SANTIAGO RAMON Y CAJAL 1852–1934

Santiago Ramon y Cajal, foreign member of the Society, died at his home, Madrid, on October 18, 1934, in his 83rd year. Strength of intellect and character had won him, in face of adverse circumstances, high and international position in the world of science. He had become in his own country a very symbol to the people of cultural revival of the nation.

He had passed his early childhood in the mountain village of Petilla, where he was native, on the southern Pyrenean slope. His father practised surgery there among the peasants, himself of peasant stock, a doctor’s boy who had later acquired a barber-surgeon licence. Compact of energy and ambition, his father had by dint of grim economies moved later to Zaragoza, the University town. Little Santiago at school showed precocity. When not yet seven he was scribe for the family during an absence of his father in Madrid. But as he grew older the boy proved headstrong, with likes and dislikes intense and passionate. Thus, his love of watching birds on an occasion kept the countryside scouring for him in vain all night, with morning to discover him half up a precipice beside a martin’s nest where he had waited daybreak unable to get farther up or down. His other passion was to sketch: a sheet of paper made his fingers tingle to draw something—anything; the mule kicking, the hen sitting, the castle on the height, the toper at the inn. Some of this draughtsmanship is extant and published. His father disapproved it; he feared it might divert his son from medicine. So it was that the boy was packed off to Jaca, to the College of the Aesculapian Fathers. There Latin was a corner-stone of the instruction. Young Santiago, like young Helmholtz, could not learn by simple memorization; the Latin teaching given required that. The college discipline was severe. Punishment came and grew relentless—the rod, incarceration, and prison-fare. The lad’s reaction became unpromising rebellion. So was it that he was discharged, thin and sullen, silent about Jaca save for a rhapsody on the beauty of its valley.

His father tried him next at The Institute, Huesca. No Latin there, but mathematics and science. This time the luckless boy chanced on a stock of old romances stored in a neighbouring attic. This treasure proving irresistible, daily he truanted thither to enjoy Robinson Crusoe’s island or Don Quixote’s knight-errantry. In due time of course his delinquency stood revealed; his science and the Institute he had utterly neglected. His father, in despair, apprenticed him to a barber.
To the boy this ignominy meant haircutting all day, while his trade master played the guitar, chatted, and talked politics. Romance still in the lad's ears this bred bitterness in his heart. Off duty he consorted with a band of young scapegraces and became their leader. They played at brigands, and baited the country police. In these escapades it was said he scaled walls like a lizard. Children were bidden avoid him; and among them one, the little girl who in after years was to be his dear and devoted wife. Ostracized and humiliated, wounded in self-respect, he was defiant and miserable, when relief came by way of a friendly shoemaker who declared he saw in the boy the makings of an excellent cobbler. His father transferred him to shoemaking. Then at last he proved a success. A year later, reassured, his father entered him again at the Institute for further study; and the lad did well, with but one public contretemps. A freshly whitened wall by moonlight proved too tempting; that and a burnt stick, and the town waked to find a portrait gallery, none too kindly, of the teaching staff at the Institute itself; and there were those who did not forgive.

At sixteen he began anatomy, under personal instruction from his father. Cajal always extolled his father's teaching for its gift of analytic description. Later, at the University, where the son gained promotion to help his father in the anatomical room, his drawings from dissection were so good that there was talk of issuing an atlas. But no publisher could be found. Cajal has left in his Memoirs an account of the medical teaching at Zaragoza in his student-time. Barthou of Montpellier and eighteenth-century vitalism still prevailed. The rubor et tumor of inflammation were still defensive acts emanating from a vital principle. There was little practical instruction even in the clinic; thus the obstetric teaching was purely oral, "as though," Cajal remarks, "we could learn gunnery without a gun."

His four years of University studies passed over him, he said in after years, without appreciable mark. Not, of course, that they were uneventful for his development, but that what significance they had was extraneous to the university. He tells us he experienced in those years three successive fervours: first, for writing verse and composing fiction, under influence of Victor Hugo and Jules Verne; next, for intensive cultivation of his muscles, by "English exercises"—his chest measurement increased to 47 inches, and his arm musculature became phenomenal, his Recuerdos documents this by a photograph taken at that period. The stoical régime attending this muscular training led him incidentally to his third enthusiasm, an insatiable thirst for reading every book on philosophy he could get. Thus, after various metaphysical adventures,
he tells us he finally embraced what he terms “absolute idealism”—
despite protests, some violent, some mildly reproachful, from all friends
about him.

