

# OMNI

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DECEMBER 1991



**STAR TREK VI:** AN EXCLUSIVE LOOK AT THE FILM, THE FAMILY, AND THE FUTURE OF STARSHIP ENTERPRISE BY DIRECTOR NICHOLAS MEYER • **CLASS ACTS:** SCHOOLS THAT INVENT THE FUTURE • **THE NEW CARTOGRAPHERS:** IMAGING A WORLD THAT HASN'T HAPPENED YET • **SAGDEEV:** TO MARS WITH THE SOVIETS AND OTHER TECHNOROMANTIC REVELATIONS

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# OMNI

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EDITOR IN CHIEF & DESIGN DIRECTOR: DOB GUCCIONE

PRESIDENT: KATHY KEETON  
EDITOR: KEITH FERRELL  
GRAPHICS DIRECTOR: FRANK DEWIND  
MANAGING EDITOR: PHIL SCOTT  
ART DIRECTOR: DWAYNE FUNCHUM

## 10

### First Word

By Lauro Escorial  
Looking for locations for  
the new film  
*At Play in the Fields of  
the Lord*, the  
Brazilian cinematographer  
saw his  
hometown in a new light

## 12

### Omnibus

The Who's Who  
of contributing authors

## 16

### Communications

Readers' letters

## 18

### Earth

By Joanne K. Hanson  
Scientists  
intently study the newest  
place on Earth  
to discover how life evolved  
when the  
planet was young

## 20

### Political Science

By Tom Dvornetky  
Why doesn't  
the U.S. buy the nukes  
the Soviets are  
tossing out to keep up with  
the Bushes?



The image is as familiar as Warhol's  
soup cans, Mickey's ears or the Coca-Cola logo: the  
massive starship *Enterprise* standing  
ready for battle, as countless stars light up the darkness  
of deep space. Now twenty-five years  
old, the *Star Trek* story continues to fascinate and  
entertain us, in-fused to dumfreaks  
us. (Additional art and photo credits, page 124)

## 22

### Tools

By Sandy Fritz  
Everything you always  
wanted to know  
about the paranormal but  
were afraid  
to ask, plus so new they  
haven't been  
invented yet, and more

## 26

### Electronic Universe

By Gregg Keizer  
You've read the genre,  
now play the  
games! Science fiction  
games always  
a week imitation of  
written SF  
begin to hold their own

## 30

### Entertainment

By A.J.S. Ray  
The writer of the movies  
a new *Adams*  
Family, an invisible *Chevy*  
Chase, and a  
thirtysomething *Rain* Run

## 33

### Continuum

TV without the guff,  
what's black  
and white and munched by  
farm  
animals?, and more

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# OMNI

**52**

## **Boldly Going Nowhere?**

By Melinda Snodgrass  
Despite predictions that it would crash and burn, *Star Trek: The Next Generation* continues to thrive, delighting Trekkers and new fans alike with the adventures of Picard and his crew. But has it abandoned the original's rockier spirit for a more pedantic view of the future?

**56**

## **Interview**

By Doug Stewart  
Physicist Rosalind Sagdeev guided the Soviet Union's unmanned space program to new heights but made more headlines down on Earth when he bucked the Communist political system back in 1988, when parastatks was untested



**48**

## **Star Trek: The Director's Chair**

By Nicholas Meyer

After twenty-five years of meeting alien races, romancing beautiful women, and saving the universe, James T. Kirk and his crew are heading for home to take a well-deserved rest. The director and screenwriter of the new film, *Star Trek VI: The Undiscovered Country*, talks about working with the *Star Trek* cast and characters

**42**

## **Class Acts**

By Gregg Kassar

Science has certainly changed over the past few decades. Fortunately, many schools have adjusted, teaching science not just with textbooks but with satellite hookups, computer networks, and old-fashioned ingenuity and enthusiasm

**66**

## **Fiction: The Other Shore**

By J.R. Dunn

Several years ago, renegade geneticists cooked up a modern version of the Black Death that attacked only non-Caucasians, devastating the population of the Third World. As the world struggles to recover, FBI agent Dave must escort Bedford, one of the accused scientists, to trial, where he faces almost certain death. There's just one problem: Dave thinks the likable Bedford is innocent.

**74**

## **The New Cartographers**

By Gregory T. Pope  
Maps and legends. We've come a long way from the days when mapmakers labeled uncharted areas with "Here be dragons." Cartography has become a science, employing the latest satellite and computer technology to not only map the seas but also help prevent environmental damage and deliver mail faster.



# FIRST WORD

AT PLAY IN THE FIELDS OF THE LORD:  
Confronting the mythic—and the not so mythic

By Laura Escorel

Lately the Amazon and its inhabitants have been a frequent focus of international attention. Anyone who is attentive to the larger issues of our contemporary world has an inner vision of the Amazon. For a long time even I, as a Brazilian, had mythical images of that part of my country: Anacondas, Indians, and the vastness of the forest were my only references. Today ecological consciousness, the critical concern about the invasion of indigenous peoples' land, and the images of death and destruction caused by strangers seeking gold are bringing about a new vision of the Amazon.

As director of photography on the movie *At Play in the Fields of the Lord*, I realized the project offered a unique opportunity to unite two visions—the real and the imagined—of the Amazon. I knew I also faced the challenge of finding the proper balance between the intimate drama of each character in the movie and the scope of the Amazonian scenery.

The process of discovering the Amazon began for all of us—producer Saul Zaentz, director Hector Babenco, and production designer Clovis Bueno—when we began to look for loca-

tions. For more than six months, in successive trips throughout the region, we fully experienced the confrontation between the real and the imaginary Amazon. We traveled from north to south, from east to west, by canoe, small plane, car and, very often, foot, and on each trip our perceptions changed and broadened. Sometimes the forest revealed its secrets, at other times it seemed to escape us. While there we often rejected what we saw because it did not correspond to our preconceived ideas. When we were far away from the forest, everything seemed to grow and gain value. The light of day could make the place look like paradise or very frightening.

The river's appearance varied depending on the area, the light of day, and the tides. In some places, the height of the tides, sometimes 22 feet, could drastically alter the look of a particular spot. We had to return several times to the same area just to confirm our impressions.

Meeting the original inhabitants of the region was also part of our education. When we obtained the permit to visit the Indians, Brazilian officials asked us to take parcels to them. When I discovered the contents of the packages—plastic sandals, microwave jars, knives, clothes, and other goods of our society—the myth of the purity of the Indians was immediately dispelled.

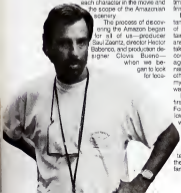
I still recall the emotion of our first trip to a Yanomama village. For more than an hour we followed our guide without knowing where he was taking us. When we finally arrived at the maloca (collective habitation), we were enchanted by its dimensions, the beauty of its architecture, and the original way they divided the space for each family group. Slowly each one of

us started picturing in our minds the ideal scenery for the film. I attentively observed the multiple light effects in the forest, wondering, for example, what the best time of day would be to capture the beauty of the Indians' bronzed skin tone.

The clash of cultures is one of the main themes of the film, and it was interesting to watch the integration between the Indian cast and the film crew. Once when the Indians discovered we were not shooting because I was waiting for a cloud—diffused light was best for their skin color—they started to dance, calling for clouds. In a few they clapped their hands and bent their bodies backward and forward while crossing from one end of the set to the other. At each turn they would pull a crew member into the line as they sang, looking to the sky and back to the set. Soon the whole film crew was involved in the surprising ritual. Shortly thereafter clouds appeared in the sky and we finished the scene with the same intensity that we had begun it with. Was it the more passage of time or their faith that brought up the clouds? I don't know. Had we simply crossed our arms and waited, I do know their energy would have vanished.

The crew had the privilege of living in the Amazon for almost a year, and I believe *At Play* successfully captures some of the multiple images of the Amazon—images that bring us closer to the myth and, at the same time, brighten the scenery where one of the biggest tragedies of our time is taking place: Indian genocide, deforestation, the pollution of the rivers—and, ultimately, the demise of the Amazon. These are the symptoms of a sick world that we, as its inhabitants, must reflect on in order to discover what kind of future we really want. □

A few reflections by Escorel on the movie *At Play*.  
Novel: Peter Matthiessen. Script: Jean-Claude Carrière and Hector Babenco.



# OMNIBUS

WHERE NO ONE HAS GONE BEFORE:

Our writers boldly explore new classes, modern maps, the latest movies, and a newborn island

In the fall of 1966, when Captain Kirk, Mr. Spock, and the rest of the starship *Enterprise* crew made their first voyage across the nation's television screens, mass-media science-fiction was not yet a part of mainstream American culture. Stanley Kubrick's 2001: A Space Odyssey would not appear for two years, and George Lucas's *Star Wars* was ten years off. But through constant syndication and the intense loyalty of its fans, *Star Trek* permeated the national consciousness so thoroughly that the first operative space shuttle was

named after Captain Kirk's starship. *Star Trek* was one of the factors that brought science-fiction concepts to a much broader audience and thus made a magazine like *Omnibus* possible. We thought we should take a look at the *Star Trek* phenomenon on its twenty-fifth anniversary.

In his first piece for *Omnibus*, writer/director Nicholas Meyer ("Star Trek: The Director's Chair," page 48) offers some thoughts on why *Star Trek* appeals to so many people. Meyer directed *Star Trek II: The Wrath of Khan* and *Star Trek VI: The Undiscovered Country*, released by Paramount in December, and coauthored the screenplays for *Star Trek IV: The Voyage Home* and *Star Trek V*.

Melinda Snodgrass ("Boldly Going Nowhere?," page 52) served as executive script consultant on the TV series *Star Trek: The Next Generation* for two seasons. Her latest science-fiction novel, *Double Solitaires*, is due out from Bantam in early 1992.

Our world has seen many changes since *Star Trek* first aired, not least of which is the increasing importance of science and technology in our lives. In "Class Acts" (page 42) Gregg Kaezer shows us how some schools are working to prepare students for a highly technologized future. But a few programs are not enough. "Every kid in every class in every school ought to have the same opportunities as the children in Carolyn Flanagan's class and Albert Tarendish's high school," says Kaezer, a former junior high school teacher.

Rapid change has overtaken not only our schools but the very face of our planet. Gregory T. Pope ("The New Cartographers," page 74) went to the U.S. Geo-

logical Survey headquarters in Reston, Virginia, to see how computers and satellites are changing the way we make and use maps. "I grew up in the Washington D.C. area," says Pope, "but the region has changed so fast that I needed a map to get to the Survey center—and even then I got lost."

*Star Trek* aired at the height of the Cold War, and Doug Stewart (Interview, page 68) spent a month in the Soviet Union during that tense era. In interviewing Rod Sagdeev both before and after the August coup attempt, Stewart noticed a profound change in the former Soviet space-science chief's mood. "Before the coup, Sagdeev talked about Soviet scientists as if they were an endangered species. But afterward, he was as excited as a new Nobel prize winner."

*Star Trek V* is only one of many science-fiction and fantasy films coming soon to theaters near us. A.J.S. Rayl (Entertainment, page 30) takes us on a tour of the latter from Steven Spielberg, John Carpenter, David Cronenberg, and others.

A few years before *Star Trek* first appeared, the sea off of the southern coast of Iceland gave birth to a brand-new island. Once a dangerous place of quaking earth and flowing lava, Surtsey is calm now—though Jennie K. Hanson's (Earth, page 18) trip to the island was not so peaceful.

"When it came time to go back, the North Atlantic waves had become huge, and the raft couldn't get through the surf," she reports. "I was soaked from head to toe."

With the threat of nuclear war fading, J.R. Dunn's "The Other Shore" (page 66) becomes all the more chilling, as he envisions worldwide disaster resulting from overpopulation, racism, and the horror of biological warfare. **DC**



Clockwise from bottom: J.R. Dunn, Gregory T. Pope, A.J.S. Rayl, and Doug Stewart





# EARTH

## OCEANS OF FIRE

The Earth's newest place may show how life appeared billions of years ago

By Jeanne K. Hanson

**O**ur rubber dinghy slips cold surf. We jump out and land on a black beach littered with boulders. Two tall hills hold the rest of the bare island. In the foreground we see just four signs of life: a piece of dried green seaweed, a gray feather, the footprint of a gull and a chip of white shell brilliant against the black sand.

This is already the strangest place I have ever been, eerie in its emptiness and dramatic in its abstract shape, an odd northern Eden that brings to mind the art

of sculptor Isamu Noguchi. But Surtsey—named for Surtur, a giant who, in Norse mythology came from the sea bearing fire—is Earth's newest island.

The ocean glowed gold when Surtsey began to rise from the sea just 28 years ago off Iceland's southern coast. Along a 600-foot-long fissure that split the deep ocean floor, then later from craters, lava flowed for almost four years at 45 miles per hour. A lava wall formed to hold back the sea, "lava bombs" as large as automobiles flew through the air. During one period the energy of the eruption could have illuminated a city ten times the size of New York. The earth is still warm beneath the surface.

Iceland has designated Surtsey a nature preserve, a place to study how life colonizes new land. Visitors are allowed on the island only in the company of a scientist and with the seldom-offered permission of Iceland's Surtsey Research Council. Our guide, Jon Olafsson, a marine chemist with the Marine Institute of Iceland, seems glad that even our footprints "would be gone in the first southeaster." The only signs of human presence consist of a small shed where scientists can spend the night and some wooden measuring sticks next to plant samples.

Olafsson shows us the island's surprising variety of topography. We climb the smaller of the two hills through sand and over mberg, or solidified lava. We also see a hardened lava "lake," large purple-black boulders, a moss-filled lava crater, two black sand beaches and a high black "sand dune" cliff that descends into a canyon.

In the 28 years since the last eruption, 27 species have made

passage here. Sea rockets arrived first, probably via ocean currents. Others came by air. Snow buntings brought seeds from Scotland in their gizzards. Wind, water and birds also carried blue-bloomed lungworts and various mosses and grasses to Surtsey.

Nesting birds are rare, with fewer than 100 nests found since the island was born, says Sturla Fridriksson, a biologist and ecologist at Iceland's Agriculture Research Institute. "The birds need cliffs to nest on, and it took a while for the lava to break up into cliffs," he says. Six species nest here: herring gulls, fulmars, black-backed gulls, kittiwakes, guillemots and arctic terns.

The first visitors to Surtsey were fulmars, arctic seabirds that landed briefly, even before the eruption ended, to eat fish killed in the hot ocean plume, Fridriksson says. Later, insects came over to feed on the remains of the fish or bits of seaweed. And now every April, mother seals leave themselves up on the fresh black beach to bear their young.

Research projects involving each species draw scientists from all over the world. To aid them in their unheralded quest to study the development of life, visitors may not take even a souvenir rock. Even the old bones of a bird must be left undisturbed.

These days only nature is allowed to affect this unique environment. Eroding winds have already shrunk the island's land mass to three quarters of its original one square mile or so, and from a height of 575 feet to 490 feet. In time, Surtsey will become steeper and smaller until it disappears altogether from sight. "Then those who study it will be able to tell how a society is built up—and how it's destroyed," Fridriksson says. **OC**



**Mountain High.** Visitors respect Surtsey's odd terrain for clues about the development of life.



The only difference in  
today's basic research is  
in the tools we use.



*In the 1600s, Sir Isaac Newton led the scientific revolution with breakthrough discoveries in optics, mathematics and physics using little more than his incredible mind. Today, America is about to provide scientists with a basic research tool that promises to expand our knowledge as never before.*

The Superconducting Super Collider (SSC) will propel subatomic particles at near the speed of light. Head-on collisions will shatter the particles to reveal the constituents of matter. Such basic research will provide scientists at the SSC laboratory with answers to some of our greatest questions.

*And that's only the beginning. Because once we possess this information, the resulting applications for medicine, computers, materials and a host of other technological areas will exceed our wildest dreams.*

Obviously, much has changed since Newton's time. Yet, the driving forces that have taken us so far still remain the same. Our hunger for knowledge and our need for basic research.

**GENERAL DYNAMICS**  
*A Strong Company For A Strong Country*



# POLITICAL SCIENCE

## BEATING SWORDS INTO DOW SHARES

What do I hear for a dozen ICBMs with MIRVed 20-megaton warheads?

by Tom Dworetzky

It's nice to see the new sensitivity has finally touched the macho heart of nuclear diplomacy. First President Bush unilaterally announces that he'll get rid of a bunch of nuclear weaponry, the type known as tactical (These are things like land mines and artillery shells and short range rockets that you could set off over the same battlefield that your troops are fighting on.)

Then Gorbys sees him and raises the ante. He will do all that plus pull back a bunch of his submarine-based strategic missiles (These are the things that travel 3,000 to 6,000 miles to explode over your homeland.)

It's nice to see the stakes raising in this antimacho poker game. But the betting isn't high enough. Now it's time to bring the

big bucks into it as well. The way that someone without any more chips might toss his grandfather's pocket watch into the pot. We victorious capitalists have a completely unprecedented opportunity, one so unbelievable that I think it truly does signify the most profound fork ever trod on the historical road.

It's simple, it's free market: it will feed clothe, house, and heat the Russians, and it will buy us more bang for our defense bucks than ever before.

Put straight, it's this. Let's start putting the United States' economic clout—and our defense dollars—directly into the pot by offering to buy the rest of the Soviet Union's nuclear arsenal lock stock, and barrel for cold cash and then destroying the stuff completely. We might as well. Before the smoke clears from the collapse of the Soviet Union, we'll be shipping aid dollars to them in box-cars. After all, they've got all those bloody nukes. We don't want them to get cranky and hungry, now do we?

The Soviets have gold, oil, traza, and what all, but their greatest natural resource is actually plutonium. Think I'm kidding? What's the going rate these days for a fully functional ICBM with a MIRVed 20-megaton warhead on the open arms market? Hard to say for sure, but considering what some folks have spent to produce not even enough plutonium for one such warhead, I've estimated the coal (or a it worth?) of these things to be from \$10 million to \$100 million.

We could start the betting at \$10 million and see what sort of deal we can strike for quantity. And we're talking not just your raw goods here but the full value-added package of a fully assembled and tested warhead mounted on a rugged, ready-to-go mis-

sile. Considering the damage they can cause, the way I see it, it's an unbeatable value. Taking these things off the market permanently is a better way to neutralize them than Star Wars—or some shaky agreement by both sides to store the stuff in their respective cellars.

After all, if some unstable and greedy individual got hold of one of these babies, ring up Hussein and said, "Sure, it's big bucks, Saddam—but this hog'll reach D.C. and there's no way to stop it," don't you think that Saddam would draw up a cashier's check on his BCCI account then and there?

