NUCLEAR RADIATION:

Living in the Shadow of Chornobyl

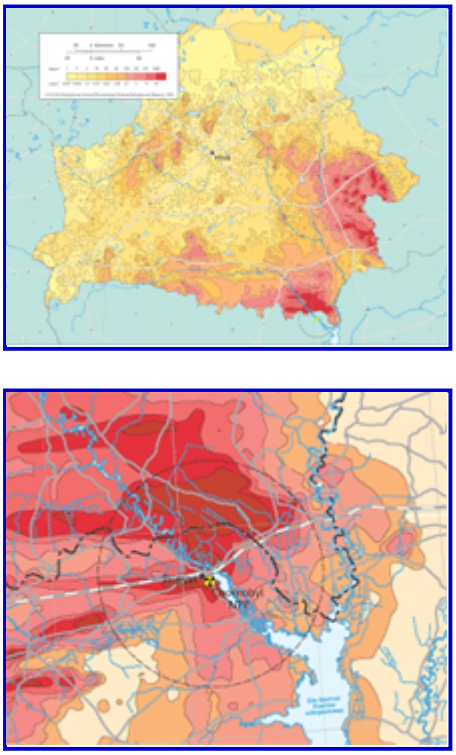
Richard Stone

Fifteen years after the world's worst nuclear accident, the entire population of Belarus is involuntarily taking part in a decades-long experiment on how radiation affects human health

MINSK, BELARUS, AND KYIV, UKRAINE--Early on a warm, sunny morning on 26 April 1986, Valeriy and Natasha Glygalo went to buy groceries at the open-air market of Pripyat, a Ukrainian town near the Belarusan border. Despite the splendid weather, Natasha began to feel strange: She had an odd, bitter taste in her mouth. Valeriy, a nuclear physicist and safety officer at the Chornobyl Nuclear Power Plant, missed that early clue to the unfolding disaster. "I was smoking and didn't taste anything," he says. Moments later, however, a babushka told them that an explosion had rocked the power station just a few kilometers south of Pripyat. With mounting dread, Valeriy rushed to the edge of town, where from the top of a bridge he could see clearly the gigantic duplex housing the plant's third and fourth reactors. Unit four lay in ruins, as if it had been bombed. Glygalo remembers staring numbly as flames, fed by the graphite rods that had moderated the fission reaction in the uranium fuel assembly, licked above the ruins and smoke poured into the sky. "We never conceived of something like this happening," he says. The fumes swept toward Pripyat and its 50,000 residents, who were inhaling the invisible radioactive particles that coated the town.

The world's worst nuclear accident had begun at 1:23 that morning, when Chornobyl's unit four exploded and sent a plume of radioactive particles 2 kilometers into the air. As the cloud raced northwest, it rained radioactive particles on a swath across Belarus, Poland, the Baltic nations, and into Scandinavia. Over the next 10 days, the reactor pit belched a staggering 100 million to 200 million curies of fission products, about 100 times the amount of radiation released by the atomic bombs dropped on Hiroshima and Nagasaki. Much of it settled on northern Ukraine, southern Belarus, and Russia's Bryansk region, defiling millions of hectares of land. The Chornobyl catastrophe, as it's called in Russian, triggered political unrest in Belarus and Ukraine and halted nuclear power projects, sparking an energy crisis that may well have applied the coup de grâce to a dying Soviet Union.

Chornobyl took a substantial human toll as well. Two plant personnel were killed instantly by the blast, while 28 firefighters and plant workers died horribly days later from radiation poisoning. In Belarus, more than 700 children under the age of 14 have been treated for thyroid cancer--a disease that occurs spontaneously in only one in a million children. "These are incredible numbers," says Japanese thyroid disease specialist Akira Sugenoya, whose 5-year stint working in Belarus has helped convince Western experts that the numbers are real and attributable to a massive exposure to radioactive iodine (see p. 425). Although the disease has one of the highest cure rates of any cancer, four Belarusan children are known to have died after their tumors spread to other organs. What's more, thyroid cancer cases among adolescents in Belarus are still on the rise.



Radioactive fallout. Deposition of cesium-137 in Belarus (above) and around the Chornobyl power plant. (Activity levels as of May 1986; Cs^{137} has a half-life of 30 years.

CREDITS: MODIFIED FROM EC/IGCE, ROSHYDROMET (RUSSIA)/MINCHERNOBYL (UKRAINE)/BELHYDROMET (BELARUS),1998)

Fifteen years after the Chornobyl explosion, some scientists fear that the worst is yet to come. Compared to the general population, rates of some noncancer diseases-- endocrine disorders and stroke, for instance--appear to be rising disproportionately among the roughly 600,000 "liquidators" who cleaned up the heaviest contamination in the plant's vicinity and entombed unit four's lethal remnants in a concrete sarcophagus. Whether people living in the shadow of Chornobyl remain at risk for health problems is a subject now under intense scrutiny. And at Chornobyl's epicenter, an international effort is about to embark on an unprecedented engineering project that aims to prevent further release of radionuclides from the sarcophagus (see p. 422).

