and Landscapes", and "Fascist Labscapes", (ref 5)

[10] Letter from Abílio Fernandes to Luís Archer, 4 November 1989, in Archer, "Contribuições para a História da Genética em Portugal" in História e Desenvolvimento da Ciência em Portugal no século XX, (Lisboa: Academia das Ciências de Lisboa, 1992), p. 1054.

[11] Letter from Abílio Fernandes to Luís Archer, ref (10) pp. 1054-1055.

[12] A Fernandes, "Prof. Dr. Aurélio Quintanilha", Boletim da Sociedade Broteriana, 36, 2ª série (1962), 9.

[13] Isabel Amaral, A emergência da Bioquímica em Portugal: As escolas de investigação de Marck Athias e de Kurt Jacobsohn, (Lisboa: Fundação Calouste Gulbenkian e Fundação para a Ciência e Tecnologia, 2006).

[14] Relatório dos trabalhos efectuados em 1929/30, Lisboa: Junta de Educação Nacional, 1930; Relatório dos trabalhos efectuados em 1930/31, Lisboa: Junta de Educação Nacional, 1932.

[15] Aurélio Quintanilha, "História da Genética em Portugal", Brotéria XLIV, 3-4 (1975), 11.

[16] Relatório dos trabalhos efectuados em 1929/30, Lisboa: Junta de Educação Nacional, 1930, p. 64.

[17] In 1931, his collaboration with Kniep was solely described as having produced "very important scientific research, Relatório dos trabalhos efectuados em 1930/31, Lisboa: Junta de Educação Nacional, 1932, p. 126. Only, one year later, when genetics was finally being implemented among the Portuguese scientific community, he reported his investigations "on the problem of the sex heredity of fungus and on the genetic and cytological aspects of this problem", Relatório dos Trabalhos Efectuados em 1931/32, Lisboa: Junta de Educação Nacional, 1933, p.137.

[18] Maria do Mar Gago, The Emergence of Genetics in Portugal: J. A. Serra at the Crossroads of Politics and Biological Communities (1936-1952), MSc thesis on History and Philosophy of Sciences, Faculty of Sciences of the University of Lisbon, 2009, chapters 2 and 3.

[19] In his recollections Quintanilha refers to his return to Portugal in 1931. During the academic year 1931/32 Serra attended Medical Botany, a course delivered by him. However, according to the reports of the Board for National Education Quintanilha's last year abroad was 1931/32.

[20] Relatório dos trabalhos efectuados em 1932/33, Lisboa: Junta de Educação Nacional, 1934.

[21] Gago, The Emergence of Genetics (ref 18), chapter 3.

[22] Aurélio Quintanilha, "O papel da investigação e as suas necessidades em Portugal", O Século 26 Mar1933.

[23] Clara de Barros Queiroz, "Importância da obra de Quintanilha na genética", in Luís Archer, "Centenário do Professor Aurélio Quintanilha" Brotéria Genética XIV (LXXXIX) (1993) 23-27, 25.

[24] Gonçalo Duro dos Santos, A Escola de Antropologia de Coimbra, 1885-1950: o que significa seguir uma regra científica? (Lisboa: ICS Imprensa de Ciências Sociais, 2005), p.167.

[25] Gago, The Emergence of Genetics (ref 18), chapter 4.

[26] This congress was part of the 1940 Portuguese Commemorations which signalled the foundation of the nation (1140) and the independence from Spanish rule (1640). José Antunes Serra, "Novos métodos de estudo da pigmentação e sua importância racial", in Congresso Nacional de Ciências da População, Comemorações Portuguesas de 1940, Porto (1940), 1.

[27] Gago, The Emergence of Genetics (ref 18), chapter 4.

[28] J. C Antunes-Correia. "A contribuição fundamental do professor José Antunes Serra na Genética do melhoramento dos ovinos", in Luís Archer "Homenagem ao Prof. Doutor José Antunes Serra", Brotéria Genética XIII (LXXXVIII) (1992), 15-18. The National Board for Husbandry initially inquired abroad for a suitable professional. It was advised to contact Serra who had specialized in genetics and was very well- known abroad. So far we could not identify the foreign personality who suggested Serra for the job.

[29] Gago, The Emergence of Genetics (ref 18), chapter 5.

[30] Gago, The Emergence of Genetics (ref 18), chapter 5.

[31] Antunes-Correia, A contribuição fundamental do Professor José Antunes Serra na Genética do melhoramento dos ovinos, Brotéria Genética, XIII (1992), p. 15-16.

[32] R. M. Albuquerque Matos, "Professor José Antunes Serra", (Introduction and Curriculum Vitæ) Brotéria Genética XII (LXXXVII) (1991), 5-44, 10

[33] J. A. Serra "Composition of chromonemata and matrix and the role of the nucleoproteins in mitosis and meiosis", Cold Springs Harbor Symp. Quant Biology 12 (1947), 192-210.

[34] Matos "Professor José Antunes Serra" (ref 32) 13-14.

[35] Manuel Valadares, Francisco Mendes, "Étude des satellites La, de l'élément 82 (Pb) ", C. R. Acad. Sc. Paris 206 (1938), 744. For a detailed description of the research school built at the Laboratory of Physics see Júlia Gaspar, A investigação no Laboratório de Física da Universidade de Lisboa (1929/1947), (Braga: Centro Interuniversitário de História das Ciências e da

Tecnologia, 2009); Júlia Gaspar and Ana Simões, "Techno-physics on the Periphery: A Research School at the University of Lisbon under Salazar's Dictatorship (1929-1947)" submitted for publication.

[36] Armando Gibert, "Cosmic Rays and Poisson's Law", Nature 146 (1940), 198.

[37] Fernando Brangança Gil "Núcleo de Matemática, Física e Química: uma contribuição efémera para o movimento científico português", Boletim da SPM 49 (2003), 77-92; João Mário Mascarenhas and Ilda Perez, Movimento Matemático 1937-1947, (Lisboa: Câmara Municipal, 1997).

[38] The four books were Bento de Jesus Caraça, Cálculo Vectorial (1937); Ruy Luís Gomes, Teoria da Relatividade Restrita (1938); Herculano Amorim Ferreira, Teoria da Radicação Térmica e dos Calores Específicos (1938); António da Silveira, Teoria da Electricidade, vol.I Campo Electrostático (1941) and vol.II Campo Electromagnético (1948).

[39] For the historiography of research schools see Gerald L Geison and Frederic L. Holmes, eds., Research Schools: Historical Reappraisals, Osiris 8 (1993).

[40] Manuel Valadares, "O Laboratório de Física da Faculdade de Ciências de Lisboa, sob a direcção do Prof. Dr. A. Cyrillo Soares (1930-1947) e a investigação científica", Gazeta de Física 2 (1950) 93-106. For the "moral economy" concept see Robert E. Kohler, "Moral Economy, Material Culture and Community in Drosophila Genetics," in The Science Studies Reader, ed. Mario Biagioli, (New York and London: Routledge, 1999), 243-257. Kohler summarized this definition in the following words "access, equity, authority," (p.249).

[41] For other research schools on the periphery see José M. Sanchez-Ron and Antoni Roca-Rossel, "Spain's First School of Physics,: Blas Cabrera's Laboratorio de Investigaciones Físicas", Osiris 8 (1993), 127-155, and Agustí Nieto-Galan, "Free radicals in the European periphery: 'translating' organic chemistry from Zurich to Barcelona in early twentieth century", British Journal for the History of Science 37 (2004), 167-191.

[42] Among others it included papers by Rutherford (1911 and 1919), Gamow (1928), Chadwick (1932), Anderson (1933), Fermi (1934), Curie and Joliot (1934), Yukawa (1935) and Hahn and Strassman (1939).

[43] Robert T Beyer., Foundations of Nuclear Physics: Facsimiles of thirteen fundamental studies as they were orgininally reported in Scientific Journals, 1947.

[44] Manuel Valadares, "As Faculdades de Ciências devem ser reformadas porque, tal como funcionam actualmente, são, quando muito, liceus de primeira classe", República 22 Oct 1945.

[45] Resende and Gibert saw their dismissal suspended by Salazar.

[46] Joaquim L. Rocha Cabral, "Companhia Portuguesa de Indústria Nuclear" in H. Machado Jorge, Carlos Jorge M. Costa, O Reactor Português de Investigação no panorama científico e tecnológico nacional, 1959-1999. (Lisboa: Instituto Tecnológico e Nuclear, 2001), pp 102-3.

"Ideologically-Correct" Science: The French Revolution

*By Mark Walker**

(1) Introduction

In 2003, together with several colleagues, I published a paper entitled "Ideologically Correct Science".[1] This phrase, of course, is meant to be analogous to "politically correct," which different dictionaries define in various ways, for example:

> The avoidance, often considered as taken to extremes, of forms of expression or action that are perceived to exclude, marginalize, or insult groups of people who are socially disadvantaged or discriminated against.[2]

However, this definition does not capture the potential for dishonesty in political correctness, whereby actions or statements are justified by the concerns listed above, but in fact were for other reasons. Most important for this article, this definition also does not include the modification of behavior or speech, not out of the concern mentioned above, but rather in order to avoid criticism for transgressing or even appearing to transgress against the accepted conventions of political action and speech.