He passed his Licentiate ship in Medicine. Then military service
claimed him. Gazetted surgeon to an infantry battalion, he spent ten
months chasing about Spain Carlist insurrectionists never actually come
up with. Then came rebellion in Cuba; promoted captain, he was sent
thither. He has given his experiences; lack of organization, want of
supplies, arrears in pay, peculation, insanitation, mosquitoes, dysentery,
malaria. With shattered health, after fifteen months he was invalided,
and returned home shaken not in patriotism but in faith in his country’s
system. At Zaragoza he then settled down to win back his health and
to pass the Doctorate in Medicine. The Doctorate examination itself
was always held in Madrid, but he could work for it at Zaragoza. On
presenting himself finally at Madrid he found the examination on “theory
of Medicine” involved a vitalistic commentary of Hippocrates! How­
ever, during examination in histology, he was shown actual preparations
under the microscope; he had not seen such before. They keenly excited
his interest. The examination over, back again in Zaragoza he unearthed
a microscope in the Physiological Department. It was old-fashioned and
cumbrous, but with it he saw for his first time the circulation of the blood
in the frog’s web, “an astonishing spectacle, an unforgettable event in my
life”; Spallanzani has recorded how likewise it was so to him, indeed, as
also originally to Malpighi himself. Cajal, remembering a French (Vereck)
microscope he had admired in a shop at Madrid, sent for the instrument
and, dipping into his slender savings from Cuba, paid 140 duros. Also he
bought Beale’s Microscope in Medicine, and Protoplasm and Life.
Further, he started subscribing to his first scientific journal, Lankester’s
Quarterly Journal of Microscopical Science. It must have been about that
same year that Professor Pavlov, as he once told some English friends,
first felt the call of Physiology likewise through an English book of that
period, namely, Lewes’s Physiology of Common Life.

At Zaragoza Cajal was now appointed Director of the University
Museum of Anatomy, to his delight. But trouble lay ahead; he suffered
suddenly a severe haemoptysis, and then again another, and another.
Diagnosis was not left doubtful; night-sweats, fever, wasting, cough—no
symptom failed. Never even in Cuba had things looked so desperate to
him. His medical knowledge did but intensify his foreboding. He was
sent to try a mountain ‘cure’ for the tuberculous, at S. Juan
de la Pena. His autobiography of this time must rank for frank
and tragic revelation unique among memoirs of scientific men. The
supreme beauty of the mountain scene only heightened and quickened his reluctance to die. The passion that was in him to achieve something that should redound to his country's credit or even bring it glory, something that should endure, now that he was to pass away at once, became almost a risible thing and bitter from the futility of its ambition. In all his metaphysical welter two points alone held fast: the probability of a supreme being, and of some form of existence after death. His early heroes, Byron and Lamartine, now failed him, even disgusted him. From Leopardi, however, he drew courage. Through Leopardi it was that he steeled himself, gradually, to a practical resolve, namely, to force himself still to take interest in life just as though his life still lay before him. He found the very attempt to do this seemed to yield him some relief. Then, to his own amazement, haemoptysis slowly lessened and later ceased. In fifteen months he was pronounced recovered.

His restored health brought to him thoughts of marriage. His family were averse to the step. His stipend was but 40 duros a month. He married, nevertheless. The story of his choice of his life's partner has been told engagingly in his own memoirs. It has been given in English more than once; I quote it here in Fielding Garrison's translation:

"Returning one evening from a walk I encountered a young girl of modest appearance, accompanied by her mother. Her blushing, springlike face suggested Raphael's Madonna. Attracted by the sweet, pleasant disposition apparent in her features, her slender figure, her large eyes veiled by long lashes, her abundant hair, I was even more impressed by the air of childlike innocence and melancholy resignation which her whole being breathed. Unseen, I followed to her home, learned her the orphaned daughter of a modest workman, and that she enjoyed a reputation for honour, modesty, and domestic tastes. I made her acquaintance and shortly after married her. My acquaintances said: 'Poor Ramon is lost. Good-bye to study, science and generous ambitions'... Eulogies do not flow readily from my pen, but I delight to say that, with beauty which seemed formed to shine in promenades, visits, and receptions, my wife cheerfully condemned herself to the obscurity of my lot, remaining simple in her tastes, and with few aspirations other than tranquil contentment, order and system in the management of the home and the happiness of her husband and her children.'"

His young wife's care of him and the even tenor of their enforced and frugal quietude cradled his first researches. *Investigaciones experimentales*
sobre la genesis inflammatoria; con dos laminas litograficas, appeared at Zaragoza in 1880. To lessen its cost of issue he made the lithographs himself, and limited its edition to a hundred copies. Again next year another memoir, and again a hundred copies. What treasure for the bibliophile to-day! Most of them went to personal friends. They caused some comment in Zaragoza; "our Cajal passes judgment on foreign savants!" For himself, however, these publications gave him his feet in science.

He competed for the Chair of Anatomy at Valencia, and was successful; the stipend was small, 3500 pesetas a year. His colleagues were wont to eke out their stipends by gaining fees from private practice; Cajal, however, instead gave post-graduate instruction in normal and pathological histology. He succeeded so well that he could buy a large microtome and subscribe to another journal, Journal de l'Anatomie et de la Physiologie.

