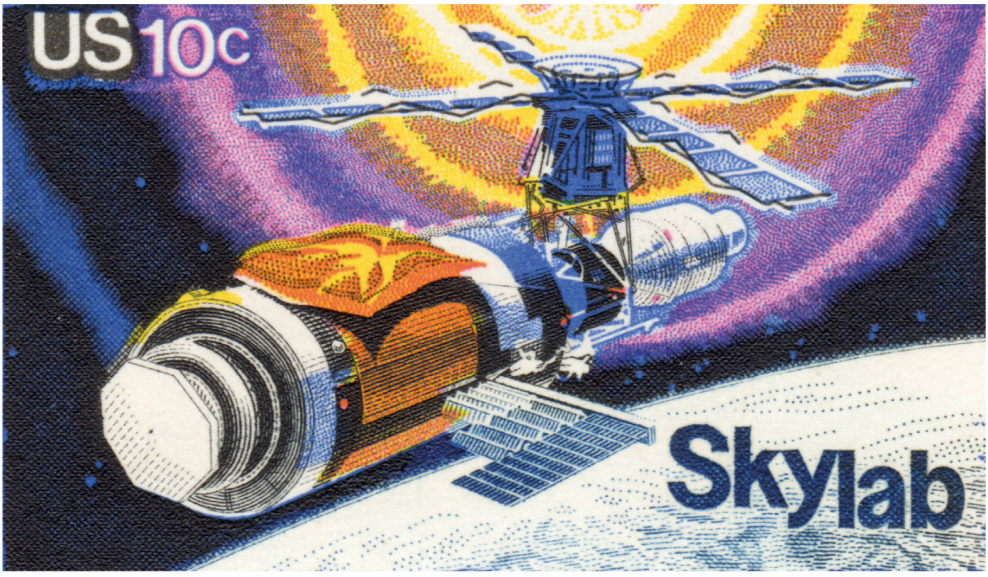

Axel Jansen, Andreas Franzmann, Peter Münte (eds.)

Legitimizing Science

National and Global Publics (1800–2010)

campus

Legitimizing Science

Axel Jansen, PD Dr., has taught American history in the US and in Europe, currently at Eberhard-Karls-Universität Tübingen. *Andreas Franzmann,* PD Dr., teaches in the Department of Sociology at Johann-Wolfgang-Goethe Universität Frankfurt. *Peter Münte,* Dr., has been an assistant professor at the University of Bielefeld.

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The workshop at Universität Tübingen on "Science and the Public in the Nation-State: Historic and Current Configurations in Global Perspective, 1800–2010" took place in the context of a research project by Andreas Franzmann and Axel Jansen on "Professionalization and Deprofessionalization in the Public Context of Science since 1970." The project is co-hosted by the Department of History at the University of California, Los Angeles (UCLA), and we would like to thank our colleagues in both institutions for their kind support. We thank the Volkswagen Foundation for sponsoring the research project that provides the intellectual backdrop for this book, and we also thank the sponsor of our conference and of the publication of this book, the Vereinigung der Freunde der Universität Tübingen (Universitätsbund) e.V., and our second sponsor for this publication, the Dr. Bodo Sponholz Stiftung für Wissen, Kunst und Wohlfahrt. Lars Weitbrecht provided organizational support at the conference and Ian Copestake of slovos.com helped proofread manuscripts. We thank both of them, and also Jürgen Hotz at the Campus Verlag for facilitating this book.

Section I:
Approaches

Legitimizing Science: Introductory Essay

Andreas Franzmann, Axel Jansen and Peter Münte

1. The Continuing Dependence of Science on a Plurality of Political Communities

The pursuit of science requires legitimacy that science itself cannot provide. The most obvious reason why such legitimacy is required today is that science costs a lot of money. At an accelerating pace during the nineteenth and twentieth centuries, scientists have had to raise funds to cover salaries and apparatus at institutions such as academies, universities or research institutes. But science has needed legitimacy, even at times when science was run by experimental scientists not employed to do research but pursue such interests on the side. Then as now, investigating nature by asking unfamiliar questions requires resources but also protection, freedom from political or religious constraints, the leisure to tackle fundamental problems without obvious practical value, and authorization through cultural and political affirmation. All of these matters point to the issue of legitimacy, and in the context of the modern nation-state such legitimacy relates to a political public and its endorsement.[1] At a time of increased

