Chapter 1

Introduction: Daughter of Time

In 1956, Dr. Alice Stewart discovered that a single exposure to a diagnostic x-ray shortly before birth will double the risk of an early cancer death. Her finding made a revolution in medical practice: on account of it, doctors have become very cautious about x-raying pregnant women. A few decades later, she produced a study showing that the nuclear weapons industry is about twenty times more dangerous than worker safety standards admit, a discovery that put her on a collision course not only with the U.S. Department of Energy but with the regulatory commissions that set international nuclear safety guidelines. If Alice Stewart had discovered that radiation was good for you, she might have won the Nobel Prize, as more than one of her admirers has commented. But since she is the bearer of bad news, there's been a tendency to ignore her.

Whereas no one disputes the dangers of radiation at high dose, Alice Stewart has been a lone voice warning of radiation risk at low dose. "In the old days, they killed the messenger who brought bad news," she's fond of saying; "a Cassandra is never popular in her time." But hers is a voice that is gaining power and credibility, as the biological effects of radiation come to be better understood.

I first met Alice Stewart in Berkeley, in May 1994. I knew her by reputation, as the woman who had discovered the link between fetal x-rays and childhood cancer and who had gone on, in her seventies, to ignite the controversy about nuclear worker safety and become a kind of guru to the anti-nuclear movement. I'd been a literary scholar who'd made a mid-career change to writing on health and the environment and was working, with Dr. Vicki Ratner, on a book on cancer. If you do any reading at all in the area of cancer and radiation, you come across the name of Dr. Alice Stewart—her work is a lodestone to the anti-nuclear movement. She is that rare thing in radiation research, an independent scientist who has found ways of surviving without institutional support, who has made her expertise available to activists and put her science to the service of

society. The *New York Times* calls her "perhaps the Energy Department's most influential and feared scientific critic."[1]

Vicki and I felt honored to get an interview with her.

Alice was (I later realized) trying to enjoy one of her rare days off, spending the weekend with an old friend, Dr. Joyce Lashoff, who had worked with her on several projects and had recently retired from the University of California at Berkeley. But Alice had generously agreed to give up her afternoon to be interviewed by these two strangers, who came barging in on her at her friend's elegant Berkeley hills home. Lashoff was somewhat miffed, Vicki and I felt awkward, and everyone was slightly out of sorts—everyone except Alice, that is, who, though decades older than any of us (she was eighty-eight), warmed to the interview with an energy and enthusiasm that sparked ours.

Anyone who has met Alice Stewart knows what I mean by the Stewart charm. She seems a slight, granny-like presence, until you hear that strong, sculpted Oxford English and get a glimmer of her scientific acumen. She has fine deep-set eyes that sparkle with humor and curiosity and a gaze that holds yours. She is brisk, blunt, and to the point—one would not like to be on the wrong end of that wit—yet she is also amazingly patient. She has been over this material maybe a million times yet she takes pains to go over it again, carefully, precisely, until she's made sure you've got it—"got it?" she'll say. She has a smile that could melt stone.

Alice takes over and runs with our questions, putting Vicki and me at our ease. Though she is moving too rapidly and not chronologically, I begin to form a picture. It's a remarkable story of scientific discovery and its suppression by politics. It's a complicated story of a career in several stages. There are her early years in clinical medicine, when she gains honors that few women attained in this area, being elected—the youngest woman ever—to the British College of Physicians, while raising two children on her own. There are her years as head of Social Medicine at Oxford, when, on a grant of £1,000, she launches the landmark study that turns up the link between fetal x-rays and children's cancer. There's a remarkable post-retirement career when, at age sixty-eight, she ignites a firestorm in international scientific circles by suggesting that nuclear safety standards are too lax and wins, in her eightieth year, a grant for $2 million to study nuclear workers' records from the entire U.S. weapons complex. This is a woman who is courageous (and stubborn) enough to stick to her positions against the attempts of powerful authorities—the

medical profession, the nuclear establishment—to discredit her. This is a scientist who has learned the cost of challenging mainstream opinions, in terms of funding and recognition, yet has kept, through it all, faith that "truth is the daughter of time," as she's fond of saying; "It's an old saying, but very true; it goes back to the classics, and earlier." And indeed, I know this saying from Shakespeare, only I'm surprised to hear it from this world-class radiation epidemiologist.

