Martino Rossi Monti, Patrick Singy
and Albena Yaneva

on

Lorraine Daston and Peter Galison's *Objectivity*, MIT Press, 2007

Snowflakes and Spiritual Exercises

Martino Rossi Monti

"These were little plates of ice, very flat, very polished, very transparent, about the thickness of a sheet of rather thick paper [...] but so perfectly formed in hexagons, and of which the six sides were so straight, and the six angles so equal, that it is impossible for men to make anything so exact." With these words René Descartes describes, in his treatise *Les Météores* (1635), some snowflakes observed with the naked eye. Not long before, Johann Kepler had celebrated the beauty and perfect symmetry of snowflakes in a short treatise entitled *Strena Seu de Nive Sexangula* (1611 – *A New Year's Gift of Hexagonal Snow*). Since then, those who have described and drawn snowflakes, from Robert Hooke to the nineteenth-century English meteorologist James Glaisher, have seen them as absolutely perfect forms, marvelous expressions of invariable mathematical relations. Everything that appeared asymmetrical or irregular, whenever noted, was labeled as an "exception" or declared inessential. There was a sort of blindness or annoyance towards the irregularities of nature. The human eye, as St. Augustine had remarked, is "irritated" by asymmetry (*De vera religione*, XXX, 54).

Around Christmas 1892, in Berlin, the photomicrographer Richard Neuhauss, under the direction of the meteorologist Gustav Hellmann, took a series of photographs of snow crystals. Accustomed to the "absolute regularity" and "perfect symmetry" of the snowflakes drawn by earlier scientists, Hellmann and Neuhauss were met with a disappointing sight: the crystals appeared irregular, imperfect. Only the cold and ruthless precision of the photographic camera had been able to give them a faithful image of how nature really was. As Hellmann wrote: "despite the icy hardening of the surroundings, these are *natural pictures*, warm with life" (151 – my italics). The snowflakes reproduced by Hellmann and Neuhauss were not ideal forms or "types," produced by abstracting from all the particularities and imperfections of single flakes observed in nature. They were not *the* ideal snowflake, but *this* or *that* snowflake.

This is just one example – enriched by a few details – of the history of the birth of what Lorraine Daston and Peter Galison call "scientific objectivity" or "mechanical objectivity." In *Objectivity* the authors provide us with many others, no less interesting and stimulating, always anchored to the world of scientific images (the scientific atlases published from the eighteenth century to the present time). The idea of scien-

Iris, ISSN 2036-3257, I, 1 April 2009, p. 277-288

tific objectivity – this is the main thing this book shows – has a history. But there is more: the book also shows that science has not always been defined in terms of objectivity. In fact, for Daston and Galison, only around the mid-nineteenth century – with positivism the rage – did the idea begin to emerge that in order to represent a scientific object faithfully one had to eliminate all *subjective* interferences: "to be objective is to aspire to knowledge that bears no trace of the knower – knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving. Objectivity is *blind sight*, seeing without inference, interpretation, or intelligence" (17 – my italics). Up to that moment, quite another kind of "epistemic virtue" had prevailed: that which, let us say, an eighteenth-century botanic atlas sought to represent was not an array of specimens – *unique* in their singularity – but, on the contrary, the ideal form, the *type* of each species. In order to grasp such a primary form, the naturalist had to perform a sort of platonic purification: through tenacious and tireless observation, he had to discard everything he judged inessential and accidental, in order to extract the universal from the particular. Far from being passive, the naturalist had to exercise his intelligence actively in order to abstract the perfect form from the chaos of multiplicity. Daston and Galison call this epistemic virtue "truth-to-nature."

According to the authors, both these virtues – truth-to-nature and objectivity – were strongly connected to the philosophies and theories of knowledge of their time. During the eighteenth century, subjectivity was often seen as something essentially passive – a sort of aggregate of sensations, impressions and images whose fragile identity was ensured only by memory and self-consciousness (think of David Hume). Hence the scientist had to be as active as possible. Post-Kantian subjectivity, by contrast, was conceived as fundamentally active, "constructive," and as organizing experience. In German Idealism objectivity was nothing less than a product of thinking subjectivity (*ob-jectum*). It was to counterbalance this pervasiveness and intrusiveness of the "I" that the nineteenth-century scientist had to be as passive and "absent" as possible: only in this way could the object emerge in its purity. The best way to obtain this was to let oneself be *replaced* by a machine. Machines (such as the photographic camera) seemed able to record phenomena without human intervention (even if, as Daston and Galison remark, objectivity and photography did not necessarily imply one another): "nonintervention – not verisimilitude – lay at the heart of mechanical objectivity" (187).

