Chapter 3

Transforming Pure Science into Basic Research

The Language of Science Policy in the United States

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Between the seventeenth and early nineteenth century, various European scholars introduced a distinction between a pure and a practical or applied part of their respective disciplines (Kaldewey 2013: 328–330). Differentiations between "pure" and "mixed" mathematics, for example, were elaborated by the Flemish mathematician Adriaan van Roomen in 1602, by the English philosopher Francis Bacon in 1605, and, later, by the German philosopher Christian Wolff in 1716. While those distinctions had their roots in the ancient concepts of theory and practice, in 1751 the Swedish chemist Johan Gottschalk Wallerius developed a modern division of pure and applied chemistry that avoided the connotations of the older distinction, because both pure and applied chemistry included theoretical as well as practical work (Meinel 1983). In the late eighteenth century, Immanuel Kant granted the natural sciences the status of "pure science" in general because they were based on "a priori" conceptualizations of nature such as assumptions on causes and effects (see also chapter 2), and in 1817 the British polymath Samuel Taylor Coleridge, inspired by Kant's transcendental philosophy, introduced the terms "pure sciences" and "applied sciences" to the English language (Link 1948; Yeo 1991; see also chapter 1). Given these various categorizations and their heterogeneous cultural backgrounds, it does not make sense to assign priority to any one term's origin. It is evident nevertheless that debates about such terminologies, as well as the associated strategic identity work, took place in those European nations forming the core of the developing modern science system. Against this background, the question we address in this chapter is whether and how American scientists in the nineteenth and twentieth century built on this European tradition. The question is important not least because it is well known that, after World War II, it was scientists and policy makers from the United States who were most influential in establishing the distinction between basic and applied research in science policy regimes around the globe. It appears, therefore, that the global language of science policy was first developed in Europe, but then, in the course of the twentieth century, became coupled to the rise of the United States as the leading science nation.

It is, however, too simple to assume that in the beginning U.S. scientists and engineers merely adopted European semantics. While at first glance there are no original American concepts of science or research before World War I, a closer look reveals that a "pure science ideal"—or, in a more critical reading, a "pure science ideology"—emerged between the 1850s and 1880s (albeit slowly) that was not identical with European notions of pure science. In the late nineteenth century, this ideal was so strong that conceptions of "technology" and "engineering" were commonly construed as "applied science," thus leaning on the positive connotations of "pure science"—that is, the scientific spirit and rigorous methodological standards (Kline 1995; Forman 2007). Around 1900, the United States thus firmly had established a distinction between pure and applied science (Lucier 2012). The pervasiveness of this distinction in public and scientific communication at that time, however, disguises the subtle differences between European and American categorizations, as well as the fact that the meanings and values associated with the terms "pure" and "applied" were still far from being stable.

The American pure science ideal in its most famous articulations—the mainstream reference is physicist Henry Rowland's "A Plea for Pure Science" from 1883—was formulated against utilitarian research ideals and professional scientists who were more interested in business than scientific explorations (Daniels 1967; Hounshell 1980). The idea of pure science, however, was never truly devoid of utilitarian references. Rather, pure science had from the very start been characterized as the origin for future practical applications—an argument in place as early as the 1830s in Britain and which may be summarized as "postdated utilitarianism" (Shapin 2008: 43). Meanwhile, roughly between 1900 and 1940, several new research ideals and practices emerged that gradually transformed the semantic field for categorizing scientific endeavors: new categories such as "industrial research" or "fundamental research" emerged, transcending the boundaries between pure and applied science. It thus became more common to talk about "research" instead of "science" (Godin and Schauz 2016; Kaldewey and Schauz 2017). Finally, in the 1930s and 1940s, these various semantic developments began to merge into “basic research,” a new concept that became predominant after 1945 (Pielke 2012; Schauz 2014).

In short, the role and reputation of American science in relation to Europe changed radically between 1850 and 1960. The historiography of American science has extensively debated and reflected upon this transformation. The starting point for such debates was the notorious verdict of Alexis de Tocqueville ([1840] 2010: 775–788), who stated that “Americans are more attached to the application of the sciences than to the theory.” The narrative that American scientists in the nineteenth century and beyond draw on the scientific output from the Old World was reiterated until the mid-twentieth century (e.g., Shryock 1948), presuming “that there was no American science worth speaking about before 1945, let alone as far back as 1880” (Kevles, Sturchio, and Carroll 1980: 27). This picture became more nuanced in the 1970s, after several historians pointed to nineteenth-century America’s genuine contributions to diverse fields in the natural sciences (Reingold 1964, 1972, 1976, 1979; Daniels 1972; Cohen 1976; Kevles [1977] 1995). Moreover, the history of industrial research in the first half of the twentieth century reveals a specific American style of organized research (Reich 1985; Wise 1985; Dennis 1987; Hounshell and Smith 1988; Hounshell 1996; Shapin 2008). While this reassessment of the United States’ history of science concerns the actual progress of scientific knowledge production, in this chapter we ask how scientists and other stakeholders in the nineteenth and early twentieth centuries communicated the means and ends of scientific research in the United States. The fact that similar terms (e.g., “abstract science,” “pure science,” and “applied science”) were deployed in the old and the new world does not mean that their related meanings and rhetoric were synonymous.

After 1945, the United States became not only the key player in the global repositioning of science policy, but also the source of semantic innovations: since then, Europeans have been copying key concepts and ideas from American discourse on science policy. The most successful “export” product is likely the category of basic research, which gained a specific meaning in the Bush Report and was a tremendous influence on science policies around the world. Yet even after the heyday of the ideal of basic research in the 1960s, the United States has remained a prime exporter of science policy concepts, as can be seen in the more recent discourse about “grand challenges” or in the metaphorical notion of “frontier research” (see final chapter). An entire body of literature discusses the new “social contract for science,” as well as the establishment of U.S. federal science policy in the second half of the twentieth century (e.g., Guston and Keniston 1994; Sarewitz 1996; Elzinga 2012). Yet such literature focuses far less on the semantic shift leading to the new key concepts of basic and applied research and their multiple meanings and discursive functions.

We reconstruct the history of changing science and research categorizations in the United States from the 1840s to the 1960s in four steps. In the first section, we look at how U.S. scientists built upon semantic traditions from Europe, most commonly upon the distinction between "abstract" and "practical" sciences. We then trace the ideal of "pure science" and its transformations during the second half of the nineteenth century. The third section concentrates on the new categories of industrial, fundamental, and basic research that appeared at the dawn of World War I. The fourth and final part of this chapter analyses how "basic research" prevailed over former concepts and functioned as a contested but successful boundary concept that could deal with conflicting demands upon science in Cold War America.

Semantic Heritage: Abstract and Practical Sciences

In 1815, the well-rounded man David Humphreys—a colonel during the Revolutionary War, an American ambassador to Portugal and Spain, confidant to George Washington, entrepreneur, and, finally, a poet and author—published a drama playing upon the cultural differences between Americans and Englishmen. Humphreys argued that there was not as great a difference as might be expected between "educated men in Europe and America" because they studied the same classical authors. On the other hand, he held that Americans were more prone to practical than contemplative activities: "But Americans in general, and more especially in the Eastern States, from the smallness of their fortunes, the necessity of applying themselves to some profession, and the consequent want of leisure, have fewer opportunities than Englishmen, for indulging themselves in the pursuit of abstract science, or the acquisition of ornamental accomplishments" (Humphreys 1815: 11). Although not addressing science or scholarship in this drama, Humphreys anticipated an argument that became a common diagnosis in nineteenth-century American science. This diagnosis built on the distinction between "abstract" and "practical" sciences, a semantic pair that originated in eighteenth-century Britain (see chapter 1). The meanings of both these terms, however, were ambiguous. Daniel Kevles ([1977] 1995: 6) stated that for nineteenth-century American professionals, "abstract science" meant the "study of nature for the sake of understanding its substance, its working, its laws"; whereas "practical science" implied "the exploitation of nature and nature's laws for the sake of material development." Kevles' definition, however, projects a twentieth-century meaning of the basic/applied distinction onto the past.[1]

It might be more true to say that, in the first half of the nineteenth century, there was no genuine U.S. terminology categorizing different forms of research. Rather, there was a belief among the enlightenment-influenced political founding fathers that science is necessarily both revealing the truth of nature and practically relevant (Cohen 1976: 370). Scientists did not feel the need to "draw the sharp line of cleavage between 'pure' and 'applied' science" (Cohen 1948: 62–63; see also Reingold 1970: 174). There was, in other words, an appreciated social practice called "science," but no requirement to distinguish variations within that category.

