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# The Objective Image

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**Inaugural Address**

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## Introducing Right Depiction

What is it to get a correct picture of the basic working objects of science? Is it to idealize the phenomena around us, to strip the things we see and reveal essences? Is it to hold ourselves back in a super-human effort of restraint in order to let nature and our instruments record things as they are—to achieve mechanical objectivity? Is it to apprentice ourselves to the best of the world's scientists, to master the most probing instruments—and then to exercise trained judgment to adjust and correct our images until they are right? Or is it to manipulate the artificially colored, moving, simulated digital renditions of processes otherwise too small, too far, or otherwise out of our visual range to see? In this brief exploration, I want to reflect on what it means to get to a right depiction of nature—to explore, historically, the shifting regulatory structures that shape both the kind of scientific image we want as well as the kind of scientific self needed to produce it.[1]

Where does one find the working images of science, the reference leaf, skull, galaxy or cloud? For several hundred years, the answer was clear: go to the reference library attached to the research laboratory or clinic. There you would find the scientific atlases. Atlases of turtles and eyeballs, of leaves, blood cells, and particle physics—in fact, there are atlases from just about every scientific field you can imagine. These are the books that spelled out the basic things, the working ontology of science: large-format volumes, durable paper, outstanding reproductions, minimal captions in English, French, and German. Strewn throughout these volumes are discussions of objectivity and how to get it for this most crucial, foundational part of science. Scientists the world devoted a staggering effort to the preparation of these several thousand volumes, but not for the casual reader or philosophical onlooker. No, these are texts by scientists for scientists. Collectively they represent the bottom line of science, the things, now on paper, that ground what know.

My interest is in understanding the trajectory of right depiction and what getting the image right demands of the scientist self.

**Objectivity and the Scientific Image**

All virtues–even all epistemic virtues–are not the same. Ethicists remember the competition among their ideals, epistemologists too easily forget. Pedagogical utility is not the same as finding the hidden, true structure of things. Obtaining accuracy in science is not precision—and neither is, in any obvious way, the same task as obtaining certainty. And for the tradition of scientific atlas-makers before 1800, it was a singular good to depict the body, plants, and sky phenomena in ways that would be "true to nature." Being true to nature allowed–indeed demanded–massive intervention, even if the plant or skeleton or crystal stood before the scientist-illustrator's eyes. In sum, before mechanical objectivity (before it became a virtue to exercise a maximum of self-restraint against intervention), one could not simply draw what one saw because the *Typus* could not depend on any particular instance. Here is Goethe in 1792:

> [A]n anatomical archetype [*Typus*] will be suggested here, a general picture containing the forms of all animals as potential, one which will guide us to an orderly description of each animal. . . The mere idea of an archetype in general implies that no particular animal can be used as our point of comparison; the particular can never serve as a pattern [*Muster*] for the whole."[2]

Not incidentally, but *essentially* anyone preparing a visual representation of a natural kind must, in the search for truth to nature, select and idealize. For it is the best that stands for the truest representation of nature. Albinus, in 1749, put it this way as he explained why he put forward the skeleton that he depicted.

> And as skeletons differ from one another, not only as to the age, sex, stature and perfection of the bones, but likewise in the marks of strength, beauty and make of the whole; I made choice of one that might discover signs of both strength and agility; the whole of it elegant, and at the same time not too delicate; so as neither to shew a juvenile or feminine roundness and slenderness, nor on the contrary an unpolished roughness and clumsiness; in short, all of the parts of it beautiful and

> pleasing to the eye. For as I wanted to shew an example of nature, I chused to take it from the best pattern of nature."[3]

But even Albinus's careful choice did not suffice. So, as he dutifully reports, he had to remove the "blemish" to make more "perfect," to alter the parts so as to render the whole more "altogether just." This genial depiction is, as we will see, a long way from the mechanical objectivity that largely displaced it.

The surprising, indeed astonishing transformation that takes place between the eighteenth century and the years after the 1820s and 1830s, involves the inversion of the values espoused by a Goethe or an Albinus. No longer is intervention by the genial author the most important feature to be prized in scientific representation, it becomes a veritable epistemic vice. Rather than a required improvement of nature, it was only through superhuman self-restraint that the author could aspire to let nature "speak for itself." As Hermann Pagenstecher and Carl Centus wrote in 1875, they "endeavored in these [pictures], to represent the object as naturally as possible. It cannot be hoped that they have always succeeded in the attempt: they are but too conscious how often in its delineation the subjective idea [*subjective Anschauung*] of the investigator has escaped his hand." Against the seduction of the subjective, the authors squelched their own views and "prevailing theories," theirs was to be an endeavor that would be "purely objective." Others struggled to minimize the "personal element."[4] Technologies that aimed to automate the transfer from nature to page were many, including various forms of the mechanical trace, the direct impression of objects on the page, along with the cameras lucida and obscura. When film entered the scene, it, like other technologies before and after, was celebrated as a release from the "artistic aids" that always threatened to make interpretation a personal, subjective feature of depiction.

Here, in this celebration of self-abnegation, in the horror at the personal, the subjective, the artistic, the interpretive. Here, in the direct transfer of nature onto the picture lies the ideal of mechanical objectivity: an objectivity defined by its moralized and automatic status beyond the reach of the artist's hand. What practitioners faced in the nineteenth century was, however, anything but a self-evident epistemic virtue. Objectivity may not carry with it accuracy. More than one author happily renounced the precision, the color, the sharpness, the depth of field, even the research and pedagogical usefulness that a genial scientific illustrator could bring to the table. In place of these lost attributes, mechanical objectivity boosters often could produce only blurry black and white photographs, incomplete tracings, or partial projections. But, they insisted, their photographs were automatic–and as such did not pass through the dreaded distorting glass of interpretation. In directness, so the defenders would have it, lay the real virtue of the objective. Objectivity was not (and is not) accuracy.

Mechanical objectivity is also not to be confused with truth. An objective procedure with its restraint and automaticity might create the conditions under which the true might be encountered. But the objective would not guarantee truth and could not make claim to be the only path to truth. Neither was objectivity certainty. Indeed, in contemplating the ferocious insistence on objectivity during the mid-nineteenth century, one is left with the uneasy sense that mechanical objectivity, examined close-up, may well be the most peculiar of epistemic virtues. Objectivity in its mechanical guise emerges as a ferociously austere, self-denying virtue, a virtue present when all the special skills, intuitions, and inspirations of the scientist could be quieted and nature could be transferred to the page without intervention or interpretation. Like the ascetic through whom God would speak, advocates of objectivity took the scientist's self-silencing to create the moral and epistemic conditions under which Nature could speak. In this hushed domain of science, the whispered voice of nature still needed to be amplified by machinery, and could only be heard against the muted background of a silenced scientific soul.