But Daston and Galison's narrative does not end here. The twentieth century was the epoch of another epistemic virtue: "trained judgment." Reacting to the cult of self-denial typical of objectivity, scientists now insisted on the importance of intuition, judgment, and the capacity to interpret, be it in the processes that lead to scientific discoveries and in the criteria that regulate the production of scientific images. Far from searching for the truth hidden under the veil of appearances (truth-to-nature) or from sacrificing their own will and judgment (objectivity), scientists have to develop a sort of "physiognomic sight": "a capacity of both maker and user of atlas images to synthesize, highlight, and grasp relationships in ways that are not reducible to mechanical procedure, as in the recognition of family resemblance" (314). A simply "natural" image, such as a photograph of a single and unrepeatable scientific object (a plant, an animal. a human organ), turned out to be as enigmatic and impenetrable as the nature it promised to represent (357); hence, the necessity of "reasoned images," drawn by an expert and trained eye and designed to train and instruct other eyes.

Note that, in their narrative, Daston and Galison emphasize several times how these three different epistemic virtues, each arising in reaction to the others, far from being nullified or "overcome" by one another, persist in more or less peaceful co-existence. What is more, the diversity of paradigms and approaches within scientific knowledge constitutes, according to the authors, "a permanent aspect of science" (371).

A second highly original aspect of Daston and Galison's work consists in locating the history of objectivity within a broader history of the self. Also the scientific self, in fact, has a history. It has not always existed, but is the fruit of long work on one's self and of self-perfection, motivated by a strong moral drive. In support of all this, the authors refer to the works of Michel Foucault, Pierre Hadot and Arnold Davidson on the "technologies of the self" and "spiritual exercises." As Hadot has argued with great clarity, in antiquity philosophy, rather than a collection of abstract theories, was essentially a way of life based on the search for and exercise of wisdom. There was a common ideal underlying the different philosophical systems (Platonism, Stoicism, Epicureanism, etc.). To philosophize meant to put one's spirit and body continually to the test through specific exercises such as meditation, self-control, reading, listening, representation of future misfortunes (*praemeditatio malorum*), fasting, and so on. It was literally a *conversion* to a different style of life: the aim was control of the passions, tranquility of the soul, and harmony with the universal reason (the *Logos*).

Albeit on a totally different level, for Daston and Galison an ideal of self-perfection is proper to the scientific self as well. The goal is certainly different (not wisdom but a scientific knowledge of the world), but the stress upon the necessity of practices of self-discipline and sharply defined exercises is the same: the scientist *must* remain motionless for hours and observe phenomena and natural beings, scrupulously recording his observations, dividing himself into "active experimenter" and "passive observer" (38), reading and studying thousands of pages of scientific texts and so on. Like the philosopher of antiquity, he *converts* to another style of life. Daston and Galison insist that the link between epistemology and ethics is very strong: whatever the epistemic virtue (truth-to-nature, objectivity or trained judgment) recommended by the scientific literature of the time, the exhortations are nearly always religious and ascetic in tone. There is always an "ethical imperative" at the core: "the mastery of scientific practices is inevitably linked to self-mastery, the assiduous cultivation of a certain kind of self" (40).

