Chapter One

The Creation of a New Scientific Persona

Santiago Ramón y Cajal and the Rise of Popular Photography in Spain

The story of the development of modern science in the West, and the rise of scientific models through which the environment could be either comprehended or controlled, contains a variety of interpretive knots. Among the many components of this narrative history, one focus of scholarship has held fast to the importance of "the extraordinarily rich and complex relationship between science and religion in the past" and that "during their history, the natural sciences have been invested with religious meaning, with antireligious implications and, in many contexts, with no religious significance at all. Not only have the boundaries between them shifted with time, but to abstract them from their historical contexts can lead to artificiality as well as anachronism" (John Hedley Brooke 16). While this statement appears to cover the gamut of possible relations between early modern European natural history dedicated to the description and cataloging of phenomena, and natural philosophy that sought out the causes or sources of those phenomena, it confines any intellectual discussion of the scientific revolution in Spain to very limited quarters. For many, it cancels out any possibility of discussion at all.

There are alternative paradigms, however, that encourage debate and discussion to fill in the blanks and look "elsewhere" for clues to the practice of what we might call the observational sciences in a variety of venues. For example, the volume edited by Daniela Bleichmar, Paula De Vos, Kristin Huffine, and Kevin Sheehan successfully argues against "an image of . . . empires built on the quicksand of superstition and greed," concluding with excitement and accuracy

that one finds evidence to support the central premise that "'science' was the handmaiden of the Iberian empires" (Cañizares-Esguerra 10). Scientific practice responded to colonial expansion and documentation, to the empiricism of empire, to the "green treasures" of native fauna found even before the gilded ones sought, and to the necessity of creating "mnemonic aids to help distant audiences experience . . . without traveling" (Cañizares-Esguerra 1, 4). As Daniela Bleichmar strikingly encapsulates the two poles of exploration and material production, the empire's undertakings had to be made both "visible and useful." Archives of exacting images were deemed a record of "the colonial machine [that] was a visual apparatus" (309). Maritime charts and navigational technologies fed the enterprises of collecting and cataloging, but they were the successful recipients of imperial investment as well. Among the growing number of scholarly projects related to "things scientific" that have begun to circulate regarding the knowledgeable intellectuals of the Spanish empire on both sides of the Atlantic, Miruna Achim's excellent overview of the critical shift in such studies over the past two decades makes it abundantly clear that earlier scholars' orientation toward viewing the Counter-Reformation and ensuing cultural closure of the nation had turned a blind eye toward a possibility of scientific riches. The reason is, as William B. Ashworth Jr. writes, "we have not been asking ourselves the right questions" (133).

The presupposition of an anachronistic vision of the world from the vantage point of Spanish culture, even well into the nineteenth century, has subsequently made way for the scrutiny of documents, charts, diaries, notebooks, and albums of specimens related to medicine, engineering, mining and metallurgy, and many other spaces where scientific research was collecting data and recording observations. In addition, comprehending and administering the wealth of the natural world over which imperial Spain had taken control was an urgent goal. Achim concentrates on

> specific cases, communities, and contexts, in order to understand why and how science was practiced at different moments and locations in the Spanish-speaking world . . . and more inclusive definitions of scientists and scientific practice, making room for sailors, bureaucrats, travelers, publishers, and merchants, and for activities like collect-

> ing, trading, legislating, and entertaining, . . . making maps, planning cities, collecting and recording data about plants, animals, minerals, climate, and topography. . . ." (107–08)

These are many of the activities embedded in the state's administration, natural resource strategizing, and transatlantic economic development, and the embedding of them within the cultures of exploration, geography, the collection of written records, and many other fields as well as across continents specifies. But they also bring together the many facets of how science was practiced and observed. Scientific facts and artifacts, alongside evidence of how they have been produced and consumed and by whom, literally cover the cultural landscape and leave behind a legacy of material objects as well as documentary evidence. Spain's traditionally seen failures and absences in the area of theoretical sciences such as astronomy or physics had closed the door to anything but handwringing. On the other hand, a consideration of the central role of scientific instruments and processes in Spanish culture is worthy of more attention. These might include Humboldt's early nineteenth-century information collected in "mobile laboratories" (Nieto Olarte 236), accompanied by a pamphlet titled *Paintings of Nature* that synthesized climate, physiognomy, and "an intense collaboration between art and science" (Mattos 143) through Santiago Ramón y Cajal's microscopy and photomicrography, dark rooms, telescopes, photo-phonographs, and stereoscopic cameras. Both on the Iberian Peninsula and in the colonies, scientific instruments were employed to measure, catalog, calculate the value of, and record the holdings of the empire and its inhabitants. Scrutiny of such material objects and the products resulting from their use makes sense in the context of the adoption of the epistemological values of modern empirical science as part of a collective project of modernizing advanced from the middle of the nineteenth century. This push for the modern is especially visible in the wake of the Spanish-American War as the new century dawns. Dale J. Pratt aptly signals the revolution in the fall of 1868 as a breaking point in the historically difficult relationship between the sciences and the arts in Spain, finding that historical time as one that "has evinced an ever-increasing concern with the implications of scientific inquiry" (3). The turn-of-the century war spurred that shift toward inquiry and observation even more insistently, but the groundwork for a focus on science had been laid even before that critical moment.