Unlike the regime of genial depiction ("truth to nature") the regime of mechanical objectivity bore imperfection as a sign of righteousness on its sleeve. Here are two fossil experts just after the turn of the twentieth century, proclaiming that it was

> obviously necessary to give such figures of the fossils themselves–by mechanical means if possible–showing their imperfections as well as their perfections, that the reader might

> be in a position to judge of the fidelity of the descriptions by the figures themselves, and might also be able, should the need arise, to identify the actual fossil or type specimen represented on the plates.[5]

No improvement here, no removal of blemishes in the interest of a truth behind the appearances; in fact, blemishes signaled the viewer that no one had inappropriately interposed interpretation between visible nature and the printed page. To those who gaze at this picture: no one has stood between you and the original object for this is nature's own autograph.

There is a distal end of objectivity, a time after which it became possible to see mechanical objectivity as but one virtue among others. More specifically, atlas makers begin to be unapologetic about using expert judgment to alter, interpret and select figures. They undertake these very un-automatic steps not in defense of a hidden nature that can be revealed only to them, but rather in a frank admission that the expertly trained eye can often sort phenomena more quickly and effectively than the rote application of a mechanical protocol. This "judgmental objectivity," if you will, begins to displace mechanical objectivity in the 1920s, 30s and 40s. For example, in 1951 the mid-twentieth century Frederic A. and Erna Gibbs launched a new edition of their comprehensive *Atlas of Encephalography*. Unlike the library of mechanically objective atlases of the previous century, the authors explicitly renounced the ideal of objectivity as the ultimate goal of their representation. Patiently they explained all the ways that algorithmic, indexed, and quantitative approaches might be applied to the sorting of the electro-encephalograms. These mid-twentieth-century authors understood perfectly that such automatic procedures were precisely the goal of mechanical objectivity. To make that clear, they even referred to "objective measurements" when describing the various imagined ways one might invoke try to create a diagnostic category, distinguishing, for example, between epileptic and non-epileptic brain traces. But objective measurement is *not* what they advocated. Instead they concluded: "Accuracy should not be sacrificed to objectivity; except for special purposes analysis should be carried on as an intellectual rather than an electromechanical function."[6] Viewed after perusing hundreds of nineteenth-century atlases following the ideal of mechanical objectivity, a statement like that one is stunning: a deliberate renunciation of an automatic record of nature in favor of judgment.

One sees this advocacy of judgment *over* objectivity time and again, in absolute distinction to the myriad atlases of the mid-nineteenth century. This judgmental phase required expertise, but it is a trained expertise, not a genial leap. In an *Atlas of Star Spectra* published in 1943, for example, the authors explicitly tied the sorting of star spectra to the thoroughly integrative human judgment employed in the assessment that a particular face belongs to a specific race. (I should note, perhaps unsurprisingly, that facial-racial metaphors prospered from the late 1930s up to the end of the war.) "The operation of spectral classification is similar. The observer must use good judgment as to the definiteness with which the identification can be made from the features available; but good judgment is necessary in any case, whether the decision is made from the general appearance or from more objective measures."[7] It was impossible, so said the authors, to classify stars based on a routinized and quantified procedure.

Some precision: mechanical objectivity did not die a sudden death in the 1920s, one can find examples of mechanically objective atlases deep into the 1960s or 1970s. What one does not tend to find are examples of judgmental objectivity (explicit repudiations of mechanical objectivity) in the middle or late nineteenth century). Similarly, the older *Typus* (genial depiction) type argument did not vanished overnight with the objectivist approaches launched in the 1820s and 1830s; and again similarly, one does not tend to find mechanically objective atlases in the mid eighteenth century. The important point is two-fold: first, there is a longer-term order to be ascertained here marked by the introduction of new forms of organizing pictures to stand for and classify natural objects. Second, the procedures, morality, image status, and even the persona of the author-artist took on different forms in these regimes of representation: genial depiction, mechanical objectivity, judgmental objectivity.

At the risk of schematizing the already schematic, consider the following necessarily abbreviated chart (bearing in mind that the start dates are of course only schematic and that while each innovation starts at a particular time, the older forms of sight are not extinguished—no Kuhn or Foucault disjunction here):

| | **Beginning 1820 Genial Depiction** | **Beginning 1820 Mechanical Objectivity** | **Beginning 1920 Expert Image** |
|---|---|---|---|
| **Scientific Self** | sage | manufacturer | trained expert |
| **Practice** | intervention | automatic transfer | practiced judgment |
| **Image** | metaphysical image | mechanical image | interpreted image |
| **Ontology** | universals, truth to nature | individual standing for a class | families of objects |

The pictorial regime before 1830, for example, carried with it a scientific persona, the sage or genius, appropriate to unveiling nature's true face behind the veil. Necessarily that parting of appearances required massive intervention–recording merely what one saw would manifestly lead astray. Precisely because the picture produced by an Albinus or Goethe was not what one saw of nature in the raw, the image itself had a status beyond that of a mere reflection–a metaphysical image. And the ontology associated with such a world was clear: there were universal forms, skeletons for example, of which the too-thin, too-fat, or chipped examples to be found in the sublunary morgue or under our own skins were but imperfect realizations.

Set against the pictorial regime of truth to nature, that of nineteenth-century mechanical objectivity stood in striking contrast. The scientific persona became not that of the intervening genius, but rather one at ease with the self-discpline and self-restraint of tending precise machines. Like the manufacturer who guarded against the faulty running of factory looms, the scientist supervised apparatus to insure its proper functioning. When the machine moved properly, the product would be regular, precise, and independent of the skill of the operator. This mechanical transfer of nature to page produced images held to be homomorphic to the original object. Tracing, stamping, photographing, projecting (the particular method is not so important)– the mechanical transfer aimed to produce a record of an individual in nature that would stand for a type or class. Crucial is that the image is the visual signature of the natural object, *that* natural object not an abstracted, improved, or idealized *Urbild*.

Having understood the pictorial regime to be at once about the right kind of practical procedure, ontological commitment, and moral practitioner, the question then arises: How can we understand the nature of the shifts from genial depiction to mechanical objectivity to judgmental objectivity?

**Self and Subjectivity**

There is no doubt that that mechanical objectivity is deeply linked with broader historical shifts in the late eighteenth and early nineteenth centuries, developments that altered the understanding of the self in moral, practical, and political dimensions. Indeed, this moralized technology predicated on a new centrality of the will, lies at the heart of the matter. Objectivity is romantic.

In English, it was Samuel Coleridge who first popularized the term objectivity in its modern sense: knowledge not dependent on our whims and desires. Revealingly enough, when Coleridge first encountered the new use of the concept, in Heinrich Steffens' 1806 work *Grundzüge der philosophischen Naturwissenschaft*, Coleridge scribbled in the margins: "Steffens has needlessly perplexed his reasoning by his strange use of Subjective and Objective – his S = the O of former Philosophers, and his O = their S."[8] "Perplexed," presumably, because Coleridge was familiar with the older, thirteenth century meaning of the term in which Duns Scotus and many followers took *subjectivum* to apply to that thing being thought, and *objectivum*, in contrast to the thing as grasped by the mind. For no reason apparent to Coleridge, Steffens appeared to have inverted the two terms.