This is the sense in which "ideologically correct science" (ICS) is meant here: scientists and scientific institutions were accused of being out of step or worse with political or ideological principles and sometimes responded by actually or apparently modifying their speech and conduct in order to avoid this criticism. We compared several case studies in this regard, including the French Revolution, the Russian Revolution and subsequent Stalinist regime, National Socialism in Germany, Imperial Japan during the Second World War, the McCarthy period in the United States, and the Cultural Revolution in Communist China.

Our treatment of the French Revolution was hindered by the available secondary literature. In particular, we were waiting for Charles Gillispie to publish his second volume of his history of science and polity in Old Regime and revolutionary France. In the mean time, this book has appeared. This article draws upon Gillispie's two-volume history[3] to revisit ICS in the context of the French Revolution, and briefly compare this with our other examples.

There is a pattern that recurs, at least in large part, throughout our examples. Each begins with science in an “Old Regime,” before the respective political and ideological transformation. Science, scientists, and scientific institutions are an important part of the state, and well-integrated into it, although the role they play may be quite different from what will come. Just as there is little if any hint during the last years of the Old Regime of the political and social change that will come, the scientific community and its relationship with the state also do not appear to be anticipating or preparing for change.

When the political revolution does come, for example in late eighteenth century France, Russia at the end of the First World War, Germany between the world wars, and China under Mao, or when there is a profound shift in the political climate, as in the Second World War in Japan, or during the McCarthy error in the United States, these bring with them a political and ideological threat to the established, orthodox scientific community. This threat includes, but is not limited to, a call for a different type of science (thus the title of this paper), one that is compatible with the politics and ideology of the movement. These calls are often made by a rebel subset of the scientific community, sometimes by outsiders, sometimes by both.

This is what is meant by an “ideologically-correct” science. In France, revolutionaries denounced “aristocratic” science. More than a century later in Russia, a “proletarian” science should replace a “bourgeois” one. National Socialist scientists in Germany attacked “Jewish” science in favor of “Aryan” science. Japanese leaders called for a distinctly Japanese form of technological development based on the nation's imperatives during the Second World War. During the Cold War American politicians denounced “international” science and demanded instead an “anti-communist” one. Finally, during the Chinese Cultural Revolution, “bourgeois” science was supposed to be replaced by a “people's” science.

There was much more to ICS than mere calls or denunciations, however. Scientists were purged in all of these examples except perhaps Japan, and in France, Russia, and China sometimes executed. In some cases this was because of their position as scientists, other times scientists fell victim to more general purges of their society. Where the push for a “purer” science was spearheaded by rebel members of the scientific community, these often took the place of the colleagues who were now gone. The purges itself shook the entire scientific community.

Just as important, if not more so, was the transformation of scientific institutions, for these are the main vehicles for science interacting with the state. This also took several different forms. Some institutions were shuttered, with new ones created in their place. Others were taken over by scientists loyal to the new political constellation. Still other institutions were transformed. In the end, the result was the same: both the scientific community and its institutions were thereby yoked more tightly to the political and ideological goals of the state.

After this initial phase of political attacks, purges, and takeovers of institutions, the established, orthodox scientific community, or rather what was left of it, responded by entering into a closer cooperation or collaboration with elements in the state or government in order to counter the rebel threat, beat back calls for ICS, and secure their position. With the help of the state, the initial, radical threat was silenced, both because--which is often not appreciated, either at the time, or subsequently--this radical threat was never equivalent to the political or ideological movement as a whole, and because the state recognized that the scientific community can make a valuable, indeed sometimes necessary contribution to its policies.

The result was a tighter integration of the scientific community and the state, for the benefit of both--at least in some respects. Scientists are dependent on the state, for only it can provide the material and institutional support necessary for modern science, including the educational system. Along with material support, for scientists and their institutions, professional autonomy, or at least partial autonomy, trumps other concerns. ICS was a direct threat to this autonomy, whereas placing science more effectively and immediately in the service of the policies of the state, even extreme ones, was not. The fact that science is an inherently elitist profession with regard both to talent and education makes the scientific community vulnerable to attacks from outsiders, especially in the context of populist revolutionary movements, but also more willing to accommodate itself to the state in return for the safeguarding of its elite status.

(2) “Old Regime” Science

France, at the end of the Old Regime, enjoyed an established and productive scientific community, complete with institutions, publications, and prize competitions. British science, like the British Empire, was a worthy rival, but hardly eclipsed the French. No other nation--Germany did not yet exist, and the United States was in its infancy--came close in the quality and quantity of scientists and scientific institutions.

Demonstrated mathematical ability was the usual prerequisite for success in French science, despite the fact that several individuals, after having thus gained entrance to the scientific community, then branched out into other fields. The exact sciences were more prestigious than the descriptive sciences like natural history, although these were also well established and embodied in the Botanical Garden.[4] Science, just like the greater society, was fundamentally elitist and aristocratic. Ability was required, but, with few exceptions, the education that was also necessary was only provided to the social elites. If a commoner managed enough education and demonstrated ability, he might succeed in science, but there was no perception that such talent latent in the lower classes needed to, or even should be fostered by the state.

The government valued science and mathematics, and their applications through engineering and medicine, for their value to the state, not as an end in itself. Engineering, both civil and military, was cultivated through schools with competitive examinations based on mathematics. Medicine and medical education was similarly fostered for maintaining the public health. Institutions allowed engineering, medicine, and science to be elite professions, including various societies and schools, and culminating in the Academy of Sciences.[5]

The Academy, like its counterpart in Britain, the Royal Society, was one of the first scientific institutions that appear modern. Scientists were elected on the basis of their scientific work--although professional rivalries and political influence resulted in some positions being given to individuals with lesser talents--and received both honor and a salary. The Academy's journals provided a forum for its members to publish their work. All of this was in the service of the French state, which meant in particular that the Academy was called upon to provide advice, to judge applications for royal privileges (analogous to having patent rights) and scientific works, and occasionally to investigate cases of possible charlatanism.

These responsibilities occasionally brought the Academy and its scientists directly into conflict with scientific outsiders and the larger population. The French state used the Academy to judge inventions and their inventors' desire for royal privileges.[6] It was sometimes a frustrating, if not humiliating experience when the inventor and his work were judged, and especially when it was turned down. The Academy was also called upon to assess the effectiveness of mesmerism, Franz Anton Mesmer's technique of using animal magnetism to heal people. When the Academy commission concluded on the eve of the Revolution in 1784 that there was nothing to this treatment, its “arrogant dismissal of what everyone found fascinating” collided with the fact that many people were convinced that they had been cured.[7]

Antoine Lavosier, along with being a prominent scientist, was also an investor in tax farming, whereby private individuals paid the state for the privilege of collecting taxes in a given jurisdiction for profit. When the corporation of tax farmers, acting on Lavosier's initiative, obtained the authority to erect a wall around Paris in order to thwart traffickers smuggling dutiable commodities into the city by way of many side streets, both Lavosier as an individual and science in general were resented.[8]

But perhaps the most foreboding conflict between the Academy and a pretender was between its scientists and Jean-Paul Marat, the former physician turned propagandist who subsequently played so important a role in the French Revolution. During the Old Regime Marat published his own scientific work, including experiments with optics and new theories of light, heat, and electricity that conflicted with those of Newton himself. When Marat did not receive the recognition he felt he deserved, he blamed the arrogant mandarins sitting in the Academy.[9] As Gillispie comments:

> ... scientists throughout history have considered themselves the benefactors in their work and influence of the whole people whose friend Marat now [during the Revolution] set up to be, and ... scientists probably have been right, materially at least. But it remains true that science has not always, or perhaps usually been perceived as benefaction by those subjected to the authorities whose powers it augments. Of course it is only coincidence that ... Marat ... should have traversed most of the misery of his own life vainly and unequally contending with and against science.[10]

Scientists who received the royal favor benefitted, others did not, but whereas individuals felt that they had been wronged, there was no perception that the relationship between science and the state should be different. In particular, as Gillispie notes in concluding his volume on science and polity during the Old Regime:

> What is it that statesmen have generally wanted of science? They have not wanted admonitions or collaboration, much less interference, in the business of government, which is the exercise of power over persons, nor in the political maneuverings to secure and retain control of governments. From science all the statesmen and politicians want are instrumentalities, powers but not power: weapons, techniques, information, communication, and so on. As for scientists, what have they wanted of governments?

> They expressly have not wished to be politicized. They have wanted support, in the obvious form of funds, but also in the shape of institutionalization and in the provision of authority for the legitimation of their community in its existence and in its activities, or in other words its professional status.[11]

Thus this bargain, instrumentalities for legitimation, already existed before the Revolution.

