Lessons of Chernobyl: Nuclear Power Is Safe

A nuclear scientist looks back at the notorious April 1986 accident and its effects, with particular reference to thyroid cancer. A report by Zbigniew Jaworowski, M.D., Ph.D., D.Sc.

The Chernobyl catastrophe was a dramatic personal experience for me—a difficult exam, which I am not sure that I passed. For many people engaged in radiological protection—although not all—it was a watershed that changed their view on the paradigm on which the present safety regulations are based, the holy mantra of LNT. LNT is the *linear no-threshold* assumption, according to which even the lowest, near-zero doses of radiation may cause cancer and genetic harm. For the general public, the Chernobyl accident might serve as a yardstick for comparison of radiation risks from natural and man-made sources. It also sheds light on how easily the global community may leave the realm of rationality, facing an imaginary emergency.

The LNT assumption is in direct contradiction to a vast sea of data on the beneficial effects of low doses of radiation. In 1980, as a chairman of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), I tried to convince its members that we should not ignore, but rather peruse and assess these data, which had been published in the scientific literature since the end of the 19th Century. But everyone on the Committee was against it. In each of the next seven years I repeated my proposal, but to no avail.

Finally, the accident at Chernobyl appeared to be an eye opener: Two years after the accident, in 1988, the Committee saw the light and decided to study *radiation hormesis,* that is, the adaptive and beneficial effects of low levels of radiation. Six years of the Committee's work, and many hot discussions later, Annex B, titled "Adaptive Responses to Radiation in Cells and Organisms," appeared in the UNSCEAR 1994 Report—14 years after my original proposal.

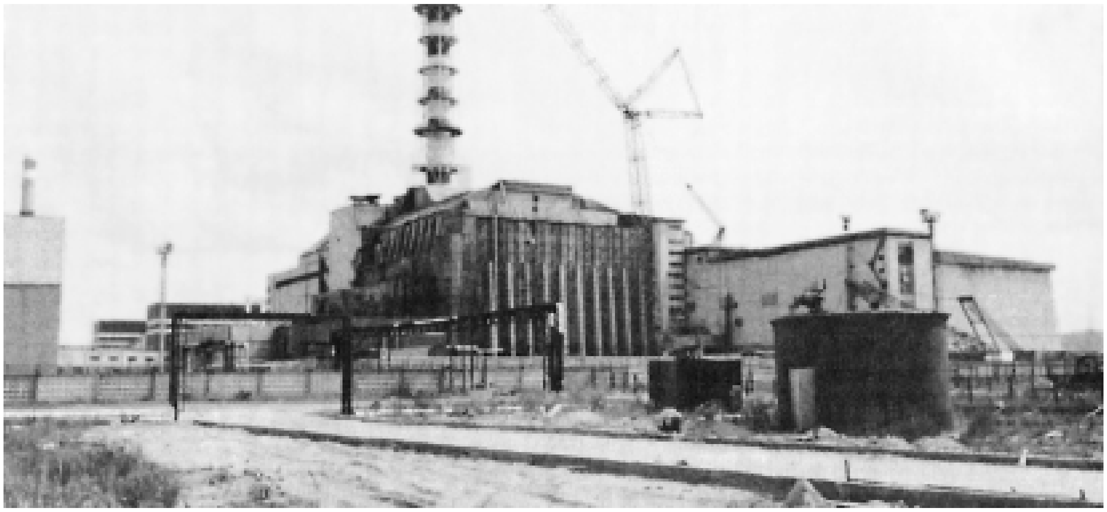
This Annex started a virtual revolution in research related to radiation protection. However, because of many vested interests and a conservative reluctance to change the international and national regulations, there is still a long way to go.

The LNT/hormesis controversy is not limited to radiation. It poses problems for practically all noxious physical, chemical, and biological agents which we meet in life.[1] Ionizing radiation was discovered relatively recently—at the end of the 19th Century—but, like these other biological and chemical agents, it has been with us since time immemorial.

The Radiation Shock

The Chernobyl accident was a radiation event unique in human history, but not in the history of the biosphere. There is evidence of a number of episodes of greater radiation levels during the evolution of life on Earth, for example, as a result of supernovae. In terms of human losses, it was a minor event as compared with many other man-made catastrophes. But, in political, economic, social and psychological terms, its impact was enormous. Let's look at what happened.