In 1885 Spain was swept by Asiatic cholera. The epidemic reached Valencia early. Cajal was of those, a minority even among the doctors, who determined to boil their household water in view of the possibility of a living germ. The cholera entered, and entered fatally, the very building where he and his family dwelt, but he and they were not attacked; his fourth child was born during the epidemic. When the worst was over in Valencia, Zaragoza called him to help with bacteriological diagnosis there. He devised a method for rapid detection of the comma-bacillus in plate-cultures. From Austria came a pronouncement from Professor Hueppe announcing spore-formation in the bacillus, a point of grave practical interest. Cajal disposed of this as an error; he showed the supposed spores to be merely degeneration-forms. The epidemic passed and Cajal returned to Valencia; thither the city of Zaragoza then sent him a finely equipped modern microscope in token of gratitude for his service.

He now recommenced work on his text-book Histologia y Technica Micographica; it was published ultimately in Valencia, 1889. But for original papers in Spanish to attain any wide scientific audience was, he now realized, beyond likelihood. He turned therefore to the trilingual International Journal of Anatomy and Physiology, then just started. In it his paper on Epithelium appeared in 1886; and two years later his detailed examination of insect muscle-fibre. He was making for his own satisfaction a round survey of the animal tissues, taking them in turn. He reserved the nervous till last as "obra maestra de vida"; it was with a "feverish reverence" that at length he reached it. For text-books, he had Huguenin, Luys, and Ranvier. It so happened that a little later he visited Madrid; chance there brought him in contact with the neurolo-
gist, L. Simarro, recently returned from Paris. Simarro showed him a good Golgi chrome-silver preparation. It was tissue from the cerebral cortex. Cajal was amazed by the preparation; he got no sleep that night. Next day he visited Simarro to see the preparation once more. "Against a clear background stood black threadlets, some slender and smooth, some thick and thorny, in a pattern punctuated by small dense spots, stellate or fusiform. All was sharp as a sketch with Chinese ink on transparent Japan-paper. And to think that that was the same tissue which when stained with carmine or logwood left the eye in a tangled thicket where sight may stare and grope for ever fruitlessly, baffled in its effort to unravel confusion and lost for ever in a twilit doubt. Here, on the contrary, all was clear and plain as a diagram. A look was enough. Dumbfounded, I could not take my eye from the microscope." Simarro lent him further the Golgi memoir, now a bibliographic rarity. Cajal hurried home with it to Valencia. The method was capricious; but what of that; he would get round that by making preparations wholesale. In a few short weeks he had confirmed for himself practically all that Golgi had described. So things stood within when he received the appointment of the Chair at Barcelona.

To move from Valencia to Barcelona was to step to a larger world and a more expensive. Nor was the Catalan capital disposed as a mere matter of course to open its arms to an official immigrant from non-Catalan Spain. He settled in a small house where he could fix up a laboratory; the great hospital nearby could serve him with material for the Manual of Pathology which he now at once began. As for the Golgi method, it was unceasingly pushed; it began to yield him facts which he felt to be new. He found he could improve the technique by reinforcing the metallic impregnation. The impenetrability of the fatty sheaths of the nerve-fibres he avoided by taking embryonic tissue before the sheaths had formed.

In all this work it was the texture of the grey matter which particularly drew his interest, and did so more and more. He was indeed now, though he could not know it, facing the problem which the world has come to regard as especially his own. He was already thirty-seven; as scientific careers go, a late start. A few more years, however, and he had in fact proved himself the supreme analyst of the cellular architecture of the nervous system. The orthodox teaching of that time was, and had been for many years, that the grey matter is a network of minute anastomosing nerve-fibres. Cajal sampled it from the cerebellum, retina, and optic lobe of the chick, and from the spinal cord of chick and mouse. He found in the cerebellar cortex certain fibres reaching their ending without
fusing with any others. The fibres in question sprang from little stellate cells, cells which had never been revealed in such completeness before. The main fibre springing from each of these coursed along above a row of the great Purkinje cells; as it passed above these it sent down a branch filament which carried a chandelier-like terminal suspended over the body of the Purkinje cell. Long fibres entering the grey matter from the underlying white matter he found pass toward the great stag's-horn branches of the Purkinje cell, there to end again in tiny free fibrils. In both these cases fibres came to free ends within the grey matter; they did not fuse with other fibres, but stopped as minute free terminals in close proximity to, but without actual continuity with, other fibres or cells. These terminals were of specific types and patterns; from seeing a terminal it was possible to say to what fibre-set it belonged by the type to which it conformed. The terminals always ended freely. Again, the retina showed nerve-cells in chains articulated together by points of contact; but there again the cells did not fuse together. Turning to the gigantic nerve-cells of the electric lobe of the fish Torpedo, there the stem-fibre of the giant cell broke up into a thousand branches; but of these latter, none joined with or formed a network. Finally, there was the grey matter of the spinal cord, the mare magnum as he dubbed it; here the first revelation his technique brought him was the view of the "collaterals." From the fibre-columns surrounding the grey matter multitudes of tiny fibres entered it convergingly. There, however, they did not anastomose and form a network; they ended in minute free terminals about the nerve-cell bodies plentifully present. Every cell in the grey matter lay surrounded by free terminals derived from these entering fibres; the fibres themselves were side-branches from stem-fibres running lengthwise in the spinal fibre-columns. Conversely, from every nerve-cell sprang a nerve-fibre which passed out of the grey matter into one or other fibre-column of the cord, some, namely, those of the root-cells, left the cord altogether. The spinal nerve-cells were thus distinguishable into two sets: (1) motor-neurones whose fibre, leaving the cord, went to innervate muscle; (2) "tract-cells," whose fibre entered some one of the lengthwise fibre-columns, there to ascend or to descend or to bifurcate and do both; the tract-cells were distinguishable into crossed and uncrossed according as the fibre did or did not transgress the mid-plane in gaining its fibre-column. These several types were spatially commingled, not segregated, indicating the inadmissibility of supposing homogeneous in function such crude groups as, for instance, in the cord the so-called "middle-cells," distinguished by Waldeyer. It was, however, especially the grey matter of the optic lobe of the bird which convinced Cajal that the grey matter