While Pratt persuasively studies Spanish cultural modernity reflected in the intertwined discourses of scientific and literary texts, other contemporaneous discourses existed as well. The community of individuals concerned with the role of science grew as communication did. R. V. Jones writes that

> The creative individual is, in a sense, complementary to the society in which he lives, rather as a soloist in a concerto. Both the basic ideas of science and the key inventions of mankind have generally been conceived in the minds of individuals, while the effort to gain the data on which the ideas and inventions have been based, and the subsequent effort to turn them to good account, have required the contributions of many besides the inventor and originator of ideas. So the individual and the community are necessary to one another. ("Complementarity as a Way of Life," 323–24)

Scientific communities—within the territory of peninsular Spain as well as across Europe and the Americas—influenced, informed, and challenged one another in the laboratory, the dark room, and the production and consumption of goods and ideas resulting from inventions and technologies.

I propose that those artifacts are all related to a critical appreciation of the preeminence of vision, the eye, the lens, the retina, and the scopic realm of light. The technologies related to sight were employed in the processes of photographic development, in addition to scientists' microscopic work on nerve cells, the spinal cord, the brain, and the retina, and they even came into play in the cinema. (The spectacle of Hollywood provided Ramón Gómez de la Serna with fodder for his allegorical novel *Cinelandia*, the glittering city filled with "illuminated faces" [105], meteoric "blazes of light" [102], and actors with "burnt-out retinas" [103].) The role of luminosity was to allow a pathway to the brain through the orb of sight, as a power to be harnessed in metaphor as well as in the enhanced material products of modernizing societies. While the natural eye may afford access to the details of the world—first its wonders, and then its anomalies—it may also notably be enhanced through the use of lenses that reveal more than unaided sight. When the object under scrutiny is visible, placed before the eye, knowledge of it had been deemed the most authentic and

the most doubtlessly accurate. Yet various models overlap across historical eras, challenging both the methods of seeing and how to read what is seen. Subjects, practices, and institutions went through radical changes during the nineteenth century, redefining the position of the observer, relocating the eye in picture making before a now-absent object, and shifting the desire to document experience into new and innovative forms of mass representation. Time and its passage—that inexorable movement toward death—could be seen in photographs, for instance, but the experience of it could not be direct. Cajal's healthy son in early pictures disappears from later ones, but the narrative that recounts his infirmity and death is not made available to the eye in images. Instead, there is a shift toward invisibility as a marker for time to fill in the missing face (or landscape) that has become the victim of the temporal. Terán would find the same true in the absent spaces of geographical landscapes.

William R. Everdell includes Cajal among "the first moderns," at least in part owing to the content of his study of the "atoms of brain" that figure as the components of greater structures of thought. How Cajal sought to study the forms and relationships of nerve cells and their interrelationships showed the "intellectual origins [of the modern] in an often profound rethinking of the whole mind set of the nineteenth century, the world view that gave rise to speed, industry, world markets" (Everdell 9). That worldview juxtaposed the history of science and constantly appearing inventions, the product of the artist on paper and the image produced through a lens, the "convincingness" of rapid photography and old reliable printing techniques, the examination of solar flares or eclipses and previous conjectures about the natural world, and the capturing of objects and movement "faster than the naked eye could see" (Prodger xxiii). The decomposition of entities into their component elements, of light into energy and bodies into cells, required the support of emergent technologies that appeared equally as fast. As a theoretical concept, then, modernity has provoked a complex and ongoing debate about time(s) and culture(s), one given a particular tenor by Daniel Frost, who notes a shift in the idea of "culture" as a marker of the modern, and indicates that from "cultivate" to "culture" there occurs a change in the perception of *paisaje* or landscape that bridges Spain's nineteenth century to the twentieth. Frost cites Raymond Williams on the advent of capitalist economics as a force that brings industry to replace agriculture and towns to replace

rural farms, thereby also reframing landscape as urban culture. Frost links his discussion of economics and the land—or changing notion of landscape—to a record of linguistic shifts such as that indicated by Stephanie Sieburth: "In Spain, where industrialization began later and was not as pervasive as elsewhere in Europe, the change in meaning was more gradual and it is not until the final years of the nineteenth century that Spanish dictionaries begin to register a difference" (Frost 16). The lexical register of rural to urban culture accompanied the economics of modernization as well as a shift in point of view.