As the lines of her narrative become clearer, I am more and more intrigued. "This is a great story," I say; "somebody ought to write it up."

"Oh, they've tried," she replies, "but they never got anywhere."

I want to hear more and I sense that she is interested in my interest, and I sense that this is a dangerous moment. I tell myself to slow down. I am, after all, already writing one book and teaching full time. But my mind is racing ahead with questions and the irresistible feeling that this is a story that has to be told.

It turns out that not one, but several others have tried to write Alice's story, and I offer to look at the most recent effort. Over the summer I read it, and it is, as Alice has cautioned, a bit of a jumble. But there's a lot of information in it,[2] and it takes me to a world that seems oddly familiar, a world I know from English novels—from Evelyn Waugh, E. M. Forster, C. P. Snow.

Alice Stewart was born October 4, 1906, in the northern industrial city of Sheffield, to parents who were both pioneers in children's welfare at the turn of the century and who practiced medicine in conditions I recognize from the works of Dickens. So many of her family went into medicine that they once filled a whole page of the British medical registry. She was at Cambridge in the twenties and headed a department at Oxford in the forties and fifties. There are many names I recognize: her godmother was the daughter of Elizabeth Garrett Anderson, the first woman physician in England; her godfather was godfather to the poet W. H. Auden. She knew Geoffrey and John Maynard Keynes; she shared a house with the novelist Iris Murdoch.

There is a long relationship with William Empson, later Sir William Empson, a name that leaps out at me: he is one of the most important literary critics of the century, one of the "New Critics" who shaped the way literary studies were defined on both sides of the Atlantic in the forties, fifties, and sixties. He was a poet who had strong left-wing politics and a controversial personality; he was a powerful presence in the curriculum I encountered as a student at Berkeley and Columbia. He was

Dr. Alice Stewart's lover, and though they both married other people, their relationship lasted decades. ("How long did it go on?" I asked her; "from 1929 until"—she thought a moment—"1983.")

Other things strike me as I read through this manuscript. She has strong ties with people, and not just with family—her daughter and grandchildren and various in-laws—but with a kind of extended family of friends, colleagues, fellow scientists, activists. There are many people who are devoted to her, including the author of the manuscript I am reading. There are dozens of people she befriended in some way or other, gave a job to, loaned money to, made part of a project.

One story stands out. Once upon a time, Alice bought a house for Empson's son, Mogador, when he found himself in disgrace with his mother because he was about to marry the daughter of a Labour Party politician. The house was in Leeds, near the university, and it cost very little since it was slated for demolition. When Mogador left Leeds, the demolition date got postponed, and Alice tried to give it to the university, but the university didn't want it. Then comes a startling bit—a son's nervous breakdown and return from Canada with a wife and two children. At this point, the house becomes a lifeline, for Alice can offer her son and his family a place to live; after his suicide, she gives it to his widow, Jeanette. Eventually the demolition is rescinded, the house shoots up in value, and Jeanette is able to rent the other flats in the building and go back to school to complete her nurse's training.

There's tragedy there, and serendipity, and a generous act returning in time of need, for Alice felt keenly the need to see her grandchildren through after her son's death. It was partly this responsibility that kept her working.

The Woman

By the time I finish reading this manuscript, I am hooked, and at the end of that summer I take the first of several trips to England. We spend the time at Alice's flat in Birmingham, where she has a research appointment at the medical school (which provides an office and staff), and at Evenlode cottage, Fawler, about fifteen miles outside Oxford, which she's owned since 1949. Fawler, as the cottage is called, is a large, ramshackle structure with interesting nooks, crannies, corners, and wonderful vistas onto the hills of the English countryside. The grounds are ample, with large, established trees that Alice herself planted, a stone wall, and a statue of a French peasant woman, a figure with a wise, gnomic smile—

Alice calls her the "presiding genius." There is a vegetable garden kept by her daughter Anne, a doctor who lives and practices in London.