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though a tangle is, even where densest, not an anastomotic network. The optic fibres that plunged into this tangle there split into sprays of fibrils, whose points, although touching a cell-surface, never actually penetrated or fused with it.

The tradition of the grey matter as a minute anastomotic network had carried with it certain functional implications. It was supposed to be either diffusely conductive in all its various directions, or perhaps simply trophic for the cells imbedded in it. The more he looked the more did Cajal incline to believe it resoluble into discrete branching fibres, fibres of two sets, both traceable to nerve-cells, but the one set conducting from cell into the fibre-forest and the other conducting through the forest onward toward further cells. The grey matter seemed to be, therefore, perfectly determinate in its sense of conduction. The points of contact discoverable in it seemed to him specific places of articulation between one cell-conductor and the next. These points linked the successive nerve-cells into perfectly determinate conductive cell-chains. The direction of conduction in these chains could, moreover, be read by noting certain features repeating themselves from cell to cell. So it was that he reached his generalization; in every nerve-cell the conduction runs from fibres of cellulipetal conduction toward a fibre of cellulifugal conduction, usually through the intervening cell-body; this is his "ley del la polarizacion dinamica de la celula nerviosa"; a discovery, which, for historical importance, ranks with the Bell-Magendie "law" of the spinal roots; but it is, of course, far wider and more fundamental.

In publishing it Cajal was careful to give credit to van Gehuchten of Louvain. His doing so instances his customary generosity to fellow investigators. In that connexion it is worth while tracing some of the circumstances. He had (October, 1889) issued a paper "Connexion general de los elementos nerviosas" (Medicina Practica, II, Madrid). In that paper, convinced that the protoplasmic cell-branches were conductive and not merely trophic, and mindful of the bipolar cells he had recently traced in the embryo retina, he boldly assumed the great distal fibre of the spinal ganglion-cell to be the analogue of the protoplasmic cell-branch of the tiny retinal bipolar cell, treating both as "protoplasmic" nerve-cell branches. Writing eighteen months later (April, 1891), van Gehuchten of Louvain, in a footnote to a paper published in La Cellule (vol. 7, p. 101), adverted to this pronouncement by Cajal: "Il nous semble difficile d'admettre l'hypothèse, très ingénieuse d'ailleurs, de Ramon y Cajal, d'après laquelle le prolongement périphérique serait un prolongement protoplasmatique, tandis que le prolongement central représenterait le véritable prolongement nerveux." The footnote nevertheless, rejecting
the idea though it did, yet went on to air some implications contained in it. Cajal now, in bringing forward his doctrine, recorded that it was while reading this footnote that the full evidence available for his thesis had coursed through his mind. He had then sat down and marshalled systematically the facts which show that direction of conduction through the nerve-cell, far from being indifferent, is fixed, and is indeed legible from the morphological features of the cell. It is without exception cellulipetal in the protoplasmic ramifications of the cell, and runs toward the axone in the cell-body, and in the axone itself is cellulifugal. This paper he read at the Medical Congress at Valencia, June, 1891 (Revist d. Cienc. Medicas d. Barcelona, Nos. 22 and 23, 1891), and he associated van Gehuchten's name with his own in there launching his idea. The full doctrine itself considerably later, was introduced by van Gehuchten in his well-known text-book, and in doing so Cajal's term was adopted in its French equivalent, "loi de polarization dynamique de la cellule nerveuse."