As a characteristic of that previous century's thought, the metaphor of "smoothness" (Everdell 9) gave way to new divisions and new tempos. Societies began to cast off assumptions about the ease with which the objective observer could watch processes unfold, or the linkage between moments of perception. That is to say, Cajal's focus on the study of the varied elementary parts of the whole as they related to an organism was one of the fundamental signs of modernity's quests and questions. So was his insistence on the power and potential of the photographic image to freeze time. With an increased capacity for magnification and the invention of new technologies, individual components might grow into new collections of fragments and varying articulations. They might also provide the starting point for even greater detail that, when taken as a whole structure, presented an intricacy previously unsuspected. Everdell likens the scientific deconstruction of the totality in order to reconfigure the elements to artist Georges Seurat's method of "dividing optical perceptions into their discrete elements" (64) in his pointillist manner of representing a scene. The distinct dots of color meld if observed from a distance into graduated and subtle mixtures of tone and shade, forms and shadows. If Spanish society—literally as well as metaphorically—"groped about in the dark as it slowly pushed its way into modernity" (Pratt 130), then Cajal's experiments in histology and photography indicate a turn toward the light to identify—to see "rightly"—the whole as a more problematic yet ultimately still comprehensible entity. The emergence of an image from darkness in a photograph, or the illumination of cellular structure under the microscope, held the potential to shed light on the entire world. Cajal provided light on Spain's faltering process toward modernity.

Yet Cajal knew that scientific evidence did not end that process. Had he reached some sort of ultimate conclusions that no longer required examination, he would not have referred to the ongoing

experiments in "artificial somnambulism and phenomena of suggestion" undertaken in his home in the name of "*ciencia positiva*" ["true science"] (*Recuerdos* II, ch. III), or the parade of cells, people, and Levantine landscapes that "*desfilaron sucesivamente por el objetivo de mi Kodak*" ["passed in succession before the lens of my Kodak"] (*Recuerdos* II, ch. III) across the decades. To answer Pratt's enticing question posed at the outset of his study, Cajal provides evidence that science *can* be consumed as "both a praxis and an aesthetic object" (2). That object is contained in the visual products of the scientific laboratory and the photographic dark room (slides and photographs), both as process (praxis, technology, innovation) and as objects (the innate beauty of the stained cell and its biological function, the details of the natural world that science brings to light).

Many of the mentioned relationships among disciplines, wavering between a similarity and distinction of purpose between the religious and the scientific, concern both shifting cultural and intellectual boundaries, and particular historical events related to Spain. This includes the encounter with a "'new world" to be cataloged and comprehended; the Counter-Reformation and implementation of the Inquisition; the shift from the rule of the Hapsburgs to that of the Bourbons in an on-again, off-again romance with modernity being embodied in the instruments of scientific progress; the Spanish-American War and the failures of medical and military science to save both the troops and the colonies. The breakdown of the empire in 1898 presented Cajal and others with evidence of Spain's inability to use all the resources of modern scientific progress to make life better, earn the respect of other modern nations, and "*aplicar [la] ciencia a las necesidades de la vida*" ["apply science to the necessities of life"] (Cajal, *La psicología de los artistas* 113).

He had experienced the results of an inability to harness the power of scientific knowledge for the "necessities of life" firsthand some twenty-five years earlier, as a victim of the tropical diseases rampant in the Caribbean during his short time as a volunteer medical doctor in Cuba. When faced with staggering human losses and illness in the difficult climate of the islands, to say nothing of the lack of a spirit like that of Alexander von Humboldt missing from the Spanish culture of modern times, Cajal wrote of Spain's Cuban defeat with both cultural and scientific regret. He chose his words carefully to depict the lost promise of scientific endeavors done either carelessly or without full comprehension: "La media ciencia causa la ruina. . . . Hemos

caído ante los Estados Unidos por ignorantes. . . . Eramos tan ignorantes que hasta negábamos su ciencia y su fuerza. Es preciso, pues, regenerarse por el trabajo y el estudio" ["Half-baked science causes ruin. . . . We have fallen to the power of the United States because of our ignorance. . . . We were so ignorant that we even denied their dominance in science and their strength. We must, therefore, be regenerated through work and through study"] (*La psicología de los artistas* 113, 116). There is no doubt that Cajal's conclusions are a result of the downcast historical moment at the end of the 1890s, but they are also colored by his voluntary service as a medical doctor in Cuba beginning in 1874, a hazardous enterprise cloaked in romantic imaginings. Cajal's call for a collective will to stand tall and be "regenerated" through renewed dedication to intellectual pursuits echoed throughout his entire professional career, and he would be the first to proffer his own work ethic and investigative drive for observation as models.

