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WHITE BLOOD OF THE FOREST

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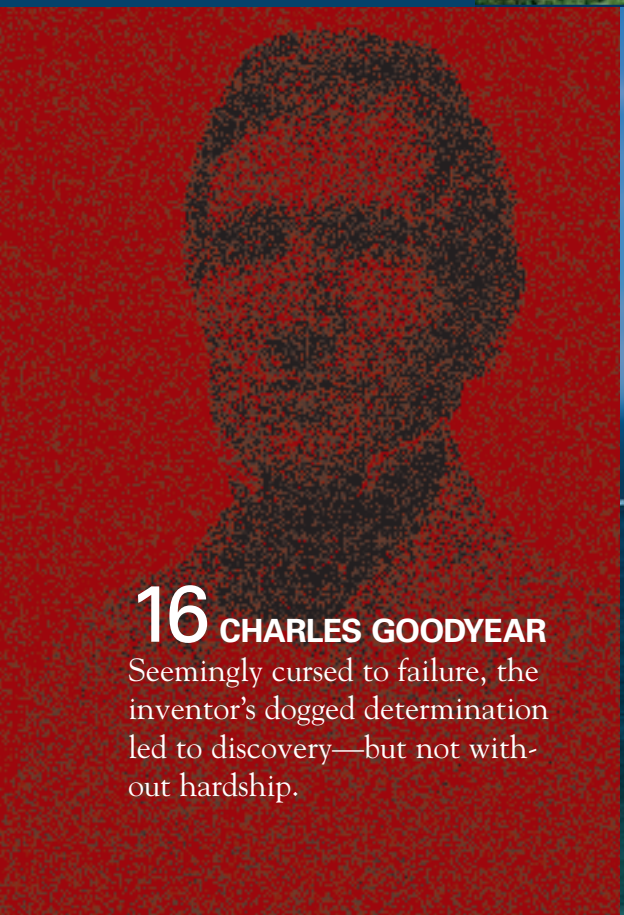