This is evident above all when what is to be cultivated is "the scientific self of objectivity": in order to reach its goal, this self has – paradoxically – to *nullify* itself. The absolute enemy of objectivity is in fact nothing less than subjectivity understood – post-Kantianly – as the source both of knowledge and error. The scientist, if he seriously wants to be objective, has to act like a sort of mystic: he must neither will nor know nor imagine. He has to die to himself and abandon his "I": "objectivity is to epistemology what extreme asceticism is to morality. [...] The demands it makes on the knower outstrip even the most strenuous forms of self-cultivation, to the brink of self-destruction. [...] It is a sacrifice" (374). A passage like this and the reference to Hadot's work called to my mind the words – quoted by Hadot himself – of the Christian monk Dorotheos of Gaza (VI cent.): "He who has no will of his own always does what he wishes. For since he has no will of his own, everything that happens satisfies him. He finds himself doing as he wills all the time, for he does not want things to be as he wills them, but he wills that they be just as they are." In other words, he has to sacrifice his own will and identify himself with the divine

will. Apart from the evident differences, this ideal can be considered valid in a certain sense also for the "objective" scientist, whose "heroic" effort of will for the suppression of subjectivity Daston and Galison emphasize in several passages of the book. His is a *will not to will*, "a will to willessness." There is, at the core of this experience, an insuppressible tension between the will to objectivity and personal will, between personal sacrifice and liberation from the personal. Objectivity is a *conquest* of the subject and of its will and, simultaneously, its *eclipse*: "objectivity is at once the enemy of the arbitrary and the highest expression of *liberum voluntatis arbitrium*, the will's free choice" (381). Daston and Galison often remark that objectivity was conceived as a regulative ideal that was never fully attainable, approached only through an inexhaustible search. When, however, the impersonal contribution of machines was judged to be incomplete without the intervention of human judgment and a trained eye, it meant that a new "scientific self" was being born, and with it a new way of creating and conceiving scientific images.

Finally, *Objectivity* also gives us a penetrating analysis of the relationship between art and science. Such an analysis is inevitable, since the entire course of the book is cadenced by a sequence of images. In its richness, *Objectivity* is also a contribution to the history of aesthetics and is, more particularly, a profound reflection on the meaning and role of the image in the modern and contemporary world. Today, when the roles of scientist, engineer and artist seem at times to overlap (as in the case of the scientist Eric J. Heller's image-simulations, exhibited not only in scientific texts but in art galleries and museums), the world of images is undergoing a further change. Thanks to digital technology, images have become interactive: they can be downloaded from the Web, modified, explored in three dimensions. They are *usable*. This occurs also with scientific atlases, which can now be contained in a simple CD-ROM. But there is more. Images, as we see in the field of so-called *nanomanipulation,* are even used to alter the physical world, to construct or modify physical objects. Daston and Galison dwell at length on the novelty and impact of these scientific processes.

Scientific images are often considered, by those who create them as by those who contemplate and use them, to be works of art. Where art was once considered the sworn enemy of mechanical objectivity (since it was based on an expansion of subjectivity), now art and science peacefully co-exist, and often overlap. In 1983, in an American Physical Society competition for the best photograph of fluids in motion, the criteria of judgment were the beauty and originality of the image, no less than its contribution to a better understanding of the phenomenon (403). Along with the image, also the scientific self is changing: it is now a "hybrid figure" (413), a scientist-engineer-artist who uses images not as copies of the real, but as a *tool* to modify the real. These changes, Daston and Galison conclude, are intrinsic to science and its paradigms: "once again, images are in flux. Once again, so is the scientific self" (415).

The book presents us with a host of quotations from various fields of knowledge. The possible quotations are, in cases such as this, innumerable. Those from Descartes and Kepler with which I opened this note can be added to the many – on snowflakes – present in the book.

Martino Rossi Monti
University of Florence
mrossimonti@gmail.com

Objectivity?

Patrick Singy

Lorraine Daston and Peter Galison's *Objectivity* is a 500-page answer to the question, What is objectivity? The present essay attempts to answer a much narrower question: What is *Objectivity*? The enigmatic shortness of the title defuses from the outset any temptation of narrowly pigeonholing this book. Daston and Galison are two of the most prominent historians of science, but *Objectivity* is much more than a traditional book of history of science, since it offers a triple critique of objectivity: historical of course, but philosophical and historiographical as well.

The core of Daston and Galison's historical critique of objectivity does not consist in showing that objectivity has a history, but much more radically in demonstrating that "objectivity has not always defined science" (17): "there can be, there has been, there is science without [...] objectivity" (371). The fusional relation between objectivity and science is historically contingent.

