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NATIONAL GEOGRAPHIC



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Like a warming wind, glasnost—openness—sweeps across the Soviet Union's vast outback, and Siberians in unprecedented numbers speak out against the misuse of their rich storehouse of natural resources. From journalists to reindeer herders to local officials, they seek more control over the environment and destiny of this frontier, an area slightly larger than the United States. Mike Edwards and photographer Steve Raymer report.

Last Days of the Gulag? 40

As the Soviets dismantle their notorious "correctional" labor camps and open their prison system to greater scrutiny by the world, French writer Jean-Pierre Vaudon and photographer Pierre Perrin visit Perm 35, a camp in the Ural Mountains.

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Soviet Union Map

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Strange drawings on a desert floor, oddly aligned stone columns, a peculiar trough carved beneath a small window . . . what do they mean? John B. Carlson, a specialist who weds archaeology to astronomy, looks to the cosmos for answers to some age-old puzzles. Photographs by Bob Sacha.

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While most of us are obsessed with keeping track of it, scholars debate what time actually is. John Boslough and photographer Bruce Dale tell the story of a concept that we think we understand until we try to define it.

Cover: At a campsite on the tundra a Nentsy woman chops wood. Nomadic reindeer herders, her people fight for a way of life as oil and gas development spreads above the Arctic Circle in Siberia. Photograph by Steve Raymer.



SOUP TIME IN A GULAG CAMP



GOLD TREX



CALENDAR ON A STRING



TINY TIMEPIECE



SIBERIA

By MIKE EDWARDS NATIONAL GEOGRAPHIC SENIOR WRITER



Young Nentsy reindeer herders welcome a supply helicopter in the frigid north of Siberia, a region yielding its enormous wealth only through heroic efforts.

In from the Cold

Photographs by STEVE RAYMER NATIONAL GEOGRAPHIC PHOTOGRAPHER





Survivor of a tragic life, 79-year-old Dusya Muravyeva lives alone in this small cottage on the Angara River near Lake Baykal. She lost two husbands and three children to war and disease. Harsh conditions have held the population to only 25 million in Siberia, a land about the size of the United States.

Like giant boxcars, apartment buildings sit on the permafrost in Novyy Urengoy atop the world's largest producing natural gas field. To the Soviet Union, Siberia is still a vast Alaska-like frontier, where such cities seemingly spring up overnight to support workers who tap the region's mineral deposits.





In their haste for development, Soviet officials often skimp on necessities for newcomers. When the government failed to provide housing in the town of Berkakit for workers building a leg of the Baykal-Amur Mainline Railroad, these men scavenged enough lumber for this dwelling that lacks running water.





CONSIDER the reindeer. "A good animal, a well-meaning animal," Georgi Kadyrov says. He adds affectionately, "It should live in heaven." It will pull a sled. As coats and tents, its fur warms in deepest winter. Its flesh is tasty, and its bones yield buttons and knife handles. Some Asians believe a powder of its antlers will make an old man young.

Georgi Kadyrov, a slight gentleman, lightly bronzed, is director of the Yamalski State Farm on the Yamal Peninsula, a thumb of tundra beyond the Arctic Circle in western Siberia (some thumb: It is nearly as large as New York State). Here his people, the Nentsy, have herded reindeer for centuries uncounted. When Soviet collectivization reached Arctic Siberia, the Nentsy were organized into work units, each bossed by a *brigadir*. But the work scarcely changed; the Nentsy still roamed, living in tents with their loyal huskies, following the reindeer to patches of lichen.

"You should not offend the reindeer," Georgi Kadyrov adds, very seriously. "You should keep him happy." But the making of great unhappiness, for man and beast, is upon the Yamal Peninsula. Beneath its permafrost and under the adjoining Kara Sea lie trillions of cubic feet of natural gas—the world's biggest deposits, say Moscow experts. So fragile is the Yamal, almost like an iceberg with a green skin stretched over, that some scientists believe intensive development may cause the peninsula to melt away.

All the same, helicopters brought geologists with tundra-ripping tractored vehicles. A railroad inched northward. Plans went forward for docks, housing, roads, drilling pads, borrow pits, gas-cleaning plants, electric power stations, compressors—all the vast facilities needed for a major field.

Energy is a major concern in the Soviet Union as petroleum reserves shrink, coal output lags, and activists, galvanized by Chernobyl, challenge any expansion of nuclear power. Western experts say the Soviets must sooner or later turn on more gas. But critics within the U.S.S.R. argue that drillers should develop more southerly fields before reaching north to the Yamal. They accuse the ministries that have a stake in this—the Oil and Gas Ministry and the Oil and Gas Construction Ministry (which builds pipelines and infrastructure)—of lusting for more jobs and more

development capital to maintain their huge bureaucracies.

In fact the ministries talk not just of supplying Soviet needs from the Yamal but of selling more gas to Western Europe or even liquefied gas to the United States.

Until recently the ministries paid scant attention to the Nentsy, who speak a language related to Finnish and number just 35,000. "They criticized us if we complained," Kadyrov said. "They would push us down and not let us say a word. Their priorities are gas, gas, gas, and you can go to hell."

In prior years the locals would have been quietly sacrificed to the alleged greater good. But the Nentsy took their case to local officials, who took it to Moscow. They found support among the growing corps of Soviet environmentalists. The juggernaut of drillers and builders was halted, even though 1.2 billion dollars had been expended. Moscow ordered a review of Yamal development plans, including the impact upon the Nentsy.

The Nentsy have not won the war; this was just a battle. And it is too early to say that the greening of Siberia, vast storehouse of Soviet resources, is at hand. But it is not too early to say that Siberia—"sleeping land," as its name means—is waking up.

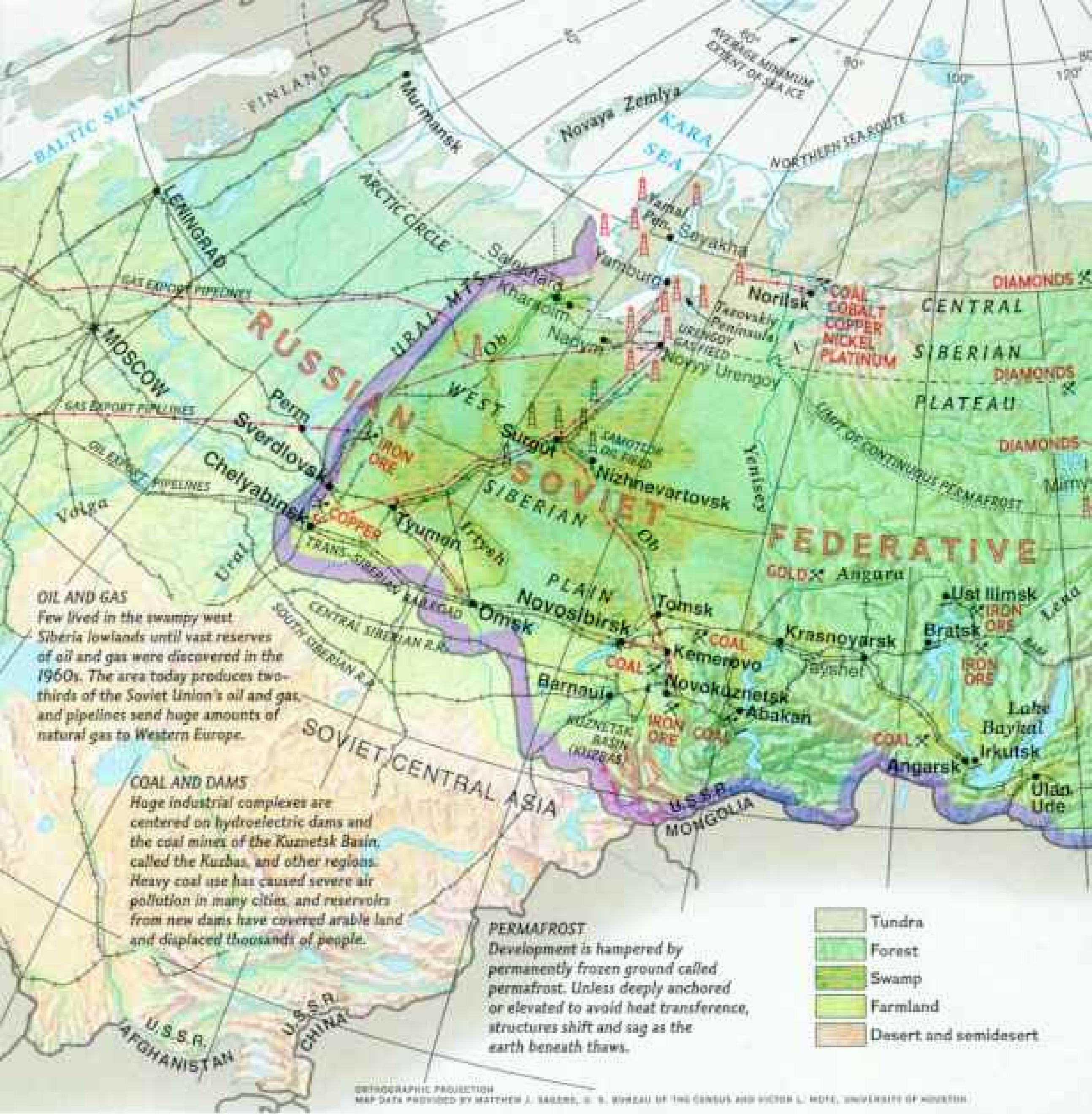
ISAY THIS after four months in Siberia. In four trips I logged 50,000 miles in the U.S.S.R., my own testimonial to the awesome size of the awakening land. At four million square miles it is about the size of our 50 states, with just 25 million people, about California's population, rattling around inside. (That's the Soviet definition of Siberia, which omits the Pacific provinces, called the Soviet Far East. Western geographers usually label an additional million-plus square miles Siberia too. See map, following pages.)

Many a Muscovite shudders at the mention of this locus of tsarist exile and of forced labor in the gulag under dictator Joseph Stalin. And many a Siberyak carries genes imprinted with these horrors.

But Siberians know something Muscovites

Soaking up the winter sun, onion plants sprout on a windowsill behind glass that reflects a vintage building in Irkutsk. Considered the most attractive city in Siberia, Irkutsk was founded by Cossacks and later thrived as a fur-processing and industrial center.





Hitchhiking child rides with the baggage on a sled—a ubiquitous carry-all for Siberians—at the airport in Norilsk, a mining and smelting center for strategic metals 200 miles above the Arctic Circle. Long distances, a limited rail system, and almost no paved roads make the airplane a workhorse of Siberian transport.





The U.S.S.R.'s frigid frontier

LARGEST REGION of the world's largest nation, Siberia sprawls across four million square miles of marshy plains, vast forests, desolate plateaus, and rugged mountains. Making up nearly half the Soviet Union, Siberia contains only 9 percent of the nation's population.

A forbidding climate and Spartan living conditions have hindered the government's attempts to exploit Siberia's immeasurable wealth of gas, oil, coal, timber, and metals.

COMPARISON OF AREAS AND LATITUDE OF SIBERIA AND NORTH AMERICA



NSC CARTOGRAPHIC DIVISION; DESIGN: ROBERT E. PRATT; RESEARCH: DAVID S. MILLER; PRODUCTION: MICKI A. MURPHY, SARAH RAMSEY MURRAY; MAP EDITOR: GUS PLATT; PRINTING BY TIGER TOPS

do not—that joy is to be found in this staggering space. Emptiness is not for everybody; in the city of Kemerovo in south-central Siberia, they tell me that while 26,000 people arrive every year, 24,000 leave.

Newcomers usually are lured by big salaries; many Siberian industrial workers earn three times as much as their cousins in the European U.S.S.R., west of the Urals. Those who put down roots revel in mountainsides of birch and larch aflame in autumn, even in the horizonless span of snow. Space translates into—how strange, given the Siberian stereotype—a kind of freedom. Alaskans will understand, and Montanans.

On the Kolyma River in eastern Siberia a transplant named Misha opens a jar and pours me a slug of his *samogon*—white lightning—as he talks of roaming the tundra for berries and mushrooms, and of fish in the rivers. He'd never go back to Leningrad.

And would Aleksandr Larichev, the mayor of Novyy Urengoy in the north, accept a transfer to Moscow? At the question, he holds big hands in front of his face as if to wail.

Siberians gaze at Moscow the way some Texans gaze at Washington, D. C., seeing bungling bureaucrats. And Siberians can be just as outspoken. "Yes, we have a two-party system," a man says. "The *nomenklatura*

Battling the elements is part of the job for Siberia's oil and gas workers. Despite the snow, roughnecks proceed with drilling at the gigantic gas fields near Novyy Urengoy, where an oil rig rises amid ice-encrusted equipment (below).

At a gas field on the Tazovskiy Peninsula, high-pressure hoses shoot hot water to melt the permafrost for a construction project. More and more Soviets decry the destruction of the fragile tundra, which can take a century to recover.



[officials and privileged persons] with their nice apartments and special stores, and the rest of us with nothing." But nothing in Siberia—rationed sausage, sugar, butter, even vodka—seems preferable to nothing on "the mainland." That's what the Siberyak calls the European side, as if Siberia were an island.

To this realm's most honored writer, Valentin Rasputin, it's a colony—"a barge moored to Russia that brings in its wealth of goods and then is pushed away from the shore." Though Siberia is sprinkled with political divisions in theory autonomous—the Yakut Autonomous Soviet Socialist Republic, for instance—they are in truth meek subdivisions of the Russian federation, which spans the Urals west to Leningrad. This is Moscow's backyard, and Moscow calls the tune on matters of development.

Now many Siberians, speaking out like activists in the Baltic republics, want control of their natural resources. That will be a fight; Siberian products—fuel, gold, timber, diamonds, furs—probably accounted in 1988 for about half (say, 20 billion dollars) of all Soviet hard cash receipts.

Emboldened by Soviet President Mikhail Gorbachev's liberalizing policies, Siberians in smokestack cities demand not only sausage and soap but also clean air. Newspapers report hitherto secret pollution figures—gleefully, for the ministries that run mills and smelters have been about as gentle as steamrollers.

Not just the Nentsy but other indigenous peoples are stirring. Stalin swept the leadership of the larger groups—Yakut, Buryat, Khakass—off to labor camps beginning in the



1930s. Tethered by genes or language to Central Asia and Mongolia, perhaps some harbored anti-Soviet notions. Just as bad to Stalin, they clung to their religions.

In Ulan Ude, a city not far from the Mongolian border, I watched Buryat, who are Buddhists with a strain of ancient paganism, welcome spring in a ceremony not publicly performed for half a century. Wearing grotesque masks, they danced around a seer and awaited his predictions. He was optimistic: Crops will be bountiful, the men handsome, the women beautiful.

Perhaps he also meant that the 422,000 Buryat will flower anew. They have long been cautious, having lost to Stalin an estimated 10,000 people and nearly all their temples.

The Buryat and other indigenous groups are minorities in their own land, outnumbered by Soviet European immigrants. So even though Siberia is Asia, it doesn't look it. With not even a Buddhist temple, Ulan Ude is no more distinctive than a coal-mining city in Ukraine. Except, of course, for the bronze visage in its main square, the world's largest head of Lenin, four yards from nape to pate.

EUROPEANS began streaming into Siberia soon after the tsar's Cossacks overthrew the Tatar khanate of Sibir, a relic of the Mongol Golden Horde, in 1581. First came the Russian fur traders, plying the rivers, seeking the lustrous sable. Like pioneers headed for Oregon, landless peasants poured into Siberia in the 19th century, escaping landlord-cursed Ukraine.

Their East, our West: Parallels abound. Cities like Yakutsk and Tyumen match Laramie and Dodge City—military posts. Norilsk is Butte, dedicated to ores. Irkutsk was St. Louis, outfitter of trappers and miners.

Moscow never provided a real transport system. A taxonomist classifying this critter by its skimpy transport network would pronounce it vertebrate based on the 5,800-mile Trans-Siberian Railroad, which joins Moscow to Asian ports. But he'd wonder where the rest of the skeleton was, finding only a rib here and there. You can't cross Siberia on pavement. Rivers still carry much traffic, as of old, but it is Aeroflot, the Soviet airline, that knits all together. Service is brusque and cabins may be tightly packed, but the fleet is huge: wide-body jets down to biplanes that ski off to villages in winter.



Changing the face of the virgin land, a natural gas processing plant at Yamburg sprawls over the waterlogged tundra of the Tazovskiy Peninsula. Fuel from the Kuzbas coalfields fires the huge blast furnace at the nearby Zapsib steel mill (right). Siberia's development, accelerated during World War II, today provides much needed export revenue.

Rail and river, however, birthed a string of industrial cities in southern Siberia. Aeroflot took me 1,700 miles from Moscow to the big daddy of these, Novosibirsk, home to 1.4 million people. It was January and frigid, yet the central square was filled. They came to see the New Year tree—substitute for the Christmas tree—that glowed with yellow and red lights. Children climbed about a cabin of ice while grills wafted the aroma of kabobs.

The city bespeaks *kultura*. In one school, I watched reed-slender boys leap to music,





At home on the snow, a young Nentsy boy stands in the sub-zero Arctic cold near his chum, a tepee shelter made of reindeer hide. Although organized into



work units under the Soviet collectivization program, the Nentsy retain much of their life-style and still follow the wanderings of their reindeer.

while girls greeted me with a poised curtsy.

About 25 small, lithe bodies is all the Novosibirsk school of ballet can accept in a year. Five thousand ten-year-olds apply from all over Siberia. Teachers observe how they move, how they feel music, and select—breaking many a mother's heart.

At 14, students practice as much as eight hours a day. Butter and sweets do not pass these lips; ballet masters intend to send their protégés slender and flexible to the corps in Leningrad or Moscow or to the local troupe.

Onto the stage of the Novosibirsk Theater one night strode Lieutenant Pinkerton, singing Russian. In past years Puccini's *Madama Butterfly* might have seemed a decadent choice for a Soviet audience; but Novosibirsk leads a privileged life. Its campusy suburb, Akademgorodok, boasts one of the best stocked department stores I saw—good cameras and coats. That helps keep the physicists, geologists, and economists happy while they ponder in this big Siberian think tank.

SIBERIAN CITIES are dirty cities, more than a dozen, including Novosibirsk, making the list of the Soviet Union's 70 most polluted. In World War II, 300,000 workers and their factories were relocated from the European U.S.S.R. to Novosibirsk, making this a major producer of steel and heavy machinery.

Later, Moscow wanted to continue placing industry here. "We practically laid down on the railroad tracks to stop more coming," said planning official Vladimir Boiko. Development halted, but the mess—foul air and waste water full of chemicals—remains.

The cleanup task falls in part to officials I met in a small office in an apartment building. Make-do quarters are a commentary on the clout of Goskompriroda, intended to be like our Environmental Protection Agency.

Established in 1988, the Soviet agency has yet to be fitted with teeth. It can't fine a dirty factory's boss more than a hundred rubles (about \$16 at the new tourist exchange rate), although it can try to have him deprived of his usual production bonus, which may be a fifth of his pay. Real enforcement awaits the working out of a new law—opposed by the manufacturing and extracting ministries.

A Goskompriroda engineer, Valentina Soboleva, said the Novosibirsk office measures 11 pollutants, including nitrogen and



sulfur compounds, and dust. She'd like to see polluting industries relocated outside the city.

Siberia's only subway leads to one of these polluters. I descended stairs in a throng of bundled people. Few Soviets can afford coats of expensive fur—most of Siberia's harvest goes to the West. But they can afford a *shapka*, a hat, of sable, mink, perhaps muskrat. Down the stairs ahead of me flowed a river of fur.

I emerged at the Oktyabrskaya station and approached an old building that looked like a school. But it was surrounded by wire, the windows were blocked, and an armored car stood beside it. Smoke rose from a chimney in back. If this wasn't a refinery for gold mined farther east, I will eat my shapka.



Crowding the dock, residents of Kharsoim await the arrival of a ferryboat on the Ob River near the Arctic Circle. Made up mostly of a Finnish-related people called the Komi, the village relies on river traffic and air-lifts for supplies.

A chamber dug 15 feet into the permafrost in the side of a cliff provides a natural freezer for a Nentsy fisherman on the Yamal Peninsula. The Nentsy people have protested the development of gas deposits, fearing destruction of their way of life.

The Soviet Union is closemouthed about gold and diamond production; by U. S. estimates, these earned more than four billion dollars in foreign exchange in 1988.

THE DEEPER I went into Siberia, the more I encountered the "period of stagnation," the term applied to the 18-year regime (1964-1982) of the late Soviet President Leonid Brezhnev. Anything that's wrong, BIOB: Blame It On Brezhnev. As Gorbachev sought to inspire *perestroika*, new methods, he excoriated his predecessor, and bureaucrats have taken up the cry.

Stagnation denied citizens improved housing and other comforts. But in development this was an era, as the Soviets say, of *gigantomaniya*. Billions of rubles were invested in huge Siberian dams, mines, mills—the bigger, the better—with scant regard for the environment. At Bratsk, 750 miles east of Novosibirsk, rose a great dam, then a great aluminum smelter to utilize its electricity. And nearby a pulp mill so large it still can't secure wood enough to run at capacity. Bratsk is reportedly among Siberia's most polluted cities. Local party officials didn't approve my request to visit—because, I believe, they didn't want me to see the environmental mess.

While building big, Brezhnev gave little thought to cleaning up existing industry. This is demonstrated in the Kuzbas, the valley of a thousand smokes.

It's only a Siberian hop-skip—about 200 miles—from Novosibirsk southeast to the heart of this coal-mining basin, the city of Novokuznetsk. I took an overnight train on a spur of the Trans-Siberian. A sleepless trip: We stopped at a dozen villages and were rattled every few minutes by passing coal trains rolling out of the Kuzbas.

In winter the air may be as still as death over Novokuznetsk. Pollutants linger. I went to the local Goskompriroda office to ask about the effects. A scientist alluded vaguely to health problems among the 600,000 citizens. Asked to elaborate, he hesitated, glancing at his colleagues; this was their first encounter with a Western journalist. Finally, he plunged on: Lung-cancer rates are 30 percent higher than the average for Soviet industrial cities, and respiratory infections and eye inflammations among children are higher. Industrial dust and sulfur dioxide are blamed.

Near that office is the huge Kuznetsky



Unorthodox approach is practiced by Dr. Elena Litusova (above) at the Institute of Circulation and Pathology in Novosibirsk. By using ice, the body temperature of a young boy will be reduced to as low as 72°F during heart surgery (right), thereby temporarily stopping the heart and blood flow. Doctors say this enables them to avoid oxygen deprivation even without heart-lung machines.

Metallurgical Kombinat (KMK) steelworks, a symbol of Soviet might. Men with shovels and wheelbarrows built this mill in the 1930s as Joseph Stalin strove to industrialize. The city grew up beside it. Workers proudly claim that in World War II KMK armored half of all Soviet tanks.

It was a rude surprise for KMK's director, Aleksei Kuznetsov, to see protesters in front of his headquarters one day. "I am being ruthlessly criticized," said Kuznetsov, a bluff man with graying hair. Goskompriroda is peppering him with hundred-ruble fines and trying to block his bonus until KMK is cleaned up.

Responding to demands from city officials and citizens, KMK has closed some of its works, including two coking ovens that sent up sulfur and nitrogen compounds. But fires still roar in 14 furnaces in the cavernous building that poured tank armor. The fumes and dust are choking.

Under *perestroika*, many heavy industries must go over to "self-financing," meaning that new equipment, including pollution-control devices, must be bought from profits. "That wouldn't be logical for us," director Kuznetsov said. "We are 55 years old." He





expects the national treasury to hand over 400 million rubles for modernization.

Some Soviet economists have a counterproposal: close KMK. The Soviet Union makes too much steel, declares Abel Aganbegyan, economics adviser to Gorbachev. The nation should make *good* tractors and harvesters, he says, instead of using so much metal making so many poor ones.

Boris Rumer, who looks at the Soviet economy from Harvard's Russian Research Center, wonders if the Soviet government can afford expensive antipollution devices. With so many other demands, especially for housing and consumer goods, he believes that many Soviet industries will stay dirty.

Rolling mills shape KMK steel into streetcar rails and construction beams. In one building I watched pots, pans, and buckets clank along an assembly line. One shape caught my eye: a wide pot with a handle. Yes, the great KMK steelworks that armored Soviet tanks now

turns out chamber pots. "There is a need," a supervisor said.

Kuzbas miners shook the Kremlin badly last year, touching off a nationwide coal strike to press their demands for better housing and necessities like soap. They won promises of wage increases and more goods. Now they have taken a new course, trying to wrest control of their union from Communist Party officials.

In a mine family's flat I dined with Vladimir and Valentina. Party officials made sure that the table was set with smoked salmon and other hard-to-get delectables and plenty of *konyak* and *shampanskoye*. I asked Valentina, a fetching blonde in a bright red dress, what she'd like to see different in her world.

Her answer: more cultural and social life; a coffee shop, a theater, movies, sports facilities, a jogging path; more trees, more plants everywhere. But if Valentina got her coffee shop, there'd probably be no coffee. And some Siberians haven't seen cheese in years.



IRKUTSK, lovely Irkutsk. No Siberian city is so pleasantly endowed. On the long white nights of summer, motorboats and rafts speckle its Angara River. I'm sure it isn't just the succulent fish called *kharius* that holds the fishermen there until dark descends at 11 p.m. Running pewter, fringed by cottonwoods and winking lights, the Angara feeds the soul.

In tsarist times the merchants and traders of this city, 700 miles east of the Kuzbas, were enriched by gold, furs, and China tea. They built sumptuous brick mansions, but I like better the log houses, two or three stories, with fretwork and jug-eared shutters painted blue and green. Four hundred of these old Siberia dwellings—some two centuries old—are preserved, for Irkutsk is conscious of its heritage.

Churches too have been saved, a rare thing in Siberia. Russian Orthodox edifices graced all the cities until Stalin's minions tore them down. Closed but not destroyed, the

Winter mists shroud frozen Lake Baykal (left), the world's largest freshwater lake by volume and home to a unique array of flora and fauna. Ice-free water marks the outflow of the Angara River. Message on a billboard placed by Siberia's increasingly vocal environmentalists vows to save Baykal from pollution by industrial wastes. An ardent defender of the lake, author Valentin Rasputin is moved to tears as he bemoans what he feels is a loss of traditional social values in the Soviet Union.

18th-century Church of the Savior now stands restored and again open for worship.

Including a mosque and synagogue, Irkutsk has nine active congregations. Ten, if you count the Baptist group whose preacher was arrested last year for conducting unauthorized services. Nevertheless, an Orthodox priest told me Siberia is not especially intolerant—"You can feel out here that there is less pressure on religion."



High-spirited food merchants enliven a Sunday morning at a private market in Irkutsk (above). In contrast to state-owned stores, with their long lines and skimpy inventories, the privately operated markets offer more bountiful supplies but at higher—often exorbitant—prices.

Kabob vendors do a brisk business in the main square of Novosibirsk, Siberia's largest city with a population of 1.4 million. The city grew rapidly during World War II, when factories were moved here from vulnerable areas.





In the Univermag, or department store, I imagined I was in a blockaded city. But a supply train had just gotten through! As fast as clerks opened boxes, shoppers grabbed shirts and shoes. Size? Color? No matter—they grabbed. A noble past does not stock shelves.

Nor does it clean the air. "As we say, 'The Soviet Union is an exceptional country,'" declared Gennadi Filshin, an economist. "Exceptions were given to build a lot of polluting enterprises." His sarcasm emphasized the Swiss cheese enforcement of a law banning environmentally damaging factories.

Nearly as big as Texas and Louisiana combined, Irkutsk Oblast (region) is heavily industrialized, producing aluminum, chemicals, and wood pulp. In nearby Angarsk a

thousand choking citizens went to hospitals when a plant producing animal-feed supplements vented a heavy dose of protein particles.

Sounding like a capitalist, economist Filshin casts a flinty eye upon "industrial oversaturation" and argues for the closing of 50 "bankrupt" factories that can't pay their way. For example, a plant fabricating concrete construction parts; builders avoid it because the work is shoddy. And a bakery whose sweets "can only be used as bullets."

Filshin was too radical for local party chiefs, who did not back him when he ran for the new Soviet Parliament last year. How they misread the public pulse! Against the party's candidate, he won 80 percent of the vote.

Irkutsk citizens march to protest pollution and stridently demand that Moscow let them share in development decisions.

Before long, I imagine, Irkutsk also will demand a share of the hard currency that Moscow earns from the furs—mink, sable, fox, squirrel—that flow into a huge Irkutsk warehouse. It handles millions of pelts from eastern Siberia: 160,000 sables, for example, in a year. Most go to international auctions and eventually cloak wealthy women in New York City and Paris and Tokyo. A single prime sable may bring a thousand dollars. The trapper is paid in rubles; the hard cash with which he could buy a good Japanese TV remains in Moscow.

ON A FROZEN AFTERNOON the soul of Siberia waited for me beside the Angara River. Valentin Rasputin wore an old sweater, corduroy pants, and high felt boots. For six days he'd been holed up in his sparsely furnished dacha—cot, stove, table, typewriter—reworking a collection of essays on Siberia.

Rasputin (no relation to the infamous tyrant) calls himself a "retrograde writer," for his stories and short novels, popular throughout the Soviet Union, remember old values—honesty, roots. *Farewell to Matyora* is about a Siberian village flooded when a hydroelectric dam is built. The children will wander, severed from their past, which is at the bottom of the reservoir.

"It is my pain," Rasputin said of old values dying. There is pain too in sending his work off to Moscow to be published and in waiting for copies to trickle back to Irkutsk.

Rasputin would rather be in a boat on Lake

Baykal, 40 miles southeast of Irkutsk, than painfully composing in his dacha. That lake, a mile deep and 395 miles long, seems made for contemplation. A man can ponder the origins of its unique species—1,500 kinds of plants and animals found nowhere else, including freshwater sponges. Or the staggering arithmetic of its volume, 5,500 cubic miles, one-fifth of all earth's fresh water. Or, in autumn, lose himself in the orange glow of birches upon the mountains round about. Rasputin has long fought to rescue Baykal from pollution.

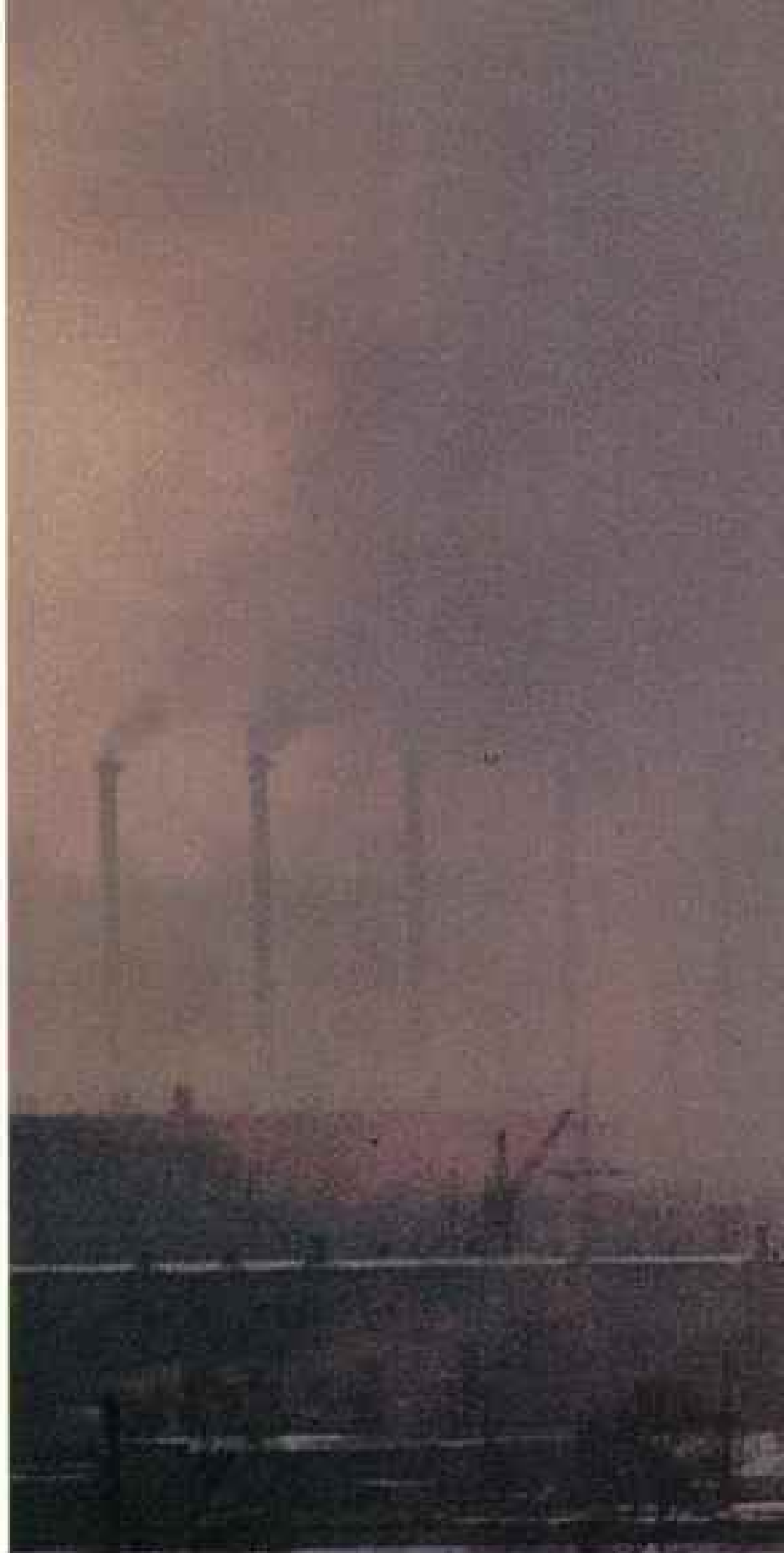
Much of this enters Baykal from tributary rivers dotted with industries. And right on Baykal's shore is a wood pulp mill. Experts say that, thanks to elaborate cleaning processes, the mill's waste water is barely toxic—purer than the effluent from U.S. mills—and that its tall stack emits only traces of sulfur compounds.

But it is *there*, a concrete and steel eyesore, sending up a high plume of smoke and vapor beside the world's most interesting lake. Many Irkutsk citizens, incensed at its presence and distrusting the experts, want the mill closed. The pulp, however, is badly needed for making rayon tire cord, and the ministry of pulp and paper seems to be trying to wait out the protests.

IT'S 9:30 AT NIGHT when *Rossiya* (*Russia*) pulls into the Irkutsk railroad station, on the fourth day of a 5,800-mile journey from Moscow to Vladivostok. But the station clock shows 4:30. For locomotive engineers and Aeroflot pilots, the eight time zones

Nearly blotting out the sky of Novokuznetsk, smoke pours from the KMK steel mill, built in the 1930s during the rule of Soviet leader Joseph Stalin. The pollution is blamed for a host of ailments in the city, which led authorities to close part of the facility. Citing a surplus of steel, some argue that the plant should be shut down altogether.

