STATES OF KNOWLEDGE

The co-production of science and social order

Edited by SHEILA JASANOFF

States of Knowledge

In the past twenty years, the field of science and technology studies (S&TS) has made considerable progress toward illuminating the relationship between scientific knowledge and political power. These insights have not yet been synthesized or presented in a form that systematically highlights the connections between S&TS and other social sciences. This timely collection of essays by some of the leading scholars in the field attempts to fill that gap. The book develops the theme of *co-production*, showing how scientific knowledge both embeds and is embedded in social identities, institutions, representations and discourses. Accordingly, the authors argue, ways of knowing the world are inseparably linked to the ways in which people seek to organize and control it. Through studies of emerging knowledges, research practices and political institutions, the authors demonstrate that the idiom of co-production importantly extends the vocabulary of the traditional social sciences, offering fresh analytic perspectives on the nexus of science, power and culture.

Sheila Jasanoff is Pforzheimer Professor of Science and Technology Studies at Harvard University.

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Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2004
by Routledge
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Routledge
29 West 35th Street, New York, NY 10001

Routledge is an imprint of the Taylor & Francis Group

This edition published in the Taylor & Francis e-Library, 2004.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
States of knowledge : the co-production of science and social order / edited by Sheila Jasanoff.
p. cm. (International library of sociology)
Includes bibliographical references and index.
ISBN 0–415–33361–X (alk. paper)
1. Science–Social aspects. 2. Science and state. I. Jasanoff, Sheila. II. Series.
Q175.5.S734 2004
303.48'3–dc22
2003017603

ISBN 0-203-41384-9 Master e-book ISBN

ISBN 0-203-67144-9 (Adobe eReader Format)
ISBN 0–415–33361–X (Print Edition)

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Acknowledgements

Any long academic project owes debts of many kinds, and this one perhaps more than most. Thanks are due, first and foremost, to the National Science Foundation, whose generous support to the Department of Science and Technology Studies at Cornell University (under NSF grant nos. DIR 9017187 to Cornell and SBR 9996124 to Harvard) made possible the interdisciplinary reflection and synthesis that inspired this volume. As the responsible program officers, Rachelle Hollander and Ron Overmann provided constant help and encouragement that went far beyond their formal administrative duties.

I would like to thank Routledge, and particularly James McNally and Mari Shullaw, for their confidence in and support of a collection that is avowedly academic and theoretical. As series editor, John Urry provided crucial and most welcome intellectual backing. In addition, three anonymous reviewers for the press strongly recommended publication. We are indebted to all of them for their support and guidance.

The ideas presented in this book were worked out in significant respects in my graduate seminar on "Science, Power and Politics," first taught at Cornell and continued at Harvard after 1998. I owe an enormous debt to the many talented students and fellows who attended that seminar over the years and who helped sharpen my thinking on the theme of co-production. Several of them have already begun to make their own original contributions to the literature of co-production, showing by example the rich possibilities of a research program couched in this theoretical idiom. Not all of these young scholars can be acknowledged by name, but I would like to thank a few whose intelligent and creative use of the co-production framework has reconfirmed my confidence in the significance of this project: Samer Alatout, Arthur Daemmrich, Robert Doubleday, Saul Halfon, Alastair Iles, Marybeth Long Martello, Shobita Parthasarathy, Jennifer Reardon, Jessie Saul, Kaushik Sunder Rajan, and Mariachiara Tallacchini. My debt to three other remarkable colleagues – Pablo Boczkowski, Martin Kusch and Stefan Sperling – is of a different order. All three read and commented in detail on my chapters in this volume; their perceptive, sympathetic, yet always challenging criticism greatly improved the clarity of the text. I am deeply grateful to them all; any remaining flaws and infelicities are, of course, my own responsibility.

At Harvard, my able assistants Seth Kirshenbaum and Constance Kowtna kept track of manuscript flow and provided invaluable help in the final editing and compilation of the texts. Their dedication and meticulous attention to detail made the final stages of a complex process seem unexpectedly easy.

My gratitude to the colleagues who contributed to the volume is almost beyond words, but it is important to note that their efforts are only partly reflected in the chapters they have written. Invisible but all-important intellectual work was done over many years while we collectively deliberated how to tackle the problem of science and social order in ways that would bring science and technology studies into productive dialogue with more traditional analyses of power and culture. Through corridor conversations and informal email exchanges, workshop meetings and, eventually, formal papers, we managed to overcome our disciplinary divisions and to create a discourse that was rigorous enough to give us shared analytic ground rules, yet flexible enough to accommodate highly varied, personal choices of topic, period, style and method.

Several institutions contributed to the success of the project at key stages, and each deserves acknowledgement. As already stated, Cornell University provided not just the physical but the spiritual home in which the ideas presented here were able to take root and flower. Harvard University's John F. Kennedy School of Government hosted, in November 1998, a workshop at which early drafts of many of the chapters were presented and discussed. Kyoto University, in the summer of 1999, offered a quiet haven for composing the first draft of the introductory chapters. Finally, in 2001–2002, the Wissenschaftskolleg zu Berlin made available the time and space for editorial reflection, without which our efforts could not have reached a successful conclusion. We hope this volume adequately expresses our thanks for all this invaluable support.

Sheila Jasanoff
Cambridge MA, May 2003

1 The idiom of co-production

Sheila Jasanoff

Science and technology permeate the culture and politics of modernity. On any day, the headline news provides crude but telling indicators of their influence. A Martian ethnographer visiting planet Earth in the first few years of the third millennium would have encountered a bewildering array of stories whose only discernible connection would have been the pervasive – though perversely inconsistent – role of science and technology in human affairs. The millennium opened with false fears of the so-called Y2K bug that might have made computer systems throughout the world crash at midnight, when 1999 rotated into 2000. In 2001, the seemingly well regulated technological system of American civil aviation was ferociously turned upon itself by young Islamic militants, who not only destroyed New York's tallest buildings, the twin towers of the World Trade Center, but used planes to expose unsuspected vulnerabilities at the heart of US domestic security. In retaliation, the United States launched two militarily successful wars in Afghanistan and Iraq, demonstrating that the advent of "smart weapons" had radically altered the dynamics of battle since the Vietnam era; by the official end of the Iraq invasion, some US observers even wondered (in a luxury permitted only to winners) whether modern warfare any longer needed human bodies on the front lines. Early 2003 also saw the loss of the US space shuttle Columbia with seven crew members, underlining again the fragility of manned space exploration. Behind the dramatic disasters and the violence of terrorism and war, ordinary human attempts to master nature proceeded at slower rhythms, as societies debated how to manage global climate change, AIDS, and other epidemic diseases; how to solve problems of clean water and renewable energy; how to improve crop yields without endangering farmers' livelihoods; how to treat the ancient infirmities of aging, infertility, mental illness, and disease; and how to stave off death itself.