Although the financial structures of the Old Regime were breaking down, science and its integration into the French state and French society were stable and productive--no revolution appeared necessary or imminent. The range and quality of French science on the eve of the Revolution demonstrates the effectiveness of the educational system through which the great majority of the Academy of Science had passed. Very few French scientists of any note were self-taught, whereas almost all of the much smaller number of their English contemporaries were.[12]

The currents of reform in science that were visible did not appear to be leading towards the changes the Revolution would bring, rather instead can be traced clearly back to the Enlightenment and its emphasis on knowledge and reason. Indeed historians have argued that Condorcet, whose life and career ended during the Revolution, represents the end of this intellectual movement. Along with Condorcet in the social sciences, Vicq d'Azyr worked to reform medicine and Lavosier chemistry during the last years of the Old Regime.[13] These reforms were intended to make the state more efficient, and to improve the quality of peoples' lives, but not to challenge the political, social, or scientific status quo.

In 1787 Lavosier, here functioning as a political representative, not a scientist, accurately and clearly described the structural failings of the feudal system and how they interfered with agriculture and the rest of the economy. However, "It was not merely on economic grounds that Lavosier deplored this structure of prescriptive abuses. He was equally vehement on the moral damage they inflicted through the systematic humiliation of the productive classes in the name of law."[14] Lavosier proved to be prescient about these matters, but not about his own fate.

(3) Calls for an "Ideologically-Correct" Science

French science, and in particular the Academy of Sciences, came under pressure because of the momentous renunciation of aristocratic privilege on 4 August of 1789 by liberal nobles in the National Constituent Assembly and the subsequent elimination of feudal privileges and payments. Careers of all sorts should now be open to talent, not birth. But the Academy was a privileged body jealous of its prerogatives.[15]

> It was a corporation, a privileged corporation, one among the myriad boxes into which the Old Regime compartmentalized French society and kept the subjects of the King in thrall to the crown and separate from each other. Or so the revolutionary generation felt. That any vestige of corporatism was inadmissible was among the unquestioned givens of politics... No intermediate allegiances, no portioning of sovereignty, must intervene between the individual citizen and the state which, in Rousseau's formula, embodies the general will.[16]

Only late in 1789 did the Academy begin to question the conformity of its own regime with the revolutionary order of things. On the eighteenth of November the Duc de la Rochefoucald, a member and one of the liberal noblemen mentioned above, called on the Academy to purge itself of the taint of the past by framing a constitution that would eliminate every feature of its organization and procedures smacking of inequality or privilege.[17] This political initiative was not popular, and the Academy members, who ranged from scientists who would subsequently embrace Jacobinism to conservative, if not reactionary royalists, were not of one mind politically. They began to consider reforms, but did not hurry.[18] On 25 August 1792, just before France was declared a republic and approximately a year before the Terror, Antoine Fourcroy moved that the Academy expel those members who were know for lack of civic spirit[19] then and there. This unwelcome motion was postponed.[20]

The latent antagonism towards the Academy became very clear when the Convention opened in September 1792 with the tasks of governing France and drafting a new constitution for the republic. Condorcet, the permanent secretary of the Academy, was elected vice president of the Convention. He had become a republican, but as Gillispie notes, Condorcet was too principled to succeed in the Convention.[21] Condorcet also dominated the Convention's

Committee of Public Instruction, and used it to make a proposal for a reformed national educational system.

Condorcet would have preserved the Academy under another name, a National Society for Science and the Arts, and placed it on the very top of the national system of education. Science would have been the strong backbone of the curriculum, with everything under the oversight of scientists. The essential scientific functions of the Academy would have been sheltered within the apolitical educational framework.[22]

The Convention reacted with hostility to every suggestion of preserving institutionalized authority of any sort in science as in culture generally.[23] Strident voices objected that advanced education of any sort would produce an "aristocracy of savants" and "reproduce the academies under another name."[24] Indeed:

> ... this system subverts every principle of liberty and equality... it will have no other effect then to create two classes of men, those who think and reason, and those who believe and obey... you will reject, with justified indignation, this monstrous concept of a National Society, serving mainly to intrude into the State a National Administration, an autocratic government for science and the arts, a seminary, a literary priesthood... which would quickly become nothing but a nest of intrigue and corruption...[25]

and

> It is passing strange that the nation, after having shaken off the yoke of tyrants, after having rid itself of priestly domination, should under the guise of science and enlightenment be visited with the proposition of conferring special and permanent status at the expense of the public upon a certain class of citizens. And what citizens? Precisely those men with the greatest ability to dominate public opinion and to steer it. For self-named savants are held in a kind of superstitious awe like that surrounding kings and priests. I allude to our vaunted academies... [Suggesting that] the sciences are more harmful than advantageous to morality... It may be that we became so corrupt only because we had too much learning... In order to be happy, the French people need only enough science to be virtuous.[26]

This is the romantic ideology of the radical Enlightenment philosophe Jean-Jacques Rousseau, where virtue and emotion trump science and reason. The political class of the revolutionary years was deeply marked by Rousseau and the Rousseauist mentality that "loves nature and hates science." Any perception that the authority of science compounds abuses of authority accentuated those hostile attitudes and brought them out into the open.[27] Thus the condemnation of the Academy resonated strongly with the main Jacobin thrust of the Revolution as it led France into the Terror.

(4) Purge of Scientists and Transformation of Scientific Institutions

The practice of science under the Convention was dominated by three topics: reform of education and scientific institutions; a new metric system of weights and measures; and the war.[28] How these played out were determined by the course of the French Revolution, the Convention and the dictatorial Committee of Public Safety it created, and the Terror. Not surprisingly, the Terror, which saw such great loss of life through the guillotine and other radial policies like dechristianization, was also the period of the Revolution when scientists were purged and the transformation of institutions begun.

Resentment of the Academy of Science had long festered in the breasts of artisans, inventors, apothecaries, and laborers subject to its authority. The most paranoid voice and the most venomous pen were Marat's,[29] whose influence soared during the Revolution when he turned his hand to propaganda and politics. He launched his denunciations the Academy and its scientists in his newspaper, The Friend of the People.[30]

Marat took his revenge for the Academy rejecting his experiments and theories during the Old Regime in a forty-page pamphlet, The Modern Charlatan or Letters on Academic Charlatanism, published in September 1791, concurrently with the elections to the Legislative Assembly. He portrayed himself, not as the enemy of reason and knowledge, rather their defenders. "In a century said to be philosophic and amid a nation calling itself free, can it be thought a crime to unmask academic charlatanism, and to repudiate the epoch of barbarism that its ensconced adepts seek to revive?" Stipends were paid gratuitously to academicians and were part of the generalized scandal of pensions lavished on the favored few. Marat argued that such corporatism among the elite did not at all encourage scientific productivity, rather stifled creativeness.[31]

But Marat went beyond such arguments to muckraking and deceptive, if not false claims. He accused mathematicians like Laplace and Monge of being automatons--the opposite of what followers of Rousseau would want. Condorcet was essentially accused of being a second-hand pimp: Marat accused his patroness of benefitting financially from having been the mistress of a nobleman, and then Condorcet of helping her and getting a cut of the money she had "earned."

Marat was even harder on Lavosier:

> Since he has no ideas of his own, he takes over those of others, but since he almost never knows what to make of them, he abandons them just as easily and changes systems as he does shoes... If you ask me what he has done to be so extolled, I shall reply that he has procured himself an income of 100,000 livres, that he formed the project of turning Paris into a vast prison, and that he changed the name of acid to oxygen, of phlogiston to nitrogen [Marat had this wrong]... These are his claims to immortality. Proud of these great things, he now sleeps on his laurels while his parasites praise him to the sky...

After painting such harsh portraits of leading academicians, Marat asked his readers to "Judge from that the utility of academies and the virtue of their members... vile henchmen of despots, cowardly boosters of despotism." [32]

There was also a significant number of actual or would-be inventors who were advocating for new patent laws and wanted to be judged by their peers, not the haughty and excessively intelligent academicians, who would judge their cases at so high a level that the true merit would not be recognized: "The most enlightened body may be the most dreaded."

