Muddling Through

Pursuing Science and Truths in the 21*st* Century

Mike Fortun

Herbert J. Bernstein

COUNTERPOINT
WASHINGTON, D.C.

Muddling Through

At the Interface

Not a day went by during the writing of this book that didn't include an announcement of some event which challenged how we think about the relationship between government, the sciences, and the democratic society in which we all live—or at least hope for and work toward. New drug therapies of great promise and uncertain risk, new environmental hazards postulated or refuted, more data on and more elaborate theories of climate change, new ways to conceive and bear children, enormous anxieties raised by mammalian cloning, the reorganization of work through new information technologies, another reorienting "big picture" of the cosmos—the scope and pace of social change accompanying the sciences is overwhelming. We live with an implacable need for more, and better, social policies bearing on scientific and technological change.

The fact that we have written only tangentially about the governmental policy aspects of the sciences doesn't mean we think they're unimportant. But better science policies will absolutely not be enough. Policy has to come, but it will inevitably come too late. To demarcate the pursuit of the sciences from the promulgation of policy, as our society does, is to forever play a catchup game. Because the sciences make reality, they exercise their power in many ways other than the conventionally political ones. When it comes to the sciences, politics—in the sense of social power being created and directed—happens in ways other than government action. The power of science happens before policy, and policy—as necessary as it is—is always after the fact.

The need for more, and more critical, readings of the sciences is not a small demand, and it is one which it is difficult to remain optimistic about in the current cultural climate. In 1996 a fiscally and politically conservative Congress dealt a quick and relatively quiet death to its own Office of Technology Assessment (OTA), one of the most important sources of inquiry into the effects of science and technology on democratic society. Since its establishment in the early 1970s, the

OTA had been one of the few institutions where social problems and promises associated with the sciences and technologies could be analyzed. Even if Congress didn't always know what to do with them, OTA reports provided a great deal of information on hazardous waste and its cleanup, nuclear weapons production and proliferation, the economic impacts of computer technologies, the patenting of biological materials, and hundreds of other topics.

At the same time this source of critical readings of the sciences was being dissolved, a disquieting report came from the National Science Foundation (NSF), the government agency so crucial to the funding and directing of the sciences in the post–World War II era. The NSF had convened a panel of experts for a workshop on "Science, Technology, and Democracy: Research on Issues of Governance and Change" in 1994; their subsequent report opened with the following sentences:

> [I]t is hard to imagine a modern industrial democracy without close coordination between scientists, engineers, and public officials. Yet the practices and processes that link science and engineering research to government in industrial democracies are largely implicit. The scope and pace of changes based on science and technology challenge democratic governance. Attempts to translate the social structures for research and governance from one society to another, or to modify it in existing ones, go awry because the human dimensions of that interface are poorly understood.[1]

Buried in the bland bureaucratese is a rather stunning statement: Science and technology raise fundamental questions of social governance, but the ways in which they do so, and the ways in which we might respond, exceed our grasp. In other words, this thing called modern industrial democracy happens in the absence of our full understanding. Immense, rapid changes occur "implicitly," with practically no foreknowledge or planning. We don't know how we got here, let alone what we might do. The fantasy of a social evolution that can be mastered, understood, and guided may very well be just that: a fantasy.

And yet we harbor a persistent hope and desire to make the implicit explicit, to understand the interfaces between science, technology, and government more fully, in hope that this understanding will lead to better planning and governing. Where does this desire come from? What makes us think that we can get even a little bit more control of this monstrously complex event—a modern industrial democracy that is practically, economically, and culturally dependent on the sciences—that has so obviously been taking place without our full willingness for so long?

And what if we can't? What if being at the interface between the sciences, technologies, policies, and something apparently separate from these called "human

dimensions," means not being in control? What if we're in the middle, and can't get to a safe perspective and effective leverage point outside the system?

Where Were We, Now?

There is another response to the intellectual, political, and ethical demands the sciences place on democratic society besides "better policies and more control." As much as a vital democratic society needs new legislative and regulatory frameworks for the sciences, it needs something else equally, if not more. There's something indirect, subtle, accidental, and perhaps even unknowable about the incredible power of the sciences. They change the world, through processes which we can only dimly understand. Social or political mastery seems out of the question. Yet we need *something* to help us live better with the sciences, in the middle.

We may not know, now, what that something is. But we do know that to have a better shot at making that something, we will need scientists, engineers, and all other citizens capable of reimagining the sciences along the lines we've outlined here: as experimental conglomerations of things, thoughts, and so much else, which literally make our world. We need a diverse polity outfitted with critical literacy skills, able to continually question and reread the sciences and their world-making powers again and again.

Such a recognition of the need for new science literacies is visible throughout our scientific culture, although expressed in ways orthogonal to ours. The Smithsonian—that venerable nineteenth-century institution symbolizing (and carrying out) the promise of state support for the sciences and technologies – recently drew fire for its exhibit "Science in American Life." The exhibit provoked outraged responses from many scientists for showing the "other side" of the social promise science has come to signify in our culture: the environmental havoc caused by exuberant use of pesticides, the growing influence of private industry on scientific careers and research agendas, the clustering links between the sciences and the military, the social and ethical dilemmas of genetic engineering, and other less than pure situations.

The exhibit is hardly an exposé, and the dominant tone (often expressed in the words of working scientists represented by cardboard cutouts) is one of respect for the achievements of science and scientists. In an activities room children, and their parents, can undertake hands-on explorations of various scientific phenomena. But, like the war veterans who demanded changes in the Smithsonian exhibit on the *Enola Gay* and the American use of atomic weapons at the end of World War II, some scientists felt that the historical record should be a separate matter from the public display of that record in edifying social institutions (especially ones supported with federal funds). The president of the American Physical Society com-

plained to the Smithsonian that the $5.5 million exhibit was "a portrayal of science that trivializes its accomplishments and exaggerates any negative consequences. We are concerned that this presentation is seriously misleading, and will inhibit the American public's ability to make informed decisions on the future uses of science and technology."[2] The American Chemical Society, which contributed a good portion of that $5.5 million, also protested the exhibit's "built-in tendency to revise and rewrite history in a 'politically correct' fashion"; one chemist involved in organizing the exhibit complained that it was largely the work of "social scientists and pseudoscientists who had no idea of how science worked."[3] These sentiments echo a long-held concept of scientific literacy: "Scientists will tell you what you need to know. You need only accept and believe that they have the ability to muster control, of nature and society alike." Or, "We'll teach you the sounds—you don't need to learn the alphabet."

But the sciences are less about the ability to control than they are about the unleashing of new forces, new capacities for changing the world. Social or political mastery of the sciences is out of the question because the natures of the sciences, technology, democracy—as well as the relationships between these questionable terms—themselves remain a question. To paraphrase Foucault once more: What are these sciences that we use? What are their limits? What effects have they exerted, or had exerted on them, in the past? Now? In a time still to come? Where do their promises unavoidably crisscross with their dangers, and how can we live better, more justly, at those confounding and unmasterable intersections?

Still other questions: Can the sciences really answer "really?" questions? And what kind of answer could we expect for that last question, which is a "really?" question about "really?" questions? The answer to that may in fact be another question to stay close to: what would it mean to stay close to questions without resolving them? What kinds of intellectual and institutional practices can we experiment with that would allow us to give good, workable answers to "really?" questions, but without the word *really*?

New science literacies have to begin with a serious engagement with histories of the sciences. In Section I, we questioned what it has meant, in different times and in a variety of situations, to be "practicing a rationality" called the sciences. We showed how the sciences have always been exercises in muddling, in ways which have furthered the generation of new ideas, new useful artifacts, new ways to imagine ourselves and our world—new realities. We developed a set of four concepts/actions—experimenting, articulating, powering/knowing, and judging—to serve as an alternative theoretical frame for thinking about the sciences, distinct from the empirically ill-fitted and conceptually feeble one of facts, hypothesis, theory, testing, representing, and so on. To that extent, Section I was not only an en-

gagement with the history of science, but a statement of theory, our own ideal of what the sciences are.

In Section II we gave accounts of some specific pursuits of the sciences to which we've stayed particularly close in the present. We tried to show how complicated and demanding specific questions can get on all levels—scientific, social, practical, ethical—and how those situations can still be worked even in the face of enormous complexity. The contemporary issues examined in Section II show how muddling through is particularly important in times of dramatic change, when things have stopped making sense and there is an urgent need for perspectives sensitive to new social realities. So in addition to being the present to the pasts of Section I, Section II could also be thought of as the practice of the theory of Section I—stories about what happens when the ideal hits the real.

But the sciences are still more complicated than that. This structure needs a third element, a third articulation that will punctuate many of the same points of the first two sections, but with a slightly different twist. In terms of the conceptual scheme which we borrowed from Charles Sanders Peirce and kludged into Chapter 2: Section I of this book was our "Firstness": ideality, mind-stuff, our reimagining of what the sciences are, based on how they've been practiced in the past. Section II was "Secondness": actuality, rude awakenings, tales of hard encounters with one world or another in the present. They can't really be separated from each other, and indeed, Sections I and II were only different articulations of many of the same points, with past and present mixed. This Section III, then, should correspond to Peirce's "Thirdness" and should reiterate the sciences, again, from a subtly different vantage point.

