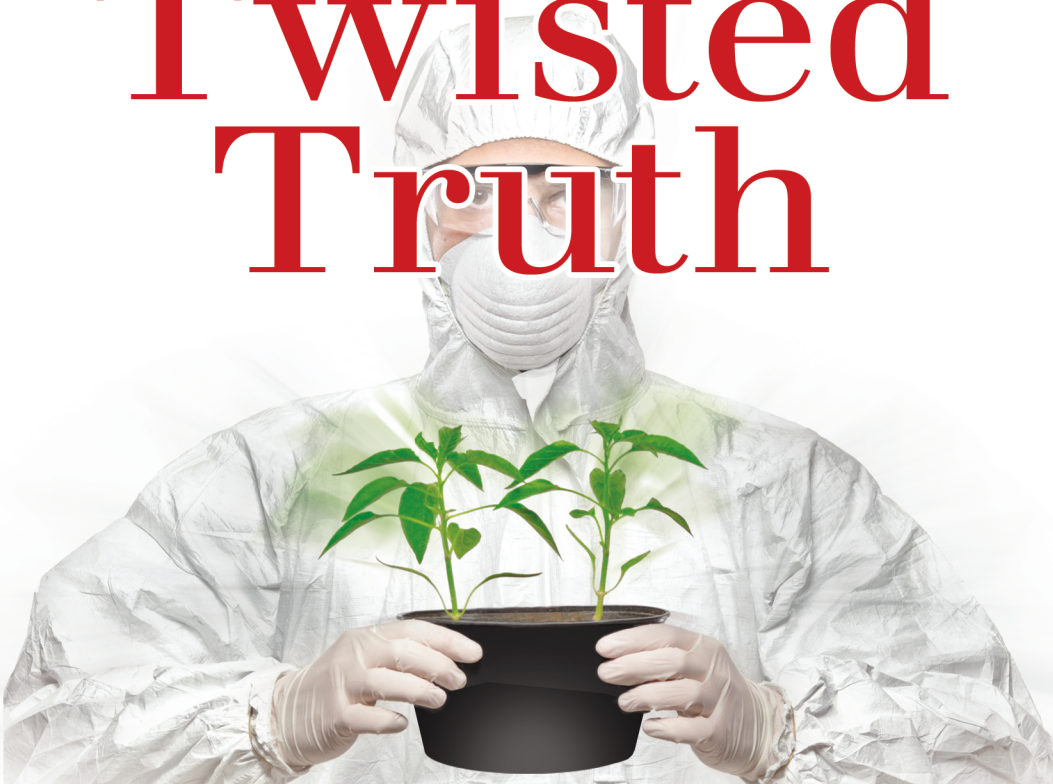
"ONE OF THE MOST IMPORTANT BOOKS OF THE LAST 50 YEARS."
— Jane Goodall, from the Foreword

Altered Genes, Twisted Truth



How the Venture to Genetically Engineer Our Food Has Subverted Science, Corrupted Government, and Systematically Deceived the Public

STEVEN M. DRUKER

Praise for *Altered Genes, Twisted Truth*

"Without doubt, one of the most important books of the last 50 years. I shall urge everyone I know who cares about life on earth, and the future of their children, and children's children, to read it. It will go a long way toward dispelling the confusion and delusion that has been created regarding the genetic engineering process and the foods it produces. . . . Steven Druker is a hero. He deserves at least a Nobel Prize."

— **Jane Goodall, PhD, DBE,** UN Messenger of Peace
(*from the Foreword*)

"A fascinating book: highly informative, eminently readable, and most enjoyable. It's a real page-turner and an eye-opener."

— **Richard C. Jennings, PhD,** Department of History and Philosophy of Science, University of Cambridge, UK

"This incisive and insightful book is truly outstanding. Not only is it well-reasoned and scientifically solid, it's a pleasure to read – and a must-read. Through its masterful marshalling of facts, it dispels the cloud of disinformation that has misled people into believing that GE foods have been adequately tested and don't entail abnormal risk."

— **David Schubert, PhD,** molecular biologist and
Head of Cellular Neurobiology,
Salk Institute for Biological Studies

"*Altered Genes, Twisted Truth* is lucid, illuminating, and alarming. As a former New York City prosecutor, I was shocked to discover how the FDA illegally exempted GE foods from the rigorous testing mandated by federal statute. And as the mother of three young kids, I was outraged to learn how America's children are being callously exposed to experimental foods that were deemed abnormally risky by the FDA's own experts."

— **Tara-Cook Littman, JD**

"Steven Druker has written a great book that could well be a milestone in the endeavor to establish a scientifically sound policy on genetically engineered foods. The evidence is comprehensive and irrefutable; the reasoning is clear and compelling. No one has documented other cases of irresponsible behavior by government regulators and the scientific establishment nearly as well as Druker documents this one. His book should be widely read and thoroughly heeded."

— **John Ikerd, PhD,** Professor Emeritus of Agricultural and Applied Economics, University of Missouri – Columbia

"*Altered Genes, Twisted Truth* will stand as a landmark. It should be required reading in every university biology course."

— **Joseph Cummins, PhD,** Professor Emeritus of Genetics, Western University, London, Ontario

"Steven Druker's meticulously documented, well-crafted, and spellbinding narrative should serve as a clarion call to all of us. In particular, his chapter detailing the deadly epidemic of 1989-90 that was linked with a genetically engineered food supplement is especially significant. I and my Mayo Clinic colleagues were active participants in the attempt to identify the cause of this epidemic. Druker provides a comprehensive analysis of all the evidence and also presents new findings from our work. Overall his discussion of this tragic event, as well as its ominous implications, is the most comprehensive, evenly-balanced and accurate account that I have read."

— **Stephen Naylor, PhD,** CEO and Chairman of MaiHealth Inc. Professor of Biochemistry and Molecular Biology, & Pharmacology Mayo Clinic (1991-2001)

"*Altered Genes, Twisted Truth* is very readable, thorough, logical and thought-provoking. Steven Druker exposes shenanigans employed to promote genetic engineering that will surprise even those who have followed the ag-biotech industry closely for years. I strongly recommend his book."

— **Belinda Martineau, PhD,** molecular biologist, a co-developer of the first genetically engineered whole food, and author of *First Fruit: The Creation of the Flavr Savr™ Tomato and the Birth of Biotech Foods*

"Steven Druker has done a beautiful job of weaving a compelling scientific argument into an engaging narrative that often reads like a detective story, and he makes his points dramatically and clearly. The examination of genetic engineering from the standpoint of software engineering is especially insightful, exposing how the former is more like a 'hackathon' than a careful, systematic methodology for revising complex information systems. I will recommend this book to my friends."

— **Thomas J. McCabe,** developer of the cyclomatic complexity software metric, a key analytic tool in computer programming employed throughout the world

"Based on over 30 years of teaching computer science at universities and on extensive experience as a programmer in private industry, I can state that Steven Druker has done an excellent job of demonstrating the recklessness of the current practices of genetic engineering in comparison to the established practices of software engineering. His book presents a striking contrast between the two fields, showing

how software engineers progressively developed greater awareness of the inherent risks of altering complex information systems – and accordingly developed more rigorous procedures for managing them – while genetic technicians have largely failed to do either, despite the fact that the information systems they alter are far more complex, and far less comprehended, than any human-made system."

— **Ralph Bunker, PhD**

"Steven Druker has written one of the few books I have encountered, in my many years of public interest work, with the capacity to drive major change in a major issue. What Ralph Nader's *Unsafe at Any Speed* was to the auto industry and what Rachel Carson's *Silent Spring* was to synthetic pesticides, *Altered Genes, Twisted Truth* will be to genetically engineered food. It is profoundly penetrating, illuminating, and compelling, and it could stimulate a monumental and beneficial shift in our system of food production.

— **Joan Levin, JD, MPH**

"Druker's brilliant exposé catches the promoters of GE food red-handed: falsifying data, corrupting regulators, lying to Congress. He thoroughly demonstrates how distortions and deceptions have been piled one on top of another, year after year, producing a global industry that teeters on a foundation of fraud and denial. This book is sure to send shockwaves around the world."

— **Jeffrey M. Smith**, international bestselling author of
Seeds of Deception & *Genetic Roulette*

"*Altered Genes, Twisted Truth* reveals how the inception of molecular biotechnology ignited a battle between those committed to scientific accuracy and the public interest and those who saw genetic engineering's commercial potential. Steven Druker's meticulously researched book pieces together the deeply disturbing and tremendously important history of the intertwined science and politics of GMOs. Understanding this ongoing struggle is a key to understanding science in the modern world."

— **Allison Wilson, PhD,** molecular geneticist
Science Director, The Bioscience Resource Project

"*Altered Genes, Twisted Truth* is a remarkable work that may well change the public conversation on one of the most important issues of our day. If the numerous revelations it contains become widely known, the arguments being used to defend genetically engineered foods will be untenable."

— **Frederick Kirschenmann, PhD,** Distinguished Fellow, Leopold Center
for Sustainable Agriculture, Iowa State University
Author of *Cultivating an Ecological Conscience*

"Steven Druker's exceptionally well-researched and well-written book elucidates the scientific facts about genetically engineered foods that the PR myths have been obscuring. It provides a unique and invaluable resource not only for concerned citizens, but for historians of science and technology as well. In a comprehensive and skillful manner, it demonstrates how the integrity of science was compromised as a highly influential community of biologists with special interests in genetic engineering muddled scientific truth in order to protect the image of bioengineered foods and to advance their growing partnerships with big business and government. Ultimately, the book reveals that what's at stake here is not only the safety of our food supply, but the future of science.

I am pleased that Steven made good use of the extensive firsthand information I shared about the unsavory behind-the-scenes machinations of biotech promoters in both scientific institutions and government agencies, and I am very impressed with the book as a whole – and expect that a large number of other scientists will be too."

— **Philip Regal, PhD,** Professor Emeritus, College of Biological Sciences, University of Minnesota

Altered Genes, Twisted Truth

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STEVEN M. DRUKER

Clear River Press

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Steven M. Druker

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Dedication

To the courageous scientists who have endeavored to uphold truth and scientific integrity regarding the risks of genetic engineering, especially those whose clarity of vision and power of expression inspired a wave of remedial action.

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Note: Appendices C and D and the Executive Summary are available online at:

http://alteredgenestwistedtruth.com/appendix-c/
http://alteredgenestwistedtruth.com/appendix-d/
http://alteredgenestwistedtruth.com/executive-summary/

FOREWORD

JANE GOODALL

I well remember how horrified I felt when I learned that scientists had succeeded in reconfiguring the genetics of plants and animals. The first genetically engineered (GE) plants were created in the 1980s, but I did not hear about them until the 1990s when they were first commercialized. It seemed a shocking corruption of the life forms of the planet, and it was not surprising that many people were as appalled as I was – and that these altered organisms became known as 'Frankenfoods'.

In fact, there were good science-based reasons to mistrust the new foods; yet GE crops have spread throughout North America and several other parts of the world. How has this come about? The answer to that question is to be found in Steven Druker's meticulously researched book. Several years in the making, it is a fascinating, if chilling story.

I did not realize what a formidable task the bioengineers faced as they struggled to introduce new genes into a variety of agricultural crops. Their intent was to make them produce toxins that would deter insect pests, or enable them to resist herbicides, and so on. A major challenge was the need to overcome the various defensive mechanisms of the plants themselves, which did their best to repel the alien material. Another was to compel the foreign genes to function in a cellular environment where they would ordinarily remain dormant. It is a testament to human persistence and ingenuity that the scientists finally succeeded!

But the reconfigured plants they eventually created were, as Druker explains in engaging detail, different in a variety of ways from their parents; and from the outset many qualified scientists expressed concerns about the safety of the new crops for both the environment and human and animal health. He further demonstrates that this very real difference between GE plants and their conventional counterparts is one of the basic truths that biotech proponents have endeavored to obscure. As part of the process, they portrayed the various concerns as merely the ignorant opinions of misinformed individuals – and derided them as not only unscientific, but anti-science. They then set to work to convince the public and government officials, through the dissemination of false

information, that there was an overwhelming expert consensus, based on solid evidence, that the new foods were safe. Yet this, as Druker points out, was clearly not true.

As the chapters progress, we read how the advocates of genetic engineering have steadfastly maintained that the crops created by this radical technology are essentially similar to those from which they have been derived, that the process is splendidly exact, and that GE foods, therefore, are if anything *safer* than their traditionally bred 'parents' – when in fact, there's significant dissimilarity, the process is far from exact, and the risks are greater, especially the risk of creating unexpected toxins that are difficult to detect.

Druker describes how amazingly successful the biotech lobby has been – and the extent to which the general public and government decision-makers have been hoodwinked by the clever and methodical twisting of the facts and the propagation of many myths. Moreover, it appears that a number of respected scientific institutions, as well as many eminent scientists, were complicit in this relentless spreading of disinformation.