> How cruel and vexatious were the exaggerated pretensions of academic bodies! How revolting was that empire, tyrannical and destructive of industry, which the wealthy accorded to these usurious vampires, these despotic hornets always eager to devour the honey produced by the bees, who took advantage of their wealth or power, whether in order to seize hold of the hives also, or in order to reduce the artisans to fabrications of a degrading and ruinous sort and to deprive them even of the honor attaching to their work by usurping their inventions, by all sorts of discouragements that wearied and rebuffed their zeal, their courage, and their steadfastness, and finally by forcing most of

> them to abandon their ideas, or their specifically successful discoveries, whether because they wounded the self-esteem of the most privileged, or because they infringed on interests in pre-existing enterprises.[33]

Given the attacks by Marat and others close to the Jacobins, it is no surprise that the Academy was dissolved early in the Terror. When Condorcet and his allies tried to put a reform through that closed the other academies, but spared the Academy of Sciences, it was rejected. On 8 August 1793 the Convention decreed that: "All the academies and literary societies licensed or endorsed by the nation are abolished" and their facilities--botanical gardens, observatories, apparatus, libraries, museums, etc. would be placed under the oversight of unspecified governmental authorities. A speech by the artist David dealt the coup de grace. Though his examples of abuses came mainly from the Academy of Painting and Sculpture, David delivered a diatribe on "the absolute necessity of destroying en masse all academies, last refuge of all aristocracies."[34]

The law of 8 August contrasts sharply with the fate of the formerly Royal Botanical Garden.[35] Two months earlier the same Convention, already dominated by the Jacobin faction, converted the Botanical Garden and Natural History Cabinet into the Museum of Natural History.[36] The contrast with how the Academy reacted to the Revolution is equally stark. Early in the Revolution, the staff at the Botanical Garden produced the first democratic constitution for a fully modern scientific organization ever written. Its new purpose would be to research and teach the whole field of natural history, with particular attention to the improvement of agriculture, arts, and trades. All of its officers would have the title of professor and would enjoy equal rights and equal salaries. The director would be elected from their number for a term of one year, could be reelected once, but not again for at least two years.[37] The legislation for the Museum of Natural History passed the Convention at once, with no discussion among deputies whose minds were on other things.[38]

Gillispie interprets this in the following way:

> One would not wish to argue that intellectual and cultural factors were a sufficient cause either of the suppression of the Academy of Sciences, or of the creation of the Muséum, or indeed of any of the myriad other events that made the Revolution what it was. In all cases, real political, social, and economic interests were in play. But latent attitudes do

> help explain how the Convention, preoccupied with saving a Republic beset by war, rebellion, and treason, could have taken the decisions it did in the few moments its agenda allotted to the affairs of science. An assembly of educated, articulate laymen responded favorably to a political démarche on behalf of an already popular institution of natural history. Thereupon, they responded unfavorably to the effort mounted by leaders of the scientific establishment to defend the structure it had inherited against attacks by external critics and enemies, many of them working-class, whom the Academy had dominated, offended, or excluded.[39]

The five Academy members who had been most widely involved in public affairs at the start of the Revolution and had been visible as champions of the public welfare all perished: Bailly, who had served politically both in the Constituent Assembly and as mayor of Paris, was guillotined along with Lavosier. The liberal Noble La Rochefoucauld was assassinated by a mob. Vicq d'Azyr was driven to death, and Condorcet hounded to death.[40] The scientists who were not mobilized for the war were primarily preoccupied with their personal safety during the Terror. Laplace and others took the simple precaution of leaving Paris.[41]

Bailly, along with Lafayette, was unfairly blamed for the massacre of the Champ-de-Mars on 15 July 1791, when troops opened fire on the crowd. This was exacerbated by journalistic jabs reminding the public of his pompous bearing while mayor, blackening his image throughout the winter and spring of 1792. His trial was staged on 11 November. Bailly was arrested, tried, and found guilty in short order of conspiring with Louis Capet (the former Louis XVI), his widow, and others to disturb the peace, excite civil war and subvert liberty. The Revolutionary Tribunal further ordered the guillotine moved to the Champ-de-Mars for his execution.[42]

Although Lavosier was brilliant in many ways, his mind could not grasp revolutionary politics. “Lavosier's own temperament was such that he could never let go, nor accept that presentation of exact facts would not in the end prevail.”[43] Among officials of the Old Regime, it was common, and not improper, to multiply sources of income by occupying several positions at once. Lavosier made money from the General Tax Farm, drew a stipend as Gunpowder Administrator, was paid a salary by the Discount Bank, and received a pension from the Academy of Sciences as well as a fee for each meeting he attended. Unfortunately, “in the puritanical light of revolutionary public spirit,” the accumulation of offices was now considered an "abuse." Lavosier, known to be a very wealthy man, then compounded his image problem by advertising his self-sacrifice, his devotion to public service, and his disinterestedness.[44]

Even in scientific circles his peers had more respect than sympathy for Lavosier, while he was distinctly unpopular among lesser scientists, the political class, and insofar as he was known at all, the general public. All the shareholders in the former federal Tax Farm within reach of the police, including Lavosier, were arrested. Both colleagues, and Lavosier himself, tried and failed to win him an exception, or at least a reprieve, because of his importance in technology. The tax farmers were summarily tried and executed. [45] With one possible exception, the scientists best placed to succor Lavosier neither said a word or lifted a finger. "Perhaps they agreed that participation in the General Farm was probably a capital offense. Perhaps they feared for themselves. Perhaps they simply averted their gaze finance being none of their concern. Or all of the above."[46]

Vicq d'Azyr had become physician to the queen in 1788, an honor that became a liability after the Revolution and a mortal danger after the royal family's aborted flight to Varrennes, when he refused to abandon his patient. He tried to compensate by demonstrating civic spirit. He was given numerous onerous jobs ranging from the trivial to the objectionable. When Robespierre staged the Festival of the Supreme Being on 8 June 1794, Vicq d'Azyr dared not stay away. He joined the crown marching through blazing heat to the Champ-de-Mars, where they listened and applauded. It was too much for him. He fell ill with congestion in the lungs accompanied by raging fever, and died delirious two weeks later.[47]

Condorcet could not join either faction in the Convention. He and Robespierre "distrusted each other politically and detested each other viscerally," which did not bode well when the latter became a dictator.[48] Condorcet helped draft one constitution that went nowhere in the Convention. When the Committee of Public Safety subsequently approved the radical constitution of the year III, Condorcet anonymously authored a broadside critique that led to the order for his arrest. He went into hiding, where he paradoxically wrote The Progress of the Human Mind, now his most famous work. He died while on the run, probably from a stroke, which spared him the guillotine.[49]

(5) Collaboration

The Terror and attacks on the scientific establishment in France brought great pressures to bear on scientists and their institutions. These did not react by resisting the

Committee of Public Safety, or rejecting its ideology, but rather by working ever closer with the state to help it achieve some of its most important goals. This collaboration both redeemed science and eventually silenced its critics.

With the exception of war work, organized scientific activity ceased during the Terror and its immediate aftermath.[50] In Cuvier's funeral oration of Berthollet, he justified scientists working for the war effort during the Revolution and under Napoleon with an argument that a scientist might well have made in the twentieth century as well: "Paradoxical though the assertion may appear, it would be easy to prove that the means of destruction furnished by science, in rendering combat more decisive, have made wars less frequent and more decisive."[51]

Lazare Carnot, the most prominent scientist, or scientifically trained engineer in the war, was simply the first military leader who "thoroughly believed in the Revolution that brought him to power." The war France was fighting had little in common with the static military operations for which he had been trained. It had to be fought, "not by noble officers animated by fading notions of chivalry in command of professional armies serving for pay, but by untrained, patriotic citizens in all ranks taking up arms to defend liberty and equality at home and impose those boons abroad."[52] Armies largely composed of raw recruits and conscripted peasants would have to overcome the training and skill of professional soldiers through their sheer mass and patriotic spirit.[53]

One of the most important ways scientists helped the revolutionary government was to use their expertise to find and seize material goods of value to France. Beginning early in the Revolution, the French government began applying the principle that property of the enemies of the people rightfully belongs to the nation. In 1790 the possessions of church, monarchy, and émigrés were expropriated. André Thouin, head gardener at the Botanical Garden, pointed out to authorities that the botanical wealth contained in the gardens of Versailles and other royal and noble estates was now being neglected (their owners had fled or were in hiding) and might be lost. He was given blanket authority to canvass the gardens and to transplant, before winter set in, whatever plants might be useful. It was important to salvage as many specimens as possible in order that provincial botanical gardens be enriched against the day when public education would begin.[54]

During the Terror, the Convention concentrated all oversight of the cultural patrimony, artistic, literary, and scientific, in the hands of a new Temporary Commission for the Arts.[55] The leading scientists were far too busy with war work, but lesser known specialists proved perfectly capable of conducting the innumerable investigations and recommending appropriate dispositions of the manifold objects and resources they identified.[56] This policy was expanded to include the property of enemies of the people outside of France. The Committee of Public Safety subsequently ordered the creation of commissions of science and arts to accompany the armies in occupied countries. Their orders were: "... to betake themselves to Belgium and other countries occupied by the Armies of the North ... in order to collect all the monuments, all things of value, and all resources of learning that had any relevance to arts and sciences in order to enrich the Republic."[57]

Although many regions were plundered, the Netherlands offered an especially valuable treasure in the form of the Collection of the Stadtholder of Holland. French scientists received orders to proceed immediately to The Hague, to assess and conserve the Stadtholder's reportedly magnificent natural history collection, and to transport to Paris whatever might enrich the Museum of Natural History.[58]

They reported back that the Stadtholder's Natural History Collection was unique in the world. Because it had drawn from Dutch colonies, which were inaccessible to others, it contained specimens little known or totally unknown elsewhere. At least two-thirds of the collection would improve, augment, and complement the contents of the Museum and would make the French national collection the greatest in the world and the most useful for the progress of natural science. The first shipment consisted of one hundred forty-seven cases containing hundreds of choice specimens. The second of seventy-four containers included seventeen additional cases of natural history, ten full of scientific books. Living animals, including two elephants, followed.[59] As Gillispie notes: "No hint that anyone in Paris felt the slightest compunction about all this has come to light in the archives."[60] This expropriation had a direct effect on the advancement of French science. The natural historian Cuvier made a successful career at the Museum and greatly advanced knowledge in his field thanks in part to the collections taken from Holland.[61]