Focusing on scientific and medical atlases, Daston and Galison argue that before the emergence of objectivity in the mid-nineteenth century, truth-to-nature governed eighteenth-century science. This "epistemic virtue" demanded of atlas makers that they actively intervene in their descriptions and depictions of natural objects by selecting the essential and leaving out the accidental. The hands-on approach of truth-to-nature was necessary given the concept and experience of the self prevalent in the eighteenth century. Locke, Condillac and many other eighteenth-century philosophers believed that the self was built piecemeal from the impressions received by the senses. Fearing that this empirical origin of the self would lead to excessive passivity, truth-to-nature required that Enlightenment savants "actively select, sift, and synthesize the sensations that flooded the too-receptive mind" (203).

If truth-to-nature is linked to the sensationalist self, the next epistemic virtue, objectivity, is linked to the subjective self. Unlike the passive and fragmented self of sensationalist psychology, the post-Kantian subjective self was active and integrated, it was "organized around the dynamic and autonomous will" and it "acted on the world, projecting itself outward" (201). What emerged in the mid-nineteenth century was therefore not merely objectivity, but subjectivity as well, for one "defines" the other (36, 197, 258). More precisely, one was born as a reaction to the other: "the subjective self of nineteenth-century scientists was viewed as overactive and prone to impose its preconceptions and pet hypotheses on data. Therefore, these scientists strove for a self-denying passivity" (203).

In the late nineteenth century a third epistemic virtue emerged: trained judgment. Distancing themselves from passive objectivity, some scientists now "championed judgment and intuition" (307). But this was no return to truth-to-nature. The active intervention of trained judgment depended on a very different self than the one of Enlightenment sensationalist philosophy: it was the self "as an archaeological site of conscious, subconscious, and unconscious levels" (44).

This highly simplified summary of Daston and Galison's argument does not do justice to its richness and complexity, nor does it address some problematic points (for instance, it is likely that the opposition between passivity and activity was an obsession of the nineteenth rather than the eighteenth century, and that Daston and Galison

have thus read Enlightenment epistemology with nineteenth-century glasses). But it is sufficient for bringing out *Objectivity*'s simple yet radical historical critique of objectivity: this epistemic virtue is "neither an inevitable nor an eternal part of science" for history has demonstrated "the possibility of alternatives" (376).

Daston and Galison's philosophical critique of objectivity takes two complementary forms: conceptual and metaphysical. First, their historical analysis reveals objectivity to be a true conceptual conundrum. Contradicting "one of the most deeply entrenched narratives about the Scientific Revolution and its impact," we have seen that for Daston and Galison knower and knowledge have never been pried apart (39). There is and has always been an "intrinsic connection between epistemology and self" (233). But while the idea that the "knowing self is a precondition for knowledge, not an obstacle to it" (53) is unproblematic for truth-to-nature and trained judgment (given that both require the active intervention of scientists in their observations), it flies in the face of objectivity. Since "subjectivity is the precondition for knowledge," the "malady" that objectivity treats is "the root of both knowledge and error" (374). Hence the "paradoxical aspirations" and "strangeness" of objectivity (374), which is oxymoronically called a "will to willessness" (38, 53, 203, 210).

Second, objectivity encourages a metaphysics that is irreconcilable with scientific research. What would a perfectly objective atlas look like? It would be "a mere collection of unsorted individual specimens, portrayed in all their intricate peculiarity" – and it would be scientifically "useless" (185–86), since "no science can do without […] standardized working objects, for unrefined natural objects are too quirkily particular to cooperate in generalizations and comparisons" (19, 22). Insofar as it opposes on principle any interpretation, objectivity has in its horizon an "implicit nominalist metaphysics," which the defenders of trained judgment rightly came to see as "destabilizing" (309). Objectivity is thus "caught between the Charybdis of interpretation and the Scylla of irrelevance" (186). This is the irrelevance of a map that would be of the same size as, and coinciding point for point with, the territory it is supposed to represent – as Jorge Luis Borges playfully described in "On Exactitude in Science". Appropriately enough, in their chapter on trained judgment Daston and Galison mention Borges's story: "the whole project of nineteenth-century mechanically underwritten naturalism suddenly seemed deeply inadequate. For the image to be purely 'natural' was for it to become, *ipso facto*, as obscure as the nature it was supposed to depict: a nightmare reminiscent of Borges's too-lifelike map" (357). Instead of taking for granted that objectivity is the solid rock on which sound scientific research must stand, Daston and Galison have revealed its "instability" (251).