Yet, in analyzing many of the defining phenomena of human history – those arising at the nexus of science, technology, culture and power – large segments of the social sciences seem almost to retreat into a conspiracy of silence. In a world increasingly driven by the market's logic, and by the discovery of knowledge as a resource, neoclassical economics and rational choice models have sought to explain why firms innovate and how governments can steer research and development for higher productivity (Branscomb and Keller 1998; also see Rosenberg

1994; Mowery and Rosenberg 1989). But these approaches provide at best schematic accounts of the varied human responses to climate change, biological weapons, mammalian cloning, genetically modified foods, new reproductive technologies, emerging diseases, loss of biodiversity, techniques of miniaturization, and the growth of the internet. Entailing prolonged, contested interactions among people, ideas, institutions and material objects, the recognition and uptake of these phenomena challenge many of the most basic categories of social thought – such as structure and agency, nature and culture, science and politics, state and society. The dominant discourses of economics, sociology and political science lack vocabularies to make sense of the untidy, uneven processes through which the production of science and technology becomes entangled with social norms and hierarchies. Still less do these conceptual frameworks allow us to evaluate how sociotechnical formations loop back to change the very terms in which we human beings think about ourselves and our positions in the world (Hacking 1999; 1992; Foucault 1972). Anthropology, with its focus on thick description (Geertz 1973) and its growing attentiveness to modern, non-exotic cultures, does better at the project of sense-making, but at the risk of losing historicity, overemphasizing locality, and sacrificing some of the abstracting and generalizing capacities of the other social sciences (but see, for example, Gingrich and Fox 2002).

By contrast, the emerging field of science and technology studies (S&TS) has adopted as its foundational concern the investigation of knowledge societies in all their complexity: their structures and practices, their ideas and material products, and their trajectories of change. Growing from many disciplinary roots – including history, philosophy, sociology, politics, law, economics and anthropology – S&TS today encompasses a rich tapestry of theoretical and methodological perspectives, all specifically directed toward investigating the place of science and technology in society (Jasanoff *et al.* 1995). Conversations between S&TS and neighboring fields about the links between knowledge, culture and power are therefore urgently needed and could be enormously fruitful. To further these discussions, however, disciplinary divisions within S&TS must be bridged, and more explicit efforts made to link the field's predominant concerns with those of the traditional social sciences. This book takes on both tasks by elaborating the concept of *co-production*, which has recently gained ground in diverse domains of S&TS research.

The book's main argument is that, in broad areas of both present and past human activity, we gain explanatory power by thinking of natural and social orders as being produced together. The texture of any historical period, and perhaps modernity most of all, as well as of particular cultural and political formations, can be properly appreciated only if we take this co-production into account. Briefly stated, co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiments are at once products of social work and constitutive of forms of social life; society cannot function without knowledge any more than

knowledge can exist without appropriate social supports. Scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions – in short, in all the building blocks of what we term the *social*. The same can be said even more forcefully of technology.

Co-productionist accounts, conceived in this way, avoid the charges of both natural and social determinism that have featured in recent academic debates around the field of science and technology studies, including the infamous "science wars" of the 1990s (Sokal and Bricmont 1998; Koertge 1998; Gross and Levitt 1994). Science, in the co-productionist framework, is understood as neither a simple reflection of the truth about nature nor an epiphenomenon of social and political interests. Rather, co-production is symmetrical in that it calls attention to the social dimensions of cognitive commitments and understandings, while at the same time underscoring the epistemic and material correlates of social formations. Co-production can therefore be seen as a critique of the realist ideology that persistently separates the domains of nature, facts, objectivity, reason and policy from those of culture, values, subjectivity, emotion and politics. However, co-production, in the view of contributors to this volume, should not be advanced as a fully fledged theory, claiming lawlike consistency and predictive power. It is far more an idiom – a way of interpreting and accounting for complex phenomena so as to avoid the strategic deletions and omissions of most other approaches in the social sciences.

The essays in this collection, then, endeavor to address audiences within S&TS and in neighboring social sciences, as well as interested readers in the humanities, sciences and policy institutions. As is implied by the book's title, *States of Knowledge*, a significant aim of several of the contributors is to explore how knowledge-making is incorporated into practices of state-making, or of governance more broadly, and, in reverse, how practices of governance influence the making and use of knowledge. States, we may say, are made of knowledge, just as knowledge is constituted by states. But the title also plays on the theme of co-production at additional levels. Knowledge, in particular, is seen as crystallizing in certain ontological states – organizational, material, embodied – that become objects of study in their own right.[1]

The authors seek to illuminate some shared concerns as well as some possible tensions between S&TS and more established fields. In pursuing these objectives, the book attempts to synthesize findings from the various subfields of science and technology studies (e.g. history of science, technology studies, sociology of scientific knowledge, feminist and cultural studies of science and technology, science and law, and science policy studies). Not all of the synthesis, however, is internalist, working exclusively within the core of S&TS. Once we approach the interconnectivity of nature and society with a co-productionist vision, we find echoes of and parallels to the concerns of science studies in other interpretive social sciences, from anthropology to political theory. Exploring some of these convergences is as much a project of this book as theorizing across S&TS. Indeed, the book makes explicit efforts to link literatures that have not previously

been in conversation, revealing connections that should not only interest S&TS researchers but reverberate throughout the social sciences.

That said, a major purpose of the synthesis offered here is to highlight some cross-cutting theoretical assumptions in S&TS scholarship, as well as their normative implications, showing why S&TS methods and findings are indispensable for the analysis of power, culture and social change. Coming from disciplinary backgrounds in history, politics, sociology, law, anthropology, physics and science studies, the contributing authors vary in their research focus and methodological preferences; yet they epitomize the common orientations of many S&TS scholars toward the relationship between knowledge and social order. In jointly presenting their views on co-production, the authors emphasize the analytic achievements of S&TS as a whole in relation to other areas of current humanistic and social thought. They also help contradict certain frequent but unfounded criticisms of S&TS scholarship: that it is too micro-focused to speak convincingly to social theory; too internalist in its focus on science and technology to hold interest for students of other social phenomena; and too lacking in normative bite to be sufficiently critical (Woodhouse *et al.* 2002; Scott *et al.* 1990).

The idiom of co-production speaks to the agendas of the traditional social sciences (and to some extent the humanities) in a number of ways. It fits most comfortably with the interpretive turn in the social sciences, emphasizing dimensions of meaning, discourse and textuality. This approach addresses and complements a number of specific disciplinary lines of thought. To political scientists, particularly those working in post-structuralist frameworks, co-production offers new ways of thinking about power, highlighting the often invisible role of knowledges, expertise, technical practices and material objects in shaping, sustaining, subverting or transforming relations of authority. To sociologists and social theorists, the co-production framework presents more varied and dynamic ways of conceptualizing social structures and categories, stressing the interconnections between the macro and the micro, between emergence and stabilization, and between knowledge and practice. To anthropologists, it offers further tools for analyzing problems of essentialism and stereotypic reproduction, showing how the cultural capacity to produce and validate knowledges and artifacts can account for long-term stability, as well as creativity and change. Finally, co-productionist accounts take on the normative concerns of political theory and moral philosophy by revealing unsuspected dimensions of ethics, values, lawfulness and power within the epistemic, material and social formations that constitute science and technology.