Napoleon Bonaparte followed this precedent in 1796-1797 when he named a commission of science and art headed by the mathematician Monge and scientist Berthollet to accompany the army of Italy. Napoleon enlarged it still more dramatically for his campaign to Egypt in 1798-1801.[62] "The tone of Monge's letters home mingles satisfaction with the rightness of exporting democratic revolution, the enthusiasm of a tourist enraptured on a first visit to Italy, and the enterprise of an art dealer with no scruples about a free hand in a good cause." Indeed Monge argued that French curatorial expertise was going to save the legacy of antiquity and the Renaissance, which had been neglected in Italy, from the mold, decay, and insects that threatened them. The restoration and installation in the Louvre of these treasures would preserve them and make them available to all Europe.[63]

In response to the military threat, the Committee of Public Safety injected a revolutionary impetus into French society for industrial production in service of the war. Copper was produced by melting down church bells[64] and new processes sought for tanning hides quicker for shoe leather.[65] This new thrust provided opportunities for scientists to prove their worth. Scientists responded to the hostility expressed towards the Academy by inventors and artisans by working with them for the good of the war effort. The Bureau for the Consultation of Arts and Trades had already established in October of 1791.[66] Here academicians joined together with delegates from the crafts and trades as well as other non-academicians. Week after week, serving on subcommittees of two or three, they pored over specifications, drawings, and models and judged concrete mechanical devices. Despite the tension, the scientists and technicians serving on the Bureau appear to have developed a working solidarity among themselves. The Bureau operated throughout the Convention. Lavosier served on it until he was guillotined.[67]

The Committee of Public safety also created a weapons laboratory, what Gillispie argues "is not fanciful to define as the distant forerunner of Los Alamos," the Meudon Proving Grounds,[68] which remained an active site of military research and development into the Napoleonic period.[69] Scientists there worked on incendiary and explosive cannonballs, which were on the cutting edge of high-tech weaponry.[70] Other scientists tried to adapt aircraft to warfare, using tethered balloons for long-range observation.[71] These applications of science to warfare were still ahead of their time, and did not significantly influence the course of the war.

What France really needed was more high-quality gunpowder and muskets. Once again, Lavosier worked to serve the Revolution in this way. In the six months before resigning definitively from the Gunpowder Administration after the overthrow of the monarchy in August of 1792, Lavosier developed simplified procedures for the cold refining of saltpeter that made possible the revolutionary production of saltpeter and gunpowder and victory abroad.[72] From mid-May through mid-August he labored virtually full time on the problem of assaying crude saltpeter. This was the first time that a serious chemist had refined saltpeter with his own hands, instead of merely studying the principles and overseeing the refinery. Since his time was running out, He wrote up and published his incomplete experiments, including an exact description of the apparatus he would have set up and the procedures he would have followed.[73]

Here, Gillispie argues, one needs to be precise about the role played by science. Gunpowder production was increased to meet the needs of the armies, but this was mainly due to the efforts of people already knowledgeable about the process, rather than consulting scientists, intervening politicians, or the participation of the general public. The influence of science was indirect. Because of the intervention of scientists, technicians became better educated, and conducted their work in a far more scientific fashion than they had done.[74]

Along with gunpowder, the French armies needed a reliable supply of muskets. During the Revolution the French experimented precociously with the development of constructing firearms from interchangeable parts. This was demonstrated in principle, but artillery officers were reluctant with regard to the social desirability of replacing skilled craftsmen with low-paid workers.[75] The Committee of Public Safety created another new institution, the Development Workshop,[76] to speed up the production of muskets. Once again, this was a technical success but a political failure. The artisans followed the new system only under duress and reverted to traditional methods for most of their output, which did increase in the late spring and summer of 1794.[77]

An important part of the revolutionary war effort was the mass mobilization of French society for the war. This included setting up armaments factories all across Paris.[78] In the late spring of 1794, at the height of the Terror, the capital of France was outwardly transformed into an open-air armory and a collective munitions factory, supplying the armies of the Republic.[79] These had been in place for a year before being closed down in November 1794; now, during Thermidor (the period following the Terror), this effort was considered impossible: the raw materials were often defective, the workers inexperienced, and the instructors incompetent. Much of the effort had gone into repair. Most important, the French armies had captured quantities of weapons from the enemy. But the goal of the Committee of Public Safety had not been just productivity. By distributing the forges massively in public places and along promenades adequate to accommodate them, they sought to inspire the people, make them feel confident in their resources, and to make "the populace itself the watchman over the impediments that this great effort of fabrication might encounter." [80]

Scientists were directly mobilized for the propagation of scientific knowledge useful for war production. In September 1793 the Committee of Public Safety ordered publications created and distributed within the several industries. In very short order a set of well-illustrated technical manuals patriotically issued from the press.[81] The revolutionary manuals contained scientific knowledge of particular techniques, authored by important scientists. What brought them to the problems, however, was neither scientific curiosity nor a wish for recognition from their peers in a defunct Academy. It was the summons from the Committee. These publications were also not as effective as hoped: “Do not believe,” wrote Roux-Fazillac to the governing committee in April 1794, “that it is possible for ironworkers to make steel with the sole help of the memoir you had distributed; it is too scientific and intelligible only by workers who already know how.”[82]

The idea of using scientists to disseminate knowledge useful for workers and artisans was taken a step further with revolutionary courses. First of all there were crash programs of courses on saltpeter, gunpowder, and weaponry. This was expanded to benefit education in general. In October of 1794, during the months following the Terror, a proposal suggested creating: “in advance a large number of teachers capable of carrying into effect a plan... the purpose of which is regeneration of the human understanding in a Republic of twenty-five million men all of whom democracy makes equal. In these schools it will not be the sciences that are taught, but the art of teaching them. The disciples will not only be educated men; they will be men capable of educating.”[83]

Young people were selected from the entire country and would receive intensive instruction given by masters in technical and other modern disciplines.[84] On 20 January 1795 some 1,400 aspirants overflowed the amphitheater of the Museum of Natural History, which had seats for 750, and spilled out into the garden. Like the munitions workers who had warmed the same benches, they had been selected by distant authorities throughout France in numbers proportional to the local population, in many cases on the recommendation of local patriotic societies.[85]

“Pedagogically the brave, or perhaps foolhardy, experiment could only be a spectacle, not a success.” Relatively few of the auditors were adequately prepared even for elementary lectures. It accomplished more for the professors than the students. Leading scientists were called upon to the whole range of their subject in public, speaking without notes, while stenographers took down what they said. The lectures were subsequently edited for publication.[86] For the first time anywhere, science and higher learning were enlisted in the service of public education. For the first time, students were to be formed by new knowledge imparted firsthand by its makers and not old knowledge.

These revolutionary courses had far-ranging consequences. In the future scientists would typically be professors at the highest level and not just researchers. Reciprocally professors at institutions of higher learning would ideally be researchers and not just teachers, as they had been in the eighteenth century and earlier. Even at the highest level, the professor was expected to address himself to the whole range of his subject, and not merely to his specialty. Scientists were transformed into professors.

Gillispie also sees the interaction between scientists and the revolutionary governments as a collaboration, although he does not use this term:

> What happened amid the urgencies of revolution and war was an increase in the density and intensity of these exchanges. For science the difference in degree amounted to a difference in kind. From 1793 through 1795, scientists in the public eye did nothing else. In consequence, the importance of its success had long held in justifying the intellectual program of the Enlightenment was institutionalized. It was not in response to some démarche of scientists but through recognition of the magnitude of its presence in the events that shaped the future, that science displaced letters as the premier element of culture in the structure of the Institut de France.[87]

(6) Tighter Integration of Science and the State

Although scientists and the revolutionary governments of France entered into a collaboration for various reasons, the cooperation itself had long-term consequences for both. After the Terror the Convention abandoned the radical constitution it had never implemented and wrote a more conservative constitution that created the Directory to rule France. This constitution institutionalized modern science in France by means of the Institute of France,[88] modeled on the abortive educational reform proposed by Condorcet. In a real sense, this was the Academy of Science reborn. Thus it was the Thermidorian Convention and the Directory that conferred pride of place on science in French culture. This was then further entrenched under Napoleon, whose favor and patronage undoubtedly fortified morale among scientists and underwrote a great deal of scientific work.[89]

The French governments of the Convention, the Directory, and Napoleonic Consulate provided the scientific and technical community with the "very prototype of a modern set of institutions, administrative, advisory, honorific, research-oriented, educational, technological, and journalistic." The Institute of France, Bureau of Longitudes,[90] the Observatory of Paris,[91] the National Museum of Natural History, the Polytechnic,[92] etc.--there was nothing comparable to this galaxy of facilities elsewhere in Europe.[93]

