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“The Long Shadow of Chernobyl”
National Geographic April 2006

1. How much more radiation did Chernobyl release than the bomb dropped on Hiroshima?
2. How many will die of cancer due to Chernobyl? Is this more or less than the initial estimate?
3. What led to the Chernobyl accident?
4. Who were the “liquidators”?
5. What type of childhood cancer rose dramatically in children who lived near Chernobyl?
6. What is the “exclusion zone”?
7. What is the most immediate threat to the sarcophagus?
8. What is the New Safe Confinement?
9. How many people now live in Prypiat?

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BY RICHARD STONE
 PHOTOGRAPHS BY GERD LUDWIG

In the wan light of a snowy spring morning, belongings scattered on the floor of an abandoned kindergarten speak of a time before the children of Pripyat lost their innocence. Musty sandals and ballet slippers for tiny feet. Cardboard pictures of Lenin as a young boy and as a youthful leader—the Soviet equivalent of baseball cards. In the next room, dolls in various states of dress and dismemberment, lolling on metal cots where the children once napped. Finally, on the gymnasium wall, photos of the children themselves—doing calisthenics, climbing monkey bars, balancing on boards.

Twenty years ago this month, life in Pripyat came to a shuddering end. Before dawn on April 26, 1986, less than two miles south of what was then a city of 50,000, the Chernobyl Nuclear Power Plant's number four reactor exploded. Thirty people died in the blast and fire or were exposed to lethal radiation. The destroyed hulk burned for ten days, contaminating tens of thousands of square miles in northern Ukraine, southern Belarus, and Russia's Bryansk region. It was the worst nuclear accident the world has ever seen.

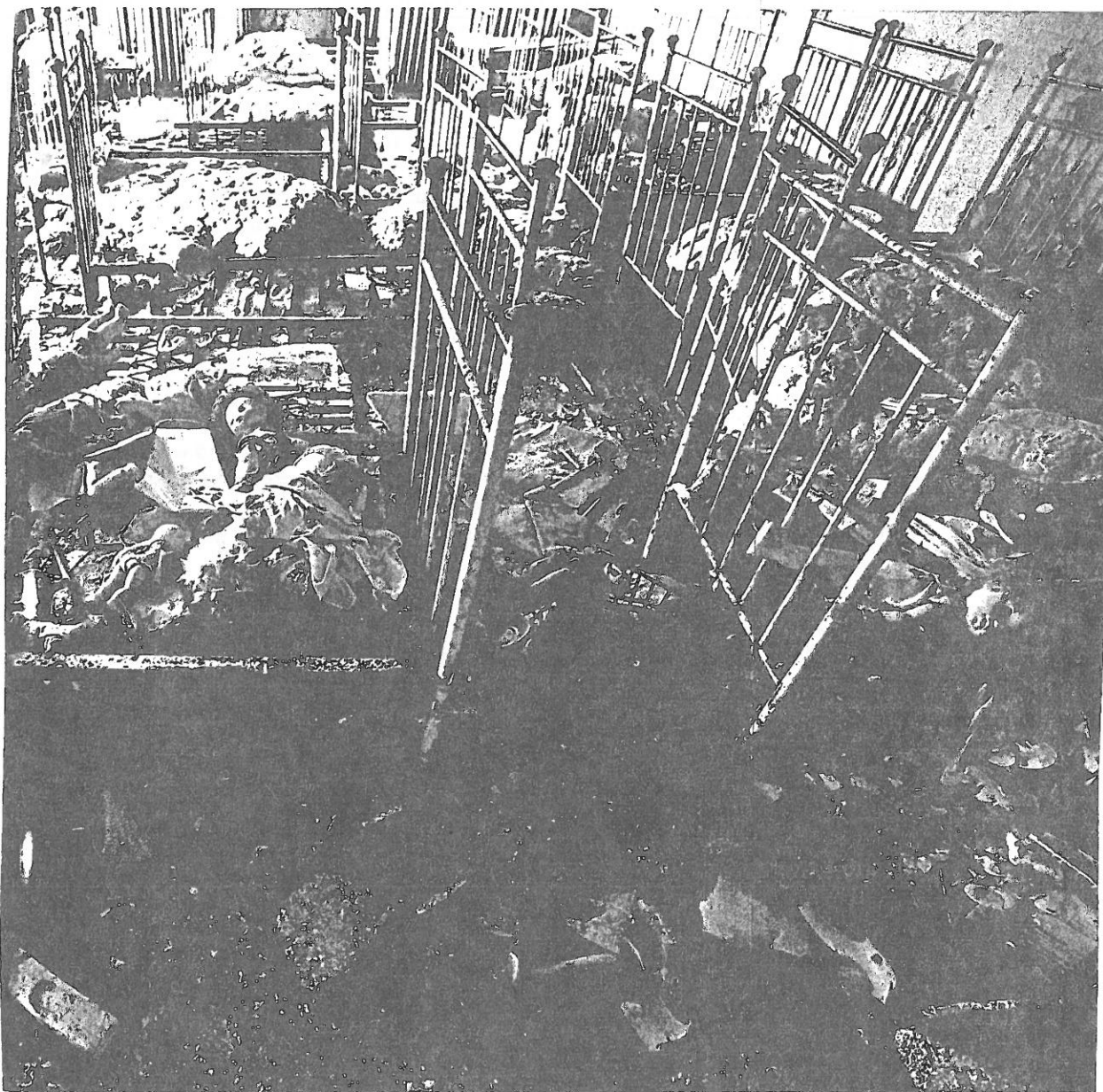
The fallout, 400 times more radioactivity than was released at Hiroshima, drove a third of a million people from their homes and triggered an epidemic of thyroid cancer in children. Over the years, the economic losses—health and cleanup costs, compensation, lost productivity—have mounted into the hundreds of billions of dollars. As evidence of government bungling and secrecy emerged in its wake, Chernobyl (or Chornobyl, as it is now known in

