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52. A. A. Michelson, "On the Application of Interference Methods to Astronomical Measurements," *Philosophical Magazine* 30 (1890): 1–21.
53. See David DeVorkin, "Michelson and the Problem of Stellar Diameters," *Journal for the History of Astronomy* 6 (1975): 1–18; A. A. Michelson, "Measurement of Jupiter's Satellites by Interference," *Nature* 45 (1891): 160–65.
54. G. E. Hale, "The Aim of the Yerkes Observatory," *Astrophysical Journal* 6 (1897): 310–21, 311; G. E. Hale, "The Solar Observatory of the Carnegie Institution of Washington," *Astrophysical Journal* 21 (1905): 151–72, discussed in Lankford with Slavings, *American Astronomy*, 70.
55. Livingston, *The Master of Light*, 188–90.
56. Donald E. Osterbrock, "Founded in 1895 by George E. Hale and James E. Keeler: The *Astrophysical Journal* Centennial," *Astrophysical Journal* 438 (1995): 1–7.
57. Gould, Seth Chandler, John Ritchie, and Eastman offered this kind of attack; Pickering and the Harvard Observatory were particular targets; and Langley, Keeler, and Hale were prominent advocates of astrophysics. See Lankford with Slavings, *American Astronomy*, chapter 3.
58. J. R. Eastman, "The Neglected Field of Fundamental Astronomy," *Proceedings of the American Association for the Advancement of Science* 43 (1892): 17–32. For the middle ground see Susalla, "The Old School in a Progressive Science."
59. A. A. Michelson, "On the Conditions Which Affect the Spectro-Photography of the Sun," *Astrophysical Journal* 1 (1895): 1–9.
60. Paul Hartman, *A Memoir on the Physical Review: A History of the First Hundred Years* (New York: American Institute of Physics, 1994).

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Even the Tools will be Free: Humboldt's Romantic Technologies

JOHN TRESCH

Humboldt's Aesthetic Anxiety

Alexander von Humboldt's *Cosmos: A Sketch of a Physical Description of the Universe* was an overview of all past and present knowledge of the earth and heavens. In taking on such a staggeringly vast topic, Humboldt confessed in his first paragraph to an anxiety with a "two-fold cause": "The subject before me is so inexhaustible and so varied, that I fear either to fall into the superficiality of the encyclopedist, or to weary the mind of my reader by aphorisms consisting of mere generalities clothed in dry and dogmatical forms." The solution he found was an aesthetic one: "Nature is a free domain," he wrote at the end of the introductory paragraph, "and the profound conceptions and enjoyments she awakens within us can only be delineated by thought clothed in exalted forms of speech, worthy of bearing witness to the majesty and greatness of the creation."

Many have emphasized that Humboldt's "exalted forms of speech" in *Cosmos*, like the beautiful colored prints that accompanied his books, appeal to the senses and attempt to convey, indeed to produce, the "different degrees of enjoyment presented to us by the aspect of nature and the study of her laws" that *Cosmos* announces as one of its topics. Yet as we know from many recent studies, the concept of "the aesthetic" has philosophical and political implications that go well beyond sense pleasure and formal harmony.[1] The tension that Humboldt expresses between two opposed tendencies—one leaning toward the limitless play of particular empirical phenomena, the other to dogmatic, formal generalities—lines up precisely with the oppositions that troubled Friedrich Schiller in *Letters on the Aes-*

40. Telescopes observe the eclipse of 1842. J. J. Grandville, *Un autre monde: transformations, visions, incarnations, ascentions, locomotions, explorations, pérégrinations, excursions* (Paris: H. Fournier, 1844), 94. Reproduction by permission of Herzog August Bibliothek Wolfenbüttel: Ars Libr. 4: Grandville 16. 4° 185.

thetic Education of Man (1794). Schiller, the poet, philosopher, and playwright who was closely associated with Goethe and the Humboldt brothers, balanced these oppositions in an intermediary "aesthetic state." Between the barbaric formal emptiness of excessive refinement and the slavish attachment to savagery lies a middle ground where the two fundamental urges of humanity—the formal drive and the sense drive—are reconciled. This third drive, the "play drive," roves freely between form and sense, and expresses itself in the beautiful appearances of fine art. Schiller's view of the aesthetic was inspired by Kant's third critique, in which aesthetic judgment is examined as a subjective universal intimately connected with the goal of culture and *Bildung*.

Alexander von Humboldt had a sustained exposure to this set of concerns. Schooled in French mathematical physics and German romanticism, Humboldt brought about a revolution in the organization and direction of the sciences throughout Europe and the Americas in the first decades of the nineteenth century. Like his brother Wilhelm, who in his study of languages strove for "a conception of the world in its individuality and totality," Alexander described the different spaces of the globe in their singularity and their interactions, studying the reciprocal combinations of forces on a cosmic scale.[2] He used a vast range of instruments to measure geophysical phenomena; in addition to findings taken on his own voyages, he helped to establish international networks of observers to collect similar data from around the world. New techniques of combining data into striking visual images allowed him to chart the changes in average temperature across the globe and changes in vegetation in different milieus. With the beautiful images accompanying his texts and the evocative language that filled them, he sought to format and diffuse the sciences to reach the widest audience possible. His hope was that exposing readers to the pleasures of nature and the methods of the sciences would contribute to moral and political reform.[3] While his nomadic geophysical wanderings set a heroic example, he always remained tethered to the observatory. The very idea of an assembly of techniques that can be identified as "observatory science" owes much to the heterogeneous regime of concerns and approaches that Humboldt tied together in this period.

This chapter explores the relation between the "aesthetic" dimension of Humboldt's work and his instrumental practices, in which observatories played such a central role. In particular, I will concentrate on the ways in which Humboldt adopted the language and assumptions of Kant's and Schiller's moral and political philosophy in his new mode of conducting

the sciences. Their conception of the aesthetic had a significant impact on Humboldt's scientific work, not only on his evocative writing style and his visual representations but on the very content of his "physical description of the universe" and the theory that it provided for his practice of observation and his efforts to organize the sciences. Describing how precision instrumentation and its numerical data helped to create a common language for an extended community of researchers, Marie-Noëlle Bourget has written of Humboldt's "republic of instruments."[4] I suggest that some of the key "citizens" of this republic were the instruments themselves. I begin by looking at themes and approaches in Kant and Schiller that Humboldt drew upon to construct his polity of science. In keeping with Humboldt's political concerns, a guiding question of this genealogy of the morals of the observatory science of the first half of the nineteenth century is the relation between objectivity, as both theory and practice, and the views of *freedom* that were associated with it.

This examination of the moral, aesthetic, and political underpinnings of Humboldtian science is a contribution to the history of scientific objectivity, yet it raises questions for certain accepted claims. The early nineteenth century plays a crucial transitional role in Lorraine Daston's and Peter Galison's influential explorations of the multifarious historical and conceptual strata of the ideal of objectivity. In this period, they claim, the notion of objectivity as an escape from an individual perspective was transferred from the domain of moral judgments to epistemology; at the same time, an idealist meaning of objectivity, as the internal agreement in thought with a formal truth, was externalized and materialized. The outcome of this phase, "mechanical objectivity," exemplified by the daguerreotype, aimed at removing the influence of individual prejudice and human error by means of images produced by machines.[5]

In both of these transitions Humboldt played a central role. Yet neither "aperspectival" nor "mechanical" objectivity fully grasps Humboldt's practice and the philosophical discourses which nourished it. Like many late Enlightenment thinkers, Kant in his reflections on instrumentality acknowledged a boundary between the mechanical and the organic or human, yet he would eventually blur and undo this distinction; Schiller developed this dialectic between the organic and the mechanical into a view of human artifice as part of a vital cosmic circuit integrating humans and nature. Influenced by both Kant and Schiller, Humboldt did not perceive the machines that he used to make readings of natural phenomena as the antithesis of the human, organic, or natural, as they would be for many.[6] Furthermore, the version of objectivity which appears in the writings of Schiller and Humboldt was not a theory of escape, negation, or disconnection. For Humboldt the best way to know the world was to multiply mediations and observers, not eliminate them. The kind of "freedom" pursued in the Humboldtian regime of observatory science, and the version of "objectivity" that it realized, were associated with interdependence, mediation, and community.

