The Bonds of Science

Like the colonial theologians and regimental soldiers discussed in chapter 1, sacrificial scientists in the late nineteenth-century encountered a problem of exchange. Would suffering be compensated by new scientific knowledge? If so, just how readily ought one to embrace it? Might particularly painful, spectacular effort guarantee science’s favor? As before, such questions gave practical form to the question of how one should live. And as before, answers to such ethical questions occasioned appraisal of the unseen force consummating the exchange. Where God or nation once bestowed value on the self’s offerings, by the last quarter of the nineteenth century, science occupied a similar role.

The efflorescence of self-sacrifice in discussions of science after 1875 relied not only on a general preoccupation with voluntary suffering but also on an imagination of science as sovereign, immortal, and deserving of oblation. As discussed, the figure of the suffering scientist stemmed from the transformation of selfhood and property that attended the demise of racial slavery and the ascendance of industrial capitalism. However, it grew equally out of the increasing visibility and authority of science, which itself rested on two interrelated developments: the first primarily material, involving the growth and organization of institutions, standards, and networks; the second primarily symbolic, involving a transformation in vocabulary and customs of reference. Attending to both of these developments, in this chapter I recount how a staggering new array of buildings, practices, participants, methods, and findings came to be understood as aspects of the single, quasi-metaphysical entity *science*. What relations existed between an emerging science and the postbellum voluntary self? Framing the connection between scientist and science as one of self-sacrifice opened scientists to not only the indeterminacy of the free self but also the ambiguous nature of the *gift*: that point at which “obligation and liberty intermingle.” This chapter illustrates the tangled and conflicting types of gift evident in scientists’
sacrifices and addresses the particular roles allotted to science in framing those relationships.

**THE ETHOS OF** self-sacrifice evoked by late nineteenth-century scientists emphasized both voluntarism (the act must be intentional rather than accidental) and loss (it must be governed by something other than calculated self-interest). An 1895 essay by Edwin Emory Slosson exemplifies the importance of this principle of loss in scientists’ usage. Writing for a popular New York newspaper, the young chemist from Wyoming argued that a common urge toward sacrifice unified seemingly disparate kinds of investigators:

A biologist who wishes to study the life history of the tapeworm grows one in his own body; a physician ruins his health by experimenting on processes of digestion in his own stomach; a geographer risks his life to get a barometric reading; a bacteriologist inoculates himself only too successfully with a disease germ; a sanitarian, in order to test the effect of decomposed organic matter on the human system, drinks sewer water for a month; a chemist works for years on compounds so explosive that the careless touching of a few grains would kill him.

Yet these cases were merely the most spectacular examples of “self-sacrifice.” Even more theoretical or abstract scientific pursuits, Slosson continued, “cost someone years of toil or, perhaps, his life.”

“Immense expenditure” stands at the center of this account of science. The rewards of scientific work do not “outweigh” individual sacrifices of life and limb. Suffering does not complete a grand theory of physical forces or unravel the mysteries of the human body. At best, Slosson proposed, self-sacrifice might help deduce the “fourth decimal” of some infinitesimal fact, the vaporous traces of a fundamentally unattainable truth. Indeed, voluntary submission to science’s limitless movement is the scientist’s defining attribute. “It may safely be said that if it were known that an important scientific discovery, say one which would fill a few lines in some large manual, could be made, but only at the cost of the life of the investigator, there would be no lack of volunteers.” Far from appearing intrinsically calculating and acquisitive, the scientist here appears peculiarly prone to forfeiture. Science proceeds not through the investigator’s cautious allocations of effort but through ostentatious giving—through what Slosson terms “self-immolation on the altar of science.”

Slosson’s self-immolating scientist reproduces the characteristic tensions of the “willing captive” discussed in chapter 1, including the ambiguities of possessive individualism inherent to the voluntarily suffering self (the biologist grows a tapeworm in his own body, the bacteriologist inoculates himself, and so on). At the same time, Slosson’s remarks help introduce a second set of tensions, which similarly recur throughout the examples discussed in the four sub-
sequent case studies: namely, the undecided character of the sacrifice. For late nineteenth-century scientists no less than for combatants in the war between the states, the sacrificial act must remain purposeful lest it be confused with simple self-destruction. The investigator who ate tapeworms just to eat them would not be giving something of himself for science; he would simply be de-ranged, degenerate, ignoble. The reason for activity was of primary importance in bestowing sacrificial meaning. Thus, the sacrificial gift entailed finding the appropriate balance of liberty and obligation: involuntary forfeiture—immolation by force rather than self-immolation—implied only the vile debasement of captivity; voluntary trade, such as contractual exchange, implied only the alienation of the market. The true self-sacrifice must be freely chosen but not too calculated. It must be willful—an intentional, reasonable offering—while remaining somewhat immoderate, uncompensated, “excessive in advance.”