1 The relationship between science and public has caused a great amount of interest in the last two or three decades. See, for example, Steven Shapin, "Science and the Public," in *Companion to the History of Modern Science*, edited by Robert C. Olby et al. (London: Routledge, 1990) 990–1007. For the debate in Germany, see Peter Weingart, *Die Wissenschaft der Öffentlichkeit: Essays zum Verhältnis von Wissenschaft, Medien und Öffentlichkeit* (Weilerswist: Velbrück, 2005). This interest seems to arise from debates on the role of science in society. Concerning this connection, see Peter Münte's essay in this volume. In the fields of history, the relationship between science and the public has become an important topic in the context of attempts to reintegrate the history of science with general history. See, for example, Rüdiger vom Bruch, *Wissenschaft, Politik und öffentliche Meinung: Gelehrtenpolitik im Wilhelminischen Deutschland 1890–1914* (Husum: Matthiesen, 1980); Rüdiger vom Bruch, "Wissenschaft im Gehäuse: Vom Nutzen und Nachteil institutionengeschichtlicher Perspektive," *Berichte zur Wissenschaftsgeschichte* 23 (2000), 37–49.

global interdependencies, furthermore, this raises the issue of whether the legitimacy of science is shifting to a transnational and global plane.

The need for a legitimacy of science has been particularly evident in times of conflict. In the past, opponents of an experimental approach to testing truth claims have represented the church, cultural *Weltanschauungen*, or political ideologies. Conflicts have tended to unfold when the results of research questioned conventional explanations. Galileo, Kepler, Darwin, and Freud are prominent examples in the history of science.[2] At the beginning of the twenty-first century, debates on cloning and on stem cells are a reminder that science continues to be associated with provocations to world views and ethical convictions.[3] Such debates challenge politics to balance the demands arising from such beliefs with competing demands for scientific freedom and economic opportunities. While we have come to accept and demand from science technological innovation relevant for the economy and for society's other needs, science has remained a potential source of cultural, political, and economic instability. Hence this particular mode of truth-seeking continues to require the kind of protection, promotion, and authorization for which science has sought the political sovereign's patronage since early modern times. Science claims to work out a collectively binding understanding of the world. This presupposes a general acceptance of science as the source of such knowledge and the continuous integration of such knowledge in general education and political decision-making.[4]

From the Renaissance and into our own time, political, cultural, and economic elites have played a key role in shielding the experimental sciences from religious or cultural attack and in supporting and transferring authority to them. Such protection, promotion and authorization has been granted by elites in the emerging context of the modern state, but also through private philanthropy or foundations that have provided essential support. Their decision to support research often reflected a broader na-

2 Joseph Ben-David, "The Ethos of Science in the Context of Different Political Ideologies and Changing Perceptions of Science," in *Scientific Growth* (Berkeley: University of California Press, 1991), 533–59.

3 See Axel Jansen, "Stem Cell Debates in an Age of Fracture," in this volume.

4 As in most debates in the sociology and history of science, the focus here is on the kind of science that evolved into the empirical or natural sciences that were institutionalized in Europe from the seventeenth century. Fabian Link's contribution to this volume demonstrates, however, that similar questions may well be asked with respect to the social sciences, in general, and with respect to a critical theory of society, in particular.

tional commitment to the role of science in society.[5] By supporting research financially or by endorsing such work symbolically, they bestowed public affirmation and significance on the larger scientific enterprise. Today, the principles of this approach have become relevant in all areas of political leadership and administration that touch on scientific knowledge. The relationship between the state and science has not merely served to protect science but also to endorse its particular commitment to establishing truth-claims on behalf of a wider community. Such an endorsement of science has become an important element in national cultures and their self-perception. For scientists, public affirmation of their work has translated into cultural prestige and leverage.

The emerging legitimacy of science may be studied with particular effectiveness by focusing on a period when its social and political position remained unsettled. The founding of the Royal Society in seventeenth-century England provides a well-known case in point.[6] After the Puritan interregnum, a small group of natural philosophers including Robert Boyle was able to commit the returning king to provide patronage and his seal for the founding of a scientific organization. The king's protection and endorsement of the Royal Society implied that after its founding period in the 1660s, no one else could lay claim to discovering the laws of nature in the name of the king and of the nation he represented. But Charles II had to leave it to the Royal Society's active nucleus to define experimental philosophy because the king himself could not provide that definition. The Royal Society used this privilege to establish principles of scientific activity, among them the rule that claims to findings had to be established through experiments among witnesses, that experiments had to be recorded, and that results were to be transferred to the Society's records. While a general endorsement of such principles would not take place for decades or even centuries, important norms of modern science had been recognized by an official institution representing the king, norms that otherwise would not have had the standing that they came to have. Without official endorsement such principles would have remained subject to fundamental ques-

5 Joseph Ben-David, *The Scientist's Role in Society; a Comparative Study* (Englewood Cliffs, NJ: Prentice-Hall, 1971).

6 Michael Hunter, *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge: Boydell & Brewer, 1995); Peter Münte, *Die Autonomisierung der Erfahrungswissenschaften im Kontext frühneuzeitlicher Herrschaft: Fallrekonstruktive Analysen zur Gründung der Royal Society*, 2 vols. (Frankfurt: Humanities Online, 2004).

tions concerning their relevance, validity, and authorship. Science would not have been protected against philosophical and theological attacks on experimental methods, and demands that they be replaced by other methods such as philosophical introspection or revelation. Charles II had delegated the power to define science as a mode of truth-seeking through experiment-based philosophy, and the Royal Society assumed responsibility for this particular set of universalistic principles shared by those committing themselves to the scientific project.