Chapter 5 shows how the key step in the commercialization of GE foods occurred through the unbelievably poor judgment – if not downright corruption – of the US Food and Drug Administration (the FDA). This regulatory body is supposed to ensure that new additives to foods are safe before they come to market, and it had a responsibility to require that GE foods were proven safe through standard scientific testing. But the information that Druker pried from the agency's files through a lawsuit revealed that it apparently ignored (and covered up) the concerns of its own scientists and then violated a federal statute and its own regulations by permitting GE foods to be marketed without any testing whatsoever. The evidence further shows how the agency assured consumers that GE foods are just as safe as naturally produced ones – and that their safety has been confirmed by solid scientific evidence – despite the fact it knew that no such evidence existed.

Druker makes the case that it was this fraud that truly enabled the GE food venture to take off. And he asserts that the fraud continues to deceive the public and Congress, despite the fact that the lawsuit he initiated thoroughly exposed it. His description of the proceedings surrounding this lawsuit was, to me, one of the most astounding and chilling parts of the book.

And what of the role of the media? How have the American public been so largely kept in the dark about the realities of GE foods – to the extent that until quite recently, a vast majority of the populace did not even know they were regularly consuming them? Druker describes, in Chapter 8, how

the mainstream media have been highly selective in what they report – and have consistently failed to convey information that would cause concern about these engineered products. Moreover, Druker demonstrates that the policies imposed by the media magnates have been, in his words, "not merely selective, but suppressive." And he relates several dramatic incidents in which journalists who tried to bring unsettling facts to light had their stories altered or totally quashed by higher level executives. So it is not surprising that the American public, and a good many key decision-makers, believe that there are no legitimate concerns regarding GE foods.

I am personally grateful to Steven Druker for writing this book. It has been a monumental task and reflects the passionate desire of a man with a true scientific spirit to reveal, as precisely as possible, the truth behind the misrepresentations of the truth. Nonetheless, despite its integrity, *Altered Genes, Twisted Truth* can be expected to meet fierce criticism from those who promote the GE food venture; and, like all who attempt to disclose the venture's underside, its author will probably be attacked and branded as anti-science and anti-progress. BUT it seems to me that it is not those who point to the problems of the venture who are anti-science: it is quite the other way around. Nevertheless, Druker will almost surely be subjected to the same sort of criticisms as those leveled against Rachel Carson when she published *Silent Spring* in 1962.

I think it is important that you read this book carefully, assessing for yourself how firmly it is grounded in fact and logic. You may well come to the same conclusion as I have: that Steven Druker is upholding the tradition of good science. Then read some of the books and articles written by pro-GE scientists – especially some of those by prominent biologists – and you may well decide that their standards often fall significantly short of his.

In fact, he points out several instances in which it appears that such publications are downright deceptive, not only portraying genetic engineering in a misleading manner, but even misrepresenting some basic features of biology. Further, although these scientists may genuinely believe that GE foods are the solution for world hunger, it appears that many of them have vastly overestimated the benefits of these foods – and that even *if* these products did *not* entail higher risks, it's doubtful they could significantly reduce malnutrition or solve any major problems of agriculture.

Although this book tells a story that's in many ways distressing, it's important that it has finally been told because so much confusion has been spread and so many important decision-makers have apparently been deluded. Fortunately, the final chapter shows how the story can have a

happy ending, and it clearly points the way toward realistic and sustainable solutions that do not involve genetic engineering. Thus, just as my own books aim to instill hope, this book is ultimately a hope-inspiring one too. For it describes not only some of the mistakes that we have made but how they can be rectified in creative and life-supporting ways.

Druker has, without doubt, written one of the most important books of the last 50 years; and I shall urge everyone I know, who cares about life on earth, and the future of their children, and children's children, to read it. It will go a long way toward dispelling the confusion and delusion that has been created regarding the genetic engineering process and the foods it produces.

To me, Steven Druker is a hero. He deserves at least a Nobel Prize.

– Jane Goodall, PhD, DBE and UN Messenger of Peace

INTRODUCTION

How I Reluctantly Became an Activist

– And Uncovered the Crime that Enabled the Commercialization of Genetically Engineered Foods

Most people would be surprised to learn that Bill Clinton, Bill Gates, and Barack Obama (along with a host of other astute and influential individuals) were all taken in by the same elaborate fraud.

They'd be even more surprised to learn that it was not perpetrated by a foreign intelligence agency, an international crime syndicate, or a cabal of cunning financiers but by a network of distinguished scientists – and that it did not involve change in the climate but changes to our food.

And, if they're Americans, they would be shocked to discover that the US Food and Drug Administration has been a major accomplice – and that because of its deceptions, for more than fifteen years they and their children have been regularly ingesting a group of novel products that the agency's scientific staff had previously determined to be unduly hazardous to human health.

This book tells the fascinating and frequently astounding story of how such a remarkable state of affairs has come to be; and I'm uniquely positioned to tell it, because I uncovered one of its key components.

In early 1996, I did something few Americans were then doing: I decided to learn the facts about the massive venture to restructure the genetic core of the world's food supply. And the more I learned, the more I became concerned. It grew increasingly clear that the claims made in support of genetically engineered foods were substantially at odds with the truth – and that there were strong scientific grounds for viewing such products with a cautious eye.

Of special concern was the behavior of the Food and Drug Administration (FDA), which has refused to regulate genetically engineered foods

and instead has energetically promoted them.[1] I found it problematic this agency had adopted a presumption that genetically engineered (GE) foods are as safe as natural ones and was allowing them to be marketed not only without testing but even without labels to inform consumers about the genetic reconfiguration that had occurred. I believed this was unscientific, irresponsible, and fundamentally wrong.

I also had a hunch it was illegal – a hunch my research eventually confirmed.

As my knowledge grew, there also grew a conviction that a lawsuit should be brought against the FDA to overturn its policy on GE foods and compel it to require the safety testing and labeling that consumers were being wrongfully denied. At that point, I didn't envision playing an active role in the legal proceedings or even getting extensively involved in the developmental phase of the suit. My intention was to present the idea to others who had greater expertise and resources and inspire them to carry it out. Although I have a law degree from the University of California at Berkeley, practicing law has not been the central focus of my professional life, and I had scant experience in litigation. Further, I was immersed in a project that was dear to my heart and didn't want to get sidetracked.

Yet, in the process of trying to inspire others to do the lawsuit, I gradually became the main person organizing it and driving it forward. The executives of public interest organizations with whom I spoke all thought the suit was a great idea, but none felt ready to take it on. After some weeks of attempting to find an organization that would shoulder the suit, I discussed the situation with a molecular biologist who was concerned that in the push for rapid commercialization of GE foods, the risks were being unduly discounted and testing irresponsibly neglected. As I explained how my ideas for the lawsuit had been uniformly greeted with enthusiasm but that none of the groups was prepared to turn them into reality, he said: "Steve, don't you realize this is your baby? If you don't do it, it's not going to happen." Much as I desired to have someone else do the suit so I could get back to my other project, and much as I wanted to reject his assessment, deep down I had an inescapable feeling he was right.

So I set my project aside, founded the Alliance for Bio-Integrity (a nonprofit public interest organization), and as its executive director, devoted myself full-time to organizing the lawsuit. In a few months, I gained the collaboration of the International Center for Technology Assessment, a respected public interest organization in Washington, D.C. with a skilled team of lawyers. They had substantial experience in litigation with federal

administrative agencies, and they agreed to be the attorneys of record, on the condition that I would continue to coordinate the various elements of the project and to raise the necessary finances. In time, I also became actively involved as an attorney, undertaking key research and contributing to the briefs and other documents filed with the court.

During the preparation phase, a primary goal was to attain an impressive set of plaintiffs. Over the following months, through numerous phone calls, emails, and journeys to personal meetings, I assembled an unprecedented coalition to join the suit and sign the complaint against the FDA that was submitted to the court. For the first time in US history, a group of scientific experts became involved in a lawsuit challenging the policy of a federal administrative agency, not as advisers or expert witnesses, but as plaintiffs – plaintiffs who formally objected to the policy on scientific grounds. In a bold move highlighting the unsoundness of that policy, nine well-credentialed life scientists (including tenured professors at UC Berkeley, Rutgers, the University of Minnesota, and the NYU School of Medicine) stepped up to sue the FDA and formally assert that its presumption about the safety of GE foods is scientifically flawed because they pose abnormal risks that must be screened by rigorous testing.

Equally unparalleled, they were co-plaintiffs with a distinguished group of spiritual leaders from diverse faiths who objected to the FDA's policy on religious grounds. Within this group were the President of the North American Coalition on Religion and Ecology, the chaplain at Northeastern University, and a lecturer in theology at Georgetown University. In all, there were seven ordained priests and ministers from a broad range of Christian denominations (including Episcopalian, Lutheran, Baptist, and Roman Catholic); three rabbis (Orthodox, Conservative, and Reform); the chancellor of the Americas Dharma Realm Buddhist University; and a thousand-member Hindu organization from Chicago. These plaintiffs stated that in their view, the manner in which biotechnicians are reconfiguring the genomes of food-yielding organisms is a radical and irreverent disruption of the integrity of God's creation – and that they felt obliged to avoid consuming the products of such interventions as a matter of religious principle. They alleged that by failing to require proper labeling, the FDA was unavoidably exposing them to these foods and preventing them from the free exercise of their religious beliefs. (Some of the religious-based reasons for rejecting GE foods are more fully described in Chapter 14.)

Although proponents of GE foods attempt to portray any religiously motivated opposition as due to ignorance about the facts of genetic

engineering and a resultant failure to appreciate its similarity to traditional breeding, these plaintiffs *were* well-informed; and they therefore understood how deeply it does differ from natural processes. (These differences are thoroughly discussed in Chapter 4).

Alliance for Bio-Integrity, et al. v. Shalala, et al. was filed in US District Court in Washington, D.C. in May 1998. The first named defendant was Donna Shalala because, as the Secretary of the Department of Health and Human Services at that time, she oversaw the FDA, which is one of the agencies within that department. The acting commissioner of the FDA was the other defendant.

The suit quickly achieved a major effect because, as part of the discovery process, it forced the FDA to hand over copies of all its internal files on GE foods. Eager to delve beneath the agency's public pronouncements and see if they jibed with what it really knew and how it had actually operated, I assumed responsibility for analyzing this trove of documents. As I combed through the more than 44,000 pages of reports, messages, and memoranda, I made several startling discoveries. By the time my investigation was finished, I had compiled extensive evidence of an enormous ongoing fraud. It revealed that the FDA had ushered these controversial products onto the market by evading the standards of science, deliberately breaking the law, and seriously misrepresenting the facts – and that the American people were being regularly (and unknowingly) subjected to novel foods that were abnormally risky in the eyes of the agency's own scientists.

This fraud has been the pivotal event in the commercialization of genetically engineered foods. Not only did it enable their marketing and acceptance in the United States, it set the stage for their sale in numerous other nations as well. If the FDA had not evaded the food safety laws, every GE food would have been required to undergo rigorous long-term testing; and if it had not covered up the concerns of its scientists and falsely reported the facts, the public would have been alerted to the risks. Consequently, the introduction of GE foods would at minimum have been delayed many years – and most likely would never have happened.

So it's vital that the story of the FDA's crime be fully told; and this book does so in a comprehensive and vivid manner, disclosing how a government agency with the duty to safeguard the nation's food supply was induced to perpetrate such a fraud, how the fraud was carried off, and how, even after being exposed and conclusively documented, it has maintained its strength and continued to deceive the public.

Moreover, in fully telling this story, the book relates a much bigger one, a story in which the FDA's behavior does not stand as an isolated aberration but forms an integral part of a broader pattern of misconduct. It presents a graphic account of how the genetic engineering venture arose, the stages through which it has advanced, and how, at every stage, the advancement relied upon the sustained dissemination of falsehoods. In line with its title, it demonstrates that the broad-scale altering of genes has been chronically and crucially dependent on the wholesale twisting of truth – and shows how for more than thirty years, hundreds (if not thousands) of biotech advocates within scientific institutions, government bureaus, and corporate offices throughout the world have systematically compromised science and contorted the facts in order to foster the growth of genetic engineering, and get the foods it produces onto our dinner plates.

Thus, the narrative that unfolds in the following pages is fundamentally a story about the corruption of science and its concomitant corruption of government, not through the machinations of a scientific fringe group in league with a pack of powerful political ideologues, but through the workings of the mainstream scientific establishment in concert with large multi-national corporations – and their co-optation of government officials across the political spectrum, and across the globe. Further, by the time the story ends, it will be clear that the degradation of science it depicts has not only been unsavory but unprecedented: that in no other instance have so many scientists so seriously subverted the standards they were trained to uphold, misled so many people, and imposed such magnitude of risk on both human health and the health of the environment.