Furthermore, early uses of the term "abstract science" indicate a certain uneasiness. In 1830, for instance, *The North American Review* published a report about the New England Asylum for the Blind, the first school for the blind in the United States. The anonymous author discussed the possibility that abstract science might be a useful occupation for blind people:

> The blind, from the cheerful ways of men cut off, are necessarily excluded from the busy theatre of human action. Their infirmity, however, which consigns them to darkness, and often to solitude, would seem favorable to *contemplative habits,* and to the pursuits of *abstract science* and *pure speculation.* Undisturbed by external objects, the mind necessarily turns within and concentrates its ideas on any point of investigation with greater intensity and perseverance. It is no uncommon thing, therefore, to find persons setting apart the silent hours of the evening for the purpose of composition, or other *purely intellectual exercise.*[2]

The notions associated with abstract science—"contemplative habits," "pure speculation," and "purely intellectual exercise"—evidence the influence of a European, particularly humanist, tradition, and reveal a tremendous cultural distance: abstract science is depicted here not as an occupation for noblemen and the higher strata of society but rather for the disabled, who may in turn, however, ennoble their life. In other words, we see here not hostility toward abstract, theoretical, or intellectual activities, but rather a feeling of strangeness.

The *locus classicus* of the argument that Americans felt more inclined toward practice than theory is Alexis de Tocqueville's *Democracy in America,* an extensive work published originally in French in two volumes in 1835 and 1840. Again, it is important to keep in mind that this book was written from a European perspective and thus imposed European categorizations of science on American tradition. The work contains a famous chapter titled "Why the Americans Are More Attached to the Application of the Sciences Than to the Theory" (Tocqueville [1840] 2010: 775–787). In his notes on the chapter,[3] Tocqueville divides the sciences into three parts: (a) "purely theoretical" or "abstract," (b) "theoretical but close to application," and (c) "absolutely applied" (Tocqueville [1840] 2010: 775). "The Americans," he continues, "excel in the last two and neglect the first one." Thus while the American mind is "clear, free, original and fruitful," there is also "hardly anyone in the United

States who devotes himself to the essentially theoretical or abstract portion of human knowledge" (Tocqueville [1840] 2010: 778).

Tocqueville ([1840] 2010: 781) assumes that there are different "motives that can push men toward science": "material interest," "desire for glory," and a "passion to discover the truth." Perhaps, he notes, "the greatest scientists are due uniquely to this last passion." The American people, he argues, lack this quality, and one finds mostly a "selfish, mercenary and industrial taste for the discoveries of the mind." But why is this the case? Tocqueville's answer was that the valuation of applied science is specific for all democratic peoples. While he did not rule out the possibility of some speculative genius in a democratic environment, he was convinced that the "pure desire to know" had in general other preconditions (Tocqueville [1840] 2010: 781), namely, an aristocratic structure that detached science from everyday needs: "All that I want to say is this: permanent inequality of conditions leads men to withdraw into proud and sterile research for abstract truths; while the democratic social state and democratic institutions dispose them to ask of the sciences only their immediate and useful applications. This tendency is natural and inevitable" (Tocqueville [1840] 2010: 785).

For the present argument, the point here is not to assess the plausibility of this hypothesis but rather to understand the changing categorizations of science that Tocqueville's thesis implies. Until today, many authors have cited Tocqueville to frame different narratives of how science and education developed in nineteenth-century America. By following the debates on this issue through the nineteenth and twentieth century, we learn a lot about identity work of scientists and science policy makers in the United States. For example, some four decades after Tocqueville's journey to America, a group of "frustrated American scientists," led by Joseph Henry and Edward Livingston Youmans, invited one of the most famous British lecturers on science, John Tyndall, to promote science and scientific education in America (Cohen 1976: 377–378).

Tyndall closed a series of lectures on light, delivered between 1872 and 1873 in various locations of the United States, with some general remarks about the position of science in American society. The message was simple, and at that time, resonated with the emerging U.S. ideal of pure science: "This, ladies and gentlemen, is the core of the whole matter as regards science. It must be cultivated for its own sake, for the pure love of truth, rather than for the applause or profit that it brings" (Tyndall 1873: 212). Tyndall (1873: 214) then turned to the sensitive issue: "I know what De Tocqueville says of you." Having said so, he did not try to refute the pessimistic assessment by Tocqueville about the problematic relation between democracy and pure science. He expressed, however, the hope that things might have changed in the meantime. One indicator, according to Tyndall, was that practical men were attending his lecture, not because they expected a monetary award but because they were interested in science as an "intellectual good." Furthermore, Tyndall explained that the reductionist view of science as delivering useful material results was not only an American problem, but rather quite salient in England, insofar that both countries "have reason to bear those things in mind" and were in danger to "forget the small spiritual beginnings of such results in the mind of the scientific discoverer" (Tyndall 1873: 216–217). Tyndall ended his lecture by proposing that his American hosts support every student and researcher willing to devote his life to pure science as much as possible. According to him, there was in America "a willingness on the part of individuals to devote their fortunes in the matter of education to the service of the commonwealth," with the chance now given "to wipe away the reproach of De Tocqueville" (Tyndall 1873: 225).

At a farewell banquet for Tyndall, one of the hosts, physicist and amateur astronomer Henry Draper, adopted this argument. He reiterated Tocqueville's thesis by stressing what U.S. scientists owed to their aristocratic British colleagues, believing it was possible to overcome the predicament in the future:

> Together we must try to refute what De Tocqueville has said about us: that communities such as ours can never have a love of pure science. But, whatever may be the glory of our future intellectual life, let us both never forget what we owe to England. Hers is the language that we speak; hers are all our ideas of liberty and law. To her literature, as to a fountain of light, we repair. The torch of science that is shining here was kindled at her midnight lamp. (Draper 1873: 736)

In sum, there was at least a small group of scientists in the 1870s eager to learn how to love "pure science." One might conclude that we can observe a transfer of the European, idealistic tradition to the United States. We should not, however, conclude in haste that this conception of "pure science" was of purely European origin.

Semantic Substitution: The Rise of the Pure Science Ideal after 1850

Given the debates that evolved around Tocqueville's critique of American science, one might conclude that there was no genuine American understanding of pure science until the 1870s.[4] Indeed, most scholars assume that the idea of pure science was firmly established in the 1880s, an assumption backed mostly by Henry Rowland's famous speech "A Plea for Pure Science," delivered in

1883 and published in several prestigious American and British journals.[5] A century later, science studies turned Rowland into the representative of "the *ne plus ultra* of pure science rhetoric in the nineteenth century" (Hounshell 1980: 612).[6] Along with figures such as Robert Merton, Vannevar Bush, and Michael Polanyi, science studies scholars often associate Rowland with elitist notions of unfettered, independent, and autonomous scientific research (e.g., Oreskes 2003: 727).[7] Furthermore, suspicion has been raised that Rowland's ideal of pure science has, "at least implicitly, guided the historiography of science" (Johnson 2008: 611).[8] The actual historical developments, however, are more complicated—for two reasons. First, it is problematic to conceive of historical actors as the "inventors" of new concepts. Contested concepts develop over centuries, travel through various cultures and languages, and only momentarily become stable. In this regard, "pure science" was no novelty in the 1880s: there were various lines of tradition reaching back to both European and American discourses. Second, even if concepts are introduced successfully, they are not stable, but in constant flux.

As indicated above, the terms "pure" and "applied" science were not or only occasionally used before the 1860s; it was more common to distinguish between "abstract" and "practical" sciences (Kevles [1977] 1995: 6; Lucier 2012: 528–529). There are, however, earlier debates dealing with tensions resulting from commercially-oriented research. Around 1850, Alexander Dallas Bache, a physicist that had gained high reputation as superintendent of the U.S. Coast Survey, gathered some scientists and formed a group that he self-mockingly named the "Lazzaroni."[9] Originally, the "Lazzaroni" were lower class beggars in Naples, Italy—scientists in the United States at the time seemed to have felt like beggars asking for money from their fellow citizens in order to indulge in their idiosyncratic lifestyle of scientific research (Jansen 2011: 250). The members of this group were involved in the formation of the American Association for the Advancement of Science (AAAS), the National Academy of Sciences (NAS), and the Smithsonian Institution.[10] While historians have discussed how influential this group has been (Beach 1972), for our argument it is more important to examine what kind of language they employed to communicate the intricate relationship between science and its social environment in a society where no traditional or stable scientific institutions existed.