We could probably win the hand—that is, take the Soviet Union's entire nuclear cache of 27,000 or so weapons—for \$200 billion or \$300 billion. That's a lot of money, I know (but for \$200 billion you could build exactly 238 B-2 bombers at their present price tag of \$875 million. Frankly, even at ten times the price it would be worth it—if we could buy it over time.

All right, I know it will take jobs away from our boys in the military-industrial complex. And why should the taxpayer spring for this useless Russian stuff anyway? Fair enough.

Here's another way to finance it. Let's offer a junk bond issue for a company called Nuclear Deterrence Inc. Anyone who wants the Soviet stockpile bought and destroyed could buy in—\$5, \$10 a share, whatever. Let Nike Milken or the Salomon boys handle it in exchange for a little time off for good behavior (it might even be such a good deal that the U.S. bomb makers would start selling their stuff off, too).

Two hundred billion dollars may be a lot of money, but all of these goodies would still be a bargain at twice the price. ☐

\$200 billion may be big bucks, but those Russian nukes'd be a bargain at twice the price.



# TOOLS

FOR THE TWENTY-FIRST CENTURY

Into the mystic, writing to the top, motoring into the future, and the past

By Sandy Fritz

## HARPER'S ENCYCLOPEDIA OF MYSTICAL & PARANORMAL EXPERIENCE

Rosemary Ellen Guiley, ed. Harper, San Francisco, 1991. \$19.95

**PLUSES:** Always entertaining.

**MINUSES:** Poor binding.

**VERDICT:** Worthy.

Let's get it straight: The Lemurians, not the Adairians, are humanity's Third Root Generation. And in case you were wondering, the symbol for modern pharmacies, **R**, is derived from three pieces of the Eye of Horus, the son of Osiris and Isis.

These two examples give a fair indication of the depth and breadth of this 600-plus-page gem. Among the high points to check out: the mystical experience of Charles Lindbergh while piloting the Spirit of St. Louis;

and the gigantic vegetables that grew in Scotland (within the Arbroath Carrot) after an elderly couple befriended a plant spirit.

## CHANGEWATER LETTERS

Software: Changewater Computing, Box 4468, Warren, NJ 07059-0468. \$29.95 plus \$1.50 postage.

**PLUSES:** Verbs dignification in a constructive manner.

**MINUSES:** A) present, only IBM compatible.

**VERDICT:** Worth at least three times its price.

This software is actually a database with the names, addresses, and appropriate forms of addresses for letters to government officials, leaders of nations and their cab-



inets, and even the CEOs of major businesses, from food processors to publishers.

Menu-driven in order to foil even the most inept computer user, Changewater Letters lets you contact key decision makers in all areas with ease and grace. Power to the people.

## AUTO 2010

Paul Van Valkenburgh. Self-published, 1991. Box 3611, Seal Beach, CA. \$14.95 plus \$2 to cover postage.

**PLUSES:** Good ideas presented with subtle humor.

**MINUSES:** Pie-in-the-skyish.

**VERDICT:** An automobile lover's dream.

Paul Van Valkenburgh has a headache. His *Auto 2010* looks, feels, and reads like a magazine, which has resulted in a flood of subscription requests. "Please tell 'em it's a book, not a magazine," Crazy, Paul, but the cover does proclaim your "book" is a "magazine from the future."

This publication blends automotive fact, fantasy, and speculation; sports a humorous tone; features realistic photographs (jointly taken by the author); and boasts a strong readership in the automotive industry. The author "guarantees at least 100 future automotive concepts that not even you have ever heard of before." Is that a compliment?

## THE ARTIFACT CATALOG

OCE, Box 21F, Hazlet, NJ 07730. Seven issues for \$30.

**PLUSES:** You can buy a piece of history.

**MINUSES:** Plenty of junk among the gems.

**VERDICT:** Real time travel.

You can now buy ancient artifacts and coins via a mail-order

catalog. The artifacts include both lowest acceptable bid and suggested retail. You bid what you want to pay, and if no one bids higher, it's yours.

Each catalog is different, and the items range from authentic Egyptian scarabs to pen knives from fourteenth-century Venice. If you're not satisfied with your purchase, you can return it within five days. **CC**





You always come back to the basics:



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# ELECTRONIC UNIVERSE

FROM THE BOOK TO THE SCREEN  
Science-fiction games get closer to the real thing

By Gregg Kaezer

Cruisers glide slowly through space, alien worlds fall under apocalyptic weapons, vast civilizations stretch across light-years.

Science fiction (SF) paints on a broad canvas, from near-future expectations to far-fung improbabilities. No wonder, then, that it grabs hold of the imagination and won't let go.

Computer and video games take advantage of this to create new worlds for your monitor and television screen. And while no game can yet approach the drama or intricacies of a short story, much less a novel, some recent electronic SF is crawling closer.

*Accolade's Star Control* (Sega Genesis, IBM PC compatibles) may be more war game than science fiction, but it's great fun, especially in its new Sega form. You'll leap into a twenty-sixth-century war of annihilation between the Ur-Quan Hierarchy and the Alliance of Free Stars (Who makes up those names, anyway?)

Part strategic knapsack, part blast 'em arcade, *Star Control* lets you move fleets and get down and dirty in hand-to-hand combat. The revolving star map takes some adjustment, but its



**NICE KITTY: IN WING COMMANDER II, PLAYERS ENGAGE THE NASTY, CATLIKE KILRATHI IN AN ONGOING WAR**

unique perspective forces you to think in three dimensions. You move ships between stars, explore planets, colonize worlds, develop resources, and battle a futuristic counterpart to Saddam Hussein.

But it's the ship-to-ship combat that makes *Control*. You fly across a scene where gravity wells suck at your ship and inertia blasts your opponent into a cloud of expanding debris. This video game's a xenophobic's delight.

Even so, SF has a tenuous hold on *Star Control*. You could transplant the action and strategy from

spaceships to tall ships and it wouldn't lose much in the move. For something a lot closer to science fiction's heart, try *Electronic Arts' Starflight* (Sega Genesis, IBM PC compatibles), a classic PC game now in cartridge format.

The idea is straight from hoary SF tales of exploration and first contact. You cuff a ship with crew and equipment, then set out on a galactic grand tour. Although practicalities intrude—you have to turn a profit to keep yourself in fuel—the fun lies in dropping into an unknown system to see what's what. You'll come across various intelligent races. Be nice, be respectful, be mean—how you act affects their response.

*Starflight* boasts several hundred systems to explore, the ruins of Old Earth to sift through, and enough plots and subplots to keep you busy for weeks.

Taking up 15 megabytes

of your hard drive, *Origins' Wing Commander II* (IBM PC compatibles) puts a sophisticated spaceflight simulator inside a science-fiction jacket lined with romance, teasing and fighter-pilot ego. The mar isn't great SF, but the space combat is great video.

WGP extends the popular original to take you on more missions against the feline Kilrathi. You sit in the cockpit of any of several Confederate ships, your tools ranging from vid screens and target-locking systems to particle cannons and torpedoes. Think of it as *Top Gun* 2001, with lots of fireballs.

Each mission you fly—and its success or failure—affects the campaign against the pernicious Kilrathi and can change the story as it unfolds. The open-ended nature of the entire war makes possible add-on disks with new battles, something *Origins* hasn't overlooked.

A clutch of even newer games are also worth a look. *Dynasty's Nova 9* (IBM PC compatibles) is a fun, futuristic tank-and-flight simulator set on nine different worlds, with just enough oddities to turn it funky (was until the giant bulldozer shoves you around).

And keep an eye out for *Access Software's Madan Memorandum* (IBM PC compatibles), a science-fiction role playing game that shows some promise.

SF games may not have grown up yet, but even in their arrested development, they're a great way to see the stars from the comfort of your couch. **DD**



# ENTERTAINMENT

## WINTER CHILLS AND THRILLS

The Addams Family and a new Star Trek head the list of upcoming films

By A.J.S. Rayl

**T**hey're creepy and they're kooky, mysterious and spooky" the television theme song says, and Gomez, Morticia, and the rest of the Addams family make their motion picture debut in one of the season's most intriguing releases this winter. And in later films, science-fiction and fantasy fans will glimpse virtual reality, get caught up in the business of immortality, encounter yet more aliens, and take what may be a final voyage. "Whose no man has gone before."

Starring Anjelica Huston as Morticia and Raul Julia as Gomez, *The Addams Family* will introduce a new generation to the gothic suburban clan, including Uncle Fester (Christopher Lloyd) and butler Lurch (Tim Peake's giant Carol Sanyoukian). The film draws more on the spirit of Charles Addams's New Yorker cartoons than on the Sixties sitcom. But with the aid of the Turner network, which is airing the series, not seen on TV in quite some time, *The Addams Family* may still experience a revival.

Memories of an invisible Man, however, will probably bear little resemblance to its progenitor, *The Invisible Man*, made in 1933. Directed by John Carpenter and starring Chevy Chase as a



victim of an experiment gone awry. *Manos* is billed as a suspense-filled adventure with romance and comedy.

Meanwhile Steven Spielberg has lined up J.M. Barrie's characters for *Hook*, an epic fantasy adventure based on Peter Pan. A woman played Peter in the musical, but Spielberg cast a male—Robin Williams. Also featuring Dustin Hoffman as Captain Hook and Julia Roberts as Tinkerbell, *Hook* should draw long lines.

As *Hook* opens in mid-December, however, lines will also be forming for yet another adventure with the original crew of the starship *Enterprise*, *Star Trek VI: The Undiscovered Country*, promises a thematic resolution for *Star Trek*'s twenty-fifth anniversary. The next *Star Trek* feature film will probably involve the crew of *Star Trek: The Next Generation* (See "Star Trek: The Director's Chair," with production photos from *Star Trek VI*).

Other sequels scheduled for release include *Robocop 3*—more enemy robots, big explosions and high-tech scenarios, but now starring Robert Burke, taking over for Peter Weller.

Of course, horror doesn't always lurk in the physical world, as writer and director David Cronenberg (*The Fly*) reveals in his celluloid version of William S.

Burroughs's *Naked Lunch*, starring Peter Weller. Don't expect a literal translation of the Burroughs novel, though. That would have cost four hundred million dollars and been banned in every country in the world," Cronenberg says. Instead the director takes viewers into Burroughs's Interzone, a world that produces stunning hallucinatory effects that include leaping sex blobs and fatly black centipedes.

The business of immortality becomes ominous in *Freejack*, based on "Immortality, Inc.," a novella by former *Omni* fiction editor Robert Checkley. In the year 2020, people live forever by having their brains and souls transplanted into the bodies of young people plucked from the past just seconds before their certain death. Mek Jagger portrays a villainous twenty-first-century bounty hunter pursuing race-car driver Alex Furlong (Emilio Estevez).

And the general moviegoing public will get its first glimpse of Hollywood-style virtual reality in *Lawnmower Man*, starring Pierce Brosnan. With a 9th that sounds like a sequel to last year's *Edward Scissorhands*, *Lawnmower Man* is actually the first of what will probably become many films involving computer technology that allows viewers to interact in a three-dimensional artificial world as if they were physically in that world. The futuristic suspense film features intriguing computer-animated moments inside virtual reality.

Special effects aside, the real magic of Hollywood is sometimes just getting films into theaters. Two films highlighted in our June 1991 issue—*Radio Flyer* and *A Gnome Named Gnorm*—were rescheduled for winter releases, as was *Freejack*. But that, we hope, doesn't necessarily reflect on the quality of the films. **CC**

**Hook** and **crooks**: Will the classically **Captain Hook** snag the **grown-up Peter Pan**? Will **Robocop** round up the latest batch of **bad guys**? Find out at the **movies**





# CONTINUUM

DOES INTERACTIVE MEAN INACTIVE?

New TV-dependent technologies may create better-educated couch potatoes. Plus, the modern telephone salesman, and spinning straw into money

It looks as if the techno-marketeers may reach their elusive goal at last: put a computer in every American home. We might all succumb this time because the computer is cleverly disguised to look like a television.

Collectively these new devices are often called I-TV: interactive television. The first models hit the stores when the Christmas buying rush began this fall. A leader, the Dutch electronics company Philips, sells the Magnavox line. Philips has been developing I-TV longer than anybody. In fact, it is the original developer of the laser-optic technology that also underlies audio-compact discs. Now it's pushing for compact-disco-interactive—or, GDI, Philips's name for I-TV—to be the next big consumer hit.

In September the computer maker Commodore started selling its Dynamic Total Vision I-TV deck in stores across the country. It runs different software discs than Philips machines, a fact that will no doubt confuse people for a while. But both of these devices, and the numerous others to come, work the same.

The I-TV player looks like a music CD deck and wires to a television and stereo system like a VCR. It has a remote control pad that is similar to a VCR panel, with the addition of a video game's thumb-stick direction controller. The deck is packed with the processing power of a personal computer, programmed to deliver multimedia extravaganzas: video, audio, sound, graphics, text, all responding to the whims of a viewer lounging in his easy chair. The players will start at about \$1,000.

Programs for the machines will retail from about \$35 and up. They come on an ordinary-looking CD because of its tremendous data-storage capacity. Commodore processes 100 files by Christmas. Philips says it will begin with about 50 programs. Its offerings include games from Nintendo's Super Mario Brothers and Donkey Kong to ABC Sports Golf's Palm Springs Open, with photo-realistic simulated play of actual courses. In addition, there are super coffee-table books, like Treasures of the Smithsonian, which take viewers on self-guided tours and even let them play ancient musical instruments. Two Sesame Street titles let children play with letters and numbers.



It's much more compelling than the stuff computer makers offered the first time they tried to sell their machines to ordinary consumers. About a decade ago, when personal computers were still rare, marketers trumped up stories about how folks could store recipes and balance the checkbook using a PC. No wonder they felt deeply short of their wish to put a computer in every home. Nintendo

has come much closer, selling nearly 30 million game systems since the early Eighties. But then, Nintendo doubts what people seem to want most from computers in their leisure fun.

Hence I-TV, like Nintendo, introduces personal computers into homes by linking them with television. For all its potential, the resulting hybrid runs the risk of combining the worst attributes of both: the superficiality of TV and the seductive power of personal computers. But the technology also holds great promise. The question is whether or not the promise will be realized.

Television-induced cerebral atrophy is already much discussed in the media. The challenge to computer and I-TV developers is to use the medium's interactive potential to overcome both TV's cerebral atrophy and the dead-end nature of many video games. It's not a simple challenge: many people would rather see their children deftly manipulating clay on an Apple Macintosh, churning out computer-precise pictures and posters, than getting preprogrammed images, however captivating, out of a computer. It's largely a mechanical skill. Creativity is limited because a person can get out of the machine only what a programmer has already put in. The computer's tabula rasa is not so blank as a blank piece of paper, nor does a disk filled with images hold as much imaginative potential as a hand clutching a crayon.

Yet I-TV in its various forms need not be just another version of the "same old TV." Interactive technology remains in its infancy, and it may be that the hardware and software manufacturers rise to the challenge. If so, they could transform TV from a passive spectator deadening device into a truly interactive tool, one that prods you to interact as well with the real world. —JEFFREY ZYGMONT



## CONTINUUM

### **BUOY DID WE GET THE WRONG NUMBER**

In a scene out of a bad made-for-TV movie, the U.S. Air Force and the Coast Air Patrol (CAP) suddenly received a signal one day last March that indicated that a Soviet aircraft had crashed near Washington, D.C.

The alarmed CAP traced the signal—to the underside of a display table at the University of Maryland's Adult Education Center's exhibit of state-of-the-art Soviet high-tech products. The culprit—a Soviet-made emergency locator transmitter—was indeed stowed under the table.

"Someone must have accidentally pushed a button before I secured the unit under the table for the

night," says Yuri G. Gm, deputy director of the Moscow telecommunications firm ECOS—WE. Gutman

*"Is it progress if a cannibal uses knife and fork?"*

—Stanislaw J. Lec

### **REACH OUT AND SELL TO SOMEONE**

Advertisers spend hours watching their brains for new methods to get their message across to a potential customer. They put advertisements on billboards and before movies on videocassettes. Now they're even slipping ads in during telephone calls.

A circuit board patented by Neil Steev, a telecommunications consultant in Weston, Mass., will, when wired to a telephone or a



One ring-ding, two ring-ding: Both residents and advertisers may make money by slipping ads in between the rings of a phone call.

phone line, insert advertisements into the four-second intervals between rings of a telephone call. Although residents near his home complained when he and Fidelity Telephone tried the technology out on them,

**A LIGHTNING BOLT HEATS THE AIR AROUND IT TO THREE TIMES THE TEMPERATURE OF THE SUN'S SURFACE**



Flax grows in star fields, not in lines.

### **JUST THE FLAX, MA'AM**

Some farmers in Saskatchewan and Manitoba, Canada, used to have money to burn, but not any

more. A flax farm company building a pulp mill that will turn flax straw, a waste product of linseed oil production that farmers burn every autumn, into the type of paper used for U.S. currency.

The patented pulping process uses potassium instead of the conventional sulfur chemicals, making the technology so clean it's being hailed by the initial Greenpeace chapter, according to Ai Wong, president of Arbockem Inc.

The potassium will be recycled and converted into fertilizer, the pulp will need no chlorine bleaching to be whiter than copy paper, and the mill will discharge about as much water as

would 100 guys drinking a lot of beer," he says.

By law, U.S. currency contains 25 percent flax pulp. Flax's long fibers make for a strong pulp that can produce high-quality paper ideal for recycling. Better yet, Wong says that his process can be used for other crops that farmers now burn, including sugar cane and rye grass.

Arbockem, which, "currently we're in a shop looking in" to using coffee resin as an insecticide and a desiccant, will open the pulp mill and start production in the town of Sarny, British Columbia. It will employ 25 people and produce 20 tons of pulp a day.—Jim Speck

Steev thinks they'll snag a different angle if they can save money on the deal.

Bell Atlantic, the huge regional telephone company, agrees. It bought the rights to Steev's patent and wants to place special phones in airports, "perhaps green ones, which would be marked like local phone calls," Steev says. As arriving travelers call relatives or hotels, they will hear ads between rings. The first phones could be in airports by January.

Bell Atlantic may also offer discounts to residential customers who consent to have the ads on their line. Advertisers polled said they'd pay up to \$3 a month to reach each customer.

—Mark Fischel



## CONTINUUM



A new discovery will help uniquely tuberclose

### NEUTRALIZING TUBERCULOSIS

A discovery by a Denver researcher will significantly change the way doctors fight tuberculosis.

Early research into tuberculosis used dyes to stain and kill the disease-causing bacteria and appeared to show that tuberculosis lived in an acidic environment inside macrophages, infection-fighting white blood cells. However, Alfred Crowley, professor of microbiology and immunology at the University of Colorado's Webb-Waring Lung Institute, found that the stain-and-kill process itself made the bacteria's environment appear acidic. Using high-resolution elec-

tron microscopy and a macrophage model developed in his laboratory to study the inner workings of still-living bacteria, he saw that tuberculosis' environment is actually neutral.