A variety of documents (including transcripts of scientific conferences, statements by government agencies, newspaper reports, journal articles, and books by historians of science) collectively chronicle the bioengineering venture. Together, they amply illumine its underside, revealing how the integrity of science and the integrity of government have both been routinely sacrificed so the enterprise could advance. I have drawn deeply from these resources, often crystallizing key facts that were not widely known. Additionally, because I was engaged in the campaign to properly regulate GE foods for many years on several continents (meeting a broad range of government officials, interacting with scientists and journalists, and participating in conferences and debates), I have repeatedly witnessed the corrosive processes firsthand; and the narrative has been enhanced by a number of these experiences.

Further, many striking accounts of the corrosion were imparted by scientists who have striven to stop it. One of the foremost is the eminent biologist Philip Regal, who for twenty years spear-headed the endeavor to get the genetic engineering enterprise aligned with solid science and tempered by responsible regulation. His story, which forms part of several subsequent chapters, illustrates the diverse and often shocking ways in which the scientific establishment and the government consistently frustrated this endeavor – to the extent he became convinced that when dealing with GE foods, the US executive branch would not honor science and the law unless compelled by a court, and so decided to become a plaintiff in the lawsuit I organized. By sharing his insights and experiences with me over the course of many personal meetings, phone conversations, and emails, and by giving me the extensive set of recollections he had recorded, he has enabled me to expose the infirmities and delinquencies of the bioengineering venture in a much richer way than would otherwise have been possible.

Like Dr. Regal, a growing number of experts have recognized that this enormous venture rests on shaky assumptions and relies on questionable claims – and that increased creativity is required to chart the best way forward. Among them is Evelyn Fox Keller, a distinguished professor of the history and philosophy of science at the Massachusetts Institute of Technology. In her book, *The Century of the Gene*, she notes that the apparent efficacy of genetic engineering provides no assurance that it's free from unintended harmful effects.[2] She further points out that with the rise of this technology, an "unprecedented" bond has grown between science and commerce – and that as this bond has tightened, scientists have become increasingly invested in the rhetorical power of a persuasive mode of "gene talk" that imputes a precision and predictability to bioengineering that it does not possess.[3] Keller emphasizes that the "shortcomings" of such gene talk necessitate its transformation.[4] Her book concludes with the hope ". . . that new concepts can open innovative ground where scientists and lay persons can think and act together to develop policy that is both politically and scientifically realistic."[5]

The following chapters aim to help clear the way to such innovative ground by revealing that the most scientifically realistic policy can easily coincide with the most politically realistic one – and that it's only because the politics of genetic engineering became detached from the scientific realities that the current problems we face were allowed to arise. It's my hope that the information they contain and the insights they convey will

end the confusion that has caused the split and speed the implementation of needed reforms, the reinstatement of scientific standards, and the growth of an agricultural system that yields abundant wholesome food in a safe and sustainable manner.

Ways to Enhance Your Enjoyment of this Book: Utilizing the Executive Summary and Easily Accessing the Endnotes

I've endeavored to make this book a good story and have employed a narrative style as much as feasible. But because the story is about science – and the corruption of science by many of its practitioners – it was necessary to explain many technical facts and examine some rather complex scientific issues. And because I've aimed to produce a book that's not only accessible and enjoyable for the general reader but also serves as a reliable and comprehensive resource for experts, some chapters discuss a substantial amount of information. Many readers will find these discussions stimulating and will appreciate their depth; but others may, at some stage in one of the longer chapters, develop a desire to simply get the gist of the remainder and move on to the next chapter.

In the event such a feeling arises, you can skip to the Executive Summary and read that chapter's main points. (It can be downloaded at: http://alteredgenestwistedtruth.com/executive-summary/) You can also look at a chapter's summary after you've completed it in order to crystallize the basic facts. And even if you read the entire book without glancing at the summary, you may then wish to read it to gain a holistic overview and solidify your understanding.

Of course, some individuals with limited time may prefer to read the Executive Summary first and later read the entire book (or selected chapters) to gain more detailed knowledge.

However, I don't encourage this, because if you read it first, it might spoil the experience that can be gained by allowing the story to unfold chapter by chapter. Several of those who reviewed the book have remarked that it's engaging and often imbued with drama, and some have described it as a "page-turner." But the drama could be dampened by reading a summary of each chapter ahead of time.

So, if you intend to read the entire book, I advise that you initially ignore the Executive Summary. Further, if you want to examine the issues even *more* thoroughly than is done in the main text, you will find that many significant points are discussed in greater depth in the appendices and the endnotes – which leads to an important note about these notes.

For those of you reading the e-book version, hopping to an endnote and returning to the text is simple. But if you're reading the printed book, it would ordinarily be a lot more complicated and time consuming. So to make the endnotes more readily accessible in this situation, they're located not only at the end of the physical book but also online at http://alteredgenestwistedtruth.com/endnotes/. That way, you can download the endnote section and either print it or store it on your computer, tablet, or e-reader. Then, as you read a chapter, you can have a copy of its endnotes nearby and easily transition between the two.

Further, so you won't need to travel back and forth between the notes and a bibliography that contains the full references for the sources that are cited, when a source is cited in a chapter's note section for the first time, it will be fully referenced (even if it's already been fully referenced in the notes for an earlier chapter). Then, subsequent citations of that source will indicate at what preceding note within that section the full reference can be found.

A Note Regarding Terminology

The term "biotechnology" is sometimes broadly employed to refer to all techniques that utilize (or modify) biological processes, including ancient practices that rely on fermentation such as making wine, brewing beer, and leavening bread. But the term can also be used in a narrower sense, to refer exclusively to modern techniques, such as genetic engineering, that depend on highly artificial interventions and that have no established history of safe use. In this book, I employ the terms "biotechnology" and "biotech" in their restricted sense to denote only this latter group of techniques that have not stood the test of time.

Further, because instances of "misrepresentation," "misstatement," "misinformation," "inaccuracy," and "falsehood" can occur through ignorance of the truth, and none of the terms necessarily denotes an intent to deceive, I do not use them to imply that one existed – even though it may have. Instead, I reserve the words "fraud," "lie," "deception," and "disinformation" to denote deceit. Moreover, when I refer to a fraud, deception, or disinformation campaign that was propagated by many individuals, I do not imply that every person who in some way abetted it has been guilty of deception – merely that some have. Furthermore, due to the difficulty of discerning who spoke from ignorance and who did not, unless I specifically assign guilt, it should not be assumed that anyone in particular has been accused.

CHAPTER ONE

The Politicization of Science

– *And the Institutionalization of Illusion*

As he returned the phone to its cradle, Philip Regal knew that his scientific career was about to enter an important and distinctly challenging phase. Ernst Mayr had just urged him to assume a crucial role in connection with the most profound technological revolution since the splitting of the atom.

Mayr was a towering figure in the life sciences. Numerous colleagues, including several of his fellow Harvard professors, considered him to be the greatest biologist of the 20th century, and he was widely regarded as the most influential theorist in the field since Darwin.[1]

For several weeks during that year of 1983, he and Regal had been engaged in a series of discussions via phone and mail about the unprecedented power of genetic engineering and the pressing need to manage it wisely. But this conversation had taken a new turn. Besides endorsing Regal's concerns about the deficiencies in the way the venture was being conducted and the damage that might result from pushing ahead absent adequate knowledge, Mayr asked him to do something about it. He encouraged him to take the lead in organizing a concerted endeavor to induce change and ensure that genetic engineering would be deployed in accord with sound scientific principles – and that the novel organisms it produces would not be released into the environment without sufficient forethought. He counseled him to continue his risk analyses, to stimulate similar assessments by others, and to foster a dialogue within the scientific community that would engender fuller understanding of this technology and a more responsible manner of employing it. Mayr believed that unless there was such deliberation and dialogue, life scientists, the biotechnology industry, and government regulators would not be prepared to intelligently handle the new potencies that had been brought within human grasp.

Yet, even as Mayr urged Regal ahead, he warned him to proceed with caution. He reminded him that the biotech industry and its allies in the molecular biology establishment wielded great economic, academic, and political power – and noted that any attempts to subject their projects to thorough scientific scrutiny would be regarded not only as unnecessary impediments to progress but as major provocations. Then, his voice growing more solemn, Mayr spoke words that still resonate in Regal's memory: "They will try to crush you." Accordingly, he advised Regal that although his credentials were excellent and he was well-respected, he should not go it alone and should get other respected biologists to join him.

Mayr's words were compelling, and despite the difficulties that would be entailed, Regal resolved to undertake the task. But what he didn't realize at that time was just how formidable a task it would turn out to be – and how massive would be the resistance, not only within the confines of the biotechnology industry, but within the corridors of government and the halls of academia as well. Nor did he foresee that over the next three decades, the resistance would in large part prevail.

Regal's concerns about genetic engineering were first aroused in the early 1980's when word spread among life scientists that all its practices and products were soon to be fully deregulated. Because for several years the proponents of this revolutionary technology had been promising that it *would* be carefully regulated, he was surprised at this news – and equally surprised at how many biologists were elated by it. At the University of Minnesota, where Regal was a professor in the College of Biological Sciences, the college's dean enthusiastically announced that the molecular biologists in the National Institutes of Health and the National Academy of Sciences, along with key officials in government, had decided that genetic engineering was safe and were going to give unconditional approval to all its applications.

But Regal did not share the enthusiasm – nor, as he was to learn, did numerous other scientists. For one thing, he found it strange that genetic engineering was being treated as a process that could be considered safe in itself irrespective of the diverse uses to which it was put – and that its proponents assumed this inherent quality of safety would then automatically adhere to all its various products. This approach struck him as fundamentally flawed, because these products could be enormously different from one another in many biologically important ways.

Genetic engineering (technically termed "recombinant DNA technology" and also referred to as "bioengineering" and "gene-splicing"[2]) comprises a set of novel and powerful procedures that restructure the genomes of living organisms by moving, splicing, and otherwise re-arranging pieces of DNA in ways that were formerly impossible. Through it, a wide range of outcomes can arise. It can endow an organism with extra copies of some of its own genes, reconfigure the sequences of some of its genes, and re-program the ways in which its genes are turned on or off, or transplant genes from a distinct and distant species into its genetic program. Further, it can transform any kind of organism, whether a bacterium, a plant, or an animal; and each transformation could give rise to a unique set of effects (both intended and unintended) depending on the organism involved, the genetic alterations performed, their location on the DNA molecule, and the environment in which the organism is placed. Therefore, Regal regarded the claim that genetic engineering would always be safe to be just as bizarre as the claim that all art would be non-offensive.

Yet, molecular biologists promoted this claim as scientifically sound; and most were so sure of it that they shunned discussing the issue with any scientists who disagreed, even if those scientists possessed greater expertise in some relevant areas of knowledge. Nor were they prepared to consider whether their own expertise was broad enough to adequately manage all the facets of genetic engineering.

Regal had first encountered this insular attitude while serving on a committee at the University of Minnesota that reviewed graduate degree programs. To keep the university apace with the latest developments in biotechnology, a new graduate curriculum in microbial engineering had been proposed. As was typical of such programs at other universities, the course work largely consisted of chemistry, biochemistry, molecular genetics, and some physiology. During the committee's discussion of the proposal, Regal expressed the opinion that the students should also study ecology, biological adaptation, and population genetics (fields in which he had expertise) so they could better comprehend the full dynamics of genetically engineered organisms. He emphasized that without such expansion of the curriculum, the graduates would only know how some of the microscopic components of these new organisms functioned in isolated biochemical pathways but would not be able to understand how they functioned as wholes, especially in relation to other organisms. He pointed out that because biotechnicians were planning to release their creations into the environment, it was important that they be able to assess how these living entities would interact within ecosystems.

But his input provoked an indignant response from the promoters of genetic engineering, who flatly asserted that broader training was not necessary because gene-splicing would be invariably safe. They further maintained that genetic engineering was an intensely competitive field, that no universities required budding practitioners to "waste time" in studying the topics Regal had suggested, and that if the University of Minnesota did impose such an extraneous burden it could not keep up with the other schools.

Regal was both stunned and stirred by these statements. As he later wrote:

> I went away from that meeting walking slowly across campus, eyes on the pavement, pondering the flock of serious questions that had been roused in my thinking. How could people whose expertise was limited to chemistry be so sure that radical modifications of complex biological organisms living on farms or within broader populations in nature would necessarily be safe and effective? How could they be so certain? The promoters of genetic engineering at that committee hearing had not the slightest scientific credentials for estimating ecological adaptations and disturbances. It was not simply that they did not have degrees or had not taken courses. One can certainly be self-taught. But they had no credible knowledge. Yet, they were claiming they did not need to acquire any additional understanding or seek advice from experts beyond the bounds of their narrow training – and that no other molecular biologists recognized such a need either. This was an astonishing prospect for me to contemplate at the time, but it turned out this was indeed the prevailing attitude among molecular biologists the world over.[3]

Regal believed it was highly misleading for scientists whose expertise was restricted to molecular biology to present themselves as fully qualified to estimate the ecological effects of genetically engineered organisms. In his mind, it was like someone who knows the details involved in the printing of dollar bills purporting to be an expert forecaster on how the dollar will be valued against the euro and the yen, despite the fact his technical knowledge of dollars was limited to the realm of engraving plates, inks, and printing presses and he had no training or meaningful experience in economics and the intricacies of international currency markets. Nonetheless, the categorical claims of the molecular biologists would increasingly be accepted as authoritative, and would powerfully shape government policy.