independent Ukraine) even sped the breakup of the Soviet Union.

Today the fiercely radioactive remnants of reactor four continue to smolder beneath the so-called sarcophagus, a decaying concrete-and-steel crypt, hastily built after the accident, that now threatens to collapse. Work is about to get under way on a replacement: an arched structure, the size of a stadium, that will slide over the sarcophagus and seal it off. With its completion the destroyed reactor will be out of sight. But for the



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SILENT NURSERY On the day of the disaster, children oblivious to the nuclear accident played in this kindergarten in Pripyat, the reactor's company town. They were evacuated the next day.

region's people it will never be out of mind, as a slow-motion catastrophe continues to unfold.

Early estimates that tens or hundreds of thousands of people would die from Chernobyl have been discredited. But genetic damage done 20 years ago is slowly taking a toll. No one can

be sure of the ultimate impact, but an authoritative report estimated last year that the cancer fuse lit by Chernobyl will claim 4,000 lives. Alexei Okeanov of the International Sakharov Environmental University in Minsk, Belarus, who studies the health effects of the accident, calls it "a fire that can't be put out in our lifetimes."

Yet Chernobyl's most insidious legacy may be the psychological wounds borne by those who fled blighted homes, and by the several million who continue to live on contaminated land. "The

psychological effects have been devastating," says Mikhail Malko, a physicist in Minsk. "Many women feel they will give birth to unhealthy babies or babies with no future. Many people feel they will die from Chernobyl."

Olesya Shovkoshitnaya doesn't know whether to blame Chernobyl for her terrible headaches and the fact that, she says, "sometimes I forget everything." But she has fond memories of growing up in Pripjat, built in the 1970s for the Chernobyl plant's personnel. "It was fantastic. It was a warm town, lots of trees, roses," she says over a bowl of the cherry dumplings called *vareniki* in Kyiv, about 70 miles south of Chernobyl, where she now lives. "We had sport classes. I played handball, swam, played checkers. We had music. I was in choir. I enjoyed my childhood."

That life ended when Olesya was ten. At 1:23 a.m. that April morning, technicians botched

a routine safety test on reactor four. The graphite-core reactor, a Soviet design, had an inherent instability, and in seconds the nuclear chain reaction raced out of control. The reactor's cooling water flashed into steam, blasting apart the fuel rods. Western reactors are sealed inside heavy steel and concrete shells, but this one had little to contain the explosion. It blew off the roof, scattered the guts of the reactor around the building, and ignited a raging fire in what was left of the graphite core.

Olesya's mother, a technician at the plant, reported to work as usual that morning, several hours after the accident. Olesya went off to school. "It was hot that day, real summer," she recalls. At school, "people were gossiping. We were shut indoors. I couldn't understand why." After their lessons the children were told to go straight home and not to linger outside playing.

Olesya's mother returned in the afternoon and

CHERNOBYL'S DEADLY FOOTPRINT

Windblown fallout like the plume shown below fell thick near the reactor, forcing the evacuation of more than a thousand square miles straddling the Ukraine-Belarus border (right). High-altitude winds swept radioactive smoke and ash across a wider area (map, lower right), which scientists traced from soil levels of cesium 137, a long-lived isotope.

RADIATION RELEASE

After the initial explosion of the reactor, emergency workers tried to smother the fire with materials like sand and lead. But the next day, the material was ejected in a smaller blast that sent a plume of radioactive particles toward the town of Pripjat (below).