As subsequent chapters will show, late nineteenth-century commentators diverged on their negotiation of this tension. Some suggested that science would amortize individual suffering; all that was needed was a reasoned assessment of the proper investment. Others argued that such judicious calculation was incompatible with the ethos of sacrifice. The scientist could never strategically barter suffering for knowledge since exchanging blood or labor in order to acquire a new fact annulled the meaning of the gift. For these proponents of self-sacrifice, an evident lack of compensatory reason is precisely what preserved the special status of the self’s offering.

Some readers will recognize in such divergence echoes of a long-standing argument in social theory concerning the nature and function of the gift. In the most influential contribution to this debate, anthropologist Marcel Mauss argues that the free gift as such is illusory. In actuality, each gift perpetuates a complex system of reciprocity. Every item seemingly given (“food, women, children, property, talismans, land, labour services, priestly functions, ranks”) possesses something of the giver, something that is “there for passing on, and for balancing accounts. Everything passes to and fro as if there were a constant exchange of spiritual matter.” There is no true, pure gift in Mauss’s framework since the obligation to reciprocate persists: “exchange-through-gift” is the rule. Challenging the presumptive freedom of the gift, his essay effectively troubles the notion of autonomous selfhood at the center of English liberalism. Supplanting ahistorical understandings of the free individual with a fundamentally social sense of personhood, Mauss emphasizes the obligations attendant on all actors, whose norms of conduct fluctuate with changing modes of production.

Yet critics point out that, in conflating gift and exchange, Mauss forecloses the question of uncompensated expenditure. “One cannot deny the phenomenon of the exchanged gift, Jacques Derrida writes, but “the apparent, visible contradiction of these two values—gift and exchange—must be problematized.” Indeed, one might say that Mauss rejects the autonomous, voluntary self of
English liberalism, but only by elevating the utilitarian functioning of the total social system, its overall tendency toward reciprocity and solidarity. In contrast, Georges Bataille shifts the register of analysis from modes of production to modes of consumption, from a universal principle of stability and equilibrium to one of wasteful excess and purposeless destruction. Whereas Mauss viewed the “madly extravagant” destruction of the Northwest Indian potlatch as the “monstrous product” of an overarching principle of obligatory reciprocity, Bataille gives the potlatch fundamental paternity: immoderate squander is the real impetus of social activity.

Rather than placing my reading of late nineteenth-century self-sacrifice in one or the other camp of this theoretical debate, I want to stress that the scientists discussed in subsequent chapters display similar equivocation on the nature of the gift. Moreover, their navigation of the tension between gift and exchange reveals the changing status of science, inscrutable recipient of the sacrifice. Whether sacrifice implied a kind of wholly excessive self-immolation or a form of stabilizing reciprocal exchange hinged on two related questions: the extent to which the suffering self was seen as wholly free (or in some way captive to or possessed by science) and whether science was seen as conforming to procedures comprehensible to its human subjects. Was science a person in the sense that its movements held significance, purpose, desire, aspiration? Or was it more akin to a god, compelled by the bonds of covenant: do ut des, I give so that you may give? The autonomy of science, in short, was as murky as that of the voluntary self.

We thus turn to an exploration of that for which one might choose to suffer. How did such a strikingly diverse set of endeavors (the biologist studying tapeworms, the geographer obtaining a barometric reading, the sanitarian testing the effects of decomposed organic matter) ever come to appear as aspects of a single body, one that might command sacrifice? By what processes were the leisurely investigations of a few curious gentlemen transformed into a dense transnational conglomeration of observers, experimenters, and theoreticians, an assemblage alternately personified or deified as “science”?

In many ways, this consequential transformation can be traced to the founding of local and national European academies in the seventeenth century: the Accadèmia del Cimento in Florence (1657), the Royal Society of London (1660), the Académie Royale des Sciences in Paris (1666), the Akademie der Wissenschaften in Berlin (1700), the Imperatorskaya Academiya nauk in St. Petersburg (1725), and so forth. Learned societies not only cultivated habits of assembly but also helped formalize and disseminate customs crucial to the eventual development of scientific institutions such as the preservation of journals, letters, and papers; the circulation of papers, specimens, and speakers; and the refinement of experimental methods. As historians have argued, the organization of learned societies marked
an important watershed in the move from individual, localized investigation to collective, diasporic practices of inquiry.\textsuperscript{11}