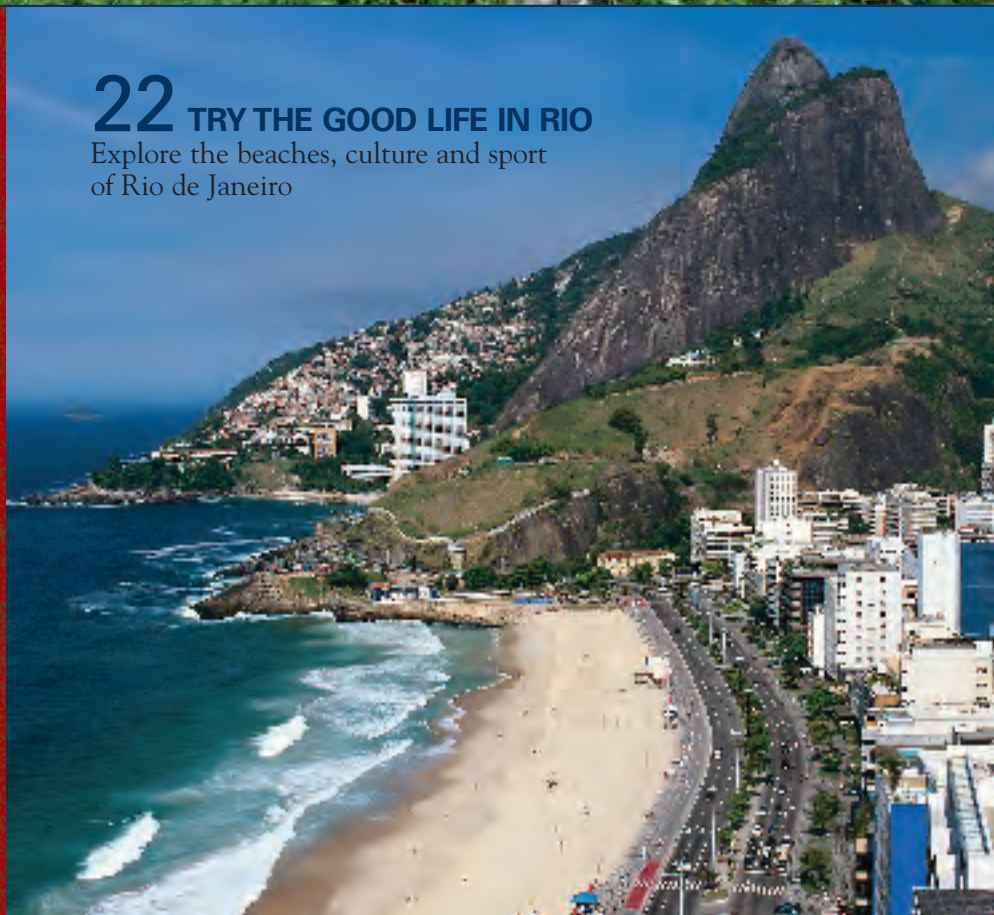

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Our feature article this quarter on the history of rubber is fascinating and filled with lots of information. We hope you enjoy reading BOSS magazine. If you have any comments or questions about the articles you read, please e-mail us at boss@dixonvalve.com. We want to hear from you!

Thank you,

Dick Goodall

R.L. Goodall
CEO, Dixon Valve & Coupling Company

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Reaching for the Stars

Two decades after the space shuttle Challenger *tragedy, the legacy of the woman who would have been the first "Teacher in Space" lives on*

BY SUE DE PASQUALE

In an interview with *USA Today* a few days before the launch of the space shuttle *Challenger* in early 1986, Christa McAuliffe was asked how she would feel as she sat waiting for takeoff.

"It's kind of like the first time you go on a carnival ride," the 37-year-old replied. "You've said, 'I've got enough courage,' and you're really excited about doing this and conquering your fears."

For the woman who'd been selected from nearly 11,500 applicants to be the first "Teacher in Space," the importance of the mission superseded any concerns she may have had for her personal safety.

"A lot of people thought it was over when we reached the moon. They put space on the back burner," said McAuliffe, then a mother of two young children. "But people have a connection with teachers. … My message to everyone will be that space is for everybody. It's not just for a select group of astronauts."

Days later, on January 28, 1986, in a horrific moment that remains indelibly etched in the minds of a generation of Americans, the mission that had started out with such high hopes met its tragic end just 73 seconds after launch. As a stunned nation and its schoolchildren looked on, the *Challenger* exploded in the Florida sky above Cape Canaveral, killing all seven crew members aboard.

"I don't think it was that we didn't understand something very horrible had happened," McAuliffe's mother, Grace Corrigan, told CNN after the disaster. "I think it was the fact that we didn't want to believe it."

For McAuliffe's family (including husband, Steve, son, Scott, 8, and daughter, Caroline, 5), for her social studies students at Concord High in New Hampshire, and for millions of others who felt they'd come to know her in the year leading up to the launch, the death of the effervescent young teacher was indeed impossible to fathom. McAuliffe, with her easy grin and curly brown hair, had been so alive, radiating an infectious excitement about her looming space adventure, about the many opportunities the space industry would one day open up for students.

Her motto: "I touch the future. I teach."

For a woman who made history, Christa McAuliffe's childhood was pleasantly unremarkable. The oldest of five, born to Edward and Grace Corrigan, she grew up in Framingham, Mass., where she was active in the Girl Scouts, played the piano and was a pitcher on her parish softball team. Christa was 13 in February 1962 when John Glenn and *Friendship 7* made history by orbiting the Earth three times before landing in the Atlantic. On the bus the next day, she marveled about the flight with her friend Barbara Cmar Eldridge. "Do you realize that someday people will be going to the moon? Maybe even taking a bus, and I want to do that!"

Christa dated Steve McAuliffe throughout high school and college and the couple married soon after she graduated from Framingham State College. They moved to Washington, D.C., so that Steve could attend Georgetown University Law Center, and there Christa taught social studies and American history and earned her master's degree at Bowie State. In 1978, the young family moved to Concord, N.H., and Christa quickly found her way back into the classroom, teaching first at Bow Memorial School and later at Concord High.

McAuliffe was a popular teacher who worked hard to make course material relevant. She used the New

Hampshire driver's handbook as a basis for one of her English courses, and developed a new course on the role and history of women in the United States. Wherever she taught, she was known as the "queen of the field trips."