At about 9:00 a.m. on Monday, April 28, 1986, at the entrance of the Central Laboratory for Radiological Protection (CLOR) in Warsaw, I was greeted by my assistant with a statement: "Look, at 7:00 we received a telex from Mikolajki monitoring station saying that the radioactivity of air is there 550,000 times higher than a day before. I found a similar increase in the air filter from our station in the backyard, and the pavement in front of the institute is highly radioactive."



The damaged Chernobyl plant in 1992. The accident led to the first in-depth study of the long-term effects of low-level nuclear radiation, carried out by UNSCEAR.

Soon, to our relief, we found that the isotopic composition of radioactive dust was not from a nuclear explosion, but rather from a nuclear reactor. Reports that flowed in successively from our 140 monitoring stations suggested that a radioactive cloud over Poland travelled westwards, and that it had arrived from the Soviet Union; but it was only at about 6:00 p.m. that we learned from BBC radio that its source was in Chernobyl.

This was a terrible psychological shock. The air over the whole country was filled with the radioactive material, at levels hundreds of thousands times higher than anything we experienced in the past, even in 1963, a record year of fallout from nuclear test explosions. It is curious that all my attention was concentrated on this enormous increase in air radioactivity, although I knew that on this first day of "Chernobyl in Poland," the dose rate of external radiation penetrating our bodies reached 30 picorads per hour, or 2.6 millisievert (mSv) per year—that is, only higher by a factor of three than the day before. This higher dose rate was still *four times lower* than the dose rate I would experience visiting places in Norway, where the natural external radiation (up to 11.3 mSv/year) from the mountains there is higher than that over the Central European plain. The higher dose was also some *50 times lower* than in Ramsar, an Iranian resort, where the annual radiation dose reaches about 250 mSv per year; or more than *300 times lower* than at the Brazilian beaches (790 mSv per year) or in southwest France (up to 870 mSv per year). *No adverse health effects have ever been reported among the people living in areas with high natural background radiation.*

The Cost of Ad Hoc Remedies

But in 1986, the impact of a dramatic increase in atmospheric radioactivity dominated my thinking and everybody else's thinking. This state of mind led to immediate serious consequences in Poland, in the Soviet Union, throughout Europe, and later across the globe.

First, there were different hectic actions, such as the ad hoc coining of different principles and emergency countermeasures, the sense and quality of which lagged far behind the excellent, existing measuring techniques and monitoring systems. An example of this was the radionuclide concentration limits (the derived intervention levels) implemented a few days after the accident by various countries and international organizations, which varied amongst themselves by a factor of up to 50,000. The rationale behind some of these limits was not at all scientific, but reflected the emotional state of the decisionmakers, and also political and mercantile factors.

For example, Sweden allowed for 30 times more radioactivity in imported vegetables than in the domestic ones, and Israel imposed lower limits for radioactivity in food imported from Eastern Europe than from Western Europe. The limit of cesium-137 concentration in meat, of 6 bequerels per kilogram (Bq/kg) was accepted in the Philippines, but in Norway the limit was set at 6,000 Bq/kg.

The monetary costs of such restrictions were estimated in Norway. At first, the cesium-137 limit for meat was set there at 600 Bq/kg. From a health physics point of view, this standard is meaningless, because consumption of 1 kilogram of such meat would correspond to a total dose of 0.0078 mSv—in other words, negligible. If someone were to eat 0.25 kg of this meat every day for one year, his internal radiation dose would reach only 0.7 mSv, still negligible.

This limit was often surpassed in mutton, however; and the farmers received compensation for destroying that meat, and for the special fodder they were forced to feed the sheep for months before slaughtering. Such a low limit could have destroyed the living of the Lapps, whose economy depends on reindeer, an animal whose special food chain is based on lichens. Because of this food chain, the reindeer meat in 1986 contained high concentrations of cesium-137, reaching up to 40,000 Bq/kg.

Contrary to the scare stories about a nuclear wasteland, the region around Chernobyl most "contaminated" with radiation, is now a magnificent nature preserve, with abundant flora and fauna.

