JUAN LUIS RUBIO MAYORAL & GUADALUPE
TRIGUEROS GORDILLO

SCIENCE AND EDUCATIONAL MODELS IN EUROPE. FROM THE DISASTER OF 98 TO THE WEIMAR REPUBLIC (1898–1932)

During the first years of the 20th century the States began to coordinate and organize the development of institutions and other initiatives focused on scientific research through establishment, private patronage and other means of encouragement (Santesmases, M.J.; Romero de Pablos, A., 2008). The importance of each model is essential for understanding the development of their higher education systems, and also the development of Science and its implementation in different aspects of reality. They are part of the determining factors of technique improvement and the increase in their economies in relation to the political systems that developed them. Between 1898 and the years that marked the end of the dictatorship of Primo de Rivera, Spain underwent important times in its political and cultural history. Three literary and intellectual generations cover the silver age of Science and Culture[1].

Our research aims to analyze the Hispanic and German models within the European context. The purpose is to relate European science to university teaching in Spain between 1898 and 1936. Separately, although it was not the aim of this study, we reviewed some of the interdisciplinary debates about the comparison in the social and historical sciences (Schriewer, J.; Kaelble, H., 2010). We were aware that this explanatory attempt included in its basic assumptions the fact that *a)* social contexts (national, cultural, etc.) exert a decisive influence on intra–social events (intra–national, intra–cultural, etc.) and on their resulting effects and problems, which in turn *b)* may be separated into determining factors (explanatory variables) that *c)* allow investigation of the relationships between the determining factors (system–level variables) and events of particular interest (within–system variables) (Schriewer, J.; Kaelble, H., 2010). The initial basis of the origin of the study was the information published in the journal *Residencia*[2]. This information was compared with the most recent studies about both institutions. The initial hypothesis also relates the production areas and their development levels to the scientific research model, and the role of the State concerning science and teaching.

L. Vega (Ed.), Empires, Post-Coloniality and Interculturality, 87–98.

SCIENTIFIC INSTITUTIONS. GERMANY

In Germany there is an initial reference from 1887, when the *Physikalisch–Technische Reichsanstalt* (Meyenn, K. 1988) (PTR) [Imperial Institute of Technical Physics] was set up. Werner Siemens (1816–1892) was the main person responsible for its design near Berlin. It was agreed that they would not research fields or issues that might interfere with those of universities, polytechnic schools, private industries or some of the government agencies. He began his research under the presidency of Hermann von Helmoltz (1821–1894) and at the beginning he focused mostly on a basic issue for production and commerce: metrology; measures and units that allowed the unification if production standards in German industry. Despite this, the PTR did not decrease its contributions to fundamental physics. The United States and Great Britain suggested the model, although for the very long term, especially regarding the capital invested. In 1901 the United States Congress approved the establishment of the National Bureau of Standards (NBS). The British National Physical Laboratory (NPL) initiated its work in 1902. In 1917, Japan created its Research Institute of Physics and Chemistry reflecting the PTR (Sánchez Ron, J.M., 2008). In 1901, The *Caisses des Recherches Scientifiques* was created in France, which in 1939 were grouped with other institutions at the *Centre National de la Recherche Scientifique*. In 1916 the *Comitato Nazionale Scientifico Tecnico per lo Sviluppo e l'Incremento dell'Industria Italiana* initiated its activities, which was the predecessor of the Consiglio Nazionale delle Ricerche.