Crowley likes current tuberculosis drugs designed to work in an acidic environment, to an appliance fitted with upside-down wings. His team's discovery, he says, will enable the creation of a much-improved class of drugs, perhaps in as little as five years, to which the bacteria will be hard-pressed to develop a resistance.

Before anti-tuberculosis drugs came on the scene in the Forties, tuberculosis, also called consumption, was one of the leading causes of death. Now it's on the rise again. Each year brings some ten million new cases of tuberculosis worldwide, with 20,000 to 30,000 of them in the United States. Immigrants from Southeast Asia and Central America, where tuberculosis is prevalent, spread the disease around the world. "It's going to be worse than the spread of AIDS," Crowley says.

—Peggy Noonan

### BREEDING A BETTER BUFFALO

Most of India's dairy products come from buffalo milk. But farmers find buffalo expensive to raise because of their insatiable demands for fodder and their calf mortality rate, which has risen to 25 percent in some

parts of the country. To increase milk production, thereby making buffalo more profitable to raise, scientists at India's National Dairy Research Institute, with technical help from the United Nations Food and Agriculture Organization, have begun using a sophisticated genetic breed-

### AFTER MATING, THE FEMALE SCORPION STINGS HER PARTNER TO DEATH AND EATS HIM. YOUR BRAIN USES 10 TIMES MORE OXYGEN THAN THE REST OF YOUR BODY

ing method called multiple ovulation and embryo transfer (MOET).

Buffalo have been reared domestically in India for centuries, and the country boasts eighty million of them—half the world's buffalo population.

An Indian milk buffalo usually produces just one calf a year. "But she may shed as many as ten eggs," says Patrick Cunningham, the Food and Agriculture Organization's director of animal production and health. "The idea is to fertilize those eggs by artificial insemination."



The newer genetic breeding techniques will improve the milk production of India's buffalo, similar to these water buffalo.

hoping to get perhaps four viable embryos which can be transferred to surrogate animals."

The scientists take eggs from the females proven to be outstanding milk producers and sperm from the males whose daughters have performed well. "What the MOET scheme does is to amplify the reproduction of certain individuals by artificial insemination on the male side and embryo transfer on the female side," Cunningham says.

Buffalo bred in this manner will be returned to breed with local herds. The resulting general improvement in milk production should help to ease the financial plight of India's rural dairy farmers.

—George Nobile

*"The great pleasure of a dog is that you may make a fool of yourself with him and not only will he not scold you, but he will make a fool of himself too."*

—Samuel Butler



# LOCK THE DOOR

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poor Carrie White, drenched in blood, poised to wreak supernatural revenge against her tormentors? Or author Paul Sheldon's "number one fan," Annie Wilkes, crippling her beloved with a sledgehammer to keep him captive?

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## CONTINUUM

### BATTERED BALLS

Is your golf game a little over par? Relax—the fault may be not in your game but in your balls. Bruised golf balls can ruin a player's game, according to golf ball specialist John Mutch of the U.S. Golf Association (USGA).

"Most balls get beaten way out of shape" after as few as three holes, says University of Cincinnati applied-science graduate Gary Guisano, who has designed and built a programmable desktop inspection system that checks balls' shape for distortion. The machine automatically tests up to 200 balls an hour for compression, diameter, and roundness.

When Guisano recently checked out 75 used golf balls, only 80 met USGA standards, which call for balls to be spherical, have a diameter of no less than 1.68 inches, weigh 1.62 ounces or less, and have a compres-

### THE AVERAGE AMERICAN ADULT HAS 23 DECAYED OR FILLED TOOTH SURFACES

sion value of between 90 and 100 (the higher the compression, the harder the ball).

"One ball I tested looked like a boiled egg, just from being hit too much," says the twenty-four-year-old golf fanatic. "The others had defects that were not so easy to notice."—Scott Fierman

"It all could be a small universe that we could explore thoroughly and fully comprehend."

—Timothy Ferris

### MORE POWER TO THE JURY

Juries can ignore the law and get away with it.

In criminal cases, the U.S. legal system gives juries the power called jury nullifica-



Not to worry, wild halophytes like up sea water.

### POURING ON THE SALT

Delaying conventional horticultural wisdom, scientists at the University of Arizona in Tucson have used seawater pumped from wells in Puerto Penasco, Mexico, to grow a spiky, leafless plant called wild halophyte.

"I didn't even realize everybody felt there was no possible use for seawater to grow crops," says plant physiologist Jamie W. O'Leary. The seeds of the salt-tolerant halophyte, *Sarcocornia*, whose name in Greek means "salt plant," are rich in polyunsaturated fatty acids, used in food for both humans and chickens.

Each day, O'Leary and his team irrigated the test halophyte, a variety known as *Sarcocornia bigelovii*, with seawater pumped from wells in the nearby dunes. The crop yielded about two tons of seed per acre, equal to or slightly better than sunflower and soybean yields produced with freshwater and the same fertilizer.

Halophytes must be irrigated frequently to flush salt from the root systems, O'Leary says, but the process also carries away precious fertilizers. The scientists will thus experiment with clay soils that could reduce irrigation requirements.

—George Nabbie



The golfer's handicap: Most balls don't stand up too well to the whack of a golf club, losing their shape after just a few holes.

tion, to refuse to convict a defendant who they know is guilty of the charges. Moreover, no matter how biased the decision, the jurors cannot be penalized.

"Jurors have no idea how much power they have," says Don Dogg, co-founder of the Fully Informed Jury Association (FIJA) in Helena, Montana.

FIJA supports laws requiring judges to tell juries of their power. So far, fifteen state

legislatures are considering the issue.

"I'd be amazed if any legislatures give juries the right to use the power," notes Myra Reed, chairman of the Committee on Rules of Criminal Procedure and Evidence of the Chicago-based American Bar Association's Criminal Justice section. "You don't generally want the jury making its own laws, it implies anarchy."

—Bretel Lane Voss



## CONTINUUM

### ALL THE NEWS THAT'S FIT TO EAT

Environmental activists and celebrities who think they're environmental activists press the public to recycle newspapers. And so we do, in large numbers. Maybe the message should be changed to "Build more recycling plants," because the supply of old newspapers outstrips the nation's ability to reprocess it into usable paper products. Larry Berger, however, may have a solution: Feed the newspapers to cattle and sheep.

Newsprint doesn't contain much in the way of vitamins or minerals, but it does have plenty of cellulose, long chains of energy-rich glucose molecules. While ruminants, like cattle and sheep, can digest the cellulose found in most plants, they can't break down the more tightly bound cellulose fibers in newspaper.

Berger, a professor of animal nutrition at the

**FINGERNAILS GROW FOUR TIMES FASTER THAN TOENAILS—ABOUT TWO HUNDREDTHS OF AN INCH PER WEEK.**

**BY AGE 70, MOST PEOPLE HAVE SLEPT FOR 220,000 HOURS.**

University of Illinois, has developed a process that makes yesterday's news easier to stomach. He soaks the newspapers (using only those with soybean oil-based ink, known to be safe for human consumption), treats them with water and two percent hydrochloric acid, and then boils the mixture for up to two hours. The heat and acid break apart the cellulose fibers enough for bacteria inside ruminants' stomachs to finish the job.

In preliminary experiments, Berger replaced about 30 to 40 percent of sheep's regular alfalfa feed



An artificial star may benefit the Keck Observatory.

### NEW STAR ON THE HORIZON

"Twinkle, twinkle, little star" actually refers to a problem that's plagued astronomers for centuries: Wind and temperature changes in our atmosphere slightly alter the path of a beam of light traveling through the atmosphere. As a result, stars seem to twinkle, a charming phenomenon for most observers that translates into frustratingly blurred images for astronomers.

Researchers at Lawrence Livermore National Laboratory in California have begun a project, called Laser Guide Star that they hope will resolve this problem. Using a high-powered laser, they will excite a one-meter-wide spot of sodium atoms 100 kilometers above the earth, creating an artificial star.

By taking detailed measurements of the one-meter spot of light, the Laser Guide Star researchers can easily figure out how much its light "wiggles" as it passes through the atmosphere. This information will then be relayed to a telescope's computer-controlled mirror and consisting of hundreds of small, piston-driven mirror sections that can be programmed to rapidly correct the wiggling image. To keep up with the changing atmosphere, the researchers will have to update the adaptive optics system 1,000 times per second, according to project leader Glenn Max. The stars should be blurred no more, providing astronomers with a clear picture.

If all goes well, the technology will be applied to large telescopes in the eight- to ten-meter range such as Hawaii's Keck Observatory, allowing them to pick up objects 100 times more faint than they can see now.

"Finding planets around other stars is something which, if you had high optical resolution, you could do," Max says. "And with the Keck telescope, you could possibly see young galaxies forming."

—Joel Speth



Digesting the news: Sheep and cattle gobble up bawled newspapers thriving on the cellulose in the paper.

with the newsprint/food mix. The animals gobbled it up.

Americans now recycle about six million tons of newspapers, Berger says. About 30 million cattle live in

the United States. "If they were fed a diet of 20 percent newspapers, they could easily consume all the newspapers that are recycled today." —Billy Altshuler

## CLASS ACTS

In schools around the country, kids are getting excited about science and developing the skills they'll need to invent the future

ARTICLE BY  
GREGG KEIZER

Right now tomorrow's scientists are shooting hoops across the street, slalom-ing on a skateboard down the sidewalk, kicking a soccer ball against a wall, and getting ready for

PHOTOGRAPHS  
BY DAVID  
MICHAEL KENNEDY





a Friday night date. Technological and scientific excellence, as this year's events in the Middle East demonstrated, not only guarantee economic growth but also play midwife to America's spot as the only superpower. And the people who will research, invent, and build the next century are now only children.

Fortunately, science in the classroom is changing. Recombinant DNA labs are replacing Tinkertoy models of atoms in some classes. Air- and water-toxicity tests have supplanted litmus paper in others. And notebooks and textbooks are, in many places, augmented by computer networks and interactive video presentations.

"If you haven't seen us lately you haven't seen us," says Julianna Tekley, editor of *Science Teacher*, the National Science Teachers Association's publication for high-school teachers, and an assistant superintendent in New Baltimore, Michigan. "The newer things—the combination of video and computers, stimulation of dangerous and complex laboratories, artificial intelligence—are delivering different kinds of information to kids in the classroom."

Some schools rely on creative teaching methods that are decidedly low tech. Jeff Self puts local resources to work in teaching science to students of Washington Elementary School in Eureka, California. A nearby fish hatchery provides the inspiration, and Self guides his fourth- and fifth-graders through the process of spawning steelhead trout, raising 2,000 fish to three-inch size, then releasing them in the Mad River. A winner of the 1990 Presidential Award for Excellence in Science Teaching, Self has built an entire aquatic ecology curriculum around the experience. "Science is all around us," he says. "Everyone has a unique ecosystem around them that they can use to teach science."

According to Denise Slack, a fourth-grade teacher at Jenks East Elementary School in Tulsa, Oklahoma, "Children are naturally interested in science, but too many teachers devastate that interest by just doing exercises in the back of the book. Kids need hands-on science." Slack, another winner of the 1990 Presidential Award for Excellence in Science Teaching, stresses a global outlook to get children interested in the wonder of science. To study rain forests, her charges plaster a classroom wall with a homemade mock-up, then

raise \$50 to protect an acre of Belize's rain forest from the ax and saw.

Not every public school classroom, of course, sports an award-winning teacher, not every public school classroom even brings science up to speed or lights a burning desire for scientific inquiry in kids. But scattered across the country, from California to Colorado, through North Carolina's Piedmont region to Manhattan's Lower East Side, schools exist that excite kids and instill the skills they'll need to invent our future.

## REAL SCIENCE. REAL WORLD.

Smeck in the middle of California's Santa Clara Valley, Hacienda Elementary, a specialized science magnet school, packs in nearly 700 kids, from kindergarten to fifth grade. Designed to attract a variety of children from the city's numerous ethnic groups, Hacienda doesn't rely on high-tech equipment or networked computers. Instead it fires children's imagination with real-world science.

"They're doing relevant, hands-on science," says Hacienda principal Ken Kitajima. "Lecturing and blackboard work and a textbook are not science to these kids. The concepts that make connections to the real world are what's important. If they have no connection to the real world, they don't make sense and the kids aren't interested."

To grab their interest and then keep it, Hacienda depends on a faculty of select teachers, a fully equipped science lab, and extras that crowd the schedule with outside activities like field trips to science museums and schoolwide science assemblies every six weeks. At least once a week, each student spends time in the lab, which is staffed by two part-time science teachers and a lab assistant. Experiments too complex for the regular classrooms are conducted in the lab. An outdoor laboratory features a garden and a compressed re-creation of the valley's habitats, including a redwood grove and a small stream stocked with fish.

"Each class has a garden," says Carolyn Flannigan, one of Hacienda's science teachers. "They grow vegetables, then bring them in and the whole school makes soup—cooking is chemistry. We make everything an experiment. The kids tried to predict how adding gypsum to the soil would affect their crop. One plot was the control, one they added gypsum, and one they added sulfur. And the kids got it right."

"I try to connect whatever we're studying with something going on in the real world. When we heard of the oil spill in the Gulf, we connected it with fluid dynamics and pursued the oil/water difference." When the California drought struck home with water rationing, kids teamed up to play water department and



“Look past the silicon and see what thinking is taking place. The real computer revolution is going on in the classrooms where they are teaching the children to think.”

Previous page: Students at Tolbot Mountain Science Center, Hartford, Connecticut, gather at the observatory. Above: Students at San Jose, California's

Hacienda Elementary, a specialized science magnet school, conduct hands-on projects, including biological research in an outdoor laboratory.



using sand, gravel, and charcoal, compared to cleanse contaminated water.

Hacienda science students study acid rain in the area, monitor water pollution in San Francisco Bay, and watch the heavens with an eight-inch telescope. With the help of a specialist from the city, they examine their habitat's water, looking for bacteria and protozoans, and take a hardness reading to assess the water's mineral content. Last spring they were trying to figure out why the habitat's insect population is nearly extinct.

"These kids live in an exciting time," Rannagan says. "You've got to grab their interest and get them excited about science so they can see it's exciting, too."



#### ON THE SHOULDERS OF GIANTS

Few schools are able to say that their campus once harbored missiles. Talcott Mountain Science Center, perched upon a ridge overlooking Harford, Connecticut sits on a former Nike anti-aircraft missile site.

"From the sword to the pen," says Donald La Salle, Talcott's director. "Where once stood instruments of destruction now only stand instruments of discovery."

Founded in 1967 as a private, nonprofit science center, Talcott attracts thousands of students from the region to its daylong and weekend sessions to supplement their regular science curriculum, while sixty exceptional students study full-time at a small on-site academy. And if the kids can't come to the Mountain, the Mountain goes to the kids, courtesy of a satellite network that reaches tens of thousands of children across the country.

"We put a lot of emphasis on using technology," says La Salle. "We espouse the philosophy that you need to use the technology that you're reaching about." That's why Talcott houses more than 20 telescopes, dozens of microcomputers, an alternative energy laboratory, and a Doppler weather radar.

The sophisticated Doppler radar plays an integral role in Talcott's Student Weather Network—a video-, computer-, and telecommunications-driven collection of more than 100 schools from Maine to Pennsylvania. Kids in each school take weather measurements and log their findings with Accu-Weather, the service that hundreds of radio and television stations rely on for their weather information. Using Accu-Weather's database and the data they've

gleaned themselves, the students make local weather forecasts. Some even advise school officials when weather threatens to close classes. And ten times a year, Dan Barszow, Talcott's assistant director, plays cohost to a live television broadcast beamed to the schools. Along with meteorologist Bill Danulson, he fields weather questions and helps the kids become Lifesaver Willard Scotts. "The children are doing science, not just reading about it," Barszow says. "They used to learn about meteorology by reading about it in a text. Now they're getting hourly weather updates in their classroom."

Even more impressive, Talcott touches children from coast to coast with an interactive science satellite network. Called "On the Shoulders of Giants," the one-way video and two-way audio program lets kids ask questions of the pioneering and practicing scientists whom Talcott brings to the Mountain. Speaking to students about everything from the search for extraterrestrial life to nanotechnology, video guests have included space colony proponent Gerard O'Neill, Robert Moog, who created the electronic synthesizer, and Seymour Papert, who invented the children's computer programming language Logo.

"We just try to make our kids science and technology literate," La Salle explains. "They can't be part of the future without understanding technology."

#### HIGH-TECH HIGH

If Talcott is a glimpse of the future of science education, Thomas Jefferson High School for Science and Technology may well be the future. Southwest of Washington, D.C., in Fairfax County, Virginia, Thomas Jefferson is one of only two schools to place more than a single finalist in 1991's Westinghouse Science Talent Search. Though Larry Gaudreault, chairman of Thomas Jefferson's science department, likes to stress that the school's success results from the mix of a superior staff and outstanding students, the facilities certainly don't hurt.

Thomas Jefferson boasts eleven technology labs, letting kids specialize in such areas as biotechnology, optics, robotics, and microelectronics. But sitting in the computer lab, looking much like a bulky freezer, is something that really sets Thomas Jefferson apart from the average American high school—a supercomputer.

Thomas Jefferson's ETA 10p supercomputer calculates at 375 MIPS (millions of instructions per second), more than 100 times faster than today's most powerful desktop workstations. Like the Cray supercomputers on which working scientists light for access time, it can put its brute force and speed to work in solving complex calculations and modeling complicated artificial worlds. It's even

CONTINUED ON PAGE 88

**“ Don't sell science short. It's absolutely vital that we have the best programs possible. After all, these are the people who are going to lead the country, perhaps the world. ”**

Hacienda Elementary's outdoor lab includes a garden and model ecosystem based on the Santa Clara Valley, with a redwood grove and a stream

stocked with fish. In one set of experiments, the children hypothesized how adding gypsum to the soil would affect their crops—and tested the results.



“ At its best, Star Trek appears to function as pop allegory/pop metaphor, taking current events and issues—ecology, war, and racism—and objectifying them for us to contemplate in a science-fiction setting. The world it presents may make us see as either science or fiction, but it is truly sufficient for laying out human questions. ”

When I am asked about Star Trek, it always puts me in mind of Arthur Conan Doyle and Sherlock Holmes. Doyle has been called willfully obtuse where the appeal of his creation was concerned. His strained relationship with the great detective certainly sounds a familiar chord when I try to sort out my feelings for Star Trek.

"Holmes takes my mind from better things," Doyle remarked, referring to the undervalued historical novels he also wrote. He might have added, "I can do it, but I don't get it."