Over the next several years, as he learned that Steffans was but part of a much wider German philosophical upheaval, Coleridge joined the philosopher in this new "strange use" of objectivity. Kant, as Coleridge knew well, had launched the project of constituting objects through an active self. But Coleridge's more proximate interest turned towards more contemporary authors, including Kant's chosen successor, J. G. Fichte, who, much more than Kant, transformed the critical apparatus into a system built around the primordial importance of the willing "I." During Fichte's Jena period (1894–99), he acted as the nucleus for the Romantic circle, encouraging their shared fascination with an ego that was, according to Fichte, the starting point for an analysis that spoke of the "subject-object" or "subjectivity-objectivity." For Fichte the world was dependent on the self, and the self dependent on the world. True, the world was "exterior" to us, but (Fichte insisted) it was the subject that produced that very exteriority. Fichte: "How are we supposed to accomplish the transition from what is merely *subjective*–feeling–to something *objective*, something that can hinder the activity of the I when it is acting? *Answer*: through the *productive* imagination, which is simultaneously *free* and constrained by *laws*, thanks to which the concept of its action is at the same time also necessary."[9]

At the turn of the century there was simply nothing in Europe like Jena: Hölderlin came to hear Fichte; August Wilhelm Schlegel taught philosophy there, housing his brother Friedrich; Friedrich Schelling had received the call to Jena; Clemens Brentano was studying medicine; and Novalis came frequently to visit and participate in the circle. But of all these, it was no doubt Schelling who most assiduously pressed the new philosophy into the domain of nature.[10] True, Coleridge reckoned, Fichte had contributed some fundamental ideas. But by Coleridge's lights it was "to Schelling we owe the completion, and the most important victories, of this revolution in philosophy."[11] Through 1814 Coleridge read intensively through Spinoza, Fichte, and Schelling, hoping to bring Christian faith to this new idealist philosophy.[12]

Coleridge's 1817 *Biographia Literaria* shows his adoption of the Germans' terms: "The very words, *objective* and *subjective*, of such constant recurrence in the schools of yore, I have ventured to re-introduce because I could not so briefly, or conveniently by any more familiar terms distinguish the percipere from the percipi."[13] Continuing a bit later, Coleridge asserted: "Now the sum of all that is merely OBJECTIVE, we will henceforth call NATURE, confining the term to its passive and material sense, as comprising all the phaenomena by which its existence is made known to us. On the other hand the sum of all that is SUBJECTIVE, we may comprehend in the name of the SELF or INTELLIGENCE. Both conceptions are in necessary antithesis."[14] Here and throughout the *Biographia Literaria* Coleridge appropriated freely from Schelling, not only translating fragments and even whole paragraphs word for word, but then prefacing these borrowings with a (largely unsuccessful) pre-emptive strike against the charge of plagiarism. "I regard truth as a divine ventriloquist: I care not from whose mouth the sounds are supposed to proceed, if only the words are audible and intelligible." And elsewhere "it will be happiness and honor enough, should I succeed in rendering the system itself intelligible to my countrymen...."[15]

Ventriloquized or not, Coleridge brought Schelling's subjectively-produced objective world to the English reader.[16] Again following Schelling practically to the letter, Coleridge assured his readers that the deeply held and fundamental "prejudice" that "THERE EXIST THINGS WITHOUT US" held good, while at the same time Schelling-Coleridge endorsed an all-important caveat. Transcendental philosophy's critical approach to the world had always treated this "outside" in terms of the subject; the "I" must always be a precondition of experience. "If it be said, that this is Idealism, let it be remembered that it is only so far idealism, as it is at the same time, and on that very account, the truest and most binding realism."[17]

Of course, Schelling and Coleridge were but two of the Romantics who pushed hard on the newly enlivened "I." Looked at with the precision it deserves, the various leaders of the idealist movement come into focus with sharply differing stances on the role of the active, willing "I"; indeed, several clashed head-on. For example, Arthur Schopenhauer despised Fichte's and Schelling's claim to have united the "I" as willing self and as object of inquiry.[18] Instead, Schopenhauer saw the *suppression* of the self as the precondition for aesthetics, salvation, and knowledge itself: "[A]esthetic pleasure in the beautiful consists, to a large extent, in the fact that, when we enter the state of pure contemplation, we are raised for the moment above all willing, above all desires and cares; we are, so to speak, rid of ourselves."[19] Similarly, the will "must be denied if salvation is to be attained from an existence like ours."[20] Finally, only the suppression of will creates the conditions under which things in themselves become knowable: "We *lose* ourselves entirely in this object [of knowledge]; in other words, we forget our individuality, our will, and continue to exist only as pure subject, as clear mirror of the object, so that it is as though the object alone existed without anyone to perceive it, and thus we are no longer able to separate the perceiver from the perception, but the two have become one . . . ." In this state of affairs the object is no longer given in terms of its relation to other things. The will has vanished. What remains is what Schopenhauer called the "immediate objectivity of the will"–and the person perceiving is no longer an individual, but rather *"pure* will-less, painless, timeless *subject of knowledge*."[21]

My interest here is not to locate philological priority or to settle this or that doctrine on objectivity. Instead, it is to see how, in the years around 1800, the German idealists and their followers made central and restructured the concept, vesting it with a moral and epistemic weight that it had not previously had. In the course of bringing subjectivity and objectivity to the center of attention, the idealists created new conditions for the possibility of knowledge. For what they did was not simply to cast the objective from inside the mind to mind-independence. Theirs was a vastly more subtle project: in effect they introduced a massively powerful will directly into the possibility of epistemology. The willing subject might exist in mutual dependency with the object. Or it might be, as Schopenhauer would have it, that this ever-dominant will would need to be repressed for us to be open to knowledge. But however it was configured, the possibility of knowledge was, for the idealists, forever bound up with an *active self*. Not God then, but God's secular side, Nature, must be allowed to imprint itself on the quieted self. It is in this complex of concepts joining morality and epistemology that objectivity figures. A world, independent of us is present, no doubt, but one that could be taken as independent only insofar as an active self made it so.

We have advanced a few steps in the terrain of the objective. The profusion of objectivity talk, its primary location in Germany around 1800, the profound concern with suppressing an overwhelming will–all this becomes understandable within what Coleridge called the German philosophical revolution. Yet something is missing. For it is not among these German philosophers that one finds the fascination with machine transfer. Nowhere in Kant, Schelling, Fichte or Coleridge is there a desire to hand over knowledge to a chain of chemical, mechanical, or optical machines that would effect a smooth transfer of nature into knowledge. It is time to turn to the machines. They are closer than we might think.