It is utterly unlike any place I've ever been. After I've wandered around and got thoroughly lost, wending my way up a hidden staircase to what seems a whole other cottage, Alice explains that Fawler is actually not one but several cottages. The original cottage was built in 1600, the second cottage a century or so later, the third a century after that. These are (she tells me) the characteristic Oxfordshire dwellings, made of stone with a steep tile roof and wooden beams like eyebrows above the windows. Alice has acquired them over the years and has combined them into one large structure that can accommodate the family and friends who converge there for holidays, summers, and birthdays. "It had to be done gradually because of financial straits," she says; "That's much the best way to do things, adding according to need, because you get a feel, you adjust, you keep the character of the place."

I am enchanted with Fawler, as is anyone who's been there. The place is, like Alice herself, warm, welcoming, multifaceted, unique. Alice speaks feelingly of it: "When I'm abroad sometimes and homesick, I think of the evening light at Fawler. It's my idea of what England's about." I am amused at the contrast between this costly piece of Cotswolds real estate and the modesty of the life lived within—the disregard of matching kitchenware or finery, the chipped crockery, the utter unpretentiousness. The microwave oven in the small kitchen is a recent acquisition, a Christmas present from her daughter.

I thoroughly enjoy these visits, and over the next few summers, as I come to know Alice better, my appreciation for her deepens. We work in a large, sunny room that is painted Venetian red and has windows opening onto the garden and fields. Our conversations range from Margaret Thatcher and Margaret Drabble through marriage, academia, and other institutions. She has a wonderfully barbed wit and a well-developed sense of the absurd. The accents are upperclass, the cadences formal, even nineteenth century. Her sentences are long and complex, and she actually finishes them, as Americans tend not to. They are filled with so many ideas—she gets so many clauses up in the air that you wonder how she'll manage to keep track of them all, but down they all come, in perfect grammatical order. Some of her expressions have a literary ring—"reluctant dragons though they were." "*Bible arithmetic!*" she mutters of a researcher's calculations from the Hiroshima data, the assumptions of which she dismisses as bogus. Yet she'll reach as easily for a homespun, housewifely expression. She named her method of calculating

occupational radiation risk the *Ready Reckoner* after a book of conversion tables that children get in math classes at school.

I am intrigued by a reference to Thackeray she returns to more than once. "There's a story in Thackeray, of a godmother who doesn't get invited to the christening, and so she comes in bad temper and makes a gift of a little misfortune, and of course it's exactly the right gift to make. You must hope for a little misfortune," she says, "not too much, of course, and you've also got to be lucky. I've had my misfortunes and I think they were the making of me—but I was also lucky enough to have a steady salary."

Is this the source of the equanimity I sense in her?—for there's a marvelous calm about her, an assurance that things will work out, which is remarkable, considering the obstacles she's encountered. She has borne more than her share of slights, has had to scrape by with the barest of support. Only in the fall of 1996, as her last major grant ran out, was she given the title "professor"—an honorary title, conferring no pay. Yet there are no apparent scars—in fact, she sees her obscurity as having worked to her advantage because it's left her free to pursue her own ways. "Funnily enough, it was just right for me personally. If I'd landed a cushy job I'd have found myself sitting on committees on World Health and all sorts of things, but I stayed at my own drawing board in a way which, if I'd been a man, would never have happened."

She is an interesting text and full of complexity. She comes of good stock, of parents who both lived into their nineties, and her seven siblings all have, or had, the same amazing energy. But there's another gene there, too, for two siblings and a son have taken their own lives. She's a socialist, yet there's more than a touch of the aristocrat in her language, her background, the company she's kept. The old photographs show a woman who was stunning, with a mane of dark hair pulled back from her face, high cheekbones, a straight nose, lively eyes, and a fine figure. How did she make her way with those looks in professional circles in the thirties and forties? I wonder. The worlds she moved in—Cambridge, Oxford, the British medical profession and research establishment—were not welcoming to women, and she was a married woman, with children besides.