In November 1986, the Norwegian authorities introduced a limit of 6,000 Bq/kg for reindeer meat and game. The ordinary Norwegian diet includes only about 0.6 kilograms of reindeer meat per year, and thus this limit was aimed to protect Norwegians against a radiation dose of 0.047 mSv/year! In 1994, the costs of this "protection" were evaluated: They reached over $51 million.

Sweden was no better. When the farmers near Stockholm discovered that the Chernobyl accident had contaminated the milk of their cows with cesium-137 above the limit of 300 Bq per liter imposed by Swedish authorities, they wrote to them and asked if their milk could be diluted with uncontaminated milk from other regions, until the limit were attained; for instance, by mixing 1 liter of contaminated milk with 10 liters of clean milk. To the farmers' surprise, the government's answer was no; the milk was to be discarded. This was a strange policy, as it had always been possible to use this dilution method for other pollutants in foodstuffs, just as we dilute the polluting fumes from fireplaces or ovens with the atmospheric air.

The Swedish authorities explained that although one could reduce the individual risk by diluting the milk, such dilution would increase the number of consumers, and thus the risk would remain the same, but be spread over a larger population.[3] This was a dogmatic application of the LNT assumption, and of its offspring, the concept of the "collective dose" (that is, reaching terrifyingly great numbers of "man-sieverts," by multiplying tiny, innocuous individual radiation doses by a large number of exposed people).

In an earlier paper, I demonstrated clearly the lack of sense, and negative consequences, both of this assumption and of the concept.[4] This dogmatic application of this faulty assumption meant that the costs of the Chernobyl accident probably exceed $100 billion in Western Europe.[5]

Unnecessary Evacuations

The most nonsensical action, however, was the evacuation of 336,000 people from the regions of the former Soviet Union where, during the years 1986-1995, the Chernobyl fallout increased the average natural radiation dose by 0.8 to 1.4 mSv per year; that is, by about 30% to 50%.[6] (The average natural radiation there is about 2.5 mSv per year.) The evacuation was based on radiation limits recommended by the International Commission for Radiological Protection (ICRP) in the "event of major radiation accidents," and on its recommendations for protection of the general population.

Note that these recommended limits were *tens to hundreds of times lower* than the natural doses of radiation in many countries. In the asphalt-paved streets of the "ghost town" of Pripyat, near Chernobyl, from which about 50,000 people were relocated, and where nobody can enter without special permission, the total external gamma radiation dose rate measured by a Polish team in May 2001 was 0.9 mSv per year; that is, the same as in Warsaw, and five times *lower* than at the Grand Central Station in New York City.

The evacuation led to development of mass psychosomatic disturbances, great economical losses, and traumatic social consequences. Obviously, the ICRP will never accept responsibility for the disastrous effects of this dogmatic application of its armchair lucubrations, which has caused the present system of "radiation protection" to become a "health hazard."[3]

The Lessons of Thyroid Prophylaxis

In Poland, upon my instigation, the government administered, within three days' time, a single dose of stable iodine to about 18.5 million people, in order to save the population from effects of exposure to iodine-131. This was the greatest prophylactic action in the history of medicine performed in such short a time. My medical colleagues and the Ministry of Health were rightly proud of the ingenious and innovative way they implemented this countermeasure. Recently, several countries, including the United States, took steps to follow our course of action in case of a nuclear accident.

However, now I see our action as nonsensical. We endeavored to save Polish children from developing thyroid cancers by protecting them from a radiation dose of 50 mSv to the thyroid gland.[7] At this dose, the ICRP recommended implementation of stable iodine prophylaxis. But in studies of more than 34,000 Swedish patients whose thyroid glands received radiation doses reaching up to 40,000 mSv from iodine-131, *there was no statistically significant increase in thyroid cancers* in adults or children, who had not already been thought to have cancer before treatment with iodine-131. In fact, an opposite effect was observed: There was a 38% *decrease* in thyroid cancer incidence as compared with the non-irradiated population.[8],[9]

In a much smaller British study of 7,417 adult hyperthyroid patients, whose thyroids received average radiation doses from iodine-131 reaching 300,000 mSv, there was a 17% deficit in incidence of all studied cancers.[10]

Without the stable iodine prophylaxis and milk restrictions that we instituted, the maximum thyroid dose would have reached about 1,000 mSv in about 5% of Polish children.[7] All that I would now expect from this dose is a *zero effect.*

Fourteen years after the Chernobyl accident, in the highly contaminated areas of the former Soviet Union, there has been no reported increase in incidence in solid cancers or leukemia, except for thyroid cancers. In its *2000 Report,* UNSCEAR stated that the "population need not live in fear of serious health consequences," and "generally positive prospects for the future health of most individuals should prevail."[6] There have been no epidemics of cancers in the Northern Hemisphere, as so direly predicted, from the LNT assumption, to reach tens and hundreds of thousands, or even millions of cases.