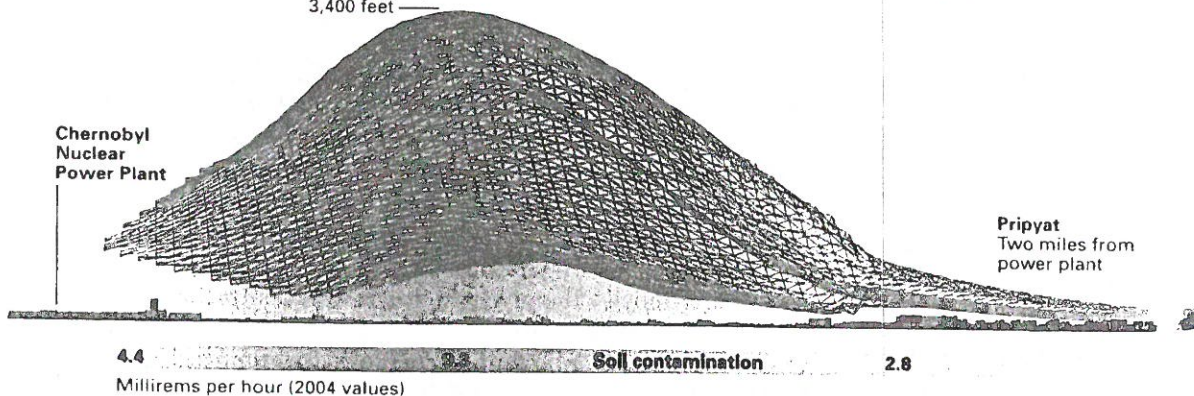
Local fallout plume
3,400 feet

THREATENING CLOUD

Scientists combined recent measurements of soil contamination with wind data from the time of the accident to create a computer model of the local radiation plume. The red shows how the particles rose and spread before falling to the ground.

NEAR MISS

Favorable winds kept this concentrated cloud of radioactive particles away from Pripjat, a city of 50,000 plant workers and their families, who had not yet been evacuated. If the city had suffered a direct hit, thousands could have fallen sick or died.

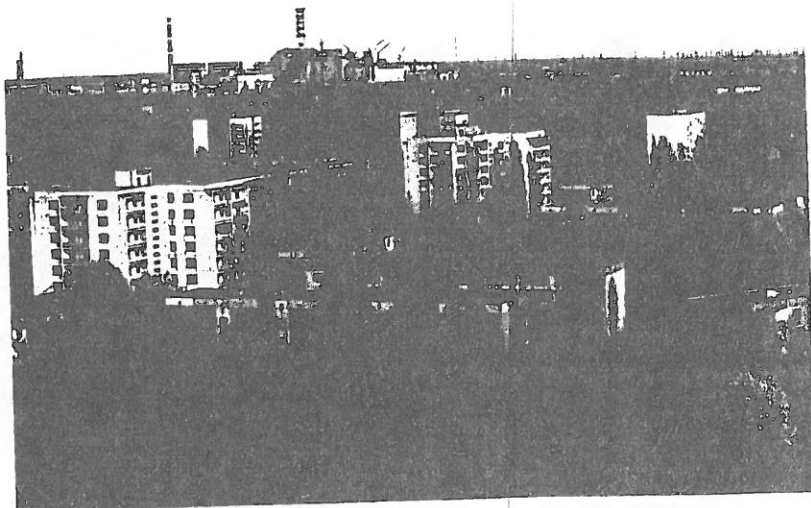


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GRIM LABORATORY

The abandoned city of Prip'yat today is used to study urban fallout patterns. Why? Chernobyl resembled a giant dirty bomb, which spreads radiation with a conventional explosion.



PLUME DATA: RONALD CHESSEY, TEXAS TECH UNIVERSITY, AND BRENDA RODGERS, WEST TEXAS A&M UNIVERSITY; ART BY DON FOLEY; LANDSAT IMAGE: UKRAINIAN LAND AND RESOURCE MANAGEMENT CENTER; CESIUM 137 DATA: INTERNATIONAL ATOMIC ENERGY AGENCY; NGM MAPS

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closed the windows. A city worker came by with iodine tablets, a prophylactic against radioactive iodine 131. Mom also gave Olesya a shot of vodka, widely believed in Soviet lands to protect against radiation. Her father, an engineer, returned that day from Moscow, where he had passed a doctoral exam. His thesis, ironically, was on the odds of a catastrophe at a nuclear power station. On his way home, he told Olesya later, he saw children splashing in puddles where the road had been hosed down. He pleaded with them to get indoors. They were drenching themselves with radiation.

In a radio broadcast the next morning, officials announced that there had been an accident and the town would be evacuated. That day 1,100 buses from across Ukraine lined up in Pripjat. By 5 p.m. the city was empty.