In Germany, a project was developed with businesses such as Agfa, BASF or Bayer in order to create an Imperial Institute of Chemistry that would be able to play a similar role to that of the PTR. The German industry was the obvious leader of the second industrial revolution, and in chemistry they had well–known scientists such as Emil Fisher, Walter Nernst, or Wilhelm Ostwald. Although a fund–raising organization was created, the idea was abandoned, giving way to the creation in 1911 of the Kaiser Wilhelm Gesellschaftzur Förderung der Wissenschaften (KWG) [Kaiser Wilhelm Organization for the Promotion of Sciences]. Among other purposes, it aimed to give room to all those private initiatives that singularized its inception. Its members could be people or entities that contributed with economic aid to the society. The purpose was the promotion of science, especially in the field of the Natural Sciences, establishing and maintaining research institutes grouped under a single organization capable of coordinating efforts, classifying them and leading them towards joint scientific objectives. Evidence indicates that the private patronage of industrial companies, along with those who promoted different associations and some municipalities through foundations, donations or scientific societies, took leadership from the State regarding science policy. However, the government kept a high degree of authority wherever it represented the main financing source[3]. In France, scientific research increased outside the university as centers such the Pasteur Institute or the Êcole de Chartres were created (López Sánchez, J.M., 2010).

KAISER WILHELM GESELLSCHAFT ZUR FÖRDERUNG DER WISSENSCHAFTEN (1911)

Founded in 1911, concurring with the first centenary of the University of Berlin[4], its main purpose was to contribute to fostering the development of sciences through the establishment of different research institutes. A considerable percentage of the monetary funds came from the private sector, and these were provided by people from the highest levels of the German economy. The uniqueness of the KWG, essentially, is that the laboratories were meant only for research, therefore completely separated from teaching. Adolf von Harnack (1851–1930), its first president, defended in 1909 that there were disciplines that could not adjust to the university, partly due to the research infrastructure they needed, and also because they focused their work on problems that were beyond the level of university studies, thus «they could not be exposed to young students» (Hermann, A., 1979). The central idea was to organize the institutes in such a way that scientists could focus on their research works without the limitations of university teaching[5].

University laboratories mostly preserved an academic and educational purpose (Renn, J.; Kant, H., [2010]). Furthermore, these had few materials and little equipment for research. Neither did the Ministry of Public Education have the financial means to found and maintain this kind of center. In 1911, Germany had not developed a science system in line with the reality of knowledge. The new institution was to be organized from the report presented by Adolf von Harnack, in which, along with his original ideas, some of the projects and thoughts of Leibniz and Wilhelm von Humboldt were included; projects and thoughts which by that time could not yet have been carried out. Leibniz stated that the natural sciences should be contrasted with practice in order to be both useful and productive. Preferential attention was paid to the establishment of institutes of Applied Physics and Chemistry. There are background references to the model of the Carnegie Institution, founded in Washington in 1902 by industrialist Andrew Carnegie with the aim of promoting research, discovery and the application of knowledge in the most extensive and freest way, dedicating its resources to outstanding individuals so that they could explore, under an atmosphere of total freedom, complex scientific problems. Its first president was Daniel Coit Gilman, founder of the Medical School at Johns Hopkins University, recognized by the Congress in 1904. These links with the development of science did not go unnoticed by chemists like Fisher and Nerst, who maintained their efforts in demanding from the State and from industry, the main beneficiary of scientific progress, the establishment of laboratories aimed exclusively at research. In the twenties, the KWG had about thirty two institutes.

Among those dedicated to research, the Kaiser Wilhelm Institute of Biology, in Berlin–Dahlem, was one of them. The Physiology sections directed by Otto Warburgand Otto Meyerhof led chemical–physiological research to prevail. Correns, Goldschmidt, Hartmann and Mangold collaborated in this. Next to the Institute of Biology was the Institute of Biochemistry, directed by Neuberg. Attached to this

institute, there was a special department for tobacco research, also under the direction of Neuberg. Also belonging to the same group of establishments was the Institute of Experimental Therapy, in which Wassermann carried out his works on improving diagnoses of syphilis, which found an explanatory base for the test that carries its name (Wassermann–reaction). An Institute of Medical Research was organized in Heidelberg, aimed at the establishment of a large research center capable of gathering studies of Physics, Chemistry and Physiology applied to clinical research.