True scientific cosmopolitanism, however, did not arise until well into the nineteenth century, when a number of disparate events and processes converged. Improved postal networks, railways, and telegraphs allowed for enhanced communication across regions and nations, as did the standardization of units, categories, and instruments of observation and measurement. Increasingly complex and numerous interactions among individuals of varying skill and status hailing from diverse linguistic and cultural backgrounds wrought other changes as well. Successful collaboration between distant, heterogeneous observers required meticulous discipline, the careful formulation of behavior and speech. Over time, this discipline was formalized: qualifications for the certification of scientific competence were established, training procedures were implemented, reward systems were enhanced, and specialized congresses and commissions were organized. American investigators participated in these transnational developments in numerous ways, sharing specimens, articles, and informal correspondence; sending students abroad for training; hosting foreign visitors; and joining large-scale efforts such as observations of the 1874 and 1882 transits of Venus and the investigations conducted during the 1882–83 International Polar Year.\textsuperscript{12}

American investigators further promoted this broad expansion and reorganization of scientific labor by reforming their domestic institutions. Among the most formidable of these changes was the transformation of American higher education that had been ongoing since the mid-nineteenth century. The passage of the Morrill Land Grant Act in 1862; the adoption of the elective system at Harvard, Yale, and other denominational colleges; and the establishment of new research universities such as Johns Hopkins (1876), Clark (1889), Stanford (1891), and Chicago (1891) created a radically different context for the production of knowledge. Graduate enrollment leapt from 198 in 1871 to 9,370 in the 1910s, and the number of scientific schools appended to academic institutions climbed from seventeen in 1870 to a height of seventy in 1873.\textsuperscript{13} From these transformed colleges and universities emerged a growing middle class dedicated to the place of science in higher education. These Americans, whose everyday lives were increasingly filled with innovations such as the telephone (patented in 1876) and electricity (established with New York’s Pearl Street station in 1882), were bombarded with claims that science had made these attention-grabbing applications possible. Broader interest in organized research soared accordingly, evident in the fanfare surrounding the opening of Edison’s Menlo Park laboratory in 1876, the popularity of spectacles such as the Centennial Exposition in Philadelphia, and the growth of popular periodicals on science.\textsuperscript{14}
Meanwhile, the establishment of federal agencies, such as an independent Department of Agriculture (1862, achieving cabinet status in 1889), the Bureau of American Ethnology (1879), and the National Bureau of Standards (1901), promoted a sense of solidarity among the various scientific investigators now dispersed around the country, as did the formation of new professional societies such as the American Chemical Society (1876), the American Society of Naturalists (1883), and the American Physical Society (1899). A series of new national journals such as *Science* (1883), the *Journal of the American Medical Association* (1883), and the *Physical Review* (1893) further unified investigators in disparate geographical, disciplinary, and institutional locations. The availability of large sums of capital upheld many of these changes as philanthropists enlarged endowments to libraries, museums, universities, and research agencies. In 1899 alone, donors gave $55 million to higher education, more than $5 million to libraries, and nearly $3 million to museums.15 Through such developments, the “impersonal collectivity” acquired form and substance.

These institutional and economic transformations corresponded to an equally consequential conceptual shift, reflected in changing usage of the word *science*. As production of knowledge about the natural world garnered new financial and institutional clout, the word came to refer to an abstract, autonomous force, one with its own independent course of evolution. To be sure, science had been depicted as an identifiable thing before 1875. In an 1838 letter to Alexander Dallas Bache, for example, Joseph Henry spoke of his desire to “advance the cause” of science, a desire realized in the founding of the American Association for the Advancement of Science in 1848. A generation earlier, the American Philosophical Society employed similar language, noting that its members were “animated by a love of science.”16 Yet these usages were unusual in American letters before the Civil War.17 In the antebellum period, *science* more typically evoked a type of mental discipline, a faculty or quality peculiar to the human mind. This conception of science lingered late into the century. As the editor of *Popular Science Monthly* wrote in 1872, science is not regarded as “applying to this or that class of objects” but “as being, in fact, a method of the mind, a quality or character of knowledge upon all subjects which we can think or know.”18

By 1875, however, references to science as an attribute of the human mind had largely evaporated. No longer implying a form of cerebral discipline, the word instead summoned forth an independent body with its own intrinsic imperatives. Physicist T. C. Mendenhall made this shift plain in an 1890 address, when he delineated the public’s “obligations to science and her votaries.” “Thanks to science,” he declared, “time and space are practically annihilated; night is turned into day; social life is almost revolutionized and scores of things which only a few years ago would have been pronounced impossible, are being
accomplished daily.” As Mendenhall’s words suggest, by 1890 science implied an exacting and captivating agent, one said to merit deference from “her” votaries. Although the boundaries of science remained flexible and contentious (it might or might not include grammar, theology, or history, for example), after 1875 science almost invariably appeared in American writings as a disembodied entity with independent command.

