Nuclear Safeguards

The International Atomic Energy Agency and World Nuclear Order. LAWRENCE SCHEINMAN. Resources for the Future, Washington, DC, 1987. xviii, 320 pp. Paper, $16.95.

In a large office building on the outskirts of old Vienna, far from the monuments to past glory tourists come to see, there dwells an international organization whose importance is matched by its anonymity. Since 1957, the International Atomic Energy Agency has tried to keep the use of nuclear energy both safe and peaceful. The agency was a product of the American idea of the early '50s that if the nuclear genie could not be put back in the bottle, it should at least be kept under strict international oversight. Rather than nations' being denied material, equipment, and knowledge they might eventually get anyway and use as they saw fit, these would be supplied henceforth through an international body under rigidly controlled conditions, of which the most important was that they should be used only for peaceful purposes. Thus, the new agency was endowed with a combination of promotional and regulatory functions: to help states use nuclear energy for peaceful purposes and thereby deter the risk of the spread of nuclear-weapon capability.

Initially, the emphasis in the agency's work was on its developmental tasks. Increasingly, however, the stress has shifted to its regulatory activities, including the important work on nuclear safety, which since the Chernobyl disaster has received special attention. But the growth in the regulatory side of the agency's program is due in particular to the increased importance attached to its "safeguards" function: the creation and application of measures to verify that states comply with treaty obligations not to use their nuclear programs for the manufacture of nuclear weapons or for other military ends.

In the early days, safeguards served mainly to ensure that supplies made by or through the agency were not put to forbidden use. Over time, safeguards were applied more and more to verify compliance with agreements among states, first in connection with nuclear supplies from one state to another and then increasingly as part of multilateral measures against the spread of nuclear-weapon capabilities to additional countries, such as the Tlatelolco Treaty, which provides for the denuclearization of Latin America, and the Non-Proliferation Treaty (NPT). Thus, as was intended by the agency's founders, the safeguards system has become a major factor in international efforts to deter the spread of nuclear weapons.

Nonproliferation has been a matter of high priority for successive U.S. administrations, and the IAEA has long enjoyed strong American support. This support has weakened, lately, both materially and politically. The results are noticeable in the agency's work and may eventually hurt U.S. interests as well. Its low public profile does not help; the American public, the media, and even the Congress know little about this unique organization and its importance to the United States. Lawrence Scheinman tries hard to change this. No one is better qualified. A long-time student of nuclear affairs, Scheinman has served in the U.S. government and in the Secretariat of the IAEA. He is a prominent member of the bipartisan group of nuclear cognoscenti in the United States who have long helped this country keep its position of enlightened leadership in the international nonproliferation community.

Scheinman starts his thorough, yet agreeably concise, book with an interesting analysis of the nuclear proliferation phenomenon, a short history of the nonproliferation regime, and a description of the measures composing it, including the role played by the agency. This is followed by a well-researched summary of the events leading to the agency's creation. This first part (worth reading by itself, even if one were, unwisely, to ignore the remainder of the book) puts the agency squarely in its nonproliferation framework—an approach fully justified in the light of history and initial intentions and necessary for a proper insight into the agency's true nature, yet one seldom taken in the literature.

The author's experience with the IAEA allows him to present a realistic picture of its structure and working procedures and the problems troubling it. In a discussion with special relevance to the United States, Scheinman cogently deals with what may well be the most serious problem for the agency today: the process of "politicization," whereby governments introduce into the agency's affairs political issues extraneous to its statutory tasks, in apparent indifference to the negative effect this may have on its work. The credibility of safeguards is another potential problem to which Scheinman devotes considerable space. Though giving an excellent exposé of the practical and administrative questions with which the agency must cope in applying safeguards, he is somewhat less clear in discussing the technical factors leading to the determination of the goals to be achieved. But he convincingly makes the point that the effectiveness of safeguards depends largely on how well they are allowed to function, by those who set the agency's mandates—and provide the financial means—and by the states where safeguards are applied. One problem flagged by Scheinman in this context is the inherent struggle for funds between those who emphasize the safeguards function and those who wish to allocate more resources to developmental assistance and who see safeguards as detrimental to their interests.

I was struck by the author's recognition of the connection between the agency's creation and the disarmament questions of that time, a connection habitually overlooked. Even so, the book does not do full justice to some of the disarmament talks of the period, so that some issues that were part of the background against which the agency was set up, and that still play a role, may not be fully clear. Similarly, some of the broader political issues that may confront the IAEA in years to come may be given insufficient attention, notably the question of the implementation of Article VI of the NPT. Many nations consider this article, which provides that nuclear-weapon states should negotiate on nuclear disarmament, as the ne plus ultra of the treaty and thus indirectly as a basic factor in the acceptability of safeguards. Its implementation may determine the outcome of the NPT Review Conference of 1990 and have an impact on the future of nonproliferation and of the agency. In a book that deserves to become a political manual for a future administration, this point might have been made more forcefully.

