Even so, the motion of the shell of plutonium turned out to be unstable, leading to ragged surfaces and even jets, which prevented the desired uniform collapse. The remedy was ultimately found in Robert Christy's suggestion to implode not a spherical shell but a solid plutonium sphere.

To deal with all these new problems, the work was reorganized so as to give highest priority to the implosion work. Experts with special experience in relevant areas were brought in, and in the end the implosion method was developed in time to use the plutonium that was arriving from the reactors in Hanford. Because of the complexity of the implosion bomb it was decided to test it in the New Mexico desert. This test took place in July 1945 at the "Trinity" site. This test at the same time confirmed the theories about chain reactions in general.

The book under review is a full account of the history of this work. It is not concerned with life in Los Alamos, and the historical and moral aspects are touched on only briefly in the epilogue. It is all about the scientific and engineering problems and their solutions. It is not a starry-eyed account of the achievement, but the achievement emerges from the facts.

Chapters 2 and 3 set the scene by discussing the events leading to the foundation of the Los Alamos laboratory in 1943. They are not written with the same care as the rest. One is mystified by the title of chapter 3, "The early materials program: 1933–1943." What program could there have been between 1933 and, say, 1940? Indeed, nothing in this chapter happens before 1941. I would suspect a misprint, if this title were not repeated in the table of contents and as a heading to notes. These chapters contain a number of minor inaccuracies.

Generally the presentation is clear and shows the care one expects of the four distinguished authors. According to footnotes, different chapters were written by the authors in different combinations, but they are well coordinated and read coherently.

The presentation can easily be followed by a scientific reader, and a non-scientist will get an interesting impression of the events. The book is organized in sections, each of which covers a specific period of a specific problem. This method has the advantage that it allows the authors to explain the progress of each activity in full detail, but it makes it more difficult to visualize the interplay of the various activities in time. For example, the discovery of the high rate of spontaneous fission of plutonium is reported *after* the reorganization of the laboratory to which it gave rise. The many illustrations, mostly photos from the Los Alamos archives, help to make the book attractive.

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Protecting Plants

Biotechnology in Plant Disease Control. ILAN CHET, Ed. Wiley-Liss, New York, 1993. xvi, 373 pp., illus. $99.95 or £83. Wiley Series in Ecological and Applied Microbiology.

The age of agricultural biotechnology entered the public mind with the image of someone in a "moon suit" spraying genetically engineered microbes on a potato field near Tule Lake, California. This relatively innocuous experiment to reduce frost damage by introducing recombinant DNA ice-minus bacteria into the microflora of potato leaves was a lightning rod for fears about how the new genetic engineering technology might upset the ecology of our crop and natural lands. The transfer of genes into plants from another plant bacterium, *Agrobacterium tumefaciens*, formed the basis of the development of plant genetic engineering. Plant pathogens have thus played a pivotal role in both the development of and the types of applications deemed suitable for agricultural biotechnology. On the eve of commercial availability of recombinant DNA plants, this book provides a timely overview of the current status of the use of biotechnology in plant disease control.

"Disease development on the leaves of tobaccos inoculated with *P. syringae* pv. *tabaci*." *Left*, "Untransformed tobacco plant with chlorotic symptoms at the inoculation sites on the leaves." *Right*, "Transgenic tobacco plant (TAB7) without any chlorotic halo at the inoculation sites on the leaves." [From Yoneyama and Anzai's chapter in *Biotechnology in Plant Disease Control*]

To control plant disease, biotechnologists can either manipulate the resistance of the plant or perturb the ecological fitness of the pathogen. We are able to grow most crop plants intensively on a grand scale today because we have been able to incorporate into them resistance to a number of diseases. The cloning of known disease resistance genes and the identification of novel resistance genes are now considered to be the most promising approaches in plant disease biotechnology. It is envisioned that once such genes are cloned we will be able to pull them from the shelf and rapidly incorporate them into plants as needed. An optimistic and thoughtful discussion of the potential use of cloned resistance genes has been contributed to the book by Keen, Bent, and Staskawicz. It is generally thought that resistance genes function by encoding membrane receptors, which after binding of signal molecules, such as elicitors, induce host defense responses. Since the response mechanisms are likely conserved between plants, it is hoped that the receptor proteins, or resistance genes, could function in any plant attacked by a particular pathogen. Initial findings on the functioning of resistance genes have not provided support for this theory, however. The first resistance gene to be cloned, the *Pto* gene of tomato, encodes a protein kinase, a type of protein that normally functions in signal transduction rather than agonist binding. The *Hm* gene of maize appears to neutralize a pathogen-produced, host-specific toxin.

Single-gene resistance to disease is probably more of an exception than the rule in nature, and genes that confer strong resistance against many of the most damaging pathogens have not yet been identified. Interest in identifying novel resistance genes is strong, and much of the book is devoted to describing progress that has been made in this regard. The first recombinant DNA plant that will become commercially available will be one with a novel resistance gene: a gene encoding the protein coat of a virus. Why such genes provide resistance against some viral diseases is not known. Genes encoding small peptides with antimicrobial properties, enzymes that degrade fungal cell walls, toxin-degrading enzymes, and viral proteins have each been transferred into plants; various chapters of this book discuss the promise of such genes for

Vignettes: Raisons d'Être

I am a scientist, a member of a most fortunate species. The lives of most people are filled with ephemera. All too soon, much of humanity becomes mired in the tepid tracks of their short lives. But a happy few of us have the privilege to live with and explore the eternal.