Humboldt's phrase "nature is a free domain" nonchalantly restates the central problem of Kant's *Critique of Judgment* and Schiller's *Aesthetic Education*.[7] Despite the occasionally dry and "anaesthetic" nature of any discussion of the central themes in Kant and Schiller, such a discussion is essential if we want to understand the particular tensions that Humboldt's observatory science confronted and sought to overcome.[8]

Kant's Objectivities

Kant's influence on late-eighteenth- and nineteenth-century circles of philosophers, literary authors, and practitioners of *Naturphilosophie* in German-speaking lands was unrivaled: the cultural upsurge of romanticism owes much to the problems that Kant posed, as well as to dissatisfaction with the answers he provided. In a famous distinction, for Kant all objects of the world have both a phenomenal (sensible) and a noumenal (supersensible) dimension. Accordingly, humanity also has two distinct natures: man "belongs to the world of sense" and is "subject to laws of nature" as an empirically observable, determined phenomenon within the system of physical, mechanical causes. But "insofar as he belongs to the intelligible world subject to laws which, independent of nature, are not empirical but are founded only on reason" man also possess a supersensible nature, a free will, which gives him the capacity to legislate laws himself.[9]

This split in humanity corresponds to a divide among the "autonomous" faculties responsible for making sense of different kinds of experience.[10] Judgments about nature come from the faculty of the *understanding*; they are "objective" to the extent that they are brought under an a priori concept. Because of their conformity to the system of categories that are the condition of the possibility of experience, they are universally valid. Thus in the realm of the theoretical—explored in the *Critique of Pure Reason*—"objectivity" arises not because of the activity of a robust object upon a passive receiver but from the logical processes of the human mind that "constitute" the object. The "Copernican revolution" of Kant's epistemology lies

in the *active spontaneity* with which the understanding attributes a concept to these sensory givens, shaping them as "objects of experience."[11] The "objectivity" of the judgments made by the understanding is internal, a function of the intellect, having no essential dependence on any sensory ("aesthetic") givens.

The "objectivity" that pertains to laws regulating desire takes a different form: instead of laws of nature, we have here to do with laws of freedom.[12] As analyzed in *The Critique of Practical Reason*, these are legislated by the faculty of reason, not understanding. Ordinarily reason leaps ahead of us, inquiring about things of which certain knowledge is impossible: the origins of the universe, the existence of God, the life of the soul. Although the freedom of the will is just such an Idea of Reason, Kant claims that here reason is justified in its certainty that we can freely choose our actions.

But for Kant "freedom" does not mean doing whatever one wants. Morality demands a purely "good will" acting only from duty, without any reference to benefits or outcomes of the act. A will that chooses to follow its duty by behaving in a given circumstance as if under the compulsion of a universal law possesses autonomy; this obedience to the law that one gives oneself is for Kant synonymous with freedom.[13] How can we know this universal law? We formulate it by abstracting from our circumstances, expressing the act we are considering as a general maxim; only if no logical contradiction follows from the idea of a world in which *everyone* followed such a maxim can it be considered an acceptable action. Our freedom as rational beings means we may choose *not* to behave in such a way, and choose instead to follow our desires, our "hypothetical" motivations for doing what we want. Yet this very freedom—an essential attribute of the supersensible side of our nature—demands that we hold ourselves to a law that is *categorical*, that is, one that holds with the same kind of determining, *objective* compulsion as the a priori categories (concepts) of the understanding, as mapped out in the *Critique of Pure Reason*. The *categorical imperative* thus demands that "I should never act except in such a way that I can also will that my maxim should become a universal law." To act morally, one must already act as if a "kingdom of ends" exists: this means treating all other rational beings with the dignity they deserve, *not as mere instruments* or means but as ends—as rational beings also endowed with freedom. Since any necessary and universally valid "law of freedom" is one that we could choose not to obey, such a law legislates over desire in a way different from the way in which the determining, a priori concepts of the understanding rule over knowledge. Although both are "objective"—both assume the

form of a universally valid law prescribed by the intellect—their modes of objectivity are completely different: the one concerns objects determined by mechanical causality, the other rational subjects free to obey or not.

Because we are both empirical beings in the system of causes and free subjects of reason, we are subject to both kinds of law; yet the vast difference between these two kinds of causality begs the question: How can the empirically perceivable, determined system of causes that is nature be brought into line with the ideal law of the kingdom of ends? In other words, how can freedom act within nature? *The Critique of Judgment* (1790) seeks to bridge this divide with a third faculty, one lying between the understanding, which legislates over *knowledge*, and the reason, which legislates over *desire*. This is the faculty of judgment. It legislates over *feeling*—for instance, the pleasure that comes from the "free play" of our faculties when confronted with a beautiful scene of nature, or the pleasure that we derive from the harmony between our faculties and the objects of the world. In neither case can we pass from subjective pleasure to a universally valid, objective intellectual concept—a judgment either that "this is beautiful" or that "there must be a creator responsible for the harmony between human faculties and the world." The system of a priori concepts involved *determinant* judgments; these were the necessary forms that any judgment about natural phenomena must take to be considered knowledge. But judgments of taste and judgments that involve the postulation of final ends make use of the *reflective* judgment, in which a priori categories are not involved. Our evaluation that some object is beautiful is based not on a concept but on feeling; we feel that everyone would assent to our view in matters of taste, but this feeling is merely a "subjective universal," not authorized by an objective a priori concept. Similarly, in teleological judgments we attribute a final end, and thus a purpose, to natural entities and to nature as a whole. Such finality cannot be observed directly in the entities being considered; nor does it involve the kind of mechanical causality of causes and effects that is cognized as one of the a priori categories of the understanding. Nevertheless, teleological explanations of the reflective judgment are necessary as *regulative principles* for the understanding. They allow us to grasp the intrinsic interrelations of parts within living organisms (and eventually nature as a whole), giving us a principle for conceiving of *generation*, a phenomenon that purely mechanical explanations cannot grasp.

Teleological explanations bring with them a version of instrumentality that highlights the difference, running throughout Kant's system, between a machine and a living being. In both a watch and an organism the motion

of each part causes and is caused by every other, the parts working in tandem as an organized whole.[14] Yet it is only in an organism that the different parts actually engender each other by self-organizing development, growth, and repair: "the part must be an organ *producing* the other parts—each, consequently, reciprocally producing the others."[15] The efficient cause of the watch is the person who made it, while the efficient cause of the organism is identical with its final cause: *itself*. Each part of the watch is at most an instrument of *art*, potentially designed and built by an external agent and set mechanically to perform some task; in the organism, however, each organ is an instrument of *nature*, formed by the organism itself. In an organism the part is both means and end.

Further, the *extrinsic* relations among organisms, such as the complementarity of the sexes, or the interactions between an organism and its habitat, encourage us to seek out the interconnections among the various domains and empirical laws of nature. Humboldt's *Cosmos* is guided by the idea—which in Kant's terminology is just that, an *Idea of Reason*—that diverse empirical laws form a single system.[16] We have an obligation, Kant says, to pursue interconnections and push our explanations of mechanical principles of cause and effect as far as we can; but at the limit of these mechanical explanations, we reach beyond the realm of appearances, to the supersensible support and goal of the system, and ultimately encounter ourselves.[17] "What is the end and purpose of these and all the preceding natural kingdoms? For man, we say, and the multifarious uses to which his intelligence teaches him to put all these forms of life. [Man] is the ultimate end of creation here upon earth, because he is the one and only being upon it that is able to form a conception of ends, and from an aggregate of things purposively fashioned to construct by the aid of his reason a system of ends."[18] Man's *understanding* allows him to clear forests, build houses, dam rivers, and bring the empirical givens of nature into conceptual order as sciences. Yet such tasks address only man's habitat and material needs; they do not draw upon his unique possession, the free use of *reason*.

This aspect of his nature calls man to a higher goal than "individual happiness," one that surpasses "the mere fact that he is the chief instrument for instituting order and harmony in irrational external nature." Humans are the "lords of nature" because they can conceive and create a "kingdom of ends"; this highest human calling takes the form of *culture*, "the production in a rational being of an aptitude for any ends whatever of his own choosing." Hence "it is only culture that can be the ultimate end which we have cause to attribute to nature in respect of the human race."[19] In the nation

culture takes the form of "a constitution so regulating the mutual relations of men that the abuse of freedom by individuals striving one against another is opposed by a lawful authority centered in a whole, called a *civil community*." At the next level up we find a *cosmopolitan whole*, a law-bound "system of all states that are in danger of acting injuriously toward each other."[20] Although such a perpetually peaceful system may only be possible as an ideal, much like the kingdom of ends in *The Critique of Practical Reason*, the activities undertaken toward this goal have immediate benefits. Kant's privileged examples are "fine art and the sciences," which, "if they do not make man morally better, yet, by conveying a pleasure that admits of universal communication and by introducing polish and refinement into society, make him civilized." Art and science, activities which are undertaken in the world of sensuous particularity but are universally communicable, prepare us for the rule of free reason.[21]

In "What Is Enlightenment" (1799) this progress appears as a metamorphosis from mechanical determinism to the rule of freedom. In current society the Enlightenment's audacious quest for knowledge is possible only in the "public" side of man's life; only there can the scholar and cosmopolitan "world citizen" question old dogmas and advance new doctrines. On the "private" side, however, duties to the state must be fulfilled; "some sort of mechanism" is needed to ensure obedience to communal laws. Eventually, however, the pursuit of freedom will allow the supersensible to act upon the mechanical: "at last," he foresees, "free thought acts even on the fundamentals of government and the state finds it agreeable to treat man, who is now *more than a machine*, in accord with his dignity."[22] The causality of freedom acts upon mechanical causality, creating a polity in which all may freely discern and obey the law that determines their duty, investigate the empirical relations of the phenomenal world, and create and enjoy works of beauty. In their function as instruments of nature, such citizens are liberated, and are now both means and ends.[23]

The Critique of Judgment united the two sides of man's being by the discovery of a supersensible goal that must nevertheless be realized within nature. *Culture* (or its cognate, *Bildung*)—the creation of institutions and practices for developing the aptitudes of mankind in keeping with reason—fuses the laws of both freedom and nature and their autonomous modes of objectivity. Despite these optimistic sketches of human destiny, many found in Kant's system only austerity, self-denial, and a grim refusal of pleasure; his works seemed to demand a superhuman refusal of natural inclinations while expressing a disdain for temporal change, human vari-

ability, and sensory enjoyment.[24] It is this impression that Schiller sought to combat by refashioning Kant's philosophy in *The Aesthetic Education of Mankind*.