Late in his life, reviewing the whole harvest of his work, Cajal spoke of this period as its richest season. In it he had addressed himself to a problem, to all appearance at that time insoluble, and had solved it. The problem, moreover, was one which concerned not merely this or that particular piece or organ of the nervous system, but concerned it universally. He had, indeed, reshaped our knowledge of the cellular architecture of the nervous system. He had, it is true, pulled down much, but he had built up more. He had resolved indeed the nervous system everywhere into branched conductive cells set end to end in circuits, and arranged, to use electrical parlance, both "in series" and "in parallel."

This conception launched and established by Cajal, namely, that the nervous system is built of conductive chains of individually distinct and discrete conducting nerve-cells is sometimes called the neurone-theory. It is then sometimes attributed to W. Waldeyer. Cajal who, as we have seen, was generosity itself to other investigators, did strongly resent the attribution of this work of his to another. The mistake wounded him, and he protested earnestly. The doctrine was his chief life-work and he felt it his due that it should be recognized as his. In his Memoirs, in each edition, he reverted to this: "that which, and all that, Waldeyer did was to publish in a weekly newspaper a résumé of my research and to invent the word 'neurone.'" Cajal had reason to feel hurt; the injustice is unaccountable. Not at any time had the researches of Waldeyer touched the subject. He had not contributed either to the discoveries or to the generalization. The whole circumstance made Cajal feel more fully and somewhat bitterly the impotence of his country's language as a medium.
for holding, let alone catching, the scientific ear, even of those cosmopolitan worlds which cultivate medicine and science.

Meanwhile, his activity was winning academic recognition at home. In 1892 he was called to the Chair at Madrid. He was then 40. It was not without misgivings that he removed to the capital. He feared wider social engagements might tax his time too largely and that his slender emolument might be overstrained. He, however, found in Madrid a University circle much more loosely knit than that either of Barcelona or Valencia. Outside some immediate colleagues he saw little of the rest. The laboratory was meagre beyond belief, but the Dean, Calleja, was enthusiasm itself; he set about getting a new building for him. One clinical confrère, the Marquis de Busto, generously paid his own University stipend over to help the running of the new laboratory.

To an English reader of the Memoirs the prominence Cajal there gives, in reciting his removes, to describing the particular café which in each new place of residence he elected to frequent comes quaintly. At Barcelona his choice had been the "Café de Palayo"; in Madrid at first he went, with army-surgeon friends, to a café which they favoured. He soon left it for the Café Suizo where was a wider social circle of habitués, some of them eminent either in academic or professional life; "it included even financiers." At the Suizo anything and everything came under discussion, politics, letters, science, and "philosophy from Plato and Epicurus to Schopenhauer and Herbert Spencer. We paid homage to the doctrine of Evolution and to its high-priest Darwin; and we reprobated the Satanic pride of Nietzsche. Above all, we hailed every book and pamphlet which urged upon Spain political reform." It was a daily clearing house for news and views. Evidently this meant much to him and he probably to it. Cajal could talk well. He had a trick at table, a habit, caught perhaps from café discussion, of gathering crumbs into a heap while he spoke and then dashing them to the floor with a rhetorical sweep when he clinched his argument—a peroration trying to a hostess in her home. His best-known contribution to general literature is entitled _Charlas de Café_ ("Café Talk")—a small volume, some of which has been translated into English by the late Dr. Garrison. In it he appears as an essayist on life and men and manners, touching science only incidentally to those themes. The book has run to three editions. Its terse Stendhal-like lucidity is incisive and sometimes mordant. Much of it is cast in the form of aphorisms, despite an opening one to the effect that "reality overruns every concise phrase like liquid poured into a tiny cup." The reflexions are those of a man of tolerance to whom few illusions are left. The wit is plentiful, the enthusiasms sparse, and
melancholy predominant, sombre, and often caustic. "Glory is nothing more than oblivion postponed." "Blessed are they who can say no, for they shall live in peace." "Truth, like a corrosive acid, is apt to blister those who dispense it." "You amount to very little if your death is not desired by many." To whom but to Cajal would it have occurred, perhaps on his visit to London or to Stockholm, to remark, as with a sigh, "the grey matter grows well under grey skies." We can understand his own life-work better from reading, "So long as the brain is a mystery, the universe, the reflexion of it, will remain so."