Friends and family urged her to apply for the "Teacher in Space" program when it was announced in 1984. She did, barely making the deadline. To her amazement, she was named one of 114 semifinalists, and then made the final 10. McAuliffe felt strongly about who should land the coveted spot. "Historically, teaching and nursing are among the few professions that have not been dominated by men," she said. "If you're going to choose someone to represent teachers as a whole, I think you should be truly representative. You should choose a woman."

Ultimately, NASA officials decided that McAuliffe was the perfect candidate to rekindle the excitement of a nation that had, by the mid-1980s, grown complacent about space travel. And rekindle she did. She quickly gained a rapport with the media, doing hundreds of newspaper and TV interviews; she made the talk show circuit and was named a hero of the year by CNN and was a presenter at the 1985 Emmy Awards. In Houston, TV crews captured her floating, all smiles, in the weightlessness of a KC-135 as she and her crewmates went through astronaut training.

On board the *Challenger* (what she dubbed "the ultimate field trip"), McAuliffe was to conduct two lessons that would be transmitted back to Earth—covering how life is lived aboard a space shuttle and describing how spaceflight works.

Tragically, of course, she never got to give those lessons.

But her legacy lives on. Today, more than 40 schools around the world bear her name and countless scholarships have been set up to perpetuate her zeal for learning. In Framingham, the Christa McAuliffe Center gives middle school students a chance to simulate spaceflight in a full-size, interactive mockup of Houston's Mission Control; the center also provides workshops and science curriculum for teachers and offers original programming for the nearby Framingham State College Planetarium.

McAuliffe's children are now grown. Scott recently finished his graduate studies in marine biology and got married. Caroline, like her mother before her, is a teacher.

Grace Corrigan continues to work to keep her daughter's memory alive. "[Christa] left a fabulous legacy," she said, on the 20th anniversary of the tragedy. "It's making people feel good about themselves, making kids feel they're important, making teachers be proud of themselves and knowing that if you really want something, all you have to do is work hard, you can do it, achieve it. Reach for the stars."

RUBBER:

WHITE BLOOD OF THE FOREST

By Sue De Pasquale

"Rubber is a servant that follows us, literally, from the cradle to the grave. We are ushered into the world by the rubber-covered hands of a doctor in surroundings made sterile and quiet by this ubiquitous substance, and we make our exit in a rubber-gasketed coffin hauled by a rubber-tired hearse."

—The late Ralph Wolf, chemist and author, in an article in the October 1964 edition of Rubber World

It's impossible to imagine a world without rubber.

Each day, from the moment we rise to slip on our rubber-soled slippers and reach to turn off our rubber-insulated clock radio, we rely on this ubiquitous substance for work, play—and everything in between. While tires consume a majority of the rubber produced each year (accounting for 68 percent of annual worldwide rubber production), there are countless other uses for this durable substance, from the weather-stripping that keeps our houses warm to the surgical implants that can keep us alive. Rubber is used for the asphalt roadways we drive on, the athletic shoes that we run on, and the outdoor gym equipment our children play on.

Lest you think the importance of rubber is overstated, consider this: Many experts contend that rubber is the world's fourth most critical resource: after air, water and oil.

Today, the vast majority of the world's natural rubber supply—90 percent—comes from Southeast Asia. Thailand is the largest producer, followed by Indonesia. But natural rubber accounts for less than half the rubber produced in the world. The majority (about 60 percent in 2005, according to the International Rubber Study Group) is artificially produced, synthesized in factories around the world by mixing synthetic polymers with oil and other substances in "recipes" as varied as rubber's myriad uses.

While the innovations that made synthetic rubber commercially viable came fairly recently, with the advent of World War II, the first use and discovery of natural rubber dates back thousands of years. The story of how this milky substance, the "white blood of the forest," evolved from being a curious plaything to becoming a bulwark of our civilization is a fascinating tale—one of intrigue and atrocity, grandeur … and serendipity.

The story begins in 1600 B.C. in the jungles of ancient Mesoamerica, the area extending from today's central Mexico to Honduras and Nicaragua, where pre-Colombian civilizations flourished. It was here that the indigenous Olmec (which means "Rubber People" in the Aztec language) extracted a milk from the *Castilla elastica*, a type of rubber tree in the area. When

the sap-like extract—today known as latex—was dropped into boiling water, it would harden and could then be shaped into spheres … that bounced!