She enjoys company—she's such good company that I have to remind myself that this is a world-renowned scientist I'm chatting with, whose work has prevented untold numbers of malignancies and saved untold numbers of lives. Yet she's fiercely independent and protective of her time. The great love of her life has been research: "research is thrill-

ing. . . . I love teasing out of figures new ideas. It's like producing a baby." Yet she has also raised two children and has helped raise four grandchildren, caring for them summers and holidays at Fawler, and has remained deeply involved in their lives. The generosity I sensed meeting her is real, and it returns to her in later life, in the form of friends who are there for her, ready to drive her about to pick up an item at the grocery store, or to meet a visiting American (me) at a bus or a train.

She is indeed a wonder. Friends have likened her to Alice in Wonderland and she herself enjoys the parallel: she sees things at odd angles, as though through a looking glass, and has found herself down more than one strange rabbit hole. She is also, I recognize, a fellow career-change artist, skilled at reinventing herself.

There are the intriguing subplots: the affair with Sir William Empson; the career of her mother, Dr. Lucy Naish, who became a physician at a time when this was barely a possibility for a woman. There's a lifelong rivalry with the esteemed Sir Richard Doll, the epidemiologist who made a reputation in the fifties by establishing the connection between lung cancer and smoking and who turns up in Alice's story during the Oxford years. His name is familiar to me from my research on the cancer book: he's well known in the United States for his 1981 studies asserting that at most 2 percent of cancers can be attributed to industrial pollution, a claim that lent authority to government agencies bent on deregulating industry during the Reagan administration.[3] Heralded by the *New York Times* as "one of Britain's foremost epidemiologists,"[4] he remains to this day at the heart of cancer research in England. His is a career with a very different trajectory from Alice's.

I begin to understand the role gender plays in Alice's story, both in marginalizing her and in making her the kind of thinker she is. She made her landmark discovery about fetal x-rays by devising a questionnaire for "the mums," asking questions that allowed them to recall what happened before the child's birth. It was a revolutionary approach: "ask the mothers? They don't know anything! To men, this would seem unscientific, whereas it made perfect sense to me that they might remember something that the doctors had forgotten." In our discussions of epidemiology, she refers to "a feeling for the data" that reminds me of the "feeling for the organism" described by Evelyn Fox Keller in relation to Barbara McClintock:[5] a willingness to keep questions open and let the material carve out its own shape. And she's not one of those women I am so tired of reading about, who breaks new ground for women but makes herself one of the old boys. She identifies strongly with women and with feminism.

The Work

Alice Stewart's findings about fetal x-rays, published in 1956 and expanded in 1958,[6] were not welcomed. Physicians didn't like being told they were killing their patients. Radiography was the new toy of the medical profession and was being used for everything from examining the position of the fetus to treating acne and menstrual disorders, to measuring foot size in shoe stores. Besides, it was the fifties, the height of the arms race, when the governments of England and America were pouring vast resources into weapons testing and building a powerful nuclear industry dependent on public trust of the friendly atom. In the United States, the Atomic Energy Commission (AEC) was waging a publicity campaign to assure the world it could survive all-out atomic war. Nuclear medicine was good publicity for nuclear power, nuclear power was a useful cover for the arms race, and there was little incentive to knowing that low-dose radiation could kill you.[7]

Alice was able to persist in her study of children's cancer, extending, refining, and elaborating her data in what became the Oxford Survey of Childhood Cancer, because she managed to scrounge together funding from America and was willing to work for a pittance. In the course of this project, she linked up with George Kneale, who became, as her collaborator, a brilliant statistician. They continued their work, collecting data on childhood cancer in relation to family history, parents' occupations and social class, illness, infection, inoculation, asking questions about cancer and the immune system that are on the cutting edge of cancer research today, until funding dried up altogether and they were made unwelcome at Oxford.