In Madrid, with his new laboratory a hive of research, he looked round for some channel of publication for the research work. In Barcelona in 1888, he had started a Revista trimestral de Histologia normal y patologica. Now in Madrid he launched (1895) the Revista Trimestral Micrographica. In 1901 he changed the name to Trabajos del laboratorio de investigaciones biologicas del Universidad de Madrid, a title which in 1910 he again altered to its French equivalent. The early Revista is now difficult to see; few libraries have it; it is already sought by the bibliophile; not only is it rare, but it contains some of the outstanding papers of a great period. Despite other calls upon him, Cajal’s output of first-rate research suffered no pause: studies on retina, on sympathetic ganglia, and on cerebral cortex. He was widely known. At the International Congress of Anatomy, held in 1890 at Berlin, his preparations had attracted attention. In March, 1894, at the invitation of the Royal Society, he came to London and delivered the Croonian Lecture on "La fine structure des Centres Nerveux," Proc. Roy. Soc., vol. 55, p. 444. Later that year his Nouvelles idées sur la fine anatomie des centres nerveux appeared (Paris), with an introduction by Mathías Duval. During his English visit the University of Cambridge conferred on him the D.Sc. degree honoris causa. "Quo verodicam de artificio pulcherrimo quo primum auri, deinde argenti ope, in corpore humano fila quaedam tenuissima sensibus motibus que ministrantia per ambages suas inextricabilis aliquatenus explorari poterant? In artificio illo argenti usum, inter Italos olim inventum, inter Hispanos ab hoc viro in melius mutatum et ad exitum feliciorem perductum esse constat." While in London he was present at, and his Memoirs thirty years later recall it with special mention, an experiment by Ferrier on the monkey brain; "¡ los fisiologos ingleses y particularmente Ferrier son prodigiosos experimentadores!" He retained always a happy memory of England and friendships made there.

The course his work then took for some years lay in the application of his own technique and observation to parts of the nervous system which
they had not yet touched. Much fresh detail emerged, and the general principles he had formulated were without exception confirmed. He devoted 1896–97 to exhaustive comparison of results given by his metallic impregnation with those given by the methylene-blue stain. He had by that time as collaborators Pedro his brother, Sala-y-Pons, Calleja, Ortega, and J. F. Tello. However, as regards his own personal work, it was for a long season all laid aside after the outbreak of the war between Spain and the United States. He felt his country’s reverses so poignantly as to take for the time being no further interest in science. Not until months later did his scientific interest revive. It was suddenly requickened by a pronouncement from Kölliker (with Michel) that the accepted view of the mammalian optic decussation as partial and not total was mistaken. This assertion coming from such a quarter struck him as nothing short of astonishing; he sat down to re-examine the question at first hand for himself. A year later he published his work; it fully re-established the existence of the long-accepted uncrossed fibres which had been denied.

That same year saw the founding of the Instituto nacional de higiene de Alfonso XIII in Madrid and its directorship was pressed upon him. The country was being again threatened by epidemic cholera, and for that reason Cajal complied. Next year Clark University at Worcester, U.S.A., with its school of modern psychology, was celebrating a decennium and he was invited to attend. Chance brought him Angelo Mosso of Turin for fellow traveller thither. His mind still aching from the recent war, he had gone somewhat reluctantly, but the United States much impressed him. He saw there “Anglo-Saxon virility in a new environment.” He returned to re-start work with a zest that reminded him of his old fervours of twelve years before. He presided over Anatomy at the International Medical Congress held in Madrid. The “nerve-net” was, at his suggestion, put up as theme for set discussion. Professor Bethe, then at Strasburg, the declared protagonist of the old nerve-cell continuum view, was to attend. He had recently based extensive speculations concerning nerve-function upon his supposed grey-matter continuum, and Cajal looked to a clearing of the situation from the opportunity thus afforded for meeting. At the last minute, however, Dr. Bethe failed to appear, and sent instead some specimens, which, he wrote to Cajal, were “exceptionally good.” Their examination, however, at the Congress revealed no nerve-net. On the other hand, the meeting was impressed by some preparations with a new silver-method, exhibited by L. Simarro; these bespoke such further success for the metallic technique that Cajal was more than ever bent on perfecting it to the utmost. Little, however, in the way of progress came until suddenly, sitting alone in a railway train on holiday far from home,
a promising idea struck him. He hastened back to Madrid and put it into execution; it succeeded forthwith. He and Tello then applied it to structure after structure. Especially they examined the terminals of the collaterals. Held had described and figured their neurofibrils as penetrating from one cell to the next. Cajal corrected this; the tiny terminal “bouton,” often a minute loop, he showed merely applies itself to the surface of the next cell, without penetration or plasmatic fusion.