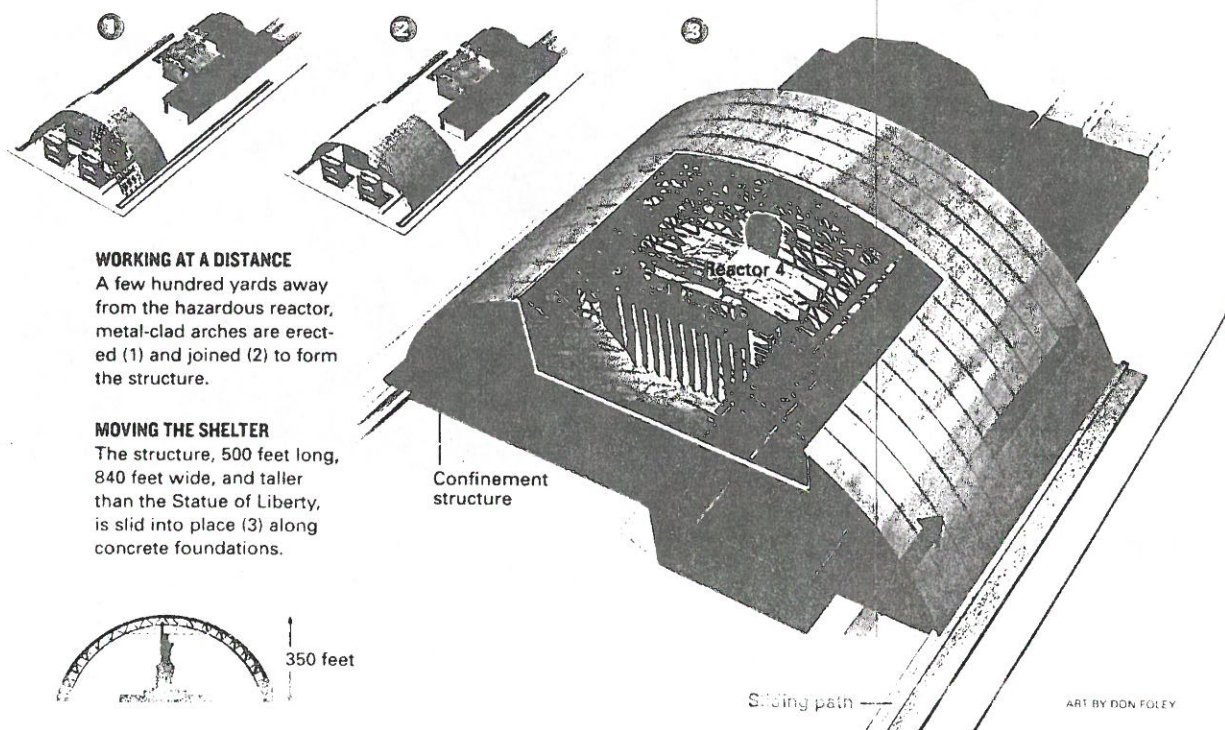
Nineteen years later, in 2005, a shivering crowd attends a midnight vigil in Slavutych, a city built

in the late 1980s as a replacement for Pripjat. Thirty miles away, it housed workers who tended the remaining three Chernobyl reactors until they were shut down, the last of them in 2000. Etched in black marble in the central square are the names and faces of the disaster's first victims. Two plant workers, Valery Khodemchuk and Vladimir Shishenok, died from the blast and fire. The others, 22 plant workers and six firefighters, were exposed to colossal radiation doses and succumbed within months. As an Orthodox priest chants and a choir hymns *Gospodi, Gospodi, Gospodi*—my God, my God, my God—family members solemnly set wreathes and candles under the engravings of their loved ones.