The Institute of France was modeled on the National Society Condorcet had placed atop his proposed educational reform. In contrast to the academies of the Old Regime, which existed by the grace and favor of government, royal or otherwise, the constitution of the year III (1795) guaranteed the Institute by civic right. Its structure demonstrated the "displacement of letters by the revolutionary dominance of science within French culture." The First Class included the physical and mathematical sciences, the Second the moral and political sciences (eventually suppressed under Napoleon), and the Third literature and the fine arts.[94]

The First Class consisted of the surviving members of the Academy together with new people named to fill the vacancies.[95] It utilized a system akin to modern peer review, and set prize contests that were very important for the development of science in the early nineteenth century.[96] Like the Academy of Sciences before it, the Institute of France was responsible for giving the government technological advice. Napoleon himself was a member, and was proud of it--which speaks volumes about the prestigious place of science in his regime. Bonaparte's esteem for the exact sciences and for his colleagues at the Institute, especially for its mathematical members, was well known.[97]

While Laplace retreated from Paris during the Terror, he wrote his soon to be famous book, Exposition on the System of the World.[98] He returned to help create and develop the new Bureau of Longitude (on the British model). This institution was charged with developing astronomy, improving hydrography, cartography, meteorology, and horology, conducting research on terrestrial magnetism, and perfecting the determination of longitudes for the benefit of the Navy and Merchant Marine.[99]

Perhaps the most famous and consequential collaboration between French science and the revolutionary and Napoleonic governments was the creation of the Metric System.[100] Old regime France had many different systems of weights and measures, which was universally condemned as inefficient and detrimental to the national economy. During the early years of the Revolution, the goal of a single system of weights and measures fit well into the passions of the time. France needed a clear break with the corruptions of the past. The revolutionary moment was to be seized. A fundamental reform yielding a standard based upon nature would be "true to the general cause of submerging all relics of feudal diversity in national uniformity."[101]

Just as the Terror in general was at times paranoid and irrational, so was its policy towards science. The Commission of Weights and Measures and its mission were considered important enough to go forward despite the demand of the war. But that did not stop the Committee from purging it in December of 1793 of valuable members at a time when scientific manpower was in short supply:

> considering how essential it is for the improvement of public spirit that those who are entrusted by the government neither delegate functions nor give missions except to men worthy of confidence through their republican virtues and their hatred of kings; after having consulted the members of the Committee of Public Instruction particularly concerned with weights and measures, decrees that from this day on Borda, Lavosier, Laplace, Coulomb, Brisson and Delambre shall cease to be members of the Commission of Weights and Measures, and shall immediately deliver to the remaining members the instruments, calculations, notes, memoirs, and in general everything in their hands related to the operation of measures, together with an inventory; And decrees, in addition, that the members remaining to the Commission of Weights and Measures inform the Committee of Public Safety as soon as possible which persons are indispensably needed to continue its work, and that it communicate at the same time its views on the means for giving all citizens the use of the new measures as quickly as possible, taking advantage of the revolutionary impetus.[102]

Work resumed on the metric system after the Terror and was completed under the Directory. It took much longer for the new system to establish itself among the common people. Indeed what succeeded was the incorporation of the metric system into the educational system.[103]

Equally impressive was Napoleon's Egyptian expedition,[104] carried out just before he came to power. It is striking how many scientists and experts from related fields he brought along. Its Commission of Science and Arts numbered at the outset some 151 persons, 84 of whom had technical qualifications while another 10 were medical men. Bonaparte himself specified which skills were to be represented and how many people he wanted of each sort.[105] Although the campaign was not a military or political success, it was for science. The results of the expedition, an enormous compilation of information on Egypt, were published in thousands of pages, including science, medicine, archaeology, and what might be considered social science.[106] Perhaps the most famous result was the discovery of the Rosetta Stone in July of 1799.[107] As Gillispie notes, the Egyptian Expedition: "marks the beginning of the spread of European science and its appurtenances to African and Asian societies under the aegis of military conquest and political power."[108]

The legacy of the revolutionary schools became enshrined in the Polytechnic. The faculty consisted of leading scientists.[109] Unlike their counterparts at earlier schools, who were nominated by local authorities, Polytechnic candidates sixteen to twenty years old had to undergo a national competitive examination on mathematics.[110] Polytechnic students received basic training. The several service schools (military and civil) were upgraded and admitted only graduates of the Polytechnic--comparable to that of a modern American undergraduate education.[111]

In 1802, Napoleon ensured the success of the reform of the lower levels of schools, the lycées, by providing many generous scholarships, so that in the short run these schools would not lack for students. His object in the longer run was not to stimulate social mobility but to mobilize talent and attach it to the regime. For that purpose the pool of talent from boys from well-situated families was more than sufficient. Once the flow through the lycées was steady, the number of scholarships could be reduced.[112]

In 1804 Napoleon regimented the Polytechnic, giving it a pronounced military flavor.[113] A year later, students were charged fees. Instead of a school selecting its students on the basis of merit alone, it became a school selecting the most meritorious students whose parents could pay tuition.[114] This fit well with Napoleon's conception of the value of an education: "For people who are not well off, it is dangerous to give them too great a knowledge of mathematics."[115]

Napoleon himself said that he had felt that he had to choose between a military and scientific career,[116] which explains the favors, both honorific and material, that were shown to men of science under the Consulate and Empire. A few favored scientists became wealthy men.[117] With a few exceptions, scientists served the Napoleonic regime as ornaments rather than instruments of state.[118]

(7) Conclusion

French science from the end of the Old Regime to Napoleon does fit the ICS model. There are some striking similarities and significant differences with other examples.

i. Almost all of the ICS examples share with the French Revolution the criticism of the established scientific community as being elitist and unresponsive, if not hostile, to the new society and state.[119]

ii. The plunder of Holland and other countries occupied by French troops in the name of science is reminiscent of the plunder of Soviet plant breeding institutes by German scientists in the service of the National Socialist state.[120]

iii. The murderous purge of the Terror was similar to Stalin's Great Terror in that the purge was not directed towards scientists in particular groups, rather some scientists were included for other reasons. This contrasts with the specific purge of Jewish scientists under Hitler and the targeting of intellectuals, including scientists, during Mao's Cultural Revolution.[121]

iv. French scientists were able to redeem themselves and their community through service to the state, which is very similar to the case with scientists working under National Socialism, but differs from the waves of purge and redemption experienced by Chinese scientists under Mao.[122]

v. Scientists have perhaps never been as honored or rewarded as under Napoleon. ICS in the Soviet Union, National Socialist Germany, Communist China, and perhaps even during McCarthyism in the United States all had a strong anti-intellectual current.

vi. Almost all ICS examples resulted in a tighter integration of science with the state. This is perhaps the main lesson from ICS.

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[1] Michael Gordin, Walter Grunden, Mark Walker, and Zuoyue Wang "'Ideologically Correct' Science," in Mark Walker (ed.), Science and Ideology: A Comparative History (London: Routledge, 2003), 35-65.

[2] Definition from the Oxford Dictionary of English, 2nd Ed. Revised, at http://www.oxfordreference.com/views/BOOK_SEARCH.html?book=t140&subject=s7, accessed 22 January 2010.

[3] Charles C. Gillispie, Science and Polity in France at the End of the Old Regime (Princeton: Princeton University Press, 1980); Charles C. Gillispie, Science and Polity in France: The Revolutionary and Napoleonic Years (Princeton: Princeton University Press, 2004). We referred to the older literature in our earlier article, this article will focus on Gillispie's work.

[4]Jardin des Plantes.

[5] Gillispie, Old Regime, pp. 81-99.

[6] Gillispie, Old Regime, pp. 96, 99.

[7] Gillispie, Old Regime, pp. 261-289, the quotation is from Gillispie, Revolutionary, p.11.

[8] Gillispie, Revolutionary, p. 11.

[9] Gillispie, Old Regime, pp. 290-330.

[10] Gillispie, Old Regime, p. 330.

[11] Gillispie, Old Regime, p. 549.

[12] Gillispie, Revolutionary, p. 135.

[13] Gillispie, Old Regime, p. 198.

[14] Gillispie, Old Regime, p. 387.

[15] Gillispie, Revolutionary, p. 10.

[16] Gillispie, Revolutionary, pp. 166-167.

[17] Gillispie, Revolutionary, pp. 186-187.

[18] Gillispie, Revolutionary, p. 188.

[19] Incivisme.

[20] Gillispie, Revolutionary, p. 210.

[21] Gillispie, Revolutionary, p. 147.

[22] Gillispie, Revolutionary, p. 189-190.

[23] Gillispie, Revolutionary, p. 158.

[24] Gillispie, Revolutionary, p. 163.

[25] Gillispie, Revolutionary, p. 154.

[26] Gillispie, Revolutionary, p. 153-154.

[27] Gillispie, Revolutionary, p. 166.

[28] Gillispie, Revolutionary, p. 141.

[29] Gillispie, Revolutionary, p. 190.

[30] L'Amie du people; Gillispie, Revolutionary, p. 95.

[31] Les charlatans modernes, ou lettrés sur le charlatanisme académique; Gillispie, Revolutionary, p. 191.

[32] Gillispie, Revolutionary, p. 193.

[33] Gillispie, Revolutionary, p. 200.

[34] Gillispie, Revolutionary, p. 165.