**The Allure of the Automatic**

Coleridge began his discussion of objectivity by pointing out that recent developments in philosophy had reversed the meaning of that term. At about the same time, one of the great enthusiast-apologists of the machine age, Andrew Ure, began his *Philosophy of Manufactures* with a similar observation about inversion:

> Manufacture is a word, which, in the vicissitude of language, has come to signify the reverse of its intrinsic meaning, for it now denotes every extensive product of art, which is made by machinery, with little or no aid of the human hand; so that the most perfect manufacture is that which dispenses entirely with manual labour."[22]

Ure himself was so enamored of the new machine world that he saw in it at once a technical triumph, a moral redemption, and a commercial boost to the world. This is a political economist who could watch the displacement of adult male workers by women and children and see nothing but moral progress. A commentator whose principal charm, as far as I can tell, was a certain directness insofar as he never tried to hide the exploding number of women factory laborers or even the manufacturers' enthusiasm for getting children to the factories at such a young age that they could be easily molded to the new way of life. Not surprisingly, Ure is one of the principal targets of Engels in his *Condition of the English Working Class*. For Engels, the moral tenor with which Ure welcomed the machine world was reversed--*Umgekehrt* as Marx liked to say. For Engels, it was not the pre-machine world that was filled with squalor, but rather the world that followed it, engendered by the new factories. Glancing back before the introduction of machines into textile industry, Engels depicted spinners leading a comfortable, peaceful existence; they were righteous, God-fearing, honest, people with a higher standard of living than would come in the factory system, they were in good physical condition, strong, well-built, the moral and intellectual equals of countrymen. Content in happy intimacy with playmates, maintaining no interest in politics, rejoicing in outdoor sports, listening devoutly to readings of the Bible–these were men and women who (and now Eden sours) vegetated happily, knowing nothing of the outside world. "They were not human beings at all, but little more than human machines in the service of a small aristocratic class . . . ." Now, that is to say in the 1840s, machines of steel and steam threatened the spinners' balanced inequity, throwing them out of work in sector after sector. One day it might be different, Engels speculated, but in the current state of affairs, "Every new machine brings with it unemployment, want and suffering."[23]

Despite their radically opposed politics, Ure and Engels concurred that the world had changed in the aftermath of the spinning jenny and its descendants, and in ways that altered at once the ethical, the epistemic and the economic domains. Ure's subtitle, *An Exposition of the Scientific, Moral, and Commercial Economy of The Factory System of Great Britain* captured that tripartite ambition. The scientific economy, the moral economy and the commercial economy were so intertwined that they could be, indeed *needed* to be taken together. Certainly this confluence was assumed by all who joined the discussion of the machine question–such as Peter Gaskell, who saw price, technique and morality at stake in the epochal struggle between "the delicate tact of the human hand" and steam-powered machinery.[24]

Ure, Engels, and many of their contemporary political economists reported on the vast increase in factory workers–according to Ure, by the 1830s some 614,200 people were at the machines of English industry. Machines represented the "scientific improvement in manufactures" and the moral force of this improvement emerged on every page Ure penned. As he saw it, the "automatic science" of machine production carried with it an improvement not only in efficiency and regularity, but also in the moral state of those in contact with the machines. For example, when writing of the slubbing process (in which fibers were twisted into long lengths of thread in preparation for spinning), Ure contended that the machine production tends to "rescue this branch of the business from handicraft caprice, and to place it, like the rest, under the safeguard of automatic mechanism." Or, in an encomium to one of the fathers of machine production, Ure judged this founder to have been sufficiently visionary to see that muscular effort would always be "fitful or capricious" as opposed to a coordinated machine in which its various parts would march with "appropriate delicacy and speed . . . ." But the problem with skilled labor was not just in the fitful, capricious character of muscular exertion, it was in the class characteristics of the workers themselves: they needed to "identify themselves" with the "unvarying regularity of the complex automation." Ure castigated John Wyatt for having been too gentle to have possessed the needed Napoleonic "nerve and ambition" needed to "subdue the refractory tempers of work-people accustomed to irregular paroxysms of diligence . . . ."[25]

Irregularity of muscles, will, and skill all conspired to make the handicraft system inferior to that of the automatic. Even that hero of political economy, Adam Smith, now appeared as archaic, irrelevant to the machine world. Hoping for an increase in efficiency, Smith had advocated a division of skill labor. Not so, said Ure. "On the contrary, wherever a process requires peculiar dexterity and steadiness of hand, it is withdrawn as soon as possible from the *cunning* workman, who is prone to irregularities of many kinds, and it is placed in charge of a peculiar mechanism, so self-regulating, that a child may superintend it." That was the goal and it was not metaphorical. Malleable children would supervise the apparatus. For example, artisans spinning cotton had required great delicacy to lay the fibers parallel to one another and draw them into spongy cords known as rovings. Only one such worker in a hundred could pull the fibers by hand with this precision. Now, Ure reported, rovings of any kind could be used because machinery, with a doubled action of twisting and extending, could sort the fibers on its own. "On the handicraft plan, labour more or less skilled, was usually the most expensive element of production–*Materiam superabat opus*; but on the automatic plan, skilled labour gets progressively superseded, and will, eventually, be replaced by mere overlookers of machines." Those overlookers, "children with watchful eyes and nimble fingers" would displace the journeyman of long experience, thanks to "our enlightened manufacturers" who had exploded the scholastic (Adam Smithian) dogma of labor as divided skill.[26]

How and when does objectivity meet the machine question? For the manufacturers and political economists of the early 19th century, disciplined machine-governed regularity was *the* salient feature of modern life: the skills of the artisan were being rendered obsolete, displaced by passive onlookers superintending the automatic system of machines. For those who celebrated the machine system, the great array of gear trains and looms promised regularity, predictability, conformity and rationality--as well as cheap goods and increased profits. But there was the flip side of that enthusiasm, an increasingly suspicious affect towards the particularity of the individual skilled worker whose muscles, judgment and temperament worked against the grain of this ever-increasing standardization.

For the scientists who celebrated mechanical objectivity, something quite similar was at work; not surprisingly, perhaps, given that the machines they used (printing technologies, photographic technologies, tracing, projecting, and casting technologies) were already of a piece with production machines. For example, when William Anderson reported in the 1880s on the state of scientific illustration, he readily conceded that the modern period held no artists to rival Leonardo da Vinci, Calcar, Fialetti, or Berrettini.. But the draughtsman of the nineteenth century made up in science what he lacked in "artistic genius." "We can boast no engravings as effective as those of the broadsheets of Vesal . . . but we are able to employ new processes that reproduce the drawings of the original object *without error of interpretation. . . .*"[27] No discretion should be left to the illustrator, another anatomist proclaimed. Instead photographs would eliminate "the possibility for subjective alteration."[28] As late as 1960, one atlas of the basal ganglia, brain stem, and spinal cord similarly cast aside hand drawn illustrations as "selective" and "uncertain." By contrast, "The photograph is the actual section. There is no artist's interpretation in the reproduction of the structures.[29]

Machine automaticity stood as bulwark against the quirks, muscles, skills, even the artistry of the individual. Eli Whitney made that perfectly clear when he summed up his reasons for preferring the new mode of harvesting and threshing–the point of the new production method was "to substitute correct and effective operations of machinery for that skill of the artist which is acquired only by long practice and experience. . . ."[30] Political economy normatively described a particular form of interaction between humans and machines. As Maxine Berg has shown so well, through hundreds of publications the economists educated workers from the time of childhood, in "habits of self control and moral discipline" in preparation for the operation of machines, while urging the manufacturing capitalist to find the "abstinence" needed to accumulate and safeguard fixed capital.[31]