In all these respects, the co-productionist approach in S&TS is entirely compatible with projects in the history of science and technology. It is hardly surprising, then, that several contributors to this volume are historians by training (Carson, Dear, Dennis, Storey). An important value of the co-production idiom is that it may encourage more fruitful dialogue between historical and contemporary studies of science and technology, denying temporality the right to operate as a preordained conceptual and methodological barrier within S&TS. As co-

productionist studies make clear, investigations of current science and technology stand to benefit immeasurably from greater historical depth, just as historical work may gain profundity and relevance through more explicit attention to questions of power, culture and normativity.

Research elaborating on the idea of co-production has condensed around a number of shared theoretical questions and their methodological consequences. At what levels of social aggregation (laboratories, communities, cultures, the nation, the state, all of humanity), and in what kinds of institutional spaces or structures does it make sense to look for co-production? Put differently, what is it that gets co-produced in nature and society? Are the most useful insights about co-production to be discovered at the level of science, power and culture writ large? Or is it more illuminating to trace in fine-grained detail how particular concepts for classifying or ordering social worlds – for example, selfhood, national identity, illness or wellness, professional standing, expertise, citizenship – gain, or have gained, stability and coherence, along with equally particular expressions of knowledge – for example, genetic markers, measures of human intelligence, climate change, agricultural science, or the scarcity of elephants? The essays in this volume demonstrate that there is no necessary unanimity about these matters in current research in the co-productionist framework; rather, the very open-endedness of the authors' methodological choices, along with the diversity of their substantive topics, gives this turn in S&TS scholarship some of its undeniable exuberance. At whichever scale individual studies are framed, though, the findings help to clarify how power originates, where it gets lodged, who wields it, by what means, and with what effect within the complex networks of contemporary societies.

Several recurrent and partially overlapping preoccupations in S&TS scholarship offer a means of organizing (and, in the future, fostering) work in the co-productionist idiom. The first has to do with the *emergence and stabilization* of new objects or phenomena: how people recognize them, name them, investigate them, and assign meaning to them; and how they mark them off from other existing entities, creating new languages in which to speak of them and new ways of visually representing them (Daston 2000; Dear 1995; Pickering 1995; Latour 1993; 1988a). The second concerns the framing and resolution of *controversy*. Under this heading, a large body of S&TS research has looked at the practices and processes by which one set of ideas gains supremacy over competing, possibly better established ones, or fails to do so (Richards and Martin 1995; Shapin and Schaffer 1985; Collins 1985). The third important line of research centers on the *intelligibility and portability* of the products of science and technology across time, place and institutional contexts. Topics under this heading range from the standardization of measures and analytic tools to the formation of new communities of practice, such as expert witnesses, who are capable of endowing claims with credibility as they are transported across different cultures of production and interpretation (Bowker and Star 1999; Jasanoff 1995; Shapin 1994; Porter 1992; Latour 1987; Kuhn 1962). The fourth significant tradition examines the *cultural practices* of science and technology in contexts that endow

them with legitimacy and meaning. Work in this vein has asked how the supposed universality of facts and artifacts fares in disparate political and cultural settings, as well as how different domains of research and development acquire and retain particular cultural characteristics (Knorr-Cetina 1999; Rabinow 1996; Traweek 1988).

In each of these four focal areas – the emergence of new phenomena, the resolution of conflicts, the standardization of knowledge or technology, and the enculturation of scientific practices – work in the co-productionist idiom stresses the constant intertwining of the cognitive, the material, the social and the normative. Co-production is not about ideas alone; it is equally about concrete, physical things. It is not only about how people organize or express themselves, but also about what they value and how they assume responsibility for their inventions. Equally to the point, co-production occurs neither at random nor contingently, but along certain well documented pathways. Four sites of co-production are repeatedly investigated by the contributors to this volume: making *identities*, making *institutions*, making *discourses* and making *representations*. These provide an important bridge between the S&TS literature and many of the core productions of traditional political and social analysis, which also revolve around these basic analytic categories.

Essays in co-production

As an interpretive framework, co-production begs for illustration rather than proof. The chapters that follow display the idiom's breadth and plasticity, but in working out co-productionist ideas through detailed empirical studies, they also demonstrate the framework's practical uses and limits. In the next chapter, I make the theoretical case for co-production as an analytically useful concept by delineating the spaces it seeks to fill between dominant frames of analysis espoused by the social sciences. The chapter provides a detailed review of the S&TS literature that underwrites work in the co-productionist idiom. Here, we encounter two streams of thought: one focused broadly on the constitution of new technoscientific cultures, often around emergent ideas and objects; the other on solving problems of disorder within established cultures. I refer to these as the constitutive and interactional strands, respectively; they correspond broadly to well documented S&TS engagements with metaphysics and epistemology – or, as Hacking phrases it, "what there is and how we find out about it" (1999: 169). The chapter next outlines the programmatic aims of research on the theme of co-production and elaborates on the pathways by which co-production most often occurs. I conclude with reflections on how co-productionist ideas may help connect S&TS work to ongoing intellectual projects in other fields of social analysis.

The remaining chapters are grouped under three sets of thematic as well as topical headings. The first group – by Miller, Thompson, Waterton and Wynne, and Storey – looks at evolving perceptions of the environment and nature as sites of co-production; all these authors centrally engage with the simultaneous emergence of new knowledges, institutions and identities related to environmental

change. The second group, consisting of chapters by Hilgartner, Rabeharisoa and Callon, Lynch, and in part Carson, investigates co-production as related to developments in the human and life sciences, especially the practices of research communities in genetics, clinical medicine and forensic science. These chapters bring to the fore issues of intelligibility and portability of knowledge, linked to the formation of new social identities and expert discourses. The third group, by Carson, Dear, Dennis, and Ezrahi, addresses a complex of issues centering on the macro-politics of knowledge; they focus on institutional conflicts among cognitive, moral and political authority, the mediating presence of experts, and the role of science and technology at times of significant political change. The connections between scientific knowledge-making and other authoritative cultural practices (religion, military, media) figure importantly in these chapters, which also deal with conflicts between alternative institutionalized knowledge-power formations. In short, these chapters play upon the book's title – states of knowledge – in its most open and obvious meaning.