On a muddy, unpaved street in the new city of Neryungri, children of coal miners play near a fire-prone wooden house. Health hazards and substandard housing, along with the lack of such necessities as soap, led to a strike by coal miners in the Kuzbas region (far right). The strike spread throughout the country before concessions were granted. Despite government laws banning such strikes, some miners struck again and tried to oust the Communist Party union leadership.





NOVOSTI PRESS AGENCOVITSMA (RELOW)



stretching from Moscow to the Pacific are meaningless; all schedules are written in Moscow time.

Rossiya, daily express of the Trans-Siberian Railroad, pauses ten minutes, boarding families, bureaucrats, and soldiers going to eastern bases. Then, electric-powered, she rocks and rolls across the snowscape at 75 miles an hour. After a change of trains in Khabarovsk, passengers reach Vladivostok—170 hours from Moscow.

For many the trip is practically a vacation. Men don blue warm-up suits and pad along the passageways. Sausages emerge from luggage. Samovars boil water for tea. Mid-train, a movie plays in a video theater.

Every five minutes *Rossiya* passes another train. The Trans-Sib is the world's busiest

track, transporting millions of people plus coal, lumber, machinery, and trucks.

The Soviets are at last switching some of this load to the Baykal-Amur Mainline Railroad, or BAM, which penetrates the wilderness 100 to 300 miles north of the Trans-Sib. Construction of this 1,934-mile line began in 1940 with prison labor but was halted in World War II. In the 1970s it became an 18-billion-dollar Brezhnev endeavor.

The builders confronted the trickery of permafrost. Slice open the surface, and the ice beneath it warms up; before long roads become little canals. Siberian engineers know a great deal about construction on permafrost. They construct high rises on it, keeping warmth well away from the surface by putting the buildings on stilts. On roads they use thick layers



of gravel and other materials as insulation.

By many accounts, builders of the BAM didn't have the time to do their job right. They had a preordained schedule, and Brezhnev wouldn't hear of delays. "The track was laid, the completion reports were written," said one official. And then track bed sank in the ice melt. Rails twisted, tunnel walls collapsed. Repairs and detours threw the BAM five years behind schedule.

THE BAM was expected to open new areas for exploitation, for timber and copper, but there is just one payoff now. That's at Neryungri, 900 miles northeast of Irkutsk. Its buildings, gleaming white, are a strange sight in the spruce and fir of the taiga.



Only 15 years old and already the home of 120,000, Neryungri is on a north-aimed rail spur, the Little BAM. It's there because of coal, scooped from a three-mile-long open pit. Japan invested three billion dollars in this mine and receives five million tons of coking coal a year, about half the production.

Nikolai Ivanov has invested five years of his life here and gets about 1,500 rubles a month. I met him at the end of a shift. Churning mud, drivers wheeled into a squishy parking area in giant U. S.-made Lectra Haul and Soviet BelAz trucks that carry 180 tons each, and 120-ton Japanese Komatsus. It seemed like a gathering of elephants.

A rope of a man, Nikolai was lured by the money—three times what he earned in Sverdlovsk in the Urals. Like many here, he's saving to buy a car and a better flat back home.

That's about all you can hope for in Neryungri. Never have I seen citizens with so many things to be angry about. I was at the train depot when shrieking passengers mobbed poor stationmaster Viktor Grachev; the public-address system had announced yet another delay of the mainland-bound train, already three hours tardy.

The city's central heating plant was down, which meant no hot water in flats. (Thank goodness it was summer.) Beside a shack made from packing crates, a nine-year veteran of Neryungri said bitterly: "I was deceived. The promises of good living conditions were never fulfilled." Hot water? He doesn't even have cold water in his shack.

It's another BIOB; Brezhnev insisted on industry first, social needs later.

Then we have the angry Evenk, one of Siberia's 30 indigenous groups. Numbering 4,000 in this region, the Evenk watched development gobble up their reindeer pastures while wastes poisoned streams and poachers killed their animals. "We must fight," declared young Valentin Alekseev. Indeed, the Evenk have complained all the way to Moscow. At least, Valentin said, "No one is closing doors to us like they used to."

Long summer days of Siberia's northern latitudes attract sunbathers to a beach on the Ob River near Novosibirsk. After the dark and bone-chilling winter ends, Siberians relish their all-too-brief stretch of warm weather, taking to the outdoors for camping, boating, fishing, and barbecues.

Oh yes—a few days after I left Neryungri, Nikolai and the other coal-mine drivers went on strike again, complaining of muddy roads.

SOMEDAY locomotives on the Little BAM may toot in the city of Yakutsk, 500 miles farther north. The route would pass through goldfields and to the east of diamond mines; the Yakut Autonomous Republic is rich. “But Moscow never gives us a drop of anything in return,” said one more angry man, a Yakut journalist.

So the territory has remained largely empty, its capital city a backwater. Its lifeline is the 2,653-mile-long Arctic-bound Lena River. Late into a summer night I watched small ships unloading cement and other freight at Yakutsk; come October, ice halts cargoes, and Yakutsk goes into prolonged hibernation in some of Siberia’s coldest weather, with temperatures dropping to minus 83°F.

On a snowy October evening I reached Norilsk, 1,250 miles northwest of Yakutsk. Before passengers left the wide-body Ilyushin jet, guards boarded to check identity cards and travel documents. Norilsk was still a closed city; even Soviet citizens needed special permission to visit. I’m told I was the first Western journalist to set foot in this infamous ex-gulag site above the Arctic Circle.

As winter sets in, the tundra’s vivid green fades to white on gray. Norilsk itself offers little visual cheer. Its core of Stalin-era buildings with their wedding-cake embellishment rise not from lawn but from asphalt. Gardening is hopeless; if frigid temperatures don’t kill your roses, sulfur will. It comes from three smelters processing ores containing nickel, cobalt, copper, and other metals.

Norilsk welcomed me hospitably, with memorable feasts, as if there’d never been a Cold War—and as if Norilsk was not a source of militarily strategic metals. I found people invariably proud that they’d accommodated to the hostile environment. Many have lived here a dozen years or more. Yelena Kalininskaya, for one. Tough, enterprising Yelena

Stolid apartment houses tower over a traditional wooden home fallen into disrepair in Yakutsk, capital of an autonomous republic the size of India. Because of the city’s permafrost, earlier high rises shifted and cracked several times before builders devised a more stable construction method.







could run General Motors, but in Norilsk she bosses the local farm, providing milk from a herd of cows as well as cucumbers and onions from greenhouses. She's one reason life is tolerable for 175,000 people.

Ores were discovered here in the 1920s. Stalin sent political prisoners to mine and build. Thousands died. After the forced labor camps were closed in the 1950s, paid workers continued to develop the mine-smelter complex. It is dirty—deadening rivers with effluent, raining sulfuric acid on tundra.

I got into a green van with Galya Pavlikova. Near a park Galya stopped and put out a metal tube to check air pollution. She checked dials on a machine and pronounced the sulfur dioxide level to be 0.02 of a milligram per cubic yard of air—within acceptable limits. Galya and co-workers take daily readings at 13 locations.

The smelters' high stacks are supposed to waft away sulfurous smoke. But on windless days Norilsk smells like hellfire, and the smelters have to cut back operations.

Despite glasnost, secrecy still cloaks smelter operations and output. Even sulfur emissions are officially secret. But not much of a secret. Norilsk citizens told me that 2.5 million tons of sulfur dioxide were released in 1984. The largest outpouring in North America comes from

two smelters at Sudbury, Ontario—about 750,000 tons last year.

When I asked officials of the kombinat—the Norilsk Mining and Metallurgical Works—what was being done to improve their pollution situation, I was introduced to a bespectacled engineer, Vladimir Volkov. He led me through a smelter's whirring innards and out into minus 5°F weather. The wind stung, as did the yellow dust it carried, which made acid in my eyes. Soon we stood on a catwalk over tons and tons of sulfur extracted from the ores.

Sulfur dioxide emissions have been halved since that bad year of 1984, Volkov told me, thanks to 900 million dollars invested in sulfur-removal processes.

Another 1.5 billion dollars is to be invested in cutting emissions further. The kombinat is wealthy and, having gone over to self-financing, will pay for this from its profits. It's the workers who will ultimately pay, for this money would otherwise be spent on housing, day care, and other amenities.

ONE AFTERNOON while I was there, Tarzan made life better in Nizhnevartovsk. After he had swung on his last vine in the 1958 Hollywood clunker *Tarzan's Fight for Life*, 60

Jockeying for position, competitors roar over a field in Neryungri during a raucous game of motoball. Combining cycling, soccer, and polo, motoball features two teams of five players each that try to push a 16-inch ball through the other's goal. Originating in France in the late 1920s, the sport caught on during the 1960s in the Soviet Union, which now fields the world's best teams.

people trooped out of the little studio at the Dialog video hall, seemingly satisfied that they'd gotten their ruble's worth of escape.

Dialog also rents videos; it has *Star Wars* and *One Flew Over the Cuckoo's Nest* among its 500 titles. Svetlana Zaitsova, who's in charge, estimates that there are a thousand video players among the nearly 300,000 citizens of Nizhnevartovsk. She considers that a lot—"People live better here."

"Here" is about the middle of 554,208-square-mile Tyumen Oblast in western Siberia. Every Nizhnevartovsk family would own a VCR if there were VCRs to buy, for Tyumen is awash in rubles from gas and oil. Drilling foremen earn a thousand a month, five times the average Soviet worker's pay.

Amid the bogs and meandering rivers near Nizhnevartovsk is Lake Samotlor—"dead lake" in the language of a local people, the Khanty. After 1969, when the first oil well gushed, Samotlor was anything but dead.

Though the easy oil is gone, the Samotlor field still delivers 780 million barrels a year, the highest production in the world.

Environmentalists say millions of barrels from this and other fields in Tyumen Oblast are spilled and soon reach streams that are the lifeblood of fishing communities.

A hotbed of protest is Salekhard, 700 miles down the Ob River to the northwest. A small, old city built mostly of wood, Salekhard straddles the Arctic Circle at the river's mouth. "Ten years ago the Salekhard people used to catch 150 tons of sturgeon," fisheries officer Evgenii Lebedev told me. No more. "Sturgeon feed on the bottom where heavy oil settles. The fishery is dying."

Much of the oil, say other critics, flows from ruptures—hundreds a year—in corroded or carelessly laid pipe. A Salekhard official declares: "They are poisoning us."

Heavy metals and other industrial waste from the south, as well as pesticides and human sewage, add to the sad picture of the Ob,

probably the most polluted river in Siberia.

In the 1980s the push for energy reached the emptiness of the far north. Soviet oil reserves were declining, and the coal industry seemed incapable of increasing production. Fearing a crisis, Brezhnev drove drillers northward to get more natural gas. Millions of tons of equipment were freighted by air. Perhaps 75 billion dollars was poured into the crash campaign.

The gas brigades spawned Novyy (New) Urengoy, a company town near the Arctic Circle. Novyy Urengoy is still raw after a decade of boom, a mixture of high rises and shacks. With virtually no roads, only 200 of the 94,000 citizens keep cars (though many garage one on the mainland).

There are roads, of course, leading to drill sites. I went 20 miles across the flat snowscape to Site 2234. Power lines soared over patches of stunted birches and larches. On the horizon gas flares burned, easily visible in the pale sun—so low that at 10:30 on a February morn, a man's shadow stretches a hundred feet.

There are 1,400 wells in the Urengoy gas field. With adjoining fields it yields 14 trillion cubic feet of gas a year—two-thirds of all Soviet production.

Novyy Urengoy can't house all the 65,000 workers who are needed, so Petya Ivaneshchev and 15,000 cohorts fly in from Ukraine, the Urals, and other regions, bunking in trailers. Petya works as a driller 12 hours a day for two weeks, then goes home with 600 rubles.

I met him up on a rig, where he fitted one section of drilling pipe to another and watched the string vanish into the well. The temperature was minus 4°F; ice was everywhere. Petya wore grease-smearred coveralls, and three more layers beneath. "If I didn't like it, I wouldn't be here," he said with an easy smile. Work doesn't stop until the temperature drops to minus 43°F; lower than that, pipe may crack if struck with a hammer.

Alaska's Prudhoe Bay never knew a furrier bunch of roughnecks than the Novyy Urengoy itinerants. No need to shave out here. I suspect that for 26-year-old Petya the raw conditions explain how he describes his job: "romantic."

HEADQUARTERS for the Arctic gas development is remote Nadym; transport to its outposts is by the orange-and-blue helicopters of Aeroflot. The Mi-8 has 22 seats arranged around a 250-gallon inboard fuel tank. On

board are shovels, in case the big thing mires.

I clattered off northward one morning with ten hitchhiking Nentsy. At a lonely herders' camp in the great treeless expanse of tundra we descended to let the passengers off.

I spoke to the brigadir, Panteley Taro, a round sausage of a man. "The rivers are spoiled by oil," he said. "We are losing the natural life." Swarms of mosquitoes found us. No Nentsy wants to work in the gas fields, Panteley continued, not even swatting. "We'd rather lead our own life."

"We don't need these buildings," a Nentsy woman exclaimed. "Why are they doing this to us?"

Then I reboarded and watched the tents vanish. Soon I was looking at the buildings she spoke of—in a new gas town, Yamburg, on the Gulf of the Ob.

THE NENTSY have a way with names; Yamburg means "messy place." It's not just the rusting junk around the prefab buildings that makes the old name fit so well. It's the myriad tracks across the tundra, and the pools and canals where permafrost has melted.

Engineers admit they did things wrong as they crash-developed Yamburg. Drilling began before insulated roads were laid. "The workers weren't supposed to drive twice on the same track," a boss said, "because three passes will cut the tundra, and it takes a hundred years to mend." Apparently a lot of workers couldn't count.

The engineers also did some things right. They decided Yamburg would be a town of 22,000 single workers—without families needing schools and such, thus reducing construction. And they prefabricated some of the heavy equipment, cutting down the number of workers on-site. Then they barged it to near the site and dragged it into place over the

Attracted to a distant land by its hunger for workers, a Vietnamese woman fraternizes with a Russian at a textile mill in Chita (above left). In the same city Tatyana Lukasheva prepares to take the stage during the first Miss Siberia contest. But there is little glamour in the lives of most Siberian women. Though their husbands draw good salaries working on the railroad, the women of Berkakit (right) find few opportunities to acquire even basic needs in their town of rude shacks.







His fury leashed by a tether, a brown bear charges a husky being trained to immobilize the animal by biting its haunches. In a gentler pursuit a Khakass farmer near Abakan drives his sheep home across the endless steppe in a land that, despite efforts to tap its riches, is still defined by its astonishing emptiness.





winter ice, to reduce scarring of the tundra.

Messy Place will soon yield seven trillion cubic feet of gas a year.

I FLEW ACROSS the Gulf of the Ob to the Yamal ("ultimate land") Peninsula and landed at Seyakha ("gut," for the nearby river opening). Beside this town on a windy bluff the Ministry of Oil and Gas Construction had set up another headquarters. Amid the mud of breached tundra were crates holding prefab buildings, trucks, spare parts.

Westward across the Yamal Peninsula's vivid green stretched more scars. Travel over bare tundra wasn't prohibited until last year, and the Yamal suffers from the Soviets' inability, thus far, to produce vehicles with soft, oversize tires that inflict less damage.

On the peninsula's western shore by the Kara Sea, where drilling would commence, I saw barracks and other facilities joined by ten-lane tracks.

The Yamal Nentsy, just 5,000 people, have already lost a staggering 13.2 million acres of grazing lands. Now that their protests have

been heard in Moscow, they've been promised all manner of good things; from paved roads to new schools. The gas builders have shown them a drawing of a big steel cabin walking on hydraulically operated stilts; the engineers say it could bring such amenities as a canteen and beauty parlor to remote reindeer camps. Really? From a ministry that can't even get off-road vehicles with soft tires?

Western economists say the Nentsy may have to settle for roads and promises because the Soviet Union sooner or later will need the Yamal's gas. There are trade-offs, of course; if gas replaces coal in polluted cities, the air will be cleaner for other citizens.

No Siberian ever told me that his realm should be independent of the Soviet Union, a status that is desired by activists in the Baltic republics and elsewhere. What Siberians do want is a new deal: more say in local matters, more protection of the land that gives their way of life its meaning. Win or lose, the Nentsy, the people of the reindeer, have helped awaken the "sleeping land," ushering in a different future. □

Last Days of the

By JEAN-PIERRE VAUDON BYOMA



GULAG?

Photographs by PIERRE PERRIN SYGMA



A WASTELAND of desolation. A tangled mass of barbed wire, wire netting, and scrap metal. A ten-foot-high fence of faded wood. Nervy-looking soldiers, leather-booted officers, and police dogs. This is Perm 35, tucked in the Ural Mountains some 800 miles east of Moscow.

For a full day in July, from 6 a.m. until 10 p.m., our team of French journalists was the first to photograph what is said to be the last Soviet labor camp for political prisoners. There were 38 then; some have since been freed. *Glasnost*.

Beyond a door pierced by a spy hole (above), beyond other doors and iron bars, we came upon a room devoid of sunlight. When we entered, Ruslan Ketenchiev, far left, and Aleksandr Goldovich declared, "You cannot believe how you have humanized us with your visit, how deeply we are touched by your coming here."





“OSIN was an enormous, flabby man . . . with small eyes and puffy eyelids, who seemed to have long ago lost interest in everything but food.” Thus Natan Sharansky, former inmate of Perm 35 (page 47), described Lt. Col. Nikolai Osin (below, at center), in *Fear No Evil*.

Osin was there in 1972 when the small labor camp was picked to specialize in political incarceration, and he will no doubt be there when it closes its doors. During the early 1980s he had as many as 270 *zeks*, prisoners. In December 1988 there were 62. In July only 38. There have been no new arrivals for the past three years. The lieutenant colonel is apprehensive that Perm 35 will be phased out before his retirement in two years.

We read him the names of reported prisoners.

“Hillel Butman?”

“Set free.”

“Vladimir Poresh, a Leningrad Christian?”

“Set free in 1987.”

“Leonid Lubman?”

“Present.”

“Bohdan Klymchak?”

“Present.”

Sixty names, called up one after the other. We find that a distinction is made between war criminals, more or less genuine

spies, and “others,” many of whom tried to leave the country illegally.

We had entered the camp through armor-clad doors (far left) and electric gates. For half an hour we did not hear a word, not even a monosyllable, only the monotonous humming of electric razors and the noise of shutting doors. The stares were terrible, broken. Some prisoners passed in front of our cameras over and over again to capture our attention. Others were hugging the walls.

A tall young man was reciting Bible verses at the foot of his bed. His neighbor was making his bed. He had switched over to the *mujahidin* during the Afghanistan war. “He was lucky that he was not shot,” one officer told me.

Officer Nureev (left) led prisoners toward the workshops. Able-bodied men work eight hours a day, six days a week for 250 rubles (\$40 U. S.) a month. Half is taken for board. Being productive is paid off in money or by reducing the sentence. Refusing to work is paid off by punishment, sometimes even by the infamous *shizo* (top right), an unheated, four-by-eight-foot cell with no blankets for the wooden plank bed folded against the wall.





ASPECTACLE. This is an exhibition," shouted Oleg Mikhailov (top right, at center), serving 13 years for planning to flee the Soviet Union in a crop-dusting plane.

"We are French," we said. "We want to speak with you."

At last he was convinced. "Ah, Frenchmen. How wonderful. We are so used to being deceived here," he said.

The isolation cell he shares with Goldovich and Ketenchiev (pages 40-41) has three iron beds without mattresses, a shelf with magazines and a couple of books, chamber pots in a corner, and just enough room to move.

"These people try to strip us of our dignity, since without

it we have no more strength," another prisoner told us.

Yuri Pavlov (above) washed and shaved as if the guards were furniture. Leonid Lubman (top) denounced the food.

"This stinking meat is inedible; even a cat could not swallow it," he declared as he crossed the cafeteria and flung his lunch into a garbage can, his metal bowl into the kitchen. Three other prisoners followed his example. The others put their noses into the pea puree and clear borscht.

Lubman, an economist, considers himself a prisoner of conscience. Refused permission to emigrate to Israel, he sent out a manuscript on the economic

and sociological problems of the U.S.S.R. He was arrested and sentenced in 1977 to 13 years for treason.

Bohdan Klymchak (right) crawled through barbed wire on the Iran border in 1978 and asked for asylum. The shah's police returned him to the Soviet Union. Our team asked to meet him. When a guard brusquely placed a chair in the center of the room, Klymchak, a veteran of KGB interrogations, sat down without hesitation. But in the camp director's presence he told us that torture by freezing still exists. He concedes that hunger tortures have ceased, but he carries a hunk of bread in his pocket, just in case.





MORNING ROLL CALL. The most depressing of camp routines.

Faces are tense, suspicious. No one knows who has been turned into an informer by the KGB.

For Vadim Arenberg (above, left foreground), imprisoned in 1979 for planning to escape from the Soviet Union by hijacking an airliner, the dream of freedom came true on September 27, 1989. Carrying a sailor's bag and two big wooden suitcases, he embraced his family (right), unable to believe he was finally on the right side of the electric gates and steel doors.

Could this small dark bundle of woman (above right) really

be Ina? Ina, the young, gray-eyed Jewish girl with whom he exchanged letters for years before finally being allowed to marry her? Ina who gave him a daughter, Jeanne, whom he has seen only once in her three years?

He made a puppet for his daughter, he tells Ina, but the camp guards smashed it to pieces. It could have contained a secret message, they said.

Now that he is a free man, Vadim has decided not to leave the Soviet Union after all but to settle his family in Kharkov and open a Hebrew school. He prays that the years of repression are gone. But forget the friends who have stayed behind? Never.





CYRIL LE TOURNEUR, STOMA (ABOVE AND BELOW LEFT)

Perm 35 revisited

"The longer I look, the more the colors strike me," says Natan Sharansky, examining photographs for this article at his home in Israel with his wife, Avital. The former dissident was released from Perm 35 in 1986. "This was a world I could only see—and still only see—in black and white."

A prisoner for nine years, three at Perm 35, Sharansky spent long periods in solitary confinement for his resistance and hunger strikes.

"Just look at that bench!" he says, pointing to the photo of the shizo (page 43). "In my time there was just a piece of wood to put the bread on. Had there been the bench, I could have lain down. We weren't allowed to lie on the floor."

His fellow inmates were the most diverse imaginable, he says. "Their lowest common denominator was



hatred of the KGB. Through that we were able to bridge the gap of our antagonisms."

Such pictures prompt strong feelings, he says. But an emotional reaction would be a mistake. "If you look more coldly at these photographs, you can see the old mechanisms at work at the heart of perestroika. They could close down Perm 35 today, but no democratic institution exists to prevent its reopening tomorrow."



The Gulag Remembered

IVAN LED THE WAY. Beside Lake Lama, an hour's flight from Norilsk in the Siberian Arctic, he marched across the snow, shoulders squared, as if again a Red Army sergeant. But today Ivan carried a shovel.

He cleared snow from a stump, revealing a paper, under glass, with half a dozen names (opposite).

In many Soviet cities committees are planning memorials to the victims of the gulag, the system of *lags*, or camps, for which Siberia is synonymous. Joseph Stalin sent 17 to 25 million (or more) to labor camps from 1928 until his death in 1953.

Ivan Sidorov was far ahead of the memorial planners, placing his simple tribute two decades ago. It is more than what has marked most graves; likely, a tin-can lid with a stenciled number did the job. Or bodies were tossed anonymously into pits.

Fourteen army officers from the Baltic States—"sent here because they weren't trusted," Ivan said—were interred near Lake Lama in 1941-42. They were building a factory to extract vitamins from fir needles. But, malnourished, they died before the factory produced.

Ivan survived perhaps because he was younger—23 when wounded in the Soviet-Finnish War of 1939-1940. Wounded and captured. He considered suicide—"Capture was bad in Stalin's eyes." Repatriated comrades who surrendered without fighting faced the firing squad. Ivan, good soldier, got off lightly: five years at labor.

Off he was taken to Norilsk, where mines and a smelter were being developed and where, recalls another survivor, guards shot 30 *zeks*—prisoners—daily, "just to frighten the rest of us."

Staggering accounts of the lags reached the West in the 1970s in Aleksandr Solzhenitsyn's *Gulag Archipelago*. Glimpses of Stalin's terror appeared in the Soviet press in the 1960s, but then a curtain dropped. Now, with *glasnost*, Soviet journals publish Solzhenitsyn's work and ex-prisoners feel free to speak.

Georgi Borisov recounts that life looked promising in 1941; a peasant's son, he had won a seat in the Leningrad Theatrical Institute. Then he opened his mouth. Seeing a man in American boots, he pronounced them better than Soviet boots. He described village store shelves as empty. He quoted Victor Hugo, dubbing soldiers "gun meat."

Borisov knows the student who denounced him. Prosecuted for praising capitalism,



TATTOOS MARKED PRISONERS EXILED TO TSARIST LABOR CAMPS KNOWN AS "KATORGA."

discrediting Soviet power, demeaning the Red Army, and, worse, attending a meeting that discussed killing Stalin ("They just dreamed that up"), he was sentenced to ten years' labor plus five of village exile.

Pathologically suspicious, Stalin expanded the tsars' system of exiling troublemakers to

Siberia. He began to eliminate his enemies, real or imagined, purging Communist Party officials, scientists, managers, writers, and, finally, in Soviet historian Roy Medvedev's words, "anyone he didn't like." By 1938 the "great terror" stalked the land: more than a million executed, perhaps seven million in camps (graph).

Drenched in fear and propaganda, the masses applauded the elimination of "enemies of the people" and "wreckers" of the five-year plans (even peasants who stole potatoes from a collective farm). Citizens denounced bosses, friends, kin.

Dmitri Mikhailov's "crime" also was capture—by the Germans in World War II. Freed from Buchenwald, he returned to Leningrad thinking he'd seen the end of terror. Instead he got 25 years. In Archangel Oblast he cut timber. It was hell on ice—"God created the earth and skies, but the devil created Archangel."

After the war the lags swelled with German and Japanese POWs, Soviet citizens who had fought or were forced to labor on the German side, and Russians, Ukrainians, and Balts who had fled Soviet rule. Roosevelt and Churchill had agreed to return Soviet citizens found in Western Europe; two million were handed over.

Camps spread across the Soviet Union (map). Prisoners dug canals, laid roads and railroads, farmed, mined. They died of malnutrition, tuberculosis, execution—about 10 percent or more a year. Historian Medvedev puts it at 30 percent in the first years of World War II, when rations were cut and workdays stretched to 14 hours. His father, an army officer, died under such conditions in the dreaded Kolyma River mining region 3,500 miles east of Moscow.

Medvedev and Western expert

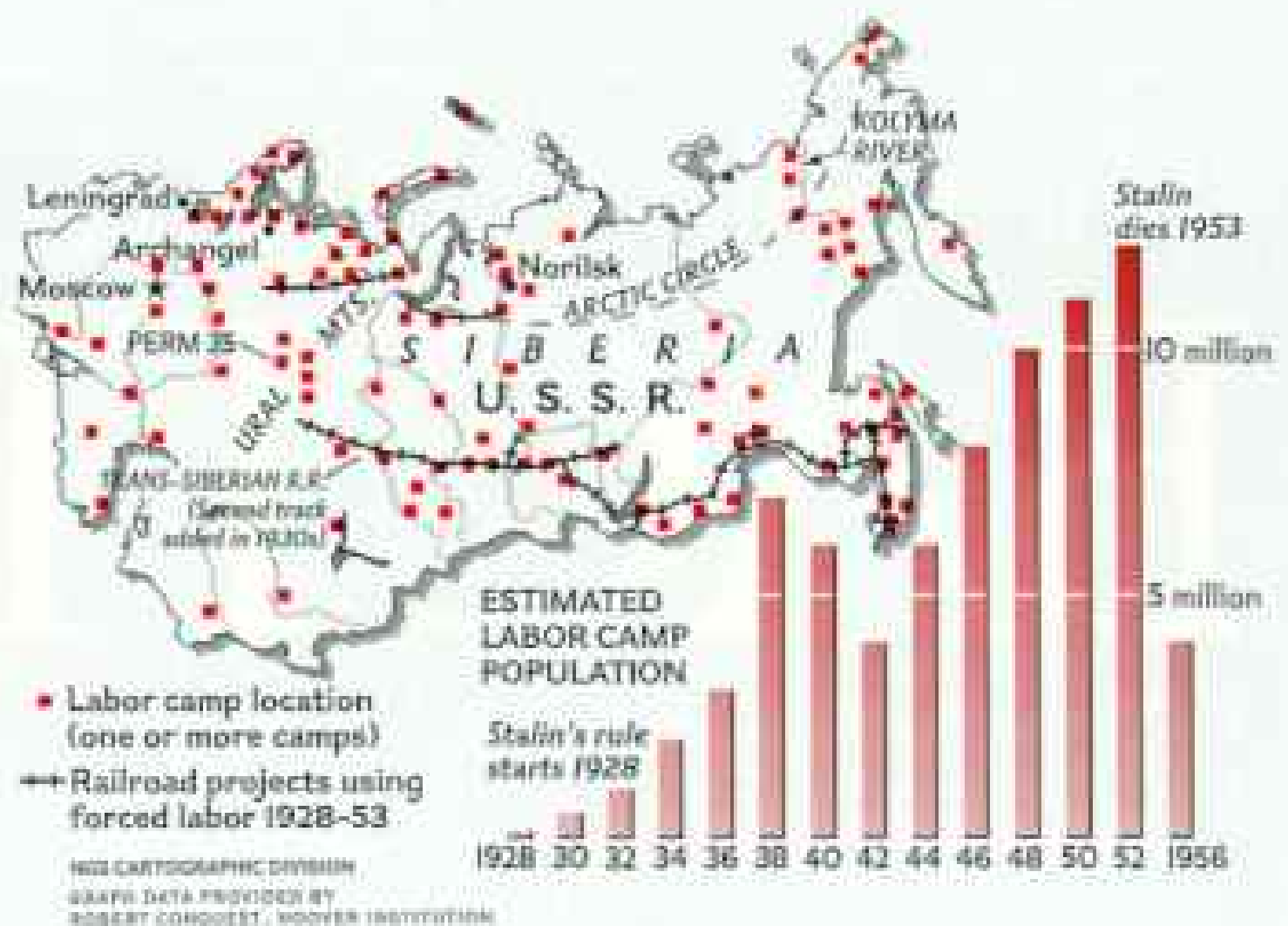
Robert Conquest of the Hoover Institution estimate gulag deaths at seven to ten million — with another ten million dying from mass dislocation and famine (officials bore off the grain harvest) as Stalin crushed the peasantry in the 1930s. Millions more suffered; for example, Ukrainians and Poles exiled to Kazakhstan.

An amnesty in 1956 enabled many zeks to resume their lives. Georgi Borisov became a theater director. Ivan Sidorov became Norilsk's civil-defense chief.

Even today no condemnation of Stalin passes Ivan's lips. When he was young, Stalin was god — as he is for many still.

Aeronautical engineer Aleksandr Zorokhovitch will never forget his American suit and French topcoat, bought on a prewar trip to engine factories abroad. Denounced by a jealous friend, he drew a ten-year sentence in the Urals.

Today he wonders what his country would be like had there



been no purges. "Do you know Stalin destroyed 40,000 Red Army officers?" he asked. "When the war began, lieutenants commanded divisions. With generals we might not have had a four-year war."

Liquidation of millions of citizens, from poets to engineers, helped shape a tragic future: repression, stifled enterprise, insularity, global aggression.

Good men perished who would have spoken out; free men, cowed, held their tongues. U. S. attitudes toward the Soviet Union hardened: containment, Cold War, the arms race, "Star Wars," trade embargoes, plain hatred. We are all Stalin's victims, victims of the lags.

Mike Edward



BEITH BY STEVE RAYMER

The Golden Hoard of BACTRIA

By VIKTOR IVANOVICH SARIANIDI

Photographs by

LEONID BOGDANOV and VLADIMIR TEREHENIN

All that glitters is truly gold in the grave of a young woman (opposite), perhaps a princess of ancient Bactria, in northern Afghanistan. When our joint Soviet-Afghan team excavated six such graves in 1978, we found 20,000 gold artifacts, among them a gold hair pendant (below). The finds shed light on a period 2,000 years ago along the great Silk Route. Now these treasures face an uncertain future as Afghanistan copes with the aftermath of civil war.

THE DARK PERIOD, it was called—the shadowy two-century span between ancient empires in the land of Bactria, on the northern plains of today's Afghanistan.

In the rainy fall of 1978 that darkness lifted. Digging in an unassuming mound known as Tillya Tepe, the "golden hill," we chanced upon the graves of eight ancients who had lived within that unknown period some 2,000 years ago. And with their bones we found the wealth they were to carry to the afterlife—more than 20,000 artifacts, mostly crafted of gold and semiprecious stones—a treasure of such artistic and descriptive richness that to speak of it was already to begin to understand that distant time.

But before we had a chance to make plaster copies of the pieces, before they could be studied or displayed, war and confusion closed on Afghanistan. Today the priceless hoard from Tillya Tepe is in Kabul, but its condition is unknown, and scholars have no access. My efforts to have the trove fully safeguarded have so far met with disappointment.

Two eventful decades have passed since I first went to Afghanistan from Moscow's Institute of Archaeology in 1969. We arrived as part of the joint Soviet-Afghan Expedition to examine the antiquities that lay beneath the fabled Bactrian Plain, once an important crossroads on the great Silk Route from the varied lands of the Roman Empire in the west to the Chinese cities protected by the Great Wall in the east. We based our camp in Sheberghan, a large village set on the dry plain between the bleak foothills of the Hindu Kush and the desert valley of the Amu Darya. It reminded me of home, for I was born in Tashkent, in Soviet Central Asia, where my father, looking for a more meaningful life, had immigrated from

(Continued on page 58)







Collapsible crown for a nomadic life

It came as a kit, this elaborate gold crown taken from Grave Six. To archaeologists it reveals a fascinating blend of style and practicality. It comes apart into six pieces—the five elaborate palmettes

are slotted into a headband. A princess on the move could disassemble the crown, lay it flat, slip it into her saddlebags, and be on the road in mere minutes.

Many of the artifacts found at Tillya Tepe were imported from faraway places along the Silk Route, but much of the local artwork, like this crown, was a cultural hybrid. Bactria was autonomous



HEIGHT: 13 CM

4,000 years ago, but through the centuries it was dominated by succeeding expansionist empires: the Persians of the Achaemenid period, the Greek colonizers in the path of Alexander the Great, and the wave of nomadic Kushan and eastern Scythians who swept in from the north to usher in the Dark Period, the time of these burials. The gold crown testifies to the

high rank of women in Kushan culture, a common tradition among nomadic tribes.

When we packed the treasures into crates, I was in despair for two days because I thought the crown, one of the most important artifacts, was missing. I finally found it, packed flat, in a box I had not searched because it was reserved for small objects.