One of the centers that gained a prominent role in the legitimation of laws and the apartheid regime, fostered by the Nazi government, was the Institute of Anthropology, Heredology and Eugenism, directed by Eugen Fischer. An Institute of Work Physiology was also created, founded by Rubner and directed by Aetzler in Berlin, mostly focused on the physiology, pathology and hygiene of physical and intellectual work. The Institute of Brain Research was founded In Berlin, where Oskar Vogt, Cecilia Vogt, Rose and Bielschowsky carried out their work. These included pioneers in the study of cerebral localizations, the psychology of neuroses and hereditary traits, while the latter worked on pathological cerebral anatomy. In 1924, at the initiative of the Board of Trustees of the Institute and the Bavarian Government, the German Institute of Psychiatry was incorporated, in Munich; this was directed by Kraepelin, until he died in 1926, with the collaboration of Plaut, Spielmayer, Rudin, Jahnel, Lange and Spatz. For the study of the hydrobiology of inland waters, the Institute of Hydrobiology was created in Ploen, where Augusto Thinenmann developed his research. The biology of alpine waters was studied at the Biological Station of Lunz am See (Austria), directed by Ruttner and maintained jointly with the Science Academy of Vienna. The research work on chemistry was conducted at the Institute of Chemistry in Berlin–Dahlem, founded jointly by the National Society of Chemistry. Within its laboratories, Hahn, Meitner and Hess were devoted to the study of different areas of chemistry. As a complement, there was an Institute of Physical Chemistry and Electrical Chemistry, where Haber, Freundlich, Ladenburg and Polanyi carried out their studies. The special Institutes of applied Physics and Mathematics were also established. The Institute of Physics in Berlin was run by Einstein and von Laue. In Göttingen, under the management of Prandtl and Betz, there was the Institute of Fluid Currents Research and, attached to it, the Aerodynamics laboratory. The Institute of Hydraulics, in Munich, was dedicated, under the direction of Oscar von Miller and Kirschner, to the study of the basis for hydraulic construction works. In 1926, the KWG took under its direction the observatories of Hoher Sonnenblick, near Gastein, and that of Obir, outside Klagenfurt, although the running costs of both observatories were shared with the Austrian Government.

Moreover, several other Institutes were founded, focused on the study of the most important raw materials of Germany: the Kaiser Wilhelm Institute for Coal Research in Muhlheim (Ruhr) and the Silesian Institute of Coal Research, established in Breslau by the Fritz von Friedlaenden–Fuld Foundation. The former, directed by Franz Fischer, dedicated its efforts to the issue of coal liquefaction. The Silesian Institute

of Coal Research went through serious financing difficulties due to the transfer of lands to Poland. Under the management of Fritz Hofmann, it was specialized in the study of tar phenols and pyridine extracts. In Düsseldorf, the Institute of Siderology was created in 1921, directed by Korber, and in Berlin–Dahlem the Institute of Metallurgy was founded. This was relocated during the summer of 1923, due to financing reasons, to the building of the Official Laboratory for Materials Analyses, whose head, von Moellendorf, was also the director of the institute. To these, the Institute of Chemistry of Fibrous Materials was attached, which was directed by Herzog in Berlin–Dahlem, focused on the research of fiber resistance and structure, especially cellulose. In April 1926, positioned on some of the free premises of this institute and run by Eiltel – a mineralogist from Koenisberg –, the Institute for the Study of Silicates was founded. This focused on finding solutions to the technical problems of the ceramics, glass and concrete industries. These industry sectors, in turn, financed part of their operations. The Institute of Tannery, directed by Bergmann in Dresden, studied, on the one hand, the chemistry of animal skins and, on the other, the chemistry of different types of leathers. In 1932, Outside Münchenberg the establishment of an Institute for Crop Selection was about to conclude. This was run by Erwin Baur, the director of the Institute of Hodology at the Higher School of Agriculture of Berlin. Other institutions supported by the Kaiser Wilhelm Society were the Institute of Entomology in Berlin–Dahlem, under the management of Horn, and the Ornithological Station of Rositten, in Courland (Kurische Nehrung), where J. Thiermann studied the international routes of migratory birds.