Joseph Henry—a physicist, member of Bache's Lazzaroni, first secretary of the Smithsonian Institution, and second president of the AAAS—expressed his concerns about how economic influences could corrupt science: "The man of science [pursues] abstract researches [that] pertain not immediately to the wants of life" (Henry 1850, quoted in Lucier 2009: 719). Paul Lucier has shown that Henry carefully distinguished the role of "scientists" from commercially-oriented "professionals." For example, while Henry himself was consulted on various occasions by telegraph companies, he "usually gave his advice for free" and actually rejected money offered to him as compensation for his advice "as a bribe" (Lucier 2009: 719). Even more explicit was Bache, who followed Henry as president of the AAAS in 1850, and said, "Applied science is profitable in a pecuniary sense; but abstract science, on which the other hangs, is not remunerating. Yet how many applications flow from one principle! The world would gain, in a very high ration, by bestowing its rewards for principles, instead of for applications" (Bache 1851, quoted in Lucier 2009: 719). David Hounshell (1980: 616) interpreted Bache's address as "in large part a plea for pure science," anticipating much of Rowland's famous speech thirty years later. Nathan Reingold (1970: 172–177), in contrast, discussed these issues ten years earlier, a time when contemporaries hotly debated American "politics of pure science" (Greenberg 1967). Reingold warned scholars against reducing Bache to a "pure science" role model. According to him, Bache's main achievement was to organize a social milieu in which scientists, engineers, and other stakeholders could come in contact: Bache and his people "did not see any chasm separating theory and practice" (Reingold 1970: 174). In a study of Bache's role in the U.S. Coast Survey, Hugh Richard Slotten (1993: 47) clarifies this argument: to communicate expensive "big science" projects both to the government and public, "the distinction between what we would today call basic and applied research was left usefully obscure."

Today, such interpretations from historians have become historical themselves, projecting specific notions of "pure science" and "basic research" onto the past. In our view, scholars can reflexively control such historiographical problems by focusing more accurately on the role of language in the politics of science. In doing so, we may see that neither Henry nor Bache used the pure/applied distinction; rather, they employed the common terminology of their time, the distinction between "abstract" and "practical" sciences. On the other hand, they are also examples for how prominent scientists began to build new institutions and therefore delivered ideas and arguments for why society should support their scientific work. These arguments, in turn, may have paved the way for the new term "pure science," which gradually took shape in the decades to come.

A valuable source for a first impression of the slow emergence of the pure science concept are the *Proceedings of the American Association for the Advancement of Science.* Between 1848 and 1872, these works contain hardly any distinct references to "pure science,"[11] while in 1873 the chemist Lawrence Smith emphatically used the term in his presidential address. We find in Smith's talk the usual postdated utilitarianism argument, which Bache had already employed two decades earlier for the same occasion. This time, Smith complemented "abstract scientific ideas" by referring to the "man of pure science":

> Let us ever bear in mind that it is abstract scientific ideas which underlie, in these modern days, all discoveries conducive to man's progress, from the making of a pen to the construction of a telescope; or, as Herbert Spencer well expresses it, "each machine is a theory before it becomes a concrete fact." The man of pure science paves the way, erects the mile-stones, and puts up the guide-post for the practical man. (Smith 1873: 5)

Three years later, the *North American Review* published an article titled "Abstract Science in America, 1776–1876" (Newcomb 1876). The author, astronomer Simon Newcomb, compared the development of American science with its European counterpart. Yet, although part of the title, the term "abstract science" appears only once in the lengthy manuscript. Instead, Newcomb employs systematically the up-and-coming terms "pure science" (101, 102, 106, 110) and "applied science" (101, 106, 119, 123). Furthermore, he uses the adjective "pure" several times in connection with "love." Each time, the phrase "pure love" (93, 99, 101) is implemented to foreground the value of science as independent from utilitarian considerations: "The first condition of really successful and important scientific investigation is, that men shall be found willing to devote much labor and careful thought to that subject from pure love of it, without having in view any practical benefit to be derived from it as an important consideration" (Newcomb 1876, 93). This conjunction of "love" and "science" was nothing new—we find it not least in the writing of Tocqueville ([1840] 2010: 775, 781, 782, 785), who was building on a European tradition. The idea of an *amor sciendi* is a recurring motive attributed to those joining the first universities in the twelfth and thirteenth centuries (Grundmann 1960). We also find the term in Rowland's (1883a: 243) speech: "There will be those in the future who will study nature from pure love, and for them higher prizes than any yet obtained are waiting." The question remains, however, on whether the notion of pure science, rooted in a love of truth, was simply a European heritage that found its way into American semantics of science, or whether there was something more unique within the American ideal.

David J. Kevles remarks that the substitution of "abstract science" for "pure science" by Rowland and others added the "connotation of high virtue" to the formerly descriptive phrase (Kevles [1977] 1995: 45).[12] Although true, it does not explain the particular success of pure science as an American ideal in the late nineteenth and early twentieth centuries. There is another, more important, religious connotation in the adjective "pure": while in the late nineteenth-century Europe, this bond had become loose and scientists started distancing themselves from religion, religious puritanism in the United States was a much more relevant cultural influence at the time.

Rebecca M. Herzig examines the relevance of religious puritanism for nineteenth-century American scientists (2005). Herzig deals, among other things, with pure science, making the intriguing point that this ideal was coupled with religious notions of suffering. "Purists" demonstrated their emancipation from material concerns through "embodied displays of deprivation"; they deliberately embraced toil and poverty, and thus enacted a "sacrificial self" (Herzig 2005: 48). Herzig (2005: 49) supports this assumption by examining the biographies of scientists such as psychologist G. Stanley Hall, chemist Ira Remsen, and physicist Henry Rowland, all of whom "imbibed while still in childhood this brew of suffering, moral uplift, and worldly labor." Sociostructural statistics of U.S. scientists between 1861 and 1876 demonstrate that over 27 percent had fathers employed in the ministry. Furthermore, several "pure science" supporters studied for the ministry, originally aiming for a spiritual career before dedicating their lives primarily to science. This trajectory proved relevant for the way they later conceived of scientific practice: "While they moved away from religious service, they maintained Protestant ideals of purification through worldly labor" (Herzig 2005: 49). As researchers, however, they did not perceive this as problematic if religious and scientific values met in the search for truth. Ira Remsen, for example, a renowned colleague of Rowland at Johns Hopkins University, saw a common purpose in religion and science: "The *ultimate* of both science and religion are *infinites* . . . something that gives meaning to all that passes, and yet eludes apprehension; something whose possession is the final good, and yet beyond all reach, something which is the ultimate ideal, and the hopeless quest" (Remsen, quoted in Herzig 2005: 61, emphasis original). Lawrence Smith's address to the AAAS, which has already been quoted above, contains a similar argument: "Science and religion are like two mighty rivers flowing toward the same ocean, and before reaching it they will meet and mingle their pure streams, and flow together into that vast ocean of truth which encircles the throne of the great Author of all truth, whether pertaining to science or religion" (Smith 1873: 24–25).

This picture of scientists transposing Puritan ideals to the sphere of science is quite different from, but not contradictory to, the more common interpretation of the pure science ideal stressing the demarcation between science and commerce. We must, in fact, assume that the religious aspects were often tacit while scientists more explicitly addressed the relationship between science, technology, and industry. Historians such as Hounshell (1980), Dennis (1987), and Lucier (2009) stress that Rowland's pure science ideal basically rooted itself in concerns about the appropriation of science by commercial interests. It would be problematic, however, to reduce the pure science ideal to this kind of boundary work. Similarly relevant for Rowland and others was a more positive definition of what science is about, a positive identity only understandable when seen against the background of religious influences and the corresponding notion of truth—the demarcation against commercialized applied science, as well as the positive, moral and religious values of science nested within each other:

> We are tired of seeing our professors degrading their chairs by the pursuit of applied science instead of pure science . . . . We wish for something higher and nobler in this country of mediocrity . . . . Nature calls to us to study her, and our better feelings urge us in the same direction. . . . Young men, looking forward into the world for something to do, see before them this high and noble life, and they see that there is something more honorable than the accumulation of wealth. (Rowland 1883a: 243, 244)

Furthermore, Rowland uses a biblical metaphor when describing how the pioneers of pure science "strike into unknown forests, and climb the hitherto inaccessible mountains which lead to and command a view of the *promised land*" (Rowland 1883a: 248, emphasis added). In the decades to come, Rowland's speech created a tremendous echo: Countless scientists adopted his rhetoric, reflecting the condition and perspectives of American scientists. They rarely, however, explicated the religious dimension of the pure science ideal, a dimension that in time became further diluted.