With these groupings in mind, let us turn to a more detailed review of the individual contributions. The theme of institutional and epistemic emergence, as already mentioned, is especially prominent in the chapters dealing with the construction and deployment of environmental knowledge and the building of transnational political orders. Clark Miller addresses these issues on a planetary, or global, scale. Creating environmental knowledge about the biosphere involves, he suggests, not only new sciences and technologies, such as satellite data, general circulation models and integrated assessments, but also the fabrication of new institutions whose authority can credibly span the globe. Globalization, on Miller's account, is not simply the result of pre-stabilized knowledges, beliefs, products and social identities traveling around the world. Rather, it requires the manufacture of a newly imagined global political order that both links and transcends earlier nation-based centers of knowledge and power. Miller shows how the framing of climate change as a global issue, replacing the earlier view of climate as an aggregation of local weather problems, supplied a rationale for creating global institutions with claims to both scientific and political legitimacy. Previewing several succeeding chapters, Miller also shows that the attempt to supersede existing political orders produces its own tensions, exposing disagreements about the nature of "good science" as well as "good politics" on a supranational scale.

In her account of elephant protection in Africa, Charis Thompson examines co-production from the standpoint of international environmental regimes. She questions the presumption that knowledge must be consolidated in particular places before it can travel freely to other locations. Thompson argues that the shift in the elephant's status from "endangered" to "manageable" was not due to a context-specific, scientific determination of elephant biology, but went hand-in-hand with the emergence of a pan-African identity that could support multi-sited management practices. Originally forced to accept an absolutist scientific discourse of endangerment, African nations were enabled, through successive rounds of international negotiation, to put forward their view that

elephants could be both hunted and protected in a regime of sustainable development. This "African" position, which merged ethics with science and made space for regional variation, successfully countered the monolithic bureaucratic rationality of some Western environmentalists. It produced, in effect, an authentically "African" elephant, unshackled by global discourse. A North–South dialogue that reopened divisions between lay and expert, and science and politics, led to the creation of a new moral economy around the elephant – thus making it possible to defend a new ontology for this most charismatic of all large animal species.

Claire Waterton and Brian Wynne also situate their study in the international arena as they examine how institutions and identities are bound up in processes of new knowledge formation. Their focus is on the European Environment Agency (EEA), a body that has been called upon to imagine and project a vision of Europe while at the same time shaping its own identity as a provider of objective, useful environmental knowledge to European policymakers. The agency sits at what one of its own analysts eloquently describes as "the eye of the hurricane" of European integration. The dilemma that Waterton and Wynne explore is that the EEA in a sense presupposes a full-blown European identity in order to legitimate its knowledge-producing activities; yet, in the very act of knowledge-making, the EEA participates in enacting Europe's nascent political order, choosing between models not yet set in stone. The evaluation of genetically modified (GM) crops and environmental chemicals illustrates the practical working out of this tension. The EEA, as Waterton and Wynne argue, recognizes that environmental uncertainty and risk demand new forms of deliberation and a critical approach to the existing centralized and officially sanctioned policy processes. At the same time, for its own legitimacy, as well as for the sake of the imagined, Platonic Europe that is aborning, the EEA cannot wholly let go of older assumptions of universal science and expert rationality. The EEA's experience in this respect is all about the messy and contested emergence of alternatives to the rationalizing, high-modernist state.

William Storey provides a historical counterpoint to the contemporary cases in his account of the foundation of the Imperial Department of Agriculture for the West Indies in 1898. The Department represented an institutional solution to a complex and overlapping set of problems: ecological and economic crisis in Britain's sugar-producing colonies; the unreliability of colonial science; Britain's changing imperial objectives and policies; and the urge to remedy, with the aid of science, perceived social problems that were deemed to be natural. As Storey observes, this was no simple case of science influencing politics or politics influencing science; rather, each set of practices – scientific and political – provided a rationale for the other. This interplay produced a powerful institutional form that was copied in agriculture departments throughout the world and provided a template for an emerging imperial politics.

The human and life sciences are particularly rewarding sites for co-productionist accounts because they are so often implicated in all of the important manifestations of this process discussed above: emergence, contestation, standardization and encul-

turation. The second group of chapters engages with these dynamics, and the associated roles of several non-state actors, such as scientists, patient groups and litigating parties. Stephen Hilgartner usefully reminds us that the institutions involved in co-production need not be those of the state. Practices for creating and contesting ownership, Hilgartner demonstrates, are deeply embedded in laboratories, where they shape both the internal workings of science and science's relations with the outside world. In his study, the laboratory becomes a site in which the institutions of property and ownership are redefined. Appropriation practices in genome laboratories thus constitute an inseparable part of their technological structure, moral order and everyday operation. Hilgartner's genome scientists challenge essentialist understandings of some basic social science categories. Their discourse blurs the contrast between micro and macro, and they remake the notions of "public" and "private" science through situated debates about who owns what in the laboratory.

Rabeharisoa and Callon also discuss a new kind of non-state institution, the "reflexive organization", which cuts across accepted divisions between lay and expert actors, and facilitates inquiry in a domain that increasingly demands the participation of the patient as an active research collaborator as well as a traditional research subject. Their investigation of the Association of French Muscular Dystrophy Patients shows lay individuals negotiating details of research and practice that are ordinarily thought to be the monopoly of specialist clinicians and scientists. The incorporation of a genetic disease as an element of their identity empowers muscular dystrophy patients and their families to participate in both knowledge-making and political action. Appearing, as it were, on both sides of scientific practice – as researchers and researched – the patients negate the conventional distinction between subject and object that has animated the work of science; only by acting as subjects can patients provide their partners, the orthodox scientific investigators, with a viable object of study. Further, by shaping novel discursive and organizational practices, they reorder many widely held assumptions about how biomedical science should be done in the contemporary world.

Michael Lynch directs his analysis toward the co-production of expert and non-expert knowledges in the context of US common law trials in the late twentieth century. This process, Lynch argues, does not consist simply of drawing a boundary between the two domains. Rather, it requires definition of the very category of expert and the assignment of particular individuals to that category. His analysis of cross-examination shows that the expert's identity is founded not on an individual's control of recognized knowledge and skills, but through mundane conversations and humdrum instruments, such as courtroom presentation of the professional résumé. Like Hilgartner, Lynch problematizes the easy distinction between micro- and macro-analytic categories. Courts engaging with forensic scientific evidence, he argues, are oblivious to such theoretical distinctions. In examining the credentials of a forensic DNA expert, for example, the court problematizes the "macro" categories of "science" and "expert" by enabling micro-, context-specific, adversarial dialogues to occur between

witnesses and cross-examining attorneys. Lynch's "grammatical perspective" shows how the use of ordinary words allows courts to shift between two registers: on the one hand, paying homage to science's transcendence by seeming to honor the categories that set science apart; on the other hand, remaking the distinctions between science and common sense through case-centered decisionmaking. Courts in this way perform some of the essential political work of liberal democracies, by invoking and continually reproducing through their own practices the boundary between science and non-science.