The Kaiser Wilhelm Society also founded some institutes dedicated to other disciplines. For example, there were the Institute of German History in Berlin, directed by Kehr, and the Institute of Foreign Public Law and Law of Nations (founded in 1926 and mainly supported by the German Government), in which von Triepel, Smend, Kaas, Glum and Erich Kaufmann collaborated, under the management of Bruns. Besides the development of a German theory of the Law of Nations, this institute focused on the compilation, scientific study and publication of matters regarding International Law and studies of international comparative Political and Administrative Law. In Treveris, there was part of the institute dedicated, under the direction of Kaas, to the study of issues related to the right of occupancy and the concordat. Parallel to the Institute of Law of Nations, since April of 1926 it was the Institute of Foreign and International Private Law, run by Rabel, and it had Ernst Haymann, Titze and Martin Wolff as scientific consultants. This institute was designed to be a research center for the incipient science of Comparative Law at the civil, trade and trial levels, for which it gathered the international material needed and submitted the diverse systems of private Law to a comparative critical study. Among others, some of its objectives were to contribute to the establishment of a general legal doctrine and to the solution of the problems of International Civil Law.

In Rome, supported by the KWG and under the direction of Ernst Steimann, was the Hertzian Library, which constituted the base of the Institute of Art History.

Through the granting of pensions, German scientists were given the chance to spend long periods of study at the Roman library. The Kaiser Wilhelm Society had the additional duty of building accommodation (the Harnack–Haus residence) in the vicinity of their centers in Dublin–Dahlem for scientists and researchers from other countries, with the aim of reactivating scientific collaboration at an international level. The old Berlin Palace, then under a reconstruction project, held the Kaiser–Wilhelm–Gesellschaft, the Alexander Von Humboldt–Stiftung, the Deutscher Akademischer Austachdienst and the Notgemeinschaft der Deutscher Wissenschaft.

LABORATORIES OF THE JAE

Comparing both institutions involves analyzing their models. In Spain, the State is in charge of promoting its establishment. The literature concerning this matter is ample and detailed[6], although reality indicates that the dimensions of the Spanish institutions are very different from those of German institutions. Looking at the basic guidebook written by José Luis Peset (2007), one can see that from their establishment to their extinction the following were created: the Center of History Studies and Student Accommodation, the National Institute of Physical Natural Sciences, the Spanish School in Rome and the Association of Laboratories, the Alpine Biology Station at Guadarrama, a Laboratory and Seminar of Mathematics (1915), the Chemistry Laboratory (1915), the Laboratory of Physics Research and the Committee of Palaeontology and Prehistory Research (1912). The Association of Laboratories and the National Institute of Physical Natural Sciences had to coordinate the institutions of several branches, such as the Botanical Garden and the Museum of Natural Sciences, with their branches in Santander and the Balearic Islands, whereas their Anthropology section became a museum. The work of the government included the Spanish Culture Institution in Buenos Aires and the Biological Mission of Galicia (1921), and the Spanish Institute of Oceanography (1914). In 1916, the Board of National Parks was established, as well as the Laboratory of Physiology and Anatomy of Nervous Centers. In 1919, the Laboratory of Normal and Pathological Histology was founded. The process ended with the establishment of the National Institute of Physics and Chemistry promoted by the Rockefeller Foundation (1932). That very year, the new building of the Cajal Institute was inaugurated. The thriving nationalisms led to the establishment of research centers such as the Institutd'Estudis Catalans and the Society of Basque Studies or Eusko Ikaskuntza (1918). In addition to these, the International Summer University of Santander (1932) and its Ladies Accommodation, under the management of María de Maeztu (1915), were also founded.