Daston and Galison's last critique of objectivity is historiographical. Having shown historically that objectivity has not always defined science, and philosophically that it is a problematic concept that leads to a problematic metaphysics, they turn back onto themselves the results of their investigation and apply them to their own methodology. This reflexive twist is a stroke of genius that sets *Objectivity* apart from other excellent books in the history of science.

While Daston and Galison lay out their methodology in several key passages, the link between what they write about and how they write about it always remains implicit – with one exception: the historical, philosophical and historiographical threads of *Objectivity* visibly intersect in the figure of Borges. As we have seen, Borges's lifelike

map is mentioned in a chapter on trained judgment. But Daston and Galison also refer to it in a methodological passage of the introductory chapter, where they explain why they do not attempt to determine with precision when and why epistemic virtues emerge: "If some Laplacean demon would turn its infinite industry and intelligence to a complete specification of all the circumstances at a given time and place, wouldn't it be possible to explain the emergence of objectivity [...] with pinpoint precision? This is a persistent and revealing historical fantasy. It is fantastical to imagine that we can deterministically identify not only the 'trigger' in historical processes – but also the detailed route of development. It is impossible not only because it is practically beyond our grasp, but also because it is incoherent. Just as in the case of the utterly useless Borgesian map that reproduces an empire in one-to-one facsimile, the Borgesian archive of all historical information would duplicate history, not explain it" (50). Daston and Galison's historiographical critique of the "persistent and revealing historical fantasy" of so many historians mirrors trained judgment's metaphysical critique of objectivity. In both cases, the desire for duplication is diagnosed as suffering from epistemological sterility.

Escaping radical nominalism, Daston and Galison seek to reveal "patterns that show that even if a historical formation is contingent, it is not thereby a hodge-podge or chimera" (205). That is, the emergence of a historical formation is contingent – Daston and Galison clearly write a "non-teleological history of scientific objectivity" (29) – but within a historical formation there are constraints and rules that govern its elements, even if only "loosely" (28). Daston and Galison's own metaphysics therefore grants to reality a certain degree of internal coherence: "history cannot arbitrarily recombine elements – otherwise we would have chimeras instead of concepts" (379). Although unacknowledged, the influence of the early Foucault is obvious here.

Instead of drawing Borgesian maps, Daston and Galison's central task consists in describing the relations between the different elements of a historical formation (for instance, the relation between objectivity and subjectivity), and in contrasting the comparable elements of different historical formations (for instance, "judgment" in truth-to-nature is contrasted with "judgment" in trained judgment). Rejecting "the metaphorical (and metaphysical) reflex that, without further justification, prefers excavation to enlargement as a privileged method of understanding" (205), they are after relations of a logical rather than a causal kind. These relations range from rigid necessity to looser yet not arbitrary relations. For instance, the relation between objectivity and subjectivity is presented as necessary: objectivity is impossible without subjectivity. On the other hand, the relation between objectivity and naturalism is less strong: with mechanical objectivity, "the orientation away from the interpretive, intervening author-artist of the eighteenth century tended (*though not invariably*) to shift attention to the reproduction of individual items – rather than types or ideals" (121 – my italics). Sir Francis Galton is one example of someone who was at the crossroads of objectivity and idealization: he mechanically created composite portraits to find the picture of the ideal type of the murderer (168–71).

Daston and Galison's historiographical critique of objectivity is not limited to the explicitly methodological passages of *Objectivity*. It is also subtly and superbly woven into the very form of their writing. Once again reminiscent of the early Foucault, *Objectivity* often reads like an elaborate commentary of a double-entry table (it is therefore most appropriate that the main argument of the book is summarized by means of a double-entry table on p. 371). The fact that Daston and Galison's argument

never really flows, even though it is served by the most limpid and elegant of prose, is not a mere stylistic quirk; it is the direct consequence of their historiographical approach. More precisely, the primary focus on the rules constraining the elements of historical formations rather than on the mere presence and causes of these elements has led them to suspend the two fundamental organizing principles that traditionally propel historical narratives, namely time and space.