Dark of ivory, light of gold

Local gold from Bactrian rivers was made into a necklace of hollow gold and black-painted ivory beads, found on a woman in Grave Two. Gold grains were painstakingly soldered on after the hemispheres of each bead were joined. The string that once held the necklace together had decomposed. Wear marks suggest it was worn often.

DIAMETER OF IVORY BEADS: 2 CM



Horned glory

Details breathe life into a Greco-Bactrian ibex, part of a ceremonial diadem. Rings under the hoofs once attached it to a base. Early Kushan, heedless of Greco-Bactrian traditions, took such pieces apart.

SIZE: 9.2 X 4 CM

Cupids astride dolphins

Curly-haired cupids on a dress clasp appear distinctly Greco-Roman. But scales on the dolphins, whose eyes are inset pearls, reveal the local goldsmith's ignorance: Dolphins have no scales.

OVERALL SIZE: 4.2 X 9.0 CM





Mix-and-match Aphrodite

Familiar yet exotic, the figure of the Greek goddess of love recalls the soft sensuousness of Greco-Roman sculptures. But the wings—never seen on Aphrodite in Greek or Roman art—stem from ancient Bactrian tradition, and the forehead mark is imported from India. Bactrian art in the Dark Period was seldom pure; patrons of the local goldsmiths combined various traditions. This Aphrodite, in the form of a pendant, was found among hundreds of gold spangles lying on the bosom of the young woman in Grave Six.

SIZE: 3 X 2.8 CM

Goddess Anahita

On a temple pendant Anahita rules an entourage of fanciful creatures in her realm of sea, land, and sky. Her classical figure suggests Grecian influence; the beasts evoke Scythian legends.

SIZE: 5.8 X 4.4 CM

Amour rides again

On another dress clasp, Dionysus fondles Ariadne on a chimera, while a drunkard extends a cup. The theme is Hellenic, but the steed is Bactrian: In Greece the lovers usually rode a panther.

SIZE: 6.5 X 7 CM





Local people gather as a team member excavates Grave Two. The burial sites had been dug down through rubble and ancient temple walls that were unrelated to the graves themselves. Though local farmers knew the mound as the "golden hill," they had forgotten why. One grave offered a clue: Field mice had looted it, and their nearby burrows were filled with thin gold platelets. Perhaps the mice had hauled some gold to the surface, where farmers found it. Hence the name.

(Continued from page 50) a village in Greece. Sheberghan was on the frontier of the struggling Afghan nation and mired in poverty. Cotton fields pressed against the mud-brick houses, and merchants sat stoically among their stacks of melons and eggplants at the central bazaar. When night fell, everything was still. Neighbors talked to neighbors in the darkness between houses, and packs of hungry dogs circled in the streets. It was much as Bactria must have been during the Dark Period. Only in the morning, when the trucks started up, did the 20th century return.

On and off for nine years we dug into the mounds near Sheberghan. At first we focused on an obvious site called Yemshi Tepe, the ruins of a monumental city dating from the first century A. D. Inside its walls we found a citadel, perhaps the palace of the local ruler who controlled a cluster of smaller villages that now appeared as small swells of sunbaked earth.

But surely an earlier people had farmed this plain. Day after dusty day I drove from mound to mound, searching for some sign of Bronze Age life, my speciality. In the brittle grass on one such mound my eyes fell on a type of painted potsherd I recognized from a prior dig in Central Asia. It pushed the date of habitation in this area back a thousand years, to the beginning of the second millennium B. C. A fantastic find! While others were excavating nearby Yemshi Tepe, my team set out to see what lay beneath this simple hillock.

Amid its top layer we found a village from the third century B. C., as we had expected. But from the layer beneath emerged the outline of a massive edifice. Inside, within a double line of columns, stood a mud-brick altar coated with ashes. Surely this was a temple for the worship of fire, built 3,200 years ago.

AS WE EXCAVATED in late 1978, Afghanistan was inching toward a civil war. A new socialist republic had been declared. We were not caught in any fighting, but one morning armed tribesmen came on horseback, like sand devils off the desert, circling Tillya Tepe, asking angry questions. The frightened workmen implored us not to say anything, or we would be shot. And then the riders were gone.

Despite the growing danger our fascination with the ancient temple urged us on, while clouds that rolled in from the Hindu Kush each day grew darker, promising the heavy, prolonged rains of winter. A cold drizzle started late at night on November 12 and forced us to break off work at noon the next day. But that morning we had found several rusted fragments of iron bands with nails sticking from them. One was bent at a right angle and looked a lot like a bracket from a wooden coffin.

When the weather cleared, a workman suddenly turned up a disk that gleamed among the clods of damp earth. Gold! We called a military guard and waded in with pounding hearts. And soon a grave emerged from beneath our picks and scoops. Staring at us were the hollow eye sockets of a skull, a young woman between 25 and 30, perhaps a princess. Surrounding her were layers of gold jewelry and ornamentation (below) that had collapsed together from her disintegrated clothing.



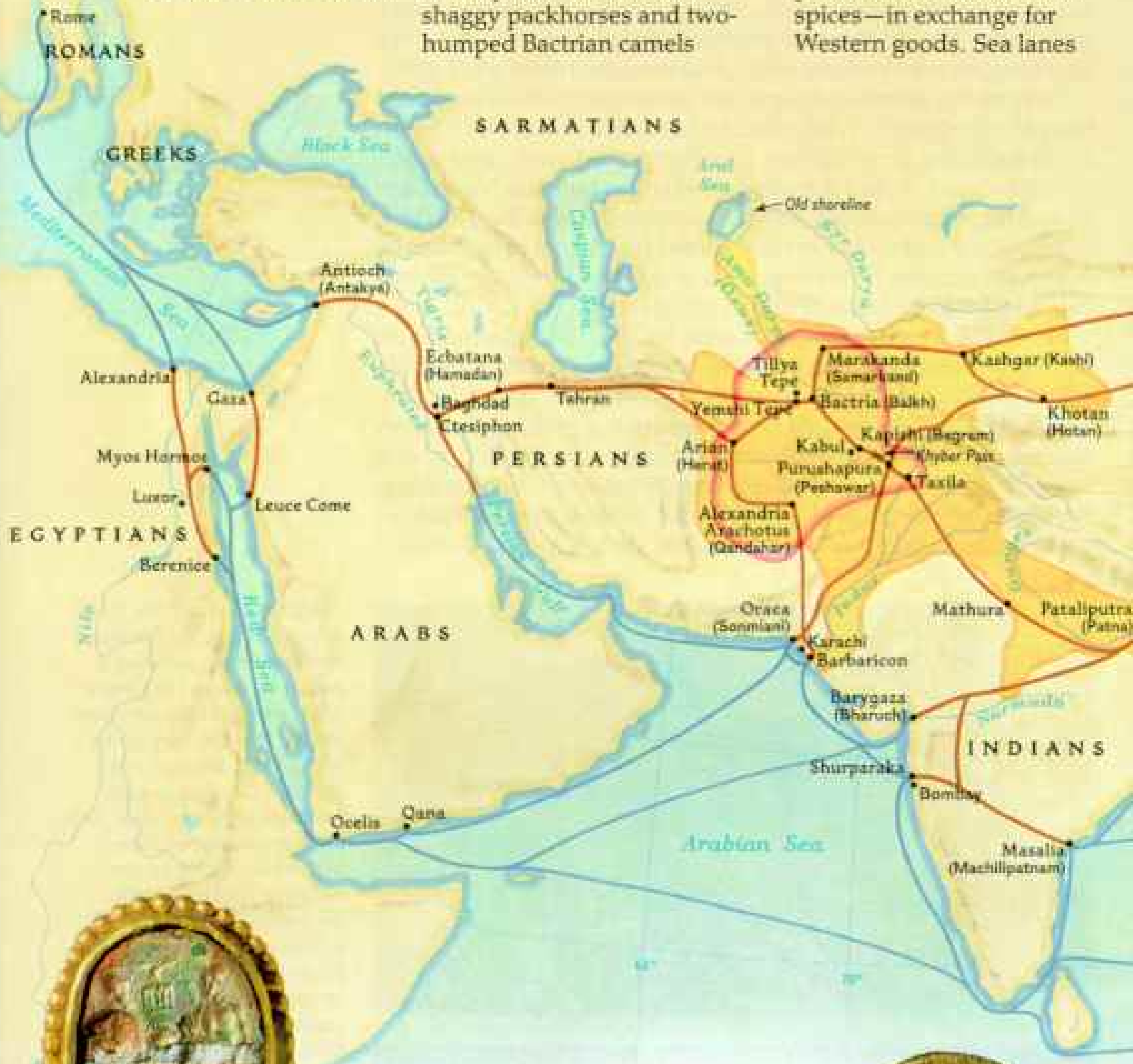
Time wore away the flesh and clothing of a Kushan noblewoman, perhaps a princess, buried in Grave One. Her gold jewelry and artifacts—the tiny disks and platelets sewn onto her robes—slowly sank among the bones, then dirt collapsed around them. We labored long to excavate the skeleton (left), separating artifacts from rubble and plotting the finds on paper, as we did to reconstruct each of the graves. We worked well into the bitter Afghan winter, our fingers numb with cold.

ALL SOVIET-AFGHAN EXPEDITION.

Bactria: hub of the great trade routes

As the Greco-Bactrian period waned and the Kushan Empire waxed in the first century A.D., caravans of shaggy packhorses and two-humped Bactrian camels

plodded along the route that led from Luoyang to imperial Rome. They carried the trade and treasure of the Orient—precious stones, silk, and spices—in exchange for Western goods. Sea lanes



SIZE:
1.8 x 1.3 CM

A Roman glass intaglio depicts the three Heraclidae, descendants of Hercules, at the altar of Jupiter. They have returned in victory from the Peloponnesian War and are drawing lots for possession of the conquered land.

A griffin carved from milky white chalcedony represents a blend of Greek and Achaemenid Persian cultures.



LENGTH:
3.1 CM



DIAMETER:
1.8 CM

A coin from the Parthian Empire of Iran, the only gold one known to numismatists, bears the profile of a bearded king wearing a knobbed crown.

NON-CARTOGRAPHIC DIVISION
DESIGN: SALLY S. SUMNER-ELL
RESEARCH: BARBARA J. ELYER
PRODUCTION: VICKI BLANCKEN-PRATT,
S. RAMSEY MURRAY
MAP EDITOR: GUS PLATT
PRINTING BY WILLIAM H. BORD

based on monsoon winds augmented caravans.

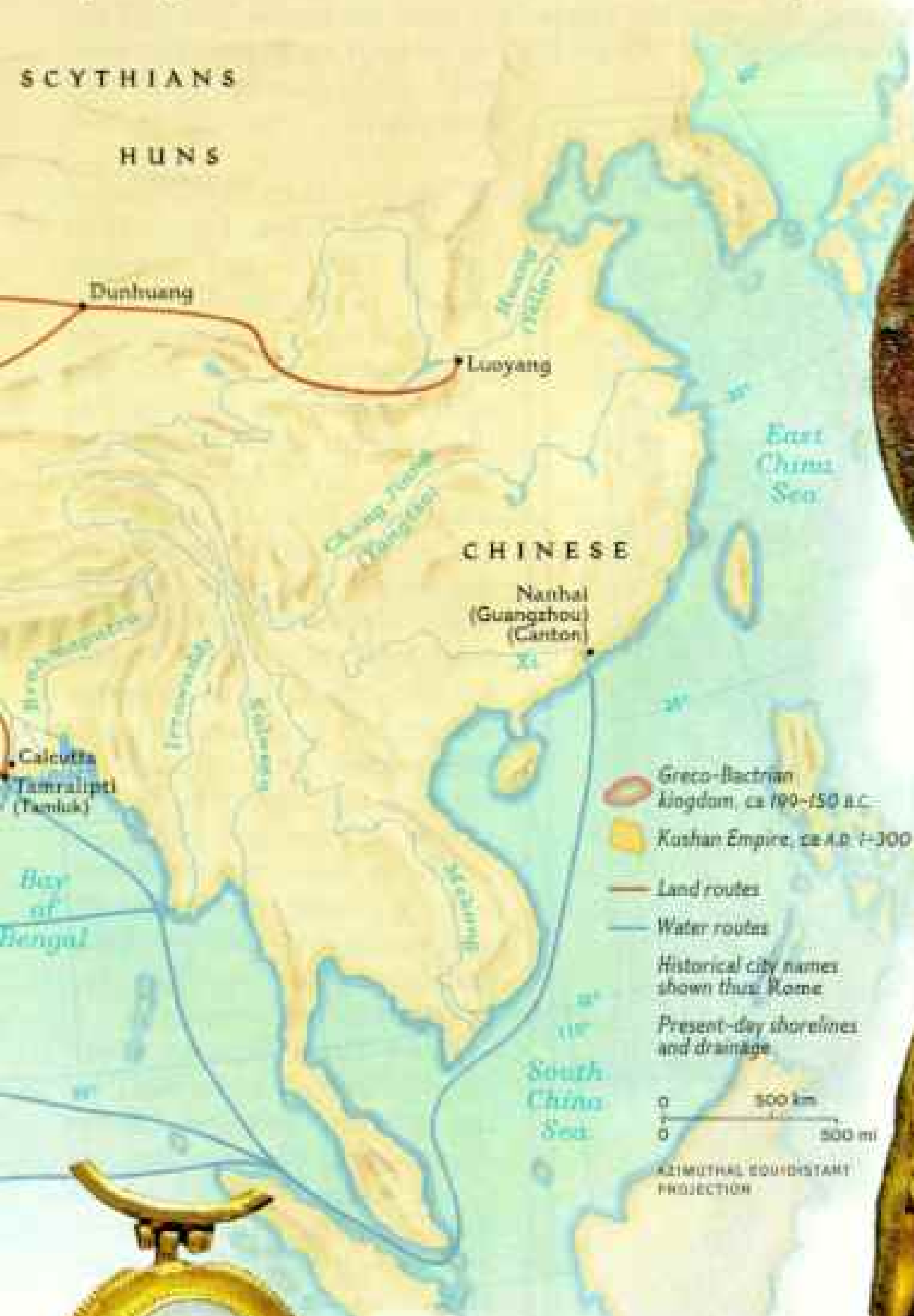
The Kushan nomads eventually learned the ways of commerce and established themselves as middlemen along the age-old trade routes.

Ensconced in the Amu Darya Valley, they exacted duties from the caravans and bartered for artifacts such as these below, all found in the excavations. The Kushan also traded along

the north-south route from India. Through the Khyber Pass came aromatic resins, sandalwood, and exotic animals—some bound for markets as far away as the Mediterranean.

SCYTHIANS

HUNS



DIAMETER: 17 CM

From the Chinese Han dynasty came a polished mirror, part of a cosmetic kit. On the mirror back, Chinese characters surround an eight-pointed star.



SIZE: 9.1 x 4.3 CM

The nomadic Scythians from Siberia fashioned this gold plaque on wooden backing, a decoration for a horse bridle. The scene depicts a panther mauling an antelope.



DIAMETER: 1.8 CM

An unknown Indian state minted this coin embossed in the Kharoshthi script and bearing the image of a man pushing the wheel of dharma.



SIZE OF CAMEO: 4 x 3.5 CM

Local artisans produced this necklace made of gold wire and set with an antique stone cameo depicting a Greco-Bactrian ruler.

The brilliance of her Dark Period finery astonished us.

The potent word "gold" soon spread across the plain, and a pilgrimage began of village people, tourists, and authorities from Kabul. Some came on donkeys, others walking. One constant visitor was the farmer whose cotton fields lay next to our excavation. He would sit for hours on the edge of the dig, looking sad. "My wife has chased me from the house," he told us. "She yelled at me, 'All my life you've kept me in poverty, with gold lying under your feet every day!'"

BUT WHAT WAS the mound of Tillya Tepe? Who buried the princess here, and why?

This is what we know: Four thousand years ago the first agricultural tribes appeared on the Bactrian Plain; those who built the fire-worship temple must have been among them. During the next thousand years the temple was rebuilt several times. When it fell out of use the mud-brick walls crumbled into a low mound. Tillya Tepe lay still for 600 years until a small village grew on the remains of the long-forgotten temple. The village did not last long, and again the site crumbled into ruin. So it would remain for 400 years until A.D. 100, when the golden graves were dug into the site's layered history.

While Tillya Tepe lay abandoned, Bactria was buffeted by the growing empires of the Achaemenid Persians and the Greek followers of Alexander the Great. Bactria itself grew into an independent state, known as the Greco-Bactrian kingdom. But the haunting nobles buried in the humble

mound were newcomers to Bactria—they had come from the east to plunder the Greco-Bactrian cities.

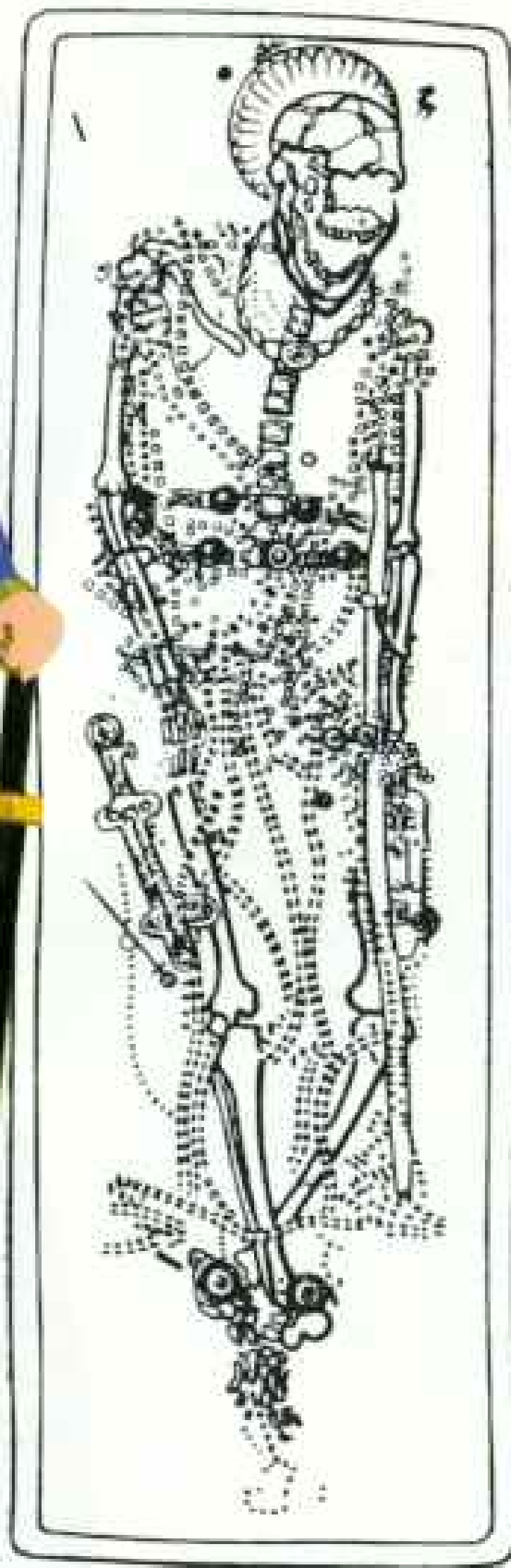
On the other side of Asia another drama was unfolding. Where wandering tribes had clashed for centuries on the frontiers of China, an aggressive group of nomads called Kushan were pushed west by the Huns into the bleak and limitless expanse of southern Siberia. There the Kushan encountered the Scythians, another nomadic tribe that had coveted the flourishing oasis cities on the trade routes to the south but



GRAVE FOUR

The warrior in Grave Four was buried with two daggers and a sword. Nearby, in nomadic custom, lay remains of his horse. While plotting his grave, we reconstructed his clothing.

PAINTING BY NATIONAL GEOGRAPHIC ARTIST WILLIAM H. BOND, AFTER IRINA MASIMOVA (ABOVE); SOVIET-AFGHAN EXPEDITION



dared not act alone. United, the horde gathered courage and raged across the Central Asian steppes 130 years before the birth of Christ, leaving charred fields and human suffering. When they crossed the Amu Darya—the Oxus River to Alexander the Great—they laid waste the Greco-Bactrian lands.

At first contemptuous of city life and Greek culture the nomads gradually became enamored of the seductive Hellenic tradition. They rebuilt the cities they had sacked and created the great Kushan Empire on their own debris. In the time between the Greco-Bactrian period and the well-documented flowering of the Kushan, ancient records fail us. As these nomads struggled with the ways of urban life and empire, the chroniclers of Rome did not visit them. The period was dark until our own time,

when the Tillya Tepe treasures speak of those days with resonance and clarity.

The gold of Bactria shook the world of archaeology. It was compared by critics to the treasures of King Tutankhamun's tomb in Egypt. The artifacts were found in context, not in some antique shop, not isolated from their owners or their time.

They gave us a chance to glimpse the extensive trade between the East and West. Nowhere in antiquity have so many different objects from so many different cultures—Chinese mirrors, Roman coins, daggers from Siberia—been found together in situ. And the local art of Bactria discovered at Tillya Tepe is a tantalizing amalgam of influences. Never has there been an artifact like the chubby little gold Aphrodite (page 57), who is Grecian in concept but has the distinctly non-Grecian wings of a Bactrian deity and an Indian forehead mark that indicates marital status!

WE LABORED into the winter with fingers numb and shriveled from the bitter winds that leaked through the plywood huts we had erected. Each thin gold platelet had to be cleaned and inventoried. We could barely hold the pincers. We slept in Sheberghan but ate noodles and tinned meat from Moscow while sitting in the truck, embarrassed at how little the workers had.

The plan was to return the following fall, in 1979. We posted an Afghan guard over the necropolis and headed for the Kabul Museum with the crates of excavated treasures. But conflict



Gold spangles sewn on the back of the warrior's robe still cling together in a layer of soil and ribs coated with preservative and lifted intact from the grave. The tunic was folded over to the left in typical nomadic Kushan fashion. Carved stone effigies of Kushan rulers, found earlier in Afghanistan, confirm the style.

Tillya Tepe's stunning cemetery

The graves of Tillya Tepe, shown below, were uncovered one by one as the mound itself was excavated. Clearly those who buried their relatives here had no knowledge of what lay beneath. Emerging from the topmost layer was a crude village dating from 350 B.C. From a lower stratum appeared a grand edifice of walls and turrets, more than a thousand years older than the graves. Within the walls we found two columned halls and an altar

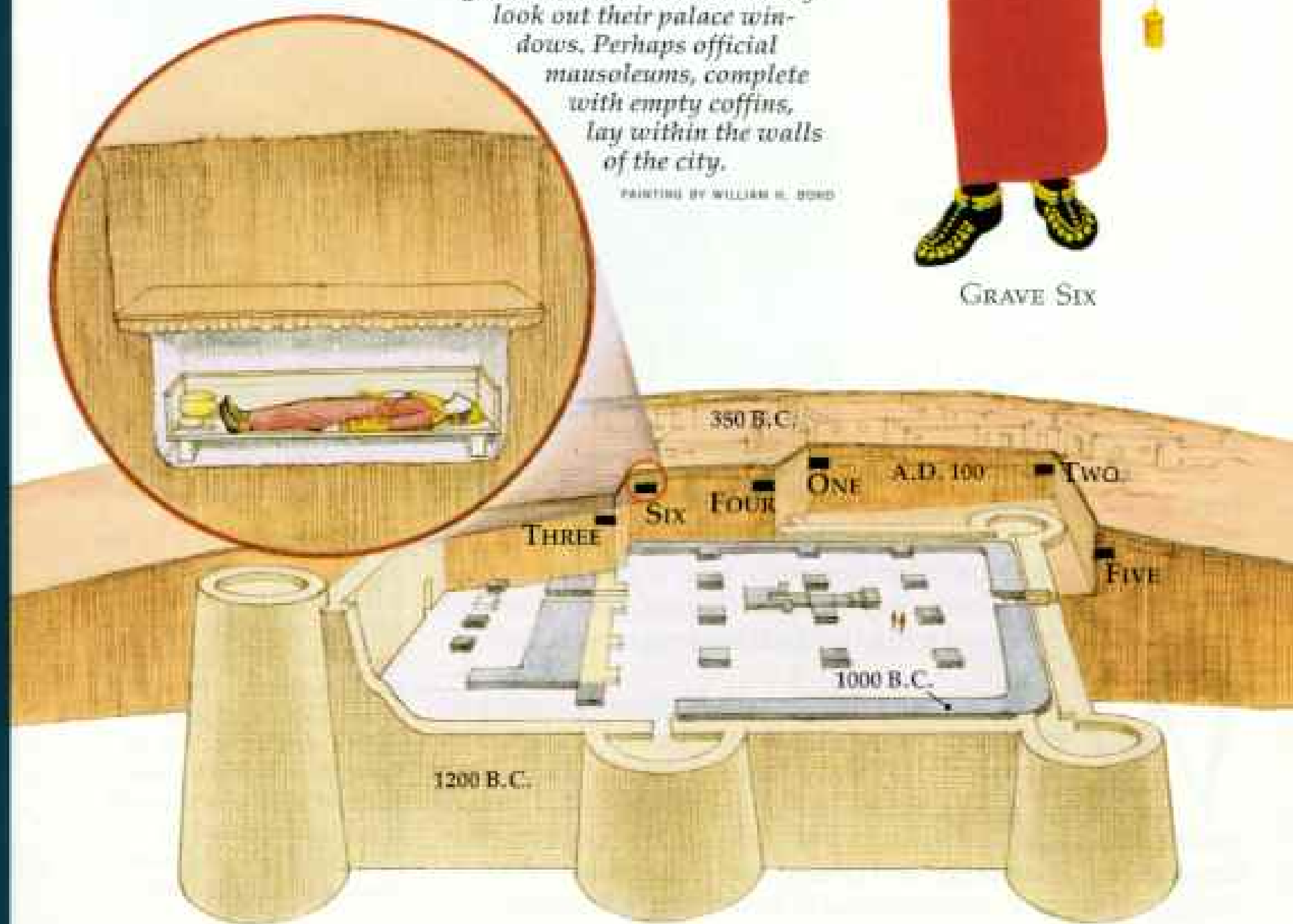
covered with the ashes we think were produced during fire-worship ceremonies.

But when the burials were made, Tillya Tepe was just another hillock. At first we were perplexed: The graves were too simple, only pits with dirt walls and wooden planks to protect the coffins (diagram, below). Why inter such wealth here? The graves should have been majestic and located in some city. My own theory is that they were deliberately camouflaged. Graves were dug in secret for the local Kushan rulers, who were fully mindful of others' greed. All the graves lay within eyesight of Yemshi Tepe, a nearby citadel that may have been the regional Kushan capital. To guard the graves, the rulers could merely look out their palace windows. Perhaps official mausoleums, complete with empty coffins, lay within the walls of the city.

PAINTING BY WILLIAM H. BOND



GRAVE SIX





GRAVE FIVE

GRAVE THREE

GRAVE TWO

GRAVE ONE

soon erupted and we left Afghanistan in a hurry in February 1979, never to return to the dig.

We had excavated six graves (left) of what may have been the family cemetery of the rulers of a large Kushan principedom. Grave Two held a bespangled matriarch between 30 and 40 years old. In Grave Three lay another female, perhaps a teenager. A tall warrior, the only male found, was buried in Grave Four. In Grave Five was a young woman whose relative lack of ornaments suggests she was of lower rank. From Grave Six emerged another woman, also perhaps a princess, who wore a collapsible crown. The seventh grave had not yet been examined, and the eighth emerged with the rains, as we sat in Moscow.

Since then darkness has again engulfed the treasures. Soldiers we had trusted apparently looted the two unexcavated graves left in the necropolis. Artifacts similar to the ones we found have turned up for sale. We saw the treasures of Tillya Tepe only once more, in 1982, when we had a chance to photograph them in Kabul.

Look well on these pictures of the Bactrian masterpieces that follow. Who knows when they will be seen again?

The faces of these women, from five of the six excavated graves, we will never know. But artist Irina Maximova spent years reconstructing their garb, based on the positioning of jewelry and artifacts, as well as knowledge of clothing styles in ancient Central Asia. Much of the women's jewelry was worn in life, as wear marks attest, but the elaborate gold-spangled bodices and heavy ankle decorations were reserved for eternity.

PAINTINGS BY WILLIAM H. BOND,
AFTER IRINA MAXIMOVA





Warrior belt

A band of braided gold connects nine gold medallions in high relief, each depicting a goddess mounted on a snarling lion (detail below). The warrior in Grave Four wore this belt around his tunic.

DIAMETER: 4 CM

Warrior clasp

A warrior garbed in Greco-Roman armor and Macedonian-style helmet stands at the ready on a garment clasp (left). The warrior may be Ares, the Greek god of war, or Verethragna, his Persian counterpart. Columns of trees filled with snarling animals surround him. Such motifs were common to Scythian art but seldom found in Greco-Roman art.

SIZE: 9 x 6.3 CM





Beasts writhe on dagger

Dragons and other animals wrought in fantasy maul one another on the gold hilt (above) and gold-plated wooden sheath (right) of a ceremonial iron dagger found with the buried warrior. Turquoise inlays adorn both scenes. On the hilt a bear gnaws a grapevine, a common Siberian or Sarmatian motif. Scenes of powerful animals were believed to enhance the owner's strength and courage.

OVERALL LENGTH: 37.5 CM



Ghostly zebu

The influence of India shines from a translucent gemstone incised with an abstract likeness of a zebu, the humped Indian ox. A hole has been bored lengthwise for beading. Because the treasures have not been available for detailed study, many of the gemstones found have not been properly identified.

LENGTH: 2.1 CM



Chinese buckles

These turquoise-studded gold buckles bear images from the East — charioteers with Oriental features driving Chinese-style canopied chariots. But the winged griffins pulling the chariots suggest local Bactrian design.

DIAMETER: 3.5 CM

Early Kushan artisans blend cultures

THEY RULED no empire but took or bartered for what suited them from the caravans that traversed their land. Gradually the sons and grandsons of the fierce Kushan learned the ways of cities, of leisure, and of higher cultures as they grew from nomads to sedentary merchants.

Early Kushan clothed their dead with barbaric magnificence, beading every square inch of finery with tens and hundreds of gold platelets and artifacts. But their art was usually clumsy, mirroring their cultural confusion. Often gold was valued only for its weight. Some bracelets weighed 300 grams; ankle ornaments, a full kilogram. But they were devoid of art.

As the Kushan grew in cultural sophistication, the old art found its way back into vogue. The cameo of a Greco-Bactrian ruler on the facing page was an antique stone worked into a local design. Bactrian craftsmen, who were working for Kushan rulers, were no less skilled than their predecessors, but they lacked a strong cultural base of their own; they worked to please their clients' tastes. From their hands came ancient kitsch as well as works of authentic art. Even artifacts that looked Grecian lacked the feeling of Greek art.



Shell-like dish

This cast, fluted vessel lay under the warrior's head. Its weight of 638 grams was stamped in Greek on the back of the dish.

DIAMETER: 23 CM



Bactrian baubles

Hearts of turquoise decorate hollow gold beads, once part of a funerary necklace.

SIZE OF ROUND BEAD:
2.3 x 1.5 CM

Royal cameo

Topped by a Macedonian helmet complete with curled ribbon, the profile of a Greco-Bactrian ruler graces a two-hued stone later set into a gold necklace.

SIZE OF CARVED: 4 X 2.5 CM



Signet ring

This crudely chiseled Greek goddess of wisdom carries a shield and spear. "Athena" is written in reverse, to produce a positive image.

SIZE: 1.5 x 1.7 CM

Cosmetic pot

Beauty secrets buried for the afterlife once filled a silver vessel inscribed with circles and interwoven vines.

HEIGHT: 4.7 CM



Antelope bracelets

Necks strain and eyes bulge as four stylized antelopes with turquoise ears, horns, and hoofs strive to meet around the wrist of the deceased noblewoman in Grave Two. Animals contorted for artistic purposes are characteristic of Siberian and Scythian design.

SIZE: 6.5 x 3.8 CM





BOTH SOVIET-AFGHAN EXPEDITION



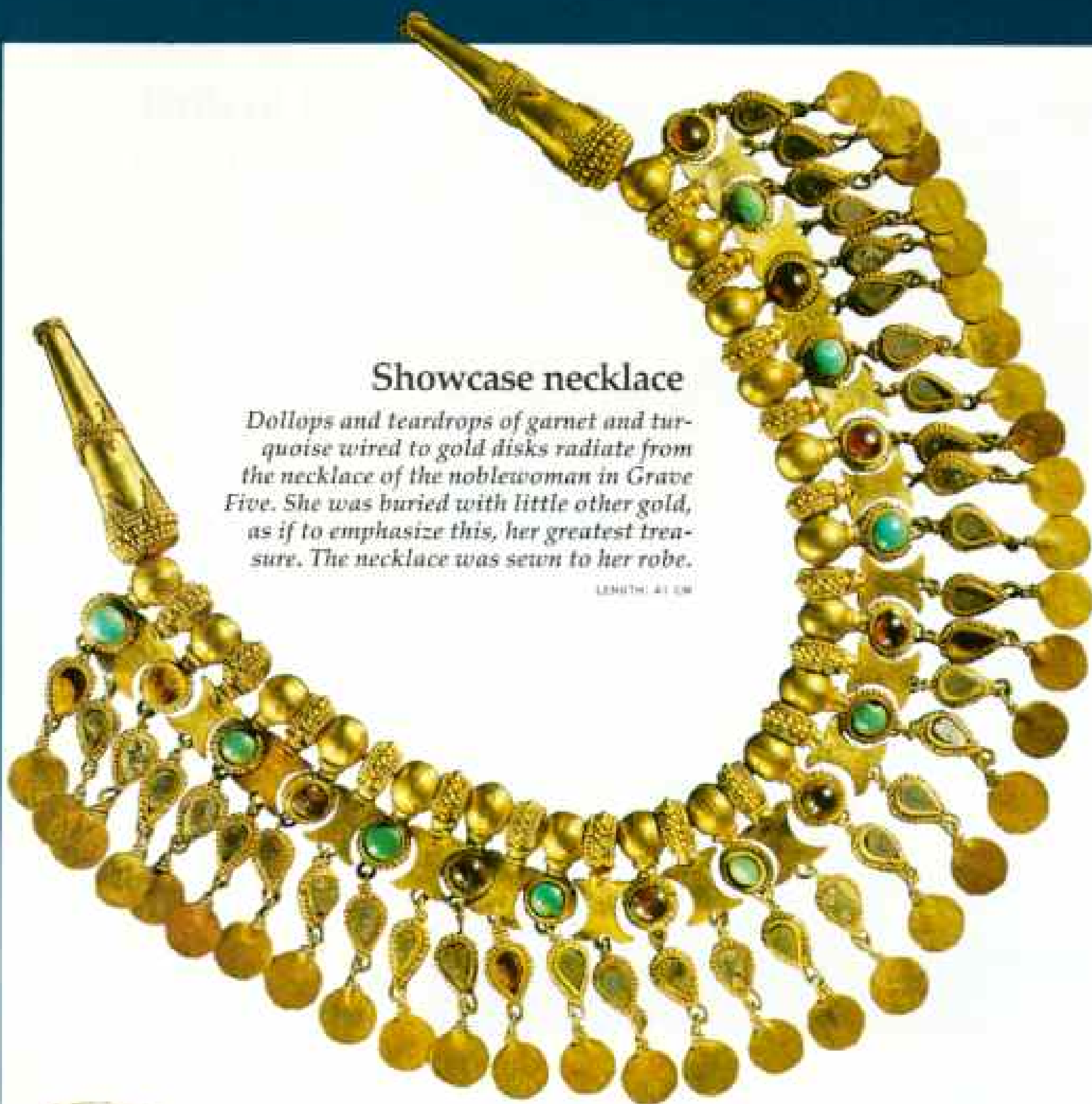
Dust to dust . . . gold lives on

AT THE BOTTOM of an unmarked earthen pit two meters down (left), a hoard of gold reveals the status of a Kushan noblewoman, perhaps 40 years old, found in Grave Two. The wooden coffin, whose outline remains, once stood on legs but had no lid.