Filled with boredom amid everyday life in the provinces, particularly in Lérida, the young scientist evoked his earlier readings of the novels of Jules Verne and his engagement with other literary adventurers in order to extend them to his own goals. There was a sense of identification between this reader and the imaginative characters that explored the nether regions of the planet in search of the unknown or the unexplained. For a young resident of Spain, these idealistic travels would first imply a visit to the American colonies, the outer reaches of the empire, and the territories of Charles Darwin's studies in the 1830s. As he recounted his emotional response to the imaginings of Verne and the observations of Darwin, Cajal confessed that:

> Me devora la sed insaciable de libertad y de emociones novísimas. Mi ideal es América, y singularmente la América tropical, ¡esa tierra de maravillas, tan celebrada por novelistas y poetas! . . . Orgía suntuosa de formas y colores, la fauna de los trópicos parece imaginada por un artista genial, preocupado en superarse a sí mismo.
>
> The insatiable thirst for freedom and for experiencing new emotions devours me. My ideal is America, and more particularly tropical America, oh that land of wonders so celebrated by novelists and poets! . . . A sumptuous orgy of forms and colors, the fauna of the tropics seems something

> imagined by a jovial artist, spending his time constantly trying to outdo himself. (cited in Laín Entrago and Albarracín 60)

The obvious exoticism of the American colonies reported by explorers and literati alike, their strikingly exciting flora and fauna, and the dream of gazing on the waves of the Caribbean Sea took him on this mission against his father's wishes.

First Cajal ventured to Puerto Rico and, from there, to Cuba. With the deaths of other physicians in Cuba, new ranks of Spanish doctors filled in to try and treat the cases of malaria and tropical diseases that had decimated the population. The romantic trajectory of exploration and the epidemiological realities would intersect at some point. A young scientist with a flair for drawing and a true utopian impulse for the unknown, Cajal set off filled with exuberance. Yet he returned to Spain within a relatively short time, another victim of intestinal disease, tuberculosis, fever, and parasites. His desire for adventure came face to face with the real conditions of the tropics. This encounter between medicine and the natural world left Cajal pondering the shortcomings of a culture choosing to ignore science and those of his own imagination. Both of these forces founder amid the spreading uprisings of the American colonists against Spain that would ultimately bring a new power to the region, the United States. All-out war would not break out in the 1870s, but it was a growing possibility summarily ignored by the center of the empire that turned a blind eye to the discontent of the islands. From the province of Camagüey where he was first assigned, Cajal saw desolation, isolation, and danger all around him. Spanish soldiers and native Cubans battled the ravages of tropical disease, using all the forces of science at their disposal. But these were not sufficient. While Cajal did not mention, and may have been unaware of, the equally catastrophic suffering of the U.S. troops in the Cuban conflict of the 1890s (although one imagines that the medical community would certainly be informed of such crucial statistical data on both sides of the battle), the knowledge potentially provided by science seems to have failed both sides owing to the shortsightedness of governments and their neglect of the scientific discoveries on the bacteriological front.[1]

Rather than concentrate primarily on previous historical times alone or on scientific investigation in a narrower sense, this study turns instead toward late-nineteenth-century and early-twentieth-

century Spain as a crucible of scientific activity in which paradigms were inherited and reconsidered. At the turn of the century, the new epistemological practice of empirical observation had become codified and exalted, but also challenged, in the sciences as well as the arts. After the proliferation of the eighteenth century's scientific conventions of truth-to-nature, nineteenth-century European scientists turned increasingly to a more mechanical objectivity insisting on the elimination, to the greatest extent possible, of the willful intervention of the scientist in how natural phenomena looked or how the artist reproduced images of nature. Even as scientists and their work rose in public stature, their interventions in the production of images supposedly retreated. The rise of progress in modern technological devices, such as the camera—and, with it, photomicrography, microphotography, stereoscopy—and an argument in favor of such an invention as a "distinctly scientific medium" (Daston and Galison 130) was accompanied by "different expectations for objectivity" (Strong 63) to live up to. Changes in perception with the deployment of increasingly powerful lenses accompanied and predicted the social transformations occurring between the nineteenth and twentieth centuries, highlighting a rational and comprehensible world now able to be observed as well as investigated with greater particularity. With one eye at the lens of a microscope and the other fixed on a sheet of paper, the scientist and observer had dual perspectives on the natural world, perspectives that required care and caution if they were to be scientifically valued and socially exalted.

In the realm of technological invention, Paul Martineau refers to photography as a technology that "shortened the distance between the eye and the hand" (7), thereby insinuating a realism of the resulting product that appeared to copy nature without any input from the observer. On the one hand, the camera seemed to show without interference, but the subtle arrangements of objects in a still life or the observation of minute cells and structures still exemplified the notion of interpretation. As Laura Otis, referring to the scientist's techniques with the microscope to acquire the greatest definition of detail, and his subsequent drawing of what was observed, astutely summarizes: "Santiago Ramón y Cajal, Spain's Nobel Prize–winning histologist, is known for his vision." She deftly points to both the concern with sight and a forward-looking attitude. What he saw through the lens of the camera was akin to human beings populating a landscape—the

composite of elemental parts from the visible to the invisible, "individual cells and human beings represent[ing] the true origin of will, creativity, and regeneration" (Otis 64). He saw the role of the scientist as an exercise of free will, aided by the apparatus of technology, akin to the freedom he sought in the Americas, accomplished by a trained human being with scientific, creative, and culturally beneficial ends. Like colonies of cells, individual scientists were intellectual leaders of a cultural collective, much as patriarchs presided over the family units comprising coetaneous Spanish society. Cajal reproduced as faithfully as possible what he observed under the microscope, down to the arrows that indicated the flow of blood or nerve activity. These images would orient other scientists and produce accurate depictions for further scientific experimentation.