John Carson turns his eye on a core problem of contemporary democracy, the fair distribution of scarce resources such as access to educational opportunities. Comparing the genesis of intelligence testing in early-twentieth-century France and the United States, he displays how one of the most taken-for-granted aspects of human identity – *intelligence* – has been configured in different ways in two different democratic cultures. Both intelligence and tests of it are emergent scientific objects, constituted through evolving expert discourses; but, going beyond normal accounts of science in the making, Carson's chapter compellingly delineates the *political* work done by these characterizations of human competence. Variations in the definition and measurement of intelligence between France and the United States can be attributed, he argues, to divergent understandings of equality in the two countries. In France, the democratic challenge is to represent existing social hierarchies as potentially open to all citizens. This has correlated with the assessment of merit through a standardized, state-administered educational system, in which performance according to collectively defined standards – not birth nor heredity – is the putative guarantor of success. In the United States, by contrast, hierarchies of merit are publicly disavowed, education is highly decentralized, and the federal role in rearing educated citizens is both constitutionally and ideologically circumscribed. The peculiarly American commitment to standardized, quantified and privately administered intelligence testing has taken root in this context as an objective, "scientific" instrument for sorting and classifying citizens – yet one which, given its power to produce inequality, remains essentially contested.

How the authority of science conflicts with or warrants other forms of authority, particularly the authority to govern at times of pronounced social change, is the central theme of the three remaining chapters; in these studies, coproduction comes into focus as different forms of authority are constituted, embodied, challenged and restabilized. Peter Dear reflects on the interdependence of civil and epistemological authority in seventeenth-century Europe, as natural philosophers wrestled with the sources of legitimate expertise. The political theory underpinning absolutist ideologies of "mystery of state" applied, he suggests, to the establishment of knowledge-claims made through new kinds of experimental procedures resting on observations of nature. The credibility of such demonstrations could not be fully broken down into reasons, or analyzable components, that did not depend, at some irreducible core, on the reliability of the experimenter. For experimental results to be authoritative, experts thus needed recourse to some shared domain of unquestioned moral authority where

further explanation was no longer felt to be necessary. In early modernity, Dear proposes, the rituals of absolute monarchy, including display to aristocratic audiences, provided natural philosophers with one such resource for establishing their own claims of transcendent expertise.

Michael Dennis' chapter focuses on the postwar confrontation in the United States between a science profoundly dependent on military funding and the state's defensive interests and the vision of science entertained by Michael Polanyi (1962) and others as an autonomous republic of free-thinking citizens. Vannevar Bush, a contemporary of Robert Oppenheimer and key presidential science adviser, embodies the precarious effort to resolve these contradictions. Dennis' portrayal of Bush uses a suggestive image – Bush's head surrounded by a crown of destructive weaponry – to symbolize the unresolved tensions between the sin of overdependence on a military agenda and redemption, through basic research, in postwar American science. Although Bush is widely identified as the chief architect of the National Science Foundation and author of American society's "contract with science", he is here revealed as a tragic figure, unable to rein in the momentum of militarization and state patronage unleashed by the war. In a personal defeat, this relic of an earlier, more gentlemanly era of independent expertise is sidelined in the less civil, more resource-hungry order of knowledge and power that he did so much to bring into being.

Yaron Ezrahi's essay deals with the most fundamental kind of political crisis – a change in the very foundations of contemporary democracy. Departing from his earlier magisterial work on modern science as legitimator and model for liberal democratic politics (Ezrahi 1990), Ezrahi notes that in today's world the representations of reality produced by science, and shared by a democratic citizenry, fight for space in the public mind with the onrush of images created and disseminated worldwide by the mass media. In contrast to the esoteric knowledge and information produced at great expense by science, media representations, which Ezrahi suggestively calls "outformations", are generally much more accessible to publics. They require less time, effort, knowledge and skills to interpret than does the information generated by science. However expensive they are to produce, media representations, once created, can be accessed by widely dispersed consumers and publics at relatively little additional cost. Media representations also contravene some of the most basic assumptions of scientific reality: that emotion, ambiguity, subjectivity and the inner self have to be bounded out of the space in which we perceive what is truly real. In these respects, they are more appealing to ordinary citizens. Increasingly, Ezrahi argues, the relatively high-cost, high-entry-barrier reality of science has had to distance itself from everyday human experience; lower-cost, more accessible media realities to some extent fill the imaginative void left by the retreat of science. Like other authors in this collection, Ezrahi is careful to note that he is not describing the overthrow of a hegemonic Enlightenment tradition by one that is equally totalizing in its fragmentation of human perceptions. What he describes is far more an emergence of competing claims on the democratic

political imagination, whose implications for liberty and order we are not yet in a position to assess.

Finally, in a brief Afterword, I pull together and reiterate the thematic connections among the chapters, noting that they collectively make a strong case against linear, unidirectional causal explanations for complex social phenomena; they also reinforce the need to integrate studies of knowledge-making and technology-production with the analysis of human identities, institutions, discourses and representations. I conclude with some observations on the possible implications of co-production as a cognitive frame that itself gets picked up into newer cycles of world-making.

Note

1 I am especially grateful to Pablo Boczkowski for helping me to articulate the multiple meanings of the title of this volume.

2 Ordering knowledge, ordering society

Sheila Jasanoff

Science in culture and politics

Science and technology account for many of the signature characteristics of contemporary societies: the uncertainty, unaccountability and speed that contribute, at the level of personal experience, to feelings of being perpetually off balance; the reduction of individuals to standard classifications that demarcate the normal from the deviant and authorize varieties of social control; the skepticism, alienation and distrust that threaten the legitimacy of public action; and the oscillation between visions of doom and visions of progress that destabilize the future. Both doing and being, whether in the high citadels of modernity or its distant outposts, play out in territories shaped by scientific and technological invention. Our methods of understanding and manipulating the world curve back and reorder our collective experience along unforeseen pathways, like the seemingly domesticated chlorofluorocarbons released from spray cans and air conditioners that silently ate away at the earth's stratospheric ozone layer. Just as environmental scientists are hard put to find on earth an ecological system that has not been affected by human activity, so it is difficult for social scientists to locate forms of human organization or behavior anywhere in the world whose structure and function have not been affected, to some extent, by science and technology.

Take culture, in particular, or more accurately cultures. Although science and technology are present everywhere, the rambunctious storyline of modernity refuses to conform to any singular narrative of enlightenment or progress. The familiar ingredients of modern life continually rearrange themselves in unpredicted patterns, creating rupture, violence and difference alongside the sense of increasing liberation, convergence and control. The terrorist attacks in the United States on 11 September 2001 acted out in brutal reality and on global television screens many contradictions that were already seething below the surface. On a clear, sparkling day in early fall, nineteen young Muslim militants hijacked four civilian aircraft and rammed them into the World Trade Center's twin towers in New York, the Pentagon in Washington, and a field outside Pittsburgh, Pennsylvania. This was suicidal violence on a previously unimagined scale. The pyres on which the hijackers immolated themselves killed more than 3,000 innocent people who had

left home for a normal day at work. The shockwaves broke America's late-twentieth-century dream of inviolability, and hastened the birth, some said, of a new empire dominated by American military might. US-led wars in Afghanistan and Iraq toppled regimes and fundamentally altered the legal and political order of the post-Cold War world.