Given the boldness of their pronouncements, someone hearing the molecular biologists in 1983 for the first time would have been surprised to learn that they had not always exuded such unqualified confidence in the safety of genetic engineering – and had even called for major precautions. But that was a decade earlier, when the technology was a startling new phenomenon and they openly acknowledged their limited ability to predict and control its effects. The story of how their initial message mutated, and their influence concurrently expanded, provides a striking example of the politicization of science – and the minimization of the role of evidence in setting public policy that's supposed to be science-based.

The Advent of an Astonishing Technology

In 1969, the attention of people throughout the world was riveted on a novel pathogenic microorganism that threatened global devastation of human life. Nothing like it had ever been encountered and the most sophisticated control strategies were being foiled by its awesome destructive capacity. What's more, this malevolent microbe was the product of human invention.

But the invention was purely literary, and the ominous entity came to life only within the pages of a book – Michael Crichton's best-selling science-fiction thriller, *The Andromeda Strain*. And although in this story the deadly organism makes its appearance through the efforts of the US Army to obtain biological weapons, it has not been created by scientists. That's because Crichton aimed for realism; and at that time, it would have been fanciful to portray this novel creature as the product of human engineering. Since DNA was still largely unmanageable, a technology that could precisely copy genes and then splice them into living organisms was well beyond the realm of what was practically achievable. Consequently, it seemed more plausible that ultra-lethal (and completely novel) microbes would be found beyond earth's atmosphere than formed within its laboratories; and Crichton crafted a plot in which the army sends satellite probes into space to collect pathogens for the bioweapons program. In this scenario, the new microbial menace arrives in a satellite that crashes to earth instead of emerging from a terrestrially-bound test tube.

After genetic engineering had become a reality, Crichton seized on it and made it an essential feature of *Jurassic Park*, the best-seller he published in 1990. But when he began to write *The Andromeda Strain*, even though scientists had detailed knowledge about the structure of DNA and the nature of the genetic code, they were far from the stage of controlled

gene-splicing; and while there was a buzz about the possibility of "genetic engineering" among biologists who believed that the means for such a radical technology would eventually be developed, it appeared that no one was anywhere close to doing so.[4]

Yet, as improbable as it might have seemed when *The Andromeda Strain* first hit the bookstores in 1969, earth-based laboratories would soon supplant plummeting space probes as the most likely point of entry for perilous new microbes. The next year, scientists finally discovered the means by which the DNA molecule could be cut with precision; and within four more, a team of researchers succeeded in copying a gene from one organism and splicing it into the DNA of another, creating the first genetically engineered bacterium.[5] (The steps of this process are described in Chapter 4.)

Soon, dozens of other new microbial strains had been similarly produced. And, although these novel organisms were created on earth, in the minds of many people, they were almost as alien as if they'd come from outer space. Not only did they contain unprecedented combinations of genetic material, it was highly unlikely that most of these conglomerates could have arisen under natural conditions. Instead, they owed their existence to extensive human contrivance. Further, regardless of the degree to which people considered them alien, a large part of the public feared that some of these creatures might prove to be nearly as dangerous as the unearthly terror portrayed in Crichton's book. Moreover, they were not alone in their apprehension. It was to a significant extent shared by the life science community. In fact, the concerns of the public were sparked by warnings that had issued from the mouths and pens of molecular biologists.

Scientists Sound the Alarm

In the early phase of the recombinant DNA revolution, several molecular biologists became struck by the enormity of the new powers with which they'd suddenly been endowed – and deeply concerned about their capacity to cause widespread harm. It seemed that unless this technology was managed very carefully, even the best-intentioned researchers could produce a high degree of accidental damage.

One of the first scientists to apprehend the danger, and voice concern, was Robert Pollack, who was running a laboratory at Cold Spring Harbor, Long Island that was directed by the Nobel laureate James Watson, a co-discoverer of the structure of DNA. In the summer of 1971, he learned that the Stanford biochemist, Paul Berg, was planning to construct a piece

of recombinant DNA that contained a gene from a virus that can induce malignant tumors in mice and hamsters.[6] And the gene Berg was going to employ was the gene that causes the tumors. What's more, he intended to insert that recombinant segment into the DNA of another virus that infects a bacterial species (named *E. coli*) that abundantly inhabits the intestines of humans and many other animals. Although Berg hoped to gain valuable knowledge from such an experiment, and had not intended to put the virus into the bacteria, Pollack was concerned that such an incursion could inadvertently happen, transforming an ordinarily friendly occupant of our gut into an agent of disease. This would in turn create a risk that such radically transformed microbes might escape the lab, widely infect the intestines of people and livestock, and cause a lot of cancer.[7]

So he called Berg, explained his concerns, and asked if he had also been troubled by such considerations. Berg said that he hadn't; but Pollack's call got him thinking. As Berg later recounted, "I began to ask myself if there was a small possibility of risk. And if there is, do I want to do the experiment?"[8] He then consulted another scientist, who told him there was potential for harm and that he would have to accept responsibility for any mishaps. According to Berg, "At that point I stepped back and asked, 'Do I want to go ahead and do experiments which could have catastrophic consequences, no matter how slim the likelihood?'"[9] He decided that he didn't; and the experiment was placed on hold.

He also decided it was important to initiate a dialogue within the scientific community so that the potential problems would be appreciated and adequate safeguards employed. And so did a number of other biologists.

One of these discussions occurred at the Gordon Research Conference on Nucleic Acids in June 1973. It resulted in a letter that appeared in the September 21, 1973 issue of the influential journal *Science* cautioning that the new ability to transfer genetic sequences between organisms was "a matter of deep concern" – and that "[c]ertain . . . hybrid molecules may prove hazardous to laboratory workers and to the public."[10] Airing this concern in such a prominent forum was a bold step, and one of the editors of *Science* reportedly questioned the wisdom of doing so.[11] Many conference participants also had reservations about going public, and the resolution to publish the letter only passed by a six-vote margin (48 to 42).[12]

Soon thereafter, the National Academy of Sciences established a committee on recombinant DNA (rDNA), which issued a letter that went much farther than its forerunner by urging scientists to refrain from specific types

of genetic engineering ". . . until the potential hazards of such recombinant DNA molecules have been better evaluated or until adequate methods are developed to prevent their spread. . . ." [13] This letter became known as "the Berg letter" because its lead signatory was Paul Berg, who was the driving force behind the committee's creation and the letter's production. Like its predecessor, the letter was published in *Science*; and it spurred even greater repercussions. It was unprecedented for a group of scientists to voluntarily restrict their research and call on their colleagues to do the same. Not only did it show an admirable level of social responsibility, it revealed the formidable uncertainties that surrounded genetic engineering – and legitimized concerns about them.

The Berg letter asked the National Institutes of Health (NIH) to establish research guidelines and oversee experimentation. It also sought involvement of the broader rDNA research community, so it proposed an international meeting to "discuss appropriate ways to deal with potential biohazards of recombinant DNA molecules." [14]

Restricting the Release of Engineered Organisms

Both recommendations soon bore fruit. On October 7, 1974 the NIH established an advisory panel (eventually named the Recombinant DNA Advisory Committee [RAC]) which played a significant role in policy formation over many years. And the following February an international meeting of over a hundred researchers convened at the Asilomar Conference Center in Monterey, California. Its main focus was on formulating guidelines that were sufficiently rigorous to prevent catastrophes yet liberal enough so biologists could end their broad moratorium and get on with research. As an article in *Science* described the outcome: "After much haggling, the group settled on a set of safety guidelines that involved working with disabled bacteria that could not survive outside the lab. The guidelines not only allowed the research to resume but also helped persuade Congress that legislative restrictions were not needed – that scientists could govern themselves." [15]

In reaching their decisions, the molecular biologists did not seek input from other perspectives, and no avenues were provided for public interest groups to participate. Further, it's clear this was not an oversight but an essential aspect of policy – a policy to restrict those outside the molecular biologists' fold from influencing the ways in which rDNA research was conducted and applied. James Watson unabashedly acknowledged that he and his colleagues at Asilomar embraced such an exclusionary policy: "Although

some fringe groups . . . thought this was a matter to be debated by all and sundry, it was never the intention of those who might be called the molecular biology establishment to take the issue to the general public to decide. We did not want our experiments to be blocked by over-confident lawyers, much less by self-appointed bioethicists with no inherent knowledge of, or interest in, our work. Their decisions could only be arbitrary." [16] In the words of Susan Wright, a historian of science at the University of Michigan who is an authority on bioengineering's first decade: "[P]olicy-making decisions were claimed to be the right and responsibility of scientists alone." [17]

Accordingly, most of the molecular biologists expected the self-imposed research restrictions to assuage public concerns and allow them to maintain exclusive control over the ways in which the genetic engineering enterprise would develop. Watson has written that as they departed Asilomar, they were "as exhilarated as they were exhausted" because "[h]aving demonstrated their integrity, they naively believed that they would now be free of outside intervention, supervision, and bureaucracy." [18]

However, contrary to the expectations of its practitioners, rDNA research did not stay free from government supervision. The day after the Asilomar conference ended, planning began for NIH research guidelines; and the initial set was issued on June 23, 1976. Despite the absence of legal penalties for violating them, there were constraints, because they applied to any organization receiving NIH funds – and they were eventually extended through presidential order to encompass all federally funded research. So funding could be curtailed if a project ignored them. Further, the NIH guidelines went beyond those agreed upon at Asilomar and banned the deliberate release into the environment of *any* organism containing recombinant DNA.

Uneasy Equilibrium

Because the open airing of concerns had stirred widespread anxiety, the ban on releasing gene-spliced organisms was necessary to calm the public enough so that laboratory research with rDNA technology could move ahead. But many scientists grew dissatisfied with the restrictions and regretted the readiness with which early apprehensions were publicized. It had become clear that bioengineering was a highly volatile issue and that any misgivings expressed by its practitioners would be seized upon by the media. Already, headlines had appeared proclaiming: "Genetic Scientists Seek Ban – World Health Peril Feared" (*Philadelphia Bulletin*), "Scientists Fear Release of Bacteria" (*Los Angeles Times*), and "A New Fear: Building

Vicious Germs" (*Washington Star News*).[19] Even the staid *Atlantic Monthly* published an article entitled "Science that Frightens Scientists."[20] Such reports significantly unsettled the citizenry.

Not only were a large number of molecular biologists disappointed by this outcome, as one observer notes, most "felt betrayed."[21] Although they had hoped their self-imposed ban would convince the public that they could be trusted to manage this new technology without government supervision, it instead had fanned public fears and induced the imposition of such supervision. Further, during 1976 more than a dozen bills were introduced in Congress to regulate rDNA research.[22] And one, initiated by Senator Edward Kennedy, called for regulation by a presidential commission.[23]

As the effort to impose restrictions gained momentum, American molecular biologists worried they would fall behind scientists in countries where research was unregulated – and that the US would lose its lead in the field.[24] Accordingly, many publicly disavowed their former precautionary stance. In one of the more dramatic turnabouts, James Watson, a signatory of the Berg letter, declared that the danger initially imputed to bioengineering was "an imaginary monster,"[25] and he registered regret that he'd signed the letter.[26]

In retreating from their previously-voiced concerns so they could assert the safety of bioengineered organisms, these scientists were falling back on the foundational faith of their field. Molecular biology was developed as a distinct discipline during the 1930's largely through the efforts of the Rockefeller Foundation, under the leadership of Max Mason and Warren Weaver.[27] These two mathematician/scientists were uncomfortable with quantum mechanics, which during the first third of the 20th century had ascended to prominence in physics. This new theory was much more complicated than the classical theory it supplanted, and, as Weaver acknowledged, he and Mason disliked what they regarded to be its "essentially unpleasant 'messiness.'"[28] Further, they thought it would eventually be replaced by something that would be simpler and "more elegant" – and consequently "much more satisfying."[29]

And, having realized that they themselves could not reshape physics along the lines they desired, they enthusiastically embraced the opportunity to do so for biology. In fact, they wanted to ground biology in physics; and they believed that by turning it into an extension of the latter, they could develop a science of life that would be essentially simple, precise, and predictable. Phil Regal has observed that their approach was fully reductionist:

"The social sciences and humanities will ultimately be reduced . . . to biology with no residue. . . . Biology will in turn be reduced to chemistry, which will reduce to physics, which will reduce to a simple deterministic unity that will allow precise predictions at all levels of life."[30] This precision would enable comprehensive control. As Weaver has written, it was "reasonable" to expect that a well-founded biology could furnish "a similar degree of control over many of the aspects of living matter" as the physical sciences exert over nonliving matter.[31]

Mason and Weaver instilled their faith in the ultimate simplicity, predictability, and controllability of life processes in the physicists and chemists they recruited to become the pioneers of molecular biology.[32] In their vision, this new science would solve most of humanity's major problems through precise genetic and chemical manipulations that would be comprehensively controlled by human intelligence – with scant space for unintended consequences. Thus, as Regal has remarked, "The agenda for molecular biology and the engineering of life . . . was infused with complete optimism from the start, and there was only a positive view of the promise of the new science and the biotechnologies it was supposed to produce. Risks and other negative developments were not considered or planned for."