While the Royal Society's founding context was distinctly British, it remains of significance well beyond this particular state. The Royal Society raised a standard of aspiration for experimental philosophers in other countries and they soon sought to emulate that model. The *Académie royale des sciences* established similar principles for France, effectively adopting the aspirations for scientific achievement and the responsibility for protecting and enhancing this particular mode of investigating nature. The Paris academy served this role even though the state kept it on a much shorter leash, paying researchers a salary and charging them with official state business.[7] The British and the French institutions have provided a template for other countries and their histories suggest that the institutionalization of experiment-based science took place by association with a political sovereign.[8]

For science to unfold, it had to be embedded in a particular community through political representatives who bestowed legitimacy on this particular mode of testing ideas. Such a community, of course, is always particular and not universal, because it is bound to a concrete country with its own territory and history. An essential tension exists, therefore, between the universalistic endeavor of science (a generalized methodology aiming at a universal validity of research results), on the one hand, and political communities, on the other.[9]

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7 Roger Hahn, *The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1666–1803* (Berkeley: Univ. of California Press, 1971); Peter Münte, "Institutionalisierung der Erfahrungswissenschaften in unterschiedlichen Herrschaftskontexten. Zur Erschließung historischer Konstellationen anhand bildlicher Darstellungen," *Sozialer Sinn* 1 (2005): 3–44.

8 James E. McClellan, *Science Reorganized: Scientific Societies in the Eighteenth Century* (New York: Columbia Univ. Press, 1985).

9 Brigitte Schroeder-Gudehus, "Nationalism and Internationalism," *Companion to the History of Modern Science*, edited by Robert C. Olby et al. (London and New York: Routledge, 1990), 909–1007.

The rise of science in the wake of its empowerment by the political sovereign since the seventeenth century opens up two key questions. The first concerns the impact on science of significant changes in the legitimacy of political power. How has the role of science shifted during and after political revolutions? What has the role of science been as it carried over from a monarchic or aristocratic state into a democratic nation-state, and what has been the impact of such momentous transformations as the emergence of the public sphere and the rise of mass media in modern democracy? Different assumptions about the role of subjects or citizens within a state's political sphere, for example, surely must have had an effect on the role assumed by science. All of this, of course, points to the more general question of how the history of science relates to political history.

The other question concerns the national and global history of science as different states chose to empower it from the seventeenth century: How has science derived legitimacy from endorsement in some countries while being stifled in others, and how has the legitimacy of science evolved from an association with key supporters such as national political elites, intellectuals, occupations, and industries? Much like China, Brazil, and India in recent decades, France, Britain, Germany, and the United States in previous centuries have all created specific traditions of science funding, lobbying structures, and legitimizing discourses that have impacted public agendas, expectations, and controversies about science policy and the development of science disciplines. While each country's tradition is unique, global dynamics of science emerge on their basis. Among transnational effects of national patterns of science organization are shifts in centers of science, with researchers looking to particular countries or regions for the development and validation of important work.

The present volume provides an opportunity to explore the legitimacy of science historically by taking as a point of departure an assessment of present challenges and problems. Hence this collection of essays does not seek to identify and trace "origins" of modern experimental science—transformations that precede the nineteenth century. This book provides a platform for looking back from the early twenty-first century to identify, chart, and compare developments that have turned out to be important or representative in legitimizing science since 1800. If the authority of science has rested on its endorsement by the political sovereign, what has been the history of that relationship in the age of the modern nation-state?

In this introductory essay, we will proceed by first taking a step back to explain how we became interested in the science-politics nexus. We will then turn to a trend that has come to characterize the relationship between science and the public during the past two centuries: the growing emphasis on the utility of research. A presentation of select historical tokens to illustrate this point will then help prepare the ground for concluding questions on the role and integrity of science in a globalized world.