Peirce's Thirdness was more subtle and elusive than either Firstness or Secondness, and gave his commentators the hardest time. Thirdness is a "gentle force" that somehow binds the other two together, and keeps them from simply colliding and bouncing off each other. Thirdness has to do with an interpretation that interpenetrates the web of ideas and things; Thirdness contextualizes, extends the articulated webs ever outward. Thirdness stabilizes and weaves, but Thirdness is also the fount of difference, instability, and change. Even as it mediates the stark opposition of Firstness and Secondness, Thirdness generates further contradictions. Thirdness works behind the scenes and indirectly, but there is no scene without it, and no direction. Thirdness may have something to do with those qualities we call imagination, creativity, and even genius in the sciences. At the same time, Thirdness is what calls for muddling through.

Gentle, subtle, ambiguous, muddled, indirect Thirdness eludes full and concise description in a language tailored for directness. If Firstness and Secondness correspond to the pasts and presents of Sections I and II, then the Thirdness of Sec-

tion III may correspond to the sciences of an unknowable future. Thirdness is Feynman's "half-assedly thought out pictorial semivision thing," or Bateson's "sort of secret" that "one *cannot* tell" and in which one has "no direct control over the matter." Thirdness has been the indirect subject of this entire book.

One and One Is . . . ?

Demographics and marketing are not our expertise. We don't know how many of the people who will buy this book are working scientists, students of the sciences, or simply people interested in the sciences. You may or may not spend long hours in the laboratory, oscillating between frustration and rapture, and then relax by reading about someone else's oscillations in the sciences. You may or may not spend your days toiling to solve arduous equations or poring through mounds of scientific articles, and then extending your passion for the sciences in your nighttime reading. But in any case, chances are you bought this book because you're in the habit of buying science books, and there's a lot of material to feed your habit. You're interested in and enjoy reading about *The Double Helix, The Coming Plague, The Search for the God Particle, A Brief History of Time, The Structure of Scientific Revolutions, The Mismeasure of Man, The Emperor's New Mind, The Selfish Gene, The Inflationary Universe, The Life of the Cosmos,* and maybe even *The End of Science*. You watch *Nova* programs on the big riddles of cosmology, *National Geographic* specials on threatened biodiversity, and the weekly mix of *Scientific American Frontiers* with Alan Alda. You listen to National Public Radio's Science Fridays program. Maybe your kids watch Bill Nye the Science Guy every day after school. You're fully immersed in our culture.

Even if only some of these marketers' generalizations apply to you, your book shelf may hold John Brockman's edited volume of interviews with scientists, *The Third Culture*, or one of the other "Reality Club" books edited by Brockman, literary agent to the science stars of today. *The Third Culture*'s title plays on C.P. Snow's 1959 definition of *The Two Cultures,* which divided the world neatly into scientists and literary intellectuals. Brockman's interviewees come from the fields of evolutionary, molecular, and theoretical biology (Stephen Jay Gould, Lynn Margulis, Richard Dawkins, Francisco Varela, Stuart Kauffman), theoretical physics (Alan Guth, Murray Gell-Mann, Lee Smolin, Roger Penrose, Paul Davies), and computer, cognitive, and "chaos" sciences (Marvin Minsky, Christopher Langton, W. Daniel Hillis)—all hot areas in the sciences. These scientists expound on the extraordinary ferment that each of their fields—and the cross-fertilizations between them—has undergone toward the end of the twentieth century. Read at face value, *The Third Culture* is an enthralling collection of the achievements and trajectories of thought "beyond the scientific revolution," as the subtitle reads.

But there is much more than that to read in these pages. First, a detectable if slight tone of resentment. By and large, these scientists feel that their fellow citizens (mostly in the U.S. and U.K.) are scientifically illiterate. The scientists of *The Third Culture* want to be taken seriously as intellectuals—as they should want, and as they should be. The sciences are indeed a major intellectual, cultural, and social force in our world today, and public understanding and appreciation of ideas from the sciences leaves much to be desired. Like these scientists, we too want people to be able to think better about the sciences, to know what's going on in these fields, to be literate. Few things would please us more than if several million people went out, bought all the books by all the scientists interviewed in *The Third Culture*, and read them.

But read them *critically*. And for all its emphasis on literacy, *The Third Culture* doesn't seem especially concerned with building a critical literacy. Rather than truly pursuing a third culture, this volume seems more a case of wanting the "first" culture of science to simply colonize, territorialize, or subsume the "second" culture of literary intellectuals. Brockman writes that these figures from the "empirical" world of the sciences are "taking the place of the traditional intellectual," whose culture "dismisses science, is often nonempirical," and "is chiefly characterized by comment on comments" in which "the real world gets lost."[4]

> *Stephen Jay Gould:* . . . There's something of a conspiracy among literary intellectuals to think they own the intellectual landscape. . . . Peter Medawar, a very humanistically and classically educated scientist, said it was unfair that a scientist who didn't know art and music pretty well was, among literary people, considered a dolt and a philistine, whereas literary people don't think they need to know any science in order to be considered educated. . . .
>
> *Richard Dawkins:* I do feel somewhat paranoid about what I think of as a hijacking by literary people of the intellectual media. . . . The very word "theory" has been hijacked for some extremely narrow parochial literary purpose—as though Einstein didn't have theories; as though Darwin didn't have theories.
>
> *Paul Davies:* . . . The fact that scientists are starting to be heard, capturing not only the minds but the hearts of the population—as evidenced by the phenomenal success of science books—is provoking what seems to be a territorial squeal from the literary side. The backlash has taken the form of hysterical ranting in newspapers and periodicals, and a spate of books denouncing scientists as arrogant and self-serving frauds. . . . For years and years scientists were ignored because they were not heard; now that they're starting to be heard, they're being stamped on by an intellectual mafia.

Nicholas Humphrey: . . . Since they don't understand science, their only defense is to say that it doesn't matter. But they're fighting a losing battle. People are voting with their feet. Who listens to what nowadays? Who watches what on TV? Who's buying what books?

Terms like "hysteria," "hijacking," and "intellectual mafia" lack the precision and detachment that we usually associate with the sciences, so there may be something more at work here than the noble desire to make sure that people are literate in the sciences. There's a sense of urgency, perhaps even emergency, expressed along with a more or less subtle triumphalism and sense of self-importance.

But another motif of the book deserves more attention. In the comments which these scientists direct at each other and each other's work, there is, beyond the dominant tone of mutual admiration, an unmistakable overtone of profound difference and disagreement. This one thinks that one is crazy, "mystical," or "romantic"; X *really* understands Darwin and evolutionary theory where Y has got it all wrong. And yet these disagreements and differences are often grounded in quite subtle expressions. To quote just a few: "I don't intersect with his mode of thought that strongly"; "there's just too much of a gap in our approach to things for there to be much useful dialog [sic] between us"; "he really says nothing particularly interesting"; "I don't understand it at all"; "although the smell is the right one, I don't think I can buy the actual theory he's trying to stitch together"; "I have gut misgivings about theories of that kind."

What should we make of such differences? Certainly not too much; they're the kind of differences that crop up all the time in the sciences, the kind of differences that make pursuing science an exciting, challenging, arduous, and rewarding experience. But neither should we make too little of them. It's all too easy to say that scientists disagree with each other all the time, but eventually the truth will out when theory (Firstness) confronts and is tested against empirical reality (Secondness). For one thing, even when the truth outs, another set of differences emerges; settle one question and two others immediately pop up.

The real problem with this conventional characterization of the sciences is that it's much too diluted to match how the sciences are actually practiced. As we've shown in numerous examples, pursuing the sciences has always involved those complex, heterogenous processes we've gathered under the rubric of muddling. So what happens when you start from the assumption that subtle as well as radical differences among scientists are not only possible, but ineradicable? What happens when you remember that the scientific method not only includes, but depends on these somewhat unmethodical elements for imbuing the sciences with power? That Firstness and Secondness, theories and facts, concept and thing, are

never sufficient in pursuing sciences and never encountered on their own, but always come packaged with Thirdness?

That, we think, would be the way to begin seeing the emerging outlines of a truly "third" culture, a third culture that in fact has always been with us, emerging, despite simple habits of dividing culture into (1) science and (2) literature. Look back at those quotes we selected: what underlies these differences between scientists is not "they got the data all wrong," or "the man couldn't make an objective observation to save his life" (as is often the case in such volumes, there are few women represented, and it's often Lynn Margulis), or "the logic is shoddy and the calculations are way off." Those things would provide a relatively easy avenue of resolution. And indeed, differences within the sciences can often be resolved by such means. But as we see here, what's frequently involved is something much more murky: a mode of thought, an approach, a smell, a stitching pattern, a gut feeling. The sciences have always, and will always, involve such opaque terms for correspondingly opaque processes. To deal with any "third"—Third Culture, Thirdness, third term—is to find yourself in the muddled middle, where you don't always have good analytical tools for working your way through the opaqueness into an open clearing.