It was in 1906 that Cajal systematically attacked the question of the repair of degenerated nerve. An old-standing divergence of view as to the cellular make-up of the myelinated nerve-fibre had recently revived. Most observers held that a severed nerve, after the dying down of the distal severed end, obtained repair by the sprouting of the cut ends of fibres in the central stump. It was now alleged that each regenerated fibre was formed not by outgrowth from an old fibre but *in situ* by a chain of cells which fusing together endwise made an anatomical and functional continuum. This doctrine of the nerve-fibre as a syncytium was, of course, allied to that which held the grey matter itself to be a syncytial reticulum. The new view was pre-eminently urged by Dr. Bethe who again made it a starting-point for some general speculation. Cajal, after three years of experiment and observation, finally issued a two-volume monograph, “Sobre la degeneracion y regeneracion del sistema nervioso.” It gives the most comprehensive account of the subject extant. It confirmed the old “monogenista” doctrine of the genesis of the nerve-fibre and of its repair by outgrowth, and it gave a wealth of new detail. It established that the growing fibre, forging its way through alien tissue, does not, as Held taught, penetrate the cells which it encounters—it passes between them. It described the growing fibre as having an apical growth-cone, with a characteristic reaction to impediment, namely, proliferation into a leash of filaments, some of which may circumvent the obstruction while others turn back from it. All this received singularly apposite confirmation later from *in vitro* experiments by Ross Harrison on cultivation of embryonic nerve tissue. Cajal’s monograph has passed into a second and enlarged edition (1927) under special supervision from him, issued in English.

The observations on nerve-repair led him to analogous experiments on the central nervous system. He found the nerve-cell slough its injured fibre back to the nearest side-branch and make of this latter a new main stem; the new stem would grow and explore and where obstructed turn back on itself, producing a tuft of tangled, thwarted filaments. By appropriate mechanical injury he could transform a nerve-cell of long axone-type into one of short axone-type. Even a peripheral ganglion cell reacted to nerve-section by extruding fibres which under the constraint of
the cell-capsule were usually short and club-ended. Cajal stressed, as an inference from these and other findings, that powerful factor as inherited disposition is for assuring a certain inherited type of architecture in the individual nervous system, the fulfilment of the ancestral plan is yet much at the mercy of many passing circumstances. During its period of development occurrences and conditions, physical and chemical, even short lived, can warp and interfere with the attainment of the heritable prototype and entail large departure from it. In indulging such reflexions, the name which Cajal perhaps most insistently quotes as inspirer of his own transcendental biology is that of Herbert Spencer.

Cajal's studies of the nervous system in its early stages and of its reactions to injury somewhat naturally gave him special interest in that other great cell-system, still something of a nervous terra incognita, the neuroglia. It is no exaggeration in regard to it to say that he with his pupils, especially Achucarro, Hortego, and de Castro, opened a fresh era of knowledge. A histological analysis of it was accomplished almost wholly original, establishing valuable view-points altogether new. The short-branched cells, notoriously refractory to staining, were revealed by a special gold-mercury impregnation. Microglia, oligodendria, and mesoglia were identified and distinguished. The whole complex was seen to emerge as a sort of benign parasite developing with and enveloping the fundamental conductive system itself; benign normally, but tending sadly to abnormal growths and tumours. Cajal here laid a foundation for much of present-day study of the tumours of the brain and spinal cord.

The Great War in its course isolated Cajal. In his backwater, aside from the fierce torrent of contemporary events, he gave himself to a problem already long in his mind as offering particular attraction, insect-vision. Insects had been a special wonder to him when a boy. Histological analysis of the vertebrate retina had been a triumph of his early career. His restudy of the mammalian optic commissure had remedied Koliker's mistake. Lastly, he had established the cell-features specific to the visual region of the cerebral cortex. He now turned to the nerve-paths of insect-vision believing that they, free from that complexity which baffles enquiry in the higher vertebrate, would reveal to his methods a relatively simple system, displaying the essential plan of nervous construction pertaining to visual function in general. With his usual ardour, industry, and patience, he began the work. To it he devoted, along with his pupil Sandez, the year 1915 and most of 1916, only to relinquish it then, with what feelings is told in a characteristic passage of the Recuerdos: "The complexity of the nerve-structures for vision in insects is something incredibly stupendous; quite unapproached in other
animal forms. From the faceted eye proceeds an inextricable criss-cross of excessively slender fibres; these then plunge into a cell-labyrinth which doubtless serves to integrate what comes from the retinal layers; next follow a countless host of anacrine cells and with them again innumerable centrifugal fibres. All these elements are, moreover, so small that even the highest powers of the modern microscope hardly avail for following them. The intricacy of the connexions beggars description. Before it the mind halts, abased. And I, starting from a naive assumption, had expected here a scheme of structure relatively simple! We misjudge the insects. We call them lowly forms. But compared with theirs the visual structure in bird and mammal, even the highest, is gross, rude, and merely elemental. In tenuis labor. Peering through the microscope into this Lilliputian life, one wonders whether what the psychologist disdainfully terms instinct (Bergson’s ‘intuition’) is not, as Fabre claims, life’s crowning mental gift. Mind with instant and decisive action, the mind which in these tiny and ancient beings reached its blossom earliest, and now for millions of years has been ousted from its due throne by a vulgar upstart, the coarse brain of fish, amphibian, and reptile.”