By the 1500s, the Aztecs were using latex extracted from the para rubber tree (*Hevea Brasiliensis*) to form 5-pound balls to play tlachtli, a game that required players to use their feet to get the ball down the field and through an elevated hoop. Teams were comprised of prisoners of war and the stakes were high: The losers were beheaded.

Though the Aztecs couldn't have known it at the time, the stretchiness of this new material was due to the scientific property of entropy—a system's inclination to move from a state of order to a state of disorder. Normally, rubber molecules, in the form of polymer chains, sit in a disordered tangled mess, like a plate of spaghetti. When stretched, the long polymer chains become aligned in one direction—reaching a state of order. But let go, and those chains return to a tangled mess. Thanks to entropy, the rubber snaps back to its original size and shape.

Whatever the cause for rubber's strange behavior, Spanish and Portuguese conquerors of the period were amazed by it. They believed the Aztecs' rubber balls to be enchanted by evil spirits, and they admired the Indians' ingenuity in using dried rubber to waterproof shoes and cloth.

Unfortunately, notes Wade Davis, an explorer-in-residence for *National Geographic* who specializes in ethnobotany, the study of plant lore and agricultural customs of populations, "All of these [early] products had a critical flaw. In hot weather a rubber cape would become a sticky

Did You Know?

- Though the para rubber tree (*Hevea Brasiliensis*) is the source of most natural latex for commercial rubber, the milk-like sap can be found in a wide variety of other plants and trees, including the dandelion and the fig.

- Silly Putty, that childhood favorite that makes its home in an egg-shaped container, was discovered by two scientists working independently to find an artificial alternative to natural rubber during World War II. By dropping boric acid into silicone oil, both James Wright of General Electric and Earl Warrick of Dow Corning happened upon the bouncing putty. Since 1950, more than 300 million eggs of silicone Silly Putty have been sold.

- Communities across the country—including areas of Santa Monica, Calif., New Rochelle, N.Y., and Washington, D.C.—have begun to install rubber sidewalks, an alternative to concrete, that bends (rather than buckles) as tree roots grow beneath—sparing root damage and protecting municipalities from injury lawsuits. Other benefits: easier snow removal, fewer injuries for runners and a smoother ride for those in wheelchairs.

Rubber is tapped (far left) by slicing away a thin sliver of bark from trees; the Aztec people used rubber to make 5-pound balls for the game tlachtli, depicted in stone carvings (left); vulcanization made pneumatic bicycle, carriage and, eventually, car tires possible. Henry Ford (right) set out to establish his own rubber plantation in Brazil in an ill-fated attempt to bolster the rubber supply.

shroud. In cold weather, a pair of rubber shoes would crack like porcelain."

Indeed, it was this "critical flaw" that prevented rubber from being used as much more than a novelty item over the next several centuries. (One particular novelty use gave the material its name, however; the 1770 discovery by Britain's Joseph Priestley that dried latex could be used for erasing or "rubbing out" pencil marks.) When early entrepreneurs tried to harvest and ship natural rubber, they found that it quickly rotted into a sticky, crumbly, smelly mess, due to the breakdown of its proteins (like milk curdling), and oxidation caused by its exposure to air.

Though scientists had some modest success at stabilization by adding such curatives as ammonia, the big breakthrough didn't come until 1839. "It was only the accidental discovery of vulcanization by Charles Goodyear that transformed rubber from a curiosity into a fundamental component of the industrial age," says Davis, a rubber expert tapped by the History Channel for its 2001 documentary, "Modern Marvels: Rubber."

In his experiments, Goodyear added sulfur to latex—and accidentally spilled some of the mixture on a stovetop. The combination of the sulfur and the heat succeeded in "curing" the rubber through a chemical process that cross-linked the material's individual polymer strands. The vulcanization process transformed rubber into a durable material, resistant to chemical action, heat and electricity. "The consequences," says Davis, "were profound." (For more information about Charles Goodyear and his invention, see page 16.)