We need a kind of "third culture," but the way to get it is not to simply invert the status of the two terms, to simply elevate science over literature. Moreover, in some sense a third culture has always been present in the sciences or, more accurately, *between* the sciences and its various Others: literature, society, culture, religion, and still more. The fact that the sciences have never been pure, have never been thoroughly rid of the influences of Others, have always been a kind of "third" hybrid term—this is what has made them so powerful, so alluring, so productive, so interesting, and, frankly, so much fun. And such a problem.

It's especially because of that last characteristic that all of us, scientists and citizens alike, need new critical literacy skills for reading the third culture that's already in our midst. To put it in other terms: What we really have to understand and cultivate is not a third culture, but a culture of the third, where *one and one is at least three.*

Cytoplasm and History

Especially in this digital age, there always appears to be an either/or choice from among the oppositions of this and that, on and off, yes and no, true and false. The *real* third culture will be a culture of the third, a world where people know that "this and that" isn't a question of two terms, but a combination of three: this, that, and *and.* And *and* is always in the middle; it's the sign of the dangerous crisscross,

the messy collusion, the maddeningly wonderful muddle. This book has described some of the intellectual and political tools for engaging, not with the either/or of this or that—theory or experiment, thought or thing, power or knowledge, social or natural, science or nonscience—but with the both/and of the 3 that lies *between* 1 and 2. We've argued that the sciences have always been both/and, have always had their Other—literature, philosophy, the historical, the social—incorporated within them, a kind of parasite to their host.

That last set of metaphors belongs in an allegory of symbiogenesis, a concept found in Lynn Margulis's work in evolutionary biology. Margulis showed—no, we have to be more precise: Margulis argued in writing, and after a decade or so of derision and dismissal, other scientists began to appreciate what was being shown—that the organelles bearing pieces of DNA in the cytoplasm of the eukaryotic cell, outside the nuclear "control center" where scientific interest and effort have mostly concentrated, are the evolutionary traces of microorganisms that symbiotically entered bacterial cells roughly two billion years ago. That merger made for new survival strategies, new reproductive possibilities, new capacities—in short, a new form of life.

In our allegory, the sciences live, the sciences evolve, the sciences are Science because they're not just a coded expression of some Platonic nucleus of ideas and logic, but because of other working, generative structures *fused* within the same cell. Make no mistake: the nucleus does operate, vitally so. Practicing a rationality and pursuing the sciences can require the most exacting obedience to exact logic, sharply defined concepts and their relationships, and various other signals that resist. But it's just as important not to mistake the nucleus for the cell. Out there in the messy, intricate mix of chemical soups, diaphanous membranes, and writhing proteins, other structures are at work, other messages created and exchanged, other substances and interactions contributing to the overall stability and vital power. Consider this the cellular variation on the metaphorical image of an articulated lobster that we set loose in Chapter 3: the sciences as amoebae, active congeries of disparate substances, structures, and motions, extending itself here, retracting there, continually changing shape.

As it happens, around the time Margulis was writing up her first paper on endosymbiosis, Thomas Kuhn's *The Structure of Scientific Revolutions* was on its way to becoming the most widely read work on the sciences. Kuhn's famous book employed something like this kind of symbiotic cellular perspective. At a time when most philosophers of science were intent on shoring up the nuclear membrane that protected the exclusively coding, logical purity of the sciences, Kuhn started mucking around in the cytoplasm of history, where messy influences abound. The process of revolutionary change in the sciences, he argued via a number of historical examples, neither obeyed simple scientific logics, nor exhibited the simple progress of better approach to an eternal and universal Truth. While there's much

in Kuhn that we disagree with, and while he eventually disassociated himself from some of the more radical (and interesting) extensions of his inquiries, his enduring legacy has allowed us to remain close to the question of the interaction between the inside and the outside of the sciences.

It's a legacy that had its own symbiogenesis. Kuhn's work alone didn't lead to the expansion of critical intellectual work in the historical, philosophical, sociological, anthropological, literary, and other social analyses of the sciences that has occurred in the academy over several decades. It combined with the social ferment of the civil rights, feminist, and antiwar movements of the 1960s and beyond, all of which challenged the received notions of truth and progress in one way or another. The result has been an extensive body of scholarship that examines the extranuclear structures of the sciences in much greater detail and nuance than the heroic narratives often penned by scientists themselves. It's a body of scholarship that has been indispensable for the writing of this book, allowing us to show how the sciences have always been a kind of emergent feature of the *and* between science and culture. It's shown how we can think about the sciences as a culture of the third—a culture which practices rationality in different ways, in different situations, at different times. These detailed studies of the sciences are an essential part of the critical literacy skills needed by both practicing scientists and everyone else in this culture of Thirdness.

The Third Without Qualities

Slippery and protoplasmic Thirdness still remains somewhat elusive. Some rather famous scientists claim to want something called a third culture, but still tend to get bogged down in the old one-two. Perhaps another detour through history, this time of the more literary kind, can guide us closer to the question of Thirdness without, once again, fully resolving it. As something that can't be fully resolved, Thirdness requires continual revisiting and requestioning. As something that can't be fully resolved, Thirdness may have something to do with contradictions, irresolvable oppositions which, in one form and another, have always been with us.

In Chapter 1 we saw the physicist Max Planck struggling to get his bearings, while trying to give some direction to what he saw as a directionless culture, in his 1932 book *Where Is Science Going?* As Planck was penning his version of this seemingly perennial question, the novelist Robert Musil was at work on his interminable *The Man Without Qualities*. Although the events of this consummately modernist novel were cast in the year before World War I, Musil was responding to the same questions—about the sciences, their historical effects, and their limits—as Planck. Musil's novel has reappeared recently in a new English translation, suggesting that its questions and characterizations of the age remain pertinent

today—good stones on which to sharpen our thinking about the sciences, the work of contradictions, and strategies for dealing with them.

Somewhere around the middle of Volume 1, a dialogue occurs between the man without qualities, Ulrich, who, if he could have qualities, might be a mathematician, and Walter, a man with definite qualities, principally those of being an artist (albeit one fully clothed in the rising bourgeois culture). Begin with the end of their argument:

> Walter continued in a low voice: "You're right when you say there's nothing serious, rational, or even intelligible left; but why can't you see that it is precisely this growing rationality, infecting everything like a disease, that is to blame? Everyone's brain is seized with this craving to become more and more rational, to rationalize and compartmentalize life more than ever, but unable to imagine what's to become of us when we know everything and have it all analyzed, classified, mechanized, standardized. It can't go on like this."
>
> "Well," Ulrich said with composure, "when the monks were in charge, a Christian had to be a believer, even though the only heaven he could conceive of, with its clouds and harps, was rather boring; and now we are confronted with the Heaven of Reason, which reminds us of our schooldays with its rulers, hard benches, and horrible chalk figures."
>
> "I have the feeling there will be a reaction of an unbridled excess of fantasy," Walter added thoughtfully.[5]

As a man with qualities, Walter sees things in terms of definite opposites: an excess of reason can lead only to a reaction of "unbridled fantasy." He thinks he *really* knows exactly what science is—mechanical, analytical, compartmentalized—and therefore what it must inevitably become, and he doesn't want anything to do with it. Planck's worst nightmare, his is a familiar figure today: the technophobic critic who can only fear the sciences in the broadest, almost caricatured terms. But Ulrich is unsure of clear definitions and limits, unsure about what science or reason will become over time once it overflows the confines of childhood memories and stunted imaginations. Having experienced them from the inside, Ulrich can read the popular critiques of the sciences that Walter depends on for what they are: sketchy chalk figures drawn more for moralistic effect than for faithful characterization.

So with Planck, Musil, Ulrich, and Walter, we are very close to the question of the two cultures as it appeared around 1932—so close that maybe we can glimpse a third. A machine might help bring it into better focus—not a machine made out of metal, but one made out of words. It doesn't have to be perfect; it just has to work. Its job will be to make opposed terms more visible, so we can see how they work and how we might get in between. We begin a chart of oppositions and their thirds, the first terms of which are:

science	literature	
Planck	Musil/Ulrich	Walter
fact	fiction	

We characterized Musil above as a novelist, which wasn't quite right. He could also be called an engineer (among many other things), which is why we put him in between science and literature. And the hybrid qualities of the factual Musil can certainly be identified in the fictional Ulrich, which is why they get joined (and separated) with that slash. Ulrich is a mathematician (among many other things) and has experienced the power and allure of science from within:

> "Scientific man is an entirely inescapable thing these days; we can't not want to know! And at no time has the difference between the expert's experience and that of the layman been as great as it is now. Everyone can see this in the ability of a masseur or a pianist. No one would send a horse to the races these days without special preparation. . . . But I'll grant you something quite different," Ulrich went on after some thought. "The experts never finish anything. Not only are they not finished today, but they are incapable of conceiving an end to their activities. Even incapable, perhaps, of wishing for one. Can you imagine that man will have a soul, for instance, once he has learned to understand it and control it biologically and psychologically? Yet this is precisely the condition we are aiming for! That's the trouble. Knowledge is a mode of conduct, a passion. At bottom, an impermissible mode of conduct: like dipsomania, sex mania, homicidal mania, the compulsion to know forms its own character that is off-balance. It is simply not so that the researcher pursues the truth; it pursues him. He suffers it. What is true is true, and a fact is real, without concerning itself about him: he's the one who has a passion for it, a dipsomania for the factual, which marks his character, and he doesn't give a damn whether his findings will lead to something human, perfect, or anything at all. Such a man is full of contradictions and misery, and yet he is a monster of energy!"