Repulsed in this attempt on insect vision, but quite unwearied, he went back to his other problems. Neurofibrils; chemiotaxis as a force in the cytoarchitectural making of the early brain; the anatomy of the synapse as, adopting a term introduced by physiologists, he not infrequently called the contact-points of nerve-cell with nerve-cell which he had himself first ascertained. These subjects all retained his interest and even enlisted his practical investigation till after he was eighty.

It had been an early ambition with him to found a Spanish school in science. Never has anyone started out on a great research more single-handed than at his beginning did he. But as the years went by, if ever man had a school it was Cajal; a school of colleagues and pupils. His pupils included such men as Nicolas Achucarro, Pio del Rio Hortega, who brought to light the mesoglia and the elusive oligodendria (1919), Francisco Tello, remarkable for discoveries on development and regeneration of nerve-endings, collaborator with Cajal in Manual of Pathological Anatomy, and finally his successor as Director of the Cajal Institute. Others have been and are de Castro (neuroglia sympathetic ganglia), Villa Verde (neuropathology), Sanchez (comparative neurohistology), Llorento de No (auditory and vestibular nerves), Wilder Penfield (neural histopathology), and many others, though space precludes an exhaustive list of them.

His just-mentioned sometime pupil, Professor Wilder Penfield, Director of the Institute of Neurosurgery in Montreal, has described finely a last
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visit, which he along with Senor Rio del Horgtega paid to their old master. “We found him in his bed, sitting upright, working on a manuscript, books piled beside the bed and ink spattered on the wall next his impatient right hand. Deafness and feebleness which had come on him recently were shutting doors between him and the world, but his eyes blazed from under shaggy brows showing an unquenched fire.” It is a scene which speaks of what remained always the problem nearest his heart for the manuscript he was busy upon was Neuronismo ó Reticularismo, the final triumphant restatement of his thesis of the morphological separate ness of the individual nerve-cells, functioning co-operatively though without plasmatic continuity.

International recognition was followed in his own country by more and more demand upon him for public work. He was constantly consulted on medical and educational organization. On occasion, he had been invited to join the Government as Minister of Education, but, in fact, he never actually entered office. Distinctions came to him from many parts. The Prix Fauvelle of the Société de Biologie of Paris; the Nobel Prize for Medicine (1906) in conjunction with Camillo Golgi; and, just after the outbreak of the Great War, the Prussian Order of Merit. In England, the Royal Society in 1909 elected him a Foreign Member; more than a century and a half had passed since last the foreign membership of the Society had been recruited from Spain. The prestige which his work brought to Spain was hailed in his own country with grateful pride. The students of Zaragoza had a medal struck in gold in his honour; so likewise the students of Madrid. The Spanish New World across the Atlantic subscribed a sum to secure adequate publication of his work on nerve degeneration and regeneration. In Madrid, a statue was erected of him in the public garden near a path he was wont to use. Finally, overlooking Madrid, the stately Institute Cajal rose, erected by the Government. The list of his honours is too numerous to rehearse fully here. His country’s esteem and pride in him gave him deep satisfaction; yet it is said that he forsook the old path through the Buen Retiro Garden when the statue appeared beside it, and that he never took up the spacious quarters provided for him in the new Instituto, but continued to do his work in his quiet laboratory at home. Assuredly he had the shyness of a sensitive nature; and he was too self-conscious to be at ease with publicity. He was at heart something of a recluse, although with strong opinions on most subjects and quite open to express them strongly if challenged.

Cajal was short in stature, wide of shoulder and long of arm, this latter showing the more because his gait tended to stoop. His olive-com-
plexioned and large-featured face was melancholy in repose. But in repose it rarely was; whether speaking or not he had an intensity of expression to which variety was lent chiefly by the remarkable eyes. Full and dark, they lit or gloomed according to each passing mood. He had but two pastimes, chess and colour-photography, if the latter can be so termed. Of chess he was so fond that he had to tear himself from it as too time-absorbing a pursuit.

His long life carried him farther and farther into a period when Spain’s protracted political unrest became more and more articulate, at last to culminate in revolution. He had come to stand in some sort as a symbol of national cultural rebirth. Despite, perhaps partly because of, his retired and simple life and his advanced years, he and his scientific devotion and prestige were taken to typify to many of his fellow countrymen what a new Spain might cherish and accomplish; he was taken as a sort of forecast of what a new Spain should stand for. In this sense he caught the national imagination. Bank-notes bore his effigy. A postal issue was to distribute his likeness millionfold as a national emblem. He deprecated the proposal at the time, but after his death it was done. We may well believe that such a memento, at once national and democratic, would have touched Don Santiago’s virile heart. It is a tribute which gives evidence of the position accorded to him by the Spanish world, a position accorded him with the sympathy and applause indeed of the civilized world entire.

C. S. Sherrington.

The portrait, from which the reproduction at the beginning of this notice was made, was kindly lent by Professor J. F. Tello, pupil, friend, and successor as Director of the Cajal Institute.