The most basic requirement for drawing the temporal equivalent of a Borgesian map would be to describe events one after the other, in precisely the order in which they occurred. At first sight, this is what *Objectivity* does: the chapter devoted to eighteenth-century truth-to-nature comes before the one on nineteenth-century objectivity, while the one on twentieth-century trained judgment is last. A closer examination of each chapter reveals however a much less straightforward use of chronology. Instead of proceeding unidirectionally, each chapter goes back and forth incessantly between historical periods, teasing out the differences and similarities between all the epistemic virtues and weaving an increasingly complex series of contrasts. For instance, the chapter entitled "Trained Judgment" of course describes trained judgment itself, but in great part it does so through multiple comparisons between this epistemic virtue and earlier ones.

Space similarly functions only as a general geographic limitation (*Objectivity* is contained within the Western world), never as a glue that would meaningfully connect elements. Instead of tracing the development of objectivity in Germany or in entomology, for instance, the argument constantly bounces from one country to another and from one discipline to another, as if in a pinball machine, until patterns begin to take shape.

Evidently, the constraints that govern historical events must be sharply distinguished from mere chronological or spatial contiguity: it is not because two elements follow one another or lie side by side that they will obey identical rules, and it is not because they are separated by many years or many kilometers that they will obey different rules. Hence the unsuitability of microhistory for bringing to the surface the patterns that interest Daston and Galison: "Just as no localized observer alone can detect the shape of a storm front or the distribution of an organic species, so some historical phenomena can be discerned only by integrating information from a spread of contexts. These phenomena will inevitably be inflected by local context, but without losing their identity" (47–48).

Objectivity's ethical passivity and metaphysical nominalism would have demanded that one submissively abide by the actual chronological and spatial unfolding of events. But Daston and Galison have opted instead for a dizzying and exhilarating crisscrossing of space and time that enables them to reveal "patterns that connect scattered elements into a coherent whole" (36). According to legend, it is by getting up and walking that Diogenes the Cynic refuted Zeno's argument against the possibility of motion. Daston and Galison's ultimate critique of objectivity similarly consists in demonstrating, in action rather than in words, that there are viable alternatives to objectivity for the production of knowledge.

Patrick Singy
Columbia University
ps2403@columbia.edu

Scientific Images and the Crafting of the Self

Albena Yaneva

In their latest book, *Objectivity*, Peter Galison and Lorraine Daston show *why* and *how* scientific objectivity emerged, in the nineteenth century, as a new way of studying nature – a new way of being a scientist. As the authors tell us, the history of objectivity does not coincide with the history of epistemology: the "history of objectivity is only a subset, of the much longer and larger history of epistemology – the philosophical examination of obstacles to knowledge" (32). Instead of taking their cue from a philosophical reflection on metaphysics, they unravel objectivity here as a set of everyday techniques for making observations and images.

Are images and drawings able to guide a scientific reflection, or not? Attempting to untangle the complex process of fluid flow into a systematic visual classification, the nineteenth-century British physicist Arthur Worthington argued: "[…] it is impossible to put together the drawings so as to tell a consecutive story, without being guided by some theory" (15). For many years he had an eye for perfection and eliminated the asymmetrical images of drops from his publications, since he believed that the morphology of drops was supposed to reflect the symmetrically perfected forms of nature. This example shows how what is considered a scientific virtue of objectivity – the tracking and documenting of scientific phenomena – becomes a psychological fault of preconceived perception. This story is told by many images, "instantaneous photographs" of "symmetrical visions" and "objective splashes" of the drops. Galison and Daston have explicitly chosen to tell the history of scientific objectivity through pictures, selecting images that identify each discipline's most significant object of enquiry. Choosing to trace the history of objectivity through the practice of scientific image-making, some questions emerge: To what extent are scientific images able to depict the physical world in its complexity, imperfection and individuality, and thus to provide an objective view of nature? At what point in history was the tendency to idealize scientific representations considered to be a vice, and why?