Moreover, when confronted by the possibility of adverse outcomes, the bioengineers displayed unrealistic confidence in their ability to manage them. For instance, at a conference Regal attended in 1984, a molecular biologist gave a talk describing all the hoped-for benefits of rDNA technology as if they were virtually certain outcomes. When someone asked, "What if you accidentally create a new disease?" she seemed offended, but unhesitatingly declared, "We'll develop a cure for it." Regal then queried, "Don't you think it would be a good idea for genetic engineers to first develop cures for AIDS and the common cold before making such bold promises?" She appeared stunned and was unable to muster a response.

Regal notes that over time, the evidence has increasingly countered the molecular biologists' convictions in the precision and predictive power of their discipline. "Abundant data has exposed a big discrepancy between the world they initially envisioned and the world as it really is – and shown that nature is more frustratingly subtle than they'd assumed both at the microscopic level and on the level of ecosystems."

Among U.S molecular biologists, the denial of the risks of gene-splicing was so deeply seated that many maintained it could not cause harm even if purposely employed to do so. Ken Alibek, who played an important role in

the Soviet Union's bio-weaponry program before emigrating to the US, says he encountered "an alarming level of ignorance" about biological weapons within the expert community of his adopted country. He reports: "Some of the best scientists I've met in the West say it isn't possible to alter viruses genetically to make reliable weapons. . . . My knowledge and experience tell me that they are wrong." [33]

Regal confirms Alibek's observation. "I had long heard the same naive opinions from leading American biotech advocates. . . . My sense is that many of them had talked themselves into sincerely believing that rDNA had no weapons potential because they felt constantly on the defense and experienced a need to protect the image of biotechnology – and to sustain their own faith in the fully benign nature of their manipulations. These arguments spread and took hold as 'common wisdom' among American biotechnologists, despite their dissonance with reality."

Yet, not all molecular biologists were averse to acknowledging risk; and several spoke forcefully about the problems they perceived. An especially strong warning was released by one of the field's major pioneers, Erwin Chargaff. In an essay in *Science* titled "On the Dangers of Genetic Meddling" he called bioengineering "warfare against nature" and emphasized its irrevocable consequences. He declared: "You can stop splitting the atom; you can stop visiting the moon; you can stop using aerosols . . . But you cannot recall a new form of life. . . . It will survive you and your children and your children's children. . . . Have we the right to counteract irreversibly the evolutionary wisdom of millions of years in order to satisfy the ambition and the curiosity of a few scientists?" [34] In contrast to the molecular biologists who argued for less regulation, Chargaff urged *greater* government intervention. Further, he expressed doubt that the RAC could handle the various problems, and he deplored that almost all its members were proponents of genetic engineering.[35]

Another eminent molecular biologist who advocated precaution was Jonathan King, a professor at the Massachusetts Institute of Technology. Moreover, like Chargaff, he critiqued what he perceived to be the RAC's promotional proclivities and alleged that it functioned "to protect geneticists, not the public." [36] And Harvard biology professor George Wald, a Nobel laureate, warned that rDNA technology entails "problems unprecedented not only in the history of science, but of life on the Earth." [37] He emphasized that the radical type of intervention it performs "must not be confused with previous intrusions upon the natural order of living organisms" [38] – and branded it "the biggest break in nature that has occurred in

human history."[39] He cautioned that "going ahead in this direction may be not only unwise, but dangerous."[40]

There were also individuals in the biotech industry with misgivings. As Phil Regal sought perspective from its members, he encountered several of them, including a friend from graduate school who had advanced from corporate researcher to administrator. Not only was his friend pleased to hear from him, like Mayr, he urged him to take on the safety issue. As he explained:

> Phil, we badly need input from ecologists and organismic biologists like you. We molecular biologists are out here by ourselves on this, and we've got no way of evaluating the safety of our own work, or of even knowing if our hype about social benefits makes sense. We never studied the sorts of things you guys studied. There was never the time or the interest. This is a very competitive business. A lot of people are trying anything they can think of when a new technique comes along or a new gene is available. "You've isolated a new gene? Lend it to me and let me see what I can get it into. Let's see what happens."
>
> Competitive gene jocks are a dime a dozen. The way to outshine the next guy, to get an offer from another company, the way to get a raise, is to do something sensational. There's a competition to do sensational things. Nobody has time to think deeply about safety or really how much good will come from this.

To some extent, the conflicting pressures exerted by the various factions in the genetic engineering controversy sustained an equilibrium over a few years which, though not deeply satisfying to any one group, did not tilt very far in any direction. The overall level of concern remained high enough so that some federal oversight was maintained, but not so high as to trigger the imposition of additional rules.

Then, in 1977, the equilibrium decisively shifted in favor of the biotechnicians. Public concern waned; and the initiative for regulation on Capitol Hill lost its momentum.[41] So substantial was the shift that, as Susan Wright puts it, "by 1979 the hazard question was almost a non-issue."[42] The main factor behind this transformation also underlay the genetic engineers' display of new-found certitude about the safety of their creations. It was the alleged emergence of important new evidence.

The Rise of 'Molecular Politics' – and the Force of Phantom Evidence

The pivotal news about new evidence arose as the result of three meetings held to evaluate the safety of engineered organisms. The first occurred in 1976 in Bethesda, Maryland, the second during the following year in Falmouth, Massachusetts, and the third in 1978 in Ascot, England. Collectively, they conveyed the impression that sufficient evidence had amassed to demonstrate that genetically engineered organisms are safe – and that there were no longer any concerns among experts. However, this impression was misleading.

For one thing, although the meetings purported to be scientific, they differed in significant ways from standard scientific gatherings. In contrast to conventional norms, the organizers carefully controlled who attended, how issues were discussed, and what information got disseminated. The conferences were not announced by normal procedures, participation was by invitation only, and the invitees predominantly favored minimal controls on rDNA research.[43] Jonathan King of MIT, one of only two scientists at the Falmouth conference who advocated stronger precaution, noted that many like-minded experts who ordinarily would have attended "were rather upset . . . to find out that a risk-assessment conference was taking place and they didn't even know about it until after the fact."[44] The Bethesda meeting had gone even farther than Falmouth in maintaining privacy, to the extent that a decade after it occurred, even the identities of the participants (other than the two chairmen) had not been officially revealed. And the organizers of the Ascot meeting did not invite any members of the British Genetic Manipulation Advisory Group (GMAG), an omission that seemed highly irregular and prompted one member of that group to state: "It might be thought a discourtesy to run an international conference on an important policy question without involving the corresponding organization in the host country. . . ." He surmised that the GMAG was snubbed because it featured "strong representation . . . of the public interest" and "would have supplied a critical presence."[45]

Susan Wright has observed, based on thorough study of the transcripts and her interviews with participants, that the meetings did not merely engage in the technical assessment of risk but were at least as concerned with how public perceptions of risk could be managed.[46] This concern was especially salient at Bethesda. Wright notes that a "strong informal theme" of the conference "was a shared sense of a pressing need, beyond containing possible hazards of recombinant DNA work, to contain the spread of the controversy

as well."[47] She reports that the discussions reveal "a siege-like feeling . . . , a shared sense of threat, of polarization, of scientists versus society"; and she notes a tendency to employ "polarized categories" and speak in terms of scientists versus "the sky-is-falling people" and "the prophets of doom."[48]

This polarized mood and the meeting's political as well as scientific aims were manifest in the chairman's opening remarks: "Part of the agenda today is to get you guys involved and get your voices heard . . . If I could say to the prophets of doom: 'Look, these guys have come out and said that there is nothing to worry about here, so let's . . . get on with serious business.' That's what I hope we can accomplish."[49]

This aim for consensus played out in the way issues were handled. Although the participants recognized that rDNA technology could entail several hazards, the focus was systematically narrowed to research employing one particular type of bacteria called *E. coli* K-12, because it appeared to pose virtually no threat.

As previously noted, *E. coli* is a bacterial species that inhabits the intestines of humans and several other animals; and *E. coli* K-12 is a distinct strain that was developed in laboratories for research purposes. Because K-12 has been used for so many years in labs, it has become quite weak in comparison to other bacteria (including other strains of *E. coli*) and would have great difficulty surviving outside the protected lab environment. As one microbiologist puts it: "K-12 . . . wouldn't stand a chance in the hugely competitive environment that is your gut where bacteria are constantly evolving to keep their 'cutting edge' and not be pushed out by other microbes. Getting K-12 to establish itself in the gut would be like trying to qualify for a Formula 1 race with a car from 1922 (which is when K-12 was taken from somebody's gut)! It was competitive at the time, but is now way off the pace."[50]

Consequently, experts could feel confident that no matter what foreign genes got implanted within *E. coli* K-12, there was scant likelihood such feeble bacteria could cause an epidemic if they escaped the lab (which accounted for their frequent utilization in rDNA research). However, many of the conference participants did have other concerns. For one thing, NIH guidelines didn't bar research with microorganisms better equipped to survive outside the lab than K-12.[51] Further, even if research remained confined to K-12, there was recognized potential for problematic genes to transfer from it to other organisms which could then become agents for novel diseases. One participant pointed out a few potential scenarios and remarked: "To me, those are frightening."[52]

Yet, as Wright observes, these and other outstanding safety issues "tended to be factored out of consideration rather than confronted." [53] She says that instead, "the sense . . . that biomedical research was threatened came increasingly into focus," accompanied by warnings that science was under "very serious attack." [54] She reports that the transcript reveals a meeting "dominated" by "visions of laboratories swathed in red tape," and that in this context, the argument that K-12 could not become an epidemic-causing pathogen was seen as the best means for "defusing" controversy.[55]

According to Wright, most participants appear to have accepted this "political strategy." [56] As one biologist stated: ". . . in terms of PR, you have to hit epidemics, because that is what people are afraid of and if we can make a *strong* argument about epidemics and make it stick, then a lot of the public thing will go away." [57] She notes that at the end of the morning session, one participant "summarized the sense of the group" by stating that the primary task was to convince the public. He then declared: "[T]hat is very easy to do. It's molecular politics, not molecular biology. . . ." [58]

In reporting the results of the Bethesda meeting to the RAC, the chairman stated there was consensus that the possibility of epidemics is "extremely remote" – and a shared opinion that this concept "should be discussed in a public forum." [59] Accordingly, an organizing committee was formed, and in June 1977 the Falmouth conference convened. However, the facts indicate that the call for a public forum was merely public relations – and that the only thing the organizers wanted to make public was an advantageous outcome, not the process through which it would be produced. Otherwise, they would not have kept the conference a private affair to which the media were not invited (and about which they were uninformed) – as had also been the case at Bethesda, and would continue to be at Ascot.[60]

The conference managers likewise followed the Bethesda strategy in keeping the focus on *E. coli* K-12. Even so, participants raised controversial issues; and they debated whether foreign genes inserted in K-12 could then transfer to robust organisms – or instead, while remaining within it, could propagate dangerous toxins or hormones to the surroundings.

According to Susan Wright, the published proceedings reveal that these "troublesome questions" were not resolved.[61] The inconclusiveness of the discussions is evident from a list of proposals for further research, introduced by a statement that ". . . from the cauldron of vigorous scientific debate will finally emerge critical experiments to assess the potential hazards in recombinant DNA technology." [62]

Thus, even in an event where participation was almost exclusively limited to scientists who wanted minimal restrictions on rDNA research, and where the format was so tightly controlled that one attendee characterized it as "choreographed" and another as "a real set-up,"[63] potential hazards were acknowledged – along with the fact that "critical" experiments to accurately assess them had yet to be done. However, neither the public nor the wider scientific community was given the impression that the participants recognized the need for hard scientific evidence and "vigorous scientific debate" to stimulate its production. That's because, with the press excluded and the official conference report left unpublished until eleven months had elapsed, there was leeway for selective communication.