The rules of machinery and motive power stood, in the mid-nineteenth century, as science itself. At the popular level, the "scientific movement" joined technology to economic improvement, with middle-class advocates of both using the Mechanics Institute Movement to propagandize during the 1820s and 1830s for a harmonious vision of capital and labor. Science, technology and labor were to meet at the Institute, with courses on chemistry and mechanical drawing, with the aim of cultivating a higher class of scientifically-trained mechanics. At the elite observatories, factory methods entered in other ways, including, as Simon Schaffer has shown, a systematic disciplining of astronomical observers to follow the regulated, standardized behaviors of the factory worker. Political economy entered the laboratory even more directly. In a study of Charles Babbage's "calculating engine" Schaffer has shown how powerfully Babbage's vision of the factory and factory morality shaped the design of the mechanical computer and how moralized was the interpretation of its capacity for memory and foresight. Crosbie Smith and Norton Wise have argued that natural philosophers like Lord Kelvin put the steam engine and telegraph cable into direct contact with the concepts of work and waste arising from political economy and the machine world–as well as building the laboratory to more closely resemble the factories producing steam power and cables. And I have shown elsewhere how, when James Clerk Maxwell outlined his account of the very nature of nineteenth-century scientific instruments, he drew directly from the machine literature: instruments, along with factory machines, divided into sources of power, means for conveying that power, and mechanisms of power application. Here Maxwell, Babbage, Thomson, and Marx were reading from the same page. The scientific laboratory and the industrial factory were linked in the nineteenth century, root and branch.[32]

Many features of the laboratory and factory coincide; they are deeply linked, and often co-produced. One can point, for example, to worker discipline, centralized power sources, and architecture–as well as shared political economic ideals of maximizing work and minimizing waste. But for our purposes here, the key commonality is the joint fascination with the reduction of individual variability through the use of machines: the production of regularity as a positive virtue that was simultaneously moral and epistemic. It was here that the quieting of the will met the discipline and self-restraint of the factory.

That morality, industrial production, and scientific authority came together became evident by the beginning of the twentieth century. When Rudolf Eucken surveyed the "Intellectual Currents of the Present," he began with the by-then standard rubrics of objectivity and subjectivity, starting, not surprisingly, with Duns Scotus and moving forwards through Spinoza, Kant and other philosophers. But that history did not end with a philosophical solution for Eucken, it ended, rather despairingly, with a discussion of objectivity as it emerged from the technics of factory life. In the fanatical attachment of modern culture to the objects and the forces that bind them, Eucken saw an evacuation of the rest of life until nothing remained outside interlinked things but a shadow realm. In his words, "So moves life's center of gravity into the objective, finding its nucleus in a work conditioned by things . . . bringing an emancipation from mere individuals and reducing man more and more into a mere servant and tool. First in the technical work with their factories, then more and more in the other domains of life."[33] In objectivity-talk the revolution of romantic idealism had met the revolution of the factory. Modernist Bauhaus architecture joined the squelching of variability, scientific ideals, and industrial production into an "objective aesthetic."[34]

So things stood throughout the long nineteenth-century reign of the machine as epistemic and moral exemplar of objectivity: art, artistry and artisans would yield to the minding and overlooking functions of the new, disciplined and self-disciplined worker. Scientific laboratory workers had long taken on the mantle of self-disciplined supervisors of machine. When scientists announced with pride in objectivity that they would do nothing to impose individual variation on the regular, uniform, and reliable output of their machines, they were testifying not only to the power of science in industry, but to the conjoint understanding of laboratory and factory.[35]

### Right Depiction: Judgment, Will, and Machine

Looking back on nineteenth-century mechanical objectivity we see far more than a mere extension of mechanical technique. Mechanical objectivity was not, for example, the straightforward perfection of microscope or telescope lenses, the wielding of ever-more sophisticated camerae lucidae or camerae obscurae, or even the fabrication of better photographic apparatus. If objectivity were purely driven by technique, it would be easier to understand. But mechanical objectivity is not so simply graphed onto procedure alone; we have seen how this new visual regime was at once about morality, procedure, ontology, and image. In that cluster lies the arresting strangeness of the project: in field after field, botanists, astronomers, anatomists and zoologists gave up their long association with gifted artists to pursue images that could hardly compete for color, depth or precision with that previous tradition. The mystery, it seems to me, is not so much why anyone would hold onto the older ideal of a genius-driven truth to nature, but rather how anyone could have preferred the often blurred, eviscerated "objective" images of the new over the etched and painted masterpieces of the eighteenth century. It is in the hope of making sense of that sacrifice and ambition that I have taken us across territories more usually associated with philosophy and political economy.

At the center of mechanical objectivity, then, lay both a fear and a hope. Fear issued from a changed concept of the individual, one in which the willing, intending, and intruding self could not be dismissed. Viewed from the vantage point of the Romantics, the rational soul was not an optional facility that could be activated on command to order perceptions of a passive pre-existing world. Instead, just because the finite, active self was required for the world to be anything for us at all, there was a grave danger, a fear that in willing, desiring, intending and schematizing, the image of nature would tell us no more than what we wanted to hear. For a Fichte, a Schopenhauer, a Schelling or a Coleridge, the ineradicable quality of the self was not a source of despair about natural knowledge. No, understanding nature through this active self was the problem of knowledge as it was given. Full stop. Idealism did not oppose objectivity; on the contrary, it was in the cauldron of early nineteenth-century Jena's idealist philosophy that there emerged, in its first and powerful form, the "modern" concept of an objectivity that *always* implicated the self. For these philosophers and their literary allies, it would have been absurd to postulate a fundamental opposition between realism and idealism. Recall Coleridge ventriloquizing Schelling: "let it be remembered that it is only so far idealism, as it is at the same time, and on that very account, the truest and most binding realism."

An active will posed a danger–the distorting, willful manipulation of the scientific image. I have suggested that, in the political economy of the early nineteenth-century machine, we once again encounter a crossing point of morality, procedure, and epistemology. When the scientific atlas makers, beginning in the 1830s, began to present themselves as self-abnegating machine minders, they were not alone. The laboratory and factory systems of the nineteenth century each, increasingly used the other as an exemplar of both technical and moral economy. And within the factory, a new persona was under construction, not only for the disciplined worker, but for the self-abnegating supervisor. Self-disciplined to remain aloof, yet ever vigilant of the machine, the mechanical objectivists resembled on one hand the abstaining manufacturer who would "police" the artist, and on the other hand the disciplined factory worker who above all was taught not to impose an interfering art or artistry on the smooth functioning of the apparatus.

What *kind* of explanation is this? It is not a causal explanation of mechanical objectivity–one cannot read, univocally, from context to content. Instead, it may be better to formulate the issue this way: What made mechanical objectivity possible or desirable in the early nineteenth century? Following Foucault it is tempting to identify the political economy of machines and the philosophies joining will and objectivity as *historical conditions of possibility*. For Foucault, the units of analysis are concepts, the historical conditions of possibility describe how one set of concepts depends on another, where that dependency is historically specific.[36] Before people can be sorted into certain kinds of groups, Foucault argues, one must have in place some notions of psychogenetic explanation.