Schiller's Aesthetic State and Its Citizens

Schiller acknowledged the influence of "Kantian principles" on his argument but paid little heed to Kant's neat divisions and rigorously patrolled boundaries.[25] *The Aesthetic Education* melded the two types of objectivity in Kant—moral and theoretical, laws of nature and laws of freedom—in Schiller's notion of the aesthetic state. His discussion's central term was *Selbständigkeit*, "self-standingness," translated and reappropriated as "autonomy" in the critical tradition that has followed him.[26] This does not, however, mean a pure, godlike state of disengagement and self-sufficiency. Schiller took up and developed Kant's reflections on instrumentality and means and ends in *practical* terms; his view of autonomy implied a connection with other humans and linked pure form with sense and inclination. In focusing on the movement, exchange, and activity of this intermediate realm, he also brought readers' attention to concrete practices and materials. As much as it was a theory of an intermediate state between universality and particularity, Schiller's *Aesthetic Education* was a theory of the action of material *mediation*.

In the *Aesthetic Education* the tension in the architecture of Kant's theory between nature and freedom became the engine for an unfolding argument whose harmonic elaboration mirrored the dialectical development of humanity from savagery through barbarism to culture and morality. Schiller set out binary pairs that were sublimated, overcome, reconciled in a higher unity or dialectical reconciliation (to speak like Hegel, who learned much from him). The form numerologically restated the content: the dyads that became triads, in the classic symphonic form of A, B, A′, are echoed throughout the twenty-seven (3^3) letters. Where Kant laid out a static map of the regions of the mind, Schiller conceived the faculties as drives and forces in active conflict; the development of the individual, like the development of society, involved a dramatic movement and struggle among faculties. He asserted a fundamental tension between the passive "sense drive," "life," the empirical world with its desires and impressions, and on the other hand the active "form drive," which concerned abstraction and active, eternal principles in science or art. Between the two lay the "play drive" which relishes the mere appearance of things—the autonomous

(self-standing) "*schöne Schein*," detached from the desire either to possess or to freeze as timeless knowledge. Writing in 1794, after the storming of the Bastille and the Terror, Schiller identified the root of the political imbalance—the viciousness of the mob as much as the arrogance and indifference of the rulers—as a fundamental imbalance within mankind. Cure the latter and you cure the former. Thus his solution demanded a transformation at once artistic, emotional, political, and moral.

Kant mocked those who would seek morality in a principle outside of reason, in their own subjective inclinations or desires, or for the rewards it would bring; he consigned them to "a dream of sweet illusions (in which not Juno but a cloud is embraced)." Early in *The Aesthetic Education* Schiller rejects the self-abnegation implied by Kant's claim that the pure will was the only possible basis of morality. "If then, man is to retain his power of choice and yet, at the same time, be a reliable link in the chain of causality, this can only be brought about through both these motive forces, inclination and duty, producing completely identical results in the world of phenomena." Duty and inclination, which for Kant were divided by the same gulf that separated man's spiritual nature from his physical nature, must fuse; law and sense must harmonize. Like Kant, Schiller aims to unite the two systems of causality laid out in the first two critiques (and their respective modes of objectivity) by means of culture, art, and science. Yet to Schiller, for freedom to play a role in nature, reason must agree with desire.[27]

An instrument (*Werkzeug*) is required to bring about this transformation. Schiller proposes fine art, the analysis of which recapitulates the fusion of *duty* and *inclination* in the realm of morality: form and matter must balance each other in a dynamic equilibrium. His key example is the famous and quite large Roman head, the "Juno Ludovisi" made into a recurrent topos of classicist and romantic criticism by Winckelmann. In what can be read as a reply to Kant's dismissal of the delusions of consequentialist ethics by reference to Juno, Schiller describes this concrete goddess as the embodiment of the ideal physiognomy: the statue balances physical and spiritual perfection, Grace and Dignity, woman and God, the sensible and the supersensible. Desire pushes us toward formal purity, and formal perfection guides our desire. The statue leads those who contemplate it into the *Aesthetic State*, one of "both utter repose and supreme agitation, and there results that wondrous stirring of the heart for which mind has no concept nor speech any name." Here the aesthetic is a specific psychological state balanced between opposed forces, combining "melting beauty" with

"energizing beauty." In contradiction with Kant, moral freedom no longer requires humanity to depart from the world of the senses. "We need, then, no longer feel at a loss for a way which might lead us from our dependence upon sense towards moral freedom, since beauty offers us an instance of the latter being perfectly compatible with the former, an instance of man not needing to flee matter in order to manifest himself as spirit." In works of beauty, man is "already free while still in association with sense"; the "objective" moral law is joined with the "stuff" of sense and matter.[28]

This psychological state paves the way for a new political state, in which the desires of the individual will harmonize with the demands of civil society: "Once man is inwardly at one with himself, he will be able to preserve his individuality however much he may universalize his conduct, and the State will be merely the interpreter of his own finest instinct." Schiller again recounts a history of humanity, this time in terms of the development of an individual's consciousness: the appearance of the play-drive takes the subject from a first state of immersion in mere sense to an awareness of the distinction between self and object and a delight in everything that offers "material for possible shaping." This new relation with things accompanies a new relation with people. Relations between men and women go from mere satisfaction of physical desire to an intellectual and existential exchange of recognition: "from being a force impinging upon feeling, [man] must become a form confronting the mind; he must be willing to concede freedom because it is freedom he wishes to please." This reciprocity spreads throughout "the complex whole of society, endeavouring to reconcile the gentle with the violent in the moral world," opening up a new, autonomous realm between "the fearful kingdom of forces" and "the sacred kingdom of laws." Schiller calls this autonomous zone "a third joyous kingdom of play and of appearance, in which man is relieved of the shackles of circumstance." This aesthetic realm is characterized by a specific notion of freedom.[29]

For Schiller freedom is not merely a state but an activity, one that can only be brought into being by the presence and reciprocal involvement of others: "To bestow freedom by means of freedom is the fundamental law of this kingdom."[30] This conception of freedom—and its vicissitudes—was a central theme in Schiller's work, from *Wilhelm Tell* and *Don Carlos* to the poem that he wrote for the chorale of Beethoven's Ninth Symphony. While the poem is known as "Ode to Joy," the original title (as those who selected it as the jingle of the European Union surely knew), was "Ode to Freedom":

Thy magic reunites those
Whom stern custom has parted;
All men will become brothers
Under thy gentle wing.

May he who has had the fortune
To gain a true friend
And he who has won a noble wife
Join in our jubilation!

Yes, even if he calls but one soul
His own in all the world.
But he who has failed in this
Must steal away alone and in tears.

Even the last lines' stinging *Schadenfreude* captures the essential point of Schiller's notion of freedom. In Kant's *Critique of Practical Reason* freedom was the property of an individual in his innermost isolation, abstracted from all social ties and fellow-feeling. For Schiller, freedom (and the morality that is founded upon it) cannot exist outside of active relations with others. In this exchange of recognizing gazes, this phenomenology of mutual and reciprocal self-possession, freedom is given to others and received back from them, implying ownership and being owned—as in Rousseau's social contract, under which each gives himself to all and receives the others back.

Schiller's conception of the state that incorporates this freedom involves a change in the definition of and relation between the "objective" and the "subjective." In Kant the "subjective" pertained to the sensuous and changing, both empirical sense givens as well as judgments not regulated by a universally valid concept; "objective" judgments involved a priori concepts, thereby constituting an object of knowledge. In Schiller the terms begin to take on more familiar contours. Again, years before Hegel, Schiller calls the state "the objective and, as it were, canonical form in which all the diversity of individual subjects strive to unite." But as if in anticipation of those who have seen in the line of political thought that grew out of this statement (from Hegel to Marx and their followers) a quasi-totalitarian theory of uniformity imposed from above, Schiller takes pains to note that "the State should not only respect the objective and generic character in its individual subjects; it should also honour their subjective and specific character." Again he seeks an autonomous middle ground: the good society

will preserve what he calls here the "subjective" character of a citizen who is "inwardly one with himself" and is therefore able "to preserve his individuality however much he may universalize his conduct." Thus the "State will be merely the interpreter of his own finest instinct." As noted with regard to morality, Schiller mixed the "objectivity" of the good will that acts in conformity to reason alone with the "subjective" desires, inclinations, and experiences of the individual. The political sphere demands a comparable adjustment of the formal laws regulating conduct to the character and circumstances of the individuals who make up a society. "Autonomy," or *Selbständigkeit*, is the name that Schiller gives to this balance between the universal or objective and the particular or subjective.[31]