2. Legitimizing Science as a Profession

In recent years, the editors of this volume have been involved, with Ulrich Oevermann, in helping develop in the history and the sociology of science a revised concept of professionalization.[10] While sociologists of science have focused their investigation on institutions of knowledge production and the cultural formation of scientific knowledge, our interest in the vocation's political legitimacy relates to the pragmatic requirements, the prerequisites, and the specific demands arising from the essence of scientific activity: research.[11]

We begin by asking what goes on when empirical scientists try to make sense of uncharted realities. While this focus to us seems central in identifying the "unnatural nature of science," it has been absent from the recent

10 See Ulrich Oevermann, "Theoretische Skizze einer revidierten Theorie professionalisierten Handelns," in *Pädagogische Professionalität. Untersuchungen zum Typus pädagogischen Handelns*, edited by Arno Combe and Werner Helsper (Frankfurt: Suhrkamp, 1996), 70–182; Ulrich Oevermann, "Wissenschaft als Beruf: die Professionalisierung wissenschaftlichen Handelns und die gegenwärtige Universitätsentwicklung," in *Die Hochschule* 14, no. 1 (2005): 15–51; Peter Münte and Ulrich Oevermann, "Die Institutionalisierung der Erfahrungswissenschaften und die Professionalisierung der Forschungspraxis im 17. Jahrhundert: Eine Fallstudie zur Gründung der Royal Society," in *Wissen und soziale Konstruktion*, edited by Claus Zittel (Berlin: Akademie Verlag, 2002), 165–230; Münte, *Autonomisierung der Erfahrungswissenschaften*; Andreas Franzmann, *Die Disziplin der Neugierde: Zum Professionalisierten Habitus in den Erfahrungswissenschaften* (Bielefeld: Transcript, 2012); Axel Jansen, *Alexander Dallas Bache: Building the American Nation through Science and Education in the Nineteenth Century* (Frankfurt and New York: Campus, 2011).

11 For the main paradigms in the sociology of science, see Bettina Heintz, "Wissenschaft im Kontext: Neuere Entwicklungen in der Wissenschaftssoziologie," *Kölner Zeitschrift für Soziologie und Socialpsychologie* 45, no. 3 (1993): 528–52; Uwe Schimank, "Für eine Erneuerung der institutionalistischen Wissenschaftssoziologie," *Zeitschrift für Soziologie* 22, no. 1 (1995); Peter Weingart, *Wissenschaftssoziologie* (Bielefeld: Transcript, 2003).

"practical turn" towards the situational realities of science.[12] In our work, we have come to assume that scientists engaged in research are not involved in solving established puzzles with established tools but that they engage with their curiosity in trying to identify new questions so as to advance their field through resolving them. The demands of their work leads them to develop a particular habitus, a habitus that is shaped by and informs a self-sufficient investigative perspective on a reality that will never conform to evolving theories about it.[13]

This approach offers an alternative to the main paradigms in the sociology of science and an answer to a key question in the sociology of the professions. The classical sociology of the professions could not explain particularly well what distinguishes science and other professions from vocations that are not professionalized.[14] Any explanation that goes beyond an institutional description of vocations claiming professional status would need to show, after all, how such claims are justified (or unwarranted) by pragmatically serving specific needs and responsibilities.

Work on this question has come to conclude that professions are distinct from other vocations in that they engage, not in solving problems by

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12 Wolpert's perspective is similar to ours. See Lewis Wolpert, *The Unnatural Nature of Science*, (Cambridge: Harvard Univ. Press, 1994). On the "practical turn" in the sociology of science, see Andrew Pickering. ed., *Science as Practice and Culture* (Chicago: Univ. of Chicago Press, 1992); Moritz Epple and Claus Zittel, eds., *Science as Cultural Practice*, vol. 1, *Cultures and Politics of Research from Early Modern Period to the Age of Extremes* (Berlin: Duncker & Humblot, 2010).

13 The term "habitus" is commonly associated with Pierre Bourdieu's work, but we use it to depict the specific attitudes and responses elicited by problem-solving in science. Compare, for example, Pierre Bourdieu and Loïc Wacquant, *An Invitation to Reflexive Sociology* (Chicago: Univ. of Chicago Press, 1992), to Andreas Franzmann, *Die Disziplin der Neugierde: Zum Professionalisierten Habitus in den Erfahrungswissenschaften* (Bielefeld: Transcript, 2012). In referring to a scientific mindset, Max Weber uses the concept of *Geistesaristokratie* ("intellectual aristocracy"). Max Weber, "Wissenschaft als Beruf," in Max Weber, *Gesammelte Aufsätze zur Wissenschaftslehre* (Tübingen: Mohr, 1988), 582–613, quotation on p. 587.