[35] Jardin des Plantes.

[36] Cabinet d'Histoire Naturelle, Museum d'Histoire Naturelle.

[37] Gillispie, Revolutionary, p. 165.

[38] Gillispie, Revolutionary, p. 183.

[39] Gillispie, Revolutionary, p. 167.

[40] Gillispie, Revolutionary, p. 10.

[41] Gillispie, Revolutionary, p. 311.

[42] Gillispie, Revolutionary, pp. 315-316.

[43] Gillispie, Revolutionary, p. 319.

[44] Gillispie, Revolutionary, p. 94.

[45] Gillispie, Revolutionary, pp. 318, 322.

[46] Gillispie, Revolutionary, p. 324.

[47] Gillispie, Revolutionary, p. 317.

[48] Gillispie, Revolutionary, pp. 147, 139.

[49] Gillispie, Revolutionary, pp. 329-332.

[50] Gillispie, Revolutionary, p. 285.

[51] Gillispie, Revolutionary, p. 339.

[52] Gillispie, Revolutionary, p. 384.

[53] Gillispie, Revolutionary, p. 385.

[54] Gillispie, Revolutionary, pp. 289-290.

[55] Commission Temporaire des Arts.

[56] Gillispie, Revolutionary, p. 290.

[57] Gillispie, Revolutionary, pp. 434-436, quotation on p. 436.

[58] Gillispie, Revolutionary, p. 439.

[59] Gillispie, Revolutionary, pp. 441-442.

[60] Gillispie, Revolutionary, pp. 442-443.

[61] Gillispie, Revolutionary, p. 451.

[62] Gillispie, Revolutionary, pp. 444, 553.

[63] Gillispie, Revolutionary, p. 554.

[64] Gillispie, Revolutionary, pp. 392.

[65] Gillispie, Revolutionary, pp. 394.

[66] Bureau de Consultation des Arts et Métiers.

[67] Gillispie, Revolutionary, p. 207.

[68] Les Épreuves de Meudon.

[69] Gillispie, Revolutionary, p. 370.

[70] Gillispie, Revolutionary, p. 358.

[71] Gillispie, Revolutionary, p. 371.

[72] Gillispie, Revolutionary, p. 212.

[73] Gillispie, Revolutionary, pp. 406-410.

[74] Gillispie, Revolutionary, pp. 416, 420-421.

[75] Gillispie, Revolutionary, pp. 424-425; also see Ken Alder, Engineering the Revolution: Arms and Enlightenment in France, 1763-1815 (Princeton: Princeton University Press, 1997), and Charles C. Gillispie and Ken Alder, "Engineering the Revolution," Technology and Culture, 1998, 39/4, pp. 733-754.

[76] Atelier de Perfectionnement.

[77] Gillispie, Revolutionary, pp. 425-426.

[78] Manufactures de Paris.

[79] Gillispie, Revolutionary, p. 382.

[80] Gillispie, Revolutionary, p. 427.

[81] Gillispie, Revolutionary, p. 389.

[82] Gillispie, Revolutionary, p. 427.

[83] Gillispie, Revolutionary, p. 495.

[84] Gillispie, Revolutionary, p. 397.

[85] Gillispie, Revolutionary, p. 496.

[86] Gillispie, Revolutionary, pp. 499, 502.

[87] Gillispie, Revolutionary, p. 444; for the Institute of France, see below.

[88] Institut de France

[89] Gillispie, Revolutionary, p. 651.

[90] Bureau des Longitudes.

[91] Observatoire de Paris.

[92] École Polytechnique.

[93] Gillispie, Revolutionary, p. 446.

[94] Gillispie, Revolutionary, p. 447.

[95] Gillispie, Revolutionary, p. 448.

[96] Gillispie, Revolutionary, p. 450.

[97] Gillispie, Revolutionary, p. 611.

[98] Exposition du Syst□me du Monde.

[99] Gillispie, Revolutionary, p. 455.

[100] Gillispie, Revolutionary, pp. 223-285, 458-494; also see Ken Alder, The Measure of All Things: The Seven-Year Odyssey and Hidden Error That Transformed the World (New York: Free Press, 2003).

[101] Gillispie, Revolutionary, p. 226.

[102] Gillispie, Revolutionary, pp. 276-277.

[103] Gillispie, Revolutionary, p. 494.

[104] Gillispie, Revolutionary, p. 557.

[105] Gillispie, Revolutionary, p. 561.

[106] Gillispie, Revolutionary, p. 597.

[107] Gillispie, Revolutionary, p. 576.

[108] Gillispie, Revolutionary, p. 600.

[109] Gillispie, Revolutionary, p. 523.

[110] Gillispie, Revolutionary, p. 524.

[111] Gillispie, Revolutionary, p. 528.

[112] Gillispie, Revolutionary, p. 620.

[113] Gillispie, Revolutionary, p. 538.

[114] Gillispie, Revolutionary, p. 539.

[115] Gillispie, Revolutionary, p. 539.

[116] Gillispie, Revolutionary, p. 611.

[117] Gillispie, Revolutionary, p. 612.

[118] Gillispie, Revolutionary, p. 612.

[119] Gordin, Grunden, Walker, and Wang "'Ideologically Correct' Science."

[120] For example, see Susanne Heim, Plant Breeding and Agrarian Research in Kaiser-Wilhelm-Institutes 1933-1945 (Boston: Springer 2008).

[121] See Alexei Kojevnikov, Stalin's Great Science: The Times and Adventures of Soviet Physicists (London: Imperial College Press, 2004); Stefan L. Wolff, Die Ausgrenzung und Vertreibung der Physiker im Nationalsozialismus – welche Rolle spielte die Deutsche Physikalische Gesellschaft? in Dieter Hoffmann and Mark Walker (eds.), Physiker zwischen Autonomie und Anpassung - Die DPG im Dritte Reich (Weinheim: VCH, 2006), 91-138; Zuoyue Wang, "Physics in China in the Context of the Cold War, 1949-1976," in Helmuth Trischler and Mark Walker (eds.), Physics and Politics: Research and Research Support in Twentieth Century Germany in Comparative Perspective (Stuttgart: Franz Steiner Verlag, 2010-forthcoming); also see Richard Beyler, Alexei Kojevnikov, and Jessica Wang, "Purges in Comparative Perspective: Rules for Exclusion and Inclusion in the Scientific Community under Political Pressure,"in Carola Sachse and Mark Walker (eds.), Politics and Science in Wartime: Comparative International Perspectives on the Kaiser Wilhelm Institutes, Osiris 20 (Chicago: U. of Chicago Press, 2005), 23-48.

[122] See Susanne Heim, Carola Sachse, and Mark Walker (eds.), The Kaiser Wilhelm Society under National Socialism (Cambridge: Cambridge U. Press, 2009) and Hoffmann and Walker, Physiker; Wang, "Physics".

Kostas Gavroglu, O Passado das Ciências como História, Porto: Porto Editora, 2007. Pp. 302, ISBN 960-524-175-7. Originally published in Greek in 2004.

*By Ana Simões**

Kostas Gavroglu, the author of The Past of the Sciences as History, is a well-known historian of science whose career has been unfolding in the international landscape for the past decades. Despite his long time interest in historiographical questions, this book is a first substantial contribution to a topic, which, with a few exceptions, has not caught the attention of historians of science qua writers despite its unquestionable interest (H. Kragh, An Introduction to the Historiography of Science, CUP, 1987, Portuguese translation, 2003; J. Golinski, Making Natural Knowledge. Constructivism and the History of Science, CUP, 1998). Therefore, it is particularly telling that the author opted to address it to a Greek audience, a choice which has been informed by his willingness to actively contribute to consolidate a culture of professional practitioners. The Past of the Sciences as History was published initially in Greek (2004), and besides the Portuguese translation (2007), there is so far just another translation in Turkish (2006).

The book addresses some of the theoretical and practical aspects of doing History of Science: the type of questions asked; the kinds of sources and the specificities of the archival material historians use in order to answer their questions; the meaning of historical problems; the various ways of articulating solutions to historical problems; the processes of formation of arguments which substantiate particular viewpoints; the meaning of interpretations and the criteria used to validate them; the chief characteristics of main historiographical trends, including comments on certain aspects of social constructivism.

Since its very beginning the author offers the reader his understanding of what is the history of science: "the History of Science is the history of all those who tried to study and understand the structure and workings of nature. (…) Science was also moulded by the ideas, techniques, and practices which they imagined to understand nature, the entities, principles, and laws which they discovered, the various institutions they created, the applications they conceived – all these dimensions shaped the sciences. But humans also shaped science with their different ideological, philosophical, aesthetic, religious and political conceptions, as well as with their different social practices. Therefore, the History of Science takes as its subject matter science as a social and cultural phenomenon and historians of science study its history having in mind that local, temporal and cultural specificities played a very important role in the formation of both the discourse of science and its social function." (p.21)

It is in this disciplinary framework that the book discusses aspects of the history of the History of Science and topics including controversies, consensus and legitimizing processes among members of the scientific community; scientific practice as a useful category of historical analysis; and the problem of priority seen as an upsetting historical problem with beneficial historiographical consequences. The book includes many examples stemming from different episodes in the History of Science, and furthermore offers a detailed analysis of various aspects of the Scientific Revolution; it also presents an extended bibliography.