The number of 1,800 new thyroid cancers registered among the children from Belarus, Russia, and Ukraine should be viewed in respect to the extremely high occurrence of "occult" thyroid cancers in normal populations.[11-14] These cancers, which do not present adverse clinical effects, are detected *post mortem,* or by ultrasonography examinations. Their incidence ranges from 5% in Colombia, to 9% in Poland, 13% in the United States, and 35% in Finland.[12] In Finland, occult thyroid cancers appear in 2.4% of children 0-15 years old.[11]

In Minsk, Belarus, the normal incidence of occult thyroid cancers is 9.3%.[15] The greatest incidence of so-called "Chernobyl" thyroid cancers in children under 15 years old, was 0.027%, registered in 1994 in the Bryansk region of Russia. Note that this is less by a factor of about 90, than the normal incidence of occult thyroid cancers among Finnish children. The "Chernobyl" thyroid cancers are of the same type and are similarly invasive, as the occult cancers.[13]

The first increase of these cancers was registered in 1987, in the Bryansk region of Russia, one year after the accident. Since 1995, the number of registered cancers has tended to decline. This is not in agreement with what we know about radiation-induced thyroid cancers, the latency time of which is about 5 years after irradiation, and the risk of which increases until 15-29 years after radiation exposure.[6]

In the United States, the incidence rate of thyroid tumors detected between 1974 and 1979, during a screening program, was 21 times higher than before the screening,[16] an increase similar to that observed in three former Soviet countries. I believe that the increased registration of thyroid cancers in contaminated parts of these countries is a classical screening effect.

Actual Radiation Deaths

There were 28 fatalities caused by very high doses of radiation to rescue workers and employees of the power station, and 3 deaths in this group as a result of other reasons. Among 237 members of the reactor staff and emergency workers, who were initially examined for signs of acute radiation sickness, this diagnosis was confirmed in 134 patients. From among these patients, 11 died, as of 1998. The causes of death were as follows: three cases of coronary heart disease, two cases of myelodysplastic syndrome, two cases of liver cirrhosis, and one death each of lung gangrene, lung tuberculosis, and fat embolism. One patient, who was classified with Grade II acute radiation sickness (acute radiation dose of 2.2 to 4.1 Gray) died from acute myeloid leukemia.

A substantial increase in the incidence of leukemia among recovery operation workers was predicted, but the evidence for a measurable radiation effect on this incidence is somewhat mixed. The average standardized incidence ratio (SIR) for leukemia ranged—among these workers for Belarus, Russia, and Ukraine—from 0.94 to 7.76; but the problem is that a similar increase was found for chronic lymphatic leukemia, a subtype deemed not to be induced by radiation exposure. Contribution of a screening or diagnostic bias to these excesses cannot be excluded. The SIR for all cancers combined, in the recovery operation workers, ranged from 0.70 to 1.02 in Belarus; from 0.91 to 1.01 in Russia; and from 1.05 to 1.11 in Ukraine.

In the general population of the contaminated regions of Belarus, the SIR for leukemia was 0.46 to 0.62 (that is, 46-62% of the incidence level characterizing the whole population of Belarus); 0.93 to 0.99 in Russia; and 1.05 to 1.43 in Ukraine. In the general population of contaminated regions, the SIR for all cancers combined ranged from 0.30 to 0.69 in Belarus, from 0.89 to 0.98 in Russia, and from 0.80 to 0.82 in Ukraine.

Children in Poland taking stable iodine in a Lugo solution, after the Chernobyl accident in 1986, to prevent their thyroids from absorbing radioactive iodine. The author, who was involved in this precaution, points out that it turned out to be unnecessary.

Hence, the incidence of all cancers in the contaminated regions appears to have been lower than it would have been in a similar but unirradiated group.