Moving from morality to aesthetics and politics, Schiller's arguments also extend to the natural sciences. His first letter decries the narrow aridity of the sciences and the murderous consequences of their investigations: "truth is a paradox for the analytic thinker; analysis dissolves the very being of that which is analysed." The same is true for the analyst himself. Humanity pays a heavy price for the extreme specialization of the modern disciplines: "Once the increase of empirical knowledge, and more exact modes of thought, made sharper divisions between the sciences inevitable, and once the increasingly complex machinery of State necessitated a more rigorous separation of ranks and occupations, then the inner unity of human nature was severed too, and a disastrous conflict set its harmonious powers at variance."[32] Here we see science linked to the "machinery" of the State, the "objective form" of human interactions. Yet the solution is not an escape from all social bonds, nor a flight from science or technology into an idealized state of nature or a subjective state of reverie. Instead the aesthetic state will take science out of its austere and self-enclosed abstraction; science must humanize itself. Though Schiller chooses to retain the term "objectivity" to refer to pure formal knowledge, in fact the model of knowledge that he implies is one that places this pure formalism in suspension with the senses. Analytic a priori judgments and synthetic a priori judgments are placed in a continuum; the fusion of sense and category now takes place in the world of objects and communal activity.[33] As in his treatment of politics, Schiller continues to use "objective" in a sense like Kant's, as validation by an abstract, formal law. But the "free" practice of science, like that of politics, demands a mixture between the pure formalism of Kantian objectivity and the variable, sensuous "life" with which it engages. Once more this state of interdependence between two poles is called autonomy.

Scientific specialists must learn to share their knowledge; with diffusion comes transformation. "From within the Mysteries of Science, taste leads knowledge out into the broad daylight of Common Sense, and transforms a monopoly of the Schools into the common possession of Human Society as a whole"; by means of the aesthetic, freedom will enter the realm of science as surely as it did the realm of politics. The result will be a transformation of the lifeless machinery of the state, and of the mere instruments of art, into a free, cosmic republic: "At the touch of the wand [of taste], the fetters of serfdom fall away from the lifeless and the living alike. In the Aesthetic State, everything—even the tool which serves [*auch das dienende Werkzeug*]—is a free citizen, having equal rights with the noblest; and the mind, which would force the patient mass beneath the yoke of its purposes, must here first obtain its assent."[34]

The mind, whose province is truth, "object, pure and simple," can only rule if it has the assent of its subjects. All individuals over which the laws of form hold sway—the laws of the objective polity, the objective law of morality, or the objective categories of science—must be liberated, allowed to choose to obey the law, all the way down to the "lifeless" instruments which were previously only means to an end. The result is a kingdom in which the means (the instruments) are also ends; this kingdom includes all of nature, along with the material mediations—art, tools, language—that shape and articulate the relations among its members.

In Schiller's aesthetic state, knowledge is no longer the relation between a transcendental subject and sense data subsumed under universal categories; it is now a liberating relation of mutual respect among users, tools, and their objects. For the pedagogic or the political artist, "man is at once the material on which he works and the goal toward which he strives. In this case the end turns back upon itself and becomes identical with the medium; and it is only inasmuch as the whole serves the parts that the parts are in any way bound to submit to the whole." We move from a vertical relation to a horizontal one, from a hierarchical to an egalitarian model, from a linear, mechanical causality to a reflexive, organic one. The subjective individuality of all entities must be preserved within the beautiful appearance of the work of art, the logical interconnections established in the scientific "tableau," the objective apparatus of the state.[35]

While Schiller's main concern was the political consequences of the aesthetic state, his arguments, as we have seen, had direct implications for natural science. The *Aesthetic Education* presented the theory of how to get from an intellectual, immaterial, and individual view of objectivity and "au-

tonomy" to one in which objectivity and autonomy are external, embodied, and collectively validated. The work of Alexander von Humboldt, culminating in his *Cosmos*, offered the practice.

A Cosmic Polity of Free Instruments

Cosmos was a true "Victorian sensation," one of the best-selling books of its time. As with François Arago's popular astronomy lectures at the Observatory of Paris, the renown of this work was to no small extent due to its pleasing style, vivid descriptions of natural phenomena, and liberal references to literature. Early on, for instance, Humboldt writes, quoting "the immortal poet" Schiller, that mankind, "amid ceaseless change [,] seeks the unchanging pole." But the "aesthetic" concerns that underwrote Humboldt's project were not just window dressing.[36] The task that Schiller announces of fusing particular, "ceaselessly changing" sensory givens with "the unchanging pole" of abstract principles is of a piece with Humboldt's overall project. Humboldt consciously worked in the "intermediate zone" balanced between extremes that Schiller opened up, with much of the same theoretical apparatus. While he set himself the task of actively submitting observations of nature "to the test of reason and intellect," he also paused to note how a "romantic landscape" can be "a source of enjoyment to man, by opening a wide field to the creative powers of his imagination." Just as Schiller found in the Juno Ludovisi a combination of melting and energizing beauty, so did Humboldt praise the "soothing yet strengthening influence" of observing nature. The guiding idea of *Cosmos*, to present the universe as a law-bound, unified whole while respecting the specificity and "freedom" of each individual part, was a scientific realization of Schiller's reconfiguration of Kantian autonomy.[37]

Cosmos made clear Humboldt's acceptance of post-Kantian epistemology: "Science is the labor of mind applied to nature, but the external world has no real existence for us beyond the image reflected within ourselves through the medium of the senses." The inclusion of the term "labor" to what might otherwise be construed as an expression of idealist faith goes beyond the Kantian assumption of a universality of perception and cognition; some kind of *activity* is demanded to shape what passes through the "medium" of the senses. On the next page, discussing the progress made in the theory of matter, Humboldt notes improvements in natural philosophy over earlier speculations and haphazard observations, "by the ingenious application of atomic suppositions, by the more general and intimate study

of phenomena, and by the improved construction of new apparatus." Contemporary science is marked by its refinements in method and, crucially, in apparatus: the technical arrangements in the middle ground between mind and nature.[38]

Like other scientists of this period, Humboldt placed a heavy emphasis on the development of new instruments and observational apparatus to measure and to reduce differences in perception. His research depended on an embarrassment of devices for registering a huge range of phenomena: chronometers, telescopes, quadrants, sextants, repeating circles, dip needles, magnetic compasses, thermometers, hygrometers (built around a strand of human hair which grew longer or shorter depending on the moisture of the air), barometers, electrometers, and eudiometers (to measure the air's chemical composition).[39] These instruments were not understood as transparent means of registering nature "in itself." Like Schiller's "fine art," Humboldt's instruments were the concrete *media* occupying the milieu, the "halfway-place" between humans and the world: the concrete locus for the fusion of sense and intellect.

In other words, Humboldt's regime of instrumentation externalized, temporalized, and "communalized" Kant's categories. Jonathan Crary has argued that in this period perception was increasingly theorized as a phenomenon of particular bodies disciplined by external devices and practices. Humboldt's work with instruments shows that in the same moment that perception was somatized and particularized, thereby dismantling the Kantian notion that the categories of experience were universal properties of the transcendental ego, these categories were *made into universals in practice*, in the technical apparatus of the observatory sciences. The processes of instrumental calibration, standardization, and coordination externalized the process of the understanding described in the *Critique of Pure Reason*. By ensuring that instruments shared the same scale of measures for quantities of time, space, and degrees of magnitude, that they were subject to identical thresholds for determining the presence and composition of substances, and that they possessed the same sensitivity to specific causal relations, the work done in observatories to bring instruments into agreement literally built the concepts of the pure understanding—the basis for the communicability of knowledge—into the physical apparatus.[40]

The new instruments of nineteenth-century science were often seen to embody the qualities of the ideal human subject.[41] For Humboldt this symbolic identification was rooted in *interchangeability* and *intimacy*. In his extensive research on galvanism and animal magnetism, he constructed

elaborate circuits for galvanic electricity in which different metals, chemical solutions, and frogs had equal status as instruments; in several experiments the main site of inscription and observation, another link in the chain, was his own body.[42] Furthermore, his correspondence repeatedly testified to his extraordinary care for his instruments: he typically identified them by the patronymic of their makers, went to great lengths to assure their well-being, and discussed his most cherished compasses, barometers, and sextants with the same enthusiastic affection as his dearest friends. Letters of introduction for human protégés followed equally solicitous letters on behalf of instruments. Gleefully describing a phase of the expedition in which all of his "instruments were in action," he followed an apparently rhetorical question, "But how can I tell you about that?," with thousands of words describing the behavior of each member of his brood. Observations, he said, must be made "with exactitude and *'con amore'*" when tropical heat makes instruments burn one's hands. Instruments which made for good traveling companions—those which were small, light, and versatile—were favored, like the portable barometer which could be fitted onto the head of Humboldt's walking stick. The tools arrayed in the famous painting of Humboldt and Bonpland during their voyage—visually uniting the two researchers at the center of the painting—were totems and extensions of the researcher's self.[43] They not only extended his senses, heightening his perceptual faculties and submitting sensory phenomena to mathematical scaling: they were embodiments of his relations with others and his place in the natural and social world.[44]