The main information released in a timely manner was in a letter sent immediately after the conference ended by the chairman of the organizing committee, Sherwood Gorbach of Tufts University, to the NIH Director. This letter, which was widely circulated in the summer of 1977, primarily shaped public perceptions of the results. Susan Wright says that it centered on the epidemic pathogen question "to the virtual exclusion of other issues" and presented "an essentially soothing view . . . in which uncertainties and unresolved issues were obscured by the emphasis on the remoteness of possible hazards."[64]

However, some of the participants tried to offset what they considered to be a misleading report of what had happened, including Richard Goldstein, one of the conference organizers. He sent a letter to the NIH Director pointing out that "though there was general consensus that the conversion of *E. coli* K12 itself to an epidemic strain is unlikely (though not impossible) . . . there was *not* consensus that transfer to wild strains is unlikely." He then stated: "On the contrary, the evidence presented indicated that this is a serious concern."[65] Several other participants wrote concurring letters.[66]

But, as a researcher with the Stanford School of Medicine observed, it was Gorbach's summary that "drew attention on Capitol Hill and in the media."[67] And the media, which assumed it was accurate, relayed its message without qualification. The *Washington Post* declared the scientists had "unanimously concluded that the danger of runaway epidemics [was] virtually nonexistent;" and a headline in the *New York Times* announced "No Sci-Fi Nightmare After All."[68] Further, as Susan Wright notes, this version of the results was not only accepted by the press and public but "quickly achieved scientific respectability" and was advanced by distinguished biologists.[69] Moreover, many of their statements (including an editorial in *Science*) exceeded the claim that *E. coli* K-12 could not become pathogenic

and asserted there was consensus that *all* research employing it was safe.[70] The National Academy of Sciences (the NAS) even extended the distortion, declaring the evidence showed that the risks of genetic engineering *in general* were insignificant.[71]

Most important for the biotech proponents, and congruent with the aims of the conference, the Gorbach report became a powerful political tool. Armed with its purportedly evidence-based assurances, both the industrial and academic components of the molecular biology establishment mounted a massive lobbying campaign, described by Susan Wright as "one of the largest" ever related to a technical issue.[72] Participants included leading investigators at the American Society for Microbiology and also the NAS; and universities weighed in through a lobbying group called "Friends of DNA," whose members included presidents of "the most prestigious American academic institutions."[73] Harvard even hired two professional lobbyists to help out.[74] So extraordinary was the campaign in both membership and magnitude that some Congressional staffers remarked "they had never seen anything like it."[75]

The goal of these scientist/lobbyists was to thwart regulation, and a key target was the proposed legislation championed by Senator Kennedy, the bill that had achieved the most formidable momentum. Susan Wright reports that it had "sailed through" the relevant Senate committees when introduced and seemed "assured of approval" at the time the biotech proponents initiated their campaign.[76]

So they swiftly set out to scuttle it. Less than a week after the Falmouth conference, a group of eminent biologists met with Kennedy and argued that in light of the "new information," his proposed legislation was unnecessary and should be dropped.[77] But he held his ground and reasserted the need for a regulatory commission.

However, many legislators were more readily won over, and less then three months after the proponents of unfettered rDNA research were rebuffed by Kennedy, their persistent campaign had effected a decisive shift in the legislative mood. Senator Adlai Stevenson III expressed this new attitude in a speech to his colleagues on September 22nd asserting that "recent evidence" about the decreased risks of such research required them to "carefully" reassess whether the benefits of regulation would outweigh its adverse impacts on scientific research.[78]

With so many legislators now aligned against regulation, Kennedy was finally compelled to capitulate. On September 27th, in a speech to the Association of Medical Writers, he announced that he would no longer

support his own bill, stating that "the information before us today differs significantly from the data available when our committee recommended the . . . legislation." [79]

According to Susan Wright, this reversal was a major event in the history of genetic engineering, ". . . demonstrating the power of the biomedical research community to retain control over regulating the field and to dictate the terms of technical discourse on the hazards." [80] It also demonstrated that this power could be gained and maintained through promotional claims that were unsubstantiated and seriously dubious, so long as they were professed to be science-based.

Moreover, the fabrications from Falmouth were not the only deceptive data employed to quash the Kennedy bill. A report on research conducted by Stanley N. Cohen of Stanford University also played a key role. Cohen, a co-inventor of recombinant DNA technology, was among the scientists who were not content merely to argue for the safety of research with *E. coli* K-12. Instead, he maintained that the technology he helped develop is *in general* safe – and even averred that it *could not* entail special hazards.[81] In 1977, he performed a study to support his stance. He wanted to demonstrate that the kinds of genetic recombinations achieved in test tubes also occur naturally in living organisms – and thus, that the splicing of genes between unrelated species is not a radically new and artificial development but something that's been innocently occurring in nature for eons. When the results were in, he declared success, because he (and his collaborator, Shing Chang) had been able to create a situation in which fragments of mouse DNA were taken up by *E. coli* K-12 and then integrated with some of the DNA that they carried.[82]

Cohen claimed broad implications for his research, arguing it showed that "scientists can only duplicate what nature can already do." [83] He sounded this theme even more boldly in a letter to the NIH Director on September 6, 1977 in which he asserted that the outcome was "compelling evidence" that recombinant DNA molecules constructed in the laboratory "simply represent selected instances of a process that occurs by natural means." [84]

Further, it appears that Cohen timed the release of his news to aid the lobbying campaign. Not only did he take what he admitted to be the "unusual step" of issuing the announcement about his findings well in advance of their publication in a scientific journal, he said he did so due to their "importance with regard to the regulation of recombinant DNA." [85]

The campaigners seized on his premature pronouncement, and because it maintained that bioengineering *as a whole* is essentially natural (and

therefore safe), it strongly augmented declarations from the Falmouth conference. Accordingly, it helped convince legislators that their prior concerns were unfounded; and due to its breadth and its apparently evidential basis, Senator Kennedy relied on it as the main justification for his momentous reversal.[86]

However, as in the case of the claims from Falmouth, the impression that Cohen's claims derived from sound evidence was illusory. Although he avowed that the experiment was conducted under natural conditions, the reality was otherwise; because in order to induce the bacteria to accept the foreign DNA, not only did he and Chang have to treat them with a calcium salt, they also had to subject them to a major heat shock (by rapidly raising the temperature by 42 degrees Centigrade, which equals a boost of 107.6 degrees Fahrenheit).

These conditions were far from natural; and most scientists knew they were. Moreover, the NIH had special reason to be aware of it. Only six months before Cohen's letter declaring the naturalness of the conditions under which he'd induced the inter-species exchange reached the Director's desk, the prominent microbiologist Roy Curtiss had sent one with a starkly contrasting view. Ironically, though Curtiss's was also instrumental in the campaign against regulation (it was an open letter that was widely distributed), it undermined the claim that Cohen would later make because its argument for the safety of rDNA research was in part based on the fact that the conditions Cohen imposed were highly unusual. In contending that the insertion of foreign DNA into *E. Coli* K-12 "offers no danger whatsoever," Curtiss asserted that even if such DNA were later released, there was scant chance that other bacteria would take it up, unless they were treated with a salt and also subjected to a rapid 42-degree Centigrade rise in temperature – conditions which, he pointed out, "were unlikely to be encountered in nature." [87]

Despite the fact that the letters contradicted one another, the NIH used both as supporting evidence for its policy statements befriending biotechnology, while never noting the glaring discrepancy between them.[88] The agency was finally forced to confront the illegitimacy of Cohen's claim during a meeting the Director held with his advisory committee in December 1977, when the artificiality of the research setup was emphatically driven home by the distinguished biologist Robert Sinsheimer.[89] Although this potent dis-creditation deterred the NIH from citing the research in subsequent publications, its response remained minimal, and it apparently did nothing to correct the false impressions that had been instilled within

the minds of Congress and the public. Thus, legislators were never properly informed that the purportedly evidence-backed proclamation on which they'd so strongly relied was bogus; nor was Senator Kennedy made aware that, half a year prior to his capitulation based on that pronouncement, the NIH possessed information undercutting it in advance – and that less than three months after his reversal, its infirmity was again revealed to the NIH, this time so directly and before so many experts that the agency didn't dare refer to it again.[90]

Ascot Compounds the Confusion

Despite the anti-regulatory victories of 1977, restrictions remained on some forms of rDNA research, and many virologists were dissatisfied that the NIH guidelines continued to classify the cloning of animal virus DNA in *E. coli* as "high risk."[91] Encouraged by the way the Falmouth conference altered perceptions, they hoped that a similar conference focused on their area of research could achieve like results. And so the Ascot meeting was held in January 1978. As was the case at Falmouth, discussion was limited to scenarios involving *E. coli* K-12; and there was likewise a meager store of evidence on which to form definitive conclusions. Based on her review of the proceedings, Wright notes: "The tenor of these discussions . . . shows that at many points, predictions were speculative. Too little was known about the mechanisms of viral infections and transformation to be able to predict the effects of cloning these genes."[92] As one participant remarked: "You see, the whole discussion has [the feeling of] a sort of Aristotelian academy because we are really just discussing extremely theoretical things and we're deriving models which are based on no experiments whatsoever. . . . that's why we're talking so much."[93] Nonetheless, the conference's final "consensus" statement confidently asserted that hazards to the public from cloning viral DNA were "so small as to be of no practical consequence."[94] As Wright observes: "The overwhelming impression produced by the report was one of reassurance. Almost all hazard scenarios were considered 'remote,' 'most unlikely,' or 'impossible.'"[95] She further notes that because the sole experiment to assess the risks of cloning viral DNA was a year away from yielding results, such conclusions "were surprisingly emphatic."[96] Moreover, it's evident that the consensus was not as broad as the document implied and that several participants had concerns that were never adequately addressed. Instead, when apprehensions were expressed about one or another perceived risk, they were rebuffed by assertions that the Falmouth conference had determined such a problem could not occur. In

the words of one participant: "The trouble with the Ascot meeting was that the moment one raised a scenario, one would be shouted down by [those] saying that the Falmouth meeting had said that the clones were not mobilizable, that they would never get out of *E. coli* K12 . . . and could not become an epidemic strain." [97]

If the actual conference report from Falmouth had been available, it would have been clear that the participants had *not* reached such conclusions and that the possibility of foreign DNA transferring from K-12 to robust organisms had *not* been ruled out – and was a lively concern in the minds of many. But that report remained unpublished for another five months, and the only seemingly official account then at hand was the overly assuring (and in some ways misrepresentative) Gorbach letter. Thus, those who opposed a precautionary approach to genetic engineering prevailed over colleagues who raised legitimate safety issues by citing the authority of an illusory scientific consensus in order to claim that those issues had been definitively resolved – a practice that would become routine over succeeding years.

In all, any Ascot participant could justifiably have felt manipulated; and some clearly did. As one remarked: "It was very obviously a political meeting . . . We were being used in the name of being a disinterested group of virologists but it was fairly clear by the end of the meeting that [the organizers] wanted to go back with a result that could be exploited for deregulation." [98]

"Political" Science Prevails

The lopsided report from the Ascot meeting complemented the Gorbach summary from Falmouth, and their combined effect was substantial. Not only did proponents of biotechnology proclaim that employing *E. coli* K-12 in recombinant research is safe, several went much further (as had Stanley Cohen the year before) and claimed there was new evidence demonstrating that rDNA technology *as a whole* poses negligible risk.[99] This misleading version of the facts quickly spread. In March 1978, a few months after the Ascot meeting, it was vigorously advanced by members of both the academic and industrial sectors at a conference co-sponsored by the World Health Organization in Milan.[100] The same month, the Senate Subcommittee on Science and Technology prepared a report stating that rDNA research presented no unusual risks;[101] and the next month the NIH Director declared that the burden of proof should shift from the technology's promoters to those who wanted to regulate it – a shift that did occur,

along with revision and substantial weakening of NIH guidelines.[102] This transfer of burden was historic, because, as will be described in the next chapter, it would carry over to all subsequent government policy on genetically modified organisms (GMOs).

Further, the influence of the inflated pronouncements extended well beyond America. Susan Wright notes that they impacted regulatory systems in many nations because "[o]nce the discourse of . . . 'negligible hazard' became established in the United States, the powerful geopolitical position of that country virtually assured the diffusion of the discourse elsewhere." [103]

And so was born molecular politics, through which overgeneralizations and unsubstantiated opinions have been passed off as sound scientific conclusions based on hard evidence. Because of the credentials of those making the assertions, neither the media nor the populace doubted the existence or solidity of the purported evidence; and even individuals as astute as Senator Kennedy were led to believe in it despite the fact it was just as chimerical as the expert consensus that was claimed to be based upon it. Further, due to the boldness and persistence with which these assertions were advanced, the bulk of the life science community came to accept them as well, including many biologists who should have realized how exaggerated they were. So powerfully did these false impressions take hold that they were essentially impervious to contrary input, no matter how well founded. Even a debunking by the eminent journal *Nature* had little effect. Although its report on the Milan conference stated that "the new evidence . . . does not seem substantial" and that the attendees "witnessed some unseemly clutching at straws," there was no retardation of the biotech juggernaut.[104] Thus, although the Falmouth and Ascot meetings had little data to go on and only reached a consensus about the improbability of *E. coli* K-12 being transformed into an epidemic pathogen, an illusion was inculcated within the minds of nonscientists and scientists alike that new evidence had been presented which uniformly convinced the participants that rDNA technology *in general* is essentially safe.

Moreover, when genuine evidence *was* garnered (as increasingly occurred after the Ascot meeting), it often clashed with the standard promotional claims. According to Susan Wright: "In many respects, this new evidence posed more problems than it resolved . . . [and] many in the scientific community . . . saw some of the results as surprising and therefore as raising new questions about hazards." [105] Yet, Congress and the public had virtually no idea that such surprising evidence was emerging, because the molecular

biology establishment impeded communication of the facts. Time after time, when faced with research results they didn't like, the biotech proponents would routinely fail to acknowledge them – or else substantially mischaracterize them.