It might be said that science was coming to be experienced as an “imagined community,” in the words of political theorist Benedict Anderson. Like the nations of which Anderson speaks, this imagined community had four chief attributes. First, science was imagined in that most of its members would never know one another. Scattered by discipline, institutional affiliation, status, and geographical location, one would never see or know all of the colleagues toiling away in distant field sites, observation stations, laboratories, or classrooms. Second, it was limited in that even the most expansive concepts of science presumed boundaries beyond which resided other domains of living: art, politics, medicine, industry, religion, and so on. Again, exactly which of these overlapping domains might be considered part of science remained subject to continual debate (for example, is medicine scientific?); but in each case, “science” was delimited. Third, science was sovereign in that, like the nation, it acquired authority as the role of divine governance receded. Indeed, what distinguished science from earlier traditions, historian Andrew Cunningham argues, “is that Natural Philosophy was an enterprise . . . about God.” In contrast, science “is an enterprise which (virtually by definition) is not about God. God, His existence and attributes are taken to be irrelevant to science and the practising scientist.”

Fourth, science was a community: as Anderson writes of the nation, despite the “actual inequality and exploitation” apparent in its institutions, science was “always conceived as a deep, horizontal comradeship,” a fraternity between members (as Lorraine Daston puts it) “equal in their anonymity.” Ultimately, Anderson proposes, it is this fictive sense of fraternity that enables so many people not merely to kill for the sake of the imagined community but also “willingly to die” in its name.

The imagination of science as a sovereign subject allowed for a reorganization of time—a submerging of the individual’s present life for the sake of the envisioned future of the collective body. Like the soldier willing to die for the nation or the disciple willing to die for God, the scientist’s deferral to a delayed destiny secured the suspension of immediate interest necessary for the continuation of science. Max Weber offered perhaps the most famous explication of this deferral in his 1918 speech, “Science as a Vocation.” Here Weber argued that because science’s continual expansion denies any prospect of culmination, the scientist must subjugate himself to the future growth of knowledge. To accentuate his vision of science as constantly expanding, Weber distinguishes it from
art. While artists might share with scientists certain attributes (like single-minded devotion), science differs from all artistic endeavors in its denial of restitution:

Scientific work is chained to the course of progress; whereas in the realm of art there is no progress in the same sense. . . . A work of art which is genuine ‘fulfillment’ is never surpassed; it will never be antiquated. . . . In science, each of us knows that what he has accomplished will be antiquated in ten, twenty, fifty years. That is the fate to which science is subjected; it is the very meaning of scientific work, to which it is devoted in a quite specific sense, as compared with other spheres of culture for which in general the same holds. Every scientific ‘fulfillment’ raises new ‘questions’; it asks to be ‘surpassed’ and outdated. Whoever wishes to serve science has to resign himself to this fact.\textsuperscript{25}

Artists might toil and suffer in the process of their work. Artists might valorize self-sacrifice. But unlike scientists, Weber insists, artists can attain fulfillment. In his view, the “very meaning” of science rejects such fulfillment. Without a willingness to defer satisfaction indefinitely, to “ask to be surpassed and outdated,” scientific work could not proceed. The scientist’s resignation to a life of forfeiture is the basis of science’s existence.

It would be a mistake to take Weber’s 1918 comments on voluntary subjection as an accurate assessment of the intrinsic nature of science (or, for that matter, of art). As noted, the idea that science as a discrete thing “chained to the course of progress” was itself an artifact of the nineteenth century. Weber’s comments concern us here not as evidence of the timeless character of science but as a way to consider the norms of scientific selfhood being configured at that time. Imagining science as eternal positioned subjects of ethical reflection as members of another, immortal body. “Let it be remembered,” wrote Cincinnati astronomer Ormsby Mitchel, “that the astronomer has ever lived, and never dies. The sentinel upon the watchtower is relieved from duty, but another takes his place, and the vigil is unbroken.”\textsuperscript{26}

Indeed, a repositioning of the subjects of science necessarily attended the growth of supranational networks of investigation in the nineteenth century. As Daston, Galison, and Levine have argued, novel forms of collaboration among far-flung investigators entailed novel expectations for knowing subjects, epistemological ideals better suited to the types of transnational practices coming into being at midcentury. In place of a focus on distinctive, trustworthy individuals, which characterized inquiry in the seventeenth and eighteenth centuries, there arose a call for observers “unmarked by nationality, by sensory dullness or acuity, by training or tradition; by quirky apparatus, by colourful writing style, or by any other idiosyncrasy that might interfere with the communication, comparison, and accumulation of results.” Drawing primarily on English, French,
and German sources, Daston and others demonstrate how the nineteenth-century investigator’s individual persona was to be submerged into the communal body of science. “L’art c’est moi,” as physiologist Claude Bernard declared; “la science, c’est nous.”