This mode of sociability was central to Humboldt's conception of scientific knowledge. As in much late Enlightenment republican thought, including Schiller's, scientific "objectivity" was linked to ideals of moral and political freedom. But Schiller's assimilation of laws of nature to laws of freedom in the aesthetic state points us toward a distinct moral meaning in Humboldtian instrumentation. In their discussions of objectivity, Daston and Galison consistently stress its *negative* aspect, likening objectivity to the hollow remainder of wax impressed by the more robust and positively defined seal of subjectivity, and defining it as an "escape from perspective" and from intention: "Instead of freedom of will, machines offered freedom from will." Elsewhere Daston explains the moral economy of science in the mid-nineteenth century in terms recalling Kant's second critique: "The self-restraining and self-effacing counsels of mechanical and aperspectival objectivity reverberate with the stern voice of moral duty: the self-command required in both cases to suppress the merely personal is indeed

the very essence of the moral." In these arguments freedom is associated with escape, suppression, and denial. Yet for Humboldt it was not simply the negative virtues of tirelessness, restraint from intervention, and lack of bias that commended machines as observers and scribes for natural observation. The freedom of Humboldtian instruments was a positive and active virtue.[45]

The well-tempered instrument, like a reliable but spontaneous human, oscillates within a specific range of values, passive in receiving its phenomena, active in transmitting them. The process of standardization and calibration builds an a priori principle into the instrument, a categorical imperative ruling over its "desire"—like Schiller's "objective man" who is "ennobled into participation with the law." Each instrument responds "freely" to its milieu and its particular circumstances; but like human laws and the regularities of human language and practice, the agreement produced between the field instrument and the master instrument, often located in the observatory, fixes the instrument's action within a defined range of values, providing the shared and stable background needed to make local difference communicable.[46] This is not, however, an automatic process or unilateral application of force. Just as freedom for Schiller can only emerge in reciprocal exchange with other beings, so does the objectivity of the Humboldtian tool demand cooperation with a highly skilled and patient human. The observer must gain the instrument's assent by entering into a dialogue, "playing" with it, becoming familiar with its limits and habits. Humboldt's letters and travel reports are filled with accounts of awkward moments at the beginning of his relationship with an instrument and his joy at learning to cooperate successfully with it. Making good measurements means knowing and adjusting to an instrument's particularities. For instance, he preferred a chronometer which lost time gradually at a regular rate to one which kept time perfectly yet was subject to unexpected stops. Precisely the same logic underwrote the device that François Arago introduced at the Paris Observatory to measure an observer's "personal equation," or regular lag time in registering a star moving across a fixed space. The law may be the same for all, yet as Schiller argued, the law is only a law of freedom if it adjusts to the living particularity of the individual, whether a person or a machine.[47]

These individuals form a cosmopolitan society. All instruments of a single type constitute a globally distributed "clan" of instruments registering the same phenomenon; this is one stratum of a larger society into which humans, machines, and certain privileged sites—notably observatories—

are woven. Humboldt played a preeminent role in the internationalization and institutionalization of science. He encouraged younger scientists, giving advice and training and supporting their candidacies; he facilitated contacts among scientists and secured government support. He organized the first meeting of the Society of Naturalists and Natural Philosophers in Berlin; his opening speech inspired Charles Babbage, in attendance, to form the similar British Association for the Advancement of Science.[48] Even more, his incessant correspondence helped him to form a network of natural scientists. The global network of investigators that Humboldt helped to coordinate directly recalled his early experiments in animal magnetism, in which animals, metals, batteries, and the experimenter formed an energetic circuit; even in the midst of inquiries about friends and their families, there is hardly a single letter in Humboldt's correspondence which does not mention an instrument or a meteorological observation.

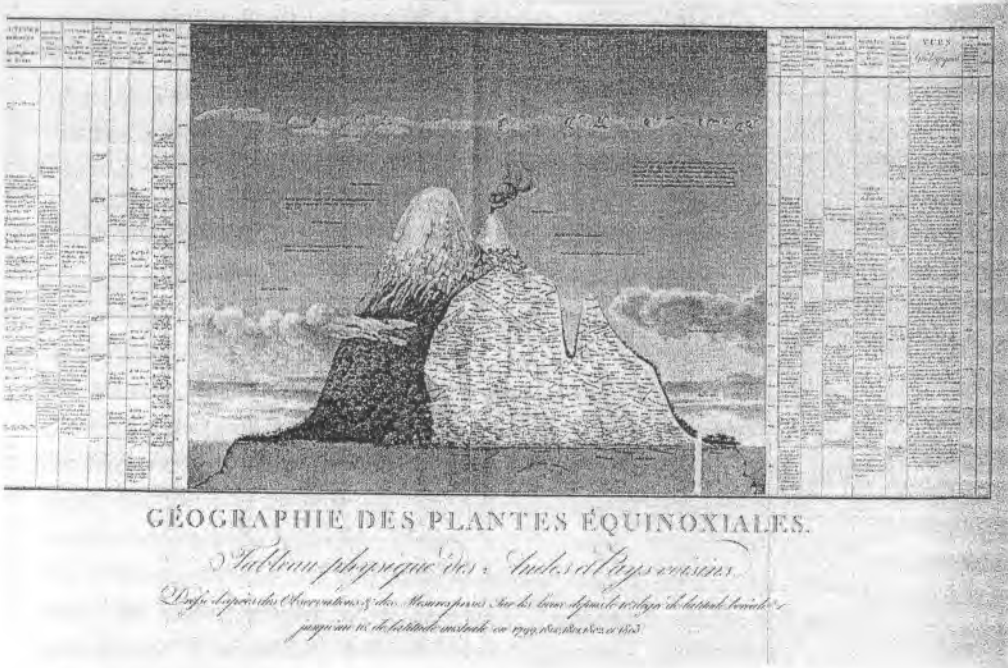
The aim of Humboldt's physics of the earth was to map the patterns of global systems of natural forces, charting in its local detail and its particular interactions "a general equilibrium which reigns among disturbances and apparent turmoil," the result of an infinity of mechanical forces and chemical attractions balancing each other out. When he charted the values registered by the instruments distributed around the globe, global patterns became manifest. The clan of thermometers and their readers, for instance, made it possible to trace *isothermal lines*, regions of shared average temperature in bands across the earth. An early article that Humboldt wrote for the Society of Arcueil contains a tableau with the position in latitude and longitude, the average temperature over the year, and maximum and minimum temperatures taken from reports at forty-eight locations around the globe. The table is a who's who of observers, field stations, and observatories: Humboldt in Curana, Saussure in Geneva, Dalton in Kendall, Arago in Paris, Euler in Petersburg, Young in London, and Playfair in Edinburgh.[49] This study, in which half of the sites' averages were calculated on the basis of around eight thousand observations, prepared the way for the "magnetic crusade" which traced the distribution of magnetic intensity, inclination, and declination around the globe. As John Cawood has shown, this campaign—for which Arago's Observatory of Paris was briefly the clearinghouse—was a major step in the establishment of a global network of observational science, highlighting the need for communication and shared standards; the multiple readings taken in observatories in both metropolitan centers and colonial outposts played a key role in maintaining and implementing standards for time, space, and other measures.[50]

The range of local variations of phenomena could be depicted across the planet in the synoptic tableaux that Humboldt invented. These were maps of the distribution and relative change of numerous phenomena across a single limited region. In the painted tableau that accompanied his *Essai sur la géographie des plantes*, each instrument and the phenomenon that it registers belongs to one vertical column; the y-axis represents altitude (figure 41). For example, for each stratum the temperature, air pressure, amount of magnetic phenomena, light quality, blueness of the sky, moisture, and boiling temperature of water could thus be seen and compared at once. In a given tableau each instrument (like each citizen) performs its Kantian duty, but not in isolation, and not in pure, abstract relation to the law. When each does its duty, the whole system is described—a balancing act among opposed forces.

In this tableau Humboldt has rendered the image of a vast natural chorus, expressing itself freely through its liberated (and at the same time law-bound) instruments. Rotate it ninety degrees to the right, so that it stands on its side, with the columns reading across horizontally, and each column traces the part played by each phenomenon, isolated and recorded by its respective instrument; the tableau follows the structure of an orchestral score, with progression over time replaced by ascension in altitude. The observers, instruments, and phenomena united in Humboldt's tableau sing the same song, one variation of which may be expressed, again, in the "Ode to Joy" / "Ode to Freedom":

> All the world's creatures
> Draw joy from nature's breast;
> Both the good and the evil
> Follow her rose-strewn path.
>
> Be embraced, Millions! . . .
> Can you sense the Creator, world?
> Seek him above the starry canopy.