Chornobyl still haunts the people of Belarus and Ukraine. "The psychological effects are devastating," says physicist Mikhail Malko of the Institute of Physical and Chemical Radiation Problems in Minsk. "Many women feel they will give birth to unhealthy babies or babies with no future. Many people feel they will die from Chornobyl."

Putting a lid on it

On a warm, cloudless day earlier this month, a German shepherd basks in the sun near the bridge leading from Pripyat to the Chornobyl Nuclear Power Plant. Other than the two Ukrainian soldiers guarding a post next to a red-and-white-striped gate that blocks unauthorized access to the town, the lazy dog is the only sign of life in this urban wasteland. The people are gone.

Within hours after Natasha Glygalo got a mouthful of bitter air 15 years ago, she, her son Roman, and nearly all other residents of Pripyat were whisked away by train to nearby Chernihiv or bused to other cities across Ukraine where they had relatives. Some 800 Chornobyl personnel, including Valeriy Glygalo, stayed behind to take stock and deal with the accident. Glygalo was not the only scientist who struggled to come to grips with

the enormity of what had occurred. "It was impossible to imagine that a reactor simply couldn't exist," says nuclear physicist Konstyantyn Rudya, who was working in Chornobyl's unit two reactor building at the time of the blast.

Although radiation monitors in Finland and Sweden had alerted the world to the explosion, Soviet authorities cast a shroud of secrecy over the cleanup and the subsequent studies carried out inside the evacuated "exclusion zone," roughly 30 kilometers in radius, around the power station. Running the show was the Soviet military and the country's premier nuclear research laboratory, the Kurchatov Institute in Moscow. Helicopters dumped sand and boron on the seething remnants of the reactor core to quench the fire--a strategy that backfired, because it raised the temperature so high that the nuclear fuel melted and released even more radionuclides into the environment. Thousands of soldiers dispatched to the zone performed tasks ranging from the mundane--bulldozing more than 1 million cubic meters of contaminated topsoil for disposal as nuclear waste--to the surreally brave: timed dashes onto the roof of the unit three building to shovel chunks of unit four's core into the maw of the destroyed reactor.

Abandoned. "No entry" sign near Gomel (*above*); Bartolomeevka's lonely cemetery, former supermarket, and World War II statue (*bottom photos*).

CREDITS: R. STONE

Besides putting a lid on reactor four, Communist Party officials studiously maintained a news blackout. But from the start, odd occurrences began to tip people off to what had happened. For example, researchers at the Institute of Genetics and Cytology (IGC) in Minsk had left some unexposed film on a lab bench the night before the accident. The next day, they found their film spotted. "We couldn't understand what happened until

we found out about the accident a few days later," when researchers began to whisper about a nuclear explosion, says IGC director Nikolai Kartel. "For a long time we just heard rumors."

A few days after muted celebrations to mark 1 May, recalls IGC geneticist Rose Goncharova, the institute's former director Lubov Khotylyova gathered her senior scientists and explained that the accident had been much worse than the government was letting on. While several institutes started investigating the harm inflicted on the Belarusan population, Khotylyova asked her staff to prepare a major research program on Chornobyl's effect on wildlife. By August, Goncharova and her colleagues were out collecting bank voles and other animals in central and southern Belarus (see p. 421).

Some institutes closer to the blast found themselves thrust into a scary new role. Located only 30 kilometers north of the exclusion zone, "our institute had a very bad fate," says Vladimir Baginsky, director of the Institute of Forestry in Gomel. A few days after the accident, a five-person team led by Ivan Bulavik hurriedly set up experimental plots near the zone and took plant and soil samples. The land was already becoming contaminated, but they would have something resembling baseline data when more fallout rained down in subsequent days. They risked their lives, says Baginsky: "Graphite was falling on them," he says, "but Bulavik would be too modest to admit this."

That May, Bulavik met with his Ukrainian and Russian counterparts to sketch out a research program on how the forests were affected by the huge doses of radioactivity. In the coming months, they discovered that the forests had concentrated far more radionuclides than had the surrounding farmlands, which were more readily cleansed by rain. "The forest played the role of a vacuum cleaner," Baginsky says. And contradicting models based on nuclear accidents in the Ural Mountains, the Gomel modelers predicted that radionuclide accumulation in the forests would worsen over time. By the mid-1990s, "we observed that the forest began to be contaminated more and more," as trees continued to soak up more radionuclides from the soil, says Victor Ipatyev, the former director of the forestry institute who 2 months ago was appointed president of the National Academy of Sciences of Belarus. He estimates that nearly 2 million hectares of forest are contaminated. Depending on prevailing winds, forest fires could spread the radionuclides far from contaminated areas.