The aims of the JAE were clearly academic. Let us consider the National Institute of Physical Natural Sciences, founded by R.D. on May 27th of 1910, during the ministry of the Earl of Romanones, with Ramón y Cajal as president and Cabrera as secretary. It was located in the departments of the Palace of Industry at Altos del

Hipódromo, where there were also «the Museum of Natural Sciences, the Automation Laboratory of Leonardo Torres Quevedo and the School of Industrial Engineers». The JAE added «already existing establishments», such as: «the National Museum of Natural Sciences (directed by Ignacio Bolívar), the Anthropology Museum (Manuel Antón y Ferrándiz), The Botanical Garden (Apolinar Gredilla), the Biology Station of Santander» and the Laboratory of Biology Research (also called the Cajal Institute). Following Sánchez Ron, humanistic studies were also fostered through the foundation of the Center of History Studies, with clear reference to the leading figure of Ramón Menéndez Pidal. Furthermore, the National Science Institute was created, which yielded «educational initiatives, practical projects, laboratories and research teams in almost every branch of the sciences: Geology, Botany, Zoology, Palaeontology, Prehistory, Histology and Histopathology of the Nervous System, Physics, Chemistry, Mathematics and general Physiology» (Barona, J.L., 2007). Linked to the National Science Institute, around the mid–twenties, there were laboratories of Chemical Analyses, Biological Chemistry and Physics Research. The latter was directed by Blas Cabrera, and had at least three different areas: Electricity and Magnetochemistry, Physical Chemistry and Electrochemistry, and Thermology, which also had an assistant devoted to the spectroscopy and chemistry of complex minerals. Besides a Mathematics Laboratory in Santa Teresa de Madrid, the team of Gonzalo Rodríguez Lafora acquired an autonomous condition that led to the establishment of the Laboratory of Physiology and Anatomy of the Nervous Centers [at the González Velasco Museum (Museo Anatómico)] (Velasco Morgado, R., 2010). With respect to the laboratories of Student Accommodation, the most detailed information can be found in several papers published in the journal *Residencia,* which we studied as a measuring element, to calculate part of the educational effort performed by the boost of the JAE, although restricted to an exclusive and small group of students.

LABORATORIES IN THE "TRANSATLANTIC"

The Student Accommodation was founded in 1910 by the Committee for the Promotion of Studies and Scientific Research. A set of laboratories was established in it as part of that project. Since its creation, its main purpose was to facilitate preparatory education for studying higher education and complementary studies of the disciplines taught in universities and other official centers. After its foundation, in 1910, those who studied Medicine, Pharmacy or Science could use them. The complementary practicals of the faculty studies and the research works were directed by several specialists. The first laboratories, established in 1912, were those of general Chemistry, under the management of the then interns José Sureda and Julio Blanco, and the laboratory of Microscopic Anatomy, directed by Luis Calandre, who performed such duties uninterruptedly for nineteen years until 1931, when he was succeeded by Enrique Vázquez López, who in turn was proposed by Calandre himself.

In 1915 the Laboratory of Physiological Chemistry was founded under the direction of Antonio Madinaveitia and J. M. Sacristán, which functioned until 1919. In 1916, two new laboratories were established: the Laboratory of General Physiology, directed by Juan Negrín, which was later fully devoted to research under the management of the Committee for the Promotion of Studies and Scientific Research, and the Laboratory of Physiology and Anatomy of the Nervous Centers, directed by Gonzalo Rodríguez Lafora, which functioned for two years. In 1919, the Laboratory of Normal and Pathological Histology was established, directed by Pio del Río–Hortega. In 1920, and under the management of Paulino Suárez, the Laboratory of Serology and Bacteriology was created. All these laboratories were founded by the Committee for the Promotion of Studies and Scientific Research, with very low resources and few vacancies. They were installed in small rooms, most of which were situated at the ground floor of the pavilion, and some others, like those of Histology and Bacteriology, were placed in the corners of a corridor. They were usually described as «a miracle of discomfort»; in the laboratory of Bacteriology three shifts had to be set up in order to meet the demand. Specifically, in 1926the Laboratory of Histology had only eleven vacancies, while more than twenty students worked in it. The same happened at the Laboratory of General Chemistry, and the Laboratory of Serology and Bacteriology had only ten vacancies, which forced the establishment of three shifts in order to teach thirty students[7].