When the woman was buried, a shroud spangled with gold disks was wrapped tightly around her body. On one finger she wore the signet ring seen on the facing page. Her jaw was bound with a broad gold chin stay. On her breast lay a Chinese mirror (like the one shown on page 61), seen here as a half-buried disk.

In the detail below, antelopes from the bracelets shown opposite peer from the soil. One still encircles the wristbone, the other lies by her upper arm. Both bracelets show strong signs of wear.

Grave Two was hollow until the wooden planks and leather hides that supported the earth above collapsed, compressing all into a jumble of bones, wooden scraps, and artifacts that took months to sort out. Every spangle, every pattern, every layer of wood dust was painstakingly analyzed. To complicate matters, the dead woman wore four or five layers of clothes, most with their own opulent style of embellishment.



Showcase necklace

Dollops and teardrops of garnet and turquoise wired to gold disks radiate from the necklace of the noblewoman in Grave Five. She was buried with little other gold, as if to emphasize this, her greatest treasure. The necklace was sewn to her robe.

LENGTH: 41 CM



Lidded gold jar

Laurel leaves wreath their way around a gold cosmetic pot of Greco-Roman influence. The handle of the lid is shaped like a pomegranate. A fine gold chain links top to bottom.

HEIGHT: 5.5 CM



Story in ivory

Only fragments remain of an ivory comb and a story etched into it. The comb may have been brought from India to Bactria, where it was buried as part of a noblewoman's toiletries.

LENGTH: 8 CM

Treasures for all humanity

GOLDEN CONFETTI, thousands of spangles were stamped out to enrich the afterlife of the departed. Each platelet weighs next to nothing. In 1978 a pocketful of them might have bought a new car in Kabul, and they sorely tested the honesty of impoverished Afghan workers on our site. As soon as gold was found, officials turned suspicious of foreigners, and soldiers kept a constant vigil. A two-man team—one Soviet and one Afghan—was assigned to each grave, and their tallies of the daily findings had to match perfectly.

Our expedition left the site on February 8, 1979, and the whereabouts of the treasures became an instant controversy. From the moment of discovery there had been rumors that the gold was being spirited out of Afghanistan, even taken to the Soviet Union. As leader of the expedition, I can reassure the world that the treasures are still in Kabul.

What happens to them now is of concern to the international community. I feel that these artifacts deserve the scrutiny of specialists. They should be seen throughout the world for all the priceless knowledge they reveal. Their story is not just Afghan, not just Soviet or Greek. They write a special chapter of history, and they belong to all humanity. □



SIZE OF SQUARES: 1.4 CM

America's Ancient Skywatchers

A gigantic figure called the Owl Man, still visible after 2,000 years on a dry hillside near Nazca, Peru, points one arm to earth, the other to heaven where the bright star Arcturus trails across the sky in May. Was he meant to be an intermediary between

two realms, a role assumed by the owl and the owl shaman in Andean lore? Or were such effigies—and the adjacent arrow-straight Nazca Lines—used as ritual walkways for



celebrants seeking communion with the divine? In the Andes today people tread such sacred paths with offerings to mountain and sky gods, an action duplicated by a flashlight-carrying walker in this time exposure. Intense observers of the stars and

planets, ancient Americans developed elaborate rituals to assure their place in the cosmos and bring order to their lives—a field explored by the new discipline of archaeoastronomy.

By JOHN B. CARLSON
Photographs by BOB SACHA





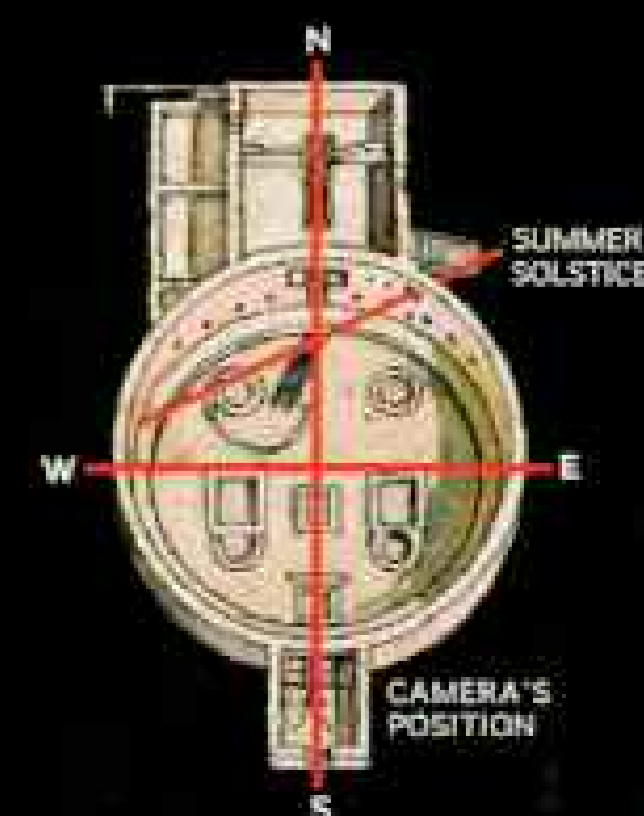
Anasazi astronomy

Symbol of the cosmos, the great kiva of Casa Rinconada in Chaco Canyon, New Mexico, reflects the concepts of Anasazi builders of the 11th century A.D. In shape it duplicates the circular sky. Its main door faces celestial north, that fixed spot in the nighttime sky around which all stars seem to revolve.

Once the kiva was enclosed by a heavy wood-and-mud roof supported by four huge pillars set in postholes, lighted here, which defined the cardinal directions (diagram below). According to stories told at Acoma Pueblo nearby, the First People emerged from the underworld by climbing four trees.

In this great chamber, fraternal groups likely sat on the wall ledge while masked dancers emerged from the underground chamber. At summer solstice, sun rays entered the window to the right of the north door and struck a niche on the northwest wall, dramatically marking the northernmost journey of the sun.

DIAGRAM BY KEN DALLISON



Mapping the cosmos

Pre-Columbian Americans left no definitive charts of their universe; clues from iconography, ethnology, and archaeology guided these reconstructions. To each culture the universe encompassed sky, earth, and underworld. Each saw celestial bodies as living beings that influenced humans and could be affected by them. Each believed its people came from the earth and resided at the center of the universe.



Maya

The Maya universe, here centered on a tiered pyramid, rested on a crocodilian in a cosmic sea. Each quarter of the earth was associated with a color; the center was a fifth direction. Four divine beings held up the dome of

heaven, shown as a two-headed dragon whose body is a sky band of celestial symbols. It arches over the moon goddess—who holds the rabbit discerned in the moon's face—a skeletal Venus, and the sun god. The star cluster

Pleiades is a rattlesnake tail. The creation of the sun and, probably, the planet Venus was explained by a tale of Hero Twins who vied with the Lords of Death in a series of ball games; the victorious twins became those celestial bodies.

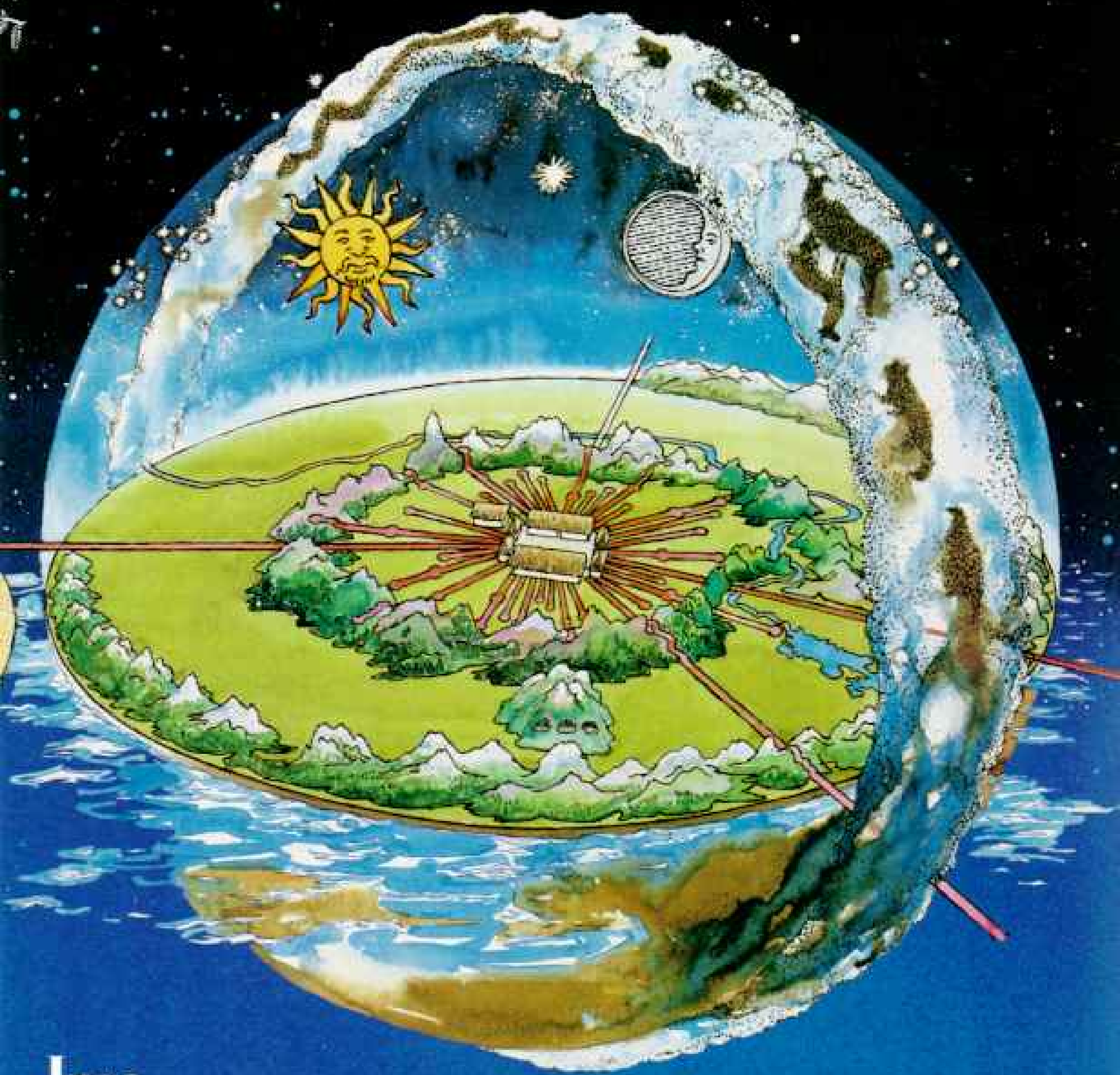


Navajo

Portrayed as a sand painting, the world view of Diné—"the people," as the Navajo call themselves—centers on the family hogan. The first hogan was built at the place of emergence of ancestors who traveled through three

previous worlds before rising through a hollow reed into this "glittering" place. Each quarter of the earth is characterized by a color, sacred mountain, time of day, and holy person. Guarded by a rainbow god, the sky

sparkles with constellations and the Milky Way, represented by the band of crosses. Young warriors carry the blue sun and white moon. Beyond the sky lies a land ruled by the Big Wind (yellow) and Big Thunder.



Inca

The Inca king believed himself the son of the sun; his universe centered on the Temple of the Sun at Cuzco, Peru. In one origin myth the Inca people came from three caves; in another they rose from Lake Titicaca. The

straight red lines shown are ceques, connections to sacred places. The major ceques formed borders of the quartered Inca world. The Milky Way flowed into the underworld and, returning, brought dark, fertile mud to

the sky, forming patches that resemble animals, such as the snake (at top), toad, tinamou bird, mother and baby llama, fox, and another tinamou. The sun appears as a male god, the moon as a female.

PAINTINGS BY KEN DALLISON. PRINCIPAL CONSULTANTS: JOHN B. CARLSON, CENTER FOR ARCHAEOASTRONOMY (MAYA); TRUDY GRIFFIN-PIERCE, UNIVERSITY OF ARIZONA (NAVAJO); GARY URTON, COLGATE UNIVERSITY (INCA)



At winter solstice the sun rises near Wijiji Pueblo in Chaco Canyon behind a sandstone pillar that probably served as a calendar marker for the Anasazi and the Navajo. Rites assured that the sun on the shortest day would not disappear forever.

The sun passing directly overhead marked a key date in the tropics. At Xochicalco, Mexico, an eighth-century stone-walled shaft directs the sun at zenith on May 14 to the floor of an underground chamber (facing page), a phenomenon measured by Stanisław Iwaniszewski and his wife, Gabriela.

WITH AN EXCITEMENT born in my first childhood visit to a planetarium, I gazed up at the star-filled dome of the Southern Hemisphere's early winter sky. The great square of Pegasus stood high in the north, while the red planet Mars coursed in Aquarius. Aquila the Eagle, with its eye the brilliant star Altair, bobbed in the spectral river of the Milky Way where it arched across the horizon.

I had come to Machu Picchu, a sacred site thought to have been one of the estates of the Inca king Pachacuti, to watch the sun rise on the June solstice, shortest day of the year there. Four companions—guide Rita Barrantes, Inca scholars John Rowe and Pat Lyon, photographer Bob Sacha—and I were gathered to observe and record the astronomical conditions that governed timing of the Inca festival of renewal still known as Inti Raymi, or Sun Festival. On this day in ancient times, according to one of the early Spanish chroniclers, the king rendered homage to the sun. Offerings were made, and omens were read in the entrails of a llama sacrificed to the sun.

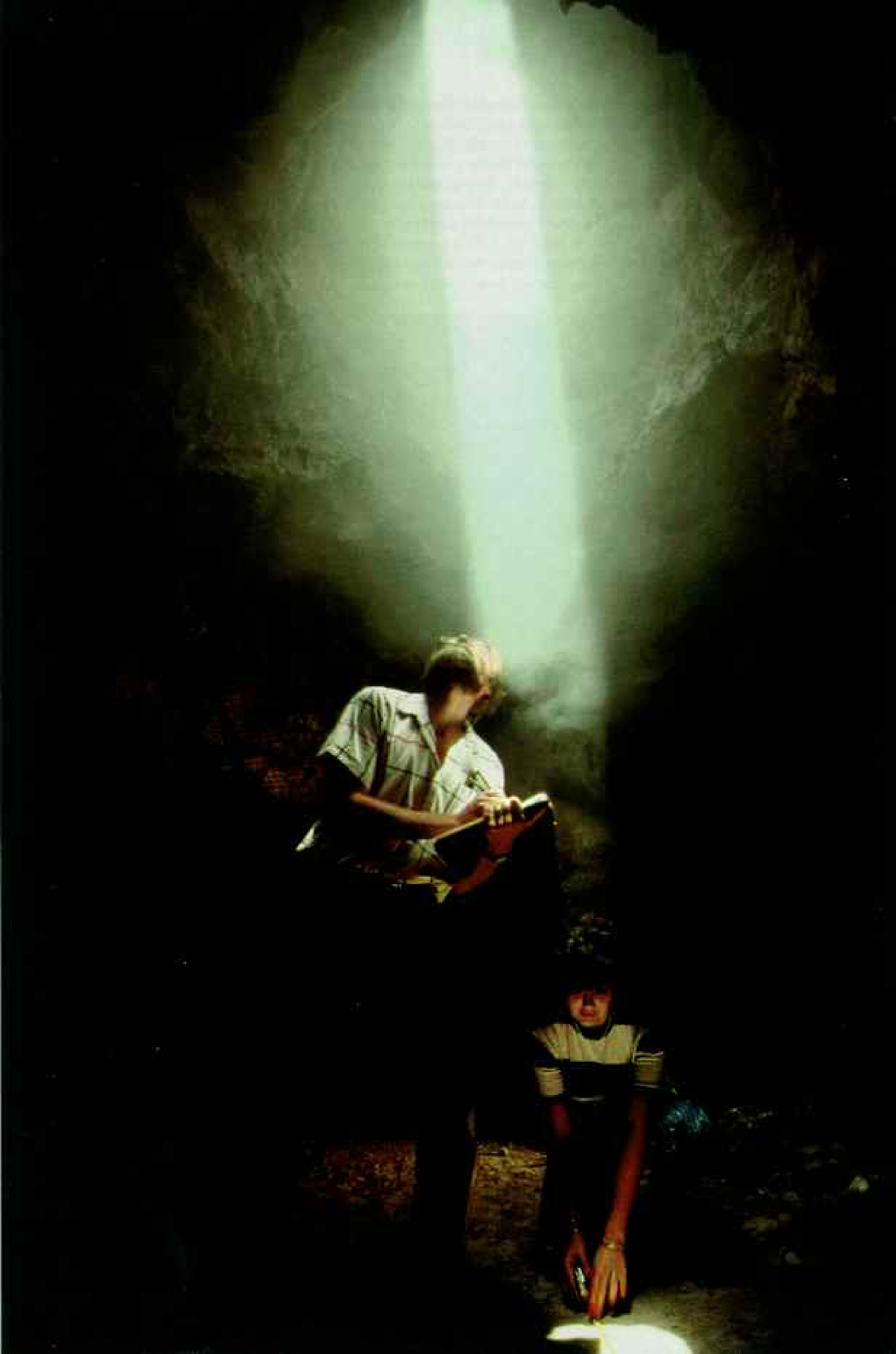
Now, in the predawn darkness, we groped along cut stones of the Inca road, bearing tripods and lights, transits and sighting compasses, our footfalls muffled by the cascades of the Urubamba River far below.

As we set up our gear by the temple called the Torreón, the halo of dawn was expanding behind San Gabriel peak. We watched the rays of the sun stream out like a fan, striking the ruins above us. Seconds later the rays poured through a window in the east-facing wall of the temple, falling parallel to the cleft hewn in a sacred stone. Inti the Sun had again entered his house as he had done silently, without witness, again and again over the centuries since the Inca worshipers had abandoned the site, until astrophysicist David Dearborn discovered the solstice alignment in 1980.

Observing that moment at Machu Picchu, I felt I had come full circle in a personal and professional quest that began in 1973. With two friends I had gone to the desert Southwest of the United States to measure alignments of Anasazi and Pueblo Indian ruins. The cliff dwellings of Mesa Verde, the towers in the canyons and on the mesas of Hovenweep, the great semicircular ruins of Pueblo Bonito, all seemed magical to me, a young physicist and radio astronomer. Within a few years—after a visit to Mexico with its great ruined city of Teotihuacan laid out like a vision of the universe—I began to stray from the study of galactic centers in the far reaches of space and joined an emerging field of study called archaeoastronomy.

This new discipline, numbering scholars from anthropology, archaeology, and art history as well as from astronomy, seeks to learn how and what ancient peoples observed about the regular and recurring motions of the sun, moon, planets, and stars. Equally important, we are trying to understand in what manner they

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In an eagle's view, Machu Picchu spreads magnificent cut-stone architecture across Peruvian heights. The spectacular city of the Inca, possibly built by the great king Pachacuti, includes the Torreón, an unusual curve-walled temple (below). Its east-facing window directs the first rays of the sun rising over San Gabriel peak on June 21—winter solstice in the Southern Hemisphere—parallel to a straight edge carved in a sacred stone.



FISHEYE IMAGE BY BOB SACHA WITH KENJI YAMAGUCHI, AGS STAFF (RIGHT)

integrated this astronomical knowledge into their religion, mythology, art, and daily lives.

For many pre-Columbian Americans, whether Inca, Maya, Anasazi—or indeed many among their living descendants—astronomy was not a science as we who are schooled in the Western tradition tend to think of it. Rather, the movements of sun and moon were the journeys of gods personified. In Mesoamerica the stars and the bright planets in their intricate wanderings were often conceived of as gods moving through the night sky en route to rebirth each sunup. They wove an enormous celestial tapestry mirrored in the warp and weft of the lives of the people themselves.

To observe and predict the recurrent paths of divine lights was to know the fates of kings and empires, to discern the proper day for rituals, to forecast animal migrations, the season of the life-giving rain, and the time for planting. The power to foretell required that observers, probably specially trained shamans or priests, make accurate records and preserve them. The information must have been accumulated over generations and generations, the observers using naked-eye sighting techniques to discover the patterns of movement in the universe. Their knowledge reached a level comparable to that of ancient cultures of the Old World.

Their records were preserved in calendars made of wood, string, and stone or, in Mesoamerica, written in accordion-fold books of





animal hide or plaster-coated bark paper. Heavenly comings and goings were also recorded in the alignment of buildings and in city plans. These provided sight lines to mark significant risings and settings of celestial bodies. Such constructions often approached our own scientific astronomy in accuracy, but they had a sacred purpose. We might compare this combination of technical knowledge and religious motive to a church window so placed that sunlight passing through it will illuminate a saint's statue on the saint's day.

Earth too was invested with divinity. Many pre-Columbian American groups believed that their ancestors emerged from the underworld by way of a cave—the mouth of the earth. The earth's surface



RICHARD ALEXANDER CODRE III

The body of a serpent seems to descend the north stairs of the Maya Temple of Kukulcan at Chichén Itzá, Mexico, at sunset on spring and fall equinoxes. Perhaps the stepped pyramid was deliberately oriented so the shadow cast by its northwest corner would create the phenomenon, which today attracts thousands of viewers. The Maya may have considered this a sacred appearance of Kukulcan, the Feathered Serpent.

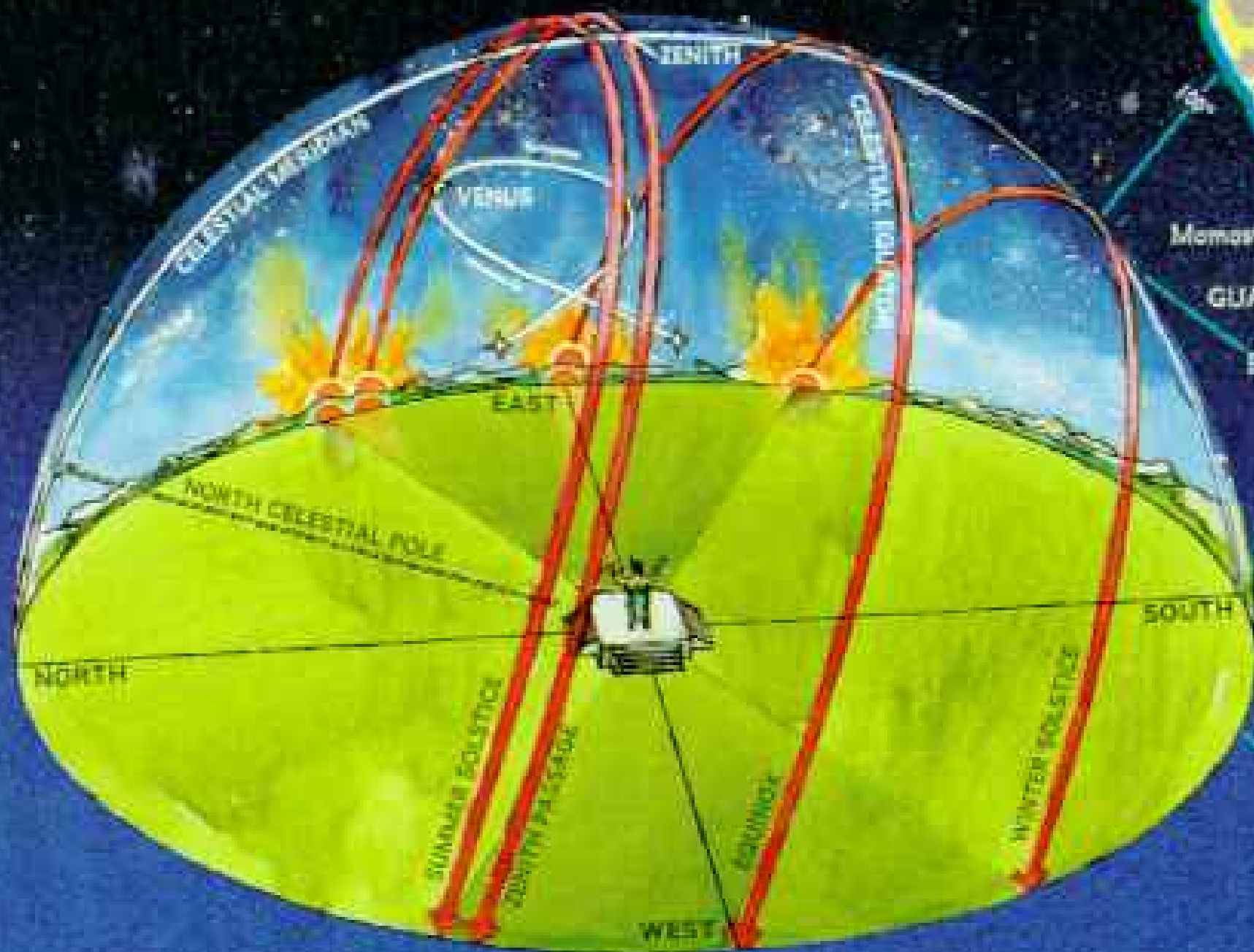
they divided into four quarters, often endowed with distinctive trees, animals, deities, periods of time, and colors. Just as they marked the sky, so they set down paths of pilgrimage on the sacred landscape.

The most notable—and controversial—of these routes may be the ground drawings made on the bone-dry desert of southern Peru. The geometric figures of animals and plants; the spirals, zigzags, trapezoids, triangles; and the straight lines that stretch as far as the eye can see—all these are called Nazca Lines for the culture that established itself in that forbidding terrain 2,000 years ago.

Many speculations, some reasonable, some fanciful, have been made about the significance of the lines. One explanation suggests that the straight lines were aligned to astronomical risings and settings. Another that at least some of the effigy figures represented constellations. Still another idea, recently investigated in depth by astronomer-anthropologist Anthony Aveni and anthropologists Gary Urton and Persis Clarkson, maintains that the long, straight lines connected sacred sites and marked ritual pathways walked by celebrants to make offerings at the far ends. These hypotheses

A skywatcher's primer

To astronomers of ancient American cultures (map) the sun traveled around the earth. Observing its shifting rise on the horizon, they were able to mark time and predict the future. Thus someone looking east from the Maya site of Uxmal could create a 365-day calendar by noting the swing of sunrise from spring equinox (usually March 20) to first zenith passage some 60 days later, to summer solstice on June 21, the sun's farthest northern reach. Moving south, the sun again hits the zenith, then the fall equinox (September 23), before its southern extreme, winter solstice (December 22). These



maximum excursions laid out earth space into four parts.

The Maya based a 584-day ritual calendar on an idealized cycle of the planet Venus: After a 236-day appearance as the morning star, shown here, it disappears for 90 days before shining in the west as the evening star for 250 days. Eight days later it is in the east again.

Not until the 16th century—in Europe—would astronomers realize that the earth revolves around the sun (small diagram). Because of the 23½-degree tilt of its axis, the earth has seasons, which are reversed in Northern and Southern Hemispheres—the June solstice signaling summer in the north and winter in the south.

PAINTINGS BY ZEN DALLISON. PRINCIPAL CONSULTANTS: JOHN B. CARLSON; LEROY E. DOGGETT, U. S. NAVAL OBSERVATORY



▲ Archaeological site
Color indicates approximate cultural boundaries.
0 600 km
0 600 mi
SCALE: EQUATOR
WORLD CARTOGRAPHIC SYSTEM



are not mutually exclusive; all may have an element of truth.

Whatever the explanation, the Nazca puzzlement can at least serve to remind us that archaeoastronomy does not end at the horizon. Ancient Americans did not divide the cosmos into discrete disciplines for study, as is our habit.

IN MY JOURNEYS of professional discovery and personal revelation, I have encountered ancient astronomy in many forms. Without fail each manifestation has comprised a bewildering array of gods, myths, cycles of time, and peoples—all tied together in a unified vision of sky and earth.

Nowhere is the bond between sky and earth more evident than at Teotihuacan in a high valley 30 miles northeast of Mexico City. Walk north along its Street of the Dead on a clear, dry-hot day; the air vibrates with the sound of insects singing in resonance with waves of heat that make you question the reality of the stepped structures looming before you. Is this a mirage, or are those mountains really massive man-made pyramids rivaling those of Egypt?



Illumined by a walking torch-bearer, an earth drawing called Needle and Loom near Nazca, background, recalls the Andean craft. Some pre-Columbian Americans saw the universe as a reflection of the weave of a fine textile.

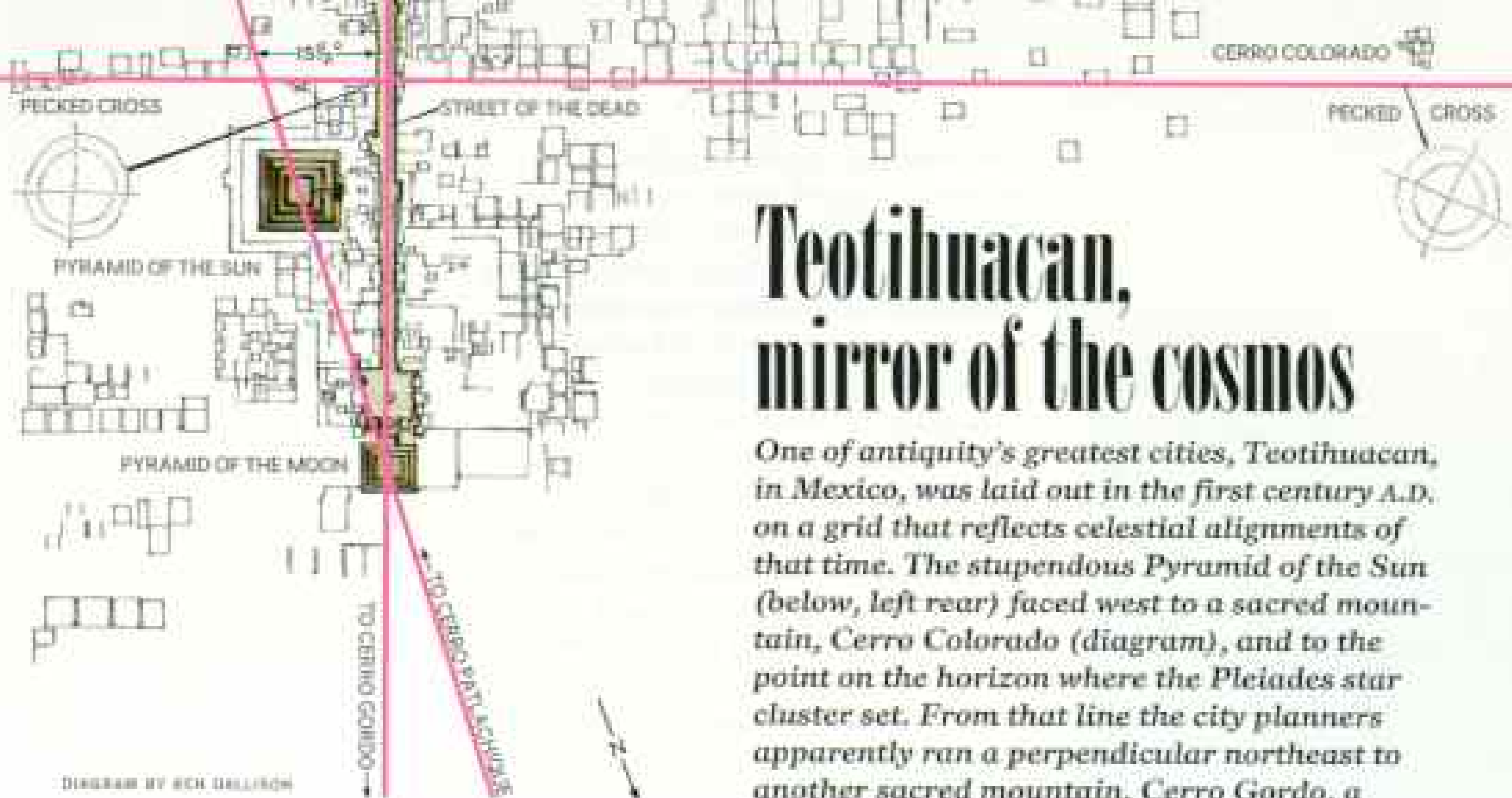
A quipu, or knotted string record, kept calendar days and inventories for the Inca. The Spanish were amazed at how the state controlled the flow of goods, without losing “count of a single hen or load of firewood.” One of the last of the Peruvian quipu makers, Nieves Yucra Huatta ties knots for festival days, his livestock, and his land.



When the Aztec entered this city in the early 14th century, it had lain in ruins for almost 600 years. Those remains, filling the Valley of Teotihuacan with an immense four-quartered grid, inspired the Aztec to name it *Place of the Gods*. To them, this was the navel of the universe, where the gods had met to create a new world under a reborn sun.