I know the feeling. My exposure to Star Trek over the years has frustrated me as before an impenetrable mystery. I have been by turns amused, chafed, and confounded in the face of it.

I am not now nor have I ever been a Trekkie or, as Star Trek fans call themselves, a Trekker. I never watched the show during its network run (1968 to 1969) or its syndi-



cation airings although friends of mine were zealously addicted to it. In the Star Trek, a Ph.D. candidate of my acquaintance dropped out and watched the show for fifty consecutive days, at the end of which time he wrote left me. Star Trek's world of the future does fascinate me, however. I cannot retroactively fit it from my present reality or from human history with which I am beset, rather it is in any way congruent with my own fantasy life. My idea of an alien is the thing that popped out of John Hurt's chest in the film Alien.

At its absolute worst, Star Trek is a piñata, rather a golf course, Republican version of the future, where white men and American values always predominate (despite blatant tokenism) and gunboat diplomacy carries the day.

And yet, having watched innumerable episodes of both the original series and Star Trek: The Next Generation, having written for three of the feature films (II, III, and VI), and directed two of them (II and VI), I must admit to greater perplexity than ever. There is some-



thing compelling about the material. Star Trek triumphs over costume and logic. It attracts, enraptures, and irritates. It affects. It can grab hold and not let go. After all, 50 million Frenchmen cannot be mistaken.

Why? There are as many theories as theorists, all going to postulate their reasons for the story's appeal. Captain James T. Kirk's similarity to that other intrepid mariner, Captain Hornblower, is doubtless the tip of the iceberg. Is it more coincidence that they both sport Latin names—Horatio and Tiberius?

At its best, Star Trek appears to function as pop allegory/pop metaphor, taking current events and issues—ecology, war, and racism, for example—and objectifying

them for us to contemplate in a science-fiction setting. The world it presents may make no sense as either science or fiction, but it is well and truly sufficient for laying out human questions. Removed from our immediate neighborhood, it is refreshing and even intriguing to consider Earth matters from the distance of a few light-years.

Like the best science-fiction, Star Trek does not show us other worlds so meaningfully as it shows us our own—for better or for worse, its sickness and its health. In truth, Star Trek doesn't even pretend to

show us other worlds, only humanity refracted in what is supposed to be a high-tech mirage.

It is also true that after twenty-five years, Star Trek is no longer the unilateral creation of any one man, or even any one group. As time has added various collaborators, Star Trek has evolved into a sort of secular parallel to the Catholic Mass. The words of the Mass remain constant, but, heaven knows, the ritual keeps changing. Verid's Requiem bears little resemblance to the one by Fauré, which, in turn, sounds nothing like the one by Mozart.



## STAR TREK:

By Nicholas Meyer

As he guides the latest Star Trek film into theaters, the director and screenwriter muses on Kirk and company's astonishing appeal



## THE DIRECTOR'S CHAIR

James T. Kirk and his intrepid crew set sail for what they promise will be their final adventure in Star Trek VI: The Undiscovered Country, one of the most eagerly awaited movies of the season. Despite the title, familiar faces pop

up in the film, including Spock's father, Sarek, played by Mark Leonard (bottom left). And there will be new characters as well: Kim Cattrall

(above right, with DeForest Kelley and William Shatner) appears as Lieutenant Valeris, a Vulcan Starfleet officer, and a Klingon leader, Brigadier Kerla, is played by Paul Rossini (far left).

“My own Star Trek films clearly owe a debt to Horatio Hornblower and my love of ships. ‘Nautical but nice,’ as my wife puts it. Many kinds of wine can be poured into the Star Trek bottle—which may help to explain its longevity—but its humanism remains a buoyant constant. Religion without theology. The program’s karma routinely runs over its dogma.”



Similarly, different writers and directors have put their stamp on the Star Trek saga, setting it to differing visual music. You can’t change the characters or the shape of the starship Enterprise, but you can fool around with the costumes, the intones, the dialogue.

The stories reflect the differences in taste and style. Some are more “realistic” than others, some more futuristic, some more pessimistic. Some have more romance, others more friction. My own Star Trek films clearly owe a debt to Horatio Hornblower and my love of ships: “Nautical but nice,” as my wife puts it. Many kinds of wine can be poured into the Star Trek bottle—which may help to explain the show’s longevity—but its humanism remains a buoyant constant. Religion without theology. The program’s karma routinely runs over its dogma.

In addition, the characters have become beloved icons—McCoy, Moser, and Dorned Duck for grownups, literature for a post-literate age. Dearthless Captain Kirk, cool and logical Mr. Spock, bluff and

glibless Scotty, common-sense Dr. McCoy. They are pleasant and familiar archetypes of what we too perceive in ourselves or observe in others. Not profound, certainly. Lacking in detail, surely. But vivid. Unforgettable.

Of course, no personal response to Star Trek on my part would be complete without mention of the actors who



embodied these raw mythic roles. What the crew of the Enterprise possesses in abundance is that almost unattainable quality known as charm. Just as it is impossible to watch the series and not be seduced by the characters, so it is equally impossible to work with William Shatner, Leonard Nimoy, DeForest Kelley, George Takei,



Nichelle Nichols, Walter Koenig, and James Doohan and not succumb in passion to the aggressive, naive, and not without, far from certain, their infinite variety. Now, when I see them on television I feel as though I am watching parts of my extended family. For so they have become. Arthur Conan Doyle, I assume, was less fortunate. Per-

#### STAR TREK: THE SCIENCE CLASSROOM

A starship without engines!

A wild new Genie article? No, it's an idea used in an episode of Star Trek: The Next Generation. In a show called "New Ground," by Ronald C. Moore, says Naren Sharikar, a Star Trek: The Next Generation science consultant, "we came up with the idea of a race pushing its spacecraft through space utilizing beamed soliton waves."

Nanotechnology? Genetic engineering? Tachyonic tracking? Star Trek territory now. Along with artist-designers Mike Okuda and Rick Bombach, Sharikar

helps make the series a gold mine of not only jargon but also scientific concepts. To be in Star Trek: The Next Generation makes people feel as good as the original Star Trek did when I was twelve, Okuda says. Maybe Star Trek: The Next Generation is even now making youngsters who will "go where no one has gone before" because Kirk and Spock—and Picard and Data—traveled there first—David Berchoff (David Berchoff's latest book is Revolution: The UFO Conspiracy, published by Warner)



haps if he had fallen in love with that famous Holmes interpreter of his day, William Gillette, he might have been less dumb about Sherlock. With Star Trek it is always the actors who bridge the final gap between my head and my heart. They better damn my national resistance to Star Trek creator Gene Roddenberry's world with their

very selves.

Unlike Doyle, I have given up the fight. After twenty-five years I have surrendered to Star Trek's mysterious attractions. In doing so, I acknowledge that there's more things in heaven and earth than can be satisfactorily explained. Human nature with its penitence conundrums is one. Star Trek is surely another. **DD**

Movie makeup and special effects have advanced light-years beyond the inexpensive, simple tricks used on the TV show in the Sixties, making Star Trek VI's cast of aliens more realistic looking than ever.

The movie will introduce audiences to fascinating new alien races to join the usual Vulcans, Klingons, and Romulans.

Both well-known actors and relative newcomers will play vital parts in Star Trek VI: Medical-actress Inman (above, second from left) portrays Maria, a mysterious, character actor Kurt-

wood Smith (above, third from left) puts in an appearance as the president of the Federation. Veteran actor Christopher Plummer (bottom right) is the venerable

Klingon warrior General Chang. And the whole Enterprise crew will be on hand for this ultimate adventure, headed up by DeForest Kelley as Dr. Leonard "Bones" McCoy and William Shatner as James T. Kirk (above right), pictured at a Klingon trial.





# BOLDLY GOING NOWHERE?

World hunger, global warming, energy depletion—affair cheese when measured against the looming dangers of a Klingon civil war and whether dilute crystals will really decrease talkies when exposed to Saelgrasium. But nobody said it would be easy to muse on *Star Trek*'s impact on society during the last twenty-five years. That's why Orm asked me, a former *Star Trek* executive consultant, to do it.

*Star Trek*'s creator and executive producer, Gene Roddenberry, has joined the august group of men with an agenda. Beware of men concerned with their place in history. With politicians this obsession usually ends up costing you in either money or blood. In the case of *Star Trek: The Next Generation*, it ends up wasting your time.

In 1966, when *Star Trek* first beamed into millions of homes, Roddenberry's agenda was getting a TV show on the air so he could make some money—a sensible and laudable goal. Although the show limped through two seasons receiving only marginal ratings, it delighted those of us who read science fiction and were starved for a visual presentation of our favorite genre.

Looking back from the perspective of twenty-five years, I realize that the original recipe was pretty good: science fiction. Not always, of course. *Classic Trek* had its share of gobblers—"Spock's Brain," "The Omega Glory." Even so, there were scripts by Robert Bloch, Harlan Ellison, Theodore Sturgeon, David Gerrold, Dorothy Fontana—people who understood that science fiction isn't about gaspies and technological gimmicks but about the affect the technological gimmicks have on people. Do back and look at "Charley X," "City on the Edge of Forever," "Encounters at Mercury."

Yes, the special effects were laughable, the sets cheesy, and you had William Shatner chewing scenery. But I'll take James T. Kirk kissing the girl, punching the bad guy, and violating the Prime Directive about twice a show over the bloodless automata who now crowd the *Enterprise*.

The old show was passionate. These were flawed individuals, people with whom we could identify be-



**By Melinda Snodgrass**

**TV's current *Star Trek* features Whoopi Goldberg (above) as her-keep Guinan and Michael Dorn as security officer Wolf.**

cause we possess the same feelings. How they met and defeated their personal demons was more gripping than the godlike-alien-of-the-week we get on *Star Trek: The Next Generation*. The dramatic problem with godlike aliens is that it takes a godlike alien to catch a godlike alien.

But all things pass, including *Classic Trek*. It faded away to that limbo where old television shows go to die, until it rose from the dead in the form of *Star Trek* conventions.

And the conventions begat movies, and the movies begat the new series *Aman*. The dreadful effect of all the hype was that Roddenberry decided he could no longer just do a television show so he could make some money. Now he had to speak to the ages because this was serious shit, this was philosophy.

In the new improved twenty-third century there is no war, no money, no crime (if you should even get a

naughty notion they'll come and *steak your mind right*—frightening prospect). And there are apparently no emotions. All of which combines to create a stultifying forty-seven minute in front of your television. The essence of drama is conflict, and there's none to be found in the new *Star Trek*. But that's dramatic criticism and it doesn't address the question of whether *Star Trek*, old or new, has fundamentally affected society.

Without question *Star Trek*'s impact is incredibly diffuse. Probably half the world's population would recognize the familiar "Beam me up, Scotty." But that's chrome. Essentially, *Star Trek* hasn't affected the ethics, morality, or philosophy of ours or any other society.

*Star Trek* has always been a reflector of the country's attitudes rather than a shaper of those attitudes. In the Sixties, we had the gung ho New Frontier democracy of racism. (Consider "The Apple.") Let's blow up the paper-mâché tyrannosaurus with the horn on its head so the people who worshipped it can experience hunger and death. (Love this plan, Jim.)

It was swashbuckling, far better entertainment than *Star Trek: The Next Generation*, which reflects the stodgy, self-righteous Reagan-Bush New World Order. *Star Trek: The Next Generation* is kinder and gentler, probably more paternalistic, but basically just as coercive as

the New Frontier activism of *Classic Trek*.

Is it important? Does it matter? No.

As I said while on *Star Trek: The Next Generation*, "We ain't eradicated world hunger here. It's just a TV show." **DD**



"Space, even orbital space, is the common heritage of humankind. So why shouldn't humankind cooperate in exploring it?" asks the former czar of Soviet space science who now shuttles between Moscow and Maryland

## INTERVIEW

# ROALD SAGDEEV

In 1988, when the Soviet Union was still a unified Communist state and not a collection of cacophonous democracies in the making, Roald Sagdeev made headlines just by raising his hand. Sagdeev was a member of the Supreme Soviet's Council of the Union, and that august body was voting on legislation designed to squish political rallies. Throughout Soviet history, all party-sponsored bills had hitherto been voted into law unanimously. Sagdeev's solitary *nyet* was a shocking breach of protocol in the upper reaches of the Soviet political apparatus. In the context of Sagdeev's 15-year career as

the maverick czar of Soviet space science, however, it was a perfectly logical action. He weighed the evidence: it didn't add up.

Roald Zemturovich Sagdeev is a world-renowned plasma physicist, an orchestrator of stunningly ambitious spaceflights, a charismatic promoter of cross-border scientific ventures, and a late-blooming politician who can out-pleasurize any out-penselista Boris Yeltsin himself. Today Sagdeev shuttles frequently between Moscow and College Park, Maryland, where he is the University of Maryland's newest Distinguished Professor of Physics.

PHOTOGRAPHS BY DAN WINTERS



Sagdeev's ascent through the anomalous Soviet scientific bureaucracy was meteoric by Russian standards. At thirty-five, he was elected to the prestigious USSR Academy of Sciences—a pantheon of barely 100 scientists, mostly elderly, some sterile, who controlled the vast state-run institutes. At forty-one, Sagdeev took over one of them, the then-underfunded Space Research Institute, or IKI ("leaky"). By 1988, when he voluntarily stepped down as IKI's director, he had turned the Soviet unmanned space program into an exemplar of daring, technically sophisticated space science.

And he did it openly. "Sagdeev," says Louis Friedman, executive director of the Planetary Society in Pasadena, California, who has observed Sagdeev at close hand in Moscow, "began a radical change within Soviet science. Before, you couldn't get a Soviet to tell you when a spacecraft would fly, even if it was already up." His status as Gorbachev's personal space policy adviser enabled him to fend off challenges from party reactionaries and openly voice some scathing opinions on his motherland's shortcomings. He publicly condemned party-dominated science as "stultifying." When the academy snubbed Sagdeev's friend and fellow physicist, the late Andrei Sakharov, he compared its electoral manipulations to those of the kingdom of Saudi Arabia.

In the flesh, Sagdeev is no fire-breathing futurist. He is more apt to make denunciations with a shrug or a joke, as Doug Stewart found when twice interviewing him in Maryland. Asked about the advanced age of so many of his fellow academicians, Sagdeev wryly attributed their persistent good health to "natural selection." A compact man with a slight slouch, Sagdeev wears fashionably baggy double-breasted suits and sporty blazers but cannot resist cramming the front pockets with pens and keeping his neckties loose. His fluent English is heavily accented. More is "Mass" (but the accent is

diminishing under the tutelage of Susan Eisenhower, whom he met at a conference in New York in 1987 and married in Moscow in 1990. The marriage makes Sagdeev the only Hero of Socialist Labor and recipient of the Order of Lenin to become the grandson-in-law of an American president.

**Orni:** How did Soviet scientists respond to the attempted coup?

**Sagdeev:** The scientific community was

raised morale tremendously among working scientists.

A small minority, the academic elite and those with administrative posts, unfortunately did not display much civil courage. Many were prepared to go along with the coup. The scientific elite is often older scientists who no longer actively engage in their own intellectual adventure but rather supervise others and set policies. Knowing that reform will cost them their special privileges, they view themselves as endangered by these changes.

The failure of the coup has triggered very serious conflict now within the Academy of Sciences. The academy, which formerly controlled all scientific work, has always been largely a product of Communist party influence. It was no secret that the country's ruling institutions have traditionally handicapped many of the academy's members, and these are the people who are unhappy with democratic reforms. Next to our union of war veterans, the Academy of Sciences has probably been the most conservative—even the most reactionary—organization in the country. After the tremendous upheaval of recent months, the academy may not survive in its old form. It just might collapse along with the Communist party.

**Orni:** Is it true the average age of academicians is seventy?

**Sagdeev:** For full members it may now be even older. Membership in the academy is a kind of lifetime sentence. You have to commit an unbelievable crime to be kicked out. Age does not

necessarily predetermine outlook, but some corrosion exists. Flexibility and freshness can be lost with age. More important, the older scientists come of age under Stalin. For many, the new political winds are quite alien.

**Orni:** You've demanded directors of each of your country's huge research institutes resign after ten years. Why?

**Sagdeev:** True scientists become bored doing administrative work year after year and they'd welcome a policy

**NAME:**  
Hasko Sagdeev

**AGE:**  
Fifty-eight

**CURRENT JOB:**  
Professor of physics, University of Maryland

**LAST JOB:**  
Head of USSR's space science program

**GREATEST ACHIEVEMENT:**  
Vega's rendezvous with Halley's Comet

**NOT LIKE TO SEE:**  
Star wars; revival of Communist Party

**LIKE TO SEE:**  
True democracy, U.S.-Soviet space collaborations, hot fusion, robots on Mars

strongly divided. The vast majority of working scientists supported democracy and Yeltsin and restoration of constitutional order. Laboratory scientists almost unanimously support democratic reform because a totalitarian, one-party mentality with central control of every day life is incompatible with the spirit of scientific exploration. Science without the intellectual freedom to debate conflicting points of view is unimaginable. The failure of the coup d'état

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THIRTY DAY RETURN GUARANTEE

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of rotation. Scientists who come to enjoy being the big boss can be quite dangerous, so it's even more important to demand their resignations. Someone who occupies the same office for many years risks losing touch with genuine science. Academician Vinogradov, a world-class mathematician, was director of our most elite institute, the Steklov Mathematical Institute, until he died in his nineties. Toward the end of his reign, morale inside his institute was known to be intolerable. Mathematicians were treated according to their ethnic origin. It became a stronghold of anti-Semitism. Omer: Did political orthodoxy lead to scientific orthodoxy?

**Sagdeev:** I think so. Until quite recently, political orthodoxy controlled the ideological life of the country. Through the academy, the political leadership was often able to manipulate the country's scientific institutions. Under Stalin and later Khrushchov, Trofim Lysenko, the evil genius of Soviet biology [as director of the Institute of Genetics from 1940 to 1965], essentially killed Soviet molecular biology in its infancy. He attacked those who studied genes and heredity and accused them of promoting anti-Marxist, bourgeois science. He created his own perversion of biology according to which you could completely change an organism's heredity by altering its environment. Yet Stalin and then Khrushchov supported him. During that time, you could find such phenomena in almost every field of science, but they were particularly pronounced in biology.

On my own, I have been trying to assess the history of Soviet science. Our scientific community has had to survive so many cataclysmic periods. Science was not terribly strong in czarist Russia to start with, but there were islands of brilliance with people like Dmitri Mendeleev, who developed the periodic table, and the physicist Pyotr Lebedev, who first measured the pressure of light. This rather thin layer of scientific achievement was endangered by the revolution and civil war that followed. Many bright scientists and engineers emigrated, some of them to America.