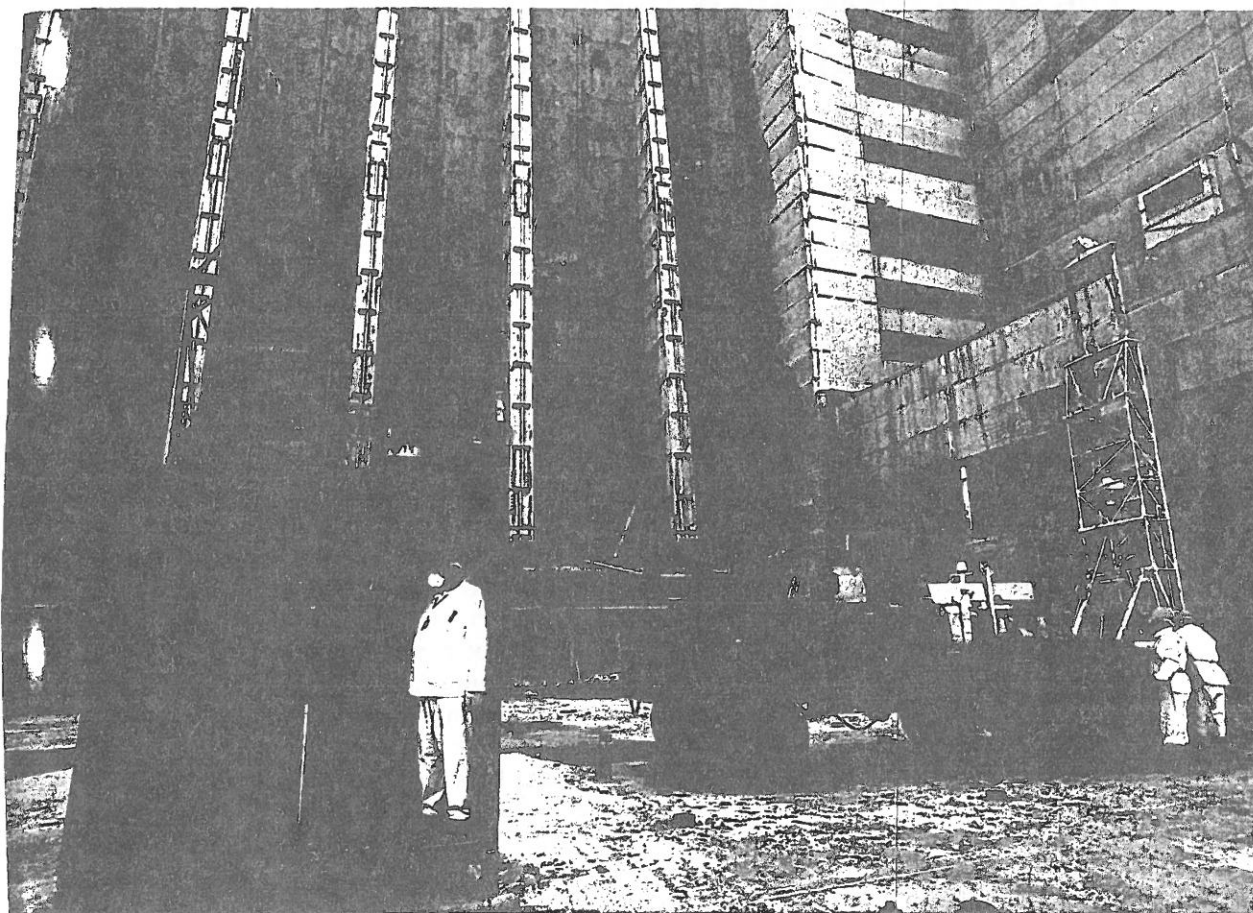
During the days after the explosion thousands of other workers, called liquidators, were rushed to Chernobyl to tame the radioactive inferno. Coal miners dug underneath the seething core

ENTOMBING THE REACTOR

A new Chernobyl disaster could result if the fragile old sarcophagus collapses. Already it leaks rain and melted snow, which further weaken the structure. But starting as early as this year, engineers will begin work on a movable hangar-like structure, expected to cost 800 million dollars, that will safely isolate the ruin until a permanent solution can be found.



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to allow liquid nitrogen to be pumped in and cool the nuclear fuel. Helicopter pilots dumped 5,000 tons of lead, sand, clay, and other material in an effort to douse the flames. Soldiers made timed dashes onto the roof to shovel smoking graphite blocks blown out of the reactor back into the core. Referred to, sardonically, as “bio-robots,” many of the 3,400 surreally brave men who took part in this operation absorbed a lifetime radiation dose in seconds.

On May 6 the fires in the mangled reactor were finally extinguished, and an army of liquidators went to work building the sarcophagus and consolidating radioactive waste at several hundred dumps near Chernobyl. In those early days doctors monitoring the liquidators watched white blood cell counts drop and feared for their health. Most recovered.

But now a new wave of ailments may be striking the 240,000 men and women who worked on the front lines of the disaster. Cataracts, a

LOOMING THREAT Beneath the buttressed western wall of the sarcophagus—one of the shakiest parts of the reactor enclosure—a worker ducks into a lead-lined booth during a moment of downtime to minimize radiation exposure.

hallmark affliction of atom-bomb survivors in Japan, are on the rise. More worrisome, a study of Russian liquidators blamed the accident for 230 “excess” deaths in the 1990s—from heart disease as well as leukemia and other cancers.

The connection between Chernobyl and heart disease is controversial. Blasts of radiation can damage blood vessels, but some scientists believe the elevated rate of heart disease among the liquidators is more likely the result of heavy drinking and smoking, stress, and a poor diet. The cancer spike among the liquidators, however, was long expected, and the smattering of cases so far could be just the beginning. Jacov Kenigsberg, the chairman of the National Commission of

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**"The shelter was and is risky.
It's a threat to people working here, to the
residents, and to the environment."**

Radiation Protection of Belarus, notes that it took 20 to 25 years for some radiation-induced cancers to appear in the atom-bomb survivors. "We can say that we're on the beginning of the road."