The Laboratory of General Chemistry was directed by José Ranedo as from 1913. The work program demanded two complete courses as the minimum time. The students belonging to the preparatory group of Medicine had only one course on Chemistry, which is why the practicals were shorter. Some students performed or started different research works. The laboratory had twenty–two vacancies, and «since it worked uninterruptedly for twenty–one years with an average of fourteen students per year, it can be calculated that perhaps 294 students worked there». The Laboratory of Microscopic Anatomy was directed since 1931 by Enrique Vázquez López, with the aid of scholarship holders Valentín de la Soma and Abelardo Gallego. Its first director was Luis Calandre and it was devoted to the elementary teaching of microscopy techniques and the structures of normal organs and tissues. Moreover, two theory lectures were taught every week, with the use of microscopes, projections and diagrams. The most advanced students performed special studies. The laboratory had 30 vacancies which, owing to the limited space, had to be distributed in two shifts. Since this laboratory had worked uninterruptedly for twenty–one years with an average of twenty–two students per year, it may be calculated that 462 students worked in it. The Laboratory of Serology and Bacteriology, directed by Paulino Suárez since its foundation in 1920, admitted new students into bacteriological studies. In it, a systematic study of all the pathogenic bacteria and the immune reactions most frequently seen in medicine was carried out. Students from previous courses also conducted analyses of pathologic products from different hospitals, becoming initiated in bacteriological problem solving. In addition to this, the laboratory organized theory lectures and workshops that complemented the education

given; these were taught by professors and former scholarship holders of the laboratory. The director of this laboratory also performed a tutelage and orientative role for the studies of the many interns that studied Medicine, in addition to his general management duties in the Student Accommodation. This laboratory held 28 students and thus, following the same calculation as for the previous laboratories, an estimated 338 students may have worked in it. In 1921, Negrín occupied the Chair of the Faculty of Medicine of Madrid and organized the practical work at the Laboratory of Physiology.

The students of the Accommodation, along with some of the most advanced students, took charge of its development. In that laboratory, a large number of interns had been initiated in physiological research, culminating in many papers that were eventually published. At some point, the experimental study of all those sections of physiology susceptible to being taught in a general course was also performed in this laboratory, with theoretical explanations regarding the technical details of the experiment. We may include in the Laboratory of Normal and Pathological Histology, directed by Pío del Río–Hortega, what was mentioned above concerning the Laboratory of Physiology. In October 1920, the Laboratory of Histopathology of the Nervous System was established under the management of Pío del Río–Hortega. All these laboratories were installed within the ground floor of the pavilion, in «such small spaces that it was only possible to work in many of them by distributing time in shifts. Thus, for instance, the Laboratory of Histology had only eleven vacancies and more than twenty students working in it; the same was the case of the Laboratory of General Chemistry; and the Laboratory of Serology and Bacteriology had only ten vacancies and it was necessary to establish three shifts in order to teach 30 students»[8].

It was also a laboratory devoted to research, and the interns who showed an interest in working on the specific issues of this discipline had the right to use it. These interns were supervised by the director of the laboratory during their development and preparation. The laboratories of the Accommodation were very specifically dedicated to students of Medicine, especially to first–year students, through a set of explanations addressing the specific issues of the different study areas, with the aim of guiding them in their preparation and facilitating their work. This task was performed along a whole academic year, and it was intensified during the half–term or final exams periods. The activity of the laboratories was complemented by the Accommodation Library, also with language lectures, which the interns could attend for free.