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Darwin's Early Thoughts

Charles Darwin's Notebooks, 1836–1844. Geology, Transmutation of Species, Metaphysical Inquiries. PAUL H. BARRETT, PETER J. GAUTREY, SANDRA HERBERT, DAVID KOHN, and SYDNEY SMITH, Eds. British Museum (Natural History), London, and Cornell University Press, Ithaca, NY, 1987. x, 747 pp., illus. $75.

During the late 1830s when he was first developing his theory of evolution, Charles Darwin recorded his ideas in a number of notebooks. Most of these notebooks have been previously published in various forms, but now, for the first time, they have all

been brought together between two covers, edited to the highest scholarly standards. The publication of such an edition is well worthwhile. During the period the notebooks cover, Darwin speculated about an enormous range of evolutionary topics, and he changed his mind about many of them as he went along. To capture the full significance of his thinking, one needs to see it all and reflect on the many connections among ideas that he made—or refused to make. Cumulatively, the notebooks yield a more comprehensive picture of Darwin's mind than we see in any of his published works. Not even *On the Origin of Species* matches the breadth of thought reflected in the notebooks, and we will never understand the *Origin* correctly unless we bear this breadth in mind.

The editors group the notebooks into three general categories. The Red Notebook and Notebook A, both edited by Sandra Herbert, deal largely with geological topics. The Glen Roy Notebook, edited by Sydney Smith, Peter Gautry, and the late Paul Barrett, also deals with geology. The lettered Notebooks B through E, edited by David Kohn, the surviving leaves of the Torn Apart Notebook, edited by Kohn and Smith, a portion of Darwin's Account Book entitled Questions and Experiments, edited by Barrett, and two shorter manuscripts deal with species transmutation. Notebooks M and N, a collection of loose manuscript pages Darwin called Old and Useless Notes, and another short manuscript, edited by Barrett, deal with psychology and religion, subjects that Darwin subsumed under the term "metaphysical enquiries."

Darwin made abundantly clear that he considered geology, zoology, botany, and "metaphysics" all integrally relevant to the establishment of his theory. Furthermore, the Notebooks contain the groundwork for books on all these topics. The Red Notebook and Notebook A contain speculations that went into Darwin's geological studies about the *Beagle* voyage but also into the geological portions of the *Origin*. Notebooks B through E, the Torn Apart Notebook, and the Questions and Experiments provided material that went primarily into the *Origin* and *The Variation of Animals and Plants Under Domestication*. Notebooks M and N and the Old and Useless Notes set the stage for the *The Descent of Man* and *The Expression of the Emotions*. The amount of botanical material is limited, but in Notebook E one even finds the early considerations that led to *On the Various Contrivances by Which British and Foreign Orchids are Fertilised*. Darwin worked for years to develop the ideas that he first set down in these documents.

The notebooks are of interest not only for what they reveal about Darwin's early scientific thinking but also for what they reveal about his ideological predilections. In fact, many of his youthful scientific ideas came packaged in a more or less ideological message. Darwin owed a great deal to his grandfather, Erasmus Darwin, and to the intellectual bugbear of early Victorian naturalists, Jean Baptiste Lamarck. He adopted their Enlightenment deism, their progressive transformism, and their conviction that animal behavior had a lot to do with the process of species change. In particular he followed his grandfather's associationist psychology and his belief in the importance of sex and reproduction. In contrast to these latter-day *philosophes*, Charles Lyell impressed Darwin with doubts about inevitable progress, and the dour Reverend Thomas Malthus instructed him about the negative side of sex: overpopulation and the struggle for existence. In subsequent publications Darwin neglected his debts to Lamarck and his grandfather while emphasizing those to Lyell and Malthus, a tactic that has frequently prejudiced modern historical accounts. However, the notebooks show clearly not only how much he owed to his forebears in both camps but how he struggled to reconcile their sometimes contradictory legacies. Darwin was never fully successful in harmonizing them. All this work was marked by a certain ambiguity and indecision that stemmed from the impossible task he assumed, and all historical interpretations of Darwin have struggled with the problem of identifying his shifting allegiances. However, it is important not to derogate these aspects of his intellectual legacy: tolerance of ambiguity is one of the hallmarks of creative genius, and Darwin derived enormous benefit from his eclectic tendencies. The evidence is right here in the notebooks.