But the "possibilities" in these various regimes of image making are not purely conceptual. That is the central point. Genial intervention or manufacturing self-abnegation are not purely intellectual choices. Nor do they simply follow *after* the concepts–we do not have a strategy of inquiry (an epistemology) followed by a morally-based reception (ethics). Instead, I take this to be the central point of this history: epistemology and ethics come in together. Said another way: There is no neutral strategy of machine usage followed by an ethical evaluation of it. The machine is moralized from the get-go. Similarly, there is no accepted practice of neutral procedure of automatic image registration that *later* acquires a valuation. Just because the persona of the scientist, the status of the image, the ontology of nature come in together, I am against positing "value" as an "extra" element imposed on a pre-existing procedure. The "factory system," as conceived in the nineteenth century, was always already moralized; the laboratory system of image production in science was as well. For all these reasons, it might be more precise to speak about *scientific comportment* (embracing the moral, technical, and epistemic), rather than free-floating *scientific concepts* (capturing the ordered rules of combination imposed on statements). By extension, we would then introduce *conditions of possible comportment* rather than *conditions of (conceptual) possibility*.

I will conclude with two final thoughts about where one might go from here with the conditions of comportment that lay behind the new sense of mechanically objective scientific images. First, it is clear that many early nineteenth century philosophers, engineers, scientists, and political economists saw the turn of the eighteenth century events in France, Britain, and England as fundamentally connected. For example, Fichte, a supporter of the French revolution, saw his own work as continuing in German transcendental philosophy what had begun in French politics. Henrich Steffans not only found his contemporary circle of Romantic poets and philosophers as properly belonging together, he judged that "[w]hat the French Revolution intended to achieve as an external natural event, and Fichte's philosophy as an inner absolute deed, this alliance [of romantics] wished to develop as pure, wildly playing fantasy."[37] Coleridge and Schelling both referred to the philosophical revolution then in progress, while Marx, who began his studies by plunging into the work of Kant, Fichte, and Hegel, often pointed to the "original" political revolution in France that found its "copy" in German philosophy. "[T]he Germans have *thought*, Marx lamented, what other nations have *done*."[38] Engels made the analogy between revolutions more explicit, arguing that the machine revolution of Britain was, in an important sense, of a piece with the political and philosophical revolutions on the Continent. "The Industrial Revolution," he wrote, "has been as important for England as the political revolution for France and the philosophical revolution for Germany.[39]

Fully elucidating the cross-links among Engels's three revolutions would, I suspect, go a long way towards articulating the reconfigured self that emerged in this period, a newly active self that was inevitably an agent in all aspects of the constitution of the world, from the conditioning of possible knowledge to a new form of self in the establishment of the political, moral, and productive order of things. That reconfiguration, properly understood, would take us further towards an historical grasp of the changing scientific persona of the early nineteenth century. We would, consequently, gain a firmer grasp on what had to be in place for a form of scientific comportment to enter that could count mechanical objectivity as its great new virtue.

Second: if the direction of explanation here is to be of use, something analogous will be required to understand what happened to the practices of right depiction in the first part of the twentieth century. For during those critical decades (beginning in the 1920s and 1930s), the consensus that had formed around mechanical objectivity began to fragment. Where might one look for the analogue conditions of comportment that shifted the persona of the manufacturer towards a trained expert, and shifted the mechanical image towards the production of scientific catalogues of images that unabashedly employed judgment? Perhaps we should track, again, scientific comportment as it shifted along with major alterations in the scientific, moral and political economy. For once again, in the early twentieth century, there was a self-conscious reappraisal of the relation of people and machines–this time in the greatly expanded scope of professional expertise as the category of scientist took on new functions.[40]

Perhaps too we should explore the reconceptualization of the machine itself as distributed electrical power, self-regulating (cybernetic) electronics and, later, digital computers began to displace centralized mechanical and thermodynamic devices as model machines. But however we proceed, such an inquiry into the partial displacement of mechanical objectivity by judgment would be begin by asking: What is the persona of the twentieth century scientist once it shifts towards a more self-confident expert and away from the self-abnegating manufacturer? What characteristic new relations do the scientists have to the machines, and what status do images have that unapologetically leave a mechanical objectivity in favor of trained, expert judgment?

I would like to end with a few observations on how one might use the framework developed here to reflect on right depiction after the first decade of the 21st century. Much of this will be speculative, and comes with a warning. Years ago, the physicist George Gamow wrote a widely-used book on atomic structure; when he came to difficult sections he placed in the margins a skull and crossbones to signal readers that they were on shaky ground. While what has come till now summarizes work of which I am largely confident, that which follows is more conjectural: a history of the present.

We are, just now, in a period of a disciplinary re-alignment unmatched since the early years after World War II. That conflagration War dramatically altered the status of the sciences. A new relation between science and the State had come into its own, a system of massive governmental infusion of funding; of a contract-based system of research support; of massive government-owned, company operated laboratories that, in the United States included Los Alamos, Hanford Site, Oak Ridge—and soon sprawled out to embrace civilian particle physics laboratories like the Stanford Linear Accelerator Center and the Fermi National Laboratory. In Europe national and international laboratories also took hold: CERN, most prominently, but then the German synchrotron, DESY and others through the Soviet Union. But as this system of laboratories grew into place, the disciplines themselves bolstered their borders: a catalogue of courses in 1965 reflected, more or less the disciplinary boundaries of 1995. In a certain sense, the Cold War made the sciences of the second half of the twentieth century, and offered the resources for an extraordinary expansion of the sciences. At the same time the Cold War froze our fields into place.

Now, in the decades from 1990 forward, that landscape is shifting. With the Cold War over, government subsidies to the great laboratories has eroded dramatically. The United States Congress canceled the Superconducting Supercollider; Fermilab, SLAC, and CERN live in with straitened means. At the same time, the massive expansion of the life sciences has left support for the physical sciences far behind. New tools—atomic force microscopes and its associated family of visualization and manipulation tools helped make nanoscience into a field with central laboratory facilities across universities, companies, and government facilities. In those spaces, atomic physicists, surface chemists, and electrical engineers and virologists regularly make common cause. Crucial objects, like the carbon nanotube, function within a shared domain, no traditional field could possibly say it "owns" these entities. Meanwhile, computational techniques have altered what it means to be geneticist or molecular biologist—computational biology is a new hybrid arena, just as massive Monte Carlo simulations are now part and parcel of astrophysics, from the interior of stars to the formation of galaxies, from black-hole dynamics to gamma-ray bursters. In the exact sciences, a generation of young theorists moves fluidly across the border that traditionally set algebraic geometry on one side, and fundamental (string) physics on the other.

All this has meant a major shift in imaging practices. Instead of the oversized scientific atlases written in three languages, printed to archival paper, and distributed to libraries around the world, new forms of standardized images have developed. For example, the National Library of Medicine and National Institutes of Health have produced a suite of Visible Human Projects—massive digitized images that can be used as a kind of meta-atlas from which other atlases can be generated.[41] There are online atlases that that use motion and false color, atlases that let the user steer through the object (corpse, molecule, mathematical structure) or for that mater cut the data set in new and previously unimagined ways as one can do in the Visible Human Project's Magnetic Resonance Images (MRI) and Computer Tomography (CT) scans.