The millions of ordinary people who had the bad luck to live downwind of Chernobyl are also at risk. The initial explosion rained radioactive material to the west of the reactor, sparing Pripjat a direct hit while killing a swath of pines that became known as the Red Forest for the eerie red needles of the dead trees. "The winds were very, very fortunate," says Ronald Chesser, an ecologist at Texas Tech University who is studying the plume as a model of what might happen if a radioactive dirty bomb exploded in an American city.

Then, as the reactor burned out of control, winds swept the cloud north. Seventy percent of the radioactivity drifted into Belarus, contaminating nearly a quarter of the country. Yet the Soviet government left people there in the dark. While children in Pripjat were taking iodine pills hours after the explosion, authorities in Belarus did not begin distributing pills for a week or more. All that time children were drinking milk laced with radioactive iodine 131 from cows that had grazed on contaminated grass. The short-lived, powerful isotope made its way to the thyroid gland, which has an affinity for iodine.

Starting in 1990, Alexei Okeanov and others observed the consequences: a sharp rise in childhood thyroid cancer. "It was absolutely obvious it was due to Chernobyl, but it was very hard to prove," Okeanov says. Before Chernobyl, Belarus had two or three cases a year in children under the age of 15. In 1995 there were 90 cases. To date about 4,000 children and teenagers in Belarus, Russia, and Ukraine have been diagnosed with the cancer, the largest fraction of them from Homyl, a heavily contaminated region of Belarus just north of Chernobyl. Although thyroid cancer has one of the highest cure rates of any

malignancy, at least nine children died when their tumors spread, and survivors must spend a lifetime on medication.

Now that a generation has passed since the accident, thyroid cancer is once again rare in children. But in adults the incidence may be rising. Okeanov says Belarus's national cancer registry also shows a rise in colon and bladder cancer in Homyl, although some experts think better surveillance after the accident may explain at least some of the cancer increases.

A report last year from the Chernobyl Forum, a group of experts convened by the International Atomic Energy Agency, the World Health Organization, and other United Nations agencies estimated that among the millions exposed to Chernobyl's radioactive cloud, nearly 4,000 will ultimately die from leukemia and other radiation-induced cancers. It's a measure of the health fears immediately after the accident that this number comes as a relief.

The impact of Chernobyl does not end with cancer deaths. In the early days "we never anticipated the psychological toll on the survivors," says Mikhail Balonov, the Chernobyl Forum's scientific secretary. Believing they are doomed, some live in fear, while others pursue a devil-may-care lifestyle: eating mushrooms and berries from contaminated soil, abusing alcohol, or engaging in unprotected promiscuous sex.

Adding to the suffering is the displacement of hundreds of thousands of people, who were either evacuated from the most heavily contaminated regions or fled on their own. Olesya Shovkoshitnaya, evacuated from Pripjat at ten, says life as a "Chernobyl child" hasn't been easy. "I was so depressed afterward," she says. Her family stayed with relatives in eastern Russia for three months before being allotted a spacious apartment in Kyiv and enough cash to buy furniture.

Not surprisingly, their new neighbors resented the torrent of evacuees and the preferential treatment they received as official Chernobyl

victims. "Some people really hated us," says Olesya. "They said, we are living in a contaminated zone as well. But they got no compensation." Even today Ukraine and Belarus spend some 5 percent of their national budgets on Chernobyl, mostly on cash, holiday trips, and other benefits for the millions of registered victims.

Those who stayed behind still inhabit a contaminated landscape. The two most pervasive radionuclides from Chernobyl, cesium 137 and strontium 90, will remain in the environment for decades. Schools and other public buildings in southern Belarus are regularly washed down. Fields are fertilized with potassium to limit the uptake of cesium into crops and lime to block strontium. Lengthy regulations spell out what should be grown in which soils (only potatoes in peat but a wider range of crops in clayey soils, which lock up radionuclides). The most contaminated land—several hundred thousand acres—still lies fallow, though the government of Belarus is taking steps to reclaim it.