Daston and Galison maintain that all scientific images encode a technology of scientific sight implicating author, illustrator, producer and reader. They are the product of a distinct code of epistemic virtues: truth-to-nature, mechanical objectivity, and trained judgment. A close examination of the key scientific practices of atlas-making throws the contrast between these virtues into relief, showing us how the making of images in scientific atlases was infused with them from the early-eighteen to the mid-twentieth century in Europe and North America. The authors explain their decision to narrow their sights to images in scientific atlases, first, because they wanted "to show how epistemic virtues permeate scientific practice as well as precept; second, because scientific atlases have been central to scientific practice across disciplines and periods; and third, because atlases set standards for how phenomena are to be seen and depicted" (19). They show us convincingly how a collection of working-images from scientific atlases can provide a very specific focus to a broad scope of scientific phenomena and their visualization. Underpinning other forms of scientific visualization, atlas images define the working-objects of disciplines and, at the same time, cultivate what might be called "the *disciplinary eye*, analogous to what art historians call the *period eye*." (48). They offer a rare and precious glimpse of seeing in the making.

Atlas images are images at work that play a crucial role for the advancement of all sciences of the eye, from anatomy to physics, from metrology to embryology. Galison and Daston's work puts forward a compelling argument for the status of "working objects" in science: atlases, models, and specimens. As systematic compilations of working objects, atlases are not seen merely as illustrations of scientific texts and theories but rather as compendiums of images intended to serve a community of practitioners, standardizing observing subjects and observed objects by eliminating irregularities and idiosyncrasies. They also serve the cause of the public diffusion of data and the cause of memory, documenting and capturing the ideal, typical and average manifestations of phenomena. Their role in science, then, is performative: not passive illustrations of certain knowledge and existing theories, but astute devices used to train the eye of scientists and teach them how to see. Images provide "how to" guidance for scientific practice: "how to describe," "how to depict," "how to teach." Through their reiterative tutorial performance, new knowledge is gained.

The choice of atlases, not as anesthetized and static documentation of the stages of scientific accomplishments but rather as tentative collections of "working objects," is emblematic of the authors' original approach to the history of scientific objectivity. Their approach is based on two assumptions. First, that scientific activity takes place not in the mind's eye but within a larger spectrum of many perceiving eyes, mobilizing the sense of many. This definition of science differs from the traditional understanding of scientific endeavor as relying on rationality, impartiality and amputated perception; science, too, is a collective venture, just as the production and use of atlases was always distributed between artists, scientists, atlas producers and craftsmen. The networks of science are made visible, and given the chance to speak. And second, that scientific visualization consists in a set of dynamic objects; far from being back-blocked, aesthetically polished illustrations attesting to stabilized epistemic objects and certain knowledge, atlas images are analyzed as dynamic cognitive objects, tentative and open, having a crucial per-formative impact on scientific practices.

The two assumptions made by Galison and Daston provide important and innovative insights into the scientific cultures of eighteenth-, nineteenth- and twentieth-century Europe and North America. The authors' attempt to track epistemology, usually considered to be abstract, via the concrete details of drawings or photographs is particularly striking. The three epistemic virtues they identify (truth-to-nature, mechanical objectivity, and trained judgment, corresponding to eighteenth-, nineteenth- and twentieth-century sensibilities) are coined "as historically specific ways of investigating and picturing nature" (28) that do not collide, but accumulate. They exist not only as ideals for science but, indeed, as workaday choices: what instrument to use, whether to retouch a photograph, disregard a data point, or how to train young scientists to see. The epistemic virtues are closely linked to the "self" of the knower.