Then with the Communist party's domination and Stalin's terror in 1937, many of our best brains were lost in the Gulag. After World War II, scientists were often attacked for ideological reasons—ideological pogroms, we call them. They would be accused of being "cosmopolitan." During the stagnation [under Brezhnev], a new code of behavior emerged. Scientists, especially those in the elite, would routinely appeal to the government to settle even ordinary scientific disagreements.

Now imagine, after these seventy-five years of cataclysm, the Soviet Union still has bright scientists! It is an important part of the world's scientific family. I've had a chance to witness and, to some extent, participate in this drama. I knew many of the protagonists and heroes of postwar Soviet science. The question—how has Soviet science been able to survive?—is the subject of the memoirs I'm writing.

**Omer:** With the rout of the hard liners, will reforms now succeed?

**Sagdeev:** In the mid-Eighties Gorbachev could not have imagined in his wildest dreams that he himself would suggest the dismantling of the Communist party. Today the new perestroika means simply joining the international family of free democratic nations. This is the only possible direction for us now. We are educating ourselves in the process of democratic reforms. Do you

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“Do you know my definition of the difference between a moderate and a radical in the Soviet Union? Six months.”

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know my definition of the difference today between a moderate and a radical in the Soviet Union? Six months.

**Omer:** In 1988 you were the first member of the Chamber of the Union ever to vote “no” on a party-sponsored bill. Why did no one join you?

**Sagdeev:** The bill put severe restrictions on public meetings and demonstrations. I had transformed earlier about this with my friends, including Andrei Sakharov, and was against it. Before the vote I'd spoken to quite a few delegates. They were supportive, but a virus of fear still held sway. Fifteen minutes later a companion bill, to establish a special group of paratroopers to enforce the first law, was introduced. Again I voted “no,” but this time, like other people in the chamber joined me. These five were good experimentalists. They observed that fifteen minutes after the first vote I was still there—no one had taken me away—and so they joined me. This is essentially the algorithm for how the Soviet people became so courageous and finally went to the

barrioade. It was done step by step. Omer: That same year you took your own advice and stepped down as director of IKI, the Space Research Institute. What was it like being a working scientist again?

**Sagdeev:** It's not easy. You wake up in the morning and realize you don't have to go to your office as director; you don't need to attend the VIP meeting with the minister or that boss. Instead you must now sit at your desk and try to revive all your working instincts. Scientists who spend years in administrative jobs stop generating ideas; they generate comments and instructions. To be a working scientist you have to be highly creative in your thinking, inventing, assessing. You have to allow your brain to be a slightly loose cannon. We have an expression in Russia: to be a white crow. It means to be considered by the rest of the community as a bit feisty or crazy. As director of IKI, I was considered a white crow by my colleagues.

**Omer:** Is that like a black sheep?

**Sagdeev:** There is a huge population of black sheep, but it's very difficult to find a white crow.

**Omer:** After taking over IKI in 1973, you pulled space scientists out of the labs and had them help build devices they wanted to launch. Why?

**Sagdeev:** We wanted them to be more responsible for designing, testing and calibrating the instruments that would carry out their experiments. Before I came to IKI, scientists would often get the institute's money, find a contractor to build an instrument, then simply wait until it was built. Our most successful projects were the result of intimate cooperation between scientists and engineers. Toward the end of my career at IKI, I worked a lot on instrumental design.

**Omer:** Don't you hold a number of patents for these designs?

**Sagdeev:** Yes, and I'm quite proud of some. One is on a system to point a spacecraft's telescope that we used for the Vega spacecraft's mission to the nucleus of Halley's Comet in 1986. The nucleus is a tiny body in a comet's huge and bright coma [the luminous cloud of gas and dust defining a comet's shape]. Vega was to pass through this coma for only a couple of minutes, but communication with Earth would take fifteen to twenty minutes. So we designed an onboard computer that decided which part of the coma was the nucleus and guided the spacecraft's telescope during the rendezvous.

But no matter how smart the instrumentation, every mission is still in the hands of the contractor responsible for

launching and controlling your spacecraft. An example is the failure of the spacecraft in 1989 a few days prior to its encounter with the Martian moon. I and my colleague Georgi Managadze designed a rather exotic mass spectrometer to measure the chemical composition of soil on Phobos. As the spacecraft drifted slowly above Phobos's surface, it would fire a powerful laser that would focus on a small piece of soil below and analyze it. The spacecraft's spectrometer would capture some ions escaping from the microexplosion. A similar technique is often used in labs but within a vacuum chamber. You cannot collect ions within an atmosphere. In our case we had to do all this with the spacecraft about one hundred meters above Phobos's surface.

**Qms:** And millions of miles from Earth. **Sagdeev:** Yes, it was one of the most technically sophisticated instruments aboard. When we lost the spacecraft a few days prior to the encounter with Phobos, I think it was the most disappointing moment in my career.

**Qms:** What went wrong? **Sagdeev:** We had also planned to do some Mars science, so when the spacecraft had almost reached the same orbit as Phobos, it turned to look at Mars. At that point, ground control in-

ternationally turned off its telecommunication dish because the spacecraft and dish were now pointed toward Mars—not toward Earth. Two hours later an onboard computer was used to re-orient the spacecraft's original orientation. We'd repeated this procedure dozens of times before, but at the appointed time, no signal came from the spacecraft. Its orientation was apparently wrong. Most likely the onboard computer had failed. I quickly tried to organize a group to investigate what had gone wrong.

**Qms:** To rescue the mission? **Sagdeev:** No, the spacecraft was already frozen. It was the temperature of space. I wanted the group to include scientists and engineers from our space industry and from the fourteen countries whose instruments were part of the mission. Our space industry must be accountable not only to its Soviet but also to its foreign scientific customers. Our space industry officials promised to sit down and find out what happened. But then I was in the process of stepping down as head of IKI. The officials used the opportunity to break their promise. They never invited either foreign or Soviet scientists to participate in their investigation.

They were trying to help their indus-

trial contractors save face. In fact, the chief contractor for the orbiter computer was never called in as part of the official investigation. Instead he was appointed to an important government post, chairman of the Supreme Soviet's Committee for Defense! There was only one possible explanation: The military-industrial complex badly needed to fill that post with someone they could control. It didn't matter that the guy himself couldn't control his own equipment.

**Qms:** Many of your dramatic successes at IKI—which put NASA to shame—were advanced in part by your recruiting of foreign scientists as collaborators. Wasn't that controversial at home?

**Sagdeev:** One reason we succeeded was that it was so unexpected. No one was ready to put up resistance. But soon battles began within the space bureaucracy that follow the old saying: No good deed goes unpunished. Some of the reactionaries used the media to attack IKI's policy of inviting in foreign collaborators. They said these collaborators deprive Soviet scientists of their right to participate. I often have been accused by name in these attacks. And then others in the West criticize me for bringing Western technology into the Soviet Union, thereby undermining the West's monopoly. So [sighing] I can't win. **Qms:** In the U.S. the relative value of manned versus unmanned spaceflight is hotly debated. Where do you stand? **Sagdeev:** I confess, as director of IKI, I was an uncompromising extremist against manned missions in favor of sophisticated robotic missions. In my view, both the Soviet and American space programs had from the beginning fallen hostage to manned spaceflight. Manned programs on both sides still get more support in budgetary terms. Now that I'm free of these heated debates and emotions, I think the wiser course is to find a proper balance between the two.

We need to encourage the common man to overcome the psychological barrier and appreciate unmanned space missions. The romance of space exploration does not come only from sending living creatures into space. Think of Vega or especially Voyager sending signals from deep space. If we're smart enough, we can design space robots to which we can delegate everything.

**Qms:** Domestically, the Soviet space program is under attack. Ross Yelkin and others have urged that space spending be curbed in favor of consumer goods production. **Sagdeev:** Suggestions like that reflect the very understandable feelings of the taxpayers. From the start, our leaders used our space achievements as a



## How to get this close without getting rattled.

tool for political indoctrination. Our space achievements were said to be proof of the superiority of socialism. During the Brezhnev era there was a slogan: For Soviet spacecraft, the launching site is socialism! Now, people reject even what succeeded in that epoch, such as the space program. The scientific community needs to respond by carefully explaining why we need space—not to prove political myths about socialism, but as an important part of modern civilization.

**Ozern:** Does the disintegration of the Soviet Union herald the end of big science in your country?

**Sagdeev:** I think it's the end of science used as window dressing, as a propaganda play. I hope it will be the beginning of genuine science.

**Ozern:** But what will become of the glorious Soviet space program?

**Sagdeev:** The Soviet space program is no longer looking for glory. It's looking for survival. Those republics interested in high technology in space—Russia, the Ukraine, perhaps Kazakhstan—might form something like the European Space Agency. It will be a very long time before any republic joins the ESA directly. It would require hard currency, for one thing. Even the East European countries, which are ahead of the Soviet Union in moving toward Europeanization, are far from becoming full members of the ESA.

**Ozern:** What's the status of Buran, the Soviet space shuttle?

**Sagdeev:** Buran was launched once, unmanned. Being a costly enterprise, the project is likely to be abandoned altogether, maybe rather soon. From the start, it had no well-defined mission. The original promise that it would be a cheap launcher compared to expendable rockets was never fulfilled. Its supporters thought: "The Americans did this, so it's important for us to do it." All the criticism of the American shuttle one hears is applicable to Buran.

**Ozern:** Energia, the giant raw Soviet rocket, has flown only twice. Is it endangered, too?

**Sagdeev:** If you can find customers who want to use it, you'll be most welcome. Energia can deliver to Earth or orbit a payload of more than one hundred tons, three times the weight of our Air space station. In the current economic crisis, our country probably can't afford a project big enough to utilize this launch capacity.

Right now Soviet space industries have the know-how to build the best launch vehicles in the world, and the cheapest. Even with a quick renaissance of launch technology in the West, its rockets for many years will be

continued on page 100



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**THEIR LAWYERS OVER THEM?" DAVE GLANCED AT BEDFORD, UNABLE TO MAKE OUT HIS FEATURES IN THE DARKNESS. A BLANK SILHOUETTE AGAINST THE PASSING OUTSIDE LIGHTS AND NO MORE. "IT'S THE BRITISH SYSTEM," HE SAID. "SOLICITORS AND BARRISTERS. ONE PREPARES THE CASE, THE OTHER**

argues it. I forget which is which. . . ."

"That's okay," Bedford said. "Long as I see justice." The words were followed by a short laugh.

Dave made no reply. Bedford had been saying that continually over the past weeks, as if the words were a kind of mantra. He usually made a joke of it, as he did most things, but Dave had stopped laughing. There was no such thing as justice where Arthur Bedford was headed.

It was well past midnight—closer to one, in fact; they'd started late. He looked out the rear window of the tall car, twenty feet behind. Four men in that one, the same in

the car ahead, and two in this one aside from Dave himself. All armed. Dave with his service revolver, the rest with MP-5s or Ingram. These were people who thought Bedford didn't need a trial.

They were taking the back roads to the report issued of the main highway. Another convoy drove that route, a decoy with a lot more cars, shepherded by Miata and helicopters. A bit obvious, Dave thought; it wouldn't fool many, but everything helped. He looked down at his watch. Another fifteen minutes and they'd be airborne and he could relax.

Words blurred by static sounded from

# W

**HAT DO THEY CALL**

the radio. In the front seat Wolfe lifted the headset and held it to one ear. He mumbled into the mike and tossed it on the dash. "Godsdamn!" he said. He turned to face Dave. "There's a not breathing at the airport. Word leaked out somehow. At least fifteen hundred marines in front of the terminal."

Dave felt Bedford stiffen. "Who is it?" he said.

"Everybody," Wolfe replied. "Black Justice Coalition, CORE, Remembrance, the Klan, that nut cult claims Satan made 'em do it, the goddamn Nazis, for Christ's sake. All about to go for each other's throats." He shook his head in disgust. "How they





found out, I don't know."

"Could have been anybody," Dave said. "There's always some jackass who's got to tell his old lady. Never fails." He turned to Bedford. "Don't worry about it," he said quietly. "A company of federal troops are there, it'll be okay." There was no reply so he turned back to Wolfe. "Any changes in the route?"

"Yeah," Wolfe said. "They're taking out a piece of runway fence half mile north of the terminal." He looked over at the driver. "They'll drop it as soon as we show, Al." The driver nodded wordlessly.

They drove on in silence for a few minutes, then Dave heard Bedford sigh. He looked over inquiringly, forgetting that he was invisible himself. Bedford spoke nonetheless. "I don't know why they can't hold the trial in the U.S.," he said. "Instead of

flying all the way over there. You'd think they'd want to save their money."

"Symbolism," Dave said. "Lots there feel they've got some control over the process. After all, they're the ones who suffered." He paused before going on. "Doesn't sound like much, but it means a lot to them."

"Well," Bedford said, louder now, "As long as I get my day in court." Another tattered laugh.

Dave stared at the black patch that was Bedford and sank lower in the seat. There was no question that Bedford had been in touch with the Porter Group. He was a geneticist, his specialty was DNA cloning, he'd known them all and had met with at least three of them in the months prior to the Plagus.

But Dave had his doubts. He was far

from convinced that Bedford was guilty, that he'd had anything to do with the Greening. During the interrogation he'd had an answer for everything. Why had he gone to Cozumel? He'd retired. He'd made plenty of money off of phages and didn't have to work anymore. Why had he met with Oibers and the others? Ship talk. The beach field was pretty small; everybody knew everybody else. Why had he stayed in Mexico all those years? Well, beaches weren't too popular after the Plagus, he'd been scared. He even had an explanation for those articles he'd written, the ones about eliminating excess biomass.

But it wasn't that he hadn't confessed, or that there was no concrete evidence. The problem was that Dave liked Art Bedford.

He'd been assigned to Bedford during

**H**<sub>E</sub>  
**KNEW BEDFORD  
HAD BEEN  
IN TOUCH WITH  
THE PORTER  
GROUP, BUT DAVE  
WAS NOT  
CONVINCED HE  
WAS GUILTY.**

the interrogation, not to question him, but simply to be there, to keep him company, be his pal, talk to him, cheer him up—and to listen when and if he decided to talk about what he'd been doing those last days of May eight years ago.

The buddy program had begun after Hollis hanged himself in his cell. The papers had gone wild over that, screaming headlines, speculations about conspiracies, pious editorials on the massive guilt that had forced him to suicide. That may have been part of it, but it had been the conditions as much as anything else: the paper prison uniform, the eight-hour interrogation sessions, the bad food, the unutterable loneliness of being a man hated by most of the world. Things had changed after Hollis—better food, normal clothing, but more important, simple human contact, somebody they didn't have to be afraid of, someone to lean on as they walked the mile. That the somebody also doubled as a bodyguard mattered not at all.

Dave had been through it four times now, and each time he'd ended up, more or less against his will, being the man he'd been assigned to—even Oibers, weird as he'd been. He knew what they were and what they'd come, but their human qualities touched him regardless. It was hard to hate a man after you'd broken bread with him.

But Bedford was different. He was a funny man, with a vast supply of stories and jokes about anything imaginable. He was able to see the humor in anything, no matter what the situation, even the one that had made him the sole prisoner on the top floor of Leavenworth. Beyond that, he'd been as careful of Dave's feelings as Dave had been of his. The others had snapped at him at one time or another as the pressure got to them, cursing him as a plant, asking if he got a kick out of watching them, but not Art. He'd taught Dave to play chess, and had even explained genetics to him, not that he understood it even now.

Dave would have liked Art no matter how they'd met. The fact that he was probably innocent had nothing to do with it.

He'd had it out with Wills, the agent in charge, earlier that evening. Wills had called Dave down to his office to talk about Bedford: how he hadn't slipped once, hadn't given one sign of guilt, how his story had held together so well. Then Wills had gotten to the point: "You like him, don't you?"

"Yeah, I do. He's what we used to call a noble bro."

Wills smiled. "So do I," he said, folding with a pain. "And you don't think he had anything to do with it."

His tone was flat, deliberately so. Dave shut his eyes and shook his head.

"Wills sat quietly, tapping the pen on the desktop, his lips pursed. "I hear you were rough on the Japanese delegation last week," he said finally.

Dave shifted uncomfortably. He'd been wondering when that would come up. "They were threatening him," he said.

"Well, you should have come to me. I got some flack on it from upstairs. But," he waved his hand, "that's past." He paused once again, then went on, his voice quiet. "Is this one getting to you?"

"They all do."  
"All of them?"  
"Almost," Dave said, giving him a

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◀The buddy program had begun after Hollis hanged himself in his cell. The papers had gone wild over that.▶

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thin smile.

"Right," Wills nodded. He stared at the wall as if deeply interested in the instructional green paint of the room. "You don't think he should go?"

"I'd like to hold him a month or so, see what turns up."

"Can't do it, Dave," Wills said, shaking his head. "Dolfs wants him. It's been two years since the last—"

Dave cut him off. "So that's it? We're on a deadline now? Maybe we should start sending over the guys who sold them the equipment. There are quite a few of them." He fell silent, surprised at his own vehemence.

Wills dropped his head. "I know it's tough," he said heavily, "and this one's tougher than most." He raised his eyes. "Do you want to be relaxed?"

Dave hesitated. He'd been anticipating the trial with more dread than he cared to admit. He could be out now, no problem—Wills wouldn't hold it against him... But it wouldn't be far to Art. He shook his head.

"You just have to say the word."

"No," Dave said. "But what I do want is this: I want to know that this thing isn't becoming an automatic process, that we aren't sending people over there just to keep the wheels turning. Anyone who goes to Deth is a dead man—the trial is just a formality. Art Bedford wouldn't be convicted in this country on what we've got on him."

Lighting another of his never-ending string of cigarettes, Wills stared thoughtfully at the coal. Dave knew he was mulling it over and he was tempted to say something, a remark about the coast maybe, that would tip the balance and get him out of it, but he remained silent.

"You know, Dave," Wills said finally, "you'd have made a good small-town cop. There's something about you makes people want to confess. You remember Reed sat here screaming he was innocent, he had his rights, every other damn thing and that..."

"On the plane he tells me everything."

"Right. Even Oibers came around in the end."

Dave nodded. Oibers had been one who hadn't bothered him. He'd sat through interrogation with utter disinterest, saying nothing even though they had him nailed—his thumbprint had been found on a flask in Mombasa. The trial had gone the same way; Oibers acting as if the whole business was a boring duty that featured his presence but not his attention. Yet at the end, as he was led out of the cell, he'd turned to Dave and said, "Three billion for one, Novak—not a bad trade, eh?" and had walked off between his guards with a slight smile that hadn't changed even when the gas hit the acid.

"You think the same will happen with Bedford?"

"Be nice," Wills said.

"What if he's got nothing to tell?"

Wills buffed the cigarette out and lit another. "Do what you can," he said quietly. "Some of us have our doubts, too."

He lifted his eyes to Dave. "I think you know what I'm saying."