At a gate and guardhouse 18 miles from the reactor, cultivation stops entirely. Fields give way to forest, dark, fragrant, and still unsettling on my fourth visit in ten years to the exclusion zone, a tightly controlled area almost twice the size of Luxembourg. The first time, in 1995, a dog pranced up as I waited for guards to inspect my papers. I felt a stab of pity: A huge tumor had deformed its jaw. As the dog got closer, though, I realized that my

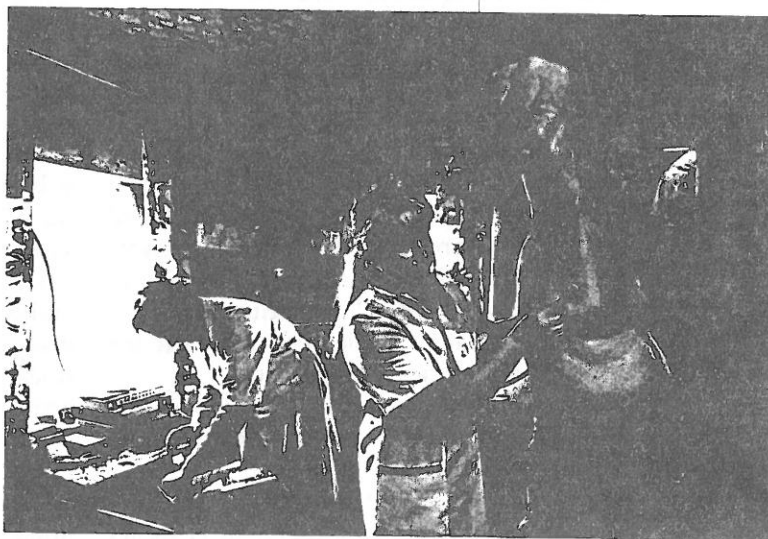
anxiety about radioactivity had played a trick on me. The tumor was really a chunk of asphalt the dog was carrying in its mouth.

At the center of this accidental wilderness stands the sarcophagus, naval gray and malignant, and rustier than I remember. Built in six months, it was planned to last at most 20 years. One beam supporting the corrugated steel roof rests precariously on a severely damaged wall of the reactor hall, while the western side of the structure has bulged several inches. None of the joints were welded: Workers couldn't get close enough. Any of a number of freak scenarios—an earthquake, a tornado, a heavy snow—could bring it crashing down. Or the sarcophagus, also known as the shelter, could simply collapse on its own.

This fragile shelter holds an estimated 200 tons of nuclear fuel, some of it in the reactor core and some in an unearthly radioactive "lava"—fuel rods, concrete, and metal that melted together in the inferno and oozed into the warren of rooms beneath the reactor. There's enough enriched uranium and plutonium in the hulk for dozens of atomic bombs.

But the immediate threat is water. A few years ago workers measured more than a thousand square yards of cracks and holes in the sarcophagus, which were allowing rain and melted snow to pool in its bowels. The water further weakens the structure, and it seeps out into the environment, carrying radioactive contaminants. Water can also act as a nuclear moderator: a substance

SWEET HOME Ivan Martynenko (left) and his wife have come home to their village near Chernobyl. Roughly 350,000 people were forced to evacuate after the explosion. Now, disaster be damned, some 400 elderly people have returned. At first Ukrainian officials discouraged them. But when it became clear they meant to die at home, medical care (right) and other services were provided.



"The psychological effects have been devastating. Many women feel they will give birth to unhealthy babies or babies with no future."

that aids a chain reaction. Though the risk is deemed minute, a renewed chain reaction could trigger another steam explosion, blowing open the sarcophagus, scattering chunks of fuel, and releasing tons of fine radioactive dust.

On the night of June 26, 1990, after two weeks of heavy rain, detectors in one lava-filled room registered a sharp rise in neutrons, a sign of an impending chain reaction. Four days later, a physicist from a technical center in the old town of Chernobyl, ten miles away, dashed in to pour neutron-quenching gadolinium nitrate on the lava. The neutrons subsided.

Similar selflessness over the years has taken a heavy toll. The technical center, run by the Ukrainian Academy of Sciences, is the home of the "stalkers," scientists who work in the sarcophagus, exposing themselves to high levels of radiation as they monitor the state of the reactor fuel. Near the entrance is a list of several dozen who have died, many in their 40s and 50s, many from cancer or heart disease. I recognize one, Edward Denisenko, whom I'd met a decade ago, and recall him musing about who in their right mind would want to work at Chernobyl. "If people from the West and Russia don't want to come here," he had asked, "who will? God? The devil?"

In the past two years 90 percent of the gaps have been plugged, and a new sprinkler system dispenses gadolinium in the central hall. Most rainwater is pumped out, though some is allowed to linger to suppress dust. But Yuliya Marusych, who works in the nuclear plant's information department, says flatly, "The shelter was and is risky. It's a threat to people working here, to the residents, and to the environment."

Marusych, a chain-smoker whose brown hair is dyed ginger red, takes me inside for a look. Radiation dosimeters in our pockets, masks on our faces, we pass through a series of corridors to a checkpoint where a plant engineer shows me a diagram marked with radioactivity levels. The hottest recorded spot in the sarcophagus,

at 3,400 roentgens an hour, would deliver a lethal dose in a few minutes.