Granted that the book was written having a specific audience in mind, in what follows I wish to highlight the main ways in which this choice is reflected in the books' content. First, the author discusses the difficult relations historians of science have always entertained with historians and scientists. While common to various local contexts, this tricky relationship is more acutely felt in peripheral contexts in most of which history of science is still an emerging discipline in the process of affirming its autonomy relative to other disciplines. Second, the detailed discussion of the contributions informed by positivism of the first generation of historians of science aims indirectly to call attention to the "dangerous seduction" of positivism which is still pervasive in many peripheral scenarios. Third, at the same time the pitfalls of positivistic and anachronistic writings are stressed (as the output of reconstructions by committed scientist-historians), it is given a prominent place to the discussion of the equally dangerous myth of the neutrality of the historian of science.

All the above features lay the ground for the author's agenda – to contribute to the consolidation of a culture of professional historians. His main strategy involves a plea for a third way for doing history of science, a middle-ground between the attraction to positivism and the excesses of social constructivism. The author argues for the need to avoid historical fashions and gurus, thereby proposing an eclectic appropriation of aspects of different, or even antagonistic, methodological approaches, which should be judged on the sole basis of their explanatory usefulness.

In this sense the book plays the double role of an introductory book to the historiography of science and a textbook in the noblest sense of the genre, aiming at forming a new generation of historians of science. This is why in my view the book is organized around very practical questions relevant to building up the historical persona of the historian of science without the author ever committing himself to a single methodological option. In fact, he opposes the existence of single methodological modes.

While I enumerated ways in which this book is especially addressed to audiences specific to contexts within which history of science is still a young discipline, I insist that what makes the book truly original, and in this instance useful and interesting for audiences in both centres and peripheries, is the emphasis on the active role of the historian of science. Most books on the historiography of science deal with the historian as a mediator between past and historical interpretations/reconstructions, hardly with any thickness. Kostas Gavroglu's historian of science has thickness. In the book we follow him/her through his/her active practicing life, that is, feeling, asking questions, acting, formulating answers, taking decisions, in sum, going about practicing the discipline. And the immense attraction, not perilous but enthralling, of the History of Science, comes out reinforced from this brilliant book.

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Edward Grant, A History of Natural Philosophy. From the Ancient World to the Nineteenth Century (Cambridge: Cambridge University Press, 2007), xiv + 361 pp. ISBN 978-0-521-68957-1

*By Luís Miguel Carolino**

In his long series of contributions to a comprehensive understanding of medieval and early modern science, Edward Grant focuses on the relation between science and natural philosophy. The central thesis of this book is that a crucial change in natural philosophy occurred in the seventeenth century as a result of the fusion of natural philosophy with the exact sciences. For this reason, although the book covers the period from around 3500 BC to the nineteenth century, the strong emphasis is placed on the transition from the late Middle Ages to the Early Modern Period.

Natural philosophy and the exact sciences were distinct subjects throughout the Medieval Ages, but in this period they gradually expanded their horizons, came close and eventually gave origin to a new kind of knowledge, a natural philosophy that became mathematized. As Grant argues, this "fusion manifested itself bilaterally: natural philosophy influenced the exact sciences to seek the physical causes of relevant phenomena, and thereby broaden the scope of their activities; as this occurred, natural philosophy was inevitably mathematized and its scope expanded." (319). In this mathematized form, natural philosophy became synonymous of science in the nineteenth century, when it gave origin to a variety of scientific disciplines. From this perspective, Grant argues that "natural philosophy was the basic instrument in the development of our many modern sciences." (p. 319).

At the origin of Grant's thesis – and probably at the origin of this very book – one can find the deep disagreement between Grant and Andrew Cunningham with respect to the nature of natural philosophy. It goes beyond the scope of this book review to analyse the whole debate between Grant and Cunningham (see, for example, Early Science and Medicine, 2000, 5, pp. 259-300). As Grant refers, Cunningham sustains that "natural philosophy was always about God, even when God is not discussed or mentioned; and, consequently, (...) natural philosophy could not be science, because the latter was never about God" (xi). Grant has a radically different understanding of natural philosophy. To him, the scope of natural philosophy is to provide natural phenomena with natural explanations. The absence of a divine concern in natural philosophy derives therefore from its very nature. Grant makes his case by arguing that theology (and metaphysics), natural philosophy and mathematics were understood for centuries as three different kinds of theoretical knowledge. Natural philosophy considered bodies undergoing change and motion while theology and mathematics treated entities that did not suffer change. The subject of natural philosophy and the fact that, in studying natural phenomena, medieval philosophers proceeded in a rational manner, enabled Grant to argue – against Cunningham – that the impact of theology in natural philosophy was minimal.

Based upon this understanding of natural philosophy and in his lifelong research on the subject, in his latest book, Grant proposes an impressive narrative of the general characteristics of natural philosophy in the different historical periods and stresses the main changes in this field over the centuries.

A History of Natural Philosophy is a major contribution for the history of this important discipline. It provides a new understanding not only of the causes of the Scientific Revolution, but also of the history of the disciplines in modern science.

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Karl-Eugen Kurrer, The History of the Theory of Structures. From Arch Analysis to Computational Mechanics, Berlin: Ernst & Sohn, 2008. Pp. 848. ISBN 978-3-433-01838-5.

By Marta Macedo[*]

The English edition of The History of the Theory of Structures follows the first edition in German language. However, we are not dealing with a classic translation. In 2002, Geschichte der Baustatik was already a massive book 540 pages long. In 2008 this new revised volume, richer in depth of detail and collected examples, continues to impress the reader. The 848 pages, despite causing an initial perplexity, soon revel no intention to intimidate. In fact, the theory of structures already has a long history, and both subject and writer are no perfect strangers. Following on the footsteps of the famous Stepan Prokofievich Timoshenko, Edoardo Benvenuto or Clifford Ambrose Truesdell, Kurrer specialized in this area for the last 30 years.

According to Kurrer, the construction of this scientific discipline's history, as well as the real understanding of the theories that allow engineers to calculate a structure's strength and stiffness, is made possible only by taking into account its human actors. By following those same actors, Kurrer manages to pursue one of his main objectives. Throughout the book he intends to establish a new pedagogic plan based on a "historico-genetic" method of teaching. As such, he rejects the common practice of teaching abstract formulas, choosing instead a method that considers the deep complexity of construction science and its transdisciplinary structure. Having mainly in mind future engineers and architects, Kurrer also intends to seduce those already working.

Divided in twelve parts, the book does not follow a chronological organization, neither are its chapters similar either in terms of subject, approach or length. In fact there are more general and introductory chapters (1, 2 and 10 for example) and others that deal thoroughly with specific cases (4 and 11). The difficulty of legibility that this strategy could entail ends up not being a problem, because the book is to be chiefly considered as a reference work and not as a textbook or a continuous narrative.

Many characters perform in Kurrer's history, weaving a dense complex plot. Because of that, toward the end of the book, Kurrer thought it would be useful to add 175 biographical portraits of the most central figures. However, the numbers involved are much more impressive. Coming from different backgrounds these characters move between the scholarly world, the professional arena, the realm of politics, and also between very different geographies. They don't always agree or collaborate, and frequently end up disputing each other's theories in public polemics and controversies. Almost all of them combine the tasks of building with those of research. And this is undoubtably one the most interesting facts for historians of science and historians of technology. This way, Kurrer places his book in the already long tradition of bringing technology into the history of science, allowing us to see both more clearly.

According to Kurrer's chronology on the history of structures, the period of discipline formation takes place between 1825 and 1900. Exactly when industrial development was at its peak, the theory of structures was establishing itself as an autonomous and solid corpus of knowledge. By then, building structures had become physical translations of scientific achievements, offering, at the same time, momentum for deeper investigations. With such beginnings, states the author, it is impossible to detach science of construction from construction itself, therefore, from economy, political discussions, and social problems.

Kurrer provides us with a great number of examples. Many "heroes" of the history of the theory of structures were profoundly involved with building practice, establishing a permanent connection between the calm environments of academic research and muddy, noisy and conflictive construction yards. Claude-Louis-Marie-Henri Navier, one of the founding fathers of the discipline, developed his structural theories after great efforts to build a suspension bridge. Benoît-Pierre-Emile Clapeyron and Gabriel Lamé, both decisive to the development of structural analysis, were also renowned railroad engineers. The same is true for the Germans Karl Culmann and Otto Mohr, the Scottish William John Macquorn Rankine and the Italian Alberto Castigliano, among many others. Gustave Eiffel's great business company, for example, could not pass without the work of creative experts in structural calculations like Maurice Koechlin.

There is no doubt about the pertinence of Kurrer's book for the field of history of science and technology. Historians however should move cautiously into this word of structural engineering. That's why Kurrer urges us to "open the Black Box of the history of theory of structures" with a plea: "do not be afraid of formulas!" (p. 29).

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