Thus, while "pure science" was firmly established as a value, the rationales associated with it (and brought forth to defend it) gradually shifted once more toward utilitarian arguments. At the turn of the twentieth century, many associated "pure science" as a necessary precondition (rather than a counterconcept) for commercialized, applied science. For example, in an article on "Utilitarian Science," the zoologist and first president of California University (Stanford) David Starr Jordan defined what would later be called the linear model of innovation: "Applied science can not be separated from pure science, for pure science may develop at any quarter the greatest and most unexpected economic values, while, on the other hand, the applications of knowledge must await the acquisition of knowledge, before any high achievement in any quarter can be reached" (Jordan 1904: 76). Lucier (2012: 582) summarizes the paradox of the late nineteenth century ideal of pure science by pointing out two contradictory rhetorical strategies: the disassociation of pure science from applied science as opposed to the causal link between them. In other words, science was either (a) purified as a distinct activity separate from technology and commerce, yet somehow related to religion, or (b) understood more broadly as encompassing applied science and technological developments as well—that is, as a complex system in which pure science was a crucial, but not the only, dimension.

Semantic Transition: Adjusting to the Pluralization of Research after 1914

In the early twentieth century we witness a semantic transition correlated with a fundamental structural change to the U.S. research landscape. The increasing industrial demand for scientific research led big companies such as General Electrics or DuPont to establish their own laboratories. Furthermore, the new level of "scientific warfare" that emerged in World War I highlighted the national and military relevance of scientific knowledge production. This, in turn, resulted in the establishment of the National Research Council (NRC) in 1916. Nevertheless, compared to Britain, which installed the Department for Scientific and Industrial Research (DSIR) in the same year, the U.S. government showed less support for scientific research. U.S. federal science policy was still rudimentary—and certainly less intervening—than the British at that time. Whereas agricultural research funding had become a regular budget item for the U.S. government, other federal agencies confined themselves to the commission of surveys on geological or geographical issues (Dupree [1957] 1986: 149–214).

The lack of federal engagement in science policy stimulated an ongoing public debate about future organization, funding, and prestige for various strands of research in early twentieth-century America. A series of *Science* articles from the late 1880s onward illustrates how scientists, engineers, and the new industrial scientists were struggling with the ideal of pure science. This came at a time when novel concepts emerged marking a new, genuine category of research associated with different attributes such as "pure," "fundamental," "basic," "applied," and "industrial." The concept of research—singled out as the act of scientific knowledge production—started to challenge the supercategory of science. Although "pure" and "applied" science had not yet lost their rhetoric power, this new set of concepts can be considered an attempt to overcome the strict dichotomy of such language.

One of the new concepts traces back to the mid-1890s, when U.S. agronomy scientists called for more "fundamental research" (Arthur 1895: 360). Problem-oriented research in plant breeding led scientists to new general aspects of plant physiology that "pure" botany had not yet raised. Scientists of applied botany, therefore, saw little reason to distinguish between pure and applied science: "All science is one. Pure science is often immensely practical, applied science is often very pure science" (Coulter 1917: 228; see also Coulter 1919). As a part of publicly-funded experimental stations at land-grant colleges, however, these researchers were expected to provide results that could directly improve farming practices and increase crop yields (Marcus 1985). The demand for more fundamental research thus expounded the problem of uncertain scientific outcomes, even if a project had a clear task to fulfill. Given this uncertainty, "fundamental research" conveyed the promise of laying a cornerstone for future technologies and new products. Furthermore, since land-grant colleges were not on an equal footing with universities in terms of scientific prestige (Thelin 2004: 135–137), the new label "fundamental research" conveyed a commitment to the quest for fundamental scientific principles that, at the same time, could improve their scientific reputation. The alternative concept of "basic research" emerged for the first time also in the context of agriculture. In a congressional hearing on agricultural policy in 1919, politicians debated on the role of public support for "basic research" in agronomy. According to Roger Pielke (2012: 340–343), "basic research" was thus an offspring of this political discourse, since its use was limited to the political arena until the late 1930s.

The support for agricultural research and its effect on yield increase became a shining example for the industry, initiating a discourse on the relevance of industrial research (Little 1913: 649–650). The term "industrial research" was, in fact, a new entry in the lexicon of science policy: before World War I, it appeared only very sporadically, but after 1918 it became quite common. *Science* first mentions the term in 1910; from that point onward, the annual number of appearances saw a steep and relatively steady rise until 1945, with the first peak in 1917 (fifty-four articles mentioning the term) and second peak in 1943 (ninety-one article). One of the earliest and most cited articles was Arthur D. Little's "Industrial Research in America" (1913). Facing increased competitive pressure from the global market, the MIT-trained chemist and entrepreneur urged U.S. companies to expand their research activities, especially the "fundamental investigation of the scientific bases" on which the industry rested (Little 1913: 645). As in the field of botany, industrial scientists questioned the hierarchy between "pure" and "applied" science: "Most of us are beginning to realize that the major problems of applied chemistry are incomparably harder of solution than the problems of pure chemistry. . . . Industrial research is applied idealism: it expects rebuffs, it learns from every stumble and turns the stumbling block into stepping stone. It knows that it must pay its way. It contends that theory springs from practice" (Little 1913: 648, 655). Nevertheless, these pioneers of industrial research embraced the belief in discovering fundamental scientific principles and the quest for new knowledge—that is, ideals traditionally associated with pure science but now acting as a substitute for manufacturers' "rule-of-thumb methods" (Bacon 1914: 878).

Although some contemporaries contrasted pure science with industrial research, the latter no longer fit into the old dichotomy of pure and applied science. "Industrial research," rather, was divided into subcategories, namely unrestricted "pure research"—or, using the term that became more popular, "fundamental research"—and "applied research," followed by a final phase of technological development. Given the "dissatisfaction with the terms 'pure science' and 'applied science'" (Carty 1916: 511) and its associated moral hierarchy—with "sublime" pure science on the top and applied science as the "prosaic activities of technology" on the bottom (Hamor 1918: 319)—the discourse on industrial research resulted not only in conceptual hybrids such as "fundamental research" but also in ample attempts to classify different types and stages of research (Hamor 1918; Balls 1926; Whitney 1927).

Studies on companies such as AT&T, General Electric, DuPont, and Eastman Kodak (Reich 1985; Wise 1985; Dennis 1987; Hounshell and Smith 1988) have pointed to the increasing relevance of fundamental research in early twentieth-century industry: the old distinction between pure and applied science was no longer appropriate for communicating research practices and goals within the industry. Historians are still puzzled, however, over how the attribute of "pure" was still appealing at the beginning of industrial research. A well-known example is the chemical company DuPont, whose leading chemist, Charles Stine, introduced a fundamental research program outlined in the memorandum "Pure Science Works." Accordingly, the building for "pioneering research" bore the nickname "purity hall" (Hounshell and Smith 1988: 223–248). Whenever industrial scientists called for more "pure research" at the beginning of the twentieth century, they intended to conjure up the scientific spirit of venturing into the unknown—a spirit, according to them, still missing among many industrial laboratories and engineers (Little 1913: 643; Bacon 1914: 871; Hamor 1918: 325).

These advocates of industrial research were aware that research was a risky, often unpredictable, and long-term endeavor in stark contrast to economic rationales—but they firmly believed that it would pay off in the end (Brown 1914: 592; Carty 1916: 512; Hamor 1918: 320). Historians David Hounshell and John Smith (1988: 247) presume that, by the end of this semantic transition, the concept of fundamental research prevailed over pure research mainly because it hinted more directly at its practical relevance for industry. Similarly, Kenneth Lipartito (2009) pointed out that Frank Jewett, director of Bell Labs, began to talk about "fundamental research" in the 1930s. His aim was to break up the traditional opposition of academic and industrial research; according to Lipartito (2009: 142), "Fundamental corporate research served business needs, though otherwise it was the same as pure research."