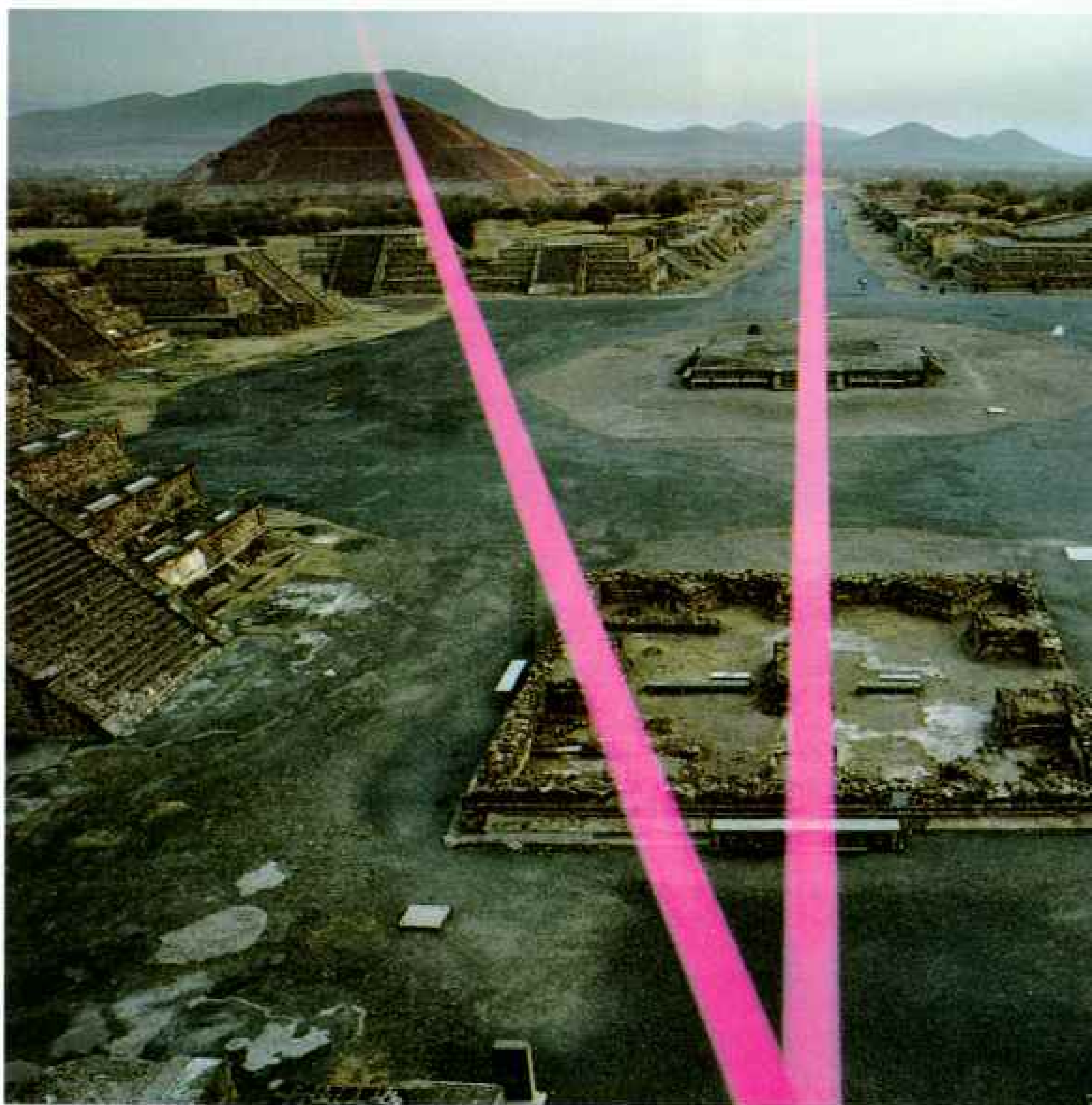
When Teotihuacan was little more than a settlement, about the beginning of the first century A.D., its people must have discovered the remarkable alignment of a four-lobed cave with a lava-tube extension on the site. (Visualize something like a four-leaf clover with its stem lying flat.) Archaeologist Doris Heyden postulated in 1971 that the four lobes corresponded to the fourfold cosmos of the Teotihuacanos, and the stem of the cave pointed in the direction of a significant point on the horizon. This was the setting point of the star cluster we call the Pleiades—the prominent constellation that makes its first yearly appearance on the first of two days each year when the sun passes directly overhead.

As the settlement grew, people embellished this sacred cave site.



Teotihuacan, mirror of the cosmos

One of antiquity's greatest cities, Teotihuacan, in Mexico, was laid out in the first century A.D. on a grid that reflects celestial alignments of that time. The stupendous Pyramid of the Sun (below, left rear) faced west to a sacred mountain, Cerro Colorado (diagram), and to the point on the horizon where the Pleiades star cluster set. From that line the city planners apparently ran a perpendicular northeast to another sacred mountain, Cerro Gordo, a





PLEIADES



A lava-tube cave with four lobes, suggesting the quarters of the universe, was discovered in 1971 under the Pyramid of the Sun. The chamber probably dictated the temple site and alignment, since, like many ancient peoples, the Teotihuacanos apparently believed caves were the places of emergence for their earliest ancestors.



major source of the city's water. On this line they laid out their main avenue, now called the Street of the Dead, and on it built the Pyramid of the Moon, the photographer's vantage point.

To illustrate the city's alignment, he held two fishlines lighted by a red strobe before his lens. One line sights due south over the Pyramid of the Sun to pyramid-shaped Cerro Patlachique. The other, along the Street of the Dead, is $15\frac{1}{2}$ degrees west of south, the basic alignment of the city.

Two so-called pecked crosses—one in a plaster floor southwest of the Pyramid of the Sun (below), the other on Cerro Colorado—may have served as surveyor's markers for the strict grid, which was maintained even to suburban barrios. Teotihuacan eventually expanded to eight square miles, an area larger than imperial Rome, before being abandoned about A.D. 750. But its influence had already spread. Some 70 known pecked crosses, possibly used in ritual, occur in ruins from northern Mexico to Guatemala. Likewise, the skewed alignment is found in many Mesoamerican sites.





Praying to sky, then to earth, shaman Andrés Xiloj prepares for a divination based on the 260-day Sacred Almanac of the Maya. By this time count, still kept in the Quiché town of Momostenango, Guatemala, each day has special meanings. The Maya consult such respected elders before making business decisions or scheduling rites of marriage, birth, and death.

Finally they built a great pyramid over it. They placed stairs leading to the temple atop the pyramid in the same alignment as the cave's extension. The temple faced, and the stairs pointed to, the Pleiades' exact setting point. Thus earth, cave, sky, pyramid, and temple came together in perfect alignment and harmony.

The Teotihuacanos oriented avenues, streets, temples, and apartment complexes (preceding pages), even channeled the San Juan River, to conform to the fourfold layout, reflecting sensitivity to significant features in the landscape and the heavens. Thus Teotihuacan became the first planned metropolis known in the Americas.

From its founding until it was destroyed by fire of unknown cause in the eighth century, Teotihuacan became also the largest and probably the most powerful city of the Western Hemisphere. With a population that may have exceeded 200,000, the Teotihuacanos created a trading network across Mesoamerica, spanning an area that today comprises the U. S. Southwest, Mexico, Guatemala, and Belize, its southernmost influence extending into Honduras and El Salvador. Among the trade items: green obsidian, pottery, clay figurines of warriors, and—quite probably—certain deep-seated ideas of the cosmos and its physical expression on earth. All these found a ready audience in outlying regions.

Leaving the great, shimmering ruins, I traveled north to what seems to have been a Teotihuacan outpost built at latitude 23° 29' N, almost precisely on the Tropic of Cancer—the northernmost latitude at which the sun will pass directly overhead one day of the year. The summer solstice, June 21, is, however, not the only significant day at Alta Vista in Mexico's Zacatecas state. The ruins there still show the layout of a square, colonnaded hall. From its southeast side a labyrinth leads to a road that points due east toward a mountain range with a prominent peak known as Picacho Pelón. Well before dawn on March 21, the day of the vernal equinox, I waited in the labyrinth with archaeologists J. Charles Kelley and his wife, Ellen, who had excavated the site, and several hundred tourists, ranchers, and townspeople come to witness the sunrise.

The day dawned cold and clear. A ruddy glow expanded to a white halo around Picacho Pelón's crest. Then the sun burst over its top to illuminate the ancient observatory, marking a new phase in the solar year and, with it, the start of the planting season—a crucial time in this semiarid region. A sense of renewal and participation in something greater than one's self touched me and the cheering pilgrims, whose numbers are increasing annually.

SOMETIME after the Teotihuacanos had passed from ascendancy in Mesoamerica, a Maya-influenced people moved onto a hill near the modern Mexican city of Cuernavaca. Today the site is known as Xochicalco, the House of Flowers. Just below the hill-top they dedicated a temple decorated with carved panels of the Feathered Serpent. Nearby they excavated and lined with stones a shaft that descends 30 feet to a cave-temple complex.

On May 14, two months after the equinox at Alta Vista, archaeologist Stanisław Iwaniszewski and I brought copal incense and a small clay *incensario* that had been given to him by a shaman. We needed its smoke to make visible the column of sunlight that would descend straight down the opening at noon, when the sun reached its zenith. We entered the chamber and waited. Clear skies—and

crowds—were with us again as they had been at Alta Vista. Our main concern was that tourists would lean out over the hole above us and artificially eclipse the sun. As the seconds ticked down, we lit the incense. It swirled in air currents and rose. Creeping rapidly down the side of the shaft, the sun's rays soon touched the earth at our feet.

The moment was captured, then it was gone. Yet again I sensed that we had shared in an ancient manifestation of the sacred. We waited without speaking for a time before emerging into the blinding sunlight.

Despite their importance, it is well not to emphasize such architectural alignments as markers of solstice, equinox, and zenith without



attempting to understand the cultural contexts in which they were created. When archaeoastronomy was new, enthusiasts rushed to plumb, align, and measure anything that looked halfway plausible—and tended to find significant celestial alignments everywhere.

Often it has proved more profitable to begin with relevant cultural traditions and work toward astronomy. For example, the ancient Mesoamerican view of life as a game played for mortal stakes is nowhere described more vividly than in the epic poem of the Quiché Maya of highland Guatemala, the *Popol Vuh*. This recounts the legendary journey of the Hero Twins Hunahpu the Hunter and Xbalanque the Jaguar Sun to the underworld called Xibalba, where they face many trials (including the house of cold, the house of knives, and the house of vampire bats) at the hands of the Lords of Death. There they play a series of ball games for their lives; their father had earlier lost such a game—and his head. The twins, however, prevail and, after sacrificing the Lords of Death, are themselves transformed into celestial beings.

Good evidence indicates that the ancient Maya identified the twins

Sacred places have drawn Momostenango villagers since ancient times. Here, on the day named 8 Monkey, celebrants enact a ritual of renewal at mountain shrines, each bearing a day number from the Sacred Almanac. They burn candles and incense as offerings to the sky, earth, ancestors, and lords of time.



AKADEMISCHE DRUCK- u. VERLAGSANTALT (HELUWI)





For the first time since pre-Columbian days the ball court at Xochicalco comes alive on the spring equinox as teams from Sinaloa play a game once common throughout Mesoamerica. In this version of the ceremonial contest—one of 15 local variations to survive Spanish repression—players may hit the hard rubber ball only with their hips as they attempt to keep it in play. For protection they wear cotton padding under a traditional deerskin loincloth.

Accustomed to playing on a flat, unfenced court, the Sinaloa teams discovered that the sloping sides of this ancient court made it easier to keep the ball in bounds. Remarked one: “Now we know how our ancestors played.” The survival of such games rests in part on the enjoyment the players and audience derive from betting on the outcome.

In antiquity players personified celestial beings, such as the powerful Tezcatlipoca, or Smoking Mirror, shown in east (red) and west (black) manifestations in the Borgia Codex (far left), an almanac from the central Mexican highlands. A striped sacrificial victim reveals the probable fate of defeated players.





Symbols of Venus, the bright planet associated with warfare and death in Mesoamerica, highlight this brilliant mural at Cacaxtla, Mexico, here examined by archaeologist José Eduardo Contreras. The distinctive belt identified Venus in a Maya style, while the five-pointed star with an "eye" was the central Mexican symbol for the death-dealing planet.

The standing male figure reflects aspects of the rain god in his goggle eyes and scorpion tail. The Maya sometimes painted their sacrificial victims blue, and this man may represent a battle captive prepared for sacrifice to appease the rain god.



with the sun and Venus. Astronomically, Venus (Hunahpu) behaves like a brother to the sun (Xbalanque), either rising before it at dawn or setting after it at dusk. The complete cycle takes 584 days.

The other twin, the sun, rises each day at a different point on the landscape and so, from solstice to solstice, apparently travels back and forth along the horizon. By astronomical coincidence, five 584-day cycles of Venus equal eight 365-day years. The Mesoamericans constructed an eight-year almanac based upon the interlocking Venus-sun cycles.

Mesoamericans were also deeply concerned with how that eight-year almanac resonated with the all-important 260-day Sacred Almanac. The latter almanac was a combination of two recurring cycles, one of 13 deified numbers and one of 20 named days.

Imagine putting the periods (260, 365, and 584 days) of the almanacs into a calendar computer set to account for a common arithmetic factor in their joint cycles. Set this computer in motion and



behold: the great Venus almanac of 104 years (65 Venus cycles and 146 Sacred Almanacs), which has been tabulated in two of the four surviving ancient Maya books, the so-called Dresden and Grolier Codices.

But what was the great Venus almanac *for*?

To Mesoamericans the bright planet was the opposite of ancient Rome's Venus, the goddess of love; it incarnated warfare and blood sacrifice. Therefore, one purpose of the Venus almanac was apparently astrological—to determine a propitious time for ritual combat and sacrifice. Although we believe the stylized battles resembled the jousts of medieval Europe, the “knights” fought for their lives, and the losers were put to death—sacrificed with honor.

MUCH OF MY OWN RESEARCH in recent years has focused on the Grolier Codex, an almanac devoted exclusively to Venus. The Grolier is the only one of the surviving Maya bark-paper books that has remained in Mexico. Found in a dry cave about 1964, it was acquired by a private collector, though later exhibited. A few scholars were initially of the opinion that the Grolier was a modern forgery, although radiocarbon dates placed the paper in the 13th century A.D. But in 1982 I was able to help demonstrate its authenticity—for it contained information discovered by Maya scholar Floyd Lounsbury only the previous year—something no forger of the 1960s could have known.

This past year, aided by a National Geographic Society grant, I have been able to clarify the identities of two Venus gods portrayed on its pages. One sudden insight came while I was visiting a site in highland Mexico known as Cacaxtla. I looked down into a newly excavated chamber at murals buried for more than a millennium. There stood two life-size, blue-skinned figures, resembling rain gods of a hybrid Maya style, with Venus hieroglyphs on their belts. These figures relate to the themes of warfare, blood sacrifice, and fertility found in the other Cacaxtla murals. And, with their Venus symbolism, they can now be linked to astronomically timed ritual warfare and sacrifice—and to the pages of the Grolier Codex.

In Maya architecture the Venus connection runs particularly strong at the monumental House of the Governor (following pages), the royal palace of a Late Classic ruler of Uxmal in northern Yucatán. The king took his name from the Maya rain god, Chac, an identification made by art historian Jeff Kowalski.

The palace is skewed in orientation from the rest of the site plan. In the early 1970s Anthony Aveni and Mexican architect Horst Hartung discovered that an axis running from the palace's central

One of four known ancient Maya books, the Grolier Codex depicts different manifestations of Venus; the column of glyphs on the left of each panel records days in a 104-year Venus almanac. These plaster-coated bark-paper pages, carbon-dated to the 13th century, represent only half of the 20-page original.

Priests used the almanac to schedule battles. For example, panels 2, 6, and 10 show Venus's evening-star manifestation as skeletal figures carrying weapons; the first appearance of the evening star was a propitious time for war.

The god on panel 6 is decapitating a bound victim. Human sacrifices were needed to appease the gods, the Maya believed, to assure rain, fertility, and the perpetuation of the people and their universe.

ENRICO FERDRELLI (ABOVE)

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Setting sun confronts angry clouds over the House of the Governor at Uxmal, Mexico, a busy Maya city a thousand years ago. Unlike most of the city, which aligns roughly

north-south, this great residence faces southeast. It sights across a pyramid three miles distant to the horizon spot where Venus would have risen at its maximum southern

HOUSE OF THE GOVERNOR

3 mi

DIAGRAM BY BEN DILLON



excursion as the morning star about A.D. 900, when the structure was completed.

The importance of Venus to the ruler who constructed the palace is written on its face.

He assumed the name and glyph of the rain god Chac and ornamented the facade with more than 200 stone mosaic masks of that long-nosed god. Such masks are common

Maya decorative devices, but ruler Chac added a special touch. The lower eyelids of each mask are carved with a glyph representing Venus.



doorway to a distant pyramid marked the southernmost limit on the horizon of Venus's rising as the morning star during the eight-year almanac cycle. Just last September archaeologist Ivan Šprajc demonstrated that a 25-foot-tall pyramid at the site called Cehtzuc was positioned precisely at that point.

Might that alignment be merely a coincidence? That would be most unlikely, for—unique in Maya sculpture—all the scores of rain-god masks decorating the palace's upper facade bear Venus glyphs on their lower eyelids. Moreover, masks on two of the lower corners display the number eight! Surely the mighty Lord Chac must have stood before dawn in his palace doorway to watch the war god,

Venus, rise before his twin brother, the sun—triumphant heroes of the *Popul Vuh* epic.

THERE IS A PLACE in the southwestern U. S. where four realms converge along perpendicular east-west, north-south lines on a single point. Visitors can hardly stop themselves from performing a common ritual. Each will put one foot in one realm and one in another, then one hand in the third and one in the fourth. Here at the Four Corners the realms are New Mexico, Colorado, Utah, and Arizona, with the lines being state boundaries laid down in the 19th century. But there is a much older fourfold realm here—the Dinétah, sacred homeland of the Diné, as the Navajo call themselves. Here is their place of origin, bounded by four "world mountains": the San Francisco Peaks (west), Hesperus Peak (north), Blanca Peak (east), and Mount Taylor (south).

With my friend Von Del Chamberlain, a specialist in the astronomy of native peoples, I was eager to travel back again into the far reaches of the

Dinétah. Harry Walters, from Navajo Community College at Tsaile, Arizona, served as guide to the domain of his ancestors, a world of desert mesas and sagebrush canyons. Hiking along canyon trails, we found ruins left both by the Navajo and the Anasazi, the "ancient ones" who had lived here before the Diné.

We also found images inscribed and painted on canyon walls and in rock-shelters. Among these were representations of the Yei, holy beings resident before the First People emerged into this, the Fourth World. One image, in the shape of an hourglass, was Child Born of Water. A bow-and-arrow figure nearby might well have represented his twin brother, Monster Slayer. This pair calls to mind the Hero Twins of Mesoamerica and other twins in pre-Columbian myths.

At day's end we came to the head of a blind canyon, where ancient images of power covering the rocks reddened in the fading sunlight.



PHOTOGRAPHED AT WHEELWRIGHT MUSEUM OF THE AMERICAN INDIAN, SANTA FE, NEW MEXICO

Mother Earth, Father Sky—sacred Navajo figures—must be depicted as "identical in shape and size since they are the two halves of a whole creation," according to Navajo lore. In this 50-year-old tapestry, sacred plants grow from Mother Earth; stars and Milky Way embellish Father Sky, shown against his domain. The image is turned to display the figures upright.

We soon had a campfire of cottonwood branches blazing, and the smell of steaks, roasting corn, Navajo fry bread, and coffee mingled with the pungent odors of sage and earth. As we joked and told stories, moving closer to the dying embers, the unseen dimension of the Dinétah penetrated our consciousness. The great sparkling dome of the desert's night sky brought home an old but deep truth. To ancient Americans the night sky was brilliant, mysterious, powerful, a vital aspect of daily experience.

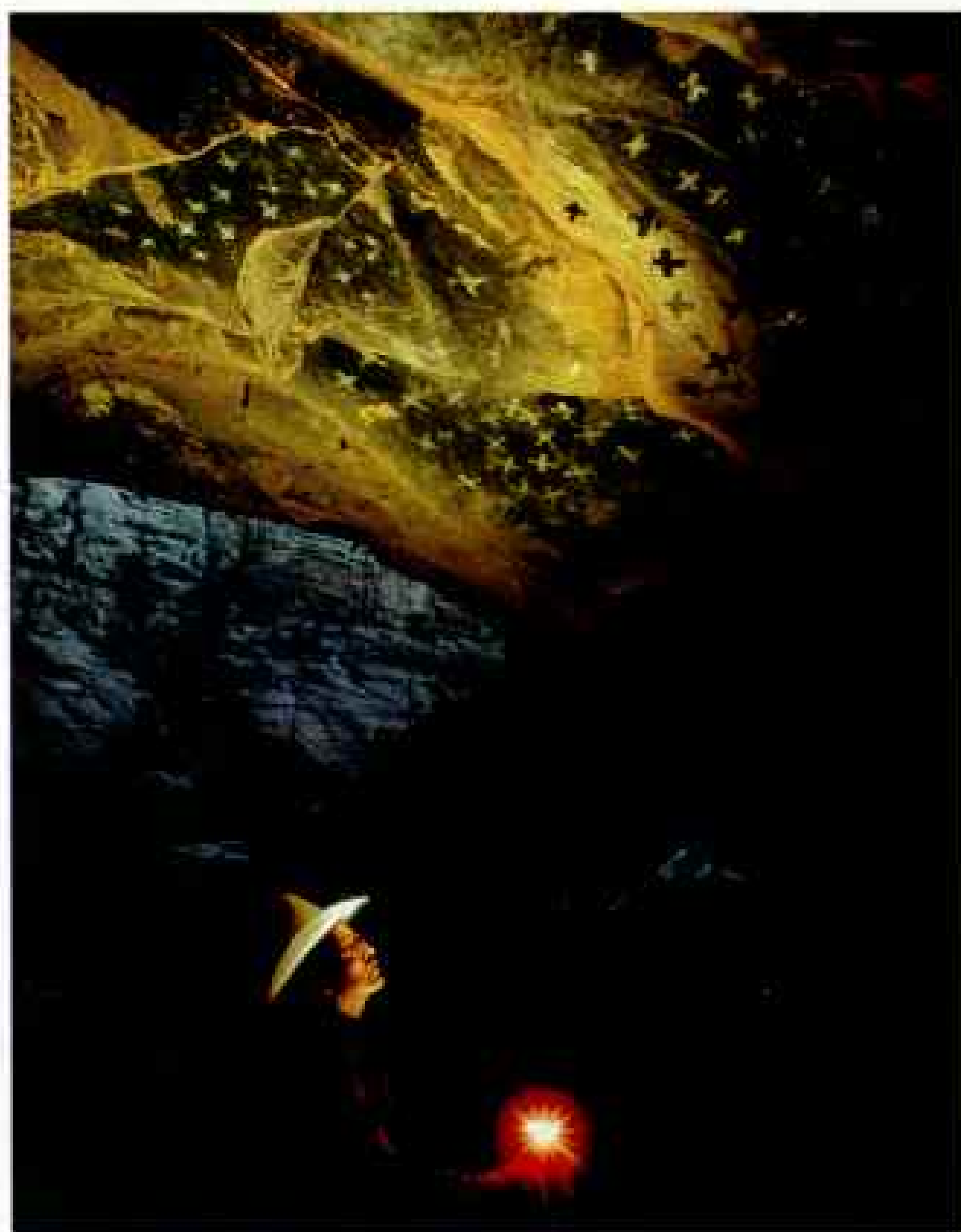
They carefully observed the comings and goings of its bodies. They peopled it with beings whose epic journeys affected the rhythms of their own lives, beings who wove human destinies into the fabric of eternity, like the finest Navajo blanket.

To most modern-day Americans, though, the night sky is routinely banished by our house lamps and all but erased by the lights of our cities and suburbs. There's not much magic—or even astronomy—in it now. We are, you might say, too enlightened.

LATER, in Canyon de Chelly National Monument in Arizona, Harry, Von Del, and I climbed at midday to a broad-domed natural shelter recessed high on a red-rock canyon wall and filled with the remains of long abandoned dwellings. We looked up to an overhanging outcrop and saw a night sky. Overhead on the soot-darkened vault shone a spray of stars, four-pointed crosses as the Navajo draw them. Some might form Navajo constellations, but most seemed randomly placed. There is much speculation about the "star ceilings" (maybe five dozen are now known), how the stars were placed, and why. One Navajo legend has it that as the stars are seen to hold up the night sky, so these stars were painted to support the roof of the shelter and protect the people and dwellings below.

How, by the way, did the stars get into the sky? Early in the 20th century, the great Navajo *hatali*, or medicine man, Hosteen Klah told a story about First Woman and First Man beginning the task. First Woman decided to spell out all the laws needed by the First People. Laws could not be written in sand or on water, since few people would see them before they disappeared. But when the laws were written in the sky, everyone could look up and study them.

First Woman and First Man had all the stars laid out on a blanket and were setting each star in place when the trickster Coyote came along. Coyote wanted to help, but the work of placing and naming the stars was too slow for him. So he grabbed a corner of the blanket and flipped the remaining stars into the sky. This is why the sky, and perhaps the star ceilings too, are filled with such a confusing array.



This "star ceiling" was found in a rock-shelter in Canyon de Chelly National Monument, Arizona, by Navajo teacher Harry Walters. Such pictographs may represent a hero who traveled to the heavens to receive ritual knowledge from the stars. Another version from Navajo mythology: Symbols keep the rock ceiling from falling, as stars hold up the sky.

Under the same high Canyon de Chelly rock-shelter where Harry, Von Del, and I had looked up at the star ceiling stands a half-buried kiva. This circular underground ceremonial chamber built by the Anasazi 700 to 800 years ago has counterparts that Pueblo Indians use today. Archaeologists find that kivas virtually always have a small hole in the floor, called the *sipapu* by the Hopi, the symbolic place of emergence from the underworld. They also have an entrance hole with a ladder in the center of the roof, symbolizing the final emergence into the world of the sun. Both emergence myths resemble those of the Mesoamericans, with whom the Anasazi traded.

From Canyon de Chelly a line running east across Arizona would intersect Chaco Canyon in the San Juan basin of northwest New Mexico. Chaco Canyon—with its great kivas, extensive ruins at Pueblo Bonito, and other Anasazi sites—is still special for me. It was the first place I went in 1973 with astronomer Ray Williamson to do field research in archaeoastronomy. With tape measure, surveyor's transit, and an old shortwave radio to pick up the time standard signal originating from the National Bureau of Standards, we combed the magnificent masonry of the ruins to survey and measure alignments of kivas and other notable structures. We found, for instance, that a great kiva in Pueblo Bonito aligned true north-south and that the town's massive southern wall ran east-west.

With its many great pueblos Chaco Canyon flourished between the 9th and 13th centuries as the center of a culture whose outposts were spread as far as 130 miles away. Chaco was the hub of an extensive road system, with segments radiating straight as arrows to outlying pueblos.

One of the longest segments, the Great North Road, ignores difficulties of terrain as it dips into gulches and rises over mesas 30 miles due north, then jogs to a place known as Salmon Ruins. Such direct connections bring to mind the Nazca Lines and the long, paved roads called *sacbes* that radiate from many lowland Maya centers. In fact, this tradition of straight lines between sacred places in a ritual landscape can truly be called pan-American.

ARCHAEOLOGISTS STILL DEBATE the nature of the huge complex at Chaco: Was it the hub of a trading network, a redistribution center, perhaps even a ceremonial center? We may never know. Yet most would now agree that at the heart of the Chaco system the great kivas such as Casa Rinconada served as the ceremonial gathering places for the Anasazi.

Casa Rinconada stands alone on the south side of the canyon, a kiva 63 feet across (pages 78-80). The massive roof, which must have collapsed centuries ago, is now all gone. What remains are four foundation holes dug to hold mighty wooden pillars that supported it. The holes form the corners of a square with sides oriented to the cardinal directions. This arrangement recalls a legend of Acoma Pueblo, one of the groups descended from the Anasazi. In the Acoma story four different trees grew up from the underworld to give the First People a way to climb to the surface.

Casa Rinconada's twin T-shaped entrances are aligned on a north-south axis. An unusual *sipapu* ramp enters from the north by way of a chamber below. From this entrance celebrants—probably looking much like *kachinas*, the dancing gods of the Pueblo Indians—might have made their dramatic emergence from the underworld into



BOB SAGMA WITH GEORGE GULLICK



The subject is the universe for artist James Turrell, who is creating a monumental earth sculpture in the Arizona desert to give viewers a heightened perception of the cosmos—an experience common for early American sky-watchers.

During visits to ancient Mesoamerican sites, Turrell had been inspired by the sense of power and presence in places “emptied of their use.” In 1974 he located Roden Crater, an extinct volcanic cinder cone (lower), while flying a small plane near Flagstaff. He purchased the cone with its surrounding area, 1,100 acres in all, and has been reshaping spaces and sight lines with bulldozers and graders ever since.

When Roden Crater is open to the public, Turrell will encourage viewers to lie on their backs in the center of the crater to view the heavens as a vault outlined by the rim (top).

the dark chamber to the sound of a throbbing ceremonial chant.

I could imagine them when I arrived for sunrise at summer solstice one year and heard the plaintive sound of a flute being played by a young woman sitting alone in the ruins like the old hunchbacked flute player Kokopelli of Hopi myth. I waited to see the first rays enter a window on the upper northeast side and illuminate a niche across the room.

Up the canyon from Casa Rinconada, on the mesa near ancient Wijiji Pueblo, are the remains of one of the most compelling sun-watching sites of the Anasazi and of the Navajo who came there much later. From a rock ledge marked by a four-pointed,



white-painted sun symbol, one can look across the canyon to a natural sandstone column rising above the horizon. According to astronomer Michael Zeilik, who has studied the site for years, an ancient sunwatcher making observations from that ledge could watch the rising sun move closer and closer to the column until the day it appeared directly behind it—the winter solstice.

The duty of the Pueblo sunwatcher was not just to announce the

actual day of solstice, but to anticipate that day in order to initiate the ritual cycle at the appropriate time. As Ray Williamson has emphasized, the presence of Navajo sun symbols and other sacred images—including one or both of the mythical twins on nearby rock panels—suggests that Navajo sunwatchers as well as the Chaco Anasazi may have anticipated the sun's renewal at Wijiji.

Among the Navajo it is the hatali who is called upon to reestablish *hezho*—balance, harmony, and beauty—in the world when it has fallen out of kilter. When someone is ill, in need of physical and spiritual balancing, the hatali may be asked to perform a ceremony that includes making a sand painting on the floor of a traditional hogan.

I witnessed the creation of such a sand painting by a venerable hatali named Mike Mitchell. At my request it was the image of Father Sky, taken from the "Male Shootingway Chant."

After carefully preparing the fine sand brought to the center of his hogan, Mike sat down with his rainbow palette and brought Father Sky alive before us. The sun, moon, Milky Way, and constellations such as Rabbit Tracks adorned his celestial form. As soon as Mike completed the painting, he quickly erased it; the inherent power of such sacred images is not taken lightly. Gathering up all the sand in a cloth, he took it far from his hogan and scattered it to the four winds.

As I watched silently, I remembered the audacity of the hatali Hosteen Klah, who first dared to record such magical creations in the only permanent form he judged appropriate. That his sacred knowledge should not be lost, that the celestial relationship of Mother Earth and Father Sky should endure, he wove the fabric of the Navajo cosmos into a blanket with the shuttles of his loom.

And today I had witnessed his legacy still alive.

Sensing that my pilgrimage in American archaeoastronomy had

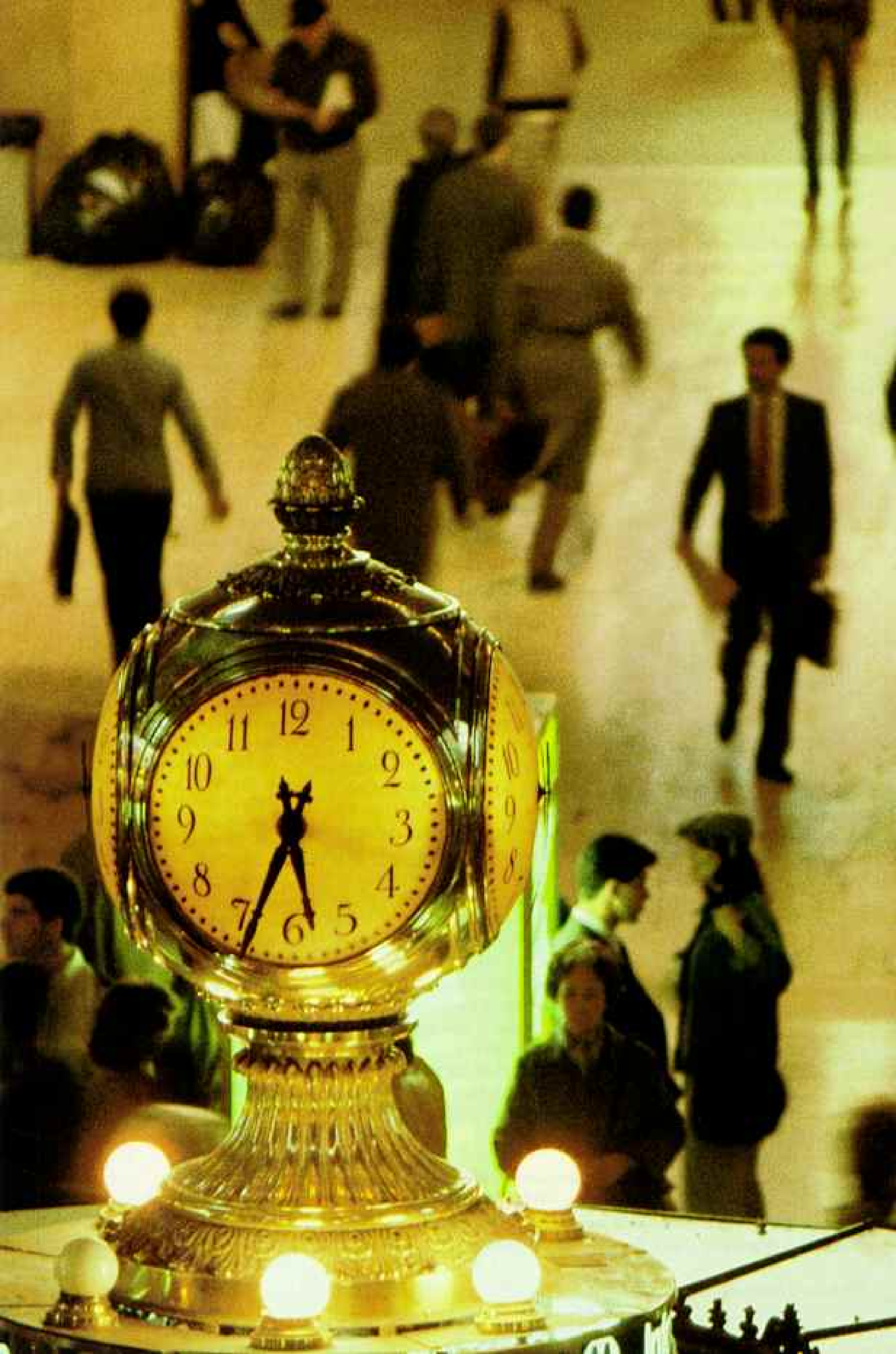
come to the completion of a cycle, I heard in my mind a favorite passage from the Navajo "Nightway Chant":

*With Harmony may I walk, / With Harmony behind me, may I walk, /
With Harmony above me, may I walk, / With Harmony below me,
may I walk, / With Harmony all around me, may I walk. . . . / It is
finished in Harmony, / It is finished in Harmony.* □

An ancient figure carries symbols of rain and fertility in this petroglyph pecked in the dark patina of a basalt boulder in northern New Mexico between 1300 and 1500. The four-pointed feathered symbol on the head may represent the morning star and identify the figure as Sotugnangu, the Hopi god of sky, clouds, and rain. That deity bears striking resemblance to the Aztec god Quetzalcoatl, who discovered maize and invented the calendar. The connection seems likely, since trade networks linked the American Southwest to central Mexico. Mesoamericans had domesticated maize by 3500 B.C., and that technology spread to the Southwest by 1000 B.C., probably with the rituals and gods that would assure its success.