Yet, at the threshold of a new millennium, this 11 September and its violent aftershocks only dramatized in horrific form much that was already known. Industrial societies, despite their many commonalities, articulate their needs and desires in different voices. Despite the ubiquity of CNN, Microsoft and the Coca-Cola can (Barber 1995) – and the global homogeneity they signal – the din of multivocality rises rapidly as one leaves the havens of the industrial West. Politicians and citizens in Washington, Paris, Tokyo and Baghdad have met the challenges and dislocations of the present with disparate resources and divergent criteria of what makes life worth living. The world is not a single place, and even "the West" accommodates technological innovations such as computers and genetically modified foods with divided expectations and multiple rationalities. Cultural specificity survives with astonishing resilience in the face of the leveling forces of modernity. Not only the sameness but also the diversity of contemporary cultures derive, it seems, from specific, contingent accommodations that societies make with their scientific and technological capabilities.

The dynamics of politics and power, like those of culture, seem impossible to tease apart from the broad currents of scientific and technological change. It is through systematic engagement with the natural world and the manufactured, physical environment that modern polities define and refine the meanings of citizenship and civic responsibility, the solidarities of nationhood and interest groups, the boundaries of the public and the private, the possibilities of freedom, and the necessity for control. What we know about the world is intimately linked to our sense of what can we can do about it, as well as to the felt legitimacy of specific actors, instruments and courses of action. Whether power is conceived in classical terms, as the power of the hegemon to govern the subject, or in the terms most eloquently proposed by Michel Foucault, as a disciplining force dispersed throughout society and implemented by many kinds of institutions, science and technology are indispensable to the expression and exercise of power. Science and technology operate, in short, as *political* agents. It would not be utterly foolhardy to write the political history of the twentieth century in terms of its most salient technoscientific achievements: the discoveries of the atom and the bomb, the gene and its manipulation, radio communication, television, powered flight, computers, microcircuitry, and scientific medicine.

In what conceptual terms, then, should we discuss the relationships between the ordering of *nature* through knowledge and technology and the ordering of *society* through power and culture? How should we characterize the connections between the human capacity to produce facts and artifacts that reconfigure nature, and the equally human ability to produce devices that order or reorder society, such as laws, regulations, experts, bureaucracies, financial instruments, interest groups, political campaigns, media representations or professional ethics?

Does it any longer make sense for those concerned with the study of power to assume that scientific knowledge comes into being independent of political thought and action, or that social institutions passively rearrange themselves to meet technology's insistent demands? Established disciplinary languages fail us in grappling with these questions; disciplinary scholars find themselves at a loss for words, almost as if a Wall Street banker were asked to interpret a Balinese cock fight or a Bangladeshi rice farmer to comment on DNA typing in the O. J. Simpson murder trial. To fill this void, we draw in this book on several decades of detailed scholarship on the workings of science and technology within society. More specifically, we elaborate on the concept of *co-production*, which has recently gained ground in the emerging field of science and technology studies (S&TS).

In this chapter, I begin to make the case for co-production by first delineating the gap it seeks to fill between frames of analysis espoused by the traditional social sciences. This is followed by a review of the literature in science and technology studies that underwrites work in the co-productionist idiom. To clarify the analytic aims of this literature, I delineate two broad streams of thought – the constitutive and the interactional – that deal, respectively, with the emergence of new socio-technical formations and with conflicts within existing formations. The next section elaborates on the patterned pathways by which co-production occurs, identifying four major research programs that have developed around this theme. The chapter concludes by recapitulating the implications of the co-productionist idiom for future work in S&TS. In the interests of cross-disciplinary engagement, the chapter points throughout to connections between work in contemporary science studies and theoretically compatible work in other related disciplines.

A language for hybrids

The need for a generative discourse for discussing the role of science and technology in society is abundantly clear. What happens in science and technology today is interwoven with issues of meaning, values, and power in ways that demand sustained critical inquiry. Consider, for example, the transformation of a sheep named Dolly, born of a virgin mother in an obscure laboratory near Edinburgh, Scotland, into a universally recognized symbol[1] – of progress for some and moral transgression for others. Cloning was hardly the kind of event that could be counted on to set in motion the machinery of high politics. The scientific claims of the Edinburgh researchers had not been tested or replicated when they captured headlines round the world; the implications of the research remained distant and speculative (Wilmut *et al.* 1997). Dolly was a product of biomedical, not military, science. Her materialization posed no immediate threat to people's livelihood or security. Yet presidents and prime ministers reacted in haste to the news of Dolly's cloning, recognizing as if by some inarticulate sixth sense that this was an event for which politicians as well as scientists would be held accountable. Similarly, on 9 August 2001, a still unseasoned President George W. Bush devoted his first ever televised news conference to his government's policies

for research with embryonic stem cells. Notably, too, the rush to find the right frames within which to fit Dolly or stem cells – in science, politics, morality or law – led to results that were far from uniform across liberal democratic societies (Jasanoff forthcoming a).

Such complicated choreography is not uniquely associated with the life sciences. In little more than a decade, a formless entity called the internet, whose organization and governance remain a mystery to most of its users, became a player in countless contemporary social transactions. In exploring its possibilities, millions of people began to alter not only the architecture of the internet but also, in diverse ways, their own preconceptions of what it means to belong to social units such as the family, community, workplace, firm or nation. The sum of their interactions has changed the nature of commerce and capital, producing integration and disruption on global scales. Sometimes with a bang, as in the work of the Al-Qaeda terrorist network and its violent aftermath, and at other times in incremental whimpers, notions of ownership, privacy, security, nation and governance are all being transformed. In the computer age, it is increasingly difficult to pin down with certainty the places where politically salient events originate, let alone to determine who controls the levers of power. Similar fragmentation and dispersal of authority have also been noted by sociologists of risk. Not without cause has the German sociologist Ulrich Beck (1998) called the politics of risk "a form of organized irresponsibility" (see also Beck 1992).