A prime example is the Rowe-Martin experiment, one of the most influential ever conducted on bioengineering, which was supposed to provide definitive answers to persistent questions about the safety of rDNA research.[106] Susan Wright reports that during 1975 and 1976, there were still "serious differences" among experts about whether some aspects of the research might be unreasonably risky – and insufficient evidence to rule out the possibility that a seriously harmful organism could in some circumstances be created.[107] She relates that such concerns surfaced at the NIH Recombinant Advisory Committee meeting held in December 1975 and that because there was no evidence demonstrating that gene-splicing was thoroughly safe, one molecular biologist proposed that a "dangerous" experiment should be performed that would attempt to make *E. coli* K-12 hazardous.[108] If it failed to do so, it would strengthen the case that the extensive rDNA research employing these bacteria is safe.

The committee liked the proposal, and one of its members, Wallace Rowe, assumed responsibility to implement it in conjunction with Malcolm Martin, a colleague at the NIH research lab he directed. As part of their planning, they organized the Bethesda conference, which they co-chaired, to furnish advice on how the experiment should be designed.

As the preceding examination of the conference indicates, Rowe and Martin intended it to do more than merely advise them on their research, and they initiated broader discussions that they hoped would convince legislators and the public that gene-splicing is safe. They led the discussions about their prospective research in the same spirit, focusing on how it could best be fashioned to calm public fears. In this vein, one participant argued they should demonstrate that *E. coli* "can't kill a mouse" no matter what's done to it. This idea was well-received, and someone suggested it could be effected by splicing DNA from a virus that can induce cancerous tumors in rodents into *E. coli* K-12 and then implanting the altered bacteria within mice. However, some of the scientists protested that such an experiment would, at best, only relate to manipulations of K-12 and would have little bearing on the safety of rDNA research in general. Further, they emphasized that because the K-12 strain was so debilitated, there was little chance it could do any damage. They argued that the experiment would therefore be of slight scientific value – and that the researchers should "take

the opportunity to do a good experiment" by employing an organism with a greater capacity for harm.[109]

However, Rowe and Martin, along with most of those present, appear to have been less interested in securing the experiment's scientific value than in maximizing its political clout.[110] So the discussion stayed focused on public relations, exemplified by a scientist who advocated the use of *E. coli* K-12 by noting that because there was scant chance it could be made harmful, the study would be a "'slick New York Times kind of an experiment'" that would gain lots of positive publicity.[111] Accordingly, the majority eschewed the type of experiment that could have revealed embarrassing risks in favor of one that was almost sure to be image-enhancing – opting for less than optimal scientific worth in exchange for the apparent certainty of a soothing outcome.

Therefore, when Rowe and Martin adopted this PR-driven approach, they, along with the community of pro-GE scientists, expected their study to yield fully favorable results. So when it concluded, no one was surprised that such results were claimed for it. And the claims were by no means modest. At a 1979 press conference, the two scientists unequivocally declared they had demonstrated that the recombinant research they investigated was "perfectly safe." [112]

However, when one probes beneath their rosy representations and examines the actual data, it's clear that the term "perfectly safe" was imperfectly applied.[113] The investigation encompassed several aspects of the *E. coli*-based research system, and (contrary to the expectations of the researchers – and the gist of their public pronouncements) not all of them were found to be problem-free. For instance, cleaving the DNA of the cancer-causing virus (which must be done in order to work with its discrete genes) substantially increased its capacity to induce tumors.[114] There were other troubling results as well, and some eminent biologists warned they showed that splicing viral genes into the bacteria could enable the virus to expand its infective range.[115] But none of the adverse findings were mentioned at the press conference or in the other references to the research that were employed for promotional purposes. Accordingly, Congress and the American people were led to believe that the results wholly supported reduction of regulation, remaining unaware that significant problems had been discovered – and that several experts viewed them as signaling the need for stronger safeguards.

Nor were they informed that Rowe and Martin had not even employed the strain of *E. coli* routinely used in rDNA research but a strain that had

been purposely rendered much weaker, to the extent it had become (in the words of one biologist) "severely disabled."[116] This occurred because, despite *E. coli* K-12's infirmities, NIH guidelines barred the transfer of tumor-causing genes into it without an exception from the Director; and he refused to grant one. So the researchers had to use the more enfeebled strain instead. Consequently, although the experiment's problematic findings *were* applicable to the hardier strain of *E. coli* actually used in most research, the favorable results were *not*; and, as Susan Wright points out, it was "not justifiable" to treat them as if they were.[117] But most people were unaware of this fact; and the biotech proponents felt no need to acknowledge it, or be restrained by it. Nor were they prepared to acknowledge, or to inform the public, that even if the Rowe-Martin results *had* been fully applicable to the strain of *E. coli* that researchers actually used, and even if they *had* all been fully favorable, they would still have been irrelevant to gene-splicing with other organisms, which was to become a prevalent practice.[118]

Thus, the key experiment designed to reassure the public primarily did so by not being fully publicized; and, with its deficiencies undisclosed, the promoters of bioengineering were able to milk it for far more than its scientific worth. Besides employing it to calm qualms and preserve the hands-off attitude on Capitol Hill, they used it to substantially reduce NIH research restrictions and significantly expand gene-splicing's permissible range. In the process, just as they had portrayed the limited discussions at Falmouth and Ascot as pertaining to bioengineering in general, they frequently stretched the relevance of the Rowe-Martin experiment well beyond legitimate bounds – not only averring it had demonstrated the safety of all forms of recombinant research, but sometimes even claiming it had done so for genetic engineering as a whole.

And these false claims continued for more than three decades. One of them was present on the website of The National Institute of Allergy and Infectious Diseases until at least November 2010. That institute is part of the NIH, and thus part of the United States Government. The falsehood appeared on the page that described the credentials and accomplishments of one of the institute's long-serving laboratory chiefs: Dr. Malcolm Martin. Thus, it's reasonable to assume not only that he was familiar with the content of the statement, but that he wrote it. And, due to the authoritative context, anyone who didn't know the details of the experiment that he and Wallace Rowe conducted would have also been led to assume that the statement was accurate – a statement which, without a trace of qualification, declared that the experiment "established the safety of recombinant DNA."[119]

On balance, not only were the claims that abetted the rapid – and largely unregulated – advance of the bioengineering venture during its first seven years more political than scientific, the scientists making them displayed the parochial attitude of a typical special interest group more predominantly than the public-spiritedness traditionally associated with the scientific endeavor. As Susan Wright puts it:

> [T]he refusal of the scientific establishment in the United States to call for hard experimental evidence . . . and the alacrity with which biomedical researchers in general rallied round to promote the public results of brainstorming sessions as 'new evidence', both suggest that the most immediate concern . . . was neither public safety nor scientific rigor. In fact, the history of the controversy indicates something entirely different: the insistence of research scientists that their freedom of investigation take precedence over the competing needs of the public.[120]

In the following years, as the molecular biologists consolidated their political power, their agenda would expand and increasingly prevail; and the needs of the public would continue to be compromised.

Notes

Introduction

1 The FDA acknowledges that it has been operating under a policy "to foster" the US biotechnology industry. See, e.g., "Genetically Engineered Foods," *FDA Consumer* (Jan. - Feb., 1993), 14.

2 Keller, Evelyn F. *The Century of the Gene*. (Cambridge: Harvard University Press, 2002), 142-43.

3 Ibid. 143.

4 Ibid. 144.

5 Ibid. 148.

1. The Politicization of Science

1 Among the Harvard professors who regarded Mayr as the greatest 20th century biologist were E.O.Wilson and Stephen Jay Gould. See Meyer, A., "On the importance of being Ernst Mayr," *PLoS Biol* 3(5):e152 (2005): 0100.

2 When used in this way, the term "gene-splicing" refers to manipulations of biotechnicians. As will be discussed in subsequent chapters, although segments of DNA are also spliced into DNA molecules through natural processes, the details of these processes significantly differ from those of recombinant DNA technology.

3 Regal recorded these words in a set of recollections about his endeavors to set the genetic engineering venture on a more scientific track – recollections that he sent to me for use in this book. The statements from him that follow in this and other chapters are largely drawn from these recollections and from my extensive conversations and email correspondence with him. Accordingly, except for quotes excerpted from his published articles, I will not provide specific references for his various statements.

4 Crichton completed the first draft of *The Andromeda Strain* in 1967.

5 Morrow, J.F., Cohen, S.N., Chang, A.C.Y., Boyer, H.W., Goodman, H.M., Helling, R.B., "Replication and transcription of eukaryotic DNA in Escherichia coli," *Proceedings of the National Academy of Sciences* 71 (1974): 1743- 47. Prior to that accomplishment, other researchers had learned how to join two pieces of DNA together. The initial fusion was achieved by a team in Paul Berg's lab at Stanford University; and Berg subsequently received a Nobel Prize in recognition of this and other groundbreaking research in recombinant DNA technology. Jackson, D. A., Symons, R. H., and Berg, P., "Biochemical methods for inserting new genetic information into DNA of Simian Virus 40: Circular SV40 DNA molecules containing lambda phage genes and the galactose operon of Escherichia coli," *Proceedings of the National Academy of Sciences* [PNAS] 69 (1972): 2904.

6 As discussed in the previous note, Berg had been able to create some recombinant DNA even before scientists had discovered how to isolate individual genes from one species, copy them, and then splice them into the DNA of other species. But his technique was relatively complicated and could not be widely employed. The tumor-inducing virus that he planned to work with is referred to as SV40.

7 For a discussion of this incident see the preface to the 2013 paperback edition of: Pollack, R., *The Faith of Biology and the Biology of Faith* (New York: Columbia University Press, 2013).

8 Berg, P., "A Stanford Professor's Career in Biochemistry, Science Politics, and the Biotechnology Industry," an oral history conducted in 1997 by Sally Smith Hughes, Regional Oral History Office, The Bancroft Library, University of California, Berkeley (2000), 92; http://texts.cdlib.org/view?docId=kt1c6001df&doc.view=entire_text.

9 Ibid., 93.

10 Singer, Maxine and Soll, Dieter, "Guidelines for DNA Hybrid Molecules," *Science* 181 (September 21, 1973): 1114.

11 Wright, Susan, *Molecular Politics: Developing American and British Policy for Genetic Engineering 1972-1982* (Chicago: University of Chicago Press, 1994), 136.

12 Ibid.

13 Berg, Paul et al., "Potential Biohazards of Recombinant DNA Molecules," *Science* 185 (July 26, 1974): 303.

14 Ibid.

15 Barinaga, Marcia, "Asilomar Revisited: Lessons for Today?" *Science* 28, no. 5458 (March 3, 2000): 1584–85.

16 Watson, J. and Tooze, J., *The DNA Story* (San Francisco: W.H. Freeman, 1981), 49.

17 Wright (1994), op. cit. note 11, 135.

18 Ibid., 26.

19 Cited in Goodell, Rae, "How to Kill a Controversy: The Case of Recombinant DNA" in *Scientists and Journalists: Reporting Science as News*, Friedman, S.M., Dunwoody, S. and Rogers, C., eds. (New York: The Free Press/Macmillan, 1986), 172.

20 Bennett, William and Gurin, Joel, "Science that Frightens Scientists: The debate over DNA," *The Atlantic Monthly* 239 (February, 1977): 43-62.

21 Lewin, Roger, "The Asilomar Conference: Was the Asilomar Conference a Justified Response to the Advent of Recombinant DNA Technology, and Should It Serve as a Model for Whistle-Blowing in the Future?" in *Bioscience Society; Report of Schering Workshop*, Roy, D.J. et al., eds., (Chichester, New York: John Wiley & Sons, 1991), 206.

22 Ibid.

23 Wright, Susan, "Molecular Biology or Molecular Politics? The Production of Scientific Consensus on the Hazards of Recombinant DNA Technology," *Social Studies of Science* 16, no. 4 (Nov. 1986): 593-620, 595.

24 Ibid.

25 Watson, James D., "An Imaginary Monster," *Bulletin of the Atomic Scientists* 33 (May 1977): 12.

26 Watson expressed his regret in a speech quoted in McAuliffe, Sharon and McAuliffe, Kathleen, *Life For Sale* (New York: Coward, McCann & Geoghegan, 1981), 176.

27 Kay, Lily, *The Molecular Vision of Life: Caltech, The Rockefeller Foundation, and the Rise of the New Biology* (New York: Oxford University Press, 1993); Pnina Abir-Am, "The biotheoretical gathering, transdisciplinary authority and the incipient legitimation of molecular biology in the 1930s: new perspectives on the historical sociology of science," *Hist Sci* 25 (1987):1-70.