American investigators joined this transatlantic revision of norms, expanding and elaborating their engagement as the upheaval of Civil War slowly settled. In their depictions, the relationship between the self and the increasingly potent figure of science was clearly one of subordination. “Man,” declared *Scientific American* in 1890, is but “the ward of science.” Man, echoed the *Pedagogical Seminary* in 1901, while not “an organ in the body of science” is at least “a cell with functions truly vital.” Whether positioned as ward to guardian, cell to body, or proselyte to deity, the characteristic forms of subjection attributed to the scientist changed in tandem with the characteristic forms of command imputed to science. Each vision of science’s governance effected a distinct vision of self-governance and vice versa.

The advent of the word *scientist* suggests the mutually constitutive relationship between science and its subjects. The word entered the lexicon for the first time in March 1834, introduced by English polymath William Whewell. Reviewing a treatise on the physical sciences, Whewell lamented the “disintegration” of investigative unity: the “mathematician turns away from the chemist; the chemist from the naturalist; the mathematician, left to himself, divides himself into a pure mathematician and a mixed mathematician.” To combat the increasing fragmentation of practices of inquiry, Whewell proposed the umbrella term *scientist* as an appropriately “general term by which these gentlemen could describe themselves.” His neologism gained currency slowly, however, and in the United States displaced more common terms such as *experimental philosopher* or *naturalist* only late in the century, as *science* came to appear as an agent in its own right.

The slight but meaningful distinction between the recent term *scientist* and the older *man of science* attests to the arrival of a novel and still unsettled subject of ethical reflection. Like *man of the cloth*, the phrase *man of science* implies an individual who exists independently of the collective, an identifiable agent who still requires a preposition (“of”) to join the larger body. With the dissemination of the word *scientist*, this emphasis on the independence of the willful human recedes; he belongs to it, is possessed by it. Science’s status as the subject in whose name action takes place is accordingly enlarged. In place of “man,” “science” itself now demands, revolutionizes, determines; the scientist, the person defined by science, merely responds.

A flexible ethic of self-sacrifice helped mediate the emergent relationship between the imagined body of science and the freshly minted figure of the scientist. As discussed, the phrase *self-sacrifice* came into English in the early nineteenth century, at the same moment that property-in-the-person superceded
the ownership of dispensable wealth as the defining condition of civic membership. Self-sacrifice's increasing prominence after 1875 can be said to reflect increasing strain on liberal ideals of autonomous selfhood and consensual contract in changing historical circumstances—including increasingly professionalized and specialized practices of inquiry. As Simon Newcomb concluded in 1904, high among the “common elements and common principles” that bind “the seemingly unending subdivision of knowledge” is the idea that science “offers an even nobler field for the exercise of heroic qualities than . . . that of battle.” Like other Gilded Age Americans seeking bulwarks against rampant greed, scientists labored to differentiate the alienable from the inalienable, seeking in science a way to protect the sacred “me” from the profane, salable “mine.”

The tensions evident in these efforts—tensions that express larger social contradictions—were given poignancy and immediacy by the matter of voluntary suffering. Would the amputation of one’s fingers or toes serve to advance knowledge, or were these efforts ultimately futile and destructive? Was nonproductive expenditure—the deliberate squander of useful things—precisely the point, in that it lifted both science and scientists beyond the debasing calculations of the market? As I will discuss in subsequent chapters, divergent answers to these questions were possible. Some writers described scientific work as a contractual relationship, in which parts of the self (stomach, hands, thought) were temporarily bartered based on assumed returns of equal or greater value. Others described a process of deliberate disowning, a principle of forfeiture designed to distance themselves from the accumulative mindset of “the masses.” Confusion and conflict over the meanings of sacrifice reflected the contradictory pressures of American life in an era of unfettered capitalism.

Again, such debates over sacrifice were not the only avenues available for framing the relationship between the scientist and science. The point is not that self-sacrifice was ubiquitous in late nineteenth-century science but that the spread of self-sacrifice at this time suggests an emergent form of ethical reasoning, new modes of working on the self. The triumph of liberalism left the status of the gift oddly uncertain. In the age of the contract, the reason of and for sacrifice was ever in question, for scientists no less than for others.