We'll add these terms to our machine:

science	compulsion to know	passion
professional expertise	incomplete accomplishment	lay incompetence
perfect	contradictions/misery/energy	human

. . . and hope that it will hold together, helping us operate in what is rapidly becoming a complicated situation. Musil/Ulrich reminds us that there is no escaping the sciences; it cannot be simply a question of "let's do something else." The sciences are, in effect, not "ours" to do with what we like. In the psychoanalytic terms that were

then beginning to percolate through Musil's culture, the sciences are akin to the drives and urges of the unconscious: an uncontrollable Outside incorporated within our most interior selves, keeping us off balance. The sciences are forever ahead of us, keeping us always "after the fact," playing catch-up with little hope of winning.

And even as we pursue the sciences, they pursue us. They pursue us, somewhat paradoxically, by resisting us: The natural world seems to force our hand with no regard for what we might prefer to be the case. A fact is a fact: The perception that the sciences supply us with self-evident facts and unassailable truths is almost inescapable, no matter how skeptical one might want to be, or knows one should be. Our character (if you'll temporarily forgive the generalization) is indelibly marked with a compulsion to know, a habit somewhere between science and passion. And that in-betweenness is a space of both painful contradictions and exuberant energies. The acute need for expertise permeates every nook and cranny of our world, from the sciences to sports—even as the limits of that expertise become all too apparent.

And there's one more question, perhaps the most important but at the same time most destabilizing of all:

> "And—?" Walter asked.
>
> "What do you mean, 'And—'?"
>
> "Surely you're not suggesting that we can leave it at that?"
>
> "I would like to leave it at that," Ulrich said calmly. "Our conception of our environment, and also of ourselves changes every day. We live in a time of passage. It may go on like this until the end of the planet if we don't learn to tackle our deepest problems better than we have so far. Even so, when one is placed in the dark, one should not begin to sing out of fear, like a child. And it is mere singing in the dark to act as though we knew how we are supposed to conduct ourselves down here; you can shout your head off, it's still nothing but terror. All I know for sure is: we're galloping! We're still a long way from our goals, they're not getting any closer, we can't even see them, we're likely to go on taking wrong turns, and we'll have to change horses; but one day—the day after tomorrow, or two thousand years from now—the horizon will begin to flow and come roaring toward us!"
>
> Dusk had fallen. "No one can see my face now," Ulrich thought. "I don't even know myself whether I'm lying. . . ."

Things are getting more complicated and confusing, perpetually in motion, and the one certainty is *speed*. Time moves faster and faster, and no one knows when it will stop this incessant changeless movement through changes: 1933? 2000? We never seem to get to the promised millennial end, but find ourselves once again in the middle:

truth-telling	pursuing	lying
light	dusk	dark
certainty	terror	
either	and . . . ?	or

But no matter how you would like to leave things there in the middle, something that you might call responsibility (issuing, in this case, from the artist's mouth) calls you to act: And? There is always the question of the *and?*, and it is actually two questions at once. It is the question of complication and addition: *And? Haven't you forgotten something? What about throwing this into the mix?* And *and?* is the question of time and ethics: *And? So? What now? What are you going to do for your next act?* And even if you are incapable—because of the constitution of your soul or because of where you are geographically located in this strange time and place of passage—incapable of whistling a happy tune in the dark ("Purifying Science Will Save Us," "Adding Soul to Science Will Save Us," "Democratizing Science Will Save Us"—all catchy tunes that we can't get out of our heads), one still hears the question reverberating in the dusky twilight: What to do, then?

> "Do you realize what you're talking about?" [Walter] shouted. "Muddling through! You're simply an Austrian, and you're expounding the Austrian national philosophy of muddling through!"
>
> "That may not be as bad as you think," Ulrich replied. "A passionate longing for keenness and precision, or beauty, may very well bring one to prefer muddling through to all those exertions in the modern spirit. I congratulate you on having discovered Austria's world mission."

Muddling: the word itself looks and sounds unattractive and pallid. Who would want to use such a gray word to advocate a presumably murky and messy set of activities, and ways of thinking that must surely be indistinguishable from muddleheadedness? Given a choice between pure science and a muddy muddling through, who wouldn't go for the former? And how, finally, can it be said that a desire for precision leads one to prefer the muddiness of muddling through over the keen appeals of modernist exertions?

When Worlds Collude

Many of the questions and characterizations of the world of *The Man Without Qualities* persist in the world of today. The excerpts above should indicate how the ideas contained in the book's narrative are still struggled over now, and its questions remain relevant. But we hope you haven't read only for content, but for the

method we applied as well. Our charting of oppositional terms and their thirds, or middles, was a kind of prototype machine for generating meanings in a fictional world marked by irresolvable contradictions stemming from the sciences and the forces they set in motion. By occupying a middle position, Musil/Ulrich was able to develop questions, experimental propositions, and even goals that were somewhat orthogonal to the expectations and demands of "the system."

The accompanying chart is a more elaborate version of that middling-machine, and should serve as a handle on where we've been in this book. In a word, all our meanderings have been designed to lead back to the same place to which the sciences are drawn, and from which they draw their power and beauty: the middle. The terms which run down the middle of our chart—experimenting, articulating, kludging, judging, contingent affinities, powering/knowing, and especially realitty—were all invented or borrowed for their capacity to evade and confuse the usual conventions about the sciences.

Thirdness, then, is akin to the third or middle term. We need to break a few habits of thinking about the middle. As logic's Law of the Excluded Middle suggests (either A or not-A, in its most abstract and simple form), the middle is usually considered a restricted area—indeed, so restricted as to be nonexistent. But when you look at the practices and concepts of the sciences in real life and real time, you find the mixings of the middle all over the place. The middle, the mess, is real—the realest of the real. Furthermore, the middle doesn't have to entail a golden mean as an ideal, nor a happy medium, nor the blandness of being middle of the road. Our middle is mean, all right—it's the harsh, stern, and demanding place where apparent opposites mix, gold and other precious metals lose some of their luster, and your limited capacities are there for everyone to see. Our middle is an unhappy medium: forever restless, questioning, insatiable, looking for trouble and almost always finding it. And while compromise is often a necessity in our middle, we remain a little too eccentric to be anywhere near the political center. For the sciences and for so much else in our world, the middle is the space of change and creativity; it's where the interesting problems and questions are; it's where things are unsettled, calling for experimentation; it's where the action is.

How to Muddle Through

The oppositional pattern of thought tends to persist because each side receives a different valuation. Epistemological or ontological propositions about the sciences almost always harbor a moral element or two. They almost always have one exalted term, while the other is at best tolerated, at worst something to be eradicated. As a generalization, the left-hand side of our chart lists the things, qualities, and values associated with the sciences in our culture, and which we mostly think of as

Chart of Oppositions and Their Muddled Middles

A	Excluded Middle	not-A
either	both/and	or
either	neither/nor	or
yes	yes and no	no
science		superstition
science		anti-science
science		religion
science	pursuing sciences	literature
science		politics
science		history
science		science studies
nucleus	symbiogenesis	cytoplasm
First Culture	Culture of the Third	Second Culture
Secondness	Thirdness	Firstness
presence	realitty	absence
reality		imagination
transparent	muddy	opaque
pure		applied
rigid		loose
elegant	crafted	messy
clever	kludged	klutzy
real		invented
neutral	charged	interested
free	contingent	driven
objectivity	robust	subjectivity
science		politics
certainty	ambiguity	uncertainty
discovering	experimenting	constructing
theory	signal that resists	practice
theory	sign-force	fact
seen		spoken
literal	articulating	metaphorical
plain language		jargon
sense		nonsense
science		values
science		politics
knowledge	powering/knowing	power
reason		force
right		might
real	judging	constructed
determined		chosen
functional logics	assemblage	chance
science		society
experts	pluralism	communities
serious		playful
playful	responsibility	serious
safety	criss-cross	danger
complete	and?	empty

"good," while those things and qualities on the right-hand side are associated with the sciences' Others and are at least "not as good as . . ." their partners on the left, if not simply "bad."

The middle terms with which we've worked and played are meant to suggest other ways of thinking and doing. They oscillate between the extremes without ever escaping them. Sometimes they hold closer to what have been the best qualities or ideals of the sciences themselves—qualities or ideals that are often forgotten, misconstrued, obscured, or twisted into unusual patterns. The encouragement of public witnessing of truth-making and fact-building, for example, the modest recognition of multiple possible explanations for a phenomenon, the idea of an "excessive nature" which constantly eludes our comprehension—there are many things about the sciences that we can't give up, and shouldn't give up. At other times, our middle or third terms have drawn more from the Others of the sciences, the "not-A" side of our charting machine. The historical examples and our present-day stories exemplify how scientists have always occupied this middle space, and how it is simultaneously productive, problematic, generative, and open-ended.