28 Weaver, Warren, *Scene of Change: A Lifetime in American Science*, (New York: Scribner's, 1970), 56.

29 Ibid., 57.

30 Regal, Phil, "Metaphysics in Genetic Engineering: Cryptic Philosophy and Ideology in the 'Science' of Risk Assessment." In *Coping with Deliberate Release: The Limits of Risk Assessment,* Van Dommelen, Ad, (ed.), International Centre for Human and Public Affairs, Tilburg/Buenos Aires (1996).

31 Weaver, op. cit. note 28, 183.

32 Regal, "Metaphysics in Genetic Engineering," op. cit. note 30.

33 Alibek, Ken, *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World – Told from Inside by the Man who Ran It* (New York: Random House, 1999), xi.

34 Chargaff, Erwin, "On the Dangers of Genetic Meddling," *Science* 192 (1976), 940.

35 Ibid., 938.

36 King, Jonathan, quoted in McAuliffe and McAuliffe, op. cit. note 26, 174; See also Bennett and Gurin, op. cit. note 20, 56-57.

37 Wald, George, "The Case Against Genetic Engineering," in *The Recombinant DNA Debate*, Jackson, D. and Stich, S., Eds. (Prentice-Hall, 1979), 127-28.

38 Ibid.

39 Wald, George, speaking at a press conference in Washington, D.C. March 1977. Quoted in Kimbrell, A., *The Human Body Shop: The Engineering and Marketing of Life,* (New York: Harper Collins, 1994), 159. Although Wald's statement that genetic engineering is the "biggest break in nature" occurred at a press conference, I think it's appropriate to include it along with statements he wrote in an earlier article because doing so does not in any way misrepresent his thinking – and enables it to be expressed in a compact manner.

40 Wald, George, "The Case Against Genetic Engineering," op. cit. note 39.

41 Lewin, Roger, (1991), op. cit. note 21, 206.

42 Wright (1986), op. cit. note 23, 593.

43 Ibid., 601.

44 Ibid., 600.

45 Ibid., 600-01.
46 Ibid., 601.
47 Ibid.
48 Ibid.
49 Ibid., 602.
50 Thomas, Gavin; http://www.microbiologyonline.org.uk/ecoli.htm.
51 Wright (1986), op. cit. note 23, 603.
52 Ibid., 602, no. 20.
53 Ibid., 604.
54 Ibid.
55 Ibid., 604-5
56 Ibid., 605.
57 Ibid., *emphasis in original.*
58 Ibid., 606. The full quote that appears on p. 45 of the transcript of the meeting is: "I think that is what you have to deal with. It may not mean a thing, but that is very easy to do. Its molecular politics, not molecular biology and I think we have to consider both, because a lot of science is at stake." In an email to me (in answer to my questions) Wright explained that from the prior discussion, it is clear the word "that" refers to the problem of convincing the public. Accordingly, in her article, Wright renders the first sentence as: "I think (the problem of convincing the public) is what you have to deal with."
59 Ibid.
60 Ibid., 600. In an email to me, Wright confirmed that the media were not invited to any of the conferences or even informed of them – and so were not present.
61 Ibid., 607.
62 Quoted in Wright (1986), op. cit. note 23, 607.
63 Ibid., 608.
64 Ibid.
65 Quoted in Dutton, Barbara, *Worse than the Disease: Pitfalls of Medical Progress* (New York: Cambridge University Press, 1992), 193.
66 Ibid.
67 Ibid.
68 Wright (1986), op. cit. note 23, 613.
69 Ibid.
70 Ibid.
71 Wright (1994), op. cit. note 11, 275. The Academy's misrepresentation appeared in a report issued by its Assembly of Life Sciences.
72 Ibid., 269.
73 Dutton, op. cit. note 65, 193.
74 Ibid.
75 Ibid., 193-94.
76 Wright (1994), op. cit. note 11, 269.

77 Ibid., 270.

78 Ibid., 271.

79 Edward M. Kennedy, speech to the Association of Medical Writers, September 27, 1977, New York, quoted in Wright (1994), 272.

80 Wright (1994), op. cit. note 11, 272.

81 Ibid., 245.

82 Chang, Shing and Cohen, Stanley N., "*In Vivo* Site-Specific Genetic Recombination Promoted by Eco RI Restriction Endonuclease," *Proceedings of the National Academy of Sciences* 74 (November 1977): 4811-15. The fragments of mouse DNA were not integrated within the central area of the bacterial DNA (its *chromosome*) but within a small ring of DNA outside of it (called a *plasmid*). Chromosomes and plasmids will be discussed in Chapter 4, which will also more thoroughly examine Cohen's experiment and the deceptive claims that were made about it.

83 Stanley Cohen quoted in Wright (1994), op. cit. note 11, 272.

84 Stanley Cohen to Donald Fredrickson, September 6, 1977, ORDAR, quoted in Wright (1994), op. cit. note 11, 246.

85 Dutton, op. cit. note 65, 194.

86 Wright (1994), op. cit. note 11, 272. Wright says Kennedy used Cohen's claim as an "escape hatch."

87 Roy Curtiss to Donald Fredrickson, April 12, 1977, *ORDAR* 8, quoted in Wright (1994), op. cit. note 11, 244. I learned of the conflict between the letters through Wright's observations.

88 Wright (1994), op. cit. note 11, 246.

89 Ibid., 291.

90 In light of the extensive information I've read, it seems reasonable to assume that most legislators, including Kennedy, were never adequately informed about the illegitimacy of Cohen's claim. However, I have seen no explicit evidence to that effect. Further, although several legislators were sent copies of the Curtiss letter in April 1977, it seems that when Cohen's claim was issued six months later, they did not realize that it was undercut by the earlier document. For one thing, Cohen's letter did not mention the unusual conditions under which the research was performed; and the fact that he'd employed them was not well-publicized.

91 Wright (1986), op. cit. note 23, 609.

92 Ibid., 610.

93 Transcript quoted in Wright (1986), op. cit. note 23, 611.

94 Ibid., 612.

95 Ibid.

96 Ibid.

97 Ibid.

98 Ibid., 615 and Wright, op. cit. note 11, (1994), 513, n. 56. Wright obtained the quote in an interview she conducted.

99 Wright (1994), 256.

100 Wright (1986), op. cit. note 23, 614.

101 Ibid.

102 Ibid., 596, 615

103 Wright (1994), op. cit. note 11, 351.

104 Newmark, Peter, "WHO Looks for Benefits from Genetic Engineering," *Nature* 272 (20 April 1978): 663-64, quoted in Wright (1986), op. cit. note 23, 614.

105 Wright (1994), op. cit. note 11, 366.

106 Wright, Susan, email communication.

107 Ibid.

108 Wright (1994), op. cit. note 11, 64. The molecular biologist who proposed a dangerous experiment was Sydney Brenner, of the University of Cambridge.

109 Wright (1994), op. cit. note 11, 250.

110 Ibid., 248-50.

111 Ibid., 249, 463.

112 Rowe quoted in Wright (1994), op. cit. note 11, 372.

113 The study was published as: Israel, M.A., Chan, H.W., Hourihan, S.L., Rowe, W.P. and Martin, M.A., "Biological activity of polyoma viral DNA in mice and hamsters," *J. Virol* 29 (1979): 990–96. The specific type of polyoma virus that was employed is referred to as PY. It's in the same viral group as the tumor-producing SV40 that Paul Berg had, several years previously, intended to insert within an E. coli-infecting virus – which roused the concern of Robert Pollack and ultimately spurred the development of the precautionary measures that the Rowe-Martin experiment was intended to relax.

114 Israel, Mark A. et al., "Interrupting the Early Region of Polyoma Virus DNA Enhances Tumorigenicity," *Proceedings of the National Academy of Sciences* 76 (August 1979): 3714.

115 Wright (1994), op. cit. note 11, 373. For a discussion of the various results, see 368-74.

116 Ibid., 368.

117 Ibid., 366-67.

118 Ibid., 375-66. At an RAC meeting in May 1979, Jonathan King of MIT noted that an experiment confined to *E. coli* (such as Rowe-Martin) could not confirm the safety of rDNA research with other organisms.

119 On November 10, 2010, I accessed the false claim at: http://www.niaid.nih.gov/labsandresources/labs/aboutlabs/lmm/viralpathogenesisvaccinesection/Pages/martin.aspx.

In January 2014, I discovered that this URL is no longer functional and that Martin's current biographical information omits the misrepresentation that was present in 2010 – and had presumably been posted for many years. In fact, the current page does not specifically mention the Rowe-Martin experiment at all. The new URL is: http://www.niaid.nih.gov/LabsAndResources/labs/aboutlabs/lmm/viralPathogenesisVaccineSection/Pages/martin.aspx#niaid_inlineNav_Anchor.

It's quite plausible that the falsehood was removed as a result of being exposed by information I circulated describing it. A supporter of the bioengineering venture may well have read it and alerted Dr. Martin about the need for revision.

120 Wright (1986), op. cit. note 23, 616.

2. Expansion of the Biotech Agenda

1 Because commercialization of a GE food was still more than a decade away, attention at that time was primarily focused on whether a gene-altered crop could damage the environment during field testing, not on whether it might eventually bring new risks to the dinner table. Food safety did not become a salient issue until much later – and it will be discussed in subsequent chapters.

2 Interview with Arnold Foudin, Ph.D., Deputy Director, Biotechnology Permits, PPQ, APHIS, USDA, Washington, DC (October 6, 1997), cited in Jones, Mary Ellen, "Politically Corrected Science: The Early Negotiation of U.S. Agricultural Biotechnology Policy," a Doctoral Dissertation in Science and Technology Studies at Virginia Polytechnic Institute (1999), 63.

3 Ibid., 88.

4 Interview with David MacKenzie cited in Jones, (1999), op. cit. note 2, p. 89, n. 231. The word "disbelief" is the term that Jones uses in describing his reaction as related to her.

5 Ibid., 101.

6 Ibid.

7 Ibid., 105-06.

8 Ibid., 108.

9 Ibid.

10 Berg, Paul et al., "Potential Biohazards of Recombinant DNA Molecules," *Science* 185 (July 26, 1974): 303.

11 At the April 22, 1981 meeting of an RAC working group, concern was raised that risk assessment data was still limited to *E. Coli* K-12; and I have seen no indication that by December of that year the situation had changed. *See* Minutes of Large-Scale Review Working Group of the RAC, April 22, 1981, in US Department of Health and Human Services, (1982); Documents Relating to "NIH Guidelines for Research Involving Recombinant DNA Molecules," November 1980-August 1982, Office of Recombinant DNA Activities, NIH Publication No. 83-2604, 78.

12 Jones (1999), op. cit. note 2, 109. Jones reports that Jonathan King (of MIT) and Ruth Hubbard and George Wald (both of Harvard) "reproached" Baltimore ". . . for conflict of interest, accusing him of promoting the deregulation of an industry in which he had a considerable economic interest." In referencing their allegations (in footnote 287), she cites documents they filed with the NIH in 1982 as: Documents relating to "NIH Guidelines for Research Involving Recombinant DNA Molecules" November 1980-August 1982, Office of Recombinant DNA Activities, NIH Publication No. 83-2604; Hubbard (p.717), Jonathan King (p.

About the Author

Steven M. Druker is a public interest attorney who initiated a lawsuit against the US Food and Drug Administration that forced it to divulge its files on genetically engineered foods. This revealed that the agency had covered up the extensive warnings of its own scientists about the unusual risks of these foods, lied about the facts, and then ushered these products onto the market in violation of explicit mandates of federal food safety law. In organizing the suit, he founded the Alliance for Bio-Integrity and assembled an unprecedented coalition of eminent scientists and religious leaders to stand with it as co-plaintiffs – the first time scientists had sued a federal administrative agency on the grounds that one of its policies is scientifically unsound.

He is a prominent commentator on the risks of genetically engineered (GE) foods and has been a featured speaker at symposia at the British House of Commons and the National Congress of Brazil and at press conferences sponsored by the Brazilian Medical Association, the Swedish Consumers' Association, and the Green Party members of the European Parliament.

He has served on the food safety panels at conferences conducted by the National Research Council and the FDA; given lectures at numerous universities (including the Biological Laboratories at Harvard, Tel Aviv University, and the University of Copenhagen); and met with government officials world-wide, including the UK's Environmental Minister and the heads of food safety for France, Ireland, and Australia. He also conferred at the White House Executive Offices with an interagency task force of President Clinton's Council on Environmental Quality.

His articles on GE food have appeared in several respected publications, including *The Congressional Quarterly Researcher*, *The Parliament Magazine*, and *The Financial Times*.

He has extensive academic background in the history and philosophy of science and in human development and ethics. He co-authored the introductory and final chapters of *Higher Stages of Human Development*, published by Oxford University Press, and wrote a chapter on ethical development for *Transcendence and Mature Thought in Adulthood*, published by Rowman and Littlefield.

He majored in philosophy at the University of California, Berkeley, received a special award for "Outstanding Accomplishment" in that field, was elected to Phi Beta Kappa in his junior year, and graduated with "Great Distinction in General Scholarship." He also received his Juris Doctor from UC Berkeley and was elected to both the California Law Review and the Order of the Coif (the legal honor society).