Rehabilitating the forests seemed out of the question until a few years ago, when institute researchers found that certain forest undergrowth plants--such as raspberry and hazel--preferentially remove radionuclides from the soil, which in turn reduces contamination in the trees. These preliminary findings have not been put into practice yet.

Early on, such studies were kept under tight wraps by Soviet officials, who hammered home the message that only a few villages in northern Ukraine had been affected by the accident. Indeed, for nearly 3 years, it was forbidden in Belarus to even speak publicly about Chornobyl. The situation dramatically changed on 20 March 1989, when all the republic's newspapers simultaneously published maps depicting cesium contamination in Belarus, setting off a firestorm of anger and demonstrations against the party.

Unforeseen consequences

In a pine grove near the village of Bartolomeevka lies a peaceful cemetery, each gravesite surrounded by meter-high wrought-iron fences. No new graves will be dug here for some time, because all the residents of this tiny village 50 kilometers northeast of Gomel--like those of 400 other villages in Belarus--were resettled in less contaminated areas around 1990. But for the former residents of Bartolomeevka and other villages and towns downwind from Chornobyl, help came too late: They received heavy doses of radiation before they were moved out.

Perhaps the biggest surprise in the first few years after the explosion was that a spate of leukemia cases, predicted from Japanese atom bomb survivor studies, never materialized. "This was completely different from our expectations," says Vladimir Ostapenko, director of the Research and Clinical Institute of Radiation Medicine and Endocrinology in Minsk. "We were preparing not only scientifically but medically for leukemia." Most scientists now believe that the amount of cesium-137 absorbed by the general population was not high

enough to trigger leukemia, says endocrinologist Shunichi Yamashita of the University of Nagasaki in Japan, an expert with the Chornobyl Sasakawa Project. And although Russian scientists have found a higher risk for leukemia among the liquidators, some of whom received cumulative doses of up to 5 sieverts--10 times the radiation dose needed to suppress the immune system and blood cell production--many researchers say that better screening could account for these elevated numbers. "It occurred to us that judging what would happen based on pre-Chornobyl experiences was useless," Ostapenko says.

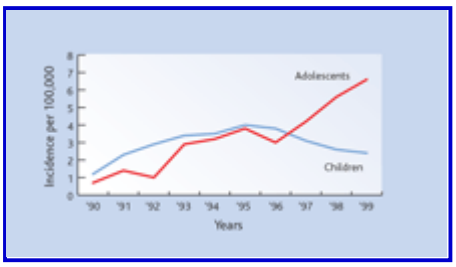
But there were unhappier surprises revealed by robust medical record keeping. Before the Chornobyl explosion, of the 15 former Soviet republics only one had a population registry of birth defects: Belarus. Since 1979, Gennady Lazjuk's Institute for Hereditary Diseases in Minsk has run the registry and thus had a good baseline for drawing comparisons between lightly contaminated regions such as Minsk (less than 1 curie per square kilometer), moderately contaminated regions (1 to 15 curies per km^2), and heavily contaminated regions (more than 15 curies per km^2). In all three areas, birth defects skyrocketed after Chornobyl: about a 50% increase in both the lightly and moderately contaminated regions, and 83% in the heavily contaminated regions. These birth defects include polydactyly--extra fingers or toes--and shortened limbs.

Western critics have pointed out that much of this rise in birth defects could be due to more assiduous screening after the accident, or from exposures to chemical pollutants. Lazjuk, along with collaborators in Japan and Europe, acknowledges that better screening undoubtedly pumped up the figures, and he doubts that any increases in birth defects seen in lightly and moderately contaminated regions were due to Chornobyl. But with Soviet industrial output falling off after the breakup of the Union in 1991, he dismisses the notion that chemical exposures played a role in the sharper rise in the most contaminated areas, which persisted until 1995. After eliminating confounding factors, Lazjuk's group concluded that radiation exposure accounted for a 12% increase in birth defects in the heavily contaminated areas. Western scientists had predicted rises of anywhere from 1.5% to 7%.

"Lazjuk's data are beautiful," says Goncharova, who notes that a major shortcoming is the dearth of data on how much radiation the parents absorbed. That makes it impossible to say with certainty that radiation was responsible. Nor is the picture likely to get any clearer: This year, the Belarus government did not come up with funds to support birth defects surveillance and research.