The chart maps out a world in which anxieties, desires, and prescriptions about and for the sciences have been with us for most of the century, if not longer, organized by the powerful oppositions between reason and irrationality, science and antiscience, the "two cultures" of scientists and literary intellectuals. Many people in this world want the two sides of the chart to be kept as far away from each other as possible, in which any mixing in the middle is considered a dangerous threat—where more and more, in Foucault's words, it is thought that "any critical questioning of . . . rationality risks sending us into irrationality." It is a world in which many people believe there to be an end (however far in the future) where inquiry will halt in the stillness of objective certainty—and it is science that will take us to that end. And it is a world in which others believe that the sciences are fundamentally misguided and misconceptualized, a species of lying, a mere mask for power, an out-of-control force which must be contained politically and socially if we are to survive. Most disturbing, each side is often more concerned with proving the other wrong—supporting or subverting the hierarchical difference, but in either case maintaining it—than with finding means of productive engagement.

Conventional wisdom has it that the sciences require clear distinctions between theory and practice, theory and fact, and fact and fiction. Truth is seen, and presented in a literal form stripped of metaphors, ideally mathematics. In this world most scientists are absolutely convinced that those clear distinctions allow them to discover a preformed reality. And they have excellent reasons for holding that conviction. In this world scientists as well as other scholars have made historical and sociological inquiries into the sciences, and are absolutely convinced that one

must speak of the constructedness of reality—that the truths of science and nature stem in fact from the worlds of language and its metaphors, politics and its interests, and culture and its values. And they, too, have excellent reasons for thinking as they do.

The Culture of the Third, however, is a world of symbiogenesis, a developmental-evolutionary system vitalized by both nuclear (reason, logic, science) and cytoplasmic (history, politics, culture) forces. It is a world not simply of interactions between these elements, but fusions, confusions, and profusions of them: wonderfully and woefully complex systems of muddy hybrid components that always present challenges and questions along with products and results.

You realize what we're talking about: muddling through. And to see if we can realize muddling through, actualize it through practical trials in this very trying, contradictory world, we offer the following experimental principles.

PURSUE A THIRD TERM

Muddling through isn't about overcoming or moving beyond oppositional thinking or contradictions. Oppositions are necessary for practicing any rationality, especially the sciences; contradictions can't be overcome, and they don't have a transcendent "beyond." We're hobbled/enabled by them. Classical logic excludes the middle or third term because its both/and, neither/nor characteristic is so horrifying—but the third term is almost always present. You have to get in between, *make* the in-between if necessary.

We're certainly not the first people to point out that the sciences—and indeed, Western culture and thought considered broadly—are boxed in by and organized according to such opposed terms. That we're not the first points to the *persistence* of these oppositions—they're a deep gravitational well which continues to capture anything that tries to circle around it or pass by it. Such oppositions shape our "thought-space" like our sun or a neutron star shapes and curves the spacetime around it. Our goal should not be to transcend binary thinking, as some people would put it (apparently not noticing that the recommendation requires its own set of oppositions, transcendence and immanence)—as if we could just shed the intellectual and cultural habits of two millennia like old clothes. Instead, we should pursue thirds, which are not syntheses of the two opposed terms, but destabilizing elements which shake the solidifying and stultifying patterns of hard and fast oppositions.

EXPERIMENTING, ARTICULATING, POWERING/KNOWING, AND JUDGING

are our efforts to approach the worlds of the sciences from this in-between. These slightly off-center focal points provide a more reasonable basis for inquiring into

and living within a nature that is less preformed than *per*formed. Our world is one in which the sciences neither discover nor construct a world (and certainly do not reflect one), but where something happens that exceeds our capacity to see, think, or speak it.

Our constructions are geared toward making "really" statements—such as "Our language is geared toward making 'really' statements." It's that little verb "is" that has such powerful effects. The "is" implies equivalences when all you ever really get is a kludge—a force-fit that allows you to speak and think quite well, but never perfectly or finally. Language compels and resists, just as the material world compels and resists. You can't say just anything, and some things are harder to say than others. Likewise, the material world isn't just anything that scientists construct; nor is it ripe for discovery as soon as there is enough funding, lab technicians, and genius-scientists. Like the sciences, language needs to be thought of in terms of possible articulations, imperfect tools, and careful, repeated attempts to find idioms for things that couldn't be spoken of previously. Even though our language is finely tuned to the frequencies of the real, it can't ever really rid itself of metaphor. It is and it isn't "realist," just as practicing scientists are, and aren't.

Of all the third terms pursued in this book, perhaps the most important is realitty. This word-invention is a constant reminder, which you have to train yourself to see and think, that what we call "real" changes drastically over historical time, as indicated by the intrusive italicized *t*, physicists' and mathematicians' symbol for time. Remember the double reading that "realitty" was supposed to put in motion: one, a changing, transitory amalgam of inner and outer worlds, natural and cultural, technical and conceptual, and so on—we have a say in what realitty is. Realitty is in the middle, which makes it ours, and our responsibility. *And* two, an anagram of alterity, the absolutely other, source of pain and surprise. Realitty has nothing to do with us. Realitty is, in principle, an undecidable both/and—which nevertheless gets decided, in practice, in different ways under different historical and social circumstances.

But wait. Aren't we pulling a move not unlike those made in the name of purity, or in the name of Science—suggesting that realitty is the one, proper way to image and enact the world? What gives us the authority, now that we've undercut the concept of the real outer world, to tell anyone how they need to think about the sciences differently, better than they have?

In the first place, undercutting the concept of the real outer world is exactly what pursuing a third term like realitty *doesn't* do. It does question the concept, shake it, trying to get a feel for what makes it so solid, *testing* what its limits are. We tried to respect the concept of the real outer world as an operation of language, ideas, and thinking, and as the way in which many scientists experience the world and their practices in it. The concept is deeply embedded, and is not something

that can be easily undercut. At the same time, we've tried to track down the contradictions that it harbors within itself, or to which it leads.

We invented the word "realitty" to make the concept and experience of the real outer world more complicated and encompassing. And by those criteria of more complex and encompassing—which the sciences themselves have often invoked to narrate their own progress—our account of the sciences is a better, more authoritative one. We've paid attention to the questions that conventional accounts often gloss over. We've examined overlooked details of practice, conceptual gaps, charged metaphors, hidden social relations, linkages to power and interests, necessary but contingent judgments—all things which are unavoidably part of pursuing sciences, but too rarely accounted for in public discussion. The complex, shifting realitty that the sciences both pursue and perform demands better accounting methods than were used in the past—the kinds of methods we provide here.

Philosophical hairsplitting? If we've learned anything over the course of this century, it should be that realitty has an incredibly fine-grained structure, demanding both the utmost precision and sensitivity to nuanced, persistent differences. With any luck, and a good deal of hairsplitting, the next century will be a more subtle one, in which the problems outlined in Section II will meet a public equipped with the ability to think critically about—and neither fear nor idolize—the sciences.

CULTIVATE A LONGING FOR PRECISION

When a critically thinking public pursues third terms, they will also be staying close to questions. This principle is very close in spirit to one of the conventional articulations of the sciences that is well worth preserving: The sciences are at their best when they're brutally skeptical, passionately working to overthrow the old regime of truths and practices. As Nobel laureate François Jacob has noted:

> [P]eople do not kill each other only for material benefit but also for reasons of dogma. Nothing is more dangerous than the certainty that one is right. Nothing is potentially so destructive as the obsession with a truth one considers absolute. All crimes in history have been carried out in the name of virtue, of true religion, of legitimate nationalism, of proper policy, of right ideology; in short, in the name of the fight against somebody else's truth. . . . At the end of the twentieth century, it should be clear to each of us that no single system will ever explain the world in all its aspects and detail. The scientific approach has helped to destroy the idea of an intangible and eternal truth. This is not the least of its claims to fame.

There's a modesty and humility that comes with an attitude of muddling through that we desperately need today, coupled with the pursuit of precision and

specificity—a goal of the sciences that has been both praised and misunderstood. Galileo, Copernicus, and Darwin pursued this goal. And, as we've seen, scientists in widely varied fields, from primate behavior to quantum teleportation, continue the pursuit.

What's true for work within the sciences is also true for inquiry into the sciences. All of our examples contain dense ethnographic descriptions of practices in the sciences, tracing and questioning the articulated webs that make meaning and produce facts. Depending on where you are in the sciences, you face the task of analyzing the particular combination of metaphors, matters, observations, instruments, and ideas involved. The demand for precision leads to a complexity to be muddled through, inquisitively: How are gender metaphors involved in our descriptions of biological reality? If they're at work there, are they at work in cosmology, and in the same way? Does a quantum physicist encounter a resisting, Second object in the same way that a hydrogeologist does? Does Thirdness in the form of cultural values get kludged onto the measure of intelligence in the same manner, with the same effects, as it does in the measure of, say, coefficients of expansion in metals? In how many different ways do the habits and trajectories of corporations and funding agencies make their presence felt in the worlds of the sciences? All these things and more will be at work—which is to say, they will be in play—in different ways in different situations. They make generalization difficult if not impossible.