As in Kant, a view of the agreement of empirical laws within the realm of appearances suggests a supersensible basis for this harmony and splendor. The shimmering intermediate zone of appearances—with each phenomenon isolated, brought into a form that allows for comparison and joined with the others in a global system of energetic forces in constant interplay—gave testimony to a higher order of eternal things. The numerous connections that Humboldt wove between the starry canopy and the sub-



41. "Geography of Equinoxal Plants," plate accompanying Alexander von Humboldt and Aimé Bonpland, *Essai sur la géographie des plantes accompagné d'un tableau physique des régions équinoxiales* (Paris: Fr. Schoell, 1807). The image encapsulates the book's sections as well as the process of its construction: vertical columns correspond to chapter headings, which in turn correspond to specific observations and in most cases to the parts played by specific instruments. Vertical columns include: Height; Temperature Scale; Barometric Scale; Hygrometric Scale; Blueness of the Sky; Horizontal Refractions; Chemical Composition of the Atmosphere; Temperature of Boiling Water; Soil Culture. The instruments analyze and the image synthesizes, in intellectual and sensuous form, tropical milieus at all elevations.

lunary globe were indices of a transcendent dimension which he sought to bring as near as possible to presence. Each particular element and each sweeping line that joined it to wider phenomenal currents, each note, each melody, each movement pointed to the dynamic *whole* that it was part of and the sublime principle of order beyond it. A "symphony" is so named because it contains a range of sounds working together at once. Humboldt spent his life composing something altogether new, combining the surge and shades of feeling tapped by romanticism with the mechanical detail and social coordination of the new worldwide regime of the precision sciences. Humboldt was composing a cosmic *symphenomenony*—and helping to assemble the worldwide orchestra needed to perform it.[51]

The notion of a polity of scientific instruments and users inevitably raises the question of who makes the laws, who enforces them, and how. Such concerns recall the enduring political issue of the Enlightenment: how to determine and enforce the laws of a polity whose legislators are as exactly as numerous as its subjects. As other chapters in this book show, it would be difficult to identify one single mode of arbitrating over such questions in the physical sciences. Instead, diverse solutions emerged for establishing the "accuracy," the "reliability," the "objectivity," or even the "truth" of claims about physical phenomena: the construction of increasingly precise instruments, relying on trust and experience in makers and users; instruments and methods to account for and to correct individual error; Gauss's mathematical method of least squares to reduce the errors in a large number of observations; the creation and maintenance of standard values. From the late 1790s to the 1830s Humboldt was involved in attempts to perfect observation, measurement, and representation according to every one of these methods. While diverse, a common thread runs through these modes of verification. In each case objectivity was the product of communal activity, a process of exchange and coordination taking place within a single sphere—a common ground between mind and nature, shaped by the social instruments that articulated it.[52]

At all levels Humboldt's works played a key role in the shifting meaning of "objectivity": from an internal and rationalist model in Kant to an external, communal, and emergent model which relied increasingly on machines.[53] The development of scientific associations, journals, and vast collective research projects in the nineteenth century which Daston presents as evidence of an ascendant ideal of "aperspectival objectivity" might thus in Humboldt's case be thought of as an ideal of *multiperspectival* objectivity. While Humboldt's science relied thoroughly on mechanical devices, these

were not seen as the negation of individual perspective and the embodiment of values of restraint and denial; they aspired to an ideal of communal, active, productive, and spontaneous mediation. Humboldt's instruments were free citizens in a cosmic polity: flexible individuals which nevertheless obeyed laws. As long as their "users"—whose actions they regulated in turn—understood and adjusted to their individual qualities and temperaments, they served as autonomous go-betweens, fulfilling their duty in the liberated universe of humans and nature depicted and, Humboldt hoped, realized in *Cosmos*.

Reframing the Modern World Picture

Humboldtian science had a generative effect on the laboratory science of the following century. Du Bois-Reymond wrote in the mid-1800s that "every industrious and ambitious man of science . . . is Humboldt's son"; and Helmholtz clearly modeled his persona as a humanist spokesman for German science on Humboldt.[54] Much suggests that after the middle of the century, however, a new image of science and of instrumentation prevailed. As noted by Daston and Galison, the image of scientific machines became increasingly inflexible, lifeless, and inhuman; Humboldt's regime was reconceptualized and tied to laboratories, with its instruments often described and developed in the direction of automatic action and self-inscription.[55] The delicacy with which such apparatus still had to be constructed and maintained was cloaked by a new rhetoric of objectivity, for which the daguerreotype has frequently been cited as the model.

Yet when it first appeared, photography, "essence and emblem of mechanical objectivity," was one more citizen in Humboldt's polity. Arago, Humboldt's close friend, introduced Daguerre's and Niepce's invention to the public in 1839 and secured a lifetime salary to its inventors. Throughout his physical and astronomical researches Arago had shown the same passion for instruments as Humboldt.[56] Obsessed with the effect of different interfering media on the observation of light, Arago did not believe that the daguerreotype's use of the "automatic" action of light implied any exceptional ontological or epistemological claim for its images. In his announcement of the discovery, he suggests a use for the technique that is completely indifferent to the content of the image. That the image develops at different rates depending on the season and weather suggests that "the meteorologist would have one more element to include in his *tableaux*, and to the former observations of the state of the thermometer, the barometer, the hygrometer and of the transparency of the air, he will have to add an element that the other instruments do not grasp."[57] Here Arago is not interested in the object depicted on the silver plate, but rather in what the process of its development tells us about invisible atmospheric phenomena. Along similar lines, he suggests that photography will allow for improvements in photometry, the comparison of intensities of light; other suggestions are firmly set among the field sciences of Humboldt, including a map of the moon and topographical applications. The daguerreotype was presented by its first public supporter as another member of the family of geophysical instruments—an interesting addition, no doubt, but for Humboldtian instruments and the experimental apparatus that they begat, the story traced here suggests that "mechanical objectivity" was not so much a set of practices as a way of *talking* about practice which developed after the revolutions of 1848, especially to an audience that had once been invited into the halls of science—by Humboldt and Arago—and, after the middle of the century, was to be kept out. After 1848 photography staged a coup d'état in the polity of instruments: only those methods that appeared untouched by human agency, like photography and the automatic, self-inscribing instruments of the graphic method, would be allowed into the court—or at least into the court's official representations. This moment of the ascendancy of "mechanical objectivity" parallels the failure of the German revolution of 1848 and the coup d'état of Napoleon III in 1851. The valence of the term "freedom" shifted as well: these instruments were now considered "free" of human idiosyncrasy, perspective, will, and imagination, no longer seen as participating in the oscillation between active and passive, whole and part, individual and general which marked other Humboldtian instruments. At the same time late romantic critics such as Charles Baudelaire virulently attacked the machine as the antithesis of the human.

In response to the demiurgic powers released by the new technologies of early-nineteenth-century science and industry, we are most familiar with those texts which express what has proved in many ways to be a horror of mechanization. Humboldt's *Cosmos*, on the contrary, is a decidedly romantic attempt to harmonize these new forces; unlike gothic and antirationalist strands of romanticism, his work incorporates the natural sciences and their machines into a vision of natural balance. The stable yet dynamic universe of *Cosmos* is a *world-picture technology* intended to bring awareness of the interconnectedness of the universe and to place human endeavors

within a wider frame of meaning. In an age when the recognition of human responsibility for both the health and the conceptual order of nature became increasingly widespread, *Cosmos* can be read as an argument against the madness of seeing human freedom as liberation from all restraint. Instead it advances a view of autonomy that applies to all beings, the effects of whose freely chosen actions reverberate throughout the system.[58]

The observatory sciences seem paradoxical. They require a huge range of "eyes"—human and artificial—distributed across the globe, each working independently and immersed in its specific circumstances; at the same time the many voices and individuals brought into this circle of exchanges must be calibrated within known parameters, measured by shared standards, and held to universal principles. How do we create a national or global community ordered by laws that preserve and respect phenomenal variety, individual spontaneity, and freedom? While it took a variety of forms, this problem was faced in the same terms in the sciences, arts, and politics of the first half of the nineteenth century. Humboldt wrote to Arago in May 1848 after the uprising for a constitutional monarchy in Berlin: "My ardent hopes for democratic institutions, hopes which date back to 1789, have been fulfilled." By the next year, after the kaiser's repudiation of the constitution, Humboldt was much less sanguine: "I am reduced to the banal hope that the noble and ardent desire for free institutions is maintained by the people and that, though from time to time it may appear to sleep, it is as eternal as the electromagnetic storm which sparkles in the sun."[59] For Humboldt the work of freedom—and the discipline that it demands—combine hope, effort, and artifice, to give shape to natural potentials which lie sleeping. It was to awaken, guide, and frame this unity, in the natural world and among humans, that Humboldt served as a charismatic and gregarious instrument.