If in the eighteenth and early nineteenth century specimens were depicted in an idealized way, by the mid-nineteenth century objective images "untouched by the human hand" were preferred. Image-making practices in the eighteenth century involved an artist or an illustrator playing a mediating role. He was supposed to passively record information from nature and submit passively to the naturalist's will (not to interpret it!), whereas the natural scientist was given the authority to interpret nature while observing it, monitoring and correcting the artist. What art-

ists did because they *saw that* was further amended and idealized by what scientists *saw as* biased by existing knowledge. A set of fascinating case-studies in the book reveal the complex ways art and science reinforce one another in these practices. The eighteenth-century illustrator later came to be replaced by mirrors, soft wax, and photographic plates, which were meant to serve as more faithful mediators of nature than the earlier, subjective and difficult-to-master illustrators. It was soon discovered, however, that photographic representations can also be retouched by many subjective hands. Minimizing intervention in order to decrease the degree of subjectivity was the overriding imperative of nineteenth-century scientists, and mechanical objectivity was needed to protect images against subjective projections.

If eighteenth-century savants located variability in the objects themselves and attempted to cope with it by regulating the relations between illustrator, scientist, and nature in order to extract the "typical," the "standard," in the nineteenth century the chief source of variability shifted to the multiplicity of viewpoints, the variability of subjectivities. Mechanical objectivity as a nineteenth-century epistemic virtue is defined as the insistent drive to repress the willful intervention of the artist-author by means of machines of mechanical actions for the reproduction of nature designed to make specimens appear without the distortion characteristic of the observer's personal taste and commitments. But mechanical objectivity did not in fact rely on a passive medium: picture making again came to involve an active manipulation of the image, retouching, correcting and improving it, snipping the edges, replacing the background, incising the object. Thus, as Daston and Galison tell us, in the twentieth century structural objectivity came to replace mechanical objectivity as a virtue. That is, an "objectivity that, in its emphasis on structural relations rather than objects per se, was both a rejection of mechanical objectivity and an intensification of objectivity on another scale" (317). Self-restrained image-making could not satisfy the early twentieth-century physicists and mathematicians. "They were suspicious of their own psychology, dubious about the deceptiveness of naive visualization, dismissive of world views and school philosophies" (301). For Einstein and Poincaré, for instance, objectivity meant identification of invariable structures; only invariable structures survive the vicissitudes of minds and words, so that a trained judgment can be generated as a way of seeing scientifically through an interpretative eye.

By tracing different practices of nature-observation and image-making, Galison and Daston also trace the mutations of the scientific self from the eighteenth through the twentieth centuries, the central question being: "How does the right depiction of the working objects of science join scientific sight with the scientific self?" In defining different "ways of seeing," atlases shape the subject as well as the object of science; they are testaments to how science is done and what kind of person one must be to do it. Galison and Daston show us that every practice of image making implies a tentative process of cognition that varies across historical settings: only when Worthington had photographs of his drops was he better equipped to see that "asymmetries and faults were not merely deviations from some clear and perfect central image – that it was irregularity all the way down" (156). While the authors show how through atlas-making and the various practices of image-making scientists engage in a new economy of "learning to see," it is sometimes regrettable that we rarely see them also *learning* from what they see: by learning to *see* they only craft their own scientific selves. In this

respect the book follows the different practices of training the scientific eye – distinctive knowledge-vision – but avoids accounting for all the epistemological implications of the new scientific gaze. How is it that *in the process of drawing or retouching photographic images* Worthington does not simply see nature differently so as to become a different scientific self? The tools of scientific visualization would rather allow him pragmatically to approach nature as knowable. In retouching image edges and correcting the illustrators' representation scientists are not only engaged in a struggle to erase uncontrolled and disordered subjectivities; in this process, they also gain new knowledge that is not graspable otherwise.

Inspired by a Foucauldian thinking of science as an art of the self, Galison and Daston argue that scientific images and atlas-making imply very specific practices and techniques of shaping the self: to learn to observe and depict in a science is to acquire at once an ethos and a way of seeing. The book's greatest merit is that it does not reduce scientific objectivity to an abstract concept but treats it as something that has a historically specific trajectory and that resolves into concrete actions and practices: in the gestures, techniques, habits, and temperament ingrained by training and daily repetition. That is a view of objectivity as constituted from the bottom up rather than from the top down, a fascinating story of the entangled histories of objectivity and scientific visualization told in an erudite, methodologically inventive, visually compelling and passionate way.

Albena Yaneva
The University of Manchester
albena.yaneva@manchester.ac.uk