14 For the "classical" sociology of professions, see Alexander M. Carr-Saunders and Paul Alexander Wilson, *The Professions* (Oxford: Clarendon Press, 1933); Talcott Parsons, "The Professions and Social Structure," *Social Forces* 17 (1939), 457–67; Talcott Parsons, "Professions", in *International Encyclopedia of the Social Sciences*, 12 (1968), 536–47; Thomas Humphrey Marshall, "The Recent History of Professionalism in Relation to Social Structure and Social Policy," in *Canadian Journal of Economics and Political Science* 5 (1939): 325–40; Everett C. Hughes, "The Social Significance of Professionalization," in *Professionalization*, edited by Howard M. Vollmer and Donald L. Mills (Englewood Cliffs, NJ: Prentice-Hall, 1966), 62–70.

only using technical standards derived from the established knowledge in their field, but in coping with crises for which no solution is at hand. Professions deal with crises that cannot be reduced to well-defined problems, and they try to resolve them on behalf of others, such as a patient, a client, or (in the case of science) on behalf of humanity at large.[15] In the case of science, researchers deal with crises of explanation and validity, crises they identify in the explanatory power of their field's theory when confronting that theory with unexplained observations. And they do so as part of a community of investigators that has come to develop and share convictions on how to do science, and on how to identify sound answers to scientific questions.

The specific nature of the activity in which empirical scientists are engaged explains why an assessment of their work through an evaluation in a market or through an assessment by administrators would be inadequate. An evaluation will have to turn to autonomous collegiate cooperation and critique rather than outside control and standards. Professional autonomy has evolved on different levels: (1) As part of a professionalized habitus, it includes the individual researcher's internalized standards of critique and refinement; (2) Professional autonomy involves criticism in a universe of discourses through colleagues and collegial control elicited through procedures of peer-review and evaluation; (3) Professional autonomy is made possible through institutions such as academies, associations, university departments and research institutes, all of which provide the field with a platform for its ongoing work, with the jurisdiction required to enforce adherence to its standards among colleagues, and procedures to raise and distribute budgets and to codify rules and standards for scientific work.[16]

It is one thing to develop an interest in the particular mode of investigation that empirical science has come to stand for, but quite another to

15 For a comparison of science to other professions, see Ulrich Oevermann, "Theoretische Skizze einer revidierten Theorie professionalisierten Handelns," in *Pädagogische Professionalität. Untersuchungen zum Typus pädagogischen Handelns*, edited by Arno Combe and Werner Helsper (Frankfurt: Suhrkamp, 1996), 70–182.

16 While sociologists and historians have investigated the collegiate role of scientists as well as their institutional settings, an empirical investigation of the scientist's internalized habitus has remained a desideratum. Such a habitus was sometimes referred to rather philosophically as "professional ethics." In his recent study on this subject, Andreas Franzmann mobilized the close-reading approach of objective hermeneutics to interpret interviews with researchers, deducing from these interviews tacit assumptions informed by internalized routines and beliefs. See Franzmann, *Disziplin der Neugierde*.

claim to speak for it and to enforce professional standards with the authority of a wider community. This is where authority comes into play. The political sovereign provides empirical scientists with protection and sometimes with financial support, but also with the authority to deal with the profession's affairs. In early modern times, the court provided patronage for individual scientists, bestowing "social and cognitive legitimation" on such individualists as Galileo.[17] With the founding of institutions such as the Royal Society, the *Académies royale* and subsequent national academies in other counties, the practice of science received a continuous institutional foundation empowering not just one scientist, but the general logic of research represented by the academy. The king's endorsement entrusted scientists with organizing the profession so as to effectively safeguard on behalf of the sovereign the advancement of science.[18] With the advent of the democratic nation-state, such institutional support and endorsement of science then took place on behalf of the people. The nation-state came to assume the role of client and supporter of science as it began to dedicate itself to the protection and support of the freedom of scientific inquiry and education.[19] In this sense, nation-states through their endorsement of scientific institutions such as academies, universities, scientific associations, or research institutes entered a "contract" with experimental science by accepting, in principle, that science would challenge and test ideas about how the world works even if science came up with new explanations that undermined established beliefs or world views.[20] This development re-

17 Mario Biagioli, *Galileo Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: Univ. of Chicago Press, 1993), 354.

18 The resulting embeddedness of the profession as a community in a wider community is the central theme in William J. Goode, "Community within the Community: The Professions," *American Sociological Review* 22 (1957): 194–200.

19 For a recent presentation of this argument, see Alfons Bora and David Kaldewey, "Die Wissenschaftsfreiheit im Spiegel der Öffentlichkeit," *Freiheit der Wissenschaft: Beiträge zu ihrer Bedeutung, Normativität und Funktion*, edited by Friedemann Voigt (Berlin: De Gruyter, 2012), 9–36.