The only real adverse health consequence of the Chernobyl catastrophe, among about 5 million people living in the contaminated regions, is the epidemics of psychosomatic diseases.[6] These diseases were not caused by irradiation with Chernobyl fallout, but by radiophobia, induced by years of propaganda before and after the accident, and aggravated by improper administrative decisions. As a result of these decisions, several million people in three countries have "been labeled as, and perceive themselves as, actual or potential victims of Chernobyl."[17] This was the main factor behind the economic losses caused by the Chernobyl catastrophe, which were estimated for Ukraine to reach $148 billion until 2000, and $235 billion until 2016 for Belarus.[17]

Victims of LNT Dogma

In 1986, most of my professional colleagues and I, the authorities, and the public in Poland and elsewhere, were pre-conditioned for irrational reactions. Victims of the LNT dogma, we all wished to protect people even against the lowest, near-zero doses of ionizing radiation. The dogma influenced the behavior of everyone, leading to a mass psychosis. In fact, with the efficient help of media and national and international authorities, Chernobyl quickly evolved into the greatest psychological catastrophe in history.[2] It seems that professionals, international and national institutions, and the system of radiological protection, did not meet the challenge of the Chernobyl catastrophe.

The following main lessons can be deduced from this accident.

(1) Ionizing radiation killed only a few, occupationally-exposed people. Because of the rapid decay of short-lived radionuclides, the Chernobyl fallout did *not* expose the general population to harmful radiation doses. On April 26, 1986, in the area covered by the dangerous radiation, near the burning reactor, the radiation dose rate reached 1 Gray per hour. (After one year, it decreased by a factor of about 3,000.) This area was limited to two patches, totalling together about 0.5 square kilometer, in an uninhabited location, and extending a distance of 1.8 kilometers from the burning nuclear reactor.

Several hundred meters outside the 1 Gray isoline, the dose rate dropped by 2 orders of magnitude, to a level of 0.01-0.001 Gray per hour. This is a completely different situation from the aftermath of a surface explosion of a 10 megaton nuclear bomb; in that case, the 1-Gray-per-hour isoline can reach a distance of 440 kilometers, and the lethal fallout can cover tens of thousands of square kilometers, and endanger the lives of millions of people.

(2) The reported excess of thyroid cancers in children and adults who were exposed to Chernobyl fallout is not consistent with the knowledge of the effects of medical use of iodine-131. The report of an "excess" appears to be an effect of medical screening, and consists only of a small fraction of the normal occult thyroid cancer incidence that occurs in populations unexposed to iodine-131.

(3) Radionuclides were injected high into the stratosphere, at least up to 15 kilometers altitude, which made possible their long-distance migration in the entire Northern Hemisphere, and a penetration over the Equator down to the South Pole.[18] With unique, extremely sophisticated radiation-monitoring systems in place in all developed countries, even the most tiny debris from the Chernobyl reactor was easily detected all over the world. No such system exists for any other potentially harmful environmental agent. Ironically, this excellent radiological monitoring capability ignited the mass anxiety, with disastrous consequences in the former Soviet Union, and the strangulation of nuclear energy development elsewhere.

(4) Psychosomatic disorders and screening effects were the only detectable health consequences among the general population. Fighting the panic and mass hysteria could be regarded as the most important countermeasure to protect the public against the effects of a similar accident, should it occur again.

(5) This was the worst possible catastrophe: of a badly constructed nuclear reactor; with a complete meltdown of the reactor core; followed by ten days of completely free emission of radionuclides into the atmosphere. Nothing worse could happen. It resulted in a comparatively minute occupational death toll—about half the death toll of each weekend's traffic accidents in Poland, and tens or hundreds of times *lower* than the number of deaths caused by many other industrial catastrophes. It is unlikely that any fatalities were caused by radiation among the general population.

In centuries to come, the Chernobyl catastrophe will be seen as a proof that nuclear power is a safe means of energy production.

Prof. Zbigniew Jaworowski is the chairman of the Scientific Council of the Central Laboratory for Radiological Protection in Warsaw. A multidisciplinary scientist, he has studied pollution with radionuclides and heavy metals, and he has served as chairman of the United Nations Scientific Committee on the Effects of Atomic Radiation.

A version of this article will appear in the Australian Radiation Protection Society Newsletter 2004, and in a compendium of papers about the environment and human health to be published by the International Policy Network.