Our involvements with reality are always a matter of power/knowledge. Our world is not one in which these two terms, power and knowledge, can be easily disassociated, contrary to what either science purists or social engineers might believe. We saw how many scientists are quick to invoke (heavily mythified) historical episodes from Nazi Germany and Stalinist Russia to put down any movements that explicitly link the so-called neutral tools of value-free knowledge and the ever-present world of political, economic, and social interests. And many social constructionists are just as quick to argue, in the name of social responsibility, for the necessity of a science completely attuned and subservient to a world of social values. Once again, we contradict each of these demands as well as conventional standard logic. We want neither of these either/or options, and both of them.

Addressing the contradiction starts with an effort at precision: How is power in fact necessary for the production of rigorous and even "objective" knowledge? How is power/knowledge manifested in laboratory experiments, in Darwinian evolutionary theory, in the collisions and collusions between Copernicus, Galileo, and other scientists who are inevitably caught in the intricate and extensive webs of religion, politics, and culture? How can we hold onto the ideals behind a "pure research" and "free inquiry" that has allowed for an incredibly productive combination of play, chance, commitment, and imagination, while dealing better with

the unavoidable dilemmas of power that accompany that privileged space? How can we legitimate difficult and complicated decisions about our social world, if not through either the objective and disinterested reading of a Book of Nature, a grounding in a preformed reality, or raw political muscle?

One of the contradictory effects of pursuing keenness and precision is that you often encounter or create more ambiguity in the process. Most of our precise categories are kludge jobs. In Chapter 2, we looked at the production and use of PET images, and the combination of precise and imprecise articulations that made them useful and informative, within certain limits. Dr. Henry Wagner, retired Director of Positron Emission Tomography and Nuclear Medicine at Johns Hopkins University, reflects on what it means to define a disease:

> I personally believe that putting anything into a category is not because there is some kind of intrinsic truth [to it] but because it is useful. My philosophy is pragmatic. Therefore when you say that a person has disease X, it should be because putting him in that pigeonhole makes a difference in some way. These are manmade categories, abstractions are manmade simplifications of an unbelievably complex external world. . . . Right now, you say you have a simple explanation where serotonin is related to mood and dopamine is related to movement and acetylcholine is related to learning or intelligence. But to say that acetylcholine is intelligence and serotonin is mood and dopamine is movement is a gross and unhelpful simplification, a counterproductive simplification. Although it is true that blocking the dopaminergenic system has been one way that it has been found to help some patients with schizophrenia, and blocking the serotonin uptake site, or inhibiting monoamine oxidase has been one way of helping patients become less depressed. If it helps, it helps. It helps solve problems, the world is surrounded with problems, people are surrounded with problems. . . . [T]he best invention of all is language—I think that the most important part of consciousness and memory is language, because it translates the past into the present.[6]

Many scientists and doctors know their truths to be "manmade" and inadequate, but those truths often provide much-needed help nevertheless. Simplification is both an aid and a trap, and this is the unavoidable double-bind of all pursuits of precision in the sciences.

Our passionate longing for keenness and precision sometimes results in only more and more information that no longer informs. A medical anthropologist asks an oncologist about how his field has changed:

> Well, the rules over the last seven, eight years have gotten much more complicated—they're now coming out to say that the older women do

> benefit from chemotherapy [for breast cancer], but also lymph-node negative women may benefit, and maybe a combination of chemo and hormonal therapy is better than either one, and then they've come out with all these different prognostic factors that may push you to give chemo in someone that you would have thought originally would have been in too good a prognostic group to need the chemotherapy.
>
> So suddenly it becomes very complicated. . . . It's easy to get data, but what to do with that data once you've got it is the hard part. . . . And it would be easy if everything were bad prognostic, or everything was good prognostic. But you're going to have all these women in the middle, and you just simply don't know.[7]

We have more information than ever, but the algorithms that make straightforward calculation and prescription possible are elusive. The ideal extremes seem clear, but actual bodies fall into a muddled middle. A visit to the doctor can no longer be predicated on faith in expertise, the simple passing on of precise information, but is now more a question of how mutual uncertainties will be negotiated and acted out. In pursuing precision, we end up confronting complexity.

KEEP IT COMPLICATED, STUPID!

Pursuing third terms, cultivating a passion for precision, staying tuned to realitty's signals that resist will eventually lead you to run afoul of the popular principle favored by management gurus, to KISS: Keep it simple, stupid! Instead, a critically literate public will have to keep it complicated, remembering that the web of articulations that are the sciences are far denser than can ever be completely comprehended, and extend farther than can be fully mapped. The sciences in their complex fullness will always be incomprehensible, to some degree, and make us look relatively stupid when it comes to understanding or controlling them perfectly.

Nobel laureate Ilya Prigogine and his coauthor Isabel Stengers have kludged together understandings based on investigations in the natural world with some religious elements drawn from the Judaic tradition to make a great argument for muddling through: realitty is just too complicated, messy, fluctuating, sensitive, and self-imbricated to be subject to any grand social scheme or pronouncement. It's better to stick with small modest changes, that nevertheless can set off a chain of self-organizing events that might turn into something beautiful:

> We know now that societies are immensely complex systems involving a potentially enormous number of bifurcations exemplified by the variety of cultures that have evolved in the relatively short span of human history. We know that such systems are highly sensitive to fluctuations. This

> leads both to hope and a threat: hope, since even small fluctuations may grow and change the overall structure. As a result, individual activity is not doomed to insignificance. On the other hand, this is also a threat, since in our universe the security of stable, permanent rules seems gone forever. We are living in a dangerous, uncertain world that inspires no blind confidence, but perhaps only the same feeling of qualified hope that some Talmudic texts appear to have attributed to the God of Genesis: "Twenty-six attempts preceded the present genesis, all of which were destined to fail. The world of man has arisen out of the chaotic heart of the preceding debris; he too is exposed to the risk of failure, and the return to nothing. 'Let's hope it works' . . . exclaimed God as he created the World, and this hope, which has accompanied all the subsequent history of the world and mankind, has emphasized right from the outset that this history is branded with the mark of radical uncertainty."[8]

Scientists can be attuned to the need to keep it complicated, particularly when they deal with complex systems in their daily work. That includes not only chaos and complexity theorists like Prigogine, but people in zoology departments or in a School of Fisheries. An article published a few years ago in *Science* by three scientists (Donald Ludwig, Ray Hilborn, and Carl Walters) working in natural resource management challenged the conventional view that scientists like themselves are capable of answering questions scientifically—that is, with absolute certainty and objectivity—regarding the amount of available natural resources, the long-term ecological effects of fishing, logging, mining, or farming operations, and what sustainable practices should be adopted. The lack of proper scientific controls; the complexity of ecological systems and the ways in which their natural variability masks overexploitation until it is too late; and the social and economic interests that aggregate around fish, timber, food, and other resources—all these make for situations in which "assigning causes to past events is problematical, future events cannot be predicted, and even well-meaning attempts to exploit responsibly may lead to disastrous consequences." Even in the cases of such "spectacular failures" as the California sardine industry or the harvesting of the Peruvian anchoveta for cattle feed (where the anchoveta yield plunged from 10 million metric tons to almost zero in a few years), "there is no agreement about the causes of these failures." It's impossible to decide finally if climatological, biological, or social forces played the decisive role. The result, they argued, is that "we shall never attain scientific consensus concerning the systems that are being exploited." And even if we *were* able to reach that kind of stable ground of certainty, history has shown that for reasons that are all too easy to understand, "many practices continue even in cases where there is abundant scientific evidence that they are ultimately destructive."

The five recommendations they make bear repeating here, in abbreviated form. Their "Principles of Effective Management" are very similar to many of the things we've been advocating:

1. Include human motivation and responses as part of the system to be studied and managed. . . .
2. Act before scientific consensus is achieved. . . . Calls for additional research may be mere delaying tactics.
3. Rely on scientists to recognize problems, but not to remedy them. The judgment of scientists is often heavily influenced by their training in their respective disciplines, but the most important issues involving resources and the environment involve interactions whose understanding must involve many disciplines. Scientists and their judgments are subject to political pressure.
4. Distrust claims of sustainability. Because past resource exploitation has seldom been sustainable, any new plan that involves claims of sustainability should be suspect. . . .
5. Confront uncertainty. Once we free ourselves from the illusion that science or technology (if lavishly funded) can provide a solution to resource or conservation problems, appropriate action becomes possible. . . . We must consider a variety of plausible hypotheses about the world; consider a variety of possible strategies; favor actions that are robust to uncertainties; hedge; . . . probe and experiment; . . . and favor actions that are reversible.[9]

These are excellent principles from scientists, the kind who usually don't write bestselling books, but who slog away in unsung jobs and institutions—excellent principles which, of course, will have to be muddled through in practice. In the exceedingly complex webs of the sciences, there's always a need for supplemental judgments, and further inquiry. Sometimes it *will* be better to wait for a greater degree of scientific consensus; in some situations we often *do* need scientists to remedy a problem; *trusting* claims of sustainability might occasionally be what's most urgently called for. And there aren't always going to be reliable guidelines for making those kinds of judgments. As a kind of Firstness, these laudable "Principles" always have to be muddled through the sideroads and detours that Secondness, in all its harsh varieties, will place in our paths.