20 This view takes for granted that the institutionalization of science is a component of building a political community, and it differs from another approach in the sociology of science prominent in Germany, i.e. an approach informed by systems theory. For the latter, see Rudolf Stichweh's contribution to this book, "Transformations in the Interrelation between Science and Nation-States: The Theoretical Perspective of Functional Differentiation." See also Niklas Luhmann, *Die Wissenschaft der Gesellschaft* (Frankfurt: Suhrkamp, 1990); Rudolf Stichweh, "Differenzierung des Wissenschaftssystems," in *Differenzierung und Verselbständigung: Zur Entwicklung gesellschaftlicher Teilsysteme*, edited by Renate Mayntz et al. (Frankfurt and New York: Campus, 1988), 45–115; Rudolf

sulted in a system of institutionalized training at universities where students internalized the scientist's role and its logic of inquiry. Eventually, this mindset would be directed at a growing number of subjects outside the natural sciences even if its proper adjustment to an investigation of culture, society, politics, and economies remains disputed. In this volume, such a broadened conception of science (in line with a German conception of *Wissenschaft*) is reflected in contributions on the history of sociology and philosophy by Fabian Link and on the history of Islamic studies by Andreas Franzmann.

So this is how the autonomy of science as a profession played out and how it was institutionalized. But the legitimacy of science has always had to go well beyond this framework. Science has never been self-referential in establishing the foci of its work, and questions researchers have chosen to pursue have not been provided by curiosity or the state of research alone. The legitimacy of science in public and in politics has drawn on a variety of motives, including cultural and utilitarian promises and competitive struggles for funding within and among disciplines. From the inception of institutionalized research science in the seventeenth century, utilitarian promises have played an important role in bolstering research, among them prospects for developing useful technology in such areas as agriculture, navigation, and medicine.[21] But the significance of such utilitarian prospects grew stronger and became dominant as science turned into a successful enterprise. In countries supporting science, administrations, the military, and industries became dependent on technological applications

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Stichweh, *Wissenschaft, Universität, Professionen: Soziologische Analysen* (Frankfurt: Suhrkamp, 1994; Peter Weingart, *Die Stunde der Wahrheit? Zum Verhältnis der Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft* (Weilerswist: Velbrück, 2001). Approaches informed by systems theory commonly focus on an exchange of services or accomplishments by self-referential subsystems of society. We argue that the state's empowerment of science to cope with crises of explaining reality on behalf of a wider community represents a relationship structurally similar to that between a physician and a patient. A physician is "empowered" by his patient to cope with his/her health crisis. Unlike physicians, however, scientists cope with more general crises that are relevant for all humans, not just one patient. In a strict theoretical sense, therefore, the client of science is not concrete for it is neither a person nor any particular community. But this universalistic and abstract client is nevertheless represented by individual communities that are able and willing to dedicate themselves to the universalistic program of science. This structural similarity to the relationship in other professions such as medicine is what we mean when we consider a community to be a "client" of science.

21 See Merton's famous study on science in its formative period. Robert K. Merton, *Science, Technology and Society in Seventeenth-Century England* (New York: Harper & Row, 1970).

derived from investigating their underlying principles. When curiosity-driven research translated into spectacular technological solutions, furthermore, the success of science through technology has led to the demand that science should assume a more significant role in education. The growth of universities in many countries in the late twentieth century has had the effect of associating larger segments of the population with institutions dedicated to science (the *Massenuniversität* in Germany) while engaging a smaller percentage of university students in "real" research. Significant investments by nation-states in research and education have gone hand in hand with the growth of management structures, and this has also further changed the relationship of science to the public.

While these developments during the past two centuries may be understood within the context of individual states, they have taken place at a time of accelerating globalization since 1970. In our next and somewhat longer section we will focus on challenges to professionalized science in the context of technology-oriented states since 1800. We will close our introduction with a brief section on issues arising from globalization.

3. Legitimizing Science: The Challenge of Utility

3.1. Science and Technology

While technology is much older than science, science and technology have been associated ever since modern science was institutionalized in the seventeenth century.[22] Because of this link, matters related to technology-development have influenced the justification and support of curiosity-driven research.

Prior to World War II, science and technology had had a long interactive history in weapons technology, chemicals and pharmaceuticals.[23] Fran-

22 On the difference between science and technology that we have in mind here, see Wolpert's lucid observations in his *Unnatural Nature of Science*, 25–34.