To be sure, the idea that the gene or the computer chip can reshape society around its inbuilt logic has lost its cachet in the world of scholarship, even though determinist arguments still predominate in much popular writing about technological developments. Unlike Athena sprung full-grown from brow of Zeus, social and political arrangements for exploiting, resisting or quite simply accommodating technological change do not emerge, intact and fully formed, in response to innovation and discovery. Technology does not, when all is said and done, "drive history" (Smith and Marx 1994). Legal and political institutions lead, as much as they are led by, society's investments in science and technology. The material and cultural resources with which human actors bring new natural phenomena into view, or seek to domesticate unfamiliar inventions, often exist before the "discovery" of the objects themselves. The design of technology is likewise seldom accidental; it reflects the imaginative faculties, cultural preferences and economic or political resources of their makers and users (Bijker 1997; Bijker *et al.* 1987). In engagements with the physical world, we are not mere spectators whose responses and destinies are ineluctably transformed by the growth of knowledge and the acquisition of novel technological capability. At the same time, when we tune into the rhythms of everyday life, even at times of exceptionally rapid technoscientific change (as arguably in the late twentieth century), we experience more often the steady hum of continuity than the sense of disequilibrium. In short, the ways in which we take note of new phenomena in the world are tied at all points – like the muscles on a skeleton or the springs on a cot frame – to the ways in which we have already chosen to live in it. Yet, astonishingly, most theoretical explorations of how social worlds evolve only imperfectly reflect

the complicated interplay of the cognitive, the institutional, the material and the normative dimensions of society.

That traditional disciplinary discourses fall short in this way should not be taken as a sign of lack of progress in understanding the intersections of science and technology with politics and culture. To the contrary, several decades of research in science and technology studies have done much to illuminate how orderings of nature and society reinforce each other, creating conditions of stability as well as change, and consolidating as well as diversifying the forms of social life. A compelling body of scholarship has demonstrated that science and technology can be fruitfully studied as social practices geared to the establishment of varied kinds of structure and authority (Biagioli 1999; Jasanoff *et al.* 1995; Pickering 1995; Clarke and Fujimura 1992; Bijker *et al.* 1987; Barnes and Edge 1982). So viewed, the workings of science and technology cease to be a thing apart from other forms of social activity, but are integrated instead as indispensable elements in the process of societal evolution. Science, made social in this way, can be compared and contrasted with other exercises in the production of power (Latour 1999; 1988a; 1987). Increasingly, the realities of human experience emerge as the joint achievements of scientific, technical and social enterprise: science and society, in a word, are *co-produced*, each underwriting the other's existence.

But where does this insight lead political and social analysis? Does the idea of co-production represent anything more than the intuitively obvious point that ideas of nature, no less than ideas of society, are constructed by human endeavor – that both science and technology are fundamentally human achievements? If that were all, it would be cold comfort. A theoretical enterprise that seeks to explain why the world is ordered in certain ways has to promise more than the line from the popular children's song, "Everything hangs together because it's all one piece". Does co-production as we have defined it in Chapter 1 yield better, more complete descriptions of natural and social phenomena than are to be found in more orthodox accounts? Can co-production serve the explanatory purposes that we have come to expect of theories in the social sciences? Can it provide normative guidance, or at least facilitate our critical interpretation of the diverse ways in which societies constitute, or reconstitute, themselves around changes in their apprehension of the natural world? Can the co-productionist approach ever predict?

Recent work in science and technology studies strongly suggests that these questions can be answered in the affirmative, although modestly, especially with regard to prediction, and with due regard for persistent disciplinary divisions within the field that have tended to obscure some of its most general insights. There has been a dearth of scholarship that integrates salient theoretical currents within S&TS, largely emanating from sociological, political and cultural studies of science, with its rich store of empirical findings, the latter deriving most importantly from the history of science and technology, but augmented lately by a growing body of work using disciplines ranging from anthropology to law. A relatively narrow focus on the particularities of scientific and technological production is also partly to blame.

Scientific biographies and studies of specific theories, artifacts or institutions have not always made explicit the connections between the mundane practices of science and those of politics and culture. Feminist theorists are an obvious exception (Haraway 1989; Keller 1985), and a handful of other authors have explicitly addressed state–science relations from an S&TS perspective (for example, Jasanoff 1992; 1990; Ezrahi 1990; Mukerji 1989; Shapin and Schaffer 1985). For the rest, research on science and technology has not sought to build systematic connections between the micro-worlds of scientific practice and the macro-categories of political and social thought. Sociology and political theory, for their part, have tended on the whole to leave science, and only slightly less so technology, out of their analytic programs – again with notable exceptions (Bourdieu 1980; Habermas 1975; Merton 1973). To date, the knowledge-making and knowledge-implementing faculties of human societies have received considerably less critical attention than such staple objects of social theory as race, class, gender, ideology, interests and power.

Among social theorists, the one who perhaps most consistently sought to bring together the analysis of knowledge and power is Michel Foucault (1971; 1972; 1973; 1979), whose work has exercised growing influence on research in S&TS. Foucault's imprint is particularly apparent in work, including contributions to this volume, that deals with classification, standardization, and the accrual of power by institutions that have the capacity to discipline people's bodies, minds and forms of life. His monumental legacy, however, is less well suited to exploring how diversity keeps reappearing and reasserting itself, even in the most entrenched institutions of modernity, such as expert bureaucracies. Some of the chapters in this volume address this problematic.

With the other contributors to this volume, I suggest that we have now arrived at a point at which we can usefully begin to pull together what has been learned in S&TS about the interpenetration of science and technology with cultural expressions and social authority. While it may be premature to propound anything so ambitious as a theory of co-production, it is not too soon to begin with more circumscribed steps. We can ask, in particular, what aspects of the role of science and technology in society may most appropriately be couched in the idiom of co-production: for instance, what sorts of scientific entities or technological arrangements can usefully be regarded as being co-produced with which elements of social order; what are the principal pathways by which such co-production occurs; how do processes of co-production relate to more orthodox accounts of technical or political change in S&TS and other disciplines; and what methods and approaches are best suited to investigating instances of co-production?

In addressing these questions, it is helpful to separate the relevant S&TS literature into two strands that have sought in disparate though closely connected ways to theorize the interplay of society, science and technology. We may call these, for ease of reference, the *constitutive* and the *interactional*. The former is primarily concerned with the ways in which stability is created and maintained, particularly for emergent phenomena, whether in a particular site where knowledge is made, such as a research laboratory, hospital or legal proceeding, or

around a novel technoscientific object, such as the human genome or a periodic table for chemicals. At the most basic level, the constitutive strain in S&TS seeks to account for how people perceive elements of nature and society, and how they go about relegating part of their experience and observation to a reality that is seen as immutable, set apart from politics and culture. This body of work is most closely related to metaphysical concerns in the philosophy of science, because one cannot discuss the constitution of nature or society without resolving questions about what it means to be natural or social, human or non-human. Co-productionist accounts, however, are not content simply to ask what *is*; they seek to understand how particular states of knowledge are arrived at and held in place, or abandoned.