KLUDGE ANOTHER UNUSUAL ASSEMBLAGE

The sciences themselves are complex, heterogenous power/knowledge assemblages of disparate elements—technical, conceptual, social, and cultural—whose linkages are always contingent: sometimes tight, sometimes loose, always changing and becoming more elaborate. Just trying to stay closer to their questions, in

all their specificity and complexity and elusive Thirdness, requires new patterns of inquiry. You can see something of this in the very materiality of our sentences on these pages throughout the book. They've been strewn with parenthetical remarks, complex subjunctive clauses, the formal and the informal juxtaposed, serious and playful comments, long lists of words to evoke multiplicity and complexity, long phrases kludged with dashes into the middle of an already long sentence—like this one—collected into longer subunits and stitched into a chapter, a section, a book.

There is an extraordinary demand for the kinds of expertise recognized as an inescapable necessity by Musil's fictional Ulrich over half a century ago. Even if they never finish their jobs—indeed, *because* they can never finish their jobs—experts who can undertake the most obsessively focused, singular pursuits of specific thoughts and problems will be of utmost importance. Hydrogeologists, immunologists, physicists, geneticists, and every other type of specialist will continue to need the institutional space that has traditionally been associated with pure science and playful curiosity. It's been a tremendously productive ideal, a "monster of energy," as Musil put it.

At the same time, the contradictory opposite is true: Experts will have to open up their obsessive focus, to understand and engage with the extended articulated webs of meanings and social forces which make their inquiries so productive and energetic. The sciences need more perspectives, from within and from without, to prevent any one view from becoming unduly authoritative; more people need to be speaking and questioning. A plurality of perspectives can help us pursue the precision that will uncover the intellectual, social, and political problems specific to each area of scientific work and inquiry. Sarah Blaffer Hrdy, whose work we discussed in Chapter 2, knows that in primatology, "we would do well to encourage multiple studies, restudies, and challenges to current theories by a broad array of observers."[10] We've seen how multiple explanations are not only possible in quantum physics, but inescapable, and even generative of creative dialogue and experimentation. In these and other cases, what's involved are multiple *disciplined* perspectives: people within the sciences who may have a different or marginalized view on things, but who have nevertheless been enculturated into some professional thought-style or another.

At the very least, the sciences and their pursuers will have to link up with the disciplines that study the sciences from historical, anthropological, philosophical, and literary perspectives, and *their* pursuers. Building such cross-disciplinary knowledge and the collaborations for producing them will meet with both logistical and ideological resistance.

In their polemic *Higher Superstition: The Academic Left and Its Quarrels with Science*, Paul Gross and Norman Levitt appeal to their fellow scientists:

> On the whole, it is regrettable that serious students of the exact sciences rarely encounter, in their training, courses in the history of their disciplines that pay close attention to social, cultural and political factors. . . . But . . . the burden of essential preparatory studies is enormous, and is continually growing. Time is precious to a young scientist, and the optimal career path leads to the frontier of the subject as quickly as possible, leaving little opportunity for historical rumination. Nevertheless, much as one might lament the rarity of historically oriented science courses . . . in our judgment their absence is, on the whole, preferable to a hypothetical curriculum that requires such courses but hands responsibility for them over to historians and sociologists of the academic left. . . . The humanities, as traditionally understood, are indispensable to our civilization. . . the indispensability of professional academic humanists, on the other hand, is a less certain proposition. . . . The notion that scientists and engineers will always accept as axiomatic the competence and indispensability for higher education of humanists and social scientists is altogether too smug. Other sentiments are clearly astir. How these matters play out in American intellectual life will depend, to some degree, on the ability of the nonscientists to rein in the most grotesque tendencies in their respective fields.[11]

There's less time than ever, more demands on and for expertise than ever, and more resistance to change than ever. That's a harsh reality. But it's also more imperative than ever that scientists inquire into the history of their disciplines, and the political and cultural webs in which they are (contingently) entwined. There needs to be not only more serious exchanges, but more working *collusions* between and among the sciences and its Others. Those collusions will inevitably be kludge jobs, creaky and noisy assemblages that will require patience, watchful maintenance, and many trials and errors. But we hope this book has shown that these assemblages can be effective and generative of new ideas and questions that are far from being "grotesque," superstitious, or antiscience.

The truly difficult questions about pluralism arise when we start throwing "citizens" into the mix. In kludging these kinds of unusual assemblages, you'll have to follow that other principle of ours, recognizing the need for precision and specificity: different sciences, and the different ways in which they intersect with "community concerns," will require different assemblages for pluralistic, democratic involvement. Our case studies of Section II suggest where and how we think the sciences require the involvement of many members of various communities, if they are to have any chance of solving more social problems than they create.

Ours is not the simple political solution of "community direction of science," which is often either an empty slogan or the beginnings of an authoritarian closure of inquiry. Such solutions often postulate a kind of natural wisdom, that the com-

munity just knows better, has some ingrained sense of rightness and limits and ethics. What we're talking about are mechanisms of *community inclusion* in the larger assemblages of the sciences, tailored differently for different tasks and questions. For example, it's neither politically feasible nor scientifically productive to have people diagnosed with MCS directing what biomedical research should be done. It is politically possible to include these individuals on NIH funding and review panels, to build their knowledge and experience into clinical trials, and to link citizen-centered advocacy groups into the network of government and corporate institutions that push and guide research on this and other conditions. And that inclusion will produce better sciences of MCS than we would otherwise have.

Our challenge is to continually reinvent and reenact intellectual inquiry as well as practical politics. There is no ready-to-hand accounting mechanism for knowing in advance how and when to value expertise, and how and when to value the pursuit of nonexpert questioning and participation. That's the challenge to be muddled through.

MUDDLE THROUGH

In popular understanding, "muddling" is not the most compelling or attractive word, but we are convinced it is imperative to rescue it from the opprobrium usually associated with it, and to make it the basic metaphor for how science must proceed in the twenty-first century. Recognizing the simultaneous complexities of nature, society, and politics, especially in an era of rapid change, demands that we shun any easy answers. Easy answers will be imprecise, and we cannot afford to sacrifice precision in an age in which uncertainty is the rule, complex and indistinct causalities abound, and every idea or action sends repercussions throughout the tightly interconnected spheres of science, political economy, and the disparate and often conflicting values of a democratic, pluralistic society. Pleas to restore values to value-free rationality, to retain an unfettered faith in pure inquiry, or to renounce technological society and its basis in instrumental reason—all amount to quick fixes, the intellectual equivalent of get-rich-quick schemes.

It could be said that the humility and incrementalism that come with muddling through are too easy for us to advocate, reflecting the fact that we (the authors) are doing relatively well by the system; the status quo is definitely in our favor. We know that muddling through is crisscrossed with potential dangers, that it is an admirable and appropriate, but potentially conservative trope. In its early articulation by Edmund Burke, "muddling through" never challenged the status quo, and left institutions and assumptions of power intact. So we, and others like us who can afford to be patient, should remain aware that we can applaud muddling through because we have time. We're not, now, under a threat that requires fast and definitive response. Many others are.

But pushing the crisscross into highest tension, we would also argue that, when it comes to the sciences, we can't afford to be impatient. The combination of enthusiasm, speed, the sciences, and technologies doesn't have a great track record. Because the sciences are such volatile power/knowledge packages, some form of conservatism might very well be in order.

Muddling through does run the risk of tending toward conservatism. But the qualifying phrases are important—muddling through "tends toward" and "runs the risk" of conservatism, reminding us, again, how different articulations do different things, compelling and resisting our efforts to use them effectively. Muddling through tends toward conservatism, but it also harbors ways of engaging the world which may be uniquely suited for these unstable times.

Muddling through may not be a perfect princple—even we haven't thought it through all the way, because you can never think something through all the way. So this book should be considered as an experiment that involves putting the idea of muddling through into circulation, to better see how it works, what and who it works for, and who responds to it and how. We're committed, in other words, to pursuing what muddling through can become, within assemblages that persistently acknowledge their own limits and contradictions.

To return to our theme of Thirdness: one of the connotations of muddling that turns people off is its supposed grayness, if gray is that muddled, middled third term between black and white. We don't have strictly cognitive judgments about gray; it comes packaged with cultural sensibilities. It's subtly charged: Muddling is gray, and gray is dismal, bleak, featureless. But that's cultural code, not cosmological fact. You can, however, look around for different coding possibilities, as Trinh Minh-ha does in Japan (without glossing over the complexities and contradictions *within* that other culture):

> Grey remains largely (in Japanese as well as in many western contexts) a dull colour within culture's boundaries: one that usually implies a lack of brightness; an unfinished state; a dreary and spiritless outlook (the grey prospects, the grey office routine); a negative intermediate condition or position (that evades for example the spirit of moral and legal control without being overtly immoral and illegal) . . . and last but not least, the polluting of the natural world by ecologically destructive technology (in which modern Japan partakes as one of the most powerful producers). . . . But plain grey . . . in Japanese aesthetics is not so much the result of a mixing of equal parts of black and white as it is "the colour of no colour" in which all colours are canceling each other out. The new hue is a distinct colour of its own, neither black nor white, but somewhere in between—*in the middle* where possibilities are boundless. *Intermezzo.* A midway-between-colour, grey is composed of multiplicities. . . .