In factories, manufacturers now had an effective material with which to seal machines—an important breakthrough with the arrival of the Industrial Age. The first pneumatic tires on bicycles and carriages became possible, foretelling the birth of the automobile. Entrepreneurs saw the potential rubber held and scrambled to make their fortunes. In an attempt to disrupt Brazil's rubber harvesting monopoly, England's Sir Henry Wickham in 1876 smuggled thousands of rubber tree seeds out of that country, planted them in London's Royal Botanical Gardens, then shipped the seedlings to Singapore and Indonesia, where huge rubber plantations soon flourished.

The quest for profits may have hit its low point with the "Rubber Barons" of the Amazon. At the height of their power, in the Brazilian city of Manaus, theirs was a frightening display of wealth. The ruling rich were said to quench the thirst of their horses with the finest champagne, according to the *National Geographic*'s Davis. Such extravagance came at the expense of the local indigenous people, for harvesting rubber required a huge work force. The "Rubber Barons" ruled by terror—through enslavement, rape, starvation, torture and decapitation.

"The atrocities unleashed at the height of the rubber boom are simply too dreadful and formidable to even speak about," Davis says. And the horror was not confined to South America. In Africa, Belgium's King Leopold rang up enormous profits—and caused an abominable loss of life—through his "rape of the Congo." Leopold's soldiers would take settlements by storm, looting and forcing the women and children into imprisonment—ransomed against an arbitrarily decided weight of rubber the men must go off and "tap." During their absence, many of the imprisoned women were raped and died of starvation and disease. If a village's men refused to endure this forced labor, the entire settlement was wiped out, the soldiers cutting off hands (and sometimes heads) from the dead as trophies.

"There seems to be no reason to doubt that 10 to 15 million natives 'vanished' in the Congo during Leopold's rubber-grabbing years," notes United Kingdom analytical chemist and rubber historian John Loadman. Not all of these deaths "can be laid at the door of rubber or, indeed, at the door of Leopold himself," concedes Loadman, since during this time Africa was swept by a devastating plague of sleeping sickness. But the historian concludes, "If we take a not-unrealistic weight of rubber to come out of the Congo as 75,000 tons [68 million kilograms] and the rubber-related loss of native life as 7.5 million, we have the value of a Congolese native life—10 kilograms of rubber!"

Not all who aimed to profit from

Synthetic rubber formed into bales is prepared for packaging.

rubber were so unscrupulous. American automobile pioneer Henry Ford saw the strain that was put on the world's rubber supply during World War I, and in the 1920s set out to establish his own rubber plantation in Brazil—a sprawling 2.5 million-acre site known as "Fordlandia." The ambitious undertaking was ultimately ill-fated: Ford's entire plantation was wiped out by leaf blight, an insidious fungus that causes the young leaves of the rubber tree to die and continues to plague rubber growers in South America to this day.

A little more than a decade later, the winds of war would begin to blow again. And this time, the impact on rubber supplies would be nothing short of devastating.

By 1939, rubber had become the single largest commodity imported into the United States. Americans were consuming 592,000 tons of crude natural rubber a year—80 percent of it for automobile tires, according to chemist and historian James J. Bohning.

Perhaps most tellingly, "98 percent [of U.S. rubber imports] came from Asia," writes Bohning in "Styrene at Dow" (*Chemical Heritage Magazine*, Fall 2004).

Japan saw its chance and moved to put a stranglehold on the Allied rubber supply. "By the end of 1941," writes Bohning, "the Japanese had completely obstructed rubber supplies from the Far East; further, entry of the United States into the war demanded unprecedented supplies for military uses—estimated in 1942 to be 842,000 tons."

Consider: A single Sherman tank required half a ton of rubber and every warship required at least 20,000 rubber parts. Though the U.S. government mounted the biggest recycling campaign in the history of the world, encouraging Americans young and old to come forward to well-publicized scrap drives with their tires and wagon wheels, such patriotic efforts could only help in the very short term.

The United States needed a way to produce vast quantities of artificial rubber—and needed it fast.

What followed next was an unprecedented collaboration between government, industry and research scientists. Earlier study by the Goodyear and Goodrich companies had shown that butadiene (a gas that is a byproduct of petroleum refining) to