"Yeah," Dave said.

"Alright," Wills said. "Now go on and get some sleep."

He'd go back to the cellblock, but sleep was another matter. After two hours spent tossing on the bed, an ordinary one, not a prison cot, he'd gotten up and spent the rest of the evening walking the corridor, thinking about what Wills had said. Gute a character, Wills. Dave had heard he'd once studied to be a priest. He should sit down with him sometime, get to know him, find out how he'd ended up in the FBI.

As the hours passed he picked up the phone more than once to call Wills,

CONTINUED ON PAGE 36

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## THE NEW CARTOGRAPHERS

ARTICLE BY GREGORY T. POPE



In a windowless chamber, scrubbed clean by heating climate control, stand towers, racks, and cabinets of computing power. Here, in the U.S. Geological Survey's Reston, Virginia, headquarters, a state-of-the-art monitor writes on, revealing a three-dimensional relief map of the Loma Prieta area south of San Francisco. At the push of a button the image wheels into motion, taking the viewer around the region's peaks and valleys on a ten-second flying-carpet ride.

In a similar room at the SPOT Image Corporation, about a mile down Reston's busy Sunnys Valley Highway, technicians are poring through data beamed down several days ago from SPOT 2, a commercial satellite that circles the globe every twenty-six days. These days, any mapmaker with as little as \$500 to spare can fashion up an outdated map. By simply summoning a map on a computer screen, and superimposing a SPOT image over it, the com-



puter whips through an automatic change-detection routine, shifting borders and other features to match the satellite picture.

It's fitting that both the Geological Survey and the SPOT Imaging Corporation—two driving forces behind today's cartographic

revolution—call Reston home, a city of 32,000 that wouldn't have shown up on most maps twenty-five years ago. The landscape—and the art of cartography—change quickly now. Gone are the pens and erasers and step-ladders and tripods of yesterday.

More precise than ever before, thanks to computerization and satellite imagery, modern maps no longer stop at simply guiding the user from point to point. Like crystal

Computerizes geographic elements.

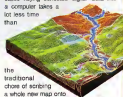


balls, they must let the user gaze into the future to answer thorny questions: where to site a landfill, how to route a fleet of ambulances, how the terrain will look after an earthquake has rpled through.

New demands have compelled mapmakers to package geographical information in innovative ways. The new cartographers use software that translates spatial features—houses, street intersections, rivers, city blocks—into mathematical points, lines, and polygons. These geometric elements are identified and tagged as street names, zip codes, soil types, population figures, whatever, and are downloaded into a computer's memory. The result isn't a map in the traditional sense but rather an information pool where every feature is digitized and stored in a vast database. Such a database, called a geographic information system, or GIS, is the crux of the new cartography. Using a GIS, cartographers can analyze geographic information without ever looking at a map. Or they can unleash an array of graphics routines to display the information in a more familiar maplike form.

The venerable mapmaking houses, whose profits hinge on the exactitude of their products, have wholeheartedly

embraced GIS technology, largely because keying corrected digital data into a computer takes a lot less time than



the traditional chore of scribing a whole new map onto a sheet of coated film. More than likely, a GIS database spawned the road map or world atlas you just bought.

The sites among the new cartographers sharpen their view of the world by employing a satellite capability known as remote sensing. Landsat 1, lofted by NASA in 1972, showcased the first glimpse of remote sensing's power, offering views of the earth unprecedented in their occurrence.

Currently, Landsat 4 and 5 can pick out objects the size of a baseball from a mound from miles above the planet.

Topographic features take on a new precision.

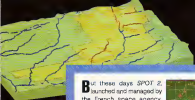
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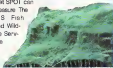
**B**ut these days SPOT 2, launched and managed by the French space agency, boasts the keenest eyes in the sky available to civilian map makers, tracing high resolution scanners on a continuous forty-mile ribbon around the earth's surface. Operating in multispectral mode (capturing red, green, and near-infrared wavelengths), SPOT's two sensors can distinguish features sixty-five feet across in black-and-white mode; they can resolve landmarks as small as thirty-two feet. The images are "rubber sheeted" by ground-based computers, a technique that stretches and doctors the data to compensate for the planet's curvature, the spacecraft's viewing angle, and other distortions. With aggressive marketing (Maps are less, SPOT is truth) goes one unofficial corporate slogan, SPOT Image Corporation packages its data in a variety of formats.

Among popular SPOT products are remotely sensed duplications of the U.S. Geological Survey's famous topographic maps. These break up the nation into standard rectangular map chunks known as quadrangles, or quads. SPOT quads provide an instant update of the Survey's



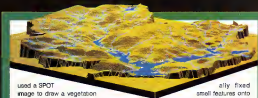
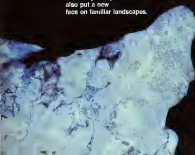
quadrangles, some of which have fallen out-of-date. "You can't say they all reflect today's landscape," says University of South Carolina geographer David Cowen of the Survey maps. "It took the Survey a hundred years to map the country side-by-side." SPOT quads help with fine-tuning. "Aided by Cowen's department, South Carolina's government, for example, has muscled up-to-date SPOT coverage of the entire state, identifying new roads in rural regions to help plot economic development."

The one-two punch of high resolution and multispectral imaging has made SPOT the instrument of choice for mapping changes in land cover, especially encroachment on wilderness areas. Trees and bar, cornfields and concrete reflect the sun's radiation in distinctive spectral signatures that SPOT can measure. The U.S. Fish and Wildlife Service



Cartographic data define areas never a truly viewed.

But today's mapmakers also put a new face on familiar landscapes.

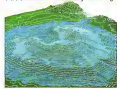


The tools of the trade: computers and satellites.

used a SPOT image to draw a vegetation base map of the Great Dismal Swamp National Wildlife Refuge, which straddles the Virginia-North Carolina border, in order to trace the shifting industrial and agricultural areas around the refuge. Meanwhile, planning new roads around Jacksonville, the Florida Department of Transportation employed SPOT data to distinguish sensitive wetlands from national uplands.

Yet even SPOT's scaly falls short of what some cartographers would like. Squint hard at a SPOT image and the geometry of streets and rivers stands out but you can't single out fence posts, electric pylons, manholes, and other small objects. In addition, objects viewed from space must be pinned to a matrix of longitude and latitude before they can be translated onto a map. Ground-based surveying teams, using plane tables, theodolites, and trigonometric handbooks have tradition-

ally fixed small features onto maps and continue to do so. Until remote-sensing satellites became more eagle-eyed, their jobs are safe. Just as mapmakers are turning to space-based tools, their counterparts in the surveying business also look skyward to refine their art. Many surveyors now rely on a fleet of military satellites called the Global Positioning System (GPS). These spacecraft broadcast meticulously timed dig-



High resolution scanning and multispectral imaging.

THE DOWNSIDE OF THE NEW CARTOGRAPHY IS THAT THIS IS THE TECHNOLOGY OF GEORGE ORWELL.

Databases streamline geographical details.



tal pulses: a ground-based receiver collecting signals from at least four satellites, can use these pulses to reckon its own longitude, latitude, and altitude.

The Pentagon designed GPS satellites to position soldiers and guide smart weapons to their targets. But GPS receivers were soon commercially available, slaming defense strategists. Anyone on the planet could tap GPS signals to steer a missile right into the men's room in the White House East Wing, for example. So last year the Department of Defense scrambled the signals so that only military receivers could use GPS to its full potential (ironically, the Pentagon had to lift GPS encryption during the Persian Gulf War because the military ran out of receivers, forcing them to equip soldiers with commercial GPS receivers.)

But surveyors have devised a neat trick to overcome the signal encryption. They place a GPS receiver on a landmark whose longitude and latitude is already known. They then walk around with another receiver to calibrate the degree of signal distortion. After adjusting for signal distortion, the receiver can establish its whereabouts to within three feet, stationary; to within inches.

The technique isn't cheap but for fast-growing areas in the Sunbelt it's worth

the cost. Local communities have traditionally maintained a plethora of separate charts for tax assessment, property lines, police precincts, water and sewer lines, and so on. Many now want to scan the collection into a computer, collecting the maps into a unified GIS to help plot growth. But there are problems. "The maps are supposed to fit together but sometimes old maps don't fit well because of the cartographic license they took back then perhaps moving a stream's location or fudging a hill's placement so it would fit on the map," says Bill Daly, manager of mapping services for Huntsville, Alabama.

To resolve these inconsistencies, Daly's department turned to GPS. Surveyors laid out a GPS-derived network of control points using landmarks that stand out on different, but overlapping, aerial photographs. Guided by these landmarks, they could piece the different photos together. The result: a seamless, accurate base map of the area, detailed enough to show manholes, tiny streams and other features. Cartographers then etched the photographic map into a computer to generate custom renderings such as three-dimensional maps. Beyond giving the city the exact locations of its infrastructure, Daly's group has used the technique to

identify slopes too steep or too aesthetically sensitive for proposed development projects.

Smaller projects are underway at the U.S. Geological Survey's GIS Research Lab, where a staff of eight is developing maps that peer into the future. "There are a lot more uses for our data than just paper maps," says Nick Van Driel, chief of the GIS lab. For example, four years ago the Phelps-Dodge Mining Company offered to trade land with the Forest Service, hoping to sink an open-pit copper mine into terrain covered by Arizona's Prescott National Forest. The Forest Service called on the GIS Lab, where researchers loaded a computer with the Survey's own elevation data, a Landsat image, paper maps showing geology and water tables, land ownership boundaries and the proposed mine plan. The computer responded with a three-dimensional view of the terrain, showing the mining operation's pits, ponds and piles and spotlighting changes in drainage caused by the rielandscape. The image then swiveled to reveal how the proposed mine would stand out from different points along a nearby scenic road. Faced with this analysis, the land-swap deal collapsed.

The ability of GIS to model the future has given land-use planners powerful new capabilities. "There's a major transition going on right now," explains Douglas Gorul, executive vice president of the mapping sciences division of Intergraph Corporation, a leading vendor of computer-based mapping equipment. "First people used computers to make maps better, faster, and cheaper. Now they're using the data to manage the areas they mapped."

Managing data is a pet project of University of Wisconsin professor of landscape architecture Ben Niemann and his colleagues. Merging Landsat imagery with property-line maps and soil charts, they developed a GIS database that pinpointed sources of erosion in rural Wisconsin. Next, they coupled the system with a water-quality assessment to model the impact of a proposed corporate headquarters on a nearby lake. Most recently they created a three-dimensional terrain map and tracked pesticides across the computerized landscape to illustrate how the chemicals would seep into bodies of water. "Before you implement a new policy," says Niemann, "you can predict its consequences on the landscape—you can ask, 'What if?'"

While local planners are benefiting from the new cartography, accurate geographic information is buoying the fortunes of modern commerce, just as



"Somehow, I expected you to be Japanese."

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improved navigational charts led Renaissance-era merchants to the riches of new worlds. Oil companies like Shell and Amoco employ 3D seismic and 3D geological maps to keep track of exploration. For Federal Express and UPS, computerized maps deliver the fastest possible routes for package trucks. U.S. West, the phone company, calls on GIS to guide the marketing of premium services and the placement of new switching facilities.

The private sector's love affair with the technology has helped boost GIS into a big business. Sales of cartographic computers and software totalled \$1.4 billion last year worldwide. But the explosive growth has led to new concerns and disturbing trends.

True, the precision demanded by computer systems has prodded many cartographers to sharpen up their data with remote sensing and other tools, but it's still possible, with some creative fudging, to shoehorn incompatible data into a single digital map. And when digital mapmakers have concocted a GIS from old maps without considering their original purpose, problems can multiply. "What happens when census maps are used for routing emergency vehicles? Who is liable when an ambulance runs into a dead end street?"

asks Michael Goodchild, codirector of the National Center for Geographic Information and Analysis in Santa Barbara, California. "Maps are being held accountable relative to reality in ways they never should be." Other concerns are even more alarming. With the who-you-live information so readily available, will the new cartographers turn from solving social problems to impinging on individual freedom? "The downside of the new cartography is that this is the technology of George Orwell," says Intergraph's Gurtel. "If anything makes the Big Brother society possible, this will."

Easy access to geographic data has inspired a different perspective in the mind of Jack Dangermond, president of Environmental Systems Research Institute, or ESRI, a top seller of mapping software. Dangermond considered a guru among the new cartographers, sees GIS as a means of opening windows for public scrutiny of governmental behavior. In short, as the technology becomes cheaper, the new cartographers will no longer just be bureaucrats—they'll be you and me. "We are the consumers of government," he argues. "Why not be a well-informed consumer?"

The current battle over congressional redistricting may furnish a proving

ground for Dangermond's vision. With widespread use of GIS technology, state legislatures and governors' offices will be able to use sophisticated tools to analyze the results of the 1990 census. As of April 1, 1991, the census data, which chart a block-by-block analysis of population, voting-age population, and racial makeup, has been publicly available on CD-ROM.

"Democrats, Republicans, caucuses, ethnic groups, anyone, can come up with their own proposal for reapportionment because the database is defined by public law," says Cowen of the University of South Carolina. "Equal access to the data elevates what was once a closed-door back-room deal to a level of democracy we've never seen before." In the case of redistricting, the new cartography stands to unlock a Pandora's box. But ESRI's Dangermond says that's just the point. He believes that digital mapping will allow people to grasp the connections between cultural, physical and geographic patterns. "We're reaching the ragged edge of sensitivity on this planet," he says. "Things are getting more complex, and there's not enough time to focus on them. GIS promises to illuminate things. Even if we can't solve our problems, we'll understand them." ☐



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# CLASS ACTS

CONTINUED FROM PAGE 46

been used to analyze Mozart's style of composition, and create hundreds of Mozart-style musical pieces.

"Having the technology is important if you want the leaders of tomorrow to develop the technology of tomorrow," says Donald Hyatt, director of T.J.a computer systems lab. "Most of the computer use has applications in other science classes. Students develop models in geoscience. In environmental science they simulate pollution and study soil types. Students from the optic labs are even doing computer-generated holograms." Judean Berkley, one of Thomas Jefferson's three Westinghouse finalists, developed a computer model of baseball physics, compared two earlier studies on how the spin of the ball and the angle of the bat affect the distance a ball will fly, and confirmed one of the studies as correct.

Freshmen at Thomas Jefferson take an integrated core of English, biology and technology classes that utilize skills in all three areas. In designing an experiment to test the effectiveness of bacteria in digesting oil, for instance, students focus on problems and solutions, create and execute an experiment, write and revise reports, and then orally present their findings to the class. "They learn problem solving, group dynamics, and good science methods," says Gaudreau.

But technology alone doesn't make good science in the classroom, according to Gaudreau. "The impetus comes from the students and the faculty. The students who have the motivation are drawn to the teachers with the energy. When that link is made, things take off."

## THE RESEARCH FACTORY

New York City's Stuyvesant High School doesn't have the kind of equipment that Thomas Jefferson offers. "You're talking about research on the cutting edge, research that requires million-dollar setups," says Albert Tarendash, head of chemistry and physics at Stuyvesant High School. What Stuyvesant does have is the city's top students. "We get the cream of the crop. And when you start with that, the rest is easy."

Within the school, technology plays a negligible role in teaching science—"Zick," says the fast-talking Tarendash. But once outside the building on Manhattan's Lower East Side, Stuyvesant's students hit high-powered research facilities. Paired with mentors, specialists

or scientists in their area of interest, students work at sites ranging from Cornell Medical School to New York University and Columbia University. Much of the advanced science kids learn at Stuyvesant is learned outside its walls.

"We're a research factory," Tarendash says. "We have a large research system in the school, the mechanism to place our students in research settings in biology, chemistry, physics." From their freshmen year, Stuyvesant's students learn the realities of scientific research by taking data, drafting proposals, designing experiments and models, and presenting their findings. A full-blown research class helps the students prepare their Westinghouse papers. The results are impressive: six 1991 Westinghouse finalists who presented on everything from virology and gerontology to membrane physiology.

"The senior class teacher [of the re-

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●The students who have the motivation are drawn to the teachers with the energy. When that link is made, things take off. ●

---

search class] believes himself to be the coach. As coach, he literally prods and nudges the kids. And they help each other. It's all very cooperative." Tarendash says. "I'd like to think that one hundred percent [of the school's students] have a burning desire for science and math, but that's not so. But we offer the kids what no other school can offer—people just like themselves. They all fit in because they all have the intellectual ability."

## FUTURE SCIENCE NOW

Around the country, other schools push the envelope of classroom science. At North Carolina's School for Science and Mathematics, for example, 500 juniors and seniors recruited from throughout the state live on a campus not far from a golf course in Durham. Like Stuyvesant, the School for Science and Mathematics stresses research; unlike Stuyvesant, the school features a substantial technological base, including a recombinant DNA laboratory that's become an important part of the

school's program. "They do their work here on campus," says the school's head of science, Steve Warshaw. "That puts some limitations on them as far as equipment and expertise, but it also produces some very impressive changes in their confidence and their ability to manage a project." From synthesizing diamonds to photographing high-speed projectiles, class projects give students "an opportunity to find out if they're really interested in research as a career." Warshaw says. The School for Science and Mathematics also spreads the seeds of scientific excellence to other schools throughout North Carolina by introducing teachers—more than 3,000 in the dozen years since it opened—to its technology during summer workshops and even by loaning them equipment.

Just outside Denver, Barry Schwartz helps manage the multitude of microcomputers that Jefferson County has put in educational science settings. Students use the computers to enter and track data from a radon measurement experiment, then share information and analyses with other schools, including one in Alaska and another in Germany. Some computers run simulations that compress time, letting impatient high schoolers see the effects of a long-term experiment in plant growth, for instance. "The technology allows us to do things we couldn't do in the past," says Schwartz. "Everybody needs access to stuff like this."

But not quite everyone sees technology as the salvation of science in schools. Jim Nelson, a Pennsylvania science teacher and veteran of thirty years in the classroom, worries that "technology can take away from the experience. At some point you have to deal with the real phenomenon. They ought to be getting their fingers dirty and seeing that things don't always work."

Real-world explorations and relevant research hinge on more than just getting today's hardware into the hands of tomorrow's scientists, at least according to the teachers at the edge of science education. "Look past the silicon and see what thinking is taking place," says Terley of the National Science Teachers Association. "The real computer revolution is in little classrooms where they're teaching kids to think."

"Don't sell science short," urges Stuyvesant's Tarendash. "It's absolutely vital that we have the best programs possible. After all, these are the people who are going to be leading the country, perhaps the world."

At some remarkable schools, they already are. **DD**

## OTHER SHORE

CONTINUED FROM PAGE 72

but each time he had a vision of Bedford's look and changed his mind. He felt oddly relieved when the guard appeared to tell him to get ready. He'd have to see it through now. Take Art over there, be his last friend. He smiled morosely as he pulled on a clean shirt. Chalon.