Other images, successor objects to the scientific atlas, are in motion—online atlases that, using simulations, show the formation of astrophysical objects or calculate the properties of mathematical spaces known as Calabi-Yau manifolds. Many of these new sets of reference images are contained in "Image Galleries"—posted online by university, government, and industry laboratories. No longer the black and white blurry diagrams of a scientific paper from the 1960s, these are highly processed images that have to make their way in many different crowds.

Take an image by Harvard University physicist and chemist Eric J. Heller—his simulations of two-dimensional electron flow between two solids, played a role in a published journal article; in highly colored form it adorned the cover of *Nature* in March 2001; and blown up has appeared in art museums and can be purchased from an online gallery. More generally, one sees nano groups with twinned websites: one academic, one entrepreneurial. Images ply all these waters.

Like their images, the scientists who make them have taken on new and more complicated identities. Presenting one day to a professional colloquium and the next to a group of venture capitalists, many scientists in the nano- or bioengineering, or genetics fields don't see themselves quite the same way their teachers or teachers' teachers did. If one wanted to construct an update to the chart given earlier, one would have to recognize the hybrid nature both of the scientist and the image. No longer is the ideal simply one of *re*-production; instead it is one of production, of making things, whether they are new forms of nanoscale matter or productive new structures that engage mathematicians as much as they do physicists. Though all this is in formation rather than fixed, though it would play out differently for the string theorist or the bio-informatician, here might be a way of sketching the scientific self, image, practice, and ontology of nanoscience:

| | |
|---|---|
| Scientific Self | Combines ethos of the scientist, the entrepreneurial device engineer, the artist-designer |
| Image | Combines ideals of simulation, intervention, mimesis, analysis |
| Practice | Presentation not representation |
| Ontology | "nanofactured goods" rather than hunt for the already-existing "natural" |

Here we are far from the idealizing sage of the eighteenth century—or the self-abnegating 19th century scientist in pursuit of mechanical objectivity. Nor are we amidst the world of the more confident, highly trained expert, able to strip out an artifact from an image on the basis of long experience. No, the space of the entrepreneur-researcher-designer opens a new kind of scientific comportment, a new way of being a scientist. True, some bits and pieces we have seen before: no fearful opposition of science and art—superficially similar to the pre-19th century artist-scientist. But that is too quick. Though both the 18th and the 21st century may have a common opponent in mechanical objectivity, the 21st century scientist comes to value the artistic and the designed for utterly different reasons. This is not a faith that art will out the essence of a process or object; in the early 21st century the increased attention to design is a concern with the world we make, the world where the design of a new molecule, circuit, mathematical structure or drug stands, more than the uncovering of a new elementary particle, at the center of science.

How we depict the basic, working objects of science tells us, of course, much about the scientific world. But our standards of right depiction also tell us a great deal about who we are.

**A Word of Gratitude**

I would like to thank The Rector Magnificus of Utrecht University, Professor Hans Stoof, and the Dean of the Faculty of the Humanities, Wiljan van den Akker, for having honored me with the invitation to serve as the Treaty of Utrecht Professor. My thanks goes also to the Utrecht Province and the Treaty of Utrecht Organization for endowing this chair. I am very grateful to the Centre for the Humanities and its director, Professor Rosi Braidotti for her support and the many productive and engaging conversations with her and her colleagues that this professorship has made possible; and to the Centre's hard-working staff: Bolette Blaagaard, Esther Rinkens, Cornelie Vermaas and Atie van Wijk who did so much to organize this and the preceding visit. I would like to thank too the staff of the Descartes Centre for supporting my visit and the terrific students I have had the pleasure of meeting.

## Notes

1 For a more developed treatment of many of the themes presented here, see Lorraine Daston and Peter Galison, *Objectivity* (Cambridge, MA: Zone Books, 2007); Daston and Galison, "The Image of Objectivity," *Representations* 40 (1992): 81-128; Galison, "Judgment Against Objectivity," in Caroline Jones and Peter Galison, eds., *Picturing Science, Producing Art* (New York: Routledge, 1998), 327-59. This essay draws extensively on Galison, "Objectivity is Romantic," *The Humanities and the Sciences*," ACLS Occasional Paper No. 47 (New York: American Council of Learned Societies, 2000): 15-43.

2 Johann Wolfgang Goethe, "Erster Entwurf einer allgemeinen Einleitung in die vergleichende Anatomie, ausgehend von der Osteologie" (1798, 1893), in Dorothea Kuhn and Rike Wankmüller, eds., *Goethes Werke*, 14 vols. (7th ed., Munich, 1975), 13:172; trans. (slightly modified) from Douglas Miller, ed. And trans., *Goethe: Scientific Studies* (New York, 1988), p. 118.

3 Bernhard Siegfried Albinus, *Tables of the Skeleton and Muscles of the Human Body* (London, 1749), sig. cr.

4 M. Allen Starr, *Atlas of Nerve Cells* (New York, 1896), v-vi.

5 Gertrude Lillian Elles and Ethel M.R. Wood, *A Monograph of British Graptolites* (London, 1901), p. 2.

6 Frederick A. Gibbs and Erna L. Gibbs, *Atlas of Encephalography* vol. 1, *Methodology and Controls* (Reading, Mass.: Addison-Wesley Publishing Company, Inc., 1951, 1958), pp. 112-13.

7 W. W. Morgan, Philip C. Keenan, and Edith Kellman, *An Atlas of Stellar Spectra* (Chicago: University of Chicago Press, 1943), p. 5.

8 Samuel Coleridge, *Biographia Literaria or Biographical Sketches of My Literary Life and Opinions* edited by James Engell and W. Jackson Bate (Princeton: Princeton University Press, 1983), note 3, vol. 1, pp. 172-3.

9 Johann Gottlieb Fichte, *Foundations of Transcendental Philosophy* (Wissenschaftslehre) nova methodo (1796/99), edited and translated by Daniel Breazeale, (Ithaca: Cornell University Press, 1992), p. 189 (H version). On Fichte, see e.g. Günter Zöller, *Fichte's Transcendental Philosophy: The Original Duplicity of Intelligence and Will* (Cambridge: Cambridge University Press, 1998), esp. cf. pages 83 and 110 for a discussion of the duplicity of the "I" and how it eliminates Kant's transcendental realism in favor of the "subject-object" and "subject-objectivity" and "self-world." This unity is one of essential cooperation, that is: no experience without freedom, no thinking without willing, and in particular no subject with out object. See also David E. Klemm and Günter Zöller eds., *Figuring the Self: Subject, Absolute, and Others in Classical German Philosophy* (Albany: State University of New York Press, 1997) for Zöller's essay, "An Eye for an I" as well as several other very helpful contributions.

10 On the circle, see e.g. Rüdiger Safranski, *Schopenhauer and the Wild Years of Philosophy* , Ewald Osers, trans. (Cambridge, MA: Harvard University Press,

1989), pp. 128-29.