Then suddenly, in the fall of 1974, as Alice was winding up work on the Oxford Survey and relocating to Birmingham, she got a phone call from America. Dr. Thomas Mancuso, who had been appointed by the Atomic Energy Commission to do a study of U.S. nuclear workers, wanted her to "take a closer look" at his findings about nuclear workers at Hanford. Alice had barely heard of Hanford, the vast weapons complex in a remote corner of eastern Washington that had been built in 1943 to produce plutonium for the Manhattan Project; but she and George Kneale made the long trek to the United States to look at Mancuso's data. Their investigations indicated that "this industry is a good deal more dangerous than you are being told"—about twenty times more dangerous.

"That put the cat among the pigeons," she says. Mancuso was dismissed, the AEC attempted to seize his data, and she and Kneale returned

to England, taking with them a copy of the data so that they could continue their analysis.

The report published by Stewart, Mancuso, and Kneale in 1977 had momentous implications. Once again, Alice found herself at odds with official assurances about the safety of low-dose radiation, only this time it was more than the medical profession she was up against: it was the nuclear industry and the international regulatory committees charged with setting safety standards. She found herself down a strange rabbit hole indeed.

At stake in this controversy are the worldwide guidelines for radiation exposure for workers and the general population. The international regulatory committees and the national committees as well—the International Commission on Radiation Protection (ICRP), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Britain's National Radiological Protection Board (NRPB), the U.S. Nuclear Regulatory Commission (NRC), and the prestigious U.S. National Academy of Sciences committee on the Biological Effects of Ionizing Radiation (BEIR)—all base their standards on the studies of the Hiroshima survivors. The Hiroshima studies were carried out by the Radiation Effects Research Foundation (RERF), which maintains that low-dose radiation is negligible, arriving at this position by extrapolating from high dose to low dose in linear fashion: radiation becomes less dangerous as dose diminishes, becoming negligible at very low dose. The RERF supports this position by arguing that since we're bombarded continually by background radiation that emanates naturally from the sun, from space, rocks, soil, and radon gas—and mostly we don't get cancer—the risks from exposure to low-dose radiation must be negligible. But the RERF is an organization that had close ties with the U.S. Atomic Energy Commission, and the AEC—created in 1946 to preside over nuclear research and development—was hardly a disinterested party.

The Hiroshima data are the basis not only of worker safety standards; they determine the standards that set risks and benefits of nuclear installations, settle liability and compensation claims, and establish classification of radioactive waste. Any acknowledgment that low-dose exposure is as dangerous as Alice suggests would have enormous consequences. "If we are correct, occupational safety standards will have to be changed and it will open the floodgates to claims from workers, veterans, and downwinders. If we are correct, radioactive waste is a bigger problem than anyone thought—you can't just dump it in the ocean or anywhere else and hope that as long as it comes off slowly to imitate background radiation,

there's no effect. Because if you increase the world level of background radiation, you increase the numbers of mutations and cancer deaths. As one rises, so does the other. Inevitably."

Also at stake are the potential compensation claims of the million or more workers in U.S. and U.K. nuclear weapons facilities, of the hundreds of thousands of people living near nuclear installations or downwind from the Nevada test site, and the hundreds of thousands of U.S. and U.K. soldiers and veterans subjected to fallout from nuclear tests and operations.[8]

No wonder nobody wants to hear what Alice Stewart has to say.

The Nuclear Industrial Complex

Alice would need all the faith she could summon that "truth is the daughter of time," for there are few areas of scientific inquiry where truth has been so slow to come out.

Nuclear science, conceived in the dark days of World War II, was born in secrecy and was to continue in secrecy. The Manhattan Project, a vast, complex enterprise organized to develop the first atomic bombs, employed 150,000 men and women and had facilities scattered across more than 37 sites in nineteen states and Canada.[9] The people working in the plants were kept ignorant of what they were producing; even the scientists were kept in the dark, and those who knew anything were sworn to secrecy, their publications censored.[10] Only a few approved experts working at the highest levels were allowed to see the whole picture. The very existence of the project was kept out of the media, concealed from Congress, concealed even from Vice President Harry Truman until he was sworn in as president.[11]