The Milky Way beyond recalls the practice of stargazing still followed by some Navajo to diagnose illness and locate lost objects. Their forebears, like other early Americans, believed in promoting reciprocal relationships with the cosmos to assure their very survival.

BOB SACHA WITH GEORGE DILLAGE





The Enigma of **TIME**

By JOHN BOSLOUGH

Photographs by BRUCE DALE

NATIONAL GEOGRAPHIC PHOTOGRAPHER

WHO BETTER TO EXPLAIN something as elusive as time than Richard P. Feynman. He dominated the physics of his generation, rewrote our understanding of how matter and energy behave, helped develop the atom bomb.

"What is time?" repeated the late Nobel laureate. "We physicists work with it every day, but don't ask me what it is. It's just too difficult to think about."

Recently I saw a graffito on a wall of a café in Austin, Texas, that attempted an answer: "Time is nature's way of keeping everything from happening all at once."

Ask six people to explain time today, and, like the six blind men poking the elephant, you may get six answers. A physicist might say time is one of the two basic building blocks of the universe, the other being space. For a clockmaker time is the ticktock of his handiwork. For a science-fiction fan it is the fourth dimension. A biologist sees time in the internal clocks that keep plants and animals in sync with nature. For a banker it is money, while a Buddhist monk contemplates time in the eternally returning cycles of nature.

"We have given more attention to measuring time than to anything in nature," says Ger- not Winkler, Director of Time Services at the

Measuring their lives in minutes, passengers rush for trains at New York City's Grand Central Station. Despite our mastery of clocks and calendars, the nature of time itself remains a mystery.

Shadows sweep Stonehenge in southern England (right), where centuries of farmers worshiped the seasons that ruled their lives. Built before 1500 B.C., this circle of stones is thought by some to be the world's oldest observatory.

Celestial movements on a vaster scale—the spinning of neutron stars—inspire scientists at Arecibo Observatory in Puerto Rico (below). Using a 20-acre receiving dish, they can measure radio waves from such pulsars to within a microsecond over several years, a precision unexcelled even by atomic clocks over similar periods.



U. S. Naval Observatory in Washington, D. C. "But time remains an abstraction, a riddle that exists only in our minds."

Psychologists tell us that children before the age of two have little sense of the passage of time. It may have been the same for our early ancestors. Some scholars believe that people once lived in a state of "timeless present" with little or no sense of past or future.

Julian Jaynes, a Princeton psychologist and author, contends this may have been true as late as the eighth century B.C., when the *Iliad* was first written down. He contends that the epic poem attributed to Homer displays little awareness of time.

According to Jaynes the poem was about people who "did not live in a frame of past

happenings, who did not have 'lifetimes' in our sense, and who could not reminisce" — abilities that were acquired only when language advanced to the point that we could describe the past in terms of personal experience.

The way science views time also has changed. Throughout most of history time was looked upon as a flow like a river. Even for the remarkable English scientist Sir Isaac Newton, the flow of time was absolute. But with the arrival of Albert Einstein's theories of relativity, time was first seen as a dimension — like height and width — giving meaning to events and the order in which they occur. Time, quite literally, was something that keeps everything from happening at once.

Einstein also showed that our perception of time is local, peculiar to our planet. This is because time is affected by the gravitational field of each celestial body, and thus is unique to any one spot in the universe.

EARLY PEOPLE presumably first realized time passed when they saw that they lived in a world of constant change. We have come to place a premium on measuring the flow of time — as if by measuring it we could begin to understand it.

Devising accurate calendars and clocks, however, proved to be one of man's most elusive and protracted intellectual pursuits. The long struggle to affix numbers to the passage of time parallels our organizing ourselves in a complex, modern world.

It began in the great civilizations that awakened five millennia ago along the life-giving rivers of the Middle East: in Sumer between the Tigris and Euphrates and in Egypt along the Nile. Drawn like most ancient people to the movements of the heavens and the changing seasons, the Babylonians developed a year of 360 days, then divided it into 12 lunar months of 30 days each. This was not a simple feat, since the sun and moon do not dance in step, the moon's cycles occurring approximately every $29\frac{1}{2}$ days and the earth's every $365\frac{1}{4}$ days.

Babylonian astronomers knew the true number of days in a year, but kept it at 360 because their priests insisted the number — which may have led to the number of degrees in a circle — possessed magical properties. The practical Egyptians extended the year by five days, which they set aside for feasting during the Nile's annual flooding. Refinements by the





PHOTOGRAPHED AT THE TIME MUSEUM, ROCKFORD, ILLINOIS (ABOVE)



Romans and by Pope Gregory XIII in 1582 gave us today's Gregorian calendar, accurate to a day in every 3,323 years.

Early societies also broke the day itself into smaller units, presumably for the same reason as do our clocks and watches—so you know when you're supposed to be somewhere.

The sun, arcing daily across the sky, was undoubtedly the first timepiece, followed perhaps by the shadow of a stick stuck in the ground—a crude sundial to mark the hours.

The time-conscious Egyptians divided the day into two cycles of 12 hours each. Why not eight or ten? The 12-hour division might have come from the numbering system of the Sumerians or from star patterns in the sky.

In the 11th century A.D. a Chinese scholar named Su Song erected a colossal contraption that was among the first mechanical water clocks.

In a Beijing museum I examined a model that did scant justice to the scale of Su Song's creativity. More than 30 feet high, powered by a waterwheel, bristling with shafts and levers, his combination planetarium-clock signaled the quarter hours with gongs, bells, and a sort of glockenspiel. Its crowning feature was a water-triggered device called an escapement that stopped the clock's movement at set intervals, forcing it to run at a steady rate.

WHETHER SU SONG'S INVENTION found its way into Europe or evolved there independently, the mechanical clock has achieved its greatest glory in the West.

Forged by an unknown ironsmith, the first mechanical clock in Europe is believed to have been built for an English monastery in the 13th century. It and other early monastery clocks consisted of crude iron gears driven by weights—a kind of reverse windlass—but no dials; initiates were called to prayer by bells, known in Middle English as "cloks."

In Pisa, Italy, I found a lamp that, according to legend, led to more accurate clocks. In the 16th century Galileo Galilei, a young medical student, spied the lantern swinging in a church. Timing it with his pulse, he found that each swing took the same amount of time, regardless of the distance traveled. He had discovered the pendulum. Exhilarated, he gave

JOHN BOSLOUGH'S last article for the *GEOGRAPHIC* was on gravity (May 1989). He divides his time between Colorado and Virginia.



up medicine to study physics. But seven decades passed before Dutch scientist Christian Huygens built the first pendulum clock, ushering in the era of precision timekeeping.

By the 17th century the clock already was having a profound effect on society. The notion that time is money became an essential ingredient of emerging capitalism. In the early 1800s some mill owners created the mill clock, an insidious device that ran fast or slow according to how hard workers labored.

In those days time zones did not exist, and the world was a hodgepodge of local times. Nor was there a prime meridian where a 24-hour count could begin for all navigators; most used the time at their home ports as they roved the seas.

At an 1884 meeting in Washington, D. C., Britain and the United States urged international adoption of Greenwich, site of the Royal Observatory, as zero-degree longitude. Jerusalem and the Great Pyramid had been proposed earlier. The French delegates were

Using the tools of his great-grandfather, Dan Parkes restores the clocks of previous centuries in his London workshop (above). "The modern digital clock is more accurate certainly," says Parkes, "but if you're talking about the art of manufacture, something beautiful to look at, then it hasn't anything to offer."

Beautiful and useful, if somewhat risky, an alarm clock believed to have been made in Paris around 1825 strikes a match as it rings (facing page, center).

Stopped by the atomic blast at Hiroshima on the morning of August 6, 1945, Kengo Futagawa's watch (top) records the moment. Three years later scientists built the first atomic clock, a nonradioactive device that counts oscillations of atoms. Today's models range in size from mantle clocks to grandfather clocks, but look more like filing cabinets. Assembly of a Hewlett Packard clock begins with a cylinder containing cesium (bottom).



SCHEDULE OF THE PRESIDENT

Monday, July 24, 1989

7:55 am (5 min)	<u>Photo for National Geographic (Valdez)</u>	Oval Office (TAB A)
8:00 am (15 min)	<u>Intelligence Briefing (Scowcroft/Sununu)</u>	Oval
8:15 am (30 min)	<u>National Security (Scowcroft)</u>	
8:45 am (30 min)		
9:15 am (45 min)		
10:00 am (45 min)		
10:45 am (15 min)		
11:00 am (15 min)		



7:03 Patrus are Oval
 7:56 add Madigan photo st
 8:17 Applebaum + DCI 8
 8:54 Scowcroft out 9:0
 9:27 Scowcroft, VP + Sununu out 9:41 Scowcroft in 9:54 Scowcroft out, add Fitzgibbon and Dick Cheney
 9:59 add Scowcroft 10:03 Patrus, others to Cabinet Rm.
 10:51 Patrus to Oval 10:55 add Sen Baker 10:58 add Scowcroft
 11:00 add VP + Fitzgibbon 11:03 add Choi He Gyoung et al 11:18 all out except VP, Baker
 11:30 add Sen Cooper + D. Bates 11:43 Sen Cooper. Bates out UNP 07/21/89 + Scowcroft
 6:00 pm
 11:57 add Walker, Mills 11:58 Patrus + Mills to Motorcade 12:00 Board + dpt
 12:06 arr Longworth Bldg → Goldy Rm 12:14 arr Committee Room - reception - lunch
 1:20 Conclude lunch + depart 1:23 Board motorcade, + depart
 1:32 arr Oval 1:45 add Amy Grant et al to Oval
 1:48 add Mrs Bush 1:56 all out except Mrs Bush 1:57 add V.P.
 1:59 announced to South Lawn 2:01 Patrus remarks 2:09 Conclude remarks
 2:11 arr Oval w/ V.P. 2:13 V.P. depart 2:33 add Scowcroft
 2:57 Scowcroft out 3:02 add Mayor Rudy, family, Oct Anderson, + Jim Wray
 3:12 all out 3:32 add Sununu, Scowcroft + Cheney
 4:30 Scowcroft + Cheney out 4:50 Gov. Sununu out
 6:12 add Rose Z - sister to Oval 6:13 Rose Z out 6:14 Patrus dpt Oval
 6:17 Patrus arr 2nd Fla Rm.

particularly outspoken for Paris. Greenwich won, but French maps did not acknowledge it until 1914. In a magnificent and rarely seen hall at the Paris Observatory, I paid homage to the old French longitude marker, a line of 32 copper bars set into the lofty ceiling, aging testimony to what might have been: PMT—Paris mean time.

There were other refinements: U. S. time zones in 1883, global time zones in 1884, daylight saving time as early as 1915—all artifices strengthening time's grip on our lives.

Watches had evolved from portable clocks four centuries earlier. The first ones were suspended from belts or worn around the neck, and later carried in pockets. The mass production of pocket watches in the United States began in the 1860s. By then watches on bracelets already had appeared, but they were worn mostly by women. They didn't become popular for men, who thought them too decorative, until World War I, when soldiers found it hard to reach inside their bulky coats to check the time.

Today watches pour off the assembly lines in unbelievable numbers: more than half a billion a year, with some 300,000 sold daily in the United States alone. This leads to my theory—and I welcome challenge—that more timepieces have been built than all other machines combined.

To see an industry pacesetter, I took a train into the mountains of central Japan to a watch factory operated by the Seiko Group, the world's largest timepiece manufacturer. In a 4.5-acre plant, 1,150 robots, moving like figures in a Charlie Chaplin movie, screwed parts into passing watches. Every two seconds a new movement popped off the assembly line.

I recalled to my host, Seiko guide Hiroshi Tsukahara, an earlier visit to Switzerland's watchmaking district in the Jura Mountains. There workmen labor for days by hand over individual mechanical watches.

"The Swiss were slow originally to adjust to the new quartz technology," said Tsukahara.

Planning his day, President George Bush meets with Timothy J. McBride, one of 15 staff members who arrange his appointments. Internal meetings and unscheduled visits, including eight by National Security Adviser Brent Scowcroft, add to time demands on the President, referred to as "Potus."

I pointed out that the Swiss are selling quartz watches now—and accruing more revenue than Japan. But Seiko alone produces more watches than all Switzerland.

The secret of Seiko's success is the quartz crystal, which it first marketed in a timepiece in 1969. Powered by battery, a crystal in a quartz watch vibrates 32,768 times a second. An integrated circuit—a series of tiny electric switches—counts the vibrations and converts them to a dial, standard or digital. In the latter there are no moving parts.

"The trick was to make the crystal in the shape of a tiny tuning fork," said Kinji Fujita, who was a member of the team responsible for Seiko's first quartz watch. "This decreased the size of the oscillator and cut power consumption." Today an inexpensive quartz watch runs more accurately than the best mechanical watch made, which is faithful within about a second a day.

IN THE FACE OF THE DIGITAL DIAL'S popularity, is the standard watch dial facing extinction? I doubt it. A digital readout does time intervals better. But it gives little relative information, such as how far it is from 5:45 to 6 o'clock. Besides, how will a child of digital time know what "clockwise" means?

Have we become slaves to the clock? David Landes, a historian of timekeeping at Harvard University, thinks not.

"The clock let individuals know what time belonged to their employers and what time was their own. Workers are now actually freer than ever before. Without the clock, and now the watch, there is no modern world. It is the difference between a complex, intricately coordinated society and a primitive one only vaguely aware of time's possibilities."

A vast global timekeeping system keeps all civilization synchronized.

How important this network is I saw for myself one chill November day in China. As I watched with a group of scientists in a frigid observatory near Xian, Ukrainian folk dancers stomped and spun in a television program broadcast from the Soviet Union, relayed by a satellite hovering above Indonesia. "Hmm," said Wu Guei-chen, China's chief timekeeper, "this program is better than most."

Wu and scientists in Shanghai and Beijing tune in Soviet television at 9:59 every evening—not for amusement but to check atomic clocks in the three cities.

By timing the TV signal's arrival, they can tell if one of these clocks is running fast or slow. China's single time zone, stretching 3,000 miles from Shanghai to Tibet, is synchronized by a signal from the observatory where we sat freezing. China's continuing effort to keep time to within a billionth of a second a day began as part of modernization, to join the rest of the industrialized world.

Most of us in or out of China couldn't care less about what time it is to within a billionth of a second. In human terms, even as you watch a second tick away, it's gone.

But our technological world needs the precise time. A navigator at sea or aloft, plotting

his location by satellite, relies on a time signal accurate to within a single millionth of a second (microsecond). Deep space probes like the planetary explorer Voyager II are guided by radio signals timed to billionths of a second (nanoseconds).

And physicists tracking motion inside an atomic nucleus reckon in picoseconds (trillionths of a second) or even femtoseconds (thousandths of a picosecond). To grasp this, consider that there are more femtoseconds in one second than there were seconds in the past 31 million years.

ATOMIC CLOCKS at some 50 timekeeping stations around the world from Washington and Paris to Moscow and Xian allow this remarkable splitting of seconds. These clocks are unbelievably precise.

Since the 1940s, scientists have known that the electrons of atoms oscillate with a rhythm so regular that—like a pendulum—they could be used to tell time.

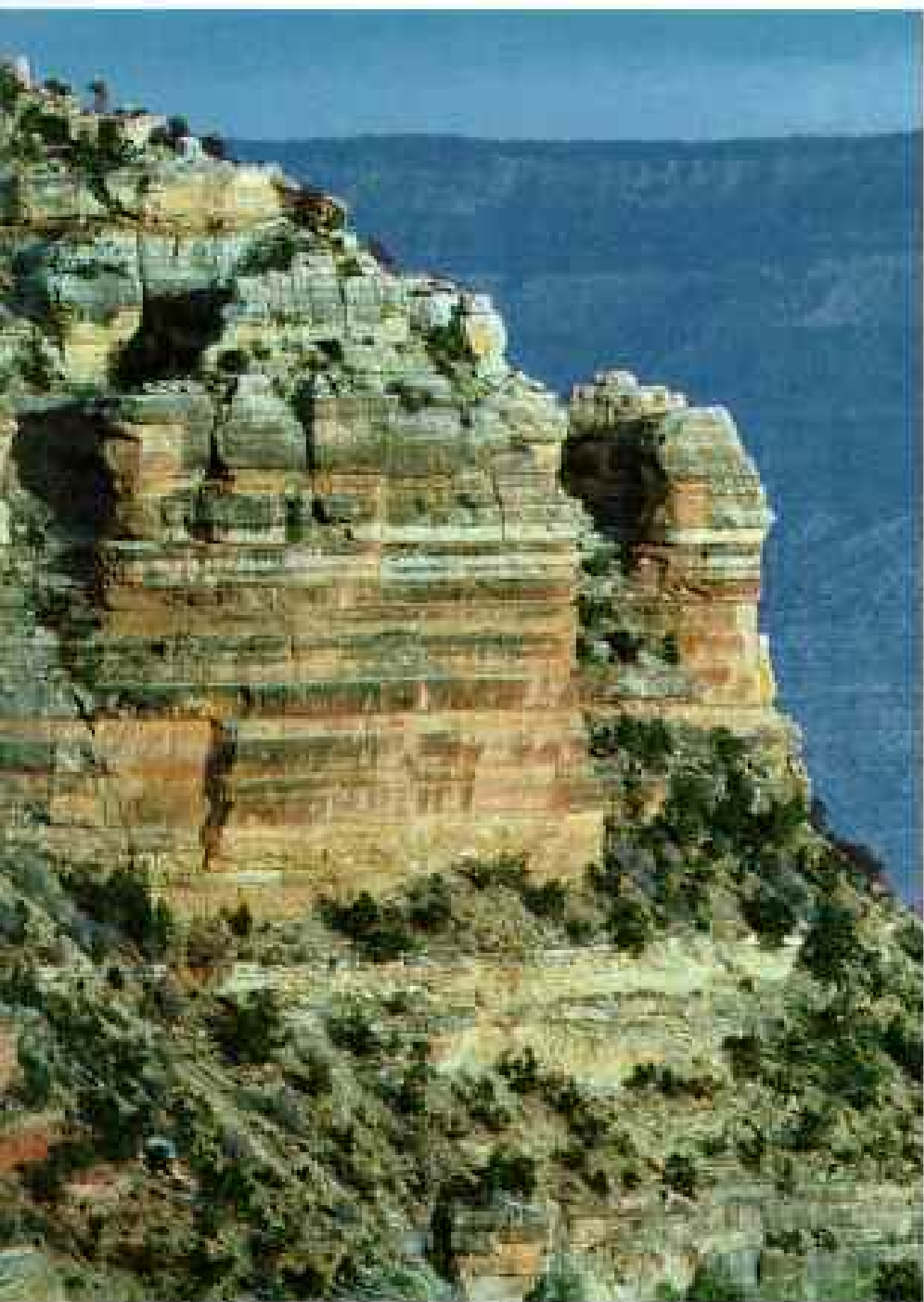
First built in 1948, these clocks generally use atoms of cesium, a silvery white metal. Cesium clocks are accurate to within a few nanoseconds a day and can help test one of this century's most profound scientific statements: Albert Einstein's theory of special relativity.

The theory predicts that a clock will slow as its speed of motion increases. In 1971 four cesium clocks were dispatched aboard commercial jetliners to go around the world, first eastward and then westward. Because of the eastward spin of the earth with its atmosphere, the plane traveling east would go faster, and its clock was expected to lose 315 nanoseconds to the clock going west. It lost 332—well within the theory's range.

In a basement room atop a splendid tree-covered hill in northwest Washington, D. C., sits a battery of what look like large suitcases with dials on top. Nothing on these dials ever indicates, as far as I could tell, when it is time to eat lunch.

Protected against moisture and temperature variations—the perennial enemies of the timekeeper—these cesium clocks at the U. S. Naval Observatory churn away the hours at the rate of 9,192,631,770 oscillations a second, like all cesium clocks.

"Our primary job is to keep the time for the military. But our product is also for civilian use," said chief time. *(Continued on page 121)*



Layers of limestone along the Grand Canyon's South Rim mark ancient seas. Below lies a mile-deep record of earth's history reaching back two billion years. By 1800 the discovery of "deep time" had questioned Genesis' 5,500-year account, even as it hardened another Judeo-Christian belief—that time moves in a line rather than in a circle.

1692 Twenty people die in Salem, Massachusetts, witch trials. Tree survives another 200 years; this cross section came from its weathered stump.

1616 Roman Catholic Church prohibits Galileo from continuing controversial scientific work.

1589 Galileo becomes professor of mathematics at University of Pisa.

1565 St. Augustine, Florida, founded, first permanent European colony in the present-day U. S.

1543 Copernicus dies.

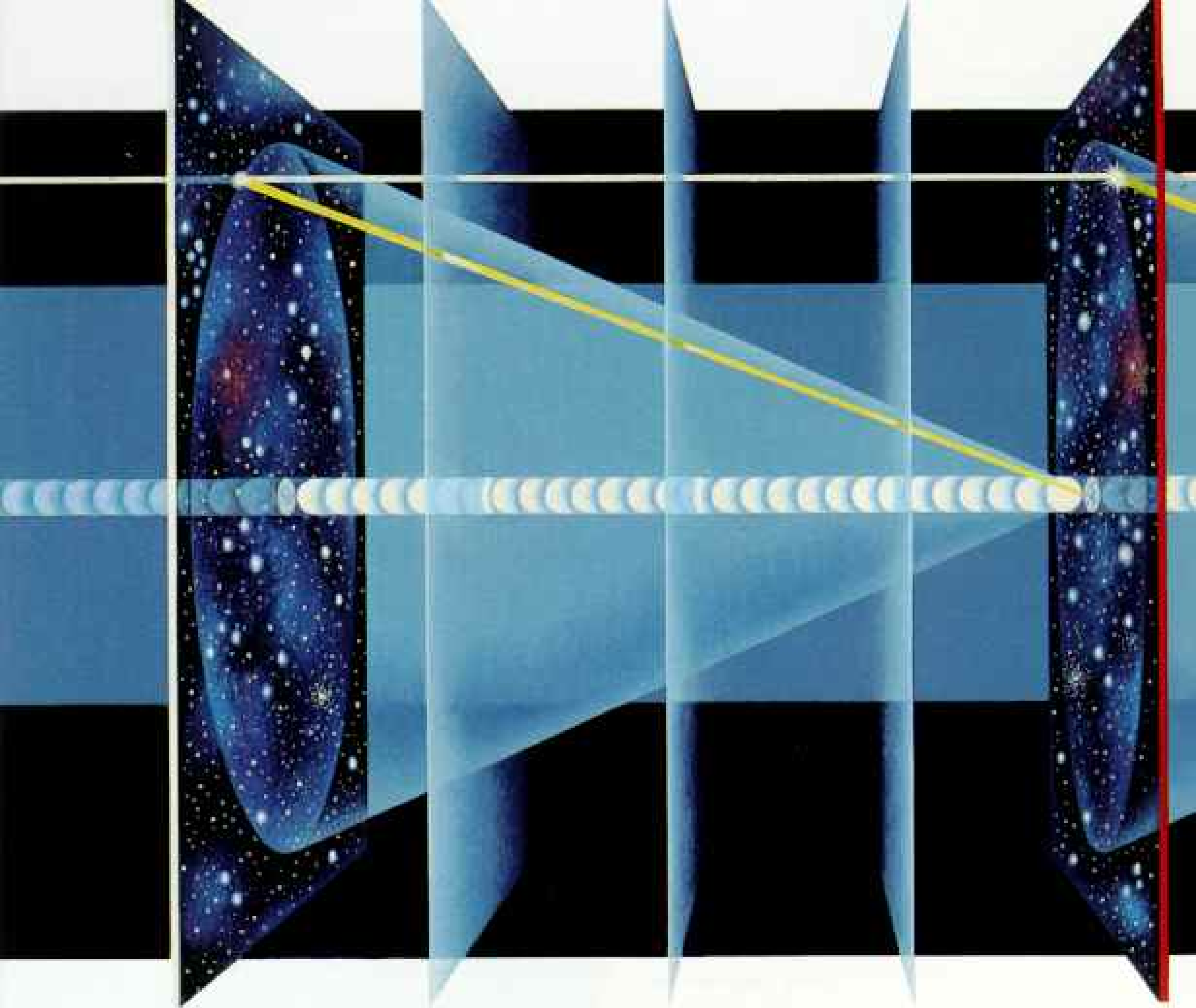
1519 Magellan begins to circumnavigate the globe.

Rings of time

A natural calendar, this ponderosa pine chronicles its 400-year existence with bands of annual growth. An accurate means of dating forest fires (here indicated by dates), droughts, and floods, tree-ring analysis now reaches back 8,600 years—an aid to climatologists, archaeologists, and others.

1484 First fire scars the tree, which had already taken root when the world's first book printed with moveable metal type appeared around 1450. Drying caused cracks.





Keeping track of time

Time is absolute, Isaac Newton declared in 1687. It “flows equably without relation to anything external.” That’s obvious, you say, rushing to your next appointment. Physicists, however, have discovered that time is intimately tied to motion and space itself. Our image of time as a river eventually runs dry.

Albert Einstein shattered our notions about time in 1905 with his theory of special relativity. The very measurement of time intervals, he declared, is affected by the motion of the observer.

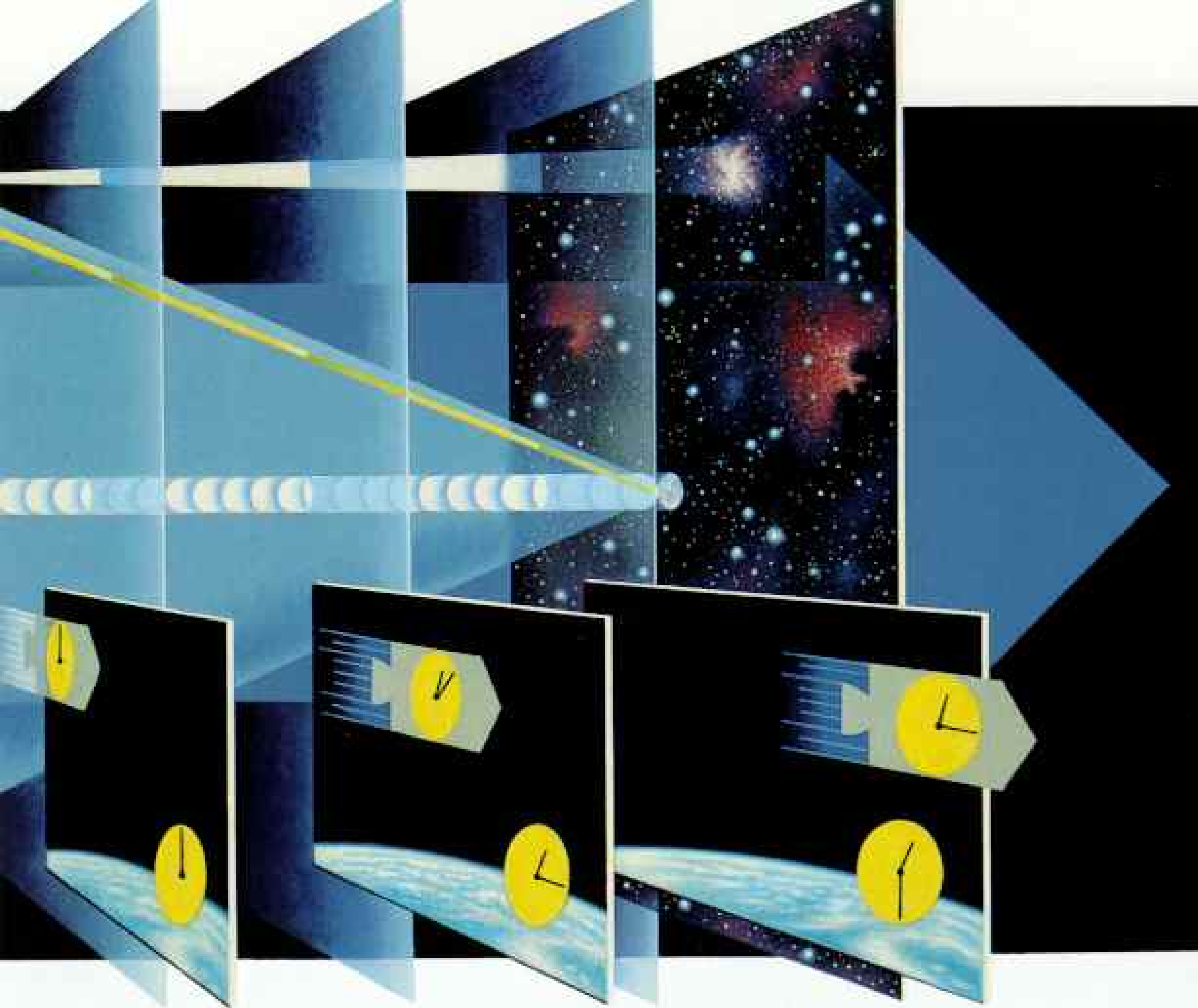
Two years later the mathematician Hermann Minkowski proposed a new geometry that adds time to the three dimensions of space. This four-coordinate system, space-time, caught on as an efficient way to simplify Einstein’s formulas.

Have you ever been in a train station and noticed the train next to yours begin to move? It’s odd, disorienting. Is it moving or are you? You don’t know until you see a third reference point, like the platform. That’s relative motion. In a similar way, time is relative. But there is no ultimate platform. We don’t notice the differences because they are infinitesimally small. The relativity of time becomes significant only at great speeds, like those achieved in particle accelerators

that produce velocities near that of light. Physicists verify special relativity daily, making it one of physics’ most widely confirmed theories.

The idea is simple but its implications are flabbergasting. It means, for example, that rapidly moving clocks tick more slowly than clocks at rest. A clock aboard a spaceship traveling at 87 percent the speed of light (inset) would tick only half as fast as a clock on earth. While such speeds are beyond present space technology, atomic clocks sent into orbit have recorded smaller differences repeatedly.

Odd? Indeed, says Princeton physicist John Wheeler (right), photographed in his office as if receding into a black hole—a term he coined for collapsing



stars that crunch not only matter but the space around it, bringing time there to an end. "Time cannot be an ultimate category in the description of nature," he declares. "'Before' and 'after' don't rule everywhere." A pioneer in quantum theory, at home measuring time by billionths of a second or by billions of years, Wheeler tests the edge of our understanding. "We will first understand how simple the universe is, when we recognize how strange it is."

One way to imagine spacetime is with a cone of light (above), each panel representing space at a different moment. The tip of the cone may be any point, say earth at this instant. Events can be divided into those whose light has had time to reach us—

those within our cone—and those about which we still have no knowledge. As earth moves through time from left to right, our cone widens on each panel of space like a spreading flashlight beam, sweeping events into our "present," our "now." We don't see a star explode as a supernova, top of middle panel, until thousands of years later, when its light has reached us to announce the event, right panel.

So time is relative, changeable. Can it be reversed? No. The second law of thermodynamics—which states that isolated systems move from order to disorder—unequivocally rules that out. Humpty Dumpty won't ever put himself back together again.



PAINTING BY HOWARD BIEBLOW; CONSULTANTS: ALAN LIGHTMAN, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, AND CHARLES W. MISNER, UNIVERSITY OF MARYLAND





Defying time—in a somewhat macabre way—Jeremy Bentham endures at University College London where his body, preserved in 1832, greets visitors. Social reformer Bentham willed that his remains be dissected for science and that his skeleton be dressed in his own clothes; a wax likeness replaces his mummified head, stored elsewhere.

In search of posterity, some put their faith in cryonic suspension—being frozen in liquid nitrogen at death until science can revive and restore them. Pam Chill views her cat, previously frozen by Trans Time, Inc., of Oakland, California; the process for humans costs \$140,000. To mend the ravages of time, some people repair to hot mud baths (below).



dispenser Gernot Winkler. His office can dispense time to 8,000 phone callers an hour.

As we talked, I realized I had set my own watch from a desk clock, which in turn had been set from a radio station, which itself took the time emanating from the pulses of Winkler's clocks. I was synchronized with the entire nation.

The global system also keeps track of the earth's rate of spin, the determinant of our day. It is not as regular as I had thought.

"The earth is an erratic timekeeper," said Graham Appleby, an astronomer at the Royal Greenwich Observatory who helps monitor the rotation of the earth. "The tides, changing

weather patterns, ocean currents, polar ice variations—all affect the earth's rotation." The net effect is that it is slowing, losing only a few thousandths of a second per century.

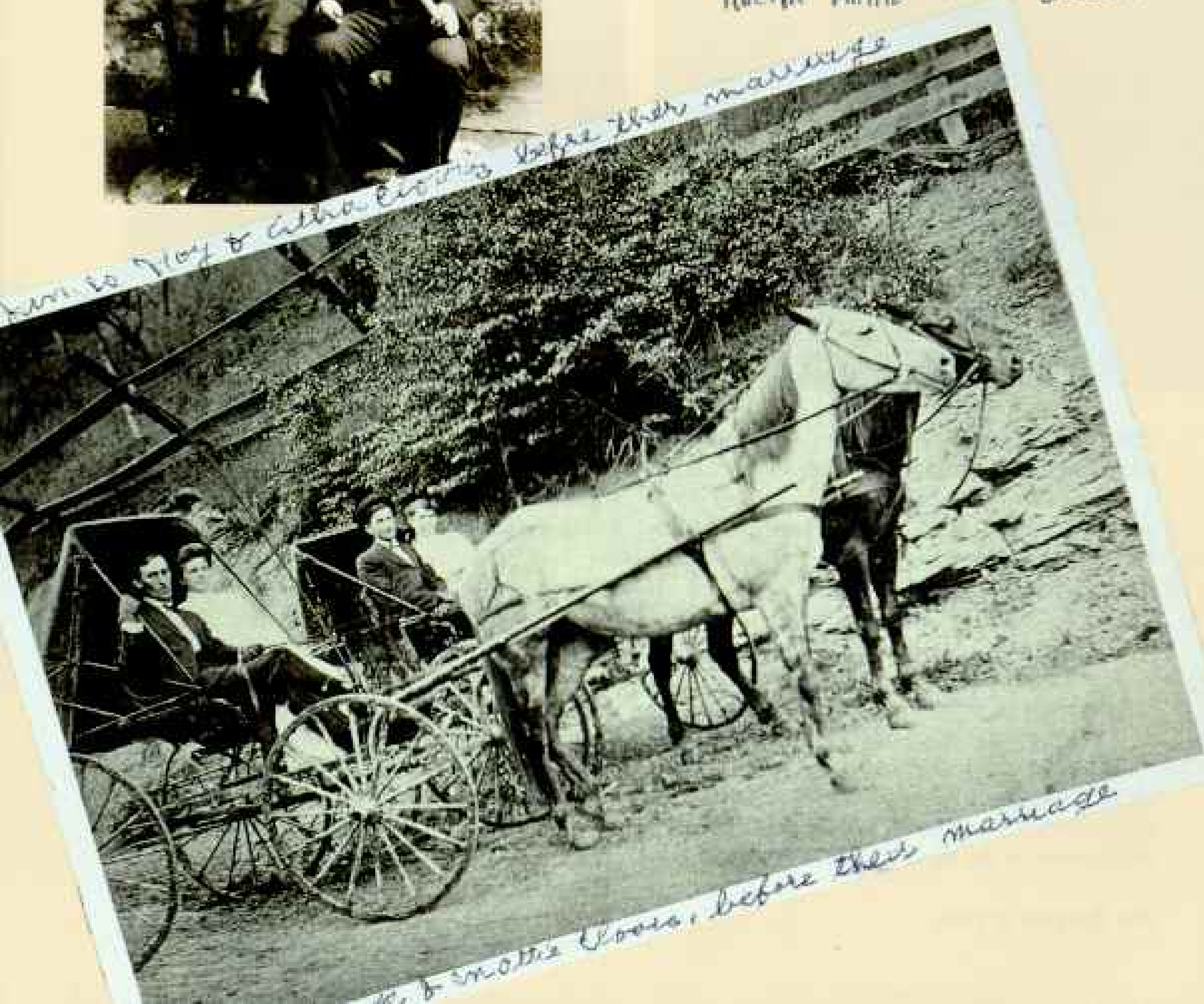
GEOPHYSICISTS believe that half a billion years ago the planet took only 20 hours to make it through the day. In another 200 million years an earth day will last 25 hours, raising some interesting possibilities. If we're still around, will we add an hour to the day or lengthen the 24 we already have?