"Okay," Wolfe said. "Should be right along here."

Dave leaned forward. They were on the airport service road, driving parallel to the fence. The terminal, brightly lit, was a short distance ahead. He narrowed his eyes, trying to make out the crowd, but the lights were too bright.

"Goddammit," the driver said. "Look where those idiots are. They'd slow down, and the lead car was now fifty feet ahead." "Get on the horn and tell those yahoos to close it up."

Wolfe was reaching for the hoodlum when the lead car suddenly turned on to the grass strip next to the road. As it did, a section of the fence sagged and shadowy figures quickly pulled it away. Doubling their headlights, they drove through the gap and onto the runway. A later hovering over the field turned toward them and thrummed overhead, vulcans hurtling aimlessly at the dull green of the army cordons barely visible against the black of the hull. A moment later they were beneath the wing of a big 828s Starfighter parked a hundred yards from the terminal.

A squad of soldiers running double-file surrounded the car. Gun at ready, Wolfe got out to inspect the scene. A moment later he leaned back inside. "Clear," he said.

Pushing the door open, Dave stepped out and paused to look things over for himself. The troops were in good order, facing away from the car guns at chest level. He turned to gesture Bedford out and discovered that he was standing beside him, gazing at the terminal over the car roof. The shouts of the mob rang out clearly. Bedford frowned, then reached up to fiddle with the knot of his tie. "Think I should go out and calm 'em down?"

Behind Dave somebody laughed, and Wolfe said: "Art, get on the goddamn airplane." Bedford shrugged and with a smile began to walk toward the plane. Dave followed him.

Halfway there Dave slowed momentarily then quickened his pace to catch up with Bedford. An army officer stood just ahead, visor up, and Dave could see that he was black. He hesitated,

wondering if he should grab Bedford's arm to pull him further away, but then they were upon the soldier. Dave glanced up as they went by. Whoever the officer was, he was a pro; his expression didn't even change as they passed.

Dave stayed right behind Bedford as they climbed the steps. At the top Sheehan and his squad perked to let Bedford through then followed him aboard.

Dave glanced into the rear cabin, which was reserved for Bedford and herself. Art was just sitting down two seats back talking to Sheehan and a couple of the others. Turning, Dave looked into the forward section, where the delegates were. He felt the muscles of his face tighten as he saw them. There were more than usual, and for a moment he wondered why until he remembered that it had been a while since the last fight. A couple of Latins

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•The mob  
got louder as he  
came  
into sight. They were  
just past  
the big plate-glass  
windows,  
right outside •

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in black suits, beyond them a small Asian, perhaps a Malay, talking to an African in tribal robes. But his eyes were caught by the two Hindus. Sheehan's men were just completing their search, going over a plump brown man in a tan suit. He was speaking angrily to a figure in uniform, who answered in quiet but firm tones. To his surprise, Dave recognized him: Parash Naqua, a colonel he'd met on a previous mission. As the search ended and the plump man walked huffily away, Naqua caught sight of Dave and raised his hand. Focusing himself to smile, Dave nodded back and walked out of the hatch.

He leaned against the gasket lining the doorway, shivering in spite of the warm night air. An officer was ordering the troops to form a line around the plane, but Dave paid them no attention. He was thinking of India, eight years ago, the fires glowing on the horizon, the wrecked towns, the constant sweet-smelling smoke.

Sending someone next to him, he turned to see that Sheehan had joined

him. He looked quizzically at Dave. "You okay?"

"What?" Dave unconsciously rubbed his hands on his chest. "Yeah. I'm fine. What's holding things up? You don't search 'em until just now?"

Sheehan grimaced. "Ain't, some mechanic came back to the plane looking for a tool. They didn't catch him until he was walking away, so we had to do it all over. Waiser look advantage to go make some calls. Now we're waiting for him to get his ass aboard."

"Nate? What the hell's he doing here?"

"Who knows. If he ain't back in five minutes, though the bird is flying regardless." He nodded toward the terminal. The shouts of the demonstrators had gotten louder, as if they were somehow aware that Bedford had arrived. "That bunch won't leave until they know he's gone, and we sure as hell don't need a riot." He glanced at his watch, then back up at Dave. "Why don't you go find Waiser?"

"I don't want to leave Art."

"Hey, I'm in charge until the plane rolls. Sooner you track down that sly bastard, sooner you'll get out of here."

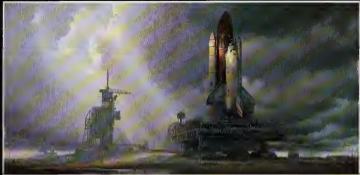
Dave thought it over, then shrugged. "Okay."

"Good enough," Sheehan said. He turned back to the hatch. "I'll keep an eye on the package."

Dave clattered down the steps and went across the concrete to the terminal. At the entrance a soldier checked his ID before waving him on. Inside the departure lounge was nearly empty, at the window a news team was filming the plane, staring intently at it as if they had been told it was going to go into a dance any minute now. They were being watched in turn by a pair of men in civilian clothes, he recognized neither of them.

There were plenty of phones in the corridor but no Nate. He walked on, the shouts of the protesters echoing down the hallway. He passed a car rental office, lights on but counter empty, then turned the corner to the waiting room.

It was probably his imagination, but he could have sworn that the crowd got louder as he came into sight. They were just past the big plate-glass windows, divided into two groups by a squad of soldiers. The largest was right outside, a varied bunch, some looking like professional demonstrators but the majority ordinary people. He studied their signs as he neared the windows: the standard symbol, a green swastika overlaying the globe, others reading DEATH TO COMMUNISM and a few with HITLER, STALIN and POL POT in small letters with a huge REDFORD in red under-



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neath. There were others, crude and homemade, but they were being shaken so much that he couldn't read them.

A much smaller group stood in the parking lot. No signs—they'd probably been confiscated—but this crew didn't need them: what they were wearing said plenty. About half wore in Klan robes or storm trooper gear: brown shirts, jackboots, and of course the armband. They were chanting, fists pushing forward in ragged unison, easily heard above the roar of the larger crowd. "Finish the job. Finish the job. Finish the job."

He looked around but saw no sign of Nate. Outside, the nearer mob had spotted him and were leaning over the crowd barrier, waving their signs. As he was turning away one of them ducked beneath the barrier and ran toward the window: a middle-aged black woman, well-dressed, somewhat plump. As she reached the curb she stumbled, catching herself and lifting the poster she was holding.

It wasn't a sign. It was a blown-up photo of a girl, a teenager, hair cut short and waved in a style popular ten years ago. The woman raised it high and shook it at Dave, shouting, her mouth

opened wide. He couldn't make out the words.

Two suits raced up to him. For a moment she struggled against them, dropping the photo as the taller cop leaned close to speak to her. She collapsed against him, body wracked with sobs and they led her out of sight, the shorter man stooping to retrieve the picture.

Dave turned and walked across the terminal, shaking his head. There had been plenty of plague deaths in the U.S., too. Not as bad as the rest of the world, but enough.

Ahead of him a loose gaggle of cops and army officers stood around a coffee stand, staring at him in open suspicion. He ignored them and went on past. He'd just spotted Nate at the other side of the terminal.

He was at a phone bank, receiver cradled on his shoulder. He had a finger in his other ear and was gesturing broadly with a plastic cup, nearly shouting into the phone. "I just wish the whole defense team wasn't American... I know nobody wants to touch it, but it was an international crime. Two of them were European, dammit."

Dave tapped him on the shoulder, pointing to his watch as he swung around. Nate frowned, then closed his

eyes and nodded. "I know it's too late for this round, but see what we can do next time. Ask the Swedes, they like to get involved... Listen, Maggie, the plane's leaving. Call you from Dahi."

He hung up, took a swig from the cup, and spat out. "Wh... cold? 'Crump' ping it, he tossed it into a trash can."

"Come on, let's move," Dave said, grabbing his arm. "What are you doing in the States anyway?"

Nate took off his glasses to polish them, peering at Dave nearsightedly. He was a virtual caricature of a trial lawyer, hair a horseshoe, glasses port-hole thick, suit a tailored masterpiece. "Got called back to Washington. They're confused about a witness, somebody supposed to have known our boy in Mexico. I had to hold their hands and explain it five times. Knew Bedford, slight, but never been south of the border." He slipped the glasses back on and smiled. "So how you doing? Been a while."

They walked through the terminal talking about nothing in particular. The crowd, backs turned to listen to someone speak, paid them no attention.

Sheehan was waiting at the top of the steps. "Hallelujah," he belowed at them, then stepped aside. "Okay, let's



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his seat belt. He reached down and did so, and a moment later the plane was rolling.

As the thrust of takeoff pushed him back, he reviewed the flight in his mind. An hour to the coast, two hours hypersonic over the Pacific, another hour to New Delhi. That made it six central-time, which would be what in India? He tried to work it out in his head but gave up. He'd check a schedule later.

Bedford was sitting with his eyes half-closed. A good-looking man, face craggy and weathered from a lot of time spent outdoors, blue eyes, wavy hair left long in what Dave called the scientist's cut. It was the kind of face women trusted, and Bedford had been a ladies man never married, always running with a different woman. Dave knew that, as he knew everything else. He'd read virtually everything written by or about Bedford before he'd ever met him.

"What are you thinking about Dave?" Bedford said without changing his expression.

Dave paused a moment before answering. If he was ever going to get the truth out of him—even a small piece of it—he'd better start now. "I was just re-

membering what Others kept calling me when I flew over with him."

"Hmm?"  
"Charon. He called me Charon. Said I was taking him to the other shore. I didn't know what the hell he was talking about. Had to look it up."

Bedford chuckled quietly. "I can't say I agree. Charon was a pretty odd SOB."

"Lot like Others himself."  
Bedford's eyebrows rose. "Couldn't say, Dave. I barely knew the man."

He closed his eyes and shifted in the seat. Dave sat back, feeling vaguely ashamed, as if he'd been taking advantage. Well, there was plenty of time. The trial would last at least a month, with every affected nation trying to get its word in, and the pressure on Bedford wouldn't lessen any.

They'd never spoken much about the Plague or its aftermath, and then only in the abstract, as if it had nothing to do with them personally. Bedford referred to it only as a technical problem, the difficulty of creating a microorganism that would infect only select populations. Concerning reasons or purpose he'd said nothing, even though he'd thought about it—his own writings were proof of that.

Dave glanced over at him, lying back, his eyes closed. He hadn't even told Bedford about India...

The plane reached cruising altitude and the seat belt sign went off. He glanced at his watch. Another half-hour before they boosted. He decided to take a look around. Unfastening the belt, he got up, walking quietly so as not to disturb Bedford. As he was about to go through the door something made him look back. Bedford had awakened, if he'd ever been asleep at all, and was staring at him with a look of sick fear. As Dave met his glance the expression vanished, replaced by a weak smile. He stood there uncertainly wondering whether to go back, but Bedford shut his eyes once again so he went on.

Just past the bathroom he came upon Nate in the small alcove that was the plane's excuse for a galley. He was pouring himself a cup of coffee out of an urn sitting in the place of honor above the microwave. He looked up at Dave inquiringly. "Want one?"

Dave mullied it over. "Guess I'd better."

Pouring another, Nate handed it to him. Dave took a sip and grimaced—the stuff had evidently been brewed for



the past week. He usually took it black, but . . . He leaned past Nate for a packet of creamer and dumped it in.

He studied Nate as he finished preparing his own, an elaborate ritual involving two and a half sugars and two packets of creamer. He took a gulp and smiled at the cup—Dave couldn't help laughing. Frowning at him, Nate took another sip.

"So where are you sitting?" Dave said.

"Oh, I set up front for takeout," Nate said, gesturing with his cup. "They didn't tell me. How's our boy?"

"About how you'd expect. Hiding it well, though. I've got to admit, He's sleeping now."

Draining his cup, Nate turned to the urn. "Sleep of the just," he muttered, so low that Dave barely heard him. Cup filled, he drew himself up and eyed Dave. "I hear you think he's innocent."

"I never said that."

Nate grabbed a couple of packs of sugar. "You said the evidence against him was shit."

"I said it wouldn't stand up in an American court."

Nate's eyes narrowed. "So what the hell do you think that means?" he said, his voice harsh.

Openmouthed, Dave stared at him. Nate had never acted like this before, not even with Dibens, when he'd had good reason. "I'm just keeping an open mind."

"An open mind," Nate said. He tore at a packet of creamer and shook it over the cup, scattering half of it on the counter. "Must be an awful nice thing to have. You, Wills, the AG, all open minds. It must feel pretty good."

"What are you, Nate, switching to the prosecution now?"

Nate ignored him while he stirred the coffee. When he looked up his face was red, his eyes slits behind the thick lenses. "You see that son of a bitch, don't you?"

Dave looked away and shrugged. Nate nodded to himself as if he'd encountered a great truth. "Yeah," he said. "Well, I think he's got the mark of Cain on him."

Wordlessly he pushed past. Still facing the gallery, Dave noticed that he'd left his work case. The top flap was open and he could see that the system was up. He turned to call out and saw Nate standing a few feet into the rear compartment. He walked back slowly as Dave pecked up the case. Grasping the handle, he stood there fiddling with his glasses. "Sorry, Dave," he said finally. "Jet lag, I guess."

Dave smiled. "It's never easy, man." "In truth," Nate headed toward the

rear. Dave noticed he didn't look down as he passed Bedford's sleeping form.

He considered another cup of coffee but decided the hell with it. Tossing the empty cup away, he walked into the forward compartment. Conversation ceased as he entered, dark heads turned to inspect his balance going on in lower tones. The plump Indian, wearing talocals, was working on some papers. He glanced up as Dave passed, sneered and went back to work.

A few feet on he saw Narjus, sitting in a sort of truncated lounge area. He rose as Dave approached, giving him a firm handshake. "How are you, old man?" Narjus said as he sat back down, hitching his pants up at the knees.

Narjus was a colonel—general now it seemed, by the new stars on his jacket—attached to the Indian government. He'd been educated in England and had the air of a British officer of the old school. His English was perfect, with none of the engaging qualms common among Hindus, and was one of the few who didn't act so fussy over just American was responsible for the Greening. Dave liked him.

Smiling, Dave sat back. "Now you get asked the question of the day: What were you doing on our side of the water?"

Oh, a detour with your new administration," Narjus said, waving a languid hand. "They've been a bit trying about our not holding elections, so I was

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sort to see to them. An entirely different lot with not the vaguest idea of where the subcontinent is, much less the conditions there. He shook his head. "And it happens every four years. I don't see how you manage."

"How are things, anyway?" Naqvi eyed him appraisingly. "Oh, that's right, you've had a full plate, haven't you? Not very good, frankly. We had an enormous riot in Kashmir two months ago, quite a number killed. The governor tried to close the camps and force the poor wretches back to the fields. Moving ahead on his own, I'm afraid. Needless to say it wasn't on, and when they weren't led they ran wild. Took us weeks to restore order. But you wouldn't have heard that in any case—we thought it best to keep the lid on."

"They're still refusing to go back to the villages."

"Yes. Of course, one can't blame them. Most of them are living better than they possibly could anywhere else." He sighed. "I suppose we'll have to put our hopes in the younger generation."

Dave merely shrugged; there was nothing that could be said to that. It was the same throughout the Southern Hemisphere; the survivors were simply willing to take up their lives again. It was

a new form of mass neurosis, a type of survivor's shock. Quite simply, they had endured the end of the world and saw no reason for going on.

Naqvi was still speaking. "Aside from that, it's the usual thing. Bandry, petty corruption, speculation in food supplies and so forth. It seems a typhoid epidemic broke out in Bangladesh this past week. I'll have to look into that as soon as we get back." He shrugged. "We're managing, at least. It could be far worse. We're better off than the Chinese, the poor devils."

Dave nodded in silent agreement. China was everybody's bad conscience. It had collapsed totally in the wake of the Plague. The Russians had taken over the northern quarter for humanitarian reasons, they said, and there was some semblance of order there. But the rest was hell on earth. It was just too big, too enormous a task for anyone to take up. There were whole crises in the interior that would not see a human being for generations, if ever, provinces virtually empty of life. More relief teams were working there than anywhere else on the planet, but it was futile. The only thing that would heal China was time.

He realized that Naqvi had spoken again. "I asked how the defendant was

doing," Naqvi said, hands clasped in front of him.

Dave grimaced. "As well as they all do."

Leaning forward, Naqvi touched him on the knee. "I understand that there's some doubt about this Train Bedford?"

Warily, Dave blinked at him, wondering how he could possibly have heard. Naqvi gazed back a moment before settling into the seat. "Yes," he said quietly.

Naqvi frowned at the cabin floor before going on. "There's something you should know," he said in a low voice. "Under the rose, of course. There seems to be a conviction in National Party circles that your government has sent in a ringer who can be proven innocent in order to halt the trial process."

"Bullshit," Dave said. "Ludicrous, I agree. Utterly paranoid, but there you are. We're doing our best to put a stop to it, but we haven't made much headway. We do know that there will be an attempt on your men sometime before the trial begins."

"Groat," Dave said. "Just what we need."

"Probably be wise to change the spot where he'll be held, but I won't tell you how to do your job." Naqvi glanced over his shoulder then went on quickly. "We'll give you what help we can, needless to say. Our problem, after all, we'll discuss it further after we land."

Dave started to reply, but Naqvi was getting up. Looking past him Dave saw a young Pakistani in uniform coming down the aisle. He halted and spoke to Naqvi in high-pitched Urdu. Naqvi turned back to Dave. "Some bother at home," he said. "We'll speak later."

"Right," Dave said. "And thanks, Parvez."

Leaning back against the seat, Dave looked up at the screen, wondering where they were. It was totally black, not even any stars—the cameras weren't sensitive enough to pick them up. Well out over the Pacific, most likely. He noticed that the coolest warning light beneath the screen was lit up. Strange, he hadn't even heard the buzzer.

He felt a stab of irritation at Naqvi but suppressed it. Normal reaction, blaming the messenger, but he had no time to indulge himself, and besides, Parvez had done him a favor. There was a hollow feeling at the pit of his stomach as he thought of what awaited them. It was different, somehow, knowing it was coming. And the government involved, too. Jesus, it was going to be rough.



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He let his head rest against the cabin wall. A distant thrumming came through the metal, no sound, they were traveling too fast for that. He closed his eyes. India. He was going back once more, eight years after he'd sworn never to set foot there again, never to so much as think about it. The place of nightmares.

He'd been twenty, in his second year of college, when he'd volunteered for one of the relief teams. They sent him to Bombay.