The sophisticated equipment that produced the plutonium and uranium used in the Manhattan Project required the expertise of large corporations like Du Pont and Union Carbide. This meant that after the war, the United States was left with an extensive physical plant, a complex of factories, production facilities, equipment, trained personnel, and a far-flung network of vested interests.[12] Atomic bombs don't easily lend themselves to commercial spin-off, but the reactors that transform uranium into plutonium give off tremendous heat, heat that could be used to boil water to produce steam to turn the turbines that generate electricity. They could thus be adapted to existing technology, whereas alternative technologies could not; alternative sources of energy, such as solar, would have required a complete redesign of the energy system and so were of

little interest to those making the decisions. "It's a hell of a way to boil water," comments author Karl Grossman. "But it did keep the machinery going."[13]

In 1953, President Dwight Eisenhower delivered his "Atoms for Peace" speech to the United Nations, promising that nuclear energy would transform life on earth. A massive and costly public relations campaign was launched that included brochures, films, literature, exhibits that went out to schools, featuring *Citizen Atom,* a friendly, smiling little fellow with a lightning bolt through his head.[14] The new technology required vast federal subsidies to make it commercially competitive: in subsequent years, the U.S. government poured $70 billion into the development of nuclear power, and the electric utilities invested an additional $125 billion—more than the cost of the entire space program or the war in Vietnam.[15]

Part of the reason nuclear energy got such large subsidies was that it linked domestic energy to the same technology as weapons production, thereby bringing commercial research and development in line with military goals. The United States began testing nuclear devices in the South Pacific almost immediately after the war. The Soviet Union exploded its first atomic bomb in September 1949. The United States responded by exploding a hydrogen bomb in 1952, with fifteen thousand times the power that devastated Hiroshima. Britain got into the race in 1952, when it exploded its first nuclear device in the Montebello Islands off the northwest coast of Australia, a device made from plutonium manufactured at Windscale (later renamed Sellafield), the soon-to-be-notorious facility built on England's scenic northwest coast. In 1956, Britain began operating its first electricity-generating reactor just across the Calder River from Windscale. In England the civilian program was even more directly linked to military goals, the production of plutonium for building bombs.[16]

The nuclear industry grew rapidly, becoming what may be the largest and most powerful business enterprise in history.[17] By the late fifties, when Alice Stewart's discoveries were making their way into the scientific literature, England and the United States were in every sense of the word *invested* in this technology and had no desire to hear the bad news.

But they had to hear, for an international anti-nuclear movement had grown up around the issue of weapons testing so strong that it succeeded, in 1963, in driving testing underground. The movement reemerged in full force in the mid-seventies, to protest the proliferation of nuclear power plants; it gathered momentum in the years the Mancuso

scandal was breaking. It ultimately succeeded—thanks to the efforts of independent scientists like Alice and owing to the industry's dangerous inefficiencies—in halting the building of new reactors and the siting of nuclear waste dumps.[18]

Cold War Science

The Atomic Energy Commission, mandated with protecting atomic secrets and assuring U.S. monopoly on nuclear technology, presided uncontested over research and development at the vast system of national laboratories that grew out of the Manhattan Project—at Hanford, Oak Ridge, Los Alamos, the Savannah River Plant in South Carolina, the Lawrence Livermore Laboratory in California, and Brookhaven on Long Island.[19] Weapons production at these facilities went on for two decades before there were any inquiries into the health effects of radiation on the workers—and even when the Mancuso study was funded, in the sixties, many felt that it was more about public relations than public safety. That suspicion was corroborated when the government clamped down so fiercely on Mancuso, Stewart, and Kneale for turning up a cancer effect. The Atomic Energy Commission—which was being reconfigured during these years as the Energy Research and Development Administration (ERDA), subsequently the Department of Energy (DOE)—tried to seize the data that the three researchers had in their possession. It didn't succeed, but it did manage to deny them further access to the workers' health records.

So began a long battle on the part of activists to wrest radiation health research away from the Department of Energy.