23 Alex Roland, "Science, Technology, and War," in *The Modern Physical and Mathematical Sciences*, edited by Mary Jo Nye, vol. 5 of *The Cambridge History of Science* (Cambridge: Cambridge Univ. Press, 2002), 559–78; John P. Swann, "The Pharmaceutical Industries," *The Modern Biological and Earth Sciences*, edited by Peter J. Bowler and John V. Pickstone, vol. 6 of *The Cambridge History of Science* (Cambridge: Cambridge Univ. Press, 2009), 126–40.

cis Bacon considered the discovery of nature's secrets and the production of useful knowledge two sides of the same coin.[24] The founding of the Royal Society took place on the utilitarian assumption that science and technology were tightly intertwined.[25] During the eighteenth century, France had taken the lead in associating the interests of the state with the elite *Ecole d'Artillerie* or the *Corps des Mines* and the *Corps des Ponts et Chausées*.[26] Such developments carried on and expanded during the nineteenth century. But World War II provided a singular opportunity for science administrators to lay claim to authority well beyond the core functions of exploring nature. Physicists came to rely and depend on massive government funds legitimized by the Manhattan Project and national security. Their success in developing technology provided them with political leverage as they assumed influential roles in policy-making. Political scientist Donald K. Price argued that scientists constituted a "fifth estate" and the scientific community a model of democracy.[27]

Science seemed to provide the tools that made or broke a state's international influence and power in the contested terrain of the Cold War.[28] Following claims by scientists to cultural leadership in the US during the Cold War, and through a representation of science as a tool to solve all sorts of societal problems, the public came to associate science

24 Francis Bacon, *The New Organon*, edited by Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge Univ. Press, 2000).

25 Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (1667), edited by Jackson I. Cope and Harold Whitmore Jones (St. Louis: Washington Univ. Press, 1966).

26 Charles Coulston Gillispie, *Science and Polity in France: The Revolutionary and the Napoleonic Years* (Princeton: Princeton Univ. Press, 2004); Terry Shinn, "Science, Tocqueville, and the State: The Organization of Knowledge in Modern France," in *The Politics of Western Science, 1640–1990*, edited by Margaret C. Jacob (Atlantic Highlands, NJ: Humanities Press, 1994), 47–80.

27 Paul Josephson, "Science, Ideology, and the State," *The Modern Physical and Mathematical Sciences*, edited by Mary Jo Nye, vol. 5 of *The Cambridge History of Science* (Cambridge: Cambridge Univ. Press, 2003), 590–91; Joseph Ben-David, "The Ethos of Science: The Last Half-Century," in *Scientific Growth* (Berkeley: Univ. of California Press, 1991 [1980]), 485–500, esp. 492. The key source for this observation, of course, is Vannevar Bush, *Science. The Endless Frontier: A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945* (Washington DC: United States Government Printing Office, 1945), https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm. See also Don K. Price, *The Scientific Estate* (Cambridge: Belknap Press, 1965).

28 For the bomb's effect on American politics and a culture of fear, see Ira Katznelson, *Fear Itself: The New Deal and the Origins of Our Time* (New York: Liveright, 2013).

ever more closely with technology. References to "pure research" had begun to be replaced in the 1960s with terms such as "basic" or "fundamental" research, suggesting that science was merely a first step in developing technology. At the same time, sociologists supplied keywords such as "postindustrial" or "knowledge" society, setting the stage for what Ben-David a few years later called a "scientific utopia." Resources for knowledge came to be considered essential components of economic growth.[29] The close association of science and technology in many countries blurred an understanding of the distinct and limited capabilities of scientific research. It helped produce a technocratic ideology that reduced society to an apparatus.[30] The rise of scientism eventually prompted a reaction.

The context for science and for technology-development shifted dramatically in all Western countries during the sixties when the very idea of scientific progress met growing academic criticism, and the legitimacy for scientific work and for its institutions began to be reviewed by an increasingly discerning public.[31] Following periods shaped by world wars and political and social crises, national publics in Europe and in the United States established or reestablished a self-assured role vis-à-vis science that encouraged a critical view of promises associated with science. Ben-David has argued that this was the period when an overly optimistic assessment of science ("scientism") faced a critical reevaluation but also the rise of an "anti-scientific" movement.[32] A critique of science addressed scientists' "complicity" with the military-industrial complex, nuclear power, chemical

29 Ben-David, *Centers of Learning*, 174.

30 See, for example, Helmut Schelsky, *Der Mensch in der wissenschaftlichen Zivilisation* (Cologne: Westdeutscher Verlag, 1961).

31 Essential for the field of the philosophy of science: Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago and London: Univ. of Chicago Press, 1976 [1962]). Kuhn's work went along with a general shift in the sociology of science where criticism of Robert K. Merton's work began to set the tone. This shift is well-documented in two volumes: Peter Weingart, ed., *Wissenschaftssoziologie I: Wissenschaftliche Entwicklung als sozialer Prozeß* (Frankfurt: Athenäum, 1973) and *Wissenschaftssoziologie II: Determinanten wissenschaftlicher Entwicklung* (Frankfurt: Athenäum, 1974). Critical perspectives on science and technology where developed by others as well, including Herbert Marcuse, *One-Dimensional Man* (Beacon: Boston 1964) and Jürgen Habermas, *Technik und Wissenschaft als "Ideologie"* (Frankfurt: Suhrkamp, 1968).