Yet unless and until others could reproduce an encounter with the image in the same manner, the plausibility and validity of the new techniques of observation rested on two things: the scientist's own meticulous records and capability of reproducing an experiment, and the status of the scientist himself. Cajal did the same for his own image as a scientific investigator as he did for the laboratory experiment through the photographic self-portrait of an intellectual constantly at work. Prodger could not state it more clearly: "Photographs assumed a dual role. They illustrated something, but they were also experiments in their own right. They became more than mere pictures—they became data" (xxiii). Both scientific processes—in the laboratory and in the dark room—developed protocols as they simultaneously cast the scientist into the spotlight. Scientific photography and other sorts of photographs occupy the space of the technologies of the eye, the first as signpost to discoveries and the second as identifier of the man who was the discoverer. Darwin was not a photographer but he advanced the science of photography when he chose to incorporate images into his theoretical books as visual illustrations. If Darwin chose with care the type and number of photographs that would prove his point for the 1872 *The Expression of the Emotions in Man and Animals*, using photographs as evidence of scientific hypotheses, Cajal surpassed that activity by the turn of the century with his expertise in developing plates and experiments in chemical processes that produced photographic specimens to prove his theories.[2]

The domestication of nature, or a search for an ultimate cause provided through scientific examination and collection, were conventions

that carried over from the eighteenth century, and such a "truth-to-nature" ideal coexisted for a time with the advent of the codes related to the rise of lenses and mechanical objectivity. The aesthetic virtue of harmony ceded only with difficulty to new visions no matter how convincing they might be, yet some aspects may have coincided simultaneously. As Cantor and Brooke conclude of earlier shifts in interpretive analysis related to the sciences, "To lose the music of the spheres was an intolerable deprivation" (174) for Johannes Kepler, whose research was rewarded later with the acceptance of an aesthetic of the ellipse as the new elegance of the planetary orbits. The standard commentary about Cajal's histological preparations of neural circuitries (with the camera lucida as an aid to drawing), cells of the cerebellum, structures of the retina, and Purkinje cells' dendritic tree that he saw as similar to a grape arbor, includes references to their elegance and texture, their attention to detail. In particular, scientists emphasize their "clarity and beauty . . . [that] are even today awe inspiring" (García-López, García Marín, and Freire 15). Not only did he find the "right" way of seeing the cells, in the process he produced a new sort of beauty. So his avid hypothesis of a *neuron doctrine*, opposed to the *reticular theory* promoted by Camillo Golgi, did not lessen the impact of scientific discovery and clarification but enhanced aesthetically what was seen and, finally, explained structures with the exactitude of the lens and eye. The new grace of Cajal's science was its breadth and inclusive vision, its aesthetics of the product and of the process simultaneously. This is noted in the words of Emil Holmgren who nominated Cajal for the Nobel Prize:

> Cajal has not served science by singular corrections of observations by others, or by adding here and there an important observation to our stock of knowledge, but it is he who has built almost the whole framework of our structure of thinking, in which the less fortunately endowed have had to, and will still have to put in their contributions." (cited in Grant 2)

Sheer intellectual drive and curiosity—"irresistible curiosidad" ["irresistible curiosity"] (*Recuerdos* I, ch. XXVI), "tenacidad" ["tenacity"] (Laín Entralgo 10), "testarudez indomable" ["indomitable stubbornness"] (Cajal, *La psicología de los artistas* 19), or "brío inquisitivo" ["inquisitive spirit"] as his brother Pedro saw it (Cajal, *La psicología de*

los artistas 41)—drove Cajal to find visual evidence of his hypotheses. It was not enough to theorize. The lens provided scientists a chance to work with the previously invisible, minute details of natural objects and phenomena, counteracting a lack of material evidence or a faulty reliance on speculation. Sight itself was as exquisitely alluring as what was observed.