Alice at this point—she is in her early seventies—becomes a major player in an international drama, in demand at conferences, hearings, inquiries throughout Europe and the United States. She becomes a familiar figure in Congressional hearings and addresses citizens' groups throughout the country. She testifies for nuclear workers seeking compensation, for American and British veterans of atomic testing, for women protesting the siting of cruise missiles at Greenham Common. Often she is the only expert witness willing to appear; often she receives standing ovations. Always she speaks out for scientific freedom.

Within anti-nuclear circles, she becomes a bit of a legend. In 1986, the year of Chernobyl, she is awarded the Right Livelihood Prize, the "Alternative Nobel," as it's called, a prestigious and well-known prize (better known in Europe than the United States), conferred in the Swedish

Parliament the day before the Nobel to honor those who have made contributions to the betterment of society. In 1991, in Carpi, she receives the Ramazzini Prize, the leading prize in Italy for epidemiology.[20]

In the mid-eighties, Alice is drawn into a wider public arena when she is awarded a $2 million grant from the Three Mile Island Public Health Fund. When activists win a $25 million class action suit against the Three Mile Island nuclear facility for the accident that occurred there in 1979 and a fund is designated to explore the effects of the radiation, they turn to Alice Stewart and the workers' records that the government still holds in its possession. Alice, then eighty, receives $2 million to study the Hanford workers' records, along with records from Oak Ridge, Los Alamos, and Savannah River. It takes several more years for the activists to pry the data away from the government, during which time she makes frequent appearances on their behalf. When they finally succeed in securing the workers' records, the event is hailed on the front page of the *New York Times* as an unprecedented victory against the Department of Energy.[21]

She and George Kneale have been at work on this data ever since.

Because radiation is invisible, imperceptible even to those exposed, and because nuclear technology is so complex, the anti-nuclear movement has been highly dependent on the support of experts.[22] But since most nuclear scientists are employed by or contracted to government or industry, few are willing to speak out, and those who do so usually find themselves without jobs.

"I speak out because there are not a lot of people who can," says Alice; "I have nothing to lose. A lot of people do."

The Shape of Things to Come

What Alice Stewart has to tell the world about the hazards of low-level radiation is, if anything, more urgent today than it was four decades ago, when she alerted the world to the hazards of fetal x-rays. The nuclear age is not over: in fact, since the end of the Cold War, nuclear technology has become more dangerous as it spreads across the globe and as radioactive waste piles up.

The nuclear industry continues to find markets for its reactors and equipment in the many countries that remain committed to nuclear energy—France, Japan, South Korea, India, Eastern Europe, the former Soviet Union. The public relations arm of the industry, with its annual budget of more than $20 million, has mounted a massive publicity campaign to promote nuclear power, pushing it as a "clean" energy solution

to the problem of global warming.[23] Far from being "clean," nuclear technology has left us with waste accumulating at 435 reactors around the world, where millions of pounds of highly radioactive spent fuel sit in corroding storage tanks.[24] The cost of the cleanup is estimated to exceed the cost of the installations themselves—assuming that anyone can figure out how to clean them up.[25]

In the former Soviet Union, where fifteen Chernobyl-type reactors continue to operate, many areas are alive with contamination from nuclear waste dumps and storage facilities, from reactors and reprocessing plants, and from thousands of waste containers dumped into the sea.[26] In both east and west, hundreds of tons of plutonium and enriched uranium must be kept track of, and as black-market trade in these materials picks up, the threat of nuclear terrorism increases.

The industry's argument is that the waste will "dilute and disperse" and disappear; but, as Alice has warned and as experts are increasingly agreeing, it will not. Wherever it is dumped, it will be blown by the wind or carried by the tides or seep into the earth; it will be eaten by insects, birds, fish, mammals, and will make its way into us. It will add, is adding, to the sum total of cancers and birth defects. Its legacy will haunt us for longer than civilization has existed.[27] Plutonium, with its half life of 24,000 years, is, in human terms, forever.