Notes

1. See Eagleton, *The Ideology of the Aesthetic*; Bürger, *Theory of the Avant-Garde*; Herbert Marcuse, *The Aesthetic Dimension: Toward a Critique of Marxist Aesthetics* (Boston: Beacon, 1978).
2. See Wilhelm von Humboldt, *On Language: The Diversity of Human Language-Structure and Its Influence on the Mental Development of Mankind* (Cambridge: Cambridge University Press, 1988); the above quote is from Martin Heidegger, "The Way to Language," *Basic Writings from "Being and Time" (1927) to "The Task of Thinking" (1964)* (New York: Harper and Row, 1977), 405.
3. My conception of Humboldtian Science owes much to the thesis and articles of Michael Dettelbach, including his introduction in Humboldt, *Cosmos* (1997 edn); see also Cannon, *Science in Culture*; Botting, *Humboldt and the Cosmos*; and Bourguet, "La république des instruments."
4. See Bourguet, "La république des instruments."
5. Notably in Daston and Galison, "The Image of Objectivity." See also Lorraine J. Daston, "Objectivity and the Escape from Perspective," *Social Studies of Science* 22 (1992): 597–618; and Peter Galison, "Objectivity Is Romantic," ACLS Occasional Paper 47 (2000).
6. See Langdon Winner, *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought* (Cambridge: MIT Press, 1977).
7. See Lenoir, "The Göttingen School and the Development of Transcendental *Naturphilosophie* in the Romantic Era"; Phillip F. Rehbock, *The Philosophical Naturalists: Themes in Early Nineteenth Century British Biology* (Madison: University of Wisconsin Press, 1983); Judith Schlanger, *Les Métaphores de l'organisme* (Paris: Vrin, 1971); and Richards, *The Romantic Conception of Life*.
8. See Frederick Beiser, *The Fate of Reason: German Philosophy from Kant to Fichte* (Cambridge: Harvard University Press, 1987).
9. Kant, *Grounding for the Metaphysics of Morals*, 53. Referring to Kant, Foucault speaks of man as the "empirico-transcendental doublet" in *The Order of Things: An Archaeology of the Human Sciences* (New York: Vintage, 1973), 318.
10. See Immanuel Kant, *Critique of Judgement*, trans. James Creed Meredith (Oxford: Oxford University Press, 1952), Introduction, sec. IX, 36; Gilles Deleuze, *Kant's Critical Philosophy: The Doctrine of the Faculties*, trans. Hugh Tomlinson and Barbara Habberjam (Minneapolis: University of Minnesota Press, 1984), 3–10.
11. On Kant on the categories see Cassirer, *Kant's Life and Thought*, 170.
12. "For we are constrained to think the pure will as something bound by law and hence 'objective,' but this objectivity belongs to a sphere totally distinct from that which is expressed in the spatiotemporal phenomenon. It is not a world of things we are assured of here, but one of free personalities; not a set of causally related objects, but a republic of self-sufficient subjects purposively united." Cassirer, *Kant's Life and Thought*, 247, 154.
13. See Kant, *Grounding for the Metaphysics of Morals*, 49. The notion of autonomy ("self-law") can be traced to Rousseau's general will: "freedom is obeying the law one gives oneself." It has roots in stoicism, in Saint Paul (who speaks of the gentiles as "a law unto themselves"), and in Luther's "Freedom of a Christian Man," in which an inner law of faith overrides laws of the state. See J. B. Schneewind, *The Invention of Autonomy: A History of Modern Moral Philosophy* (Cambridge: Cambridge University Press, 1998).
14. Kant, *Critique of Judgement*, secs. 64–65.
15. Ibid., secs. 65, 22.
16. On Kant's idea of reason see Paul Clavier, *Kant: les idées cosmologiques* (Paris: Presses Universitaires de France, 1997).
17. Kant, *Critique of Judgement*, secs. 82, 91: "the reconciliation of the two modes of picturing the possibility of nature [either mechanical or teleological] might

easily lie in the supersensible principle of nature, both external and internal. For the mode of representation based on final causes is only a subjective condition of the exercise of our reason in cases where it is not seeking to know the proper estimate to form of objects arranged merely as phenomena, but is bent rather on referring these phenomena, principles and all, to their supersensible substrate, for the purpose of recognizing the possibility of certain laws of their unity, which are incapable of being figured by the mind otherwise than by means of ends (of which reason also possesses examples of the supersensuous type)."

18. Ibid., secs. 82, 88.
19. Ibid., 95.
20. Ibid., 96. See also Kant's related arguments in "To Perpetual Peace: A Philosophical Sketch," *Perpetual Peace and Other Essays*, trans. Ted Humphrey (Indianapolis: Hackett, 1983), 106–43.
21. Kant, *Critique of Judgement*, 97; see Cassirer, *Kant's Life and Thought*, 333.
22. See Michel Foucault, "What is Enlightenment?," *The Foucault Reader*, ed. Paul Rabinow (New York: Pantheon, 1984), 32–50 (italics mine).
23. In the next decades the blurring of boundaries and the exchange of properties between humans and mechanical devices became an increasingly important intellectual and moral resource for making sense of a new technical and political order. See Schaffer, "Enlightened Automata"; and Adelheid Voskuhl, "Motions and Passions: Music-Playing Women Automata and the Culture of Affect in late Eighteenth-Century Germany." *Genesis Redux: Essays in the History and Philosophy of Artificial Life*, ed. Jessica Riskin (Chicago: University of Chicago Press, 2008). For one example in the biological sciences see Lenoir, "The Göttingen School and the Development of Transcendental *Naturphilosophie* in the Romantic Era," esp. 148 on Blumenbach's solution in biology to the opposition between mechanical and teleological explanations.
24. Perpetuated by such posthumous accounts as Thomas de Quincey, *The Last Days of Immanuel Kant and Other Writings* (Edinburgh: Adam and Charles Black, 1862).
25. Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 3.
26. Willoughby's and Wilkinson's translation of the letters systematically renders *Selbständigkeit* as "autonomy." Critical discussions of Schiller frequently assimilate the notion to Kant's term "autonomy," at the cost of some confusion. See Bürger, *Theory of the Avant Garde*, 41–46 on Kant and Schiller, 6–14 on Adorno, Lukács, and Marcuse. Bürger's argument rests upon tracing back to Schiller the theoretical source for the functional differentiation of art as a separate sphere of activity (the "autonomy" championed not only by "bourgeois ideology" but by critical theorists such as Adorno).
27. Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 34, 17.
28. Ibid., 55, 109, 189.
29. Ibid., 21, 213. On the influence of Kant's critic Reinhold on Schiller's—at times quite varied—formulation of autonomy see Sabine Roehr, "Freedom and Autonomy in Schiller," *Journal of the History of Ideas* 64 (2003): 119–34.

30. Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 215.
31. Ibid., 19, 21.
32. Ibid., 33.
33. We have here a version of the central paradox of Schiller's work. The aesthetic is presented as a means of leading us upward to the world of form, but at the same time it appears as a corrective to an excess of form; similarly, Schiller's view of truth as both "pure object" and part of the world of sense may well appear contradictory. Lovejoy attributes these difficulties to Schiller's attempt to combine into a single system "the two Gods of Plato—the immutable and self-contained Perfection and the Creative Urge which makes for the unlimited realization in time of all the possible": "Since they are essentially antithetic, in any actual juncture in experience one of them must in some degree be sacrificed to the other." Schiller's wish to have it both ways, for Lovejoy, results in incoherence, though Lovejoy's sense is that for Schiller and subsequent romantics, "plenitude has the last word": the principles of perfect form must constantly be creatively realized within the world of sense. Arthur O. Lovejoy, *The Great Chain of Being: A Study of the History of an Idea* (Cambridge: Harvard University Press, 1964), 299–303.
34. Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 217, 219.
35. Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 21. Upon mention of the "political artist" we must note the influence of Schiller on Goebbels's "Führerfestschrift" *Michael*, though as I hope to have made clear, Schiller's utopia had nothing to do with fascism. Under the Third Reich Schiller's *Don Carlos* was banned, as its performances became the occasion for protests against the Nazi regime. Cf. Eagleton, *The Ideology of the Aesthetic*; Michael Jones, "Schiller, Goebbels, and Paul de Man: The Dangers of Comparative Study," *Mosaic* 32–34 (1999): 53–72.
36. See Finkelstein, "'Conquerors of the Künlün'?"; and Dettelbach, Introduction to Humboldt, *Cosmos*, vol. 2, on Humboldt's aesthetics. Cf. also Secord, *Victorian Sensation*; Arago, *Astronomie populaire*.
37. Quotes taken from Humboldt, *Cosmos*, 1:36, 26, 25.
38. Humboldt, *Cosmos* 1:76, 77. On the visibility of scientific labor see Cawood, "François Arago, savant de l'industrie"; Blondel, "Electrical Instruments in Nineteenth-Century France"; and Frederic L. Holmes and Kathryn M. Olesko, "The Images of Precision: Helmholtz and the Graphical Method in Physiology," *The Values of Precision*, ed. Wise, 198–221.
39. Dettelbach, "Humboldtian Science."
40. See Kant, *Critique of Pure Reason*, ed. and trans. Paul Guyer and Allen W. Wood (Cambridge: Cambridge University Press, 1998), 153–92, 219–66.
41. See Daston and Galison, "The Image of Objectivity."
42. See Humboldt, *Expériences sur le galvanisme, et en général sur l'irritation des fibres musculaires et nerveuses* (Paris: Didot Jeune, 1799); Dettelbach, "The Face of Nature"; Schaffer, "Self Evidence"; and Richards, *The Romantic Conception of Life*.
43. The picture adorns the cover of Andrew Cunningham and Nicholas Jardine, *Romanticism and the Sciences* (Cambridge: Cambridge University Press, 1990).