Still, the increasing popularity of "fundamental research" indicated more than a growing demand for new scientific knowledge in agriculture and industry. It triggered a broad debate about the means and ends of science. "Fundamental research" denoted research revolving around basic scientific problems, the solutions for which were promised to advance technology, agriculture, industry, and thereby people's overall wellbeing. Scientists promoted fundamental research as a "national asset" (Coulter 1917) beneficial for the "national welfare" (Nutting 1917). In return, advocates of fundamental research, such as the chief engineer of AT&T John J. Carty, challenged the ideal of performing science for its own sake: "But surely this motive must be intensified by the knowledge that when the search is rewarded there is sure to be found, sooner or later, in the truth which has been discovered, the seeds of future great inventions which will increase the comfort and convenience and alleviate the sufferings of mankind" (Carty 1916: 514).

Against the background of World War I, even the National Academy of Science reformulated its objectives. Since science's social relevance had notably increased, the Academy wanted to increase the dissemination—that is, outreach—of scientific investigations vis-à-vis the general public (Hale 1914: 914). The Academy, however, still claimed the superiority of "pure science" as paving the way for new discoveries: "Immediate commercial value as a criterion of success will not often point the way to the discovery of fundamental laws" (Hale 1914: 919).

The plea for more research had, however, two sides: industrial research managers criticized American universities for neglecting both research activities and cooperation with the industry. They expected scholarship to serve "the immediate mass of humanity," not be a goal in itself: "Scholarship for the sake of scholarship—never!" (Brown 1914: 589). After companies had successfully built their own laboratories, industrial scientists doubted that universities were still the centers of scientific research:

> For the last fifty years it has been assumed that the proper home for scientific research is the university, and that scientific discovery is one of the most important—if not the most important—function which a university can fulfill. In spite of this only a few of the American universities, which are admittedly among the best equipped and most energetic of the world, devote a very large portion of their energies to research work, while quite a number prefer to divert as little energy as possible from the business of teaching . . . . Looking back on the history of science we can perceive that so far as research work has been associated with institutions, it has always been because those institutions required the results of the research for the effective performance of their own essential duties. (Mees 1914: 618)

Only a few universities, such as the Massachusetts Institute of Technology (MIT), were exempt from this critique. Other universities reacted to the increasing industrial demand for research and scientifically trained staff. In 1913, the University of Philadelphia founded the Mellon Institute of Industrial Research, which defined itself as a "link between the world of science and the industries" (Weidlein 1935: 562). Notably, the Mellon Institute used the term "fundamental research" as a general label for their projects and training.

At the dawn of World War I, researchers identified Germany as a role model for the United States (Bacon 1914: 872–873; Hale 1914: 918). Arthur D. Little (1913: 643) wrote, "Germany has long been recognized as preeminently the country of organized research." He admired not only the German scientific spirit, but also the scientific training at German universities and academic-industrial cooperation. Kenneth Mees (1914), director of the laboratory at Eastman Kodak, called for new institutes that were entirely devoted to research without having any teaching duties. Germany had already established this type of research institute under the umbrella of the Kaiser Wilhelm Society three years before Mees's comment was published. The state and industry funded the Kaiser Wilhelm Society, and represented a national effort to bring academia and industry together. Mees and his colleagues, however, lacked such national research institutes (Brown 1914: 588).

After World War I, scientists and industrial laboratory leaders intensively discussed the relationship between industry and academic "pure science," as well as how to organize different research activities in the most efficient way possible. Many feared the neglect of training in the natural sciences. Industrial research attracted talented researchers with good salaries, making academic positions less attractive (Hale 1914: 919; Hamor 1918: 328). In the 1920s, a public campaign for "pure science" in the *New York Times* aimed to raise support for research at universities.[13] The driving force of this plea was still the same narrative of the United States lagging behind Europe's science nations. Europe's historical situation and self-image, however, had already changed as Europe suffered from the severe consequences of World War I. American scientists were apprehensive that the springs of European scientific knowledge could dry up—they had to take the lead of knowledge production in the natural sciences.[14] Finally, the stock market crash in 1929 and the resulting economic crisis showed the vulnerability of a mostly privately-funded university system and, more generally, a scientific infrastructure based largely on philanthropy and private donations (K. Compton 1934).

Yet the old brand of "pure science" for academic research proved less successful in communicating the societal benefits of science in the late 1930s. The profound reforms of U.S. federal policy under the New Deal did not include a national funding program for academic research, but rather led to drastic cuts in federal research funding (Dupree [1957] 1986: 344–350). The increasing use of concepts like "fundamental science" in the late 1920s and early 1930s suggests that the purity metaphor, still associated with the idea of science for its own sake, was unsuitable for increasing federal funding for universities (see, e.g., Penkins 1929; Merriam 1934: 599–601).[15] On the other hand, developments in the 1920s and early 1930s revealed that industrial research could not be taken for granted: restricted to only a few large companies, even they cancelled respective programs as soon as the economic crisis left its mark in the early 1930s. In the case of DuPont, the era of high-level scientific research ended in 1932, at least for the time being. The risky investment in industrial research was one of the reasons why the industry asked for greater support for academic research—meaning pure science.

This ambiguity applied even more so to U.S. engineers who were torn between the ideal of pure science and the wish to set themselves apart from the natural sciences. According to Ronald Kline (1995: 205), "the gospel of industrial science" during World War I did not triumph over the "gospel of high and pure science," which continued determining the identity of engineers in the first half of the twentieth century. There is also evidence, however, that engineers in the late nineteenth century tried to establish their own professional identity vis-à-vis pure science. Henry Thurston (1884: 237–238, 243), vice president of the mechanical science section at the AAAS, propagandized "a system of application of science," in which scientific knowledge was interwoven with "arts" and "industries." Thurston neither argued against the spiritual value of science nor advocated its commercialization. He did, however, oppose the humanistic ideal of education, which according to him was characterized by a disdain toward any useful or practical aspects of scientific knowledge. Other "scientist-engineers" stressed the originality of their research in order to bring engineers out of the natural sciences' shadow (Kline 1995: 203). Still, engineers stuck to the disciplinary label of applied science and thus "affirmed a cultural hierarchy subordinating technology to science," which defined technology as "the application of pure science" (Forman 2007: 31). Only in the second half of the twentieth century did the engineering sciences succeed in establishing their own distinctive language through the new core references of technology, innovation, and different types of knowledge (e.g., "design," "tacit knowledge," "mind's eye").

The case of engineers demonstrates that in the first half of the twentieth century, the supercategory of science had not yet lost its prestige and integrative power—that is, engineers still put their trust in the effect of "bandwagoning" (Harris 2005: 104; see also Kline 1995: 221). This was certainly not a one-sided effect since engineers converted the scientific promise of progress into concrete material achievements and thus lent a perceptible image to the abstract notion of science—a fact those scientists were well aware of (Hale 1914: 919). In contrast to industrial scientists with a background in the natural sciences, many still assumed that engineers lacked the spirit of scientific research. In the same vein as industrial scientists, engineers used alternative concepts such as "fundamental research" and "fundamental science," which indicated their struggle with the sublime motive of pure science. Yet, given the critique from their colleagues, they still had to stress the importance of pure science for the scientific training of engineers (Trowbridge 1928). Moreover, the industry expected engineers to venture into the unknown and not be restricted to research determined by given technical problems. The industrial chemist Willis Whitney (1927: 288) put it as follows: "I am only contending against the thought that anyone can long foresee what may become our major needs and thereby circumscribe pure science research. None of our necessities were planned that way, not even a wheel. Wheels came into engineering, as steam did, through curiosity." Whitney's use of the hybrid term "pure science research" suggests he did not want to refer to the other attributes associated with "pure science." In fact, he did not evoke the notion of science for its own sake, and restricted his argument to the epistemic idea that a scientific venture into the unknown could not be planned according to present needs.

All in all, we must consider the interwar period as a phase of semantic transition. The differentiation of research activities and respective institutional settings in the early twentieth century resonated with the emergence of "research" as a category, which in many respects began to substitute the older academic understanding of science. After industrial research appeared on the map, research managers and science policy experts started to deliberate on how different "spheres," "classes," or "branches" of research related to one another, as well as what kind of division of labor could guarantee an efficient organization of research as a "whole" for the benefit of national welfare and prosperity (Godin and Schauz 2016). While the use of the term "fundamental research" reflected these developments, "pure science" was still perceived as prestigious, but its meaning had been narrowed. Many used "pure science," for example, when pointing to an open-minded curiosity and training in scientific methods. The older motif of performing science for its own sake did not sell anymore.