And cancer is not the worst of it. "Even more than the cancer is the threat to future generations," Alice warns; "that's what you ought to be really afraid of. It's the genetic damage, the possibility of sowing bad seeds into the gene pool from which future generations are drawn. There will be a buildup of defective genes into the population. It won't be noticed until it's too late. Then we'll never root it out, never get rid of it. It will be totally irrevocable."

Alice's Story

Since that day in May 1994 when I first met Alice Stewart, we have had many conversations. I have had access to dozens of interviews and lectures taped by others.[28] I have drawn on and edited this material in a way that allows for the transposition from spoken to written word and the construction of a narrative. Wherever possible, I let Alice speak for herself, for her voice is eloquent and distinctive.

Alice's story begins at the turn of the century in Sheffield, then moves to Cambridge in the twenties and to Oxford in the forties. Chapters 2, 3, and 4 concern the personal story, the education, and affairs of the heart.

Chapter 5 finds her in Oxford, heading the Institute of Social Medicine and working with Dr. John Ryle, a visionary who hoped to inspire physicians to a greater sense of social responsibility. These are chapters not only in Alice's story but in the history of medicine, for the surveys Alice designed in these years helped shape the emerging field of epidemiology.

Chapter 6 describes the Oxford Survey of Childhood Cancer and the landmark discoveries that came out of it. Chapter 7, "Dr. Doolittle's Team for the Moon," describes the company Alice kept during these years, the unique quality of life and work on the Oxford Survey.

The next chapters follow her onto the international nuclear scene, where she has lived ever since. Chapter 8 concerns her work on the Hanford nuclear workers' records. Chapter 9 describes her revolutionary challenge of the A-bomb data, which several of her colleagues believe will be her most lasting contribution. Chapters 10 and 12 detail the long struggle to pry the nuclear workers' data away from the DOE, a victory that has had major repercussions in breaking the Energy Department's hold on radiation health research and getting it transferred to the public health branch of the government, the Department of Health and Human Services. Interspersed between these two chapters is a discussion of Alice Stewart's role in the anti-nuclear movement in England. Chapter 13 looks at the ways the governments of the United Kingdom and United States have stonewalled her findings.

We then move to two chapters on Alice's science, exploring what her work has meant for the field of epidemiology and for theories of childhood cancer and cancer and the immune system. Alice's ideas deserve to be better known—and they would be, if she were. The final chapter is Alice's (and my) speculations about her special qualities as a scientist, the role gender has played in her story, the way it's worked to her disadvantage—and advantage.

The Woman Who Knew Too Much is not a biography that tells every single detail of its subject's life. I am interested in the life story as it illuminates the making of this extraordinary woman, her mind and her work, and her role in this major scientific-political controversy. The book is a kind of collaborative memoir, since there's a lot of Alice's voice in it, but it is more than a memoir, since I've added much information that contextualizes her story historically and politically. I don't give a lot of time to the other side of the controversy, though I'll state briefly what it is: it holds that the Hiroshima studies are a satisfactory basis for radiation standards; that there is no late effect of radiation except cancer; that you can predict cancer risk by extrapolating from high dose to low dose

in simple linear fashion; that risk from low-dose radiation is negligible. It maintains that current safety standards are adequate, that the risks from nuclear industry and weapons are well within those of other industrial hazards and the benefits are sufficient to warrant a certain number of cancer deaths, a number that can be arrived at according to risk-benefit calculations—calculations derived from the Hiroshima studies.[29]

The other side has on its side the power of national governments, the prestige and influence of the international regulatory committees, the wealth of the nuclear industry, and all the access to funding, publicity, and publication that money can buy. Alice Stewart has none of these. Not that she has been without access to publication—she has, despite her unpopular positions, succeeded in publishing nearly four hundred papers in refereed scientific journals, and her 1958 paper on childhood cancer and fetal x-rays is among the most quoted in the literature, after the famous DNA paper by Watson and Crick. But apart from a few pieces that have appeared in the *New York Times,* the *Times Higher Education Supplement, Ms. Magazine,* a *60 Minutes* segment, and a recent Channel 4 British television documentary,[30] she has had few opportunities to present her side.

This is Alice's story.