The interactional approach, by contrast, is less overtly concerned with metaphysics and more so with epistemology – or less with what is and more with how we know about it (Hacking 1999: 169). This line of work takes for granted that, in most exercises of world-making, neither science nor society begins with a clean slate but operates always against the backdrop of an extant order, in which people already "know" in pragmatic terms what counts as nature or science and what as society or culture. Nonetheless, boundary conflicts about where these domains begin and end continually arise and call for resolution (Gieryn 1999). As well, the recognition of new phenomena often entails confrontation between competing epistemologies. Work in the interactional mode probes how human beings organize, and periodically reorganize, their ideas about reality under these circumstances. It seeks to elucidate the myriad mutual accommodations between social and scientific practices that occur within existing socio-technical dispensations during times of conflict and change. If constitutive analysis focuses in the main on the emergence of new facts, things and systems of thought, then the interactional strain concerns itself more with knowledge conflicts within worlds that have already been demarcated, for practical purposes, into the natural and the social.

Varieties of co-production

Since scientific knowledge first came to be seen as constituted by social practices (Collins 1985; Latour and Woolgar 1979; Bloor 1976; Kuhn 1962), S&TS researchers have realized that the fruits of their labors are at best imperfectly captured by the dictum that scientific knowledge is socially constructed. This formulation gives rise to two unresolvable problems, one theoretical and the other pragmatic. The first is that it confers a kind of causal primacy upon the "social" that careful work in S&TS, broadly conceived, has consistently denied (Knorr-Cetina 1999; Collins 1998; Pickering 1995; Woolgar 1988).[2] Constructivism does not imply that social reality is ontologically prior to natural reality, nor that social factors alone determine the workings of nature; yet the rubric "social construction" carries just such connotations (Hacking 1999). The second and more practical difficulty is that the discourse of social construction tends to inhibit the symmetrical probing of the constitutive elements of both society and science

that forms the essence of the S&TS research agenda. One or another aspect of the "social" – be it "interests", "capital", "gender", "state" or "the market" – risks being black-boxed, treated as fundamental, granted agency, and so exempted from further analysis.[3] The suspicion that social constructivists are arrogating to themselves an Archimedean point from which to deconstruct science has provoked criticism of S&TS as insufficiently reflexive (Woolgar 1988). It is also this reductionist reading of the "social" that has allowed defenders of the transcendental nature of science to rail at the idea of science as a social construct; in the so-called science wars of the 1990s, attackers of science studies frequently charged the field with misrepresenting scientific knowledge as "merely" social or political (Sokal and Bricmont 1998; Koertge 1998; Gross and Levitt 1994). Of course, no adequately social representation of science could ever be dismissed with the label "merely".

With greater maturity, science studies as a field has moved to show that what counts as "social" about science is itself a subject of unsuspected depth and complexity. For example, early efforts to explain how controversies end, in both science and technology (Richards and Martin 1995; Nelkin 1992; Bijker *et al.* 1987; Barnes 1977), often represented closure as a negotiated sorting out of competing social interests. Such work assumed, along with mainstream scholarship in economics and political science, that society can be unproblematically conceptualized as composed of interest groups with clearly articulated (exogenous) positions and preferences. These interests, or stakes, were then invoked to explain the positions taken by different actors concerning knowledge claims and their technological embodiments. Newer work recognizes the inadequacy of interests as a primary explanatory category. Interests themselves have a social history: how they arise and are sustained are matters to be investigated, not taken for granted. The results of such investigation include, *inter alia*, a greatly increased concern with the standardization of scientific and social practices (Bowker and Star 1999), a sensitivity to the place of material agents in the production of stable knowledge (Galison 1996; 1987; Pickering 1995; 1992), a focus on the techniques of scientific representation (Hilgartner 2000; Lynch and Woolgar 1990), a growing appreciation of the influence of language (Dear 1995; 1991; Keller 1985), a preoccupation with the bases of trust in science (Irwin and Wynne 1994; Porter 1995; Shapin 1994), and heightened sensitivity to the ways in which knowledge achieves practical universality in widely divergent sociopolitical settings (Jasanoff and Wynne 1998; Jasanoff 1986).

Perhaps the most important by-product of all this inquiry is the recognition that the production of order in nature and society has to be discussed in an idiom that does not, even accidentally and without intent, give primacy to either. The term *co-production* reflects this self-conscious desire to avoid both social and technoscientific determinism in S&TS accounts of the world. The concept has by now acquired a respectable ancestry within the field, although there are varying schools of thought on exactly how to define and employ it. Barnes (1988) came close to a co-productionist position in talking about the nature of power; the same human capacities for learning, responding to and transmitting

knowledge, he noted, are responsible for the creation of natural and social order. His two orderings are more interactional than mutually constitutive in the sense implied by other observers of co-production, and the role of material objects in constituting order is left vague at best. By contrast, Daston (2000), introducing a collection of essays on the "coming into being" of scientific objects, calls attention to their ability not only to focus scientific inquiry but also to crystallize emergent and socially salient features of their cultural contexts. These objects, like people, have "biographies"; they are "not inert" but quite often changeable and "attain their heightened ontological status by producing results, implications, surprises, connections, manipulations, explanations, applications" (Daston 2000: 10). They are for all practical purposes not only scientific objects but also social objects, produced in indiscriminate acts of synthesis out of a society's epistemological, esthetic and instrumental strivings. All this is quite consistent with the standpoint of co-production represented in this volume, but Daston's commitment in the end is to the *history* of science's objects of study; neither power nor culture is explicitly an issue in her account, although the categories of state and society figure in the contributions of some authors. The making of science is also *political*, we argue; indeed, a central claim of our collection is that there cannot be a proper history of scientific things independent of power and culture.

Pursuing this line of thought, some S&TS scholars see co-production as a process that is as foundational as constitution-making or state-making in political theory, because it responds to people's deepest metaphysical concerns. It does so, in part, by continually reinscribing the boundary between the social and the natural, the world created by us and the world we imagine to exist beyond our control. "Science" and "politics" can then be treated as separate and distinct forms of activity rather than as strands of a single, tightly woven cultural enterprise through which human beings seek to make sense of their condition. Others working in a co-productionist vein are less concerned with metaphysics and more interested in the practical accommodation of new knowledge within existing forms of life. For them, there is nothing inherently problematic about seeing the world as organized, at any given moment, into clearly demarcated domains of "science" and "politics". Ideas and objects are simply obliged to undergo a kind of parallel processing in order for problems to be solved in either domain: that is, nothing significant happens in science without concurrent adjustments in society, politics or culture; similarly, intransigent social problems seldom yield to resolution without changes in existing structures of knowledge. Fitting technology into this picture makes for further quandaries, since humanity's material productions affect both what we know and how we behave. S&TS scholars have differed importantly in how they view the role of the material and the inanimate in constituting social order, and the degree of agency that they are prepared to grant to non-humans (Hacking 1999; Latour 1996; Collins and Yearley 1992; Callon and Latour 1992).

As we shall see in subsequent chapters, there is no univocal position on these matters in current work in the co-productionist idiom. Instead, the authors show from varied perspectives that the co-productionist idiom can shed light on the