Everdell points out in metaphorical terms that the inherited task for the taxonomist and collector "was stamp collecting. A good taxonomist had to be humble, as well as extraordinarily thorough and persistent, like Linnaeus. . . . This kind of tireless single-mindedness was very much in the character of Santiago Ramón y Cajal" (101). Yet there had to be more than mere "tenacity" in the shifting of the limits and parameters of one piece of matter or physical structure, and the beginning of the next. There had to be reason and observation. The boundary between the similarities and the differences of two objects was the central focus of any cutting-edge taxonomist, but any method of observing and judging the structural arrangement of properties could always be challenged by technological innovation. Not to be feared, technology was promoted by Cajal as provocative and helpful in the study of all aspects of the world. As Everdell proposes, taxonomy "is more epistemologically challenging than any other science . . . it makes more innocent assumptions . . . What in fact are you seeing when you classify a thing and give it a name? . . . Why are some categories appropriate for bringing things together and others not?" (104). That all life was part of a continuum, not ascribing breaks or distinctions to individual units but an unbroken chain without end, was an assumption that haunted the science of taxonomy until the turn of the twentieth century. Cajal's work in "a small corner of the learned world" (Everdell 106) in the 1880s was quiet, persistent, and in the beginning somewhat invisible, even when he began to make strides in the study of the characteristics and behavior of nerve cells. A portion of that greater framework of human thinking referred to earlier is made evident when Cajal joined Camillo Golgi in connecting the use of silver nitrate—the chemical that also launched the photographic revolution—to the staining of cells in the laboratory. The advance in science would reveal the art of the human nervous system, and open the door to new nomenclatures.

The drive toward accuracy of Cajal's "framework" was like an architectural structure built carefully from step-by-step observation. It

offered accessible and ascertainable knowledge, information that may be observed, and even challenged, by others. With the microscope and the camera, new forms of experience emerged that brought the physical world and the social world in increasingly closer contact. It was deemed incumbent on this scientist therefore to look with insistent accuracy at what appeared through the lens, not long for the imaginings of the past before the shift in the value of experience occurs. With this, as shall be discussed later, the almost mythic aura of wonder and distance felt between human beings and the rest of the natural world was punctured by technology whose development presented new opportunities as well as new investigations. In a way, the loss of aura around the natural world corresponds to Walter Benjamin's description of the effects of mechanical reproduction (film and photography) on the auratic uniqueness of the image. With advancements in technology for the mass media, the singularity and moment of originality of an image fades. Daston and Galison propose that, rather than a vision of singular certainty, objectivity in science "preserves the artifact or variations that would have been erased in the name of truth" (17). Deviations and discrepancies opened up to scrutiny theories about nature, especially through the reproduction of images. Like the implementation of mechanical reproduction and the new media of the early twentieth century—cinematography and photography among them—the microscope provided laboratory scientists an opportunity for repeatable experiments. Thus, they could confirm or contradict what others had postulated; the photographic lens afforded a constant invitation to look anew.

Howard Caygill concludes that when Walter Benjamin wrote of the decay of aura brought about by photography and the cinema, "aura is not a property but rather an effect of a particular mode of transmission" (102). This effect leads to objects and observers being brought into closer contact, but in different times and spaces. When nearness—real or simulated—is broken, the relationship of time and space (history) for the observer is also ruptured. If Cajal's insistent work attempted to emancipate science in Spain from its relegation to the edges of culture at the turn of the century, his fame brought its promise into the center of society where it might be put on display as the preeminent motif of the modern. A simultaneous paradox was produced as he was monumentalized and distanced from the public as a spectacular icon of intellectual activity that only exemplary Spaniards

could attain. In other words, as the figure of the scientist was made to feel closer than ever through publicity and journalists' reports, that same individual was rent from the social fabric owing to his extraordinary work. The photographic record of Cajal's private life sometimes contradicts the stature of the public man.

Even as technologies of the eye made more dimensions of the world accessible, bringing into focus the normally unknown and the unseen, they also cast out traditional notions of certainty about human life, the notion of time and the privileged observer. They created a distance between the expected and the innovative as well. This accessibility affirmed the need to interact with and interrogate the past and its images, not accept them as they had been inherited. In Cajal's own words, science is the tool of that inquiry: "La ciencia infatigable nos lleva de sorpresa en sorpresa, y cada invención es un placer arrebatado a nuestros abuelos." ["Science persists tirelessly in taking us from one surprise to the next and each new invention is a delight we have snatched from the hands of our grandparents"] (*Fotografía de los colores* 18). The methods of science neither came out of nowhere nor would they disappear any time soon. Invention and innovation had been documented and esteemed by previous generations, existed in current generations, and held promise for future generations. Cajal reveled in scientific conquest (the triumph of the disciplined mind over ignorance), and marked a transition from the interpretive and artistic, the painterly image, and the hopeful conjecture to the illumination of microscopic and photographic image used to critique as well as create.