In view of the significant ideological compromise Darwin introduced into the notebooks, their publication together is a noteworthy event. The publisher has provided a handsome format with large type and generous margins. Unfortunately, the editors were not always thinking as generously. Too often they seem to address their notes only to the professional historian of science, indeed only to the professional Darwin scholar. The scrappy character and technical nature of many of Darwin's remarks would have deterred the casual reader in any case, but scholars from related disciplines might have expected more guidance regarding obscure concepts. Still, the quality and thoroughness of the annotation are exemplary. The editors bring us about as close to the pertinent circumstances surrounding Darwin's early thought as scholarship can reasonably get, and their interpretative modesty does assure that the volume will age well. We owe them a substantial debt.

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The Work of Spemann

The Heritage of Experimental Embryology. Hans Spemann and the Organizer. VIKTOR HAMBURGER. Oxford University Press, New York, 1988. xii, 196 pp., illus. $29.95. Monographs on the History and Philosophy of Biology.

Experimental embryology was one of the most exciting fields of research in biology in the early part of this century, when the application of experimental techniques to the embryo promised a rigorous, causal understanding of the processes involved in development. In Europe the leader in this field was Hans Spemann, and of all Spemann's research none had a greater impact than the so-called organizer experiment. Viktor Hamburger has taken this experiment and the work it inspired as the central theme of a book describing what might be called the golden age of experimental embryology.

The organizer experiment was performed by Hilde Proescholdt, who, in 1921, began a series of experiments transplanting the dorsal lip of the blastopore from the gastrulae of *Triturus cristatus* to gastrulae of *T. taeniatus*. The transplanted tissue induced the formation of a second embryonic axis and in the most famous example included neural tube, notochord, intestine, and kidney tubules. There were two remarkable features of this second embryo; it was composed of both donor and host cells and its tissues were appropriately arranged. Spemann argued that the transplanted tissue contained a center that was endowed with the power to induce and organize the formation of an embryonic axis.

Hamburger describes Spemann's experiments in detail, showing how they were designed with great ingenuity and performed with the simplest of tools. He remarks that Spemann's greatest strength was his analytical acumen—his ability to interpret the data from these simple experiments and to design new experiments to explore further his new insights. One of the highlights of Hamburger's writing is his attempt to reconstruct the process of Spemann's thinking, reconstructions that are plausible and illuminating. Hamburger also makes a valiant effort to explicate the increasing number of concepts—"differentiation center," "organization center," "double assurance," "labile determination," "assimilative induction," and so on—that came into use.

But while Spemann and the organizer experiment are central characters in the book, Hamburger describes the work of many others who were entranced by the developing embryo. Hamburger is well placed to do this, as he was himself one of the players, spending almost 10 years with Spemann. Some scientists whose work is described, such as Schotte, Mangold, and Vogt, are well known, but one of the pleasures of this book is that Hamburger gives due credit to minor players in the drama who are usually forgotten. A large part of the book is devoted to Johannes Holtfreter, whose genius and capacity for hard work are evident from his work on the organizer. As Hamburger says, Holtfreter was "simply bolder and more inventive and willing to take risks" than those who remained more closely associated with Spemann. Such inventiveness led to Holtfreter's in vitro experiments and the analysis of heterologous inducers and the regional specificity of induction. Hamburger takes the story of the organizer through to the 1960s and the work of Chuang, Saxen, Toivonen, Yamada, and Tiedemann, and in the last chapter he discusses his views of the organizer phenomenon as a gradient system.

It is strange that Spemann has not received more attention, for he is the only embryologist to have been awarded a Nobel Prize. Spemann wrote an autobiography that has not been translated into English, and it is a pity that Hamburger does not provide more information about Spemann's life outside science. Hamburger's book is strictly a "scientific" biography and does not discuss what influence, if any, Spemann's cultural background had on his approach to science.

But this is a minor point. The story of Spemann's scientific work is fascinating and well worth telling. It is a historically interesting episode, for what began with such high expectations entered a period of what Saxen and Toivonen have called "post-war depression." Hamburger shows how this disillusionment arose as a consequence of the difficulties of applying a reductionist approach (and especially biochemical analysis) to the problem of the organizer. By 1939, Joseph Needham was predicting that at least 50 years would be needed to obtain "certain knowledge about the chemical nature . . . of the substance involved in embryonic induction." Those 50 years have gone, and although there are promising beginnings (J. Gurdon, *Development* **99**, 285–306 [1987]) that goal has not yet been met. Hamburger hopes that his book may en-