Of course, he'd known what was happening, he'd seen all the news reports, but it hadn't prepared him for what he'd found. Nothing could have, the constant stench of death, the piles of corpses, the pyres burning day and night that the Liberty crew said were visible from orbit. He hadn't foreseen how it would affect him, either. After the first week he'd taken to going off by himself so that no one could see him crying. He didn't know why he bothered—most of the others were in far worse shape. There had been two suicides the first month, one of them the team psychiatrist. It was Dave who had discovered her floating in a tub of pink-dyed water, red splat-ches printed on the wall above that must have meant something, though no sense could be made of them.

He reached his limit the fifth week, while commencing the sunrises against cholera—a small gift, from fate thrown in to keep things interesting. The tent had been maddened—there were so many of them, starved, sick, covered with sores. Three died while waiting for the shots, and sometime after that he'd lost it completely and had run off, still holding the injector. He couldn't remember much, but they told him later that he'd been screaming.

He ran aimlessly for what seemed like hours, stumbling through the wreckage in the streets, smashing into abandoned cars, falling over bodies that swarmed with maggots in the tropical sun. The faces, where there were faces, mottled with black, at times to a point where they resembled masks.

It had seemed to him then that he could run those streets forever and not reach the end, that the zone of death had expanded to swallow the world, and that he, Dave, was the final witness, the last shrieking remnant of a failed race.

Finally he collapsed before one of the camps ringing the city, injector clutched in his hand. The refugees gathered about him, staring expressionlessly. After a time he drew himself up on his knees, seeking, he thought, now, some unimaginable kind of explanation. They could have murdered him then,

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and nobody would have known—it had happened to plenty of Americans in the preceding months—but they did not. Perhaps it was the injector that stopped them perhaps just the look on his face. Whatever it had been, two of them—an old man and a boy whose thinness showed that he had just recovered himself—had taken his arms and led him out of the camp. They left him at relief headquarters, the old man saying a few words that Dave hadn't understood. He flew home the next day.

They'd had different names for it: the Salvaging, the Greening, as if giving it an innocuous label could excuse what they'd done. A simple concept that had half or more of the human race had to be eliminated to avert environmental catastrophe. Half or more—the "excess biomass" of the planet Earth. What a phrase, they had phrases for everything.

They'd tried to justify it later, after they'd been caught, but there was no justifying it. The population explosion had fizzled. The rate of increase had been dropping worldwide for decades. Everyone was being fed, not well, but enough. Environmental problems were under control. A reprieve, at the very least, though there had been plenty of debate.

But the Porter Group hadn't had time for debate. They knew better. They had made their plans, had done their work, and had cast it into the winds blowing east of Eden.

And there had been the final twist: that the bacillus had been tailored to infect only non-Caucasians. Dave had asked Reed about that, after he'd broken down on the plane. Reed had answered immediately: "Because they were the largest population reservoir, of course."

But that wasn't the answer. It hadn't exactly been racism either, as so many had said since. The truth was much simpler, far more basic, as basic as blood itself: because they'd lacked the guts to let the thing run its course, to take its portion of the whole race. Their own would have been at risk then.

It must have been so easy, working in isolation, insulated from any voice that would have questioned them on grounds of logic, of ethics, of decency. Starting out with an idea that grew into a scenario that took on a life of its own as they realized that they had the power to do a thing unimagined in history.

Someday you'll thank us, Reed had said, as he'd left the cell for the last time. Not me, Dave told himself, as he had told Reed. Not me.

He grew aware that someone was star-

ing at him. Across the aisle the overweight Hindu sat, hand posed above the pocket printer—but he was not looking at it. Instead his head was turned toward Dave, eyes fixed on him, mouth twisted in a rictus that on his round face looked like childish petulance but that Dave knew was anything but. Starled, he jerked up in the seat, looking away instinctively. When he turned back the man was tapping the keys, face as blank as if he had nothing beyond that on his mind. Dave studied him for a moment then got up and made his way down the aisle toward the rear cabin.

There was a burst of laughter behind him as he reached the door. He looked back over his shoulder. They were staring at him, smiling maliciously, the African, the Latino, all but the Hindu, who remained bent over his paperwork. He felt a sudden rush of fury and swung toward them, but caught himself and halted halfway. "Steady," he muttered aloud, then turned back and went on through the door. They began laughing again as he left the cabin, but he gave no sign that he'd heard.

He looked into the rear. Nate was sitting at the far end, staring down at something in front of him, lips moving. Dave frowned, wondering what he was up to, but then Nate raised the mike high enough for him to see it and he realized that he was dictating. Turning his eyes to Bedford he saw he was asleep. Dave shook his head, wondering once again if Art had been with them, and what part he had played, and if so how he had recoiled himself to the results, what he had told himself, in his deepest heart, to make it possible to live on afterward? To go on knowing that the wreckage of the earth had been annihilated in a manner beyond belief, that the survivors were living in even greater misery than before, that his own people would be servants to them for a hundred years.

He had half a mind to go over and shake him awake and ask him. Ask him what? If he needed a blanket?

Rubbing the back of his neck, he turned away. He glanced at the coffee urn. No, tired as he was, he had no more use for that nasty stuff. Besides, the last cup was working on him.... He looked down the length of the plane then stepped to the rest room.

The room was minuscule, he was able to rest his head on his arm as he leaned over the bowl. He finished and went to the sink to wash his hands. Plenty of hot water, anyway. Bending over he splashed some on his face. There was a small mirror above the sink and as he straightened up he saw himself

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in it, water dripping from nose and chin. His eyes were sunken, with black circles around them. He grimaced and was shocked to see the result: a stack-lipped, vicious leer that he never would have pictured. He dropped his head. Might as well face it. He was through.

He took some paper towels from the dispenser, coarse brown stuff that started to tear the minute it was damp. Nice, he thought as he dried his face. A hundred-million-dollar spacelane and they put this crap in the bathroom.

Wadding the towels, he tossed them and looked back in the mirror, straightening his tie and running a hand over his hair. He had amling at himself, but he didn't much like that effect either.

Wills had been right. He had no business being on this mission the state he was in. It wasn't fair to anybody for him to try to stagger through it at this point. He'd call from the cockpit and let Wills know so that he could arrange things with the team in Delhi.

That still left Art. He closed his eyes, wishing he'd never gotten on the plane. It was going to be twice as hard now. What could he do, tell him, "They're going to take a pop at you, buddy. Best of luck, I'm gone"? Maybe he could ask Nate... no, that was no good.

He was working up the nerve to break it to him when he heard a shout.

He pushed the door open, but it rebounded against something and he kicked it wide. Stepping out into the aisle he saw the African, stunned and off balance against the wall where the door had lunged him. Dave gave him only a quick glance before heading to the rear.

It was the Hindu, as he'd guessed it would be. He was standing with his back to the aisle, waving something with one hand while he shook Bedford with the other, lifting him bodily out of the seat, screaming in a mixture of Hindi and English that Dave couldn't make any sense of. Bedford was staring up at him, eyes wide.

Dave reached for his gun but dropped his hand as he touched the grip. He ran down the aisle and as he was reaching for him the Hindu dropped the thing he was waving, grabbing the lapel of Bedford's coat to shake him harder. Dave could see Art's head bobbing uncontrollably.

He slipped his hands underneath the man's arms and reached up to cup them behind his head. He could smell him, a combination of sweat and some kind of shaving lotion as he yanked him into the aisle. The Hindu kept his grip on Bedford, dragging him after them

# The Artist

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I should warn  
you  
I'm an artist



Artist —  
Warn me?/  
I'm the one  
with the gun!



Funny, how  
few appreciate  
the magnitude of art



"Get off him," Dave yelled, inches away from the man's ear. "Let him go or I'll snap it."

The man hesitated, then released Bedford, who flopped half in the aisle and half in the seat. The Hindu struggled for a moment as Dave pulled him away then went limp, nearly knocking them both flat. "He killed them," he cried out, his voice thick, then, sobbing, began mumbling in his own language.

Dave got him turned about and started pushing him down the aisle. They were all standing in the doorway the African, the Latin, the unidentifiable little Asian. As Dave reached them they parted to let through the orderly, followed by Naqia. The soldier grabbed the man's arm as Dave released him. Naqia had already wiped the others back, he nodded to Dave then turned to help the orderly. As they went through the doorway the Hindu pulled them to a halt and turned back to Bedford. His face was streaked with tears. "You are a very wicked man," he shouted, then let them lead him away.

At the other end of the cabin Nate was on his feet, his mouth open. He sat the mike down and hurried up the aisle. Turning to Bedford, Dave saw that he had got back into the seat and was lodged against the side, staring wild-eyed at the front cabin. As Dave went over Bedford looked down at the seat next to him and reached out to something lying atop it. He pushed at it, hesitantly, as if afraid to touch it, until it fell into the aisle. Dave picked it up. It was a photograph, wrinkled and split, showing the Hindu man, much thinner and with more hair, sitting next to a young woman in a sari. On their laps was a boy in a sailor suit, his black hair combed forward in bangs. They were smiling.

He felt Nate come up beside him and handed it to him without a word. Bedford was still crouched in the corner, eyes fixed on the now-empty doorway. As Dave watched his lips draw back from his teeth. "Fucking raghead," Bedford spat out. "Fucking dot bastard."

His eyes swung toward them, focused on Nate. "What are you looking at?"

Turning to Nate, Dave saw that he was gazing down at Bedford with no expression at all on his face. For a moment he just stood there, saying nothing, then he stepped back and walked toward the front cabin, holding the picture before him.

Dave turned to Bedford. "You all right?" he said quietly.

Bedford looked away. "What's his

problem?" he said finally.

"You wouldn't know, would you?" Dave settled into the opposite seat and studied the carpet for a few seconds. "Nate's wife was a nurse, a Japanese-American. Katherine Iku Weiner. I never met her, but..." He stopped speaking and raised his head.

Bedford was staring into space, his eyes empty. He lifted his hands to his face and pressed himself harder against the cushioned bulkhead as if that would shelter him. A shudder went through him, then he suffered as if by act of will and slowly pushed himself up in the seat. He dropped his hands and gazed at Dave, his face totally calm. Dave looked back in silence, trying to control his features as Nate had, knowing it was futile, he'd never been any good at hiding what he felt.

Bedford smiled. "Game of chess?" he said, his voice husky. He eyed Dave for a moment, then laughed, deep in his throat. "No."

He got up and stepped into the aisle. "Maybe later, Dave," he said, and walked to the back of the cabin.

Dave watched him go. Bedford the good guy, Bedford the scapegoat, Bedford the sacrifice.

The tale could be closed now. No more kidding himself, no more pretending that there was an end to it. Even if Bedford was the last of them, there was no exit, no way to lay that burden down. Not for the fat Hindu, not for Nate, not for Dave himself. He would run those dead streets for all the years he had left.

Bedford had reached the last seat. There he hesitated, raising his head slightly as if to look back at Dave, but instead he merely sat down where he could be seen by no one. Bedford the damned soul.

"I will be your Charon, Dave told him sternly. I'll lead you through it. The demonstrations, the riots, the attempts to kill you before your time, the trail, the undying hatred of the brown people. I'll be with you every step of the way. I will take you to the other shore.

He'd have to call Delta, to tell them what changes to make. As he got up the screen caught his eye. It was no longer totally dark, there was a line of light in the center, red and gold, and he realized that they had caught up with the day. The sky lightened, the clouds taking color far below. He watched until the sun peered over the horizon and, rising quickly with the swiftness of their passage, loomed over the sea. Then he walked to the front of the plane and all the work that lay ahead. **DD**



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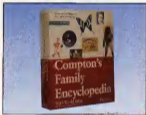


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## INTERVIEW

CONTINUED FROM PAGE 83

much more expensive than Russia's. So why not use ours? American companies are interested, but the Reagan administration said no to commercial launches using Soviet rockets. Maybe now Bush will lift this restriction.

**Orr:** What does the overthrow of the hard-liners mean for U.S.-Soviet cooperation in space?

**Sagdeev:** Soviet enthusiasm is alive, but today plans for a joint flight to Mars would not get popular support because of attacks on the space program and our economic crisis. Right now we need to attract support with more modest projects—using space for terrestrial needs like monitoring global warming and depletion of the ozone layer. Cooperation in space used as an international propaganda play is a kind of expensive handshaking in space, like the Apollo-Soyuz rendezvous in the Seventies. Has little chance today. Cooperation involving pooling of resources, not only costs but also talent and know-how, has a better chance. Many Soviet and American space projects, especially the scientific ones, compete with

each other. Why not cooperate?

There is also a kind of emotional reason for cooperation. Space, even orbital space, is the common heritage of humankind. Why shouldn't humankind cooperate in exploring it? A resuscitating or communications satellite representing many different countries can under the efforts of all these nations.

**Orr:** Were you changed by working so closely with foreign scientists?

**Sagdeev:** In my original research area, plasma physics and controlled fusion, I had many opportunities to work with foreign scientists. And I benefited from that experience. But at IKI, I had to convey this message not only to my fellow scientists but to engineers, technicians, even army officers and soldiers who worked at the launch sites.

The Vega mission to Halley's Comet was the first Soviet space mission to involve a large number of foreign scientists. Huge crowds of Soviets and people from abroad came together, at least briefly, to become part of one international space family. Counting all the employees of IKI, other research institutes, and the industrial enterprises, the number of individual lives affected by the Vega project would certainly exceed ten thousand. For most of these

people, it was their first taste of international cooperation.

**Orr:** Was this the first Soviet space mission open to outside scrutiny?

**Sagdeev:** Absolutely the first, and also the first time the launch of a Proton rocket was shown on TV. Many of my friends, some in high governmental circles, told me privately, "This is a brilliant project. But aren't you crazy to take such a risk?" It was a very complicated, multistage mission, with many innovative technical components. Earlier failures in the space program were known only to a small circle of people. This time everyone would be watching. We had a rather tough schedule to get everything ready. For example, we had to build our own computer for image processing and then had to mass-produce it to accommodate each of the teams that had an instrument onboard. The job was finished only a few hours before final operation.

**Orr:** A few hours before the launch?

**Sagdeev:** No, after the launch. I mean a few hours before we started to get data from Halley's Comet! In the days before the rendezvous, I slept two or three hours a night on the couch in my office. Quite a few scientists slept in their offices that week. It was probably

the most exciting period of my scientific career.

**Orrin:** The space program of the former USSR is strapped for cash, so it's selling cargo space, photos from orbit, ads on rockers, even rides to TV reporters. How helpful can this be?

**Sagdeev:** It's small money. Even the smartest space program can't support itself on a commercial basis. A space program must remain a program of exploration. From time to time, there will be new branches, or new leaves on existing branches, that can become completely commercial, telecommunications or weather forecasting, for example. But the bulk of a space budget must support scientific exploration. If we stop financing scientific missions, there will never be discoveries of new Americas by a future Columbus.

**Orrin:** Can Soviet inventors with promising ideas start their own businesses?

**Sagdeev:** Recently a law was adopted permitting such ventures—in Russia we call them cooperatives. Already, bright young people tend to abandon scientific careers and join cooperatives. They might, for example, develop computer software for commercial use. These young scientists or engineers can earn as much as ten times what they can at a government institute. Such disparity is not healthy; basic research in science will be neglected. Younger scientists, even within the established institutes, are unable to support their families. Even the better-paid scientists, those with established names and positions, are suffering. There are long waiting lists of young Russian scientists and engineers who want to leave. Every embassy in Moscow is under siege. Science in our republics is an endangered species.

**Orrin:** Now that you work mostly in the U.S., are you doing basic research?

**Sagdeev:** Yes. Essentially, I never stopped doing plasma physics [the study of electrically charged ions in gaseous "soups"]. In my early career I wanted to apply it to controlled fusion. Later I did plasma physics for space applications. The sparse matter of interplanetary space is also a kind of plasma. It's been a good field to work in, especially with the arrival of the interdisciplinary field of chaos. For chaotic behavior, you need instability built into the system, and plasma is the most unstable substance imaginable. You think you have plasma under control, then you see that the other end of it has developed a completely different type of instability. There's a nonlinear escalation of nonlinear phenomena—it's like an arms race!

**Orrin:** The phenomena you've chosen

to study—from plasma to Phobos—are things you can experience only vicariously. Is that frustrating?

**Sagdeev:** There's a kind of cultural barrier between physicists, especially in the twentieth century, and other people. Almost anything they study is untouchable. You can't understand quantum mechanics or particle physics using common sense. As a physicist you learn a new language to understand and describe these processes. The cultural barrier is similar to the barrier separating two strangers who can't speak the same language. To overcome this barrier, they use an interpreter. In the same way, when we launch human beings into space, we're launching interpreters. They've learned the language needed to communicate with scientific instruments and sophisticated robots. I spent many years trying to develop a theory of tokamaks. Tokamaks are

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◀ These five voters  
were good experimentalists:  
they observed  
that fifteen minutes after  
my vote I was  
still there, no one had  
taken me away.  
And so they joined me ▶

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huge, highly fortified machines used in controlled fusion. They contain a plasma deep within layers of walls and insulation. The instruments that extract data from the plasma are built like huge tunnels leading into the installation. So already you've lost touch with the plasma itself. Scientists don't even sit in the same room with the tokamak when it's operating—because of the high voltage. In a sense they are no different from space scientists or particle physicists who sit next to their computer display screens.

**Orrin:** Did you ever want to experience the life of a cosmonaut?

**Sagdeev:** I never thought about it. By the time Sputnik was launched in 1957, I was already a theoretical physicist by training and temperament. But the irony of life is such that now I'm here in America, where I often compare myself to a cosmonaut who was sent on a mission to a different planet. I've undergone a kind of combined planetary-scale jet lag and culture shock. But I find it interesting. I was shocked that I,

as a driver in America, was immediately given the freedom to turn right at a red light! Sometimes I feel there is too much choice here. In Russia my compatriots envy me because they don't even have enough to eat. Here I have to read through many pages of a menu just to select the food I want for one meal.

**Orrin:** A recent issue of *Soviet Life* recalled that as a young physicist you pledged to make one scientific discovery of international importance, two of national importance, and three of Siberian importance.

**Sagdeev:** That was a joke made by some scientific friends in the early Sixties that I recalled recently in an article in *Izvestia*. In the absence of market competition, the government created the notion of socialist competition, an artificial competition. Local apparatchiks were always pressuring everyone. "You should work hard; you should be a Hero of Socialist Labor! Will you promise?" Some friends finally gave up and said, "Okay, we promise," and made up the formula, which they promised to fulfill annually.

But when *Soviet Life* picked up the story, it didn't get the joke. In science, as in any creative profession, you cannot achieve results according to a plan somebody else prescribes. That is the beauty of science. From time to time you have a chance to be surprised by the unexpected. If you can live with that uncertainty and are willing to work patiently, you can become a good scientist. If you need to be handed an insurance policy that says, "You are guaranteed one discovery every year," you should work for an insurance company. **DD**

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