44. Letters from Humboldt to Pictet, 22 June 1798 and 7 November 1798, letter to Forell, 24 June 1799; repr. in *Lettres Américaines d'Alexandre de Humboldt, 1798–1807*, ed. E.T. Hamy (Paris: E. Guilmoto, 1904), 5, 7, 23, 39.
45. Peter Galison, "Objectivity Is Romantic," ACLS Occasional Paper 47 (2000), 83; and Daston, "The Moral Economy of Science."
46. Relevant discussions of the role of instruments in social and epistemological coordination include Crary, *Techniques of the Observer*; Sibum, "Reworking the Mechanical Value of Heat"; Galison, *Einstein's Clocks and Poincaré's Maps*. See also the various contributions to *Culture technique* 7 (1992) and *Osiris* 9 (1993).
47. Dettelbach, "Romanticism and Administration," 133; and Schaffer, "Astronomers Mark Time."
48. Morell and Thackray, *Gentlemen of Science*, 509–17; Cannon, *Science in Culture*, 181–96.
49. Humboldt, "Des lignes isothermes et de la distribution de la chaleur sur le globe."
50. Cawood, "Terrestrial Magnetism and the Development of International Collaboration in the Early Nineteenth Century"; Mary Louise Pratt in *Imperial Eyes* places Humboldt's natural history in the context of exploration and imperialism, as does Michael Dettelbach in "Romanticism and Administration." Unquestionably the projects of surveying, mapping, and artistically evoking the Americas were enticements for colonial and imperial adventures, many of which had dire consequences for the inhabitants of these lands. It is possible, however, to read an image like the frontispiece of *Views of the Andes*, in which a mythological figure representing western classical culture raises a fallen Aztec god to his feet, not as paternalistic bad faith but as a depiction of the late Enlightenment ideal of freedom as *reciprocity and interdependence*. The success of Humboldt in instituting this ideal is another question.
51. See Schiller to Körner, 23 February, 1793: "I know of no better image for the ideal of a beautiful society than a well executed English dance. . . . A spectator located on the balcony observes an infinite variety of criss-crossing motions which keep decisively but arbitrarily changing directions without ever colliding with each other. Everything has been arranged in such a manner that each dancer has already vacated his position by the time the other arrives. Everything fits *so skillfully, yet so spontaneously*, that everyone seems to be following his own lead, without ever getting in anyone's way. Such a dance is the perfect symbol of one's own individually asserted freedom as well as of one's respect for the freedom of the other." Schiller, *On the Aesthetic Education of Man, in a Series of Letters*, 300 (italics mine).
52. Humboldt frequently plays a role in accounts of the institution of standards and new instrumental verification; in his correspondence he served as a human relay at the intersection of multiple networks of scientific practitioners. On methods discussed here see transitional chapters by Wise in *The Values of Precision*; Kathryn M. Olesko, "The Meaning of Precision," ibid., 103–24; Schaffer, "Astronomers Mark Time"; Joseph O'Connell, "Metrology: The Creation of Universality by the Circulation of Particulars," *Social Studies of Science* 23 (1993): 129–73; and Alder, *The Measure of All Things*.

53. Humboldt rarely foregrounds the language of "objectivity" versus "subjectivity"; when he does so it is not to disparage the latter in favor of the former. In *Cosmos* he writes that "the objective world, conceived and reflected in us by thought, is subjected to the eternal and necessary conditions of our intellectual being." Humboldt, *Cosmos*, 76. Humboldt, like Schiller (and Hegel), saw the goal as an eventual fusion of the two terms. In the same paragraph Humboldt writes, "Science only begins when the spirit takes possession of substance, when the attempt is made to subject the mass of experience to rational knowledge; science is spirit turned towards nature. The external world exists for us only when we take it into ourselves and it forms itself into a view of nature." The existence of the "external" or "objective" world requires that a human being "takes hold" of or "overpowers" (*bemächtigt*) external substance (*Stoffe*) and then "forms" it into a view of nature (*Naturaanschauung gestaltet*)—the same dynamic interaction between "Stoffe" and "Gestalt" that Schiller calls the aesthetic state. Humboldt's "view of objectivity" should thus be understood, perhaps paradoxically, as a mixture between "objectivity" and "subjectivity," a tension analogous to the paradox of *autonomy* in Schiller (see note 33, above), in which the goal is the "moral state," itself a mixture of "morality" (form) and its opposite, "sense" (substance). In both, crucially, the two terms are balanced by concrete mediators: art, instruments. (Thanks to Aaron Davis for philological assistance.)
54. On Humboldt as transitional figure to nineteenth-century laboratory science see Finkelstein, "'Conquerors of the Künlün'?"; see also cameo appearances in Cahan, *Herman von Helmholtz and the Foundations of Nineteenth-Century Science*. Lenoir has argued that we see Helmholtz's findings as accounts of complex experimental arrangements of diverse interacting apparatuses, the kind of amalgamated system that Humboldt arranged on a global scale.
55. Note also the radical shift in modes of sociability, labor organization, and the image of the science that accompanied Le Verrier's replacement of Arago at the Paris Observatory; on factory discipline in the observatories of the 1860s, especially Airy, see Schaffer, "Astronomers Mark Time"; and Aubin, "The Fading Star of the Paris Observatory in the Nineteenth Century."
56. For recent work on Arago as a popularizer and politician see Aubin, "The Fading Star of the Paris Observatory in the Nineteenth Century"; Levitt, "Biot's Paper and Arago's Plates." Arago's interest in the labor and skill of science was part of a general rise before 1848 in reflection on "work" as scientific concept and "labor" as political and moral concern; key references on this development include William H. Sewell, *Work and Revolution in France: The Language of Labor from the Old Regime to 1848* (Cambridge: Cambridge University Press, 1980); Jacques Rancière, *The Nights of Labor: The Workers' Dream in Nineteenth-Century France*, trans. John Drury (Philadelphia: Temple University Press, 1989); Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (New York: Basic, 1990); Robert Michael Brain, "The Graphic Method"; François Vatin, *Le travail: économie et physique, 1780–1830* (Paris: Presses Universitaires de France, 1993); and Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press,

1958). "Essence and emblem" is from Daston and Galison, "The Image of Objectivity," 123.

57. On Arago see M. Susan Barger and William B. White, *The Daguerreotype: Nineteenth Century Technology and Modern Science* (Baltimore: Johns Hopkins University Press, 2000), 27; F. Arago, "Le Daguerréotype," *Œuvres complètes*, 7:455–63, is commented upon by Benjamin, "A Small History of Photography," *One-Way Street and Other Writings*, trans. Edmund Jephcott and Kingsley Shorter (London: Verso, 1979), 240–57.

58. On Humboldt and the birth of environmentalism, see Aaron Sachs, *The Humboldt Current: A European Explorer and his American Disciples* (Oxford: Oxford University Press, 2007). Humboldt's deployment of instruments as an autonomous externalization of the categories is part of a more general movement of post-Kantian philosophy. While retaining the idea that knowledge is a function of the subject as much as of things, many displaced the categories from their seat in the transcendental ego: Schiller's view that the formal universals of art, politics, and science must emerge within collective material practices was one response to this crux; Schopenhauer relocated the constitutive ego in the will and physical drives, making representations of the world a function of physiology; Wilhelm von Humboldt located the structures of thought in culturally and historically variable, external, and shared languages. For a comparison of the energetic conceptions underwriting the work of the Humboldts see Peter Hans Reill, "Science and the Construction of the Cultural Sciences in Late Enlightenment Germany: The Case of Wilhelm von Humboldt," *History and Theory* 33 (1994): 345–66; on the stature of the Humboldts later in the century and their influence on Boas's concept of "culture," see George W. Stocking Jr., *The Shaping of American Anthropology, 1883–1911: A Franz Boas Reader* (New York: Basic, 1974), and Matti Bunzl, "Franz Boas and the Humboldtian Tradition: From *Volksgeist* and *Nationalcharakter* to an Anthropological Concept of Culture," *Volksgeist as Method and Ethic: Essays on Boasian Ethnography and the German Anthropological Tradition*, ed. George W. Stocking Jr. (Madison: University of Wisconsin Press, 1996).

59. Botting, *Humboldt and the Cosmos*, 268, 273.

"I thought this might be of interest . . .": The Observatory as Public Enterprise

THERESA LEVITT

In 1862 Victor Hugo set down to record what he called one of his "deepest memories."[1] Twenty-eight years earlier, in 1834, he had paid a visit to the Paris Observatory. The director, François Arago, was in, and led him to one of the large telescopes with the instruction to look through it. As Hugo remembered it, they then had the following conversation:

> "I see nothing," I said.
> Arago replied: "you see the moon."
> I insisted: "I see nothing."
> Arago maintained: "keep looking."

Arago then explained to Hugo that he had just undertaken a voyage. Where before he had been, like all inhabitants of the earth, 90,000 leagues from the moon, he was now, because of the enlarging power of the telescope, only 225 leagues away. Hugo again claimed that he saw nothing, and Arago again instructed him to keep looking. Then, said Hugo, "I followed the example of Dante with respect to Virgil. I obeyed." Hugo marveled at the vision of the moon before him. Suddenly a streak of light appeared on the dark surface. The sun was rising on the moon. As Hugo looked, Arago listed the lunar features as the light revealed them: the volcano Messala, the Promontorium Somnii, Mount Proclus, Mount Céomèdes, Mount Petavius. "There is no more mysterious spectacle than the irruption of dawn in a universe covered in obscurity," Hugo later wrote. "One seems to be witnessing the payment of a debt of infinity."

What does this episode add to our understanding of the observatory? Was Hugo simply an extraneous guest passing through without altering the