Cited References

1. E.J. Calabrese, and L.A. Balwin, 2003. "Toxicology Rethinks Its Central Belief." *Nature,* Vol. 421 (February 13): pp. 691-692.
2. Z. Jaworowski, 1988. "Chernobyl Proportions"—Editorial. "Chernobyl Accident: Regional and Global Impacts." Special Issue of *Environment International.* Guest Editor Zbigniew Jaworowski Vol. 14, No. 2, p. 69-73.
3. G. Walinder, 1995. *Has Radiation Protection Become a Health Hazard?* Nykoping:The Swedish Nuclear Training and Safety Center, p. 126.
4. Z. Jaworowski, 1999. "Radiation Risk and Ethics. *Physics Today,* Vol. 52, No. 9, p. 24-29. Also "A Realistic Assessment of Chernobyl's Health Effects," *21st Century Science and Technology,* Spring 1998, pp. 14-25.
5. K. Becker, 1996. "Ten Years after Chernobyl." In ANS/ENS Conference Proceedings (Washington D.C., Nov. 10-14).
6. UNSCEAR, 2000. "Sources and Effects of Ionizing Radiation." United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR *2000 Report* to the General Assembly, with Scientific Annexes, United Nations: New York. p. 1220.
7. Z. Jaworowski, 1996. "Chernobyl in Poland: The First Few Days, Ten Years After," in *Zehn Jahre nach Tschernobyl, eine Bilanz* (Munich, Germany: Gustav Fisher Verlag, Stuttgart).
8. L.D. Holm, et al., 1988. "Thyroid Cancer after Diagnostic Doses of Iodine-131: A Retrospective Cohort Study." *Journal of the National Cancer Institute,* Vol. 80, N. 14, pp. 1133-1138.
9. P. Hall, A. Mattsson, and J.D. Boice, Jr., 1996. "Thyroid Cancer after Diagnostic Administration of Iodine-131." *Rad. Res.,* Vol. 145, pp. 86-92.
10. J.A. Franklyn, et al., 1999. "Cancer Incidence and Mortality after Radioiodine Treatment for Hyperthyroidism: A Population-based Cohort Study." *The Lancet,* Vol. 353 (June 19) pp. 2111-2115.
11. K.O. Franssila and H.R. Harach, 1986. "Occult Papillary Carcinoma of the Thyroid in Children and Young Adults—A Sytematic Study in Finland." Vol. 58, pp. 715-719.
12. H.R. Harach, K.O. Franssila, and V.M. Wasenius, 1985. "Occult Papillary Carcinoma of the Thyroid—A 'Normal' Finding in Finland. A Systematic Study," Vol. 56, pp. 531-538.
13. M. Moosa and E.L. Mazzaferri, 1997. "Occult Thyroid Carcinoma," *The Cancer Journal,* Vol. 10, No. 4 (July-August) pp. 180-188.
14. G.H. Tan and H. Gharib, 1997. "Thyroid Incidentalomas: Management Approaches to Nonpalpable Nodules Discovered Incidentally on Thyroid Imaging," *Annals of Internal Medicine,* Vol. 126, pp. 226-231.
15. A.W. Furmanchuk, N. Roussak, and C. Ruchti, 1993. "Occult Thyroid Carcinomas in the Region of Minsk, Belarus. An Autopsy Study of 215 Patients," *Histopathology,* Vol. 23, pp. 319-325.
16. E. Ron, J. Lubin, and A.B. Schneider, 1992. "Thyroid Cancer Incidence," *Nature,* Vol. 360, p. 113.
17. UNDP and UNICEF, 2002. *The Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery.* United Nations Development Programme (UNDP) and the UN Children's Fund (UNICEF) with the support of the UN Office for Co-ordination of Humanitarian Affairs (OCHA) and WHO, pp. 1-75.
18. L. Kownacka and Z. Jaworowski, 1994. "Nuclear Weapon and Chernobyl Debris in the Troposphere and Lower Stratosphere," *The Science of the Total Environment,* Vol. 144, pp. 201-215.

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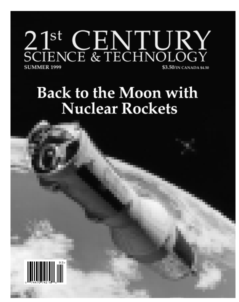

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