The thyroid mystery

The government waited more than a week to hand out iodine pills to people in the affected regions in an attempt to saturate the thyroid and prevent it from taking up radioactive iodine. By then, it was too late. Even so, "we didn't expect much of an increase in thyroid cancer," says Sir Dillwyn Williams, a thyroid cancer expert at the University of Cambridge in the United Kingdom. Radioactive iodine had been used extensively to treat Graves' disease, and studies showed no increased risk of thyroid cancer. And studies of Japanese atom bomb survivors and Marshall Islanders exposed to fallout from an atom bomb test suggested that a few additional cases of thyroid cancer might be seen about 10 years after the accident, which would fall off within a few years. Instead, the number of childhood thyroid cancer cases began rising within a year after the accident.



Puzzling numbers. Unexpected rise in childhood thyroid cancer is now showing up in adolescents, as exposed children turn 15.

SOURCE: THYROID CANCER CENTRE, RESEARCH AND CLINICAL INSTITUTE OF RADIATION MEDICINE AND ENDOCRINOLOGY, INSTITUTE OF PHYSIOLOGY, MINSK

This was so surprising, says Williams, that "there was a general reluctance in the West to believe the data." Some scientists attributed the rise to better screening, others to the misdiagnosis of benign nodules. Many Belarusan scientists are still unhappy with how the West viewed their data in those days. "People who thought that the increase in thyroid cancer was due to better screening were crazy," says Malko.

Few now doubt the trends. "We learned a lesson," says one Western expert. Although childhood thyroid cancer cases peaked in 1995, the incidence among adolescents has more than doubled since 1996. Because children are classified as adolescents when they turn 15, this group now includes all the children exposed to the radioactive iodine. There's fresh hope that the childhood and adolescent thyroid cancer wave is cresting. Yamashita and his colleagues studied 20,000 Belarusan children who were born in the 3 years before the explosion, were in the womb during the explosion, or were born 3 years afterward. Their findings, which will be presented at a Chornobyl anniversary conference in Moscow next month, show that thyroid cancer appears only in those born before the explosion.

The unusual dynamics of the thyroid cancer incidence are prompting a flurry of research. "The mechanism of this cancer has not been unveiled yet," Sugenoya says. To speed studies, Williams and Cambridge colleague Gerry Thomas, in collaboration with the governments of Belarus, Russia, and Ukraine, have set up a thyroid tumor tissue bank in each of the three countries. The tissue bank--sponsored by several heavyweights including the U.S. National Cancer Institute (NCI), the European Commission, the World Health Organization, and the Sasakawa Memorial Health Foundation--now holds DNA and RNA from more than 280 thyroid tumors from patients younger than 19 at the time of the explosion. "This will allow us to look for a specific signature of radiation-induced cancer," says Yamashita.

"All of our projects are addressing this mystery," says Ostapenko, whose institute is collaborating with NCI and various European centers to study thyroid cancer. "We have a sad joke," he says. "Why should people look for test animals for radiation research when there is a natural laboratory here·" Indeed, he and others are bracing for a Chornobyl-driven rise in breast and prostate cancer down the road.

In Belarus, this natural experiment is becoming harder to sustain, scientists say. Government funding for Chornobyl research is drying up, and earlier this month, as Belarus and Russia celebrated their 5-year anniversary as a union, researchers with the National Academy of Sciences learned that they would be receiving a 20% pay cut, to about $60 per month--endangering their ability to stay in science at all. They are reluctant to air their concerns publicly, fearing reprisals from the government of President Alyaksandr Lukashenka--so loathed by many researchers that rather than utter his name, they refer to him as "the top person in our government."

Researchers in Ukraine, meanwhile, have been more fortunate. With the country's economy booming, their salaries were doubled this year to $120 per month. And their government has aggressively courted Western support for Chornobyl research. In 1998, these efforts paid off with the creation of a radioecology laboratory in the exclusion zone and surrounding territories. Now Ukraine's Cabinet of Ministers is negotiating with China and Japan to launch a research center to study the population of Slavutych, a town built after the Chornobyl accident to accommodate the power plant's workers.

The center will probe the long-term health of residents, many of whom lived in Pripyat until the accident and received high radiation doses immediately after the explosion. Of particular interest to scientists are the 7000 or so Chornobyl engineers and scientists who work in and around the sarcophagus each day, and the 6000 to 7000 liquidators now living in Slavutych. "My dream is to have a research agreement ready by the end of this year," says Valeriy Glygalo, the one-time liquidator who is now director of the Cabinet of Ministers' International Chornobyl Center for Nuclear Safety, Radioactive Waste, and Radioecology in Kyiv. The residents of Pripyat

are gone, but they are clearly not forgotten.

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