BASIC CONCLUSIONS

Reality and its facts clearly differentiate both models. In Germany, it was industry and its search for scientific solutions for practical issues related to the different processes of production that decided part of the aims of technological research and development. Industry itself was the major funder of their establishment and maintenance, and was also the main beneficiary of the discoveries and productive

Table 1. Laboratories in "La Residencia" (1912–1926)

Establishment year	*Laboratory*	*Management*	*Location*	*Vacancies /Students*
1912	General Chemistry	José Sureda, Julio Blanco, José Ranedo	Student Accommodation / Ground floor of the pavilion	11 (1926) "more than twenty" 22 (294 in 21 years)
1912	MicroscopicAnatomy	Luis Calandre (1912–1931) (1931) Enrique Vázquez López	Student Accommodation / Ground floor of the pavilion	11 (1926) "more than twenty" 30 (average) 462 in 21 years
1919 (it was installed)	Normal Histology	Pio del Río–Hortega	Student Accommodation / Ground floor of the pavilion	
1915–1919	PhysiologicalChemistry	Antonio Madinaveitia J.M. Sacristán	Student Accommodation / Ground floor of the pavilion	
1916	General Physiology	Juan Negrín	Student Accommodation / Ground floor of the pavilion	
1916–1918	Physiology and Anatomy of the Nervous Centers	Gonzalo Rodríguez Lafora	Student Accommodation	
1920	Serology and Bacteriology	Paulino Suárez	Student Accommodation	
1920 (October)	Histopathology of the Nervous System	Pio del Río–Hortega	Student Accommodation	

Own elaboration of provisional data. Among other sources, the journal Residencia, (see bottom Note 6).

implementations. The State promoted the creation of a University model that grouped non–academic institutions devoted to research. It guaranteed, regulated and controlled its development, focusing at critical times on its own interest in technical research and applications linked to the purposes of strategy, among which those aimed at war requirements, applied in the military area, stood out.

When Sánchez Ron compared the KWG with the JAE, he found some differences and similarities. He highlighted four points. With regard to the policy of scholarships the difference is clear. There is no doubt that German science at that stage was in the forefront, and people from around the world went there to complete their education. As stated at the beginning of his publication, «the first third of the Twentieth Century was an extremely interesting and attractive period. Let us think, for example, about the discoveries carried out in Relativistic Physics (Einstein), Quantum Physics (Planck, Einstein, Bohr, Heisenberg, Schrödinger), Astrophysics and Cosmology (Hubble), Electronics and Electrotechnics (Marconi, Fleming and De Forest, diode and triode), Chemistry (Lewis, chemical bond theory), Geology (Wegener), Genetics (Morgan), Medicine (antibiotics, Fleming), Mathematics (Gödel)» (Sánchez Ron, J.M., 2008). The Committee for the Promotion of Studies and Scientific Research held most of its institutions in the capital, Madrid. As for Germany, although the region of Dahlem in Berlin harboured many of the institutions, the report published in *Residencia* offers much information about the broad network of research centers founded at different sites in the German territory. This did not correspond to the reality of Spanish Science. The JAE was an institution funded by the State, as reflected in its budgets, whereas the centers of the KWG were promoted by private initiatives from industry and other sectors that needed to solve real problems ranging from the production of scientific knowledge to applied technology.

The JAE was very distant from this reality, since the research aims of its laboratories were very different from those demanded by industry. This could be the most determining factor for science; the one that determines its evolution. Spain could have made use of the expansion of its economy after the First World War; however, it was unable to promote science and industry. Doubtless, the major differences were economic since *a priori*, even before comparing the data, the amounts of money invested in the centers of the KWG were much greater than those of the JAE. The JAE, in turn, had a clearly educational purpose. Its laboratories, especially those situated in the Student Accommodation and the scholarships for studying in other countries are the best example. However, this does not mean that the German University did not have laboratories and institutions devoted to teaching. A review on the training visits of the scholarship holders of the JAE could answer questions about this stage. Although the actual extent of that scientific and educational policy and the actual impact of its scientific institutions at the teaching level have not yet been established, there are still indelible memories from that experience. Ochoa talked about his «first steps in the Physiology Laboratory, "what a great chance for a young student of Medicine who, encouraged by the writings of Cajal, the example of Río Hortega, and the presentation by Negrín and other professors of wide horizons

and modern scientific concepts, was eager for knowledge and to start research!». By evaluating the role of that work, he was right and reflected an accurate historical perspective, since, as he said «the seed planted in La Colina de los Chopos has germinated in every level of Spain and it has spread to many places around the world. It will never die out» (Ochoa, S., 1963: 62).