In an introduction to his manual on color photography published in 1912, Cajal saw chromatic photography—as did Benjamin when he wrote of chromatism beyond the stark tones of the black and white—as a mode of visual transmission that changed the experience of the viewer as much as it reflected the positioning of the viewer toward the image. At the age of sixty, Cajal wrote with almost youthful enthusiasm about the potential power of the photographic image. That changed relationship between observer and time hinged on the fixed photograph: "¡qué dicha sería poder contemplar, sin los afeites y convencionalismos de la pintura, siempre aduladora y esquemática, las juveniles facciones de nuestras madres . . . !" ["What a pleasure it would be to be able to contemplate, without the artifices and conventions of painting, always flattering and simplifying, the youthful features of our mothers!"] (*Fotografía de los colores* 18). There is a consciousness

of his own aging that tinged this longing observation on the passage of time, yet it also drew attention to the experience of contemplation itself as it does to the inviting traces found in photographs. The mode of the painterly reflected the brushstrokes of the artist, while the camera presumably produced (or reproduced) an image of a different sort, one that accompanied the sentiment of rupture brought by modernity's attempted break with the past. In the details of photography appear flaws, nuances, facial tics and gestures, glances, and, above all, time made material, visible, and concrete. Maybe what was recognized in a painting now looked very distinct, some hidden nuance having been brought out by the capture of an image on glass, metal, or paper, or some flaw seen for the first time. That image may materially preserve a moment into which the observer may interpellate him- or herself, but it presumptively challenges and destroys traditional forms of perception—of face, space, and time—which, always the scientist, Cajal proposed to capture with the instructions provided in his volume on the best methods of color photography. The subtitle of the volume—scientific bases and practical rules—acknowledges the attributes of the scientist and those of the novice in equal terms. His photos simultaneously delve into the realm of the microscopic in search of understanding the mechanisms and architectures of the natural world, and into domestic spaces challenged by modernity's changes. What better for the production and reproduction of images than the most intense and exact color, movement, contrast, and relief, just as he had worked on all his life, in the realm of microphotography and stereoscopy?

Having internalized the melancholic lessons of 1898, and not asserting the recapture of some past moment of grandeur or glory but forging ahead "*de sorpresa en sorpresa*," Cajal instead recorded image after image. He documented people, places, and his own work, aware that new methods would come along and that each moment of progress was one of pure contingency. He did not appear to posit a return to something now lost but to an attitude of discovery that had been lost. Although many Regenerationists, aware of Spain's failure to keep pace with the social and cultural changes in the rest of Europe, "believed that Spain's problems were essentially moral" (Ross 41), concerns over land reform, public finance, corrupt politics, uneven industrialization, and the fate of the workers' movements coexisted in diverse and even contradictory measure. Cities grew as did skepticism over political solutions to the nation's divisions, and Cajal confessed that while he listened

to fellow scientists in various *tertulias* he turned in some exasperation to science rather than any political schema. When Cajal wrote of the quixotic spirit of adventure lost from Spain's most recent history, he evoked little of tilting at windmills. Instead, he sought more of a courageous spirit to confront the world as it is found then proposed how it might soon be constructed differently. For future generations in Spain who would inherit the debates to which he saw no end—to them, Cajal wrote in Spanish, whether about scientific topics or photographic ones—he summarized previous developments in his work, in color photography, and in new methods that promised to produce faster, clearer, and brighter results. That the products would also last longer did not hurt either. He frequently closed his memoir entries with references to future generations and to what he foresaw as exciting modern scientific work he would not live to see.

The term *modern* science sounds to our ears like a reference to some sort of empirical testing, putting theories under scrutiny and coming to results that prove hypotheses with a preponderance of evidence. Even popular accounts of the use of the scientific method have elicited doubts about the adequacy of some sort of procedure to produce a shift in the acquisition and integration of the natural world with each momentous innovation in technology. In the seventeenth century, the mathematician John Wallis, among the precursors of the Royal Society of London, could include in the "sciences" mathematics, philosophy, "Physick, Anatomy, Geometry, Astronomy, Navigation, Staticks, Magneticks, Chymicks, Mechanicks, and Natural Experiments" (cited in Brooke 55). But the "sciences," understood now as differentiated from theology, proposed a reconsideration of the past, of the ways of looking that belonged to the old order, to mark a cultural shift toward a reliance on reason aided by and through the senses. In particular, emphasis on vision and the lens to investigate and represent nature as both an active (the experimenter or willful self) and passive (restrained, observant, scientific self) object of cognition arose. Then photographic technology aided in hypothesizing an alternative standard and means of representation. The inquisitiveness, stubbornness, and challenge to authority that led Cajal to pursue scientific research, and the curiosity that drove him to avidly pursue photography, offer evidence to confirm the unique traits that were used to spur the promotion of this scion of science as a model of what would be required of Spain for entry into cultural modernity. Cajal's turn to drawings rather than language

in the 1889 presentation of his findings using the powerful lens of the Zeiss microscope confirm on a microcosmic level the macrocosm of a community of modern scientists and intellectuals. His French and German being less than useful in communicating his discoveries, Cajal implemented his presentations to German biologists during the session with slides and drawn versions of cells. This visual medium crossed cultural borders and conquered linguistic obstacles. The community's shared language of science was that of the human eye.