Semantic Fusion: Basic Research and the Revival of the Pure Science Ideal after 1945

After the incremental transformation of science and research in the first decades of the twentieth century, World War II marked an incisive experience for the U.S. scientific community, forcing the United States to much more profound adaptions in a very short period of time. The launch of collaborative research projects relevant to warfare—above all, the Manhattan Project at Los Alamos and radar research at MIT and Bell Labs—required national management and federal funding. Consequently, "pure science" definitively lost its grip as a leading idea, and the use of "fundamental" and "basic research" rose steeply during the war.[16] Given the immense expectations for immediate results, some scientists feared they could no longer meet the demand of new knowledge for technical development (Simons 1943: 391). Due to massive military recruitment, this fear of scarcity also applied to personnel resources in science (Barton 1943: 176; Taylor 1944: 250; A. Compton 1945: 208). In the end, the war experience created a new narrative: a concern that scientific knowledge might run short if researchers aligned knowledge production exclusively with the needs of society.

Since 1942, scientists had been discussing future institutional rearrangements. At the end of the war, plans for a new science policy regime were already on the table. Despite scientists' critique, wartime research had strengthened the position of science in society. As the U.S. government spent more money on science during World War II than ever before (Bush 1945: 82), scientists had a particular interest in perpetuating this federal commitment during peacetime. In July 1945, Vannevar Bush delivered his famous report, which justified the state's obligation to support basic research in four ways: first, the support of young researchers in the natural sciences; second, the improvement of public health through medical research; third, the advancement of public welfare, which was almost synonymous with economic growth and job security due to new technological developments; and fourth, the guarantee of national security by long-term civilian basic research, which promised to give the United States a technological edge in armaments. A plethora of literature deals with the political controversies following the Bush report (Kevles [1977] 1995; Reingold 1987; Owens 1994; Stokes 1997; Zachary 1997: 218–239, 249–260; Dennis 2004). The lines of conflict were drawn between the federal government and the states, the Republicans and the Democrats, public administration and interests of private stakeholders, as well as between scientists and federal government or industry.

In the end, "basic research" worked as an integrative political symbol (Pielke 2012). The term "basic" did the trick as it conveyed the promise to lay the foundation for all kinds of future benefits for both society and the advancement of science. Bush's short definition of basic research as "research performed without thought of practical ends" (Bush 1945: 13) contradicted the original understanding of fundamental research in the context of applications. At the same time, the Bush report envisaged *inter alia* the funding of basic research for military matters. His understanding of basic research was ambivalent. By focusing the funding program on the natural sciences or "basic disciplines," he dissociated them from the technical sciences. Bush seemed to detach basic research from any motive of practical or technical application, evoking the impression of returning to the old pure science ideal (Shepard 1946). The use of "basic research" shifted from industrial research toward the academic world of the natural sciences, formerly called "pure science." This image of science, however, was quite contested among Bush's peers, even among his closest colleagues (Conant 1948).

We must interpret Bush's draft against the background of the war experience. Despite the achievements made during World War II, researchers feared that the equilibrium between the production of scientific knowledge and its application would be disturbed (Bush 1945: 5, 8). The time-consuming and often unpredictable production of new knowledge became the common denominator for various definitions of basic research circulating in the late 1940s. Bush's proposal reacted to the organizational conditions of wartime research, particularly regarding security restrictions—a problem already discussed during the war (K. Compton 1942: 28). The report called for the prompt release of classified research after the war, as well as federal support for international exchange. According to G. Pascal Zachary (1997: 220), the plea for eliminating military secrecy was given not only for the sake of scientific progress but also in favor of civilian spin-offs arising from military research. With the upcoming Cold War rivalry and resulting military conflicts, however, secrecy policy proved an incessant challenge for scientific research.

Bush's proposal originally aimed to support basic disciplines in the natural sciences and medicine at universities.[17] Surprisingly, after having become the spearhead of scientific endeavors, American researchers looked back to continental Europe. Postwar proposals for higher education in the United States idealized European research universities and their humanistic ideas of education, associating them with democracy (Bender 1997: 4–5). The arguments for reinvigorating the university within an increasingly pluralistic research landscape were twofold: a growing need for scientifically trained researchers and free inquiry in academic science. This historical reminiscence evoked a revival of nineteenth-century pure science ideals with its high moral values. In this sense, Bush's definition was the basis for the NSF's definition of basic research:

> A worker in basic scientific research is motivated by a driving curiosity about the unknown. When his explorations yield new knowledge, he experiences the satisfaction of those who first attain the summit of a mountain or the upper reaches of a river flowing through unmapped territory. Discovery of truth and understanding of nature are his objectives. His professional standing among his

> fellows depends upon the originality and soundness of his work. Creativeness in science is of a cloth with that of the poet or painter. (NSF 1953: 38)

Despite the historical references to discovering truth and understanding nature, this definition cannot conceal the fact that it focuses on the requirements of postwar science policy, particularly regarding the sustainability of knowledge production. In other words, the history of science became an argument for federally supporting autonomous science by depicting famous scientists like Michael Faraday, John Tyndall, and Louis Pasteur as pathfinders for modern technology—a strategy well known from other contexts, such as Victorian British science (e.g., Gooday 2012: 549–551). These historical narratives construed continuity from the nineteenth century to postwar America, which concealed previous struggles over the means and ends of science. In 1961, James B. Conant, chemist and one of the leading science policy advisers of postwar America, stated: "The history of science demonstrates beyond a doubt that the really revolutionary and significant advances come not from empiricism but from new theories. The development of these theories, in turn has in the past depended on free discussion of their consequences. How much can be accomplished behind a wall of secrecy remains to be determined" (Conant 1961: 30).

A "Symposium on Basic Research," held at the Rockefeller Institute in New York City under the patronage of the NAS and AAAS (Wolfle 1959), captured the semantic fusion during the heyday of basic research as shared by various government representatives and academia, as well as industry and philanthropic organizations. Regarding the training of young scientists, the ideal of basic research led to a new version of the old boundary discourse of "pure versus applied" and "theory versus practice." Biochemist Conrad Arnold Elvehjem (1959: 94), who represented state universities and academic teachers at the symposium, declared that the ideal of training "good scientists" was incompatible with military and other contract research. Even engineering sciences felt compelled to adopt pure science ideals, whereby profit interests should be taboo in institutions of higher education so long as they are part of scientific training (DuBridge 1959: 109–110). Universities specializing in the applied sciences, such as the California Institute of Technology (Caltech), understood basic research as an integral part of modern engineering and inseparable from the overall pragmatic goal of inventing new technology (DuBridge 1959: 109–110). Yet, given the fact that the old label "applied science" still denoted technical disciplines, science policy advisors sought less confusing terms, such as "analytical engineering" (Killian 1959a: 122).

In the long run, the universities only maintained this idealist teaching policy to a certain extent, as the number of military-related research projects—often including doctoral students—grew during the Cold War (Dennis 1994).

During this time, the universities' role as "protected spaces" devoted to autonomous science (Rip 2011) was downgraded to mere symbols for Western liberal society, simultaneously providing fig-leaf camouflage for the technology-based arms race. As a political symbol, basic research offered an ideological surplus: Politicians contrasted the supposedly limited, local applications of communist countries' technology-driven research with the universality of basic research designed to benefit all mankind, with which the United States claimed ethical superiority. In his address at the symposium, President Eisenhower (1959) phrased it in his simple, well-known formula: "Science: Handmaiden of Freedom."

Support for basic research in the natural sciences was grounded in the hope that a few basic discoveries would prove sufficient to significantly broaden the potential for technological applications (Elvehjem 1959: 98). In order to protect basic research in the natural sciences, academic experts wanted such disciplines to stay clear of any kind of technical developments. As Alan T. Waterman (1959), the first president of the NSF, proclaimed at the symposium, "The growing applications of physics, chemistry, and mathematics should be shifted to engineering departments and kept out of the regular science departments." In other words, from the point of view of the natural sciences, applied research primarily meant research that yielded future technology.