11 Coleridge, *Biographia Literaria*, vol. 1, p. 163.

12 Richard Holmes, *Coleridge, Darker Reflections, 1804-1834* (New York: Pantheon Books, 1999), pp. 371 and 400.

13 Coleridge, *Biographia Literaria*, vol. 1, p. 172.

14 Coleridge, *Biographia Literaria*, vol 1, pp. 254-55; the relevant section of Schelling is: "Wir koennen den Inbegriff alles blos *Objectiven* in unserm Wissen *Natur* nennen.," see note on *Biographia Literaria*, vol. 1, p. 253.

15 Coleridge, *Biographia Literaria*, vol. 1, pp. 164 and 163 respectively.

16 Coleridge, *Biographia Literaria,* vol. 1, p. 253.

17 Coleridge, *Biographia Literaria*, vol. 1, pp. 259-61; note that Engell and Bate along with earlier commentators point out that this is paraphrased directly from Schelling's *Abhandlungen: Phil Schrift*, 273-74.

18 Christopher Janaway, *Self and World in Schopenahuer's Philosophy* (Oxford: Oxford University Press, 1989), pp. 119-21.

19 Arthur Schopenhauer, *World as Will and Representation Vol. I*, E. F. J. Payne, trans. (New York: Dover, 1969), p. 390; ibid. pp. 378-412.

20 Schopenhauer, *World as Will Vol I*, p. 405. Also *World as Will Vol. II,* p. 605.

21 Schopenhauer, *World as Will, Vol. I*, pp. 178-79; see Hans-Johann Glock, "Schopenhauer and Wittgenstein: Representation as Language and Will," in Christopher Janaway, editor, *The Cambridge Companion to Schopenhauer* (Cambridge: Cambridge University Press, 1999), p. 439; Janaway, "Schopenhauer's Pessimism," in ibid; and Janaway, *Self and World*, chapter 11 ("Freedom from Will"), esp. pp. 276ff. .

22 Andrew Ure, *Philosophy of Manufactures or An Exposition of the Scientific, Moral, and Commercial Economy of The Factory System of Great Britain* (New York: Reprints of Economic Classics, Augustus M. Kelley, Bookseller, 1967), p. 1.

23 Friedrich Engels, *The Condition of the Working Class in England,* translated and edited by W. O. Henderson and W. H. Chaloner, (Oxford: Basil Blackwell, 1958, 1971, first German edition 1845), pp. 10-12, on 12; second citation, pp. 150-59, on p. 156.

24 P. Gaskell, *The Manufacturing Population of England, Its Moral, Social, and Physical Conditions, and the Changes Which Have Arisen From the Use of Steam Machinery; With an Examination of Enfant Labour* (London: Baldwin and Cradock, 1833), p. 12. Cf. Charles Babbage, *On the Economy of Machinery and Manufacturers* 4th edition. (London: John Murray, 1846), 1st, 2nd, 3rd editions 1832. On the machine question faced by Ure, Gaskell, Babbage and many others, see, Maxine Berg, *The Machinery Question and the Making of Political Economy 1815-1848* (Cambridge: Cambridge University Press, 1980).

25 Ure, *Philosophy of Manufacture*, quotations from pp. 9, 15, 16.

26 Quotations are from Ure, *Philosophy of Manufactures*, pp. 19-20, 23 Engels blasts Ure by name in *Condition*, p. 157, responding that Ure's machine enthusiasm ignores the circumstance that the handloom weavers were led to their present

state of misery by the machine–so forecasting increased employment by machine expansion is more than misleading.

27 William Anderson, "An Outline of the History of Art in Its Relation to Medical Science," introductory address delivered at the Medical and Physical Society of St. Thomas's Hospital, 1885, *Saint Thomas's Hospital Reports* 15 (1886): 151-81, on p. 175.

28 Johannes Sabotta, *Atlas und Grundriss der Histologie und mikroskopischen Anatomie des Menschen* (Munich, 1902), pp. vi-vii.

29 Henry Alsop Riley, *An Atlas of the Basal Ganglia, Brain Stem and Spinal Cord* (New York: Hafner Publishing Company, 1960), p. viii.

30 John Ellis, *The Social History of the Machine Gun* (Baltimore: The Johns Hopkins University Press, 1986), p. 22.

31 Berg, *Machinery Question* chapter 6, on p. 144.

32 Berg, *Machinery Question*, chapter 6, esp. pp.158ff. On the disciplining of factory workers, see Simon Schaffer, "Astronomers Mark Time: Discipline and the Personal Equation," *Science in Context* 2 (1988): 115-45; idem., "A Manufactory of Ohms: The Integrity of Victorian Values," in Robert Bud and Susan Cozzens, IEEE Proceedings; Schaffer, "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry* 21 (1994): 203-227; Crosbie Smith and Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1989); on Maxwell and the classification of instruments, Galison, *How Experiments End* (Chicago: University of Chicago Press, 1987), pp. 23ff. For an excellent discussion of laboratory-factory relations in Liverpool, see Nani Clow, "the Laboratory of Victorian Culture: Experimental Physics, Industry, and Pedagogy in the Liverpool Laboratory of Oliver Lodge, 1881-1900, unpublished Ph.D. Harvard 1999. Robert Kargon, in his study *Science in Victorian Manchester* (Baltimore: Johns Hopkins Press, 1977), p. 221 summed up Arthur Schuster's plans for a new laboratory this way: "The factory system, pioneered in Manchester not far from the Oxford Road site, demonstrated to the world the efficiency and utility of the central power source. Schuster helped bring this lesson into the world of science."

33 Rudolf Eucken, *Geistige Strömungen der Gegenwart. Der Grundbegriffe der Gegenwart.* 4th edition. (Leipzig: Verlag von Veit &Co., 1909), p. 18.

34 Peter Galison, "Aufbau/Bauhaus: Logical Positivism and Architectural Modernism," *Critical Inquiry* 16 (1990): 709-52.

35 On this theme see Peter Galison and Emily Thompson, *The Architecture of Science* (Cambridge: MIT Press, 1999), esp. Peter Galison and Caroline Jones, "Factory, Laboratory, Studio: Dispersing Sites of Production."

36 On Foucault, see Arnold I. Davidson, *The Emergence of Sexuality: Historical Epistemology and the Formation of Concepts* (Cambridge: Harvard University Press, 2001).

37 Safranski, *Schopenhauer*, p. 128.

38 Karl Marx, *Early Writings*, transl. And ed. By T. B. Bottomore (New York:

McGraw Hill, 1964), pp. 44, 51.

39 Engels, *Condition*, p. 23. While this is not the right occasion for it, it would be extremely valuable to understand in detail the relation between the emerging class of French engineers and their ambition to provide interchangeable parts for weapons on one side, and the machine understanding of mid-nineteenth century British manufacturers. For more on the French engineers see the excellent book by Ken Alder, *Engineering the Revolution. Arms and the Englightenment in France, 1763-1815* (Princeton: Princeton University Press, 1997).

40 For more on the role of trained judgment in scientific depiction, see Galison and Daston, *Objectivity* (Cambridge, MA: Zone Books, 2007), esp. ch. 6.

41 http://www.nlm.nih.gov/research/visible/visible_human.html, accessed 3 October 2010.

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**Books**

Galison, Peter. *Building Crashing Thinking* (in preparation)

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