Today we are adding to the hours—the reason you hear occasionally that atomic

Grandmother with her
 parents: Sarah Eakin and
Marion Clavis. Picture taken
 about 1891 in Waynesburg, Penna.
 Grandmother remembers this
 occasion ^{well} as her forehead was
 burned with a curling iron
 in preparation for the picture.



FRIEND SISTER ATHA NORA
 RHEA MATTIE (FRIEND)



From the Day to Atha Eakin before their marriage
 to Mattie Clavis, before their marriage

clocks have a second added. The man who announces one of these “leap seconds” is Bernard Guinot of the International Bureau of Weights and Measures in Paris, with input from the International Earth Rotation Service. With data from 50 major time services, he computes universal time. As such he is final arbiter of all the world’s clocks.

Is our timekeeping obsessive? Consider this: Locked in a cellar in Boulder, Colorado, is the standard for determining the length of a second in the United States. Operated by the National Institute of Standards and Technology, this cesium device, called NBS-6, is the nation’s most precise atomic clock. It is accurate to within one second in 300,000 years.

NIST scientists have mastered timekeeping so well that they are now defining a meter—the world’s basic unit of distance—in terms of the time it takes light in a vacuum to travel its length: 3.33564095 nanoseconds—approximately.

“We can measure time intervals better than

material objects because time doesn’t have little molecules dancing all over the place,” said David Allan, a time theorist at NIST.

This was good news to me. At last, with our latest clocks, we can now declare something time is not: dancing molecules. But does this give us a clue to what time is?

Not really, says Allan. “Clocks are very limited devices.” He points out that the past does not exist except in our memory. “Nor the future, except in our expectations of it,” he says. “The most a clock gives is the time an instant ago—not even the time now.”

A clock also says how long something takes. We find this intriguing, I think, because interval time—in sports, science, driving down the interstate, or in the rhythms of music, dance, and poetry—usually involves action.

Zeno of Elea, a fifth-century B.C. Greek, was the first to wonder how a specific interval could consist of smaller intervals that could be subdivided endlessly. The paradox has bewildered the ages.



Touched by the love of family and friends, Atha Hoy (above) celebrated her 100th birthday on April 19, 1986, in Northfield, Ohio. She credited her long life to “faith in the good Lord,” as well as a happy childhood and marriage, which followed soon after the double date by horse and buggy recorded in her photo album. One of 45,000 centenarians in the U. S., she died a week after her 101st birthday.



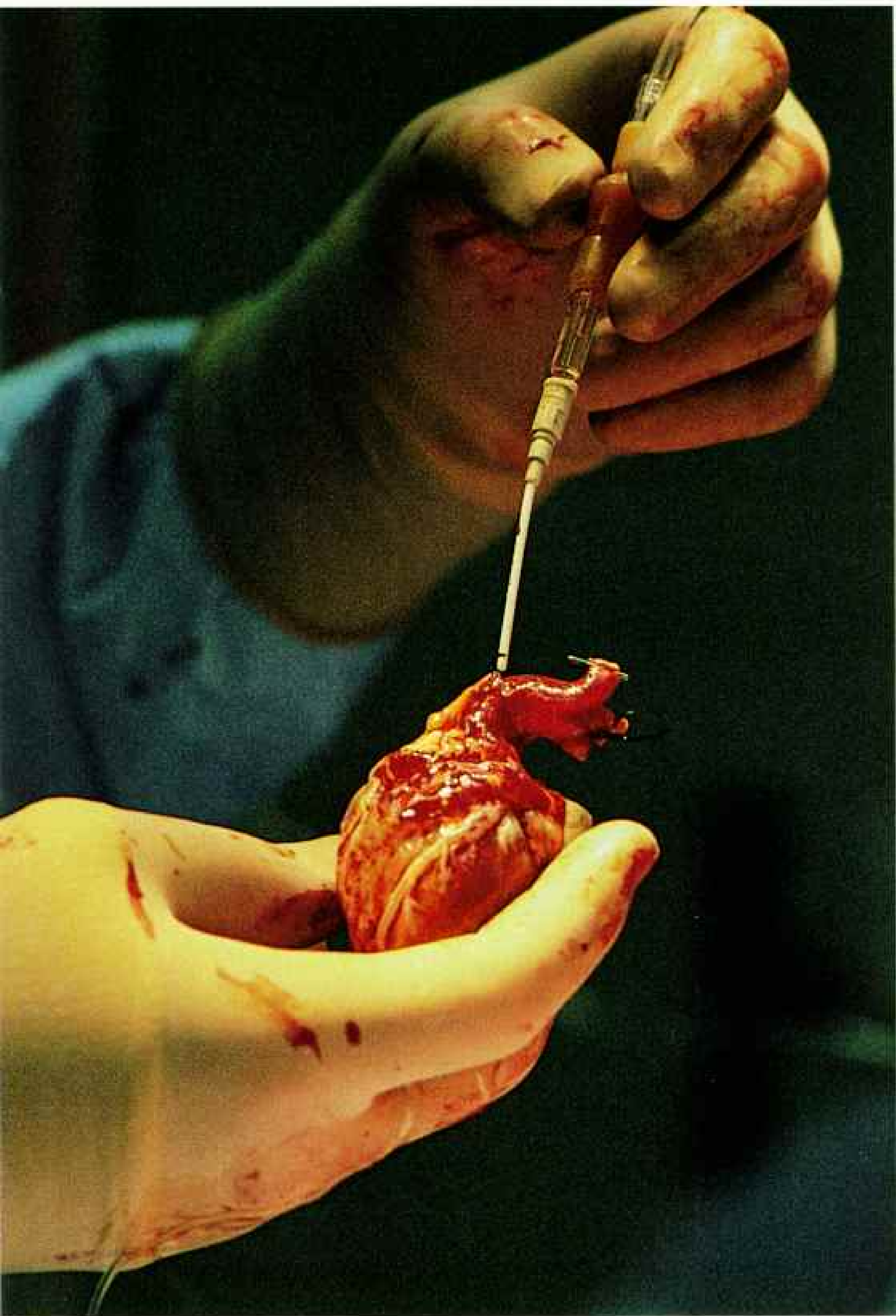
A heart the size of a walnut promises the gift of time to a baby born with an under-developed one—and an average life expectancy of five days. One of many biological clocks in humans, the heart must beat continuously or death comes in minutes.

Finding a donor heart in Texas, California surgeon Leonard Bailey adjusts a tube used to inject a paralyzing solution (facing page), then is sped by chartered jet and ambulance, carrying the heart packed in ice (above).

At Loma Linda University Medical Center, his staff lowered 20-day-old Krysta Falloon's body temperature to 61.7°F, stopping her heart for 59 minutes. After the transplant, blood flushed the heart, and slowly it began beating. Eight hours after securing the donor heart, Dr. Bailey calmly checks monitoring lines (right center).

"She's doing remarkably well," says Christina Falloon, here with six-month-old Krysta and husband Lawney. Cheered by a success rate of 80 percent since 1985, Christina still knows uncertainty. "We take each day as a gift."





But Dave Allan doesn't worry much about Zeno. To Allan a second is virtually infinite. "We can split a second into as many pieces as our technology allows. There appears to be no limit. Timekeeping is our own invention."

The clock instructs us when—maybe even how—to behave. Each hour is a little bucket of time to fill. The clock says when to pour.

Nature too has its clocks. We can read them almost everywhere if we have the tools. In 1947 American chemist Willard Libby found a clock ticking in virtually everything that lived during the past 50,000 years—the carbon-14 atom, which decays at a known rate. By comparing carbon-14 atoms with atoms that don't decay, scientists can tell the age of a pharaonic mummy or an ancient Indian hearth.

Using similar techniques, geologists can measure decay rates of radioactive elements like uranium, potassium, or rubidium to set

ages for the planet's many tiers of rock. Those at the floor of the Grand Canyon reveal two billion years of geologic history, while rocks in northwest Canada go back nearly four. Moon rocks date back 4.5 billion years, about the same age estimated for the earth.

Astronomers have gazed even further back in time. By looking at light from a faraway galaxy, they are actually looking at the galaxy as it was billions of years ago—today the best way to travel in time. The rate at which these galaxies are flying away from each other tells them the date when all the matter in the universe set out on its journey.

"We were able to show that the matter in the universe must have been infinitely compressed and dense about 15 billion years ago," says theoretical physicist Stephen Hawking of England's Cambridge University.

And before that? "Time as we measure it



"O for an engine to keep back all clocks," English poet Ben Jonson gave voice in the 17th century to our ageless lament over the brevity of human life. It echoes in a woman's grief for her younger sister, a budding writer and musician, who at 34 lies near death in a Cleveland hospital following surgery to remove a tumor.

simply did not exist," said Hawking. The reason is that the other side of the beginning of time is an abiding mystery, an unfathomable darkness without matter or motion. And to modern scientists, motion and time are invariably linked.

FOR ISAAC NEWTON time had a life of its own—an almost divine process cutting a path across all nature. Einstein changed all that with his theories of relativity. As the experiment with the traveling clocks showed, time for Einstein depends on how fast you're traveling. It no longer is absolute. And events determine how fast time passes instead of the other way around—the way I think most of us would like to view it.

I asked Stephen Hawking, often regarded as this half century's answer to Albert Einstein, to explain relative time.

"There is only one absolute," Hawking told me. "It is not time but the speed of light"—186,282 miles a second. In a sense the speed of light is Einstein's master clock, since there can be no velocity without time and the speed of light never varies. So the speed of light really is the best way to measure a meter.

But there's a hitch.

One thing that affects both light and time is gravity. In the universe of Einstein's relativity, gravity is caused by the intrusion of a large chunk of matter like the sun into space and time. It is a geometric effect, like the one you see if you place a bowling ball on a trampoline.

Gravity bends both space and time. Thus in the presence of a large stellar object, light has to travel farther between two points, and time slows down, relativistically speaking. This does present a problem. On the surface of Jupiter, with 318 times the mass of earth, a cesium clock would run noticeably slower than one at home. And what happens then to our light-measured meter?

John Wheeler, an eminent Princeton physicist and friend of Einstein, likes to take the idea to an extreme. He pictures what happens on the surface of a black hole, a superdense body created when a massive star collapses of its own gravitational pull. A black hole's gravity field is so intense that not even light can escape its surface, and time would stand still there.

"This shows us," says Wheeler, who gave black holes their name, "that time is a measuring tool, not an absolute flow or a substance."

Without an event, there is no time. This means, Wheeler believes, that time may be a secondary feature of nature, not a basic one.

"But we're only talking about the physics of time here," says Wheeler. "As much as anybody else, Einstein recognized that the mind's perception of time is a more subtle matter."

This kind of time—of our bodies and minds—has origins deep in a primordial past long before a set of gears on the wall told us when to go to bed.

The body's dominant time cycle is called the circadian rhythm, from the Latin *circa*, approximately, and *dies*, day. The control mechanism for this body clock is believed to lie in the brain's hypothalamus above the roof of the mouth. For most of us a normal circadian cycle is 25 hours, give or take 15 minutes.

Why not 24?

"Being slightly out of sync with nature may have created a kind of tension necessary for survival," explained Charles Ehret, president of General Chronobionics near Chicago. Fascinating. If the planet ever does go to a 25-hour day, will we lose our edge?

A NUMBER of body-clock watchers believe we also tick to an array of weekly cycles. These regulate changes in body chemicals, the response pattern of the immune system, and a cyclic rise and fall of heartbeat and blood circulation. These rhythms, some chronobiologists believe, may help explain the designation of the seven-day week as a unit of time—the only calendar unit that does not trace its origins to astronomy.

Charles Ehret is certain that if you abuse these powerful internal rhythms—circadian or otherwise—you are in for trouble. Afternoon drowsiness, the Monday morning blues, jet lag, even sleep disorders and depression can result from the mismatch between the clock on the wall and the ones in the body.

"The invention of the clock may have freed us from the natural cycles of the heavens," said Ehret. "But it did not free us from the natural cycles within."

The Western idea that past, present, and future are arranged in a straight line—that time does not repeat—seems to have grown out of a Judeo-Christian tradition in which events like the creation and Christ's resurrection take on special meaning because they occur in a sequence. It may also lead to a belief in life after death, rather than earthly reincarnation.

One hop bridges east and west at Greenwich, England, where a brass strip marks zero longitude (right). First used by sailors to fix their position, Greenwich mean time was adopted by railroads and, after 1884, worldwide as the standard for time of day. Time is now set not by earth's rotation but by satellite and atomic clock.

The moon's monthly orbit gives humans another natural unit of time. But on South Carolina's Stono River, the moon's pull produces a more dramatic timetable: five-foot tides that occur twice a day, captured in a double exposure.



Today when we glance at the clock and rush out the door, we are running our lives by a system of Babylonian numerology coupled with Egyptian technology within the framework of an Old Testament creation epic—all synchronized by a technology that can split a second into unlimited pieces.

“Linear time has proved to be a convenient and comfortable way to view time, at least in Europe and North America,” said Princeton science historian Michael S. Mahoney. “But more important, it led to the idea of progress, so important to the West.”

Efficiency aside, does our concept of time as a one-way track also lie at the heart of the follies of our “you-only-go-around-once” culture? The cult of youth, the type A personality, a relentless consumerism always

in search of something new? New Mexico anthropologist Edward T. Hall believes this scheduled, time-ordered, scientific existence is controlled by what he calls “monochronic” time.

In contrast, Hall says, many peoples of Asia, the Middle East, Africa, and South America live in “polychronic” time. Everything goes on at once—talking, eating, reading, praying. Scant heed is paid the clock; schedules are flexible. And nobody minds.

Similarly, almost everybody may have lived this way once, since time was usually viewed as a circle, turning back or in on itself, all things possible at all times. This view of time remains central to Buddhist and Taoist belief, in which linear history is a fiction, since all things return to a former state.

East or West, all of us may see time both ways, depending on the circumstances. Still, the competing metaphors can help explain cultural differences: the hazard of making a one p.m. appointment in Burkina Faso, or the folly of presenting a digital watch to a Buddhist monk on his birthday.

Psychologists say our conscious selves inhabit only a brief moment of the present—a little moving slot of individual time six to twelve seconds long that we carry along with us all our lives. The present cannot be instantaneous, or we would not be able to make the connections between words or music or other stimuli that transform them into coherent experiences. Tests show that other creatures lack the ability to make time-separated connections.

CAN AWARENESS OF TIME be eliminated altogether? In northern Arizona an old Hopi Indian woman talks of a close friend, dead for several years, as if he just stepped out the door.

“Hopi verbs make no distinction between past and present,” explained P. David Seaman, a linguist at Northern Arizona University in Flagstaff. “All time runs together, something like an ever continuing present.”

Clocks and calendars create the illusion that we live in a world of mathematically measured segments of time. No timekeeping device symbolizes this illusion more than the most famous mechanical clock ever built.

On a fine summer morning I climbed the tower above London’s Houses of Parliament with Brian Davis, who helps keep the great





clock working. At the top loomed a weight-driven mechanism of gears and levers spanning 15 feet and paced by a 685-pound pendulum that takes two seconds between tick and tock. The minute hands on the clock's four faces are each 14 feet long and travel 119 miles a year at the tip.

The most famous clock is also one of the loudest. Its chimes carry four miles. We climbed to the belfry where Big Ben resides. There is a story that a 19th-century works commissioner of vast girth inspired the name for the 13½-ton bell. For decades it so symbolized power that the British Broadcasting Corporation broadcast its chimes live on the quarter hour.

There are several versions of a story that two workmen a few years ago griped about their boss just as the microphones were turned on. Their explicit words were carried around the globe. Now the BBC rarely picks up the bells live.

OUR SCIENTISTS can break a second down to a thousandth of a trillionth part. We have an idea when time began and that it may not run forever. Biologists assure us that our body itself is as much a part of the clockwork universe as any clock we ever built. And we know that physical time is relative—that it depends on things that happen instead of the other way around.

But what of the questions we all have about time: Can we travel through it, or can it be reversed? Who has not wished to turn back clock or calendar—to erase mistakes, to return as a child with adult wisdom, to ride with Alexander through Asia or chat with Shakespeare?

Common sense says it's impossible: Look at a film of an egg as it falls to the floor and breaks. Run the film backward. Watch the egg reassemble, then rise through the air.

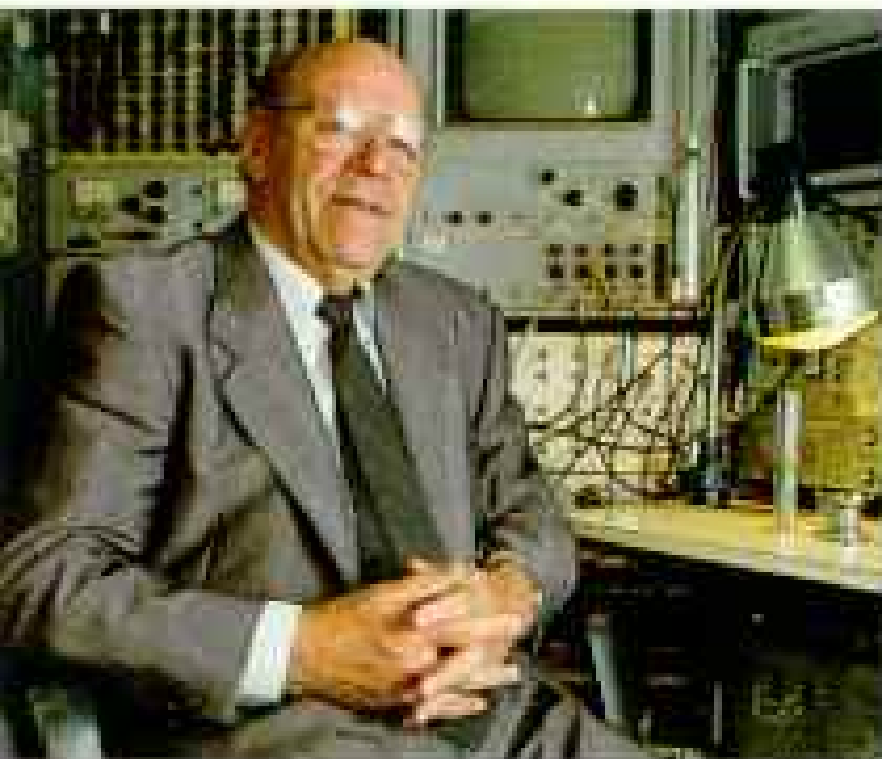
This demonstrates a basic law of science: that nature is a process of disorganization, not organization. This increasing natural disorder—or entropy—is based on the principle that there are more possible disordered states in nature than there are ordered states.

This tendency toward disorder is called an arrow of time. There is also a psychological arrow of time, which likewise gives us a sense that time is passing in just one direction. It is the reason we remember the past, but not the future. The fact that the universe is expanding and not contracting gives us another arrow of



Killing time takes but a millionth of a second for a bullet shattering a watch. Air molecules, compressed before impact, ignited into a silhouette of the bullet as it traveled at 3,200 feet a second. Such high-speed photographs, in which a flash of light acts as the camera's shutter, freeze time, revealing action invisible to the human eye. The technique enhances studies of explosives, machinery, advanced materials, birds, insects, and athletes.

Running Maryland's Savage River for the 1989 World Whitewater Championships, kayaker Fabio Ceccato blurs when photographed at one-eighth of a second (above). With a shutter speed of one two-thousandths of a second, details emerge about paddle angles and body position.



FRIEDER HILDEKE



ANDREW SACKS



MATTHEW MCVAY, SABA

A pioneer in making atomic clocks "tick," Harvard's Norman Ramsey (center) enjoys a moment of glory after winning half of the 1989 Nobel Prize in Physics. Wolfgang Paul of the University of Bonn in West Germany (left) and Hans Dehmelt of the University of Washington in Seattle share the other half. Like Ramsey's work, their research into trapping ions has advanced the science of precise measurement. It might even, in time, challenge our most basic concepts of past, present, and future.

time. All these arrows persuade most scientists that time can move in only one direction.

Yet physicists find it useful to visualize backward-running time at the subatomic level, in the energy-matter exchanges taking place deep in the atom's interior.

"Sometimes when a subatomic particle is converted into energy, it is possible to look at it as if the energy, going backward in time, created the particle," Richard Feynman of Caltech had said. "We don't know that this happens anywhere else."

Three other physicists—Kip S. Thorne, Ulvi Yurtsever, and Michael S. Morris—speculated in a study at Caltech that the laws of physics might not forbid time travel—at least in principle. A subatomic particle by traveling through a "wormhole," a shortcut between two points widely separated in space, might simultaneously tunnel backward in time. However, even if physical law permits such travel, they highly doubt that humans will ever achieve it in practice.

"TIME IS THE BEST TEACHER," a philosopher once wrote. "Unfortunately, it kills all its pupils." Today some of the pupils are attempting to outwit the master.

In Oakland, California, clients of a company called Trans Time, Inc., are signing up to have their bodies—or just their heads—frozen when they die. The bodies and heads are stored in stainless-steel capsules filled with liquid nitrogen until some point in the future when death is vanquished and science is able

to revive and restore them. Unable to defeat time, they are attempting to arrest a natural process—aging and death.

Today we seem bent on either expanding time by living longer or packing more into ever briefer periods. Our TV ads, for example, are electronically compressed to give more bang for the buck. Many viewers find such ads more vital and convincing. But Jeremy Rifkin, author of *Time Wars: The Primary Conflict in Human History*, deplores this fixation with efficiency and speed. "The humanity is sapped out of the life process because there is no room for experiencing, for savoring, or for just being."

Nevertheless, time is what we make of it. Says Harvard's David Landes: "We could time track events and swimming meets in thousandths or millionths of seconds, but we don't. We ultimately are still in control of how we use time and how it affects us."

But, still, what *is* time?

After all my travels and talking and reading, I believe that Professor Wheeler's concept of time comes the closest to an actual explanation: that it is a dimension and, like any other dimension, only a secondary quality in nature.

But we humans have internalized it so powerfully that time has taken on a meaning all its own. We run our lives by numbers on clocks and calendars that we ourselves have created. We already anticipate Saturday, January 1, 2000. But in the grand scheme of things, it will be just another day. □

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Window on the Soviet Union

THE NATIONAL GEOGRAPHIC SOCIETY

ONE FINE MORNING in June 1913 my grandfather, Gilbert Hovey Grosvenor, left Society headquarters with a Kodak folding camera under his arm, packed up his wife and family, took transatlantic passage on the S.S. *Hamburg*, and set out to explore Russia.

The photographs he made there, like that of the uniformed Kremlin guard at right, were to be the last glimpses of tsarist Russia that most GEOGRAPHIC readers would ever see. In his story about the journey, reported in the November 1914 issue, he made ominous note of the "enormous power concentrated in the hands of one individual" and the "timidity, nay fear . . . of being overheard when talking frankly on political subjects."

Who could have guessed what lay ahead—that a small but vocal group of leftists called the Bolsheviks would rise to power? Or that all Russia was on the eve of revolution, about to make one of history's most monumental leaps of faith?

Today Gilbert H. Grosvenor's Russian photographs appear as precious mementos of a lost time—like the last glimpse of daylight from a window just before its shades are drawn, plunging all within into darkness.

Writing in this space two years ago, I noted that our neighbors at the Soviet Embassy had begun the work of reopening that window and wished Mikhail Gorbachev success with his bold experiment in *glasnost*.

Since then, as we all know, headlines have chronicled the breathtaking speed with which the U.S.S.R. and the nations of Eastern Europe have been moving from the shadows into the light—clamoring to be heard and seen and understood. And as we come to know the people and regions concealed so long by the Iron Curtain, I think we may be experiencing one of the most incredible geography lessons of our time.

As the supplement map of the Soviet Union in this

issue makes clear, we Westerners have a lot to learn about the nation Churchill once described as "a riddle wrapped in a mystery inside an enigma." How many of us can name the 15 Soviet republics, much less describe the people who live there? Soviet domestic politics offers living proof that the mosaic of more than a hundred ethnic groups ruled by Nicholas II in 1913 didn't disappear after the Russian Revolution.

Seizing the opportunity to explore, in the first three months of this year the GEOGRAPHIC has published five stories (three in this issue) that shed new light on Soviet politics, archaeology, history, and environmental policy—subjects unthinkable a few short years ago.

We also took part last summer in a successful joint expedition to the bottom of the Atlantic Ocean. Staff photographer Emory Kristof descended 5,000 meters in the Soviet submersible *Mir I* in what promises to be an exciting partnership with the P. P. Shirshov Institute of Oceanology. This month Kristof will rejoin the Soviets for a deep dive in the Indian Ocean to investigate thermal vents.

Later this spring the Society will publish *The Soviet*

Union Today, a book on the nation's natural and human landscapes, along with a companion video cassette, "Discover Russia," to bring Americans face-to-face with Russian history and culture.

In all these developments we see the power of geography to demystify current events, to place the headlines of today in a larger context, to break down barriers of fear and misunderstanding.

It was on such a mission that Gilbert H. Grosvenor traveled to Russia in the summer of 1913. And in that spirit we marvel now, with our neighbors to the east, at the historic events unfolding before us.



Gilbert H. Grosvenor

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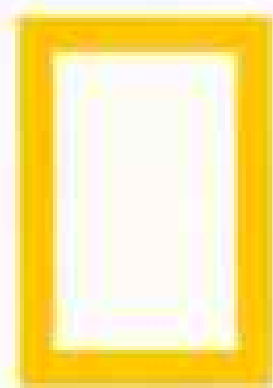
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Members Forum

Hanoi

Your articles on Vietnam today were superb (November 1989). It is indeed time for the United States to take the lead in a new era of relations. Those of us who served there seem more willing than the government that sent us there. Where are the American statesmen who can see beyond containment and Cold War, and the national tragedy of U. S. involvement?

DON MARKHAM
Rolling Hills Estates, California

I spent several months in 1989 in Vietnam as part of a United Nations effort to help rehabilitate forests severely degraded by 30 years of war, chemical defoliation, poor government policies, and rural poverty. I was prepared to be treated coolly. On the contrary I was uniformly received with genuine friendliness. Everywhere, the message was "We want to be friends with America," and hopes were high that the Vietnamese pullout from Cambodia would open the door to normalized relations with the West.

RICHARD PARDO
Alexandria, Virginia

Two historical points were not adequately explained. The murder of Diem was presented as a coup. Our leaders, notably Ambassador Lodge and President Kennedy, have been accused of connivance in the coup. If true, that act more than any others made the Vietnamese war our war. The other point, the final defeat of South Vietnam was given as an example of General Giap's military prowess. His flagrant violation of the Paris peace accord certainly made the conquest easier, as did the decision of our Congress to withhold military supplies.

JOHN R. LOEFFLER
Elbridge, New York

Peter White journeyed to Vietnam to "seek answers to a big question. How is it that these . . . people . . . have for 14 years now failed to bring to their vast majority even a halfway decent standard of living?" The answer in a word—communism. I was in Vietnam in 1967 and 1968, when the phrase "boat people" was unknown. No one then fled the war as they now flee the peace.

JOHN JAEGER
Irvine, California

To me, a former South Vietnamese citizen, it is clear why the economy is getting worse: failing communism and aging, stubborn, incapable leaders. For instance, a four-star general whose education was never more than outdated war techniques is in charge of the education, technology, and science programs. Let's not blame the poor Vietnamese. Communism never works, not in China, not in Russia, and especially not in Vietnam.

TRUNG T. NGUYEN
Coraopolis, Pennsylvania

Please do not show dogs or cats, puppies or kittens lying in baskets ready to be slaughtered for someone's meal. Eat they must, but why domesticated animals? They are the extended family of the human race, to be loved and cared for.

ANNA HALL
Vernon, New Jersey

U. S. Presidents hunt and eat birds. In Europe some people eat horses. In Vietnam they eat dogs. Are we of North American culture better than others because we do not eat dogs? We must not criticize the diet of other cultures if ours is just as strange in their view. I was pleased to read the objective explanation of the photograph on page 591, unlike some descriptions that portray Asians' consumption of dog as barbaric.

ANTHONY MENDES
Toronto, Ontario

Hue, My City, Myself

Tran Van Dinh says some of his father's prophecies for him have come true, but "I have never become a famous literary figure." I would like to dissuade Mr. Dinh of that notion. His articulate article will be read by millions in what is perhaps the most uniformly respected publication in the world. That, Mr. Dinh, is fame enough.

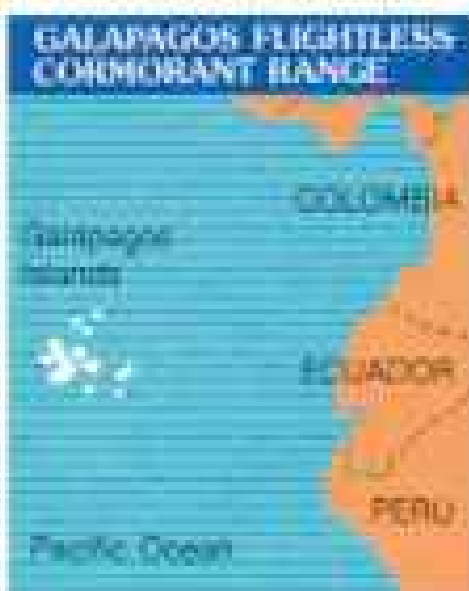
FRANK ROSS
Livonia, Michigan

The Hue massacre was much more than "brutal actions by individual soldiers." Numerous sources, including Douglas Pike of the University of California, have documented that some 5,800 civilians were executed or abducted by communist forces during the battle of Hue. Some 2,800 bodies were recovered in mass graves. Those atrocities were not "actions by individual soldiers." Guenter Lewy (*America in Vietnam*) wrote: "Local communist cadres, following prepared blacklists, rounded up key civil servants, officers, educators and religious figures—the leaders of the community—and executed them after trials before drumhead courts." The Hue massacre was, without a doubt, organized from Hanoi.

HARRY W. HAYES, Editor
*Southeast Asian and Afghanistan
Review, Geneva, Switzerland*



WILDLIFE AS CANON SEES IT



Galapagos Flightless Cormorant
 Genus: *Nannopterum*
 Species: *harrisi*
 Adult size: Length, 95cm
 Adult weight: 2.6-4.0kg
 Habitat: Rocky shorelines on Fernandina and Isabela islands, Galapagos Islands
 Surviving number: Less than 2,000
 Photographed by Tui De Roy

In the warm equatorial sun, a Galapagos flightless cormorant unfolds its wet wings to dry. These cormorants, like penguins, are unable to fly, and venturing into shallow waters offshore in search of food is the extent of their travels. The existence of the cormorants is tied to only a small stretch of coastline, which makes them extremely vulnerable to both nature and man. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Color images, with their unique ability to reach people, can help promote a greater awareness and understanding of the Galapagos flightless cormorant and our entire wildlife heritage.



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Canon

Saigon

A simple fact that American liberals conveniently disregard is that none of the incredible misery that you try to hide would have occurred if North Vietnam had not invaded South Vietnam. We in South Vietnam had peace and comfort and prosperity prior to the invasion.

NGUYEN HOANG
Garden Grove, California

The caption on page 617 solves a 23-year-old mystery for me. I was in Vietnam as a member of Detachment B-33, Fifth Special Forces Group (Airborne), and remember the incident of the ARVN tank being stolen — driven out of a South

Vietnamese Army motor pool and disappearing. We were ordered to be on the lookout, especially on operations, but, of course, we never found it. Now I know what actually happened.

ED JARMAN
Harlingen, Texas

In a Japanese Garden

This was a highly informative yet delightfully personal approach to a complicated subject, and the photographs were stunning. Bruce Coats was a classmate and friend at Rice University, but we never had occasion to share our now apparent mutual interest in landscape gardening.

ED POLK DOUGLAS
Lyons, New York

If you can't pack it



Your article made me realize how fortunate I am to live in Fort Worth, for we have one of the most beautiful Japanese gardens here, including a replica of the Ryoanji. Our garden is two miles around and complete with waterfalls, teahouses, and a moon bridge.

DONNA THORNTON
Fort Worth, Texas

Finding the *Bismarck*

As a member of the *Dorsetshire's* crew, I was gratified to see that we could have been responsible for the *Bismarck's* sinking. I note that Baron Mullenheim was one of only 115 survivors of a

crew of more than 2,200. It must have been he who informed our gunnery officer that seamen were being carried to the South Atlantic for dispersal to U-boats, as many as 2,000 over the *Bismarck's* crew requirements. The baron in his book implied there were no U-boats in the vicinity and that we could have picked everyone up. Actually a U-boat was seen by several.

WALTER G. FUDGE
Mayne, British Columbia

What I, then a boy of ten, remember is that my friend from next door in Hamburg did not return that summer of 1941. He, a midshipman of 18, was killed on the *Bismarck*. This and the grief of

or pull it with this, forget it.

Ah, the family trip. What a moving experience. Things can get emotional just packing up. Before you know it, you're sobbing uncontrollably into that sleeping bag that won't fit.

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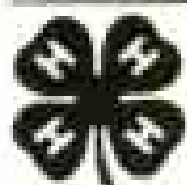
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YET.**



AMERICAN CETACEAN SOCIETY

Humpback whales by Richard Ellis

his widowed mother who had lost an only child made me begin to understand what war meant, though I was only able to fully realize this two years later when my city was destroyed by bombs.

KARL G. BOGENSCHNEIDER

Halstenbek, West Germany

I never found much authentic information on the battle of the *Bismarck* but the GEOGRAPHIC just came to my rescue. The way you people put together an article with drawings, pictures, and dates is far above average and is just one of the many reasons I have been a member for more than 40 years.