This position was backed up by the revival of old academic virtues. Geophysicist Merle A. Tuve (1959: 174, 175), who represented private research institutes at the symposium in New York, stressed that "truly 'basic research' was driven by a passionate love for knowledge. Basic research thus meant 'support for ideas' in the first place" (see also Waterman 1959). This definition of basic research tended to be averse to technology. Besides, the new federal support for basic research at universities originally focused on individual researchers so as to foster "the development of the individual scientist" (Waterman 1959: 34; see also Greenewalt 1959; 128–131; Morison 1959: 230; Weaver 1959: xi). In contrast to applied research, which was supposed to be carried out in larger, work-sharing research groups, experts believed in individual creativity as the main property of outstanding scientists, enabling them to venture into the unknown. In this context, experts understood basic research as the free flow of unconstrained intellectual creativity (Tuve 1959). This praise of individualism had its roots in the myth of the American frontier society (see final chapter), which was revived in the Cold War period under the sign of democracy.[18]

While the amount of research as a direct response to economic and military demands had increased tremendously since the Korean War (Killian 1959a: 122), universities were conceived as a reservation for long-term basic research within a changing research landscape. Protecting scientific research "from the insistent demands of applied research" became a central argument employed by scientists, industry members, and politicians (Weaver 1959: xiv; see also Greenewalt, 1959: 128). Yet what was initially intended to protect scarce knowledge resources could, in the long run, transform into an ideal of purity.

The fact that, after World War II, many associated basic research with academic research did not imply that the differentiation between basic and applied research represented a clear-cut institutional division. Big companies continued their fundamental research programs: enterprises such as DuPont or the Bell Telephone Company had always intended to expand their participation in basic research after the war ended (Fisk 1959). Since economic rationales entailed selecting projects most likely to lead to technical inventions, however, such companies welcomed the idea of federal funding to carry out riskier projects at universities (Greenewalt 1959: 130). While companies wanted to avoid the costs of failures and deadlocks, this division of labor proved financially promising. According to the president of DuPont, Crawford Hallock Greenewalt (1959), basic research was considered a "technological savings account" for the industry.

Nevertheless, "basic research" remained important in application-oriented research fields. Given Bush's definition of basic research, however, some felt the need to redefine the term. Already in the immediate postwar years, John Steelman, science adviser to President Truman, divided basic research into two subcategories: (a) fundamental research defined as "theoretical analysis . . . directed to the extension of knowledge of the general principles governing natural or social phenomena," and (b) "background research" defined as "systematic observation, collection, organization, and presentation of facts using known principles to reach objectives that are clearly defined before the research is undertaken to provide a foundation for subsequent research" (Steelman 1947, vol. 3: 6). The discussion at the symposium and new terminology such as "mission-oriented basic research" or "mission-related basic research" from the 1960s indicate that the criterion of intention, whether it be utility-oriented or not, became problematic in the long run (Tuve 1959: 174; Waterman 1965: 15; Kistiakowsky 1966: 18).

While the ideal of basic research gained momentum in the late 1940s and 1950s, overall public spending for basic research remained quite low compared to applied research projects. During the 1959 basic research symposium—at a time when the NSF had been operating for several years—scientists criticized the low federal base rate for basic research compared to the Department of Defense's contract research, which was twice as high (Elvehjem 1959: 94; Waterman 1959: 26–27). One sophisticated argument noted that many basic research projects at universities were actually mission-directed in the service of national defense (Tuve 1959: 173–176). Basic research projects in oceanographical studies, for example, carried out within the context of naval research in the late 1940s and early 1950s, illustrate three things. First, they represented basic research highly relevant for military purposes. Second, they shed light on how the postwar discourse had redrawn a line between the natural sciences, denoted as basic research, and applied research, leading to new or improved technology. Finally, the example hints at how the distinction between basic and applied research was associated with security policies: the U.S. Office of Naval Research was a staunch supporter of basic research in oceanography, yet the question of secrecy revealed that the navy and scientists differed in their classification of basic and applied research and in their notion of utility. Oceanographers defined their investigations of topographical features or meteorological conditions of the ocean as basic research as long as they did not expressly serve the development of technology destined for use by the navy. The navy, however, developed "a more sophisticated definition of basic research," taking into account its operational nature and the strategic utility of geography for military purposes (Hamblin 2002: 27). In return, one can construe from this difference of perspectives that the semantic boundary work for scientists who wanted to shake off severe secrecy constraints by identifying their projects as basic research could turn into a battleground over scientific freedom.

In addition, the technical relevance of research for military purposes bore political and ethical dilemmas, which urged scientists to develop particular boundary strategies. After the United States dropped atomic bombs on Hiroshima and Nagasaki, the role of science in society became more controversial (Cohen 1948: 4; Conant 1961: 6–13). As scientists noted, the "atom bomb once and for all explodes the 'neutrality' of technology" (Shepard 1946: 66). Given this pitfall of modern science, natural scientists were more likely to embrace the ideal of basic research, as they could avoid assuming ethical responsibility for the application of their scientific knowledge. Furthermore, in a Cold War political climate, the label "basic research" helped scientists to avoid "politicking," which they considered a "disease" within project research dominating American universities at the time (Gates 1958: 234). During the McCarthy era, liberal and left-wing scientists often couldn't afford to participate in debates on research policy (Wang 2002). In 1956, the president of the Associated Universities stated that the question of loyalty almost inevitably arose when it came to discussing technological application:

> If a scientist expresses a strong view on some technological matter that may be contrary to the application of technology to current or to subsequent policy, he is open to the accusation of taking this view with the intent of deliberate subversion. . . . Moreover, secrecy prevents him from stating the essential technical grounds on which his view is based. Therefore, in the simple process of

> doing his job for his country well, he is open to damaging criticism against which he is permitted to produce little defense. (Berkner 1956: 784–785)

Finally, during the Cold War, scientific involvement in governmental and military projects put the credibility of scientific knowledge at risk. In the late 1950s, the public became increasingly concerned about the growing power of the new scientific-technological elite as part of the military-industrial complex, which they considered a domestic threat to U.S. democracy (Eisenhower [1961] 2003: 414–415). Here, at last, the rhetorical power of the basic/applied distinction reached it limits. Articles on science's responsibility in the late 1950s show that public mediation between the needs of science versus society became increasingly problematic (Killian 1959b: 136; Sayre 1961; Price 1962). According to Thomas Bender (1997: 8–12), common notions of the autonomy of science—in particular the position of elitist experts and the neglect of their responsibilities—alienated science from society, evoked the impression of an academic ivory tower, and resulted in federal budget cuts for academic research.

In the mid-1960s, the distinction between basic and applied research came under severe attack because science could not meet the tremendous military and economic expectations. For example, the "Project Hindsight" study by the Department of Defense questioned the role of basic research (Abelson 1966b; Sherwin and Isenson 1967). Another study, "TRACES," challenged this questioning, reconfirming the relevance of basic research for technological development and claiming a continuing support for basic research (Thompson 1969). The debate remained ongoing, however, and the need for legitimizing basic research drastically increased. Articles and comments in *Science* document very well that the basic/applied distinction was no longer self-evident: Many commented on the "changing environment of science" (Waterman 1965), the "pressure on basic research" (Abelson 1966a), and the shifting "political tides" (Greenberg 1966). In this context, Michael Reagan (1967) asked, quite to the point, whether basic versus applied research is in actuality a "meaningful distinction." It is no coincidence that the same year, George H. Daniels (1967) published his important contribution to the historicization of science policy, describing how "pure science" functions as an ideology.

Conclusion

Tracing the language of science policy in the United States from around 1840 to the 1960s reveals several conceptual shifts. Initially, American scientists employed primarily European concepts to make sense of science and its applications. Throughout the nineteenth century, however, they began to develop an ideal of "pure science" that was no longer in line with the European discourse. The emergence of a self-confident class of scientists, who began to distinguish themselves from commercially oriented professionals, became crucial. The way these scientists legitimated "pure science" shows that they were influenced—among other things—by an American puritanism which allowed them to interweave scientific and religious notions of truth, while their European colleagues employed the concept of pure science to battle the claim of religion determining what is right and what is wrong. Yet at the same time, the genuinely utilitarian orientation of American culture took shape in the complementary notion of "applied science," which the United States elaborated upon during the late nineteenth century and the first decades of the twentieth century.

Until the mid-nineteenth century, there were hardly any institutions stabilizing scientific endeavors in the United States. This situation triggered an existential reflection upon the role and mission of American science not monopolized by pure science advocates. For example, it was Thurston (1884: 243, original emphasis), an advocate of applied science and engineering, who stated that "there must be inaugurated a *system* of cultivation of science." In contrast, Europe had already institutionalized such a system in the forms of research universities, academies, and learned societies. For American scientists, what was at stake was the purpose of this system. For Rowland (1883a: 242), the goal was "to understand the order of the universe"; for Thurston (1884: 243–244), the goal was "the application of science to the daily work of humanity."