The deepest that Marusych can take me is the control room of reactor four (pages 32-3). It was here 20 years ago that night-shift operators watched in horror as the chain reaction spiraled out of control. Though the ceiling tiles are gone, exposing pipes and a mass of wires and cables, the instrument boards are intact. Five years ago, the room was doused with a pink decontamination solution. Where the residue clings to the walls it looks disturbingly like blood.

This haunting monument will ultimately be dismantled. After ten years of complicated negotiations, work is expected to start later this year on a new sarcophagus, developed by the Battelle Memorial Institute, Bechtel Group, Électricité de France, and the Chernobyl Nuclear Power Plant. Longer than a football field, taller than the Statue of Liberty, costing perhaps 800 million dollars, the so-called New Safe Confinement (NSC) is designed as a giant steel arch. For safety, it will be built at a distance from the sarcophagus and then slid into place. It will be the largest moveable structure ever built.

Construction is expected to take four to five years, and it won't be easy. After the accident, reactor fuel and radioactive waste were buried haphazardly around the sarcophagus, where workers will have to excavate to build the NSC's foundation. "Who knows what we'll find down there," says project engineer Fabien Sauvadet.

Once the NSC is in place, remotely operated cranes will allow engineers to painstakingly dismantle the old sarcophagus. But the shattered reactor and its tons of nuclear fuel, far too radioactive to handle even from a distance, will stay where it is for now.

Away from ground zero, wildlife has reclaimed the hundreds of square miles of abandoned land in the exclusion zone. More than a hundred wolves prowl the forest, endangered black storks and

LIFE ENDURES A tree grows in a Pripyat school abandoned two decades ago. Nature is slowly dismantling the city even as the Chernobyl evacuation zone thrives with plant and animal life. It's a stark but perhaps hopeful contrast to the fear-plagued lives of the people who survived the world's worst nuclear accident.

white-tailed eagles nest in the marshes, and several dozen Przewalski's horses, a rare breed that went extinct in the wild decades ago, are thriving after being released here in 1998. Pines are even reclaiming the Red Forest, though patches of lingering radioactivity have left them stunted and deformed, with unnaturally short or long needles and clusters of buds where normally there would be just one. This radiation-warped forest is an anomaly. On the whole, ecologists marvel at how resilient nature has proved to be in the face of radiological adversity.

So have people. The exclusion zone was vacated after the Chernobyl explosion. But within months some residents were drifting back, in defiance of Ukrainian authorities. Today 400 mostly elderly people live in the decaying wooden villages that dot the zone, and the government has mellowed enough to provide electricity and bus service to nearby towns for shopping.

In the village of Opachichi, population 19, a rooster and hens strut next to the weathered cottage of Anna and Vasily Yevtushenko. She has just turned 70; he's 66. Vasily, dressed in gray trousers and a plaid lumberjack-style shirt, does most of the talking. We stand in a corner under a painted wooden icon of the Virgin Mary and glance through a photo album. "This is our daughter," Vasily says, and then, pointing to the opposite leaf, "this is our cow."

A week after the accident, Anna and Vasily were evacuated to a village a hundred miles away. "We didn't enjoy the place; the climate was wrong," Vasily says. Two years later they reclaimed their cottage in Opachichi. "We have everything we need," Vasily says, including home-brewed vodka.

Vasily shows me the results of blood tests he and Anna took in 2004. Everything looks normal. "If there was something, we would have already died," he says. Anna chimes in. "People ask me why I am not afraid," she says, smiling a mouthful of gold fillings. "I say this is my own house. I get up in the morning, I have chores to do. That's all."



If Opachichi is a living relic of a nuclear nightmare, Pripjat is more like the clock found in the rubble of Hiroshima, its lifeless hands forever stuck at the moment of detonation. After passing through a checkpoint with a red-and-white-striped gate to deter looters and the merely curious, I meander through what was once a tidy town. Rows of white and pastel apartment blocks stand vacant, their windows dark and their lower stories overgrown. Near a kindergarten and a sports complex with a swimming pool, now



empty and debris-strewn, that Olesya recalled from her childhood stands a rusted Ferris wheel, its yellow cars groaning in the wind. It had been built just in time for May Day 1986.

The Energetik cultural palace, a grand hall where dances and concerts were held, presides over a desolate square. Poplars are pushing up through the pavement. Moss in the cracks sets a Geiger counter chattering. Although rains have cleansed some surfaces, a skein of hot spots will keep this soulless shell radioactive for a lifetime.

"What's so spooky about standing in the heart of Pripyat is not the destruction to the concrete and steel," says Ron Chesser. "It's the lack of people, the silence." Over time, the radionuclides will run through their half-lives, the survivors' fears will fade. But this loneliness knows no cure. □

✎ **After the explosion** Revisit Chernobyl with photographer Gerd Ludwig in a multimedia show and share your thoughts on whether we are prepared for another nuclear disaster at ngm.com/0504.