Regarding experimentation and the scientific method, Brooke summarizes:

> there have been so many definitions offered by philosophers, and by scientists themselves, that it would require another book to consider them. Many refer to some singular, unique "scientific method" to which exemplary science is supposed to conform. But, as William Whewell, Cambridge philosopher and the first to coin the word "scientist" in the 1830s, observed almost a hundred fifty years ago, the *history* of science already showed that each new branch of scientific inquiry had required its own distinctive methodology. And that very process of increasing differentiation reflected a more fundamental change in the meaning of science—from when it had referred to all knowledge and when theology was "queen of the sciences," to its more modern connotations of empirical investigation and high specialization. (6–7)

A plurality of distinct methods, a specialization of types of inquiry, and a turn toward empirical information gathered from the senses by observation, experience, or experiment coincides with what Jürgen Habermas has described as the project of modernity: "Its project . . . is one with that of the Enlightenment: to develop the spheres of science, morality and art 'according to their inner logic' . . ." (Foster, xii). Beginning in the mid-nineteenth century, scientific inventions and innovations contributed to a possible shift in the acquisition and evaluation of these processes, as well as to the notion of an inner logic of disciplinary conventions. As Cantor and Brooke conclude: "there are fundamental ideas peculiar to each science" (139) and, therefore, conventions related to discrete fields that, while addressing specific concerns, might unite in a more encompassing vision of knowledge.

The grammar of histology and the grammar of photography are two codified sets of conventions that combine in the activities of Cajal as both observer and investigator; they also overlapped in scientific investigation, the focal point of his life. Despite his proclamation of breaking the codes of painting with the use of photography, there is a grammar of this technological innovation linked to the times, a set of structural rules that govern the composition of images. Cajal inherited norms and practices of composing photographs, of setting up a still life, of preparing a slide, of writing up a report. But he was never content with that, and he constantly pursued faster, truer, more accurate results, or the portability of equipment that took photography into the world. Challenges that might arise from what had not yet been made available to the human eye were not to be avoided but accepted, using sophisticated lenses of all types as light-providing intermediaries between the eye and the brain.

The increasingly potent and convincing norm of objectivity for the observation of all phenomena at all levels of perception began to take root in Spain, as in the rest of Western Europe, around 1860, following technical developments in the scientific equipment used to conduct experiments related to the description (how) and explanation (why) of what could be known about the natural world. Into this context of investigation and inquiry, the rapid translation and publication of Daguerre's manuals on the photographic process into Castilian may be added.[3] With these works, one might capture the workings and inhabitants of the world with a more radically modern—seemingly unassisted by any intervention—vision supported by the lenses of modernizing technology. These included photography, stereoscopy, photomicrography, and compound lenses whose enhanced power of sight demanded an equally enduring indelibility of the images produced. The more could be distinguished, the more one could study and comprehend. The material devices and trappings of modernization that accompanied a transition from the traditional in the realms of economics and industrialization might not necessarily have brought an epistemological change—an intellectual culture of modernity, or the notion that change had brought about a rupture with a past worldview and its quest for knowledge—along with them. It is one thing to find the construction of railways, telegraph lines, urban centers, the establishment of university chairs in science, and photographic studios; it is another to consider the technologies of modernization as valuable sources of

knowledge. Walter Benjamin did not reckon with the objectivity but with the "ecstatic" aperture of the structures of experience afforded by the camera, "the potential for infinite transformation opened by a technologically informed experience [which] can either be affirmed, leading to constant innovation in the subject or reality, or refused in the regressive use of technology to restore distance . . . and permanence—i.e., monumentality" (Caygill 105). While in later decades of the twentieth century, the Spanish state used the power of cinematic technology to proclaim and solidify its claim to rule, Cajal found in the laboratory and the darkroom the potential to put theories to the test as well as to discover the surprises of the unexplored.

Of such values, Daston and Galison clarify that objective observation was not valued always but that

> Scientific objectivity has a history. Objectivity has not always defined science. Nor is objectivity the same as truth or certainty, and it is younger than both. Objectivity preserves the artifact or variation that would have been erased in the name of truth; it scruples to filter out the noise that undermines certainty. To be objective is to aspire to knowledge that bears no trace of the knower . . . only in the mid-nineteenth century did scientists begin to yearn for this blind sight, the 'objective view' that embraces accidents and asymmetries." (17)

Nature seen as divine creation and mystery, or nature seen as a collection of harmonious typologies met up with a modern quest for firsthand knowledge about the world. Cajal recorded that his early experiments on cadavers provided him direct experience of "*cosas objetivas y concretas, acogía con ansia el pedazo de maciza realidad*" ["objective, concrete things, . . . I anxiously accepted (all) fragments of solid reality" (*Recuerdos* I, ch. XVII). These he could examine with "a passionate commitment to suppress the will" (Daston and Galison 143) and be "truthful" in his conclusions. The virtue of objectivity stood squarely at the center of Cajal's groundbreaking work, and as a clear presence in his qualms about the objectivity of the scientific practices and conclusions as practiced by co–Nobel-winner Camillo Golgi. But it also formed a substantive part of his simultaneous fascination with photography as chemical process and as a visible product. The two fields were not just