In short, scientists and engineers in the nineteenth century elaborated upon the supercategory of science. The emergence of new concepts alongside pure and applied science in the early twentieth century challenged this supercategory for the first time. Neologisms such as "fundamental," "industrial," and "basic research" created a new language, which we can interpret as a semantic extract separating the act of knowledge production from the more complex social systems of science and education. This is one reason why the term "science" became increasingly substituted by "research." It was for research that industry had developed an insatiable appetite: Industrial research managers considered the older notion of pure science—as it was, in their view, conducted at universities—as insufficient for covering the increasing national request for scientific knowledge. In contrast, "fundamental research" conveyed a promise to produce new scientific knowledge relevant for all kinds of applications. The prestige of science remained alluring, however, even for engineers.

The new dimension of organized research during the World War II finally underlined the relevance of scientific knowledge for the nation, first for warfare, then for welfare. As a consequence, "basic research" became the hegemonic concept in the postwar decades, both for the identity work of scientists and as a policy rationale for federal spending for science. As was the case with older distinctions, such as "abstract versus practical sciences" or "pure versus applied science," the now common distinction between basic and applied research soon became fragile and contested. For a short period (from about 1945 to 1965), however, it proved an extremely successful strategy for coping with the conflicting societal and political demands on science. During this period, the old concerns about the United States' lagging behind Europe's basic sciences was replaced by a new concern that an exclusive alignment of science with technological applications and military-related projects could risk the sustainable advancement of science. Here, the idea of a "system" that required cultivation was crucial, as it secured the production of new scientific knowledge as well as the growth of academic offspring. We can thus summarize this new discursive arrangement after 1945 as an "argument of knowledge sustainability" (Schauz 2014: 293).

While we might, therefore, interpret the post-1945 conceptualization of "basic research" as a revival of the older pure science ideal, there was more to this new concept. "Basic research" also included a strategy to protect science and scientists against excessive claims from various stakeholders. Moreover, in this state of semantic fusion, it also shook off the former moral and religious connotations. At the same time, many associated new values with the idea: in the politically tense climate of the Cold War, older attributes from a humanistic understanding of science were converted into democratic virtues of Western civilization. To summarize, "basic research" was an ambiguous concept that conveyed a clear materialist promise yet at the same time tended to be averse to technology. It is exactly this ambiguity that has puzzled scholars dealing with the language of American politics of science.

While our chapter closes with an analysis of the heyday of basic/applied terminology in the mid-1960s, this is not the end of the story. The subsequent developments are well documented in science studies and science policy literature (see final chapter). Our aim in this chapter was to sketch the long prehistory of a discourse that mainstream literature has reduced to the period after World War II.[19] Previous studies on U.S. science policy have predominantly focused on specific events, with the publication of the Bush report in 1945 interpreted as the beginning, and the adoption of the Bayh-Dole Act in 1980 interpreted as the end, of the basic research narrative in the United States.[20] Our analysis, in contrast, shows that a longer time horizon exists and is necessary for understanding how the language of science policy evolved. This reveals that we should be careful to not mix up different historical notions, such as those associated with the nineteenth-century term "pure science" and those of the twentieth-century term "basic research."

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Notes

1. "The professionals distinguished between 'abstract' and 'practical' science, just as a later generation would distinguish between 'basic' and 'applied' research, or between 'science' and 'technology'" (Kevles [1977] 1995: 6). While this is not wrong, it misses the point that these different distinctions indicate actual transformations in how science and its relation to social progress were perceived and conceptualized.
2. "An Act to Incorporate the New-England Asylum for the Blind." *The North American Review* 31 (68), July 1830: 66–85, quote 67, emphasis added.
3. Most of the following quotes are not from the published manuscript, but from Tocqueville's notes and drafts. These notes have been integrated into the historical-critical edition by Eduardo Nolla, which is used as the reference here.
4. Kline (1995: 196), for example, states that the distinction between "pure" and "applied" science in the United States was not common before the 1870s, while in Britain the phrase "applied science" had existed before 1840.
5. The speech was published in *Science,* the journal established only a few years earlier by the AAAS (Rowland 1883a); in a condensed form in the British journal *Nature* (Rowland 1883b); and, addressing a broader public, in *Popular Science Monthly* (Rowland 1883c). The latter reprinted the text on the occasion of Rowland's death (Rowland 1901). Another condensed reprint can be found in *Science* celebrating the journal's one hundredth anniversary (Rowland 1980).

6. For a more detailed discussion, see Lucier 2012. Cutrufello (2015) recently used Rowland as a case to investigate public addresses as a specific genre of scientific communication.
7. It is notable that Merton's famous text on "Science and Democracy" (1942) did not refer to any of the categorizations in use in the natural and technical sciences at that time: neither pure science nor basic or fundamental research.
8. Johnson (2008) proposes to instead write the history of science "from the perspective of applied science." Doing so, however, she reproduces the distinction of pure and applied science, which is—as a distinction—historical in character as well. By simply inverting the values, she remains within the same conceptual frame as Rowland.
9. Beside Alexander Dalls Bache, the group consisted of Joseph Henry, John Fries Frazer, Wolcott Gibbs, Benjamin Apthorp, James Dwight Dana, Louis Agassiz, Benjamin Peirce, and Cornelius Conway Felten (Beach 1972: 118–119). A slightly different list is presented by Slotten (1993: 34).
10. The role of the Scientific Lazzaroni and its protagonists are discussed by Dupree ([1957] 1986: 135–141), Miller (1970: 3–23), Reingold (1970: 163–164), Slotten (1993: 34–35), Lucier (2009: 709–711; 2012: 529–530), and Jansen (2011: 248–284).
11. In this period, the term "pure science" is used only three times (1849, 1866, and 1869). There are further some references to "pure mathematics" (1854, 1855, 1866) and "pure analysis" (1857, 1859).
12. In a similar way, Reingold (1972: 45) proposed an analytical distinction between pure and basic science: "*Basic* refers to intrinsic merit, usually scientific activities involved in formulating and verifying hypotheses and general theories. *Pure,* in contrast, refers to a psychological motivation unsullied by concerns other than the growth of scientific knowledge." Reingold, however, talks only about the nineteenth century, ignoring the fact that "basic science" as a concept did not exist at that time.
13. "Say Pure Science Lags in America: Leading Scientists and Public Men Issue an Appeal for Research Endowment," *New York Times,* 1 February 1926; "Hoover Leads Group Raising $20,000,000 to Aid Pure Science: Heads of Great Corporations Enter Campaign to Endow Research in Universities," *New York Times,* 21 April 1926; "Pure Science Study Seen at Standstill: Dr. Vernon Kellogg Warns that Industries Cannot Count on European Research," *New York Times,* 8 October 1926; "Millikan Pictures Gains by Pure Science: Modern Wonders like Radio and All Human Progress are Debtors," *New York Times,* 22 November 1928.
14. E.g., "Popular Science Monthly Award." *Science* 72 (1930): 648.
15. The concepts of "fundamental science" and "basic science" are older, but their use increased from the 1920s onward.
16. In order to get a better idea of the conceptual dissemination, here are some results of a statistical analysis of the journal *Science* (including the supplement *The Scientific Monthly*): between 1921 and 1930, the term basic research was used in 14 articles and fundamental research was used 121 times. Between 1931 and 1940, the term basic research showed up in 51 articles and fundamental research

in 154 articles. Just five years later, the term basic research had been employed 69 times and fundamental research 182 times.

17. The question whether the social sciences should also benefit from the NSF was part of the conflicts that delayed the launch of the new funding organization. In the end, the NSF included the social sciences, but the relation between the natural and the social sciences with regard to the financial allocation remained tense (Solovey 2012).
18. A prominent example for linking individualism, democracy, and free science in contrast to the Soviet Union was Michael Polanyi (1962), the British scientist and philosopher with Hungarian roots. Polanyi's writings, which were influenced by economic theory, became even more popular in the United States than in Britain.
19. An exception is the study from Dupree ([1957] 1986), which traces the development of U.S. science policy back to the very "first attempts" starting in 1787.
20. It is a popular diagnosis that the era of basic research comes to an end around 1980. See, for example, Slaughter 1993; Johnson 2004; Forman 2007: 34, 70; Mirowski and Sent 2008: 655–658; and Shapin 2008: 87. This interpretation builds on concrete legislative changes such as the Bayh-Dole Act. The focus on language and the semantic aspect of science policy discourse does not contradict this picture, but enables a more detailed understanding of a transformation that began much earlier in the mid-1960s, where we can observe how scientists and policy makers alike began to search for new concepts beyond the basic/applied dichotomy.

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