32 Joseph Ben-David, "The Ethos of Science in the Context of Different Political Ideologies and Changing Perceptions of Science," in *Scientific Growth* (Berkeley: Univ. of California Press, 1991), 533–59.

disasters, and environmental pollution. It also aimed at the role of scientists in colonial affairs, in producing social inequality, and in developing psychological methods for assessing and dealing with minorities and deviant behavior by administrations and in schools. A shift towards a more critical public reception of science usually took place when issues arose from prominent fields of research that came to stand for the scientific project at large. Their resolution came to shape the subsequent public and academic discourse on science. In his contribution to this volume, Shiju Sam Varughese sketches such developments for India.[33]

In the US after 1945, the field of physics had become the "public face" of science. Physics represented technological achievements relevant for the military and consumers. The secrecy of nuclear facilities added to the field's aura but also shielded from public scrutiny work attributed to it. The sixties, however, witnessed the transformation of the public sphere in the transatlantic region that brought about a reassessment of the state's role and responsibilities towards its citizens as well as a reconsideration of science and technology in modern democracies. In the US, polls indicated that Americans, despite successes such as the 1969 moon landing, considered quality-of-life issues to be more relevant than the space race.[34]

The torch symbolizing science to the public was passed from physics to biology during a controversy about the safety of recombining (altering) the DNA of a living organism, a debate that was considered by some contemporaries as helping provide the critical public assessment that nuclear technology had not received.[35] The decade witnessed a "swing from the physical to the life sciences" as public critique and public hopes came to focus on biology.[36] This shift also led to a transfer of focus from federal to private funding. Physics during the Cold War had stood for federal support

33 Shiju Sam Varughese, "The State-Technoscience Duo in India: A Brief History of a Politico-Epistemological Contract," in this volume.

34 Daniel Kevles, *The Physicists: The History of a Scientific Community in Modern America*, Revised edition (Cambridge: Harvard Univ. Press, 1995), 398.

35 Joachim Radkau, "Hiroshima und Asilomar: Die Inszenierung des Diskurses über die Gentechnik vor dem Hintergrund der Kernenergie-Kontroverse," *Geschichte und Gesellschaft* 14, no. 3 (Jan. 1, 1988): 329–63.

36 Agar, *Science in the 20th Century and Beyond*, 508. For a statistical overview of US science spending, see, for example, James Edward McClellan and Harold Dorn, *Science and Technology in World History: An Introduction* (Baltimore: Johns Hopkins Univ. Press, 2006), 418. Also consider recent data on global private and public R&D funding by Scienceogram UK, http://scienceogram.org/blog/2013/05/science-technology-business-government-g20.

within the wider political atmosphere concerned with national security but biotech came to be associated with markets and opportunities.[37] The growth of biotech drew global attention and established a new competitive arena for scientific, technological, and economic leadership. Industry continued to rely on universities for basic research and the training of scientists but public commentators both inside and outside of academia (among them historians and sociologists) differed in their assessments of what some conceived of as a privatization of science or as the emergence of "technoscience". The shift towards biology and biotechnology from the 1970s provided new opportunities and challenges for legitimizing science.

At a time when the old dream of science as a source for technological solutions finally seemed to come into its own, therefore, a cluster of transformations set in: In many countries, a critical public increasingly reflected on the societal consequences of research practices and technologies; a reassessment of the state's role included a reevaluation of the support of science where the state's role had been strong; the intellectual framework that guided the debate came to use market-models even in the case of science organization; and an academic discourse on science increasingly focused on innovative modes of knowledge production, a top-down managerial approach to innovation, and on the regulation of science and technology. While this shift towards the utility of science was most pronounced in the sphere of science studies and in science management, it played out in education as well.

3.2. Science as a Basis for Modern Education

Before 1810, the modern empirical sciences were largely confined to institutions not in charge of education. In the seventeenth and eighteenth centuries, academies had empowered research science and it was from the nineteenth century that empirical science began to be implemented within institutions of higher education.

At that time, universities were affiliated with religious denominations in the United States or had become associated with emerging territorial powers in Europe. With the rise of nation-states after 1800, education began to be secularized in many countries as states sought to educate their citizens.

37 The broader context was a "rediscovery of the market" in political debate. Daniel T. Rodgers, *Age of Fracture* (Cambridge: Harvard Univ. Press, 2011), chap. 2.