—*Robert L. Sinsheimer*, in *The Strands of a Life: The Science of DNA and the Art of Education* (University of California Press)

Each of you might find it an amusing exercise to write down twenty reasons why your science is valuable to society: anyone who accepts public monies ought to be able in good conscience to explain why he or she deserves such support. My own list ranges from developing new knowledge to enhancing national prestige to other such weighty reasons as providing an entire population class for exploitation by underemployed venture capitalists and attorneys and enabling interesting, content-laden conversations to take place at cocktail parties throughout the country.

—*Marye Anne Fox*, in *AAAS Science and Technology Policy Yearbook, 1993* (Albert H. Teich, Stephen D. Nelson, and Celia McEnaney, Eds.; Committee on Science, Engineering, and Public Policy, American Association for the Advancement of Science)

enhancing plant disease resistance. The book makes clear that we have advanced much further in our ability to manipulate plants genetically than we have in understanding the biochemical basis of plant disease; thus there remains much to learn about how to use the powerful methods of genetic engineering to enhance plant disease resistance safely.

In some instances fitness of pathogens can be manipulated by using other organisms as competitors, antagonists, or parasites. Biological control of plant disease is still in its infancy and remains essentially an empirical science. In general, we know much less about the processes involved in successful biological control than we do about how plants defend themselves against disease. It is clear that, although the genetic engineering of microbes is technically much easier than that of plants, we have made more progress in enhancing plant resistance than in developing better biological controls. In part this reflects our general lack of knowledge of microbial ecology, but it also shows the dampening effect of the initial battles over release of the ice-minus bacteria on the development of this field.

Ilan Chet has produced a balanced and comprehensive overview of biotechnological plant protection. The book suffers, however, from an absence of discussion of issues that are guiding the direction of current research, such as the safety of using recombinant DNA organisms and the potential impact of biotechnology on worldwide farming practices. Such issues are of great concern to the general public as well as to active researchers, and more attention to them would have greatly enhanced the value of the volume.

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Growth and Division

The Cell Cycle. An Introduction. ANDREW MURRAY and TIM HUNT. Oxford University Press, New York, 1993. xii, 251 pp., illus. $45 or £32.50; paper, $22.95 or £15.95.

Given the recent pace of research on the cell cycle, only exceptionally brave and hardy angels would not fear to tread the path leading to publication of a book on the subject. Fortunately, Andrew Murray and Tim Hunt have taken on the job. The result is this short and highly readable volume describing the cell cycle from start to finish and from bacteria to mammals. In addition to conveying well-established facts, the authors include a good deal of intelligent speculation. One example is a comparison between the requirement that DNA replicate only once per cell cycle and the restriction of *HO* endonuclease gene transcription in budding yeast to the late G1 phase in mother cells (we won't try to explain it, but it's fun). The authors provide teleological insight into many aspects of cell cycle control, offering explanations of why control of the embryonic cell cycle differs from that of the somatic cell cycle, why budding yeast spend longer in G1 than do fission yeast, and why protein synthesis and degradation control the "cell cycle engine." Thus what we get here is the Murray–Hunt view of the cell cycle, considered broadly and magisterially.

Recent work has made it clear that most of the transitions in the eukaryotic cell cycle are driven by a class of protein kinases called "cyclin-dependent kinases," which require binding of one of a class of proteins called cyclins for their activation. The regulation of these kinases is complex and occurs at different levels in different biological systems; best understood is the regulation of *cdc2*–cyclin B kinase activity in mitosis. In a chapter on enzymes that control mitosis, biochemical information from embryological systems is integrated with genetic identification and analysis of relevant components in fission yeast. (It is odd that the cell cycle genetics of fission yeast is discussed in this chapter rather than in the preceding chapter entitled "Cell cycle genetics," which contains a discussion of budding yeast. Perhaps the authors mean to imply that genetics should become enzymology once it is properly understood!) Related kinases control other cell cycle transitions (notably at the beginning of the cycle), although the enzymology and biochemistry of these systems is less well understood.

The mechanisms by which cyclin-dependent kinases drive cell cycle transitions are largely unknown. Throughout discussions of mitosis, mechanisms of DNA replication, and the control of rereplication, the authors consider possible substrates of cyclin-dependent kinases. For example, during mitosis, phosphorylation of the nuclear lamins, histone H1, and microtubule-associated proteins may play a role in nuclear envelope breakdown, chromatin condensation, and microtubule dynamics, respectively. During S phase, phosphorylation of the DNA replication factor RP-A may be responsible for its activation.

There is a substantial discussion of checkpoints, particularly with respect to the relationship between the somatic and embryonic cell cycles. Checkpoints are points in the cell cycle at which cell cycle progression is restrained unless certain conditions are met (for example, absence of DNA damage, presence of a functional mitotic spindle). A discussion of the possible relationships between checkpoints, tumor suppressors, genomic instability, and programmed cell death provides an