H. CLAY BERGER

Montoursville, Pennsylvania

Poland

I read a recent news clip that Poland has a new official spokeswoman, Malgorzata Niezabitowska. The photo of her made my heart leap, as I recognized her as one of your contributing writers. Her picture had appeared on the On Assignment page for "The Last Jews of Poland" (September 1986) and for "Discovering America" (January 1988). When she interviewed David Duke, she hid her incredulity and listened patiently—a true professional—as he insisted the Holocaust never happened. She must be a remarkable person. Bravo for Poland.

PETER BOSCO

Brookfield Center, Connecticut

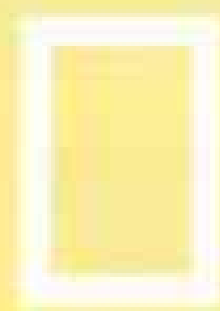
Newly installed official spokeswoman Malgorzata Niezabitowska works at her desk in Warsaw. The new regime moved to end press censorship.



JONASZ TOMASZEWSKI

Letters should be addressed to Members Forum, National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.

National Geographic, March 1990



NATIONAL GEOGRAPHIC MAGAZINE

**Keeping the Light On,
and Manned, in Boston**

Dennis Dever's job as the last lighthouse keeper in the United States is going to last a little longer than he had previously thought.

Dever is the U.S. Coast Guard officer in charge of Boston Light, the nation's oldest lighthouse. By July the Coast Guard, which has run U.S. lighthouses since 1939, will have automated all but Boston Light; it was to be automated last year, sending Dever and two assistants on to other duties in an efficiency move. "You don't have a policeman at every intersection with a traffic light," says Lt. John Brooks, a Coast Guard spokesman.

But Massachusetts congressmen and senators, pointing to the historic nature of Boston Light—the original lighthouse, built in 1716, was blown up by the British in the Revolutionary War—successfully pushed through a legal provision requiring that it be operated "on a permanently manned basis." State and federal officials and private groups are required to come up with ways to keep the lighthouse, on Little Brewster Island, manned and accessible to the public, with its historic character preserved, and with Coast Guard personnel present. "You're looking at a jewel," says Kathi Anderson, a member of the staff of Senator Edward M. Kennedy. "We'd hate to see that history compromised."

Meanwhile, Dever will keep turning the light on 15 minutes before sundown each day and turning it off 15 minutes after sunrise.

**Prehistoric Indians
in the North Cascades**

When Robert R. Mierendorf began archaeological work at the North Cascades National Park complex in the state of Washington in 1984, few thought that prehistoric Indians had ever spent much time deep in the rugged, mountainous interior of the complex's 684,000 acres. The few sites there—17 of them—that gave evidence of early human habitation were largely dismissed. Obviously, the experts believed, early Indians were simply crossing the mountains.

Since Mierendorf arrived, the picture has radically changed. He and his



GARY FARRINGTON

colleagues have found more than 175 sites, at elevations as high as 6,600 feet and with carbon-14 dates as far back as 7,500 years; at about a dozen of them, Indians stopped not just for a night but perhaps for as long as a whole season.

The findings include knives and projectile points, rock art, and the remains of fires and meals that included entrées of mountain goat, deer, salmon, and marmot. Many of the discoveries suggest that those who inhabited the northern Cascades are linked to residents of what is now British Columbia and northern Washington.

One vast outcrop of chert provided raw material for enormous quantities of stone tools. "What we've got here is a factory," Mierendorf told Senior Writer Mike Edwards, who visited the site while researching his article on Washington State (*NATIONAL GEOGRAPHIC*, December 1989).

"This is steep, high country, off the easy travel routes," says Mierendorf. "It's clear that early Indians—hunters, gatherers, and fishermen—were penetrating the high-altitude interior and relying on the resources here."

**Tracking Sea Turtles
via Outer Space**

They were here before the dinosaurs. Now, with the help of science, sea turtles are entering the space age.

For the most part, researchers have studied the mysterious creatures only during their nesting season, when females crawl ashore, lay their eggs, and head back into the ocean (*GEOGRAPHIC*, June 1967, October 1973). In the past, scientists only attached tags to nesting females, then saw where they turned up next. But in the past few years researchers have employed a new tool, satellite tracking, to find out what turtles do while at sea.

John A. Keinath of the Virginia Institute of Marine Sciences has attached small transmitters, no larger than two cigarette packs back-to-back, to the shells of more than half a dozen loggerhead turtles and sent them off to sea. Most were accidentally trapped in fishermen's nets. But last fall he freed a transmitter-bearing turtle that had been raised in the Columbus Zoo. "We'll see if it navigates or migrates as expected," Keinath says.

Keinath and his fellow researchers Robert Brandner and Susan Busford have begun to attach transmitters to a much larger species, leatherback turtles, on the beaches of St. Croix. They reveal not only where the turtles are, but also when and how long they dive.

Scientists are anxious to learn more about sea turtles because most species are threatened with extinction. Development has made many nesting beaches unusable. Turtles are killed in fishing nets or for their meat, shells, or skins. And their eggs are stolen.



JAMES L. BRIDE

Creating a List of Underwater Wonders

To the ancients the Seven Wonders of the World included such marvels as the Hanging Gardens of Babylon and the Colossus of Rhodes. Modern divers, conservationists, explorers, and marine experts have created a new list: the Seven Underwater Wonders of the World.

Organized by CEDAM International—a nonprofit conservation and education group dedicated to exploring and preserving the world beneath the sea—a panel nominated 20 sites before settling on the final seven. The winners are the waters around the Republic of Belau (Palau) in Micronesia, the Soviet Union's Lake Baykal, Ras Muhammad reef and the northern Red Sea (right), the Galápagos Islands, the Belize barrier reef, the northern portion of Australia's Great Barrier Reef, and the deep ocean vents found in Pacific, Atlantic, and Indian waters. Most have been featured in NATIONAL GEOGRAPHIC, whose staff photographer Emory Kristof served on the CEDAM panel.

Rick Sammon, who is president of CEDAM International and who conceived the idea, says the Seven Wonders list will call attention to the fragility of the marine environment. "I want the world to be as interested in underwater life as it is in animals on land," Sammon says, "and a Seven Wonders list was a good hook to get people's attention."

Sacred Belts Return to the Iroquois

Ending nearly a century of contention, the New York State Board of Regents has returned a dozen sacred wampum belts held by the New York State Museum to the Six Nations Iroquois Confederacy (GEOGRAPHIC, September 1987).

Rarely displayed in recent decades because of Indian protests, the beaded belts—recording treaties and events going back centuries—will be reconsecrated for use in religious and political ceremonies.

"You are the rightful custodians of this legacy," New York's Secretary of State Gail Shaffer told the chiefs and clammothers who attended a ceremony last fall at Onondaga, capital of the confederacy. The ceremony was the second in two years at which the Iroquois retrieved wampum belts. In May 1988, 11 other belts held by the Heye Foundation's Museum of the American Indian in New York City were returned to Canadian Iroquois at the Six Nations Reserve in Ontario. "We will use them to teach our children of their



DAVID GOVILLET

own history and of the Great Law given to us by the Peacemaker, who founded the Iroquois Confederacy so many centuries ago," said New York Onondaga Chief Irving Powless, Jr., who views the belts as symbols of sovereignty. Canadian Onondaga Chief Jake Thomas told New York State officials who participated in the return ceremony: "We're grateful you've given back our sacred wampum belts. Maybe next time you'll give us back our lands!"

A Mission, a Battle, and a Mystery Ship

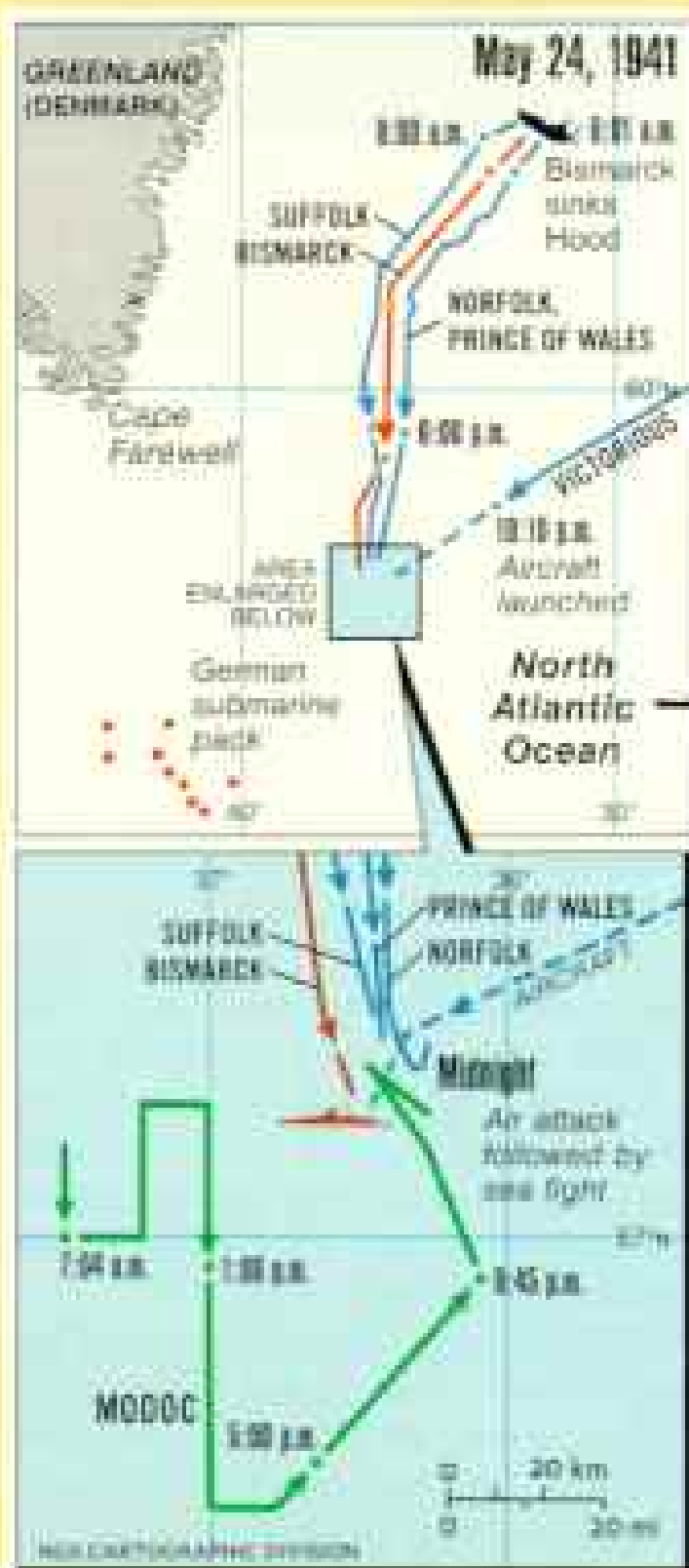
On the evening of May 24, 1941, Richard L. Davies was the 31-year-old assistant to the president of the Pennsylvania Salt Manufacturing Company, and a man on an important mission. Davies was in the North Atlantic on a U. S. Coast Guard cutter, the *Modoc*, sailing to Greenland. There he was to negotiate with officials to make certain that his firm could continue to obtain cryolite, a mineral vital in the manufacture of aluminum needed for airplanes.

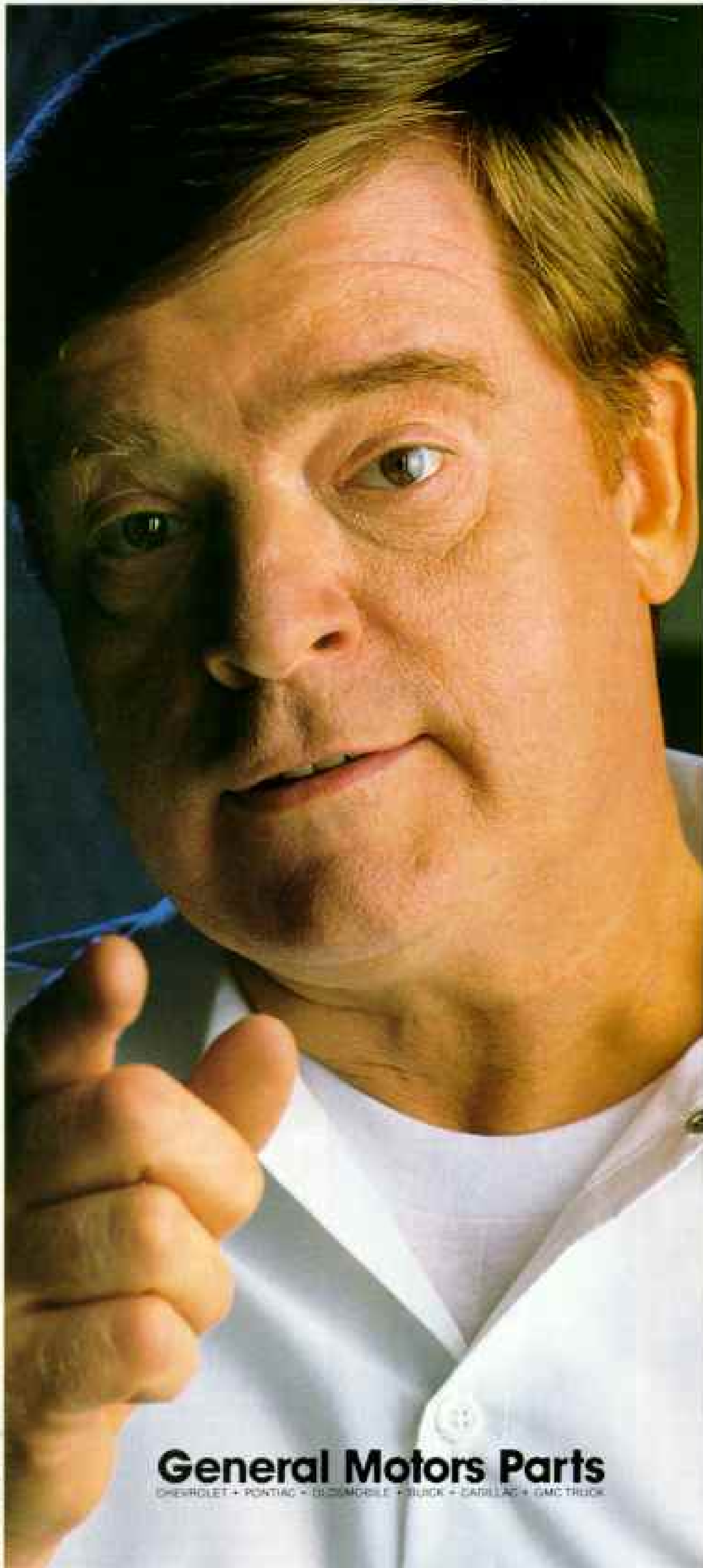
Suddenly "we sighted a large battleship broadside to us, on the horizon dead ahead," Davies later wrote his wife. "We saw the flash of the battleship's guns, firing, but not at us." The U. S. was still neutral, but the *Modoc* had found itself in the midst of a battle involving nine torpedo planes, the battleship, and three other ships.

"We didn't then know who was who," Davies wrote. "By good maneuvering, good guessing, and good luck, and the Lord having us by the hand, we got away."

The planes and the smaller ships, he learned later, were British. The battleship was German: the *Bismarck*, which had sunk the British warship *Hood* that morning and was destined to go down itself on May 27 (GEOGRAPHIC, November 1989.)

Davies is now 80 years old and lives in Washington, D. C. He has had a long, successful business career, becoming president of Pennsalt International Corporation, a subsidiary of the Pennsylvania Salt Manufacturing Company. But he still remembers vividly the night the mysterious battleship appeared on the horizon.





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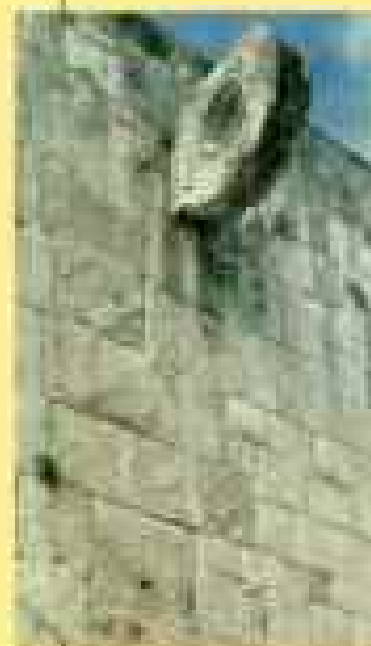
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MIKE KIRKPATRICK, FIDELLES WEST, 1986;
JOHN ELMAGE, BOB SHAFY, 1980 (BELOW)

Acid Rain Attacks Mexican Maya Sites

Visitors to ancient Mexican sites along La Ruta Maya (*Geographic*, October 1989) should be forewarned: Acid rain and other environmental factors are seriously affecting Maya monuments.



Art historian Merle Greene Robertson, who studied Maya sites in Mexico with support from the National Geographic Society, calls acid rain "the number one man-made problem" affecting Maya ruins. It is especially notable, she says, on the Yucatán Peninsula, where the Maya

Painted their structures a brilliant red or blue so that they were "ablaze in color." Due to acid deposition, algae, bacteria, and microscopic organisms that thrive in the jungle, the painted Maya cities "are almost lost to us today," Dr. Robertson reports.

Much of the acid rain that affects the Yucatán Peninsula, home to such major Maya sites as Chichén Itzá (above), and the lowlands of Chiapas is caused by oxides that come from oil-field smokestacks and uncapped oil wells not far away. But at another major site, Tulum, buses are parked directly in front of the entrance with their engines running for hours

while tourists are inside, adding powdery black soot and dirt to painted murals already damaged by acid rain. "There's no excuse for that," says Dr. Robertson.

Illegal Fur Coats: For Sale in Nepal

To Larry Barnes "it was like an open drug trade."

Barnes is a California-based wildlife biologist. What he was seeing in tourist areas of Kathmandu, Nepal, was the virtually open sale of coats made from skins of animals listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Such animals are considered dangerously threatened with extinction and therefore banned from any international commercial trade (*Geographic*, March 1981). But Barnes, with the aid of female acquaintances who posed as potential buyers, found furs of listed animals for sale in 31 of 36 shops he visited in Kathmandu in 1988. Coats were made from the skins of the leopard cat, the common leopard, the clouded leopard, and even the extremely rare snow leopard (*Geographic*, June 1986)—all of them listed in Appendix I.

Barnes says that these shops selling furs are known in Nepal as "Kashmiri stores" because they are owned by natives of Kashmir, across Nepal's border with India. The furs apparently were also tanned and sewn in Kashmir, he says. Their sale, with few excep-



NICOLAS CHOU

tions, violates Indian and Nepalese law as well as the CITES treaty.

The government of Nepal has called Barnes's study "very useful" but says Nepalese enforcement efforts alone will not be enough. It urges tourists not to buy illegal furs and to "abhor rather than adore" those who wear them.

Tracking Life in Prehistoric Times

"It's like finding a complete encyclopedia about life from 280 million years ago."

That's how Jerry P. MacDonald describes his discovery of fossil trackways, or series of footprints, in the rug-



JERRY P. MACDONALD

ged mountains not far from Las Cruces, New Mexico.

Preserved in slabs of the rock that MacDonald has pried out of several mountains, the trackways contain evidence of all sorts of life, particularly land animals, in the early Permian period. These forms include giant reptiles that were the dominant creatures of their time. And among them were mammal-like reptiles that were forerunners of dinosaurs that would rule the earth many millions of years later. MacDonald also has found tracks of horseshoe crabs and scorpions, centipedes and millipedes, cockroaches and worms—in all, more than 50 different animals. There are even the impressions of raindrops and plants, including the branches of conifers and smaller ferns. "We have a small ecosystem that shows the whole range of the food pyramid," MacDonald says.

The site was a tidal flat at the edge of an ancient inland sea. The tranquil deposition from the tides gently buried the footprints, helping preserve them, MacDonald thinks. Scientists from the Smithsonian Institution and the Carnegie Museum are poring over his findings for clues that will tell us about the animals 280 million years ago: how they moved, what they ate, and what the climate was like.

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ROLLS ROYCE CORNICHE	3 YEARS UNLIMITED	3 YEARS UNLIMITED	NONE	3 YEARS UNLIMITED	3 YEARS UNLIMITED
MERCEDES BENZ 360 SEL	4 YEARS 50,000 MILES	4 YEARS 50,000 MILES	NONE	4 YEARS 50,000 MILES	4 YEARS 50,000 MILES
CADILLAC SEDAN DEVILLE	4 YEARS 50,000 MILES	4 YEARS 50,000 MILES	\$100 AFTER 1 YR. 12,000 MILES	4 YEARS 50,000 MILES	6 YEARS 100,000 MILES
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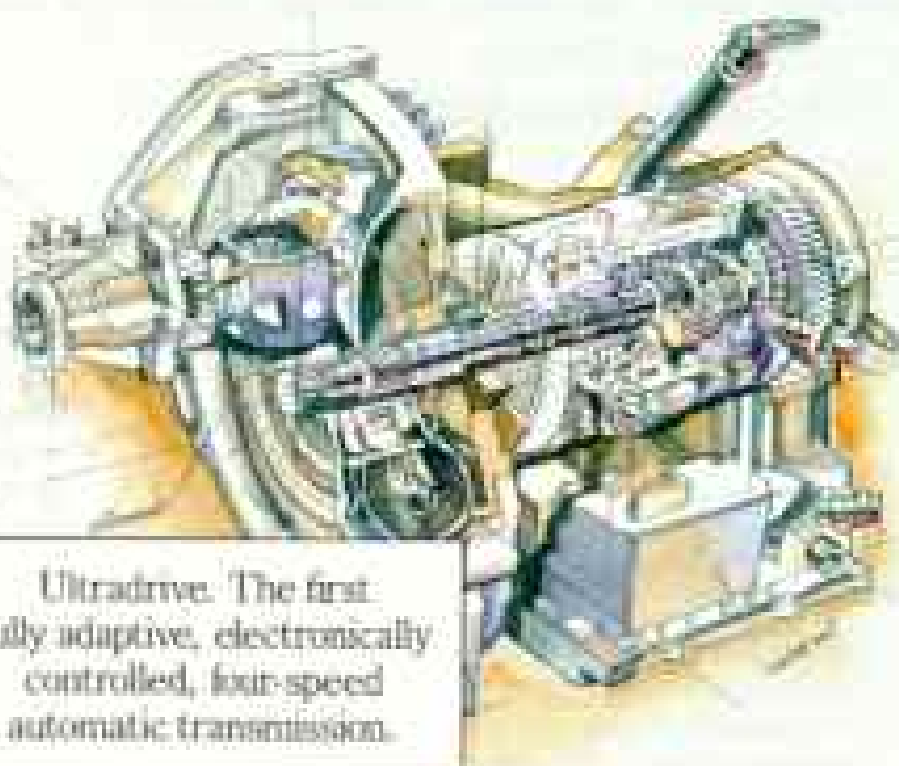
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6. Entries will be judged by the Photo Contest '91 Committee, an independent panel of experts, based on originality, composition and photographic technique. The panel's decision will be final.
7. Winners will be notified by mail and their names will be announced in the December 1990 issue of "National Geographic" magazine.
8. Entries are accepted and prizes are awarded on the condition that the entries are original photographs, are the sole property of the entrant, and have not been submitted or accepted for publication elsewhere.
9. All entries will be retained by Mazda and

will not be returned.

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11. This offer is void where prohibited by law.
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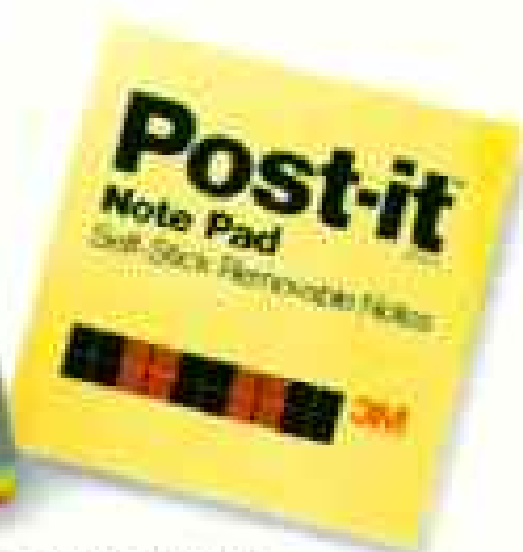
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SOME THINGS—such as the size of the universe—are beyond the mind's ability to grasp. Another is the magnitude of human suffering imposed by one man—Joseph Stalin. By conservative estimates he killed outright or worked to death some 20 million people—mostly citizens of his own nation. That's twice the number of people living in the 50 state capitals of the U. S. combined and three times the toll of Hitler's Holocaust.

In recent months we've witnessed an astonishing collapse of the repressive Stalin era throughout the Soviet Union and its Eastern European allies—emotionally dramatized in the tearing down of the Berlin Wall. A new Soviet openness, or *glasnost*, has permitted us to bring you in this issue a look at two places made infamous by Stalin's reign of terror—Siberia and the gulag.

To report on the once dreaded Siberia, staffers Mike Edwards and Steve Raymer traveled a region larger than the entire United States where life is so harsh and job locales so remote that salaries are tripled to attract workers.

Now we are told of the "official closing" of the gulag—an acronym that became part of the world's lexicon with publication of Aleksandr Solzhenitsyn's *Gulag Archipelago*. Some experts have put the number of people who suffered in the gulag as high as 25 million. Solzhenitsyn, quoting Soviet sources, says that from 1918 to 1953 about 50 million *died* in the network of slave labor camps or under harsh conditions of exile. No one can be sure.

Recently two U. S. congressmen, Frank Wolf of Virginia and Chris Smith of New Jersey, were permitted to visit Perm 35—supposedly the last political detention camp in the gulag. "Some of the prisoners we talked with have already been released," Congressman Wolf told me. "We are hopeful that by the time your article is published the rest will be free."

The article Wolf refers to is an amazing first filming—by a team of French journalists—of a labor camp still in operation. When Perm 35's gates swing open for the last time, the dreaded gulag may have ended, but the acronym that Stalin made a synonym for human suffering will remain a permanent part of our vocabulary.

Wilbur E. Garrett

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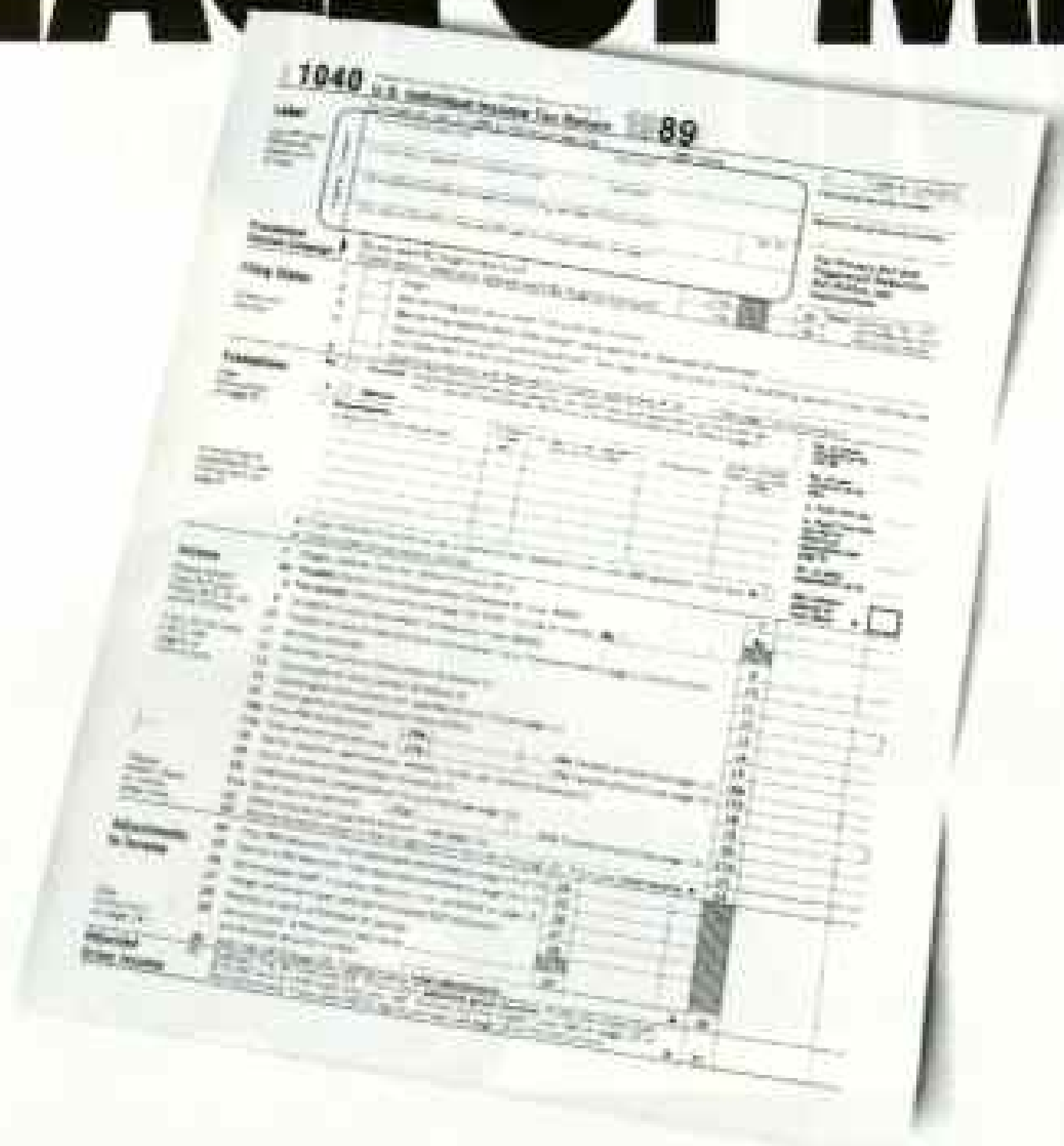
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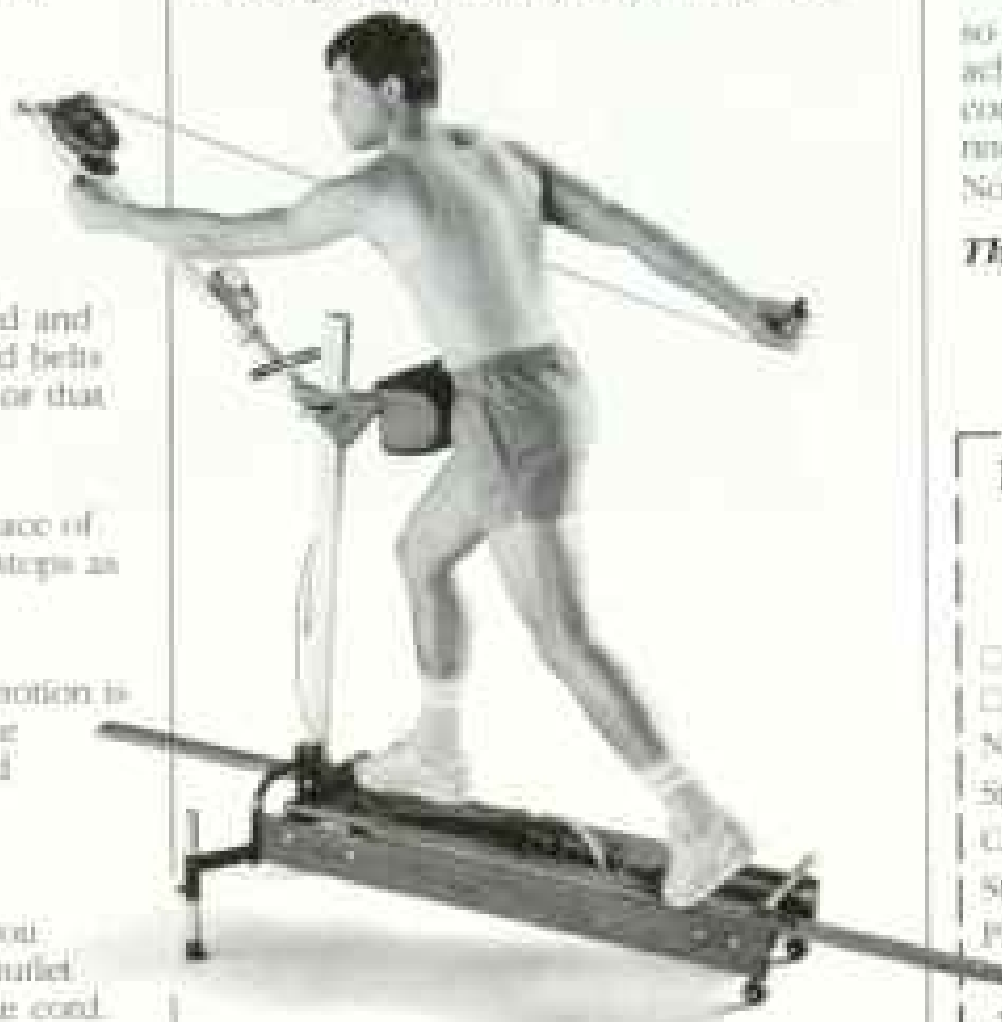
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On Assignment

NONSTOP ARCHAEOLOGIST, 61-year-old VIKTOR IVANOVICH SARIANIDI, who unearthed the golden trove in Afghanistan described in this issue, is now concentrating on Bronze Age mounds in the Turkmen S.S.R. After 40 years of fieldwork he has established that Central Asians built cities around oases starting about 2000 B.C. and developed a flourishing civilization with monumental architecture, sophisticated gold and silver craft, and irrigation agriculture.

An inflatable globe—a novelty promoting our *WORLD* magazine—helped break the ice with Siberian officials in Chara, says photographer STEVE RAYMER. They helped arrange a visit to former labor camps. Eleven trips to the U.S.S.R. and a year at Stanford



JOSEPH D. LAKENBURG, NOS PHOTOGRAPHER



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University as a John S. Knight Journalism Fellow have given Steve insights into the superpower: "I have seen some immense changes, but the Soviet Union is still a heavily armed developing country." As director of our News Service, Steve oversees a staff that provides features for 2,000 newspapers and magazines.

Staff writer MIKE EDWARDS, hoping for an autograph, carried the new English edition of *Let History Judge* when he first met its author, Roy Medvedev. Instead the Stalin authority seized the



STEVE RAYMER

book like a lost child, since his own copy from the publisher had not yet arrived. The connection helped win Mike an interview weeks later in the writer's Moscow apartment. Son of a Red Army officer who died in one of Stalin's labor camps, Medvedev was a "nonperson" until critical analysis of Stalin became acceptable under

Gorbachev; now the expert is a sought-after contributor to Soviet journals and a member of the new Soviet Congress.

Author of 27 *GEOGRAPHIC* articles, from the Shenandoah to Shanghai, Mike covered Ukraine (May 1987) and earned an Overseas Press Club award for his report on Chernobyl.

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