NOTES

[1] 1898, 1914, 1927 (Edad de Plata). Abellán, J. L. (1973). *Sociología del 98*. Barcelona: Laia. Cacho Viu, V. (1997). *Repensar el 98*. Madrid: Biblioteca Nueva. Laín Entralgo, P. (1945). *La generación del 98*. Madrid: Diana. Menéndez Alzamora, M. (2006). *La generación del 14. Una aventura intelectual*. Madrid: Siglo XXI. Díez de Revenga, F. J. (2004). *Las vanguardias y la generación del 27*. Madrid: Síntesis. Mainer, J. C. (1981). *La Edad de Plata (1902–1939): ensayo de interpretación de un proceso cultural*. Madrid: Cátedra.

[2] 1926. Laboratorios. *Residencia*, Vol.1, 88–90. 1926. Laboratorios. *Residencia*, Vol. 2, 188–189. 1931. La Sociedad Kaiser Wilhelm para el Fomento de las Ciencias. *Residencia*, 166–170. 1933. Aniversario de una inauguración: el nuevo edificio del Instituto Nacional de Física y Química. *Residencia*. Vol. 1 29–31. 1934. Los laboratorios de la Residencia. *Residencia*, Vol. 1, 26–30.

[3] Meyenn, K. V. (1988). Del conocimiento científico al poder de la ciencia. Ciencia y política en Alemania durante el Segundo Imperio y la República de Weimar. En J. M. Sánchez Ron (Coord.), *La Junta para Ampliación de Estudios e Investigaciones científicas 80 años después (1907–1987)* (63–126). Madrid: CSIC. Nipperday, T. y Schmugge, L. (1970). *50 Jahre Forschungsförderung in Deutschland. Ein Abriß der Geschichte der Deutschen Forschungsgemeinschaft, 1920–1970*, Berlín.

[4] Henning, E. & Kazemi, M. (2011). *Chronik der Kaiser–Wilhelm–, Max–Planck–Gesellschaft zur Förderung der Wissenschaften: 1911 – 2011*. Berlin, Daten und Quellen: Duncker & Humblot.

[5] Düwell, K. 1976. *Deutschlands auswärtige Kulturpolitik 1918–1932. Grundlinien und Dokumente*. Köln/ Wien: Böhlau Verlag. Schröder–Gudehus, B. (1966). *Deutsche Wissenschaft und Internationale Zusammenarbeit 1914–1928*. Genf: Dumaret & Golay. Kerkhoff, K. (1922). *Der Krieg gegen die deutsche Wissenschaft. Eine Zusammenstellung von Kongressberichten und Zeitungsmeldungen*. Wittenberg. Rebok, S. (2010). *Traspasar fronteras: un siglo de Intercambio científico entre España y Alemania*. Madrid: CSIC.

[6] Barona, J. L. (2007). Los laboratorios de la Junta para la Ampliación de Estudios e Investigaciones Científicas y la Residencia de Estudiantes (1912–1939). *Asclepio* (Revista de Historia de la Medicina y de la Ciencia). Vol. LIX, nº 2, 87–114. (1926). Laboratorios. *Residencia*, Vol. 1, nº 1, 88–90. Carrascosa, Alfonso V. (2009). El Laboratorio de Bacteriología y Serología de la Residencia de Estudiantes de Madrid. *Revista Española de Patología*, Vol.42, nº 3, 183–190.

[7] (1926). Laboratorios. *Residencia*, Vol. 1, 88.

[8] (1926). Laboratorios. *Residencia*, Vol. I, nº 1, 86–89.

AFFILIATIONS

Juan Luis Rubio Mayoral
Guadalupe Trigueros Gordillo
University of Sevilla