Trinh explores grayness in everything from the robes worn in the tea ceremony beginning in the sixteenth century, to the writings and practices of contemporary Japanese architects. In Japan, "Rikyu grey" is a combination of four opposing colors: red, blue, yellow, and white. Grayness is multiple, open-ended; it characterizes a space of transition. Gray is the shrouding fog: "One can say that the fog is a transcultural symbol of that which is indeterminate ('the grey area'); it indicates a phase of (r)evolution, between forms and formlessness, when old forms are disappearing while new ones coming into view are not yet distinguishable. . . . The delicate, diffused, ephemeral and transitory lights of dawn and dusk have always been the lights most sought after in colour photography."[12]

While there's something undeniably beautiful and even comforting about the suffused light of foggy dawns and dusks, there's also something haunting about it. It's the space of shipwrecks, navigation failed; people scream, drown, and die in the fog. It's where we lose our bearings and begin to grope around. And one of the things we grope for is better judgment.

BECOME A RESPONSIBLE HOLE-IST

Scientists often locate the "scientificity" of their project, and consequently their authority, in their methods rather than in their truths. The truths, they can admit, are of course always revisable, but the methods themselves are rock solid, and uniquely so. As we would say, it's the pursuing and not the arriving that makes the sciences "science." What we've done is ask questions about that solidity, located the holes in it, traced the more muddled, unmethodical parts of the scientific method—the many points at which judgments had to be made, or where subtle and not-so-subtle charges shifted the whole enterprise. In our pursuits of the subtle Thirdness that holds together and helps extend the articulated webs of the sciences, we've had to become hole-ists rather than holists.

The more we pursue precision, the more it seems ambiguity and uncertainty spring up somewhere else. The more elements we add to keep our conceptual systems complicated, the more holes emerge in their in-betweens. It's not very reassuring to think that our pursuits of sciences and truths never fully arrive. But at least we might be learning not to expect the sciences to deliver certainty, or to be disillusioned or paralyzed by contradictory expert judgments. *This* study recommends mammograms for all women under the age of fifty, *that* study says such a program offers little preventative value; *this* group of scientists says the increased risk of uterine cancer from estrogen replacement therapy is outweighed by the other benefits, including a decreased risk of breast cancer, *that* group of scientists says exactly the opposite—*why can't they make up their minds?*

In fact, they have simply made up their minds differently, and they've made different realities in the process: kludged together different methodologies, different populations to be studied, different assumptions and cutoff lines, different statistical analyses, different reagents, and many other differences, and all the ambiguities in between. Maybe further studies will help clarify the situation, resolve some of the differences, or fill in some of the holes. Maybe not. Judging among these different articulations and monstrously complicated assemblages is no easy task, and certainly not a science. We have to recognize that such decisions, often life and death ones, will almost always come down to someone's judgment call. We've also seen how the terms of those judgments can be specified and questioned as necessary. That's not nearly as comforting as absolute certainty—but it's not nothing.

Many people will say that the social and intellectual challenge we face in the next millennium is to figure out how science and values "go together," or "interact." These people, who are often highly critical of the "ideology of control" represented by modern scientific thought and processes, always have at least one eye turned toward how we might better control this imprecise combination of these vague terms, values and sciences. They presume that science and values are specifiable, determinate things and that their linkages are like a plumbing system: an input here, an elbow joint there, and here's where we suggest you apply the wrench or add a new valve, or value.

The "add-values-and-tighten-it-all-up" proposal displays an understandable longing for mechanism, but we need a new, less mechanical metaphor. Values and sciences can neither be simply opposed nor combined; we have to be able to see, question, and work the tensions and gaps between responsibility and experimenting. A straightforward organic metaphor won't do either, so we'll need another of our cyborg lobsters, another assemblage.

Every day, many times a day, people watch the performance of just such a science-assemblage, the weather report: a strange and wonderful combination of satellite technology, government institutions, local advertising, scientific expertise, show biz, beautiful pictures, precise measurements, history, folksy humor, "Super Doppler Radar," and helpful, often vital, predictions. The object of all this attention: the atmosphere. Oliver Wendell Holmes likened the atmosphere to the worlds of medicine and the sciences. He suggested that "medicine, professedly founded on observation, is as sensitive to outside influence, political, religious, philosophical, imaginative, as is the barometer to the atmospheric density."[13]

Think of sciences and values (or politics, cultures, etc.) as atmospheric events. Start with one enormous, chaotic, life-giving and life-deriving system. Perform an arbitrary separation for purposes of analysis: The sciences are an enormous cold air mass descending from the North, values a highly saturated warm front moving in from the South. Every winter here in New England, at least one major event

catches all the local weather forecasters off-guard. Will it snow? Where? How much? Run the computer models of historical remembrance and cross your fingers as the commercial break ends and the red light of the camera flicks on and you're forced to make your prediction. Even if you get lucky, and the contours on your map the next day correspond in some manner to the vast stretches of blanketed territory, what exactly will you have accomplished? "We're already tracking this new possible storm system for the weekend, but it's too early to tell. Stay tuned. . . ."

Sciences/values, responsibility/experimenting is that fantastic world which we inhabit, not the problem we try to solve. We can predict probabilities, we can build new technological systems to sharpen those probabilities, we can take all kinds of protective measures from grabbing an umbrella on the way out the door to evacuating cities, but to think you can control the complex confluences is a big mistake.

If muddling through the sciences responsibly is sort of like predicting the weather, it's also sort of like the law. Jacques Derrida provides a helpful articulation:

> For a decision to be just and responsible, it must, in its proper moment, if there is one, be both regulated and without regulation: it must conserve the law and also destroy it or suspend it enough to have to reinvent it in each case, rejustify it, at least reinvent it in the reaffirmation and the new and free confirmation of its principle. Each case is other, each decision is different and requires an absolutely unique interpretation, which no existing, coded rule can or ought to guarantee absolutely. At least, if the rule guarantees it in no uncertain terms, so that the judge is a calculating machine—which happens—we will not say that he is just, free and responsible. But we also won't say it if he doesn't refer to any law, to any rule or if, because he doesn't take any rules for granted beyond his own interpretation, he suspends his decision, stops short before the undecidable or if he improvises and leaves aside all rules, all principles.[14]

Responsibility and justice are defined here in terms of competing demands. The law must be upheld; the law must be overturned. The sciences must be upheld; the sciences must be overturned. A good decision, a good science happens in the middle, in that space tracked on our radar screens where currents cross and storms brew. The stakes can be as high as life and death, requiring precise calculations and the most vigilant technologies, but these will be no guarantees.

Being a good, creative, responsible scientist is very similar to being a good, creative, responsible judge. You have to be aware that you're caught in several contradictions at once. You have to abide by existing rules, but those rules are no guarantee; in addition, your own actions will establish new rules to replace the

old, which will then be seen as quaint and lacking any authority. You have to conserve existing truths *and* destroy them. You have to improvise new arrangements *and* obey old principles. You have to experiment, *and* you have to be responsible. You can't do both, and you must.

You must recognize that legal decisions necessarily adjudicate, resolving the complexity of a dispute into a final judgment. Similarly, the truths proclaimed by science necessarily silence the excess complexity of the data, resolving all ambiguity into a formula or argument that can be published and circulated. Since "each case is other, each decision is different," responsible experimenting in the sciences—in the laboratory, and in the social world—can come only from intellectual and social engagement with issues and questions on the ground.

Or on the coastline. Return again to Mark Tansey's painting *Coastline Measure* on the cover. In our chart, opposite terms meet like colliding air masses, or like furious sea and craggy rock. The front, the coastline, and the middle are all forms of Thirdness, where the pursuits of the sciences always happen. A big part of pursuing them more responsibly will involve the difficult, ceaseless measure of the fractal contours where the opposing forces meet. Triangulating on the holes—the ineradicable limits of any analysis, scientific or social—is crucial. It's a collaborative enterprise, to be undertaken by diverse teams with a variety of instruments. It's irreducibly messy and reliable, clumsy and precise, exciting and dangerous.

Our final metaphors here have shifted rapidly, from atmospheres to grounds to fractal coastlines. It says something about the simultaneous uncertainties and opportunities presented by the challenge of muddling through. But we have to turn muddling through into the hottest pursuit of the sciences, or else the next century will be even colder, less pluralistic, more dogmatic, and more obsessed with exterminating all forms of impurity than this past one. To pursue sciences and truths more responsibly, we're going to need every medium we can get, because neither realism nor cultural analysis nor studying history nor doing philosophy nor having the right politics nor being socially responsible will work on its own. But putting all of these into a new assemblage, one that threatens to fly apart any minute, will allow us to continue experimenting. There's no return to the safety of any kind of pure space, whether of science or of ethics. The first demand of responsibility in the sciences is simply to be willing and able to respond, and the first things demanding response are the ever-present holes in the sciences, ethics, and politics alike.

As with all the sciences, the reader has to take *Muddling Through* into realitty, and see how it holds up, how it works, and what it works for. Read the references we've provided, think carefully and critically about the ideas here, and, most important, run some more experiments. Do those experiments in public, where you'll be forced to account for your articulations over and over again, and where

the outcomes can be judged from many perspectives. Crack this book, rip out pages and insert new ones of your own, kludge it into other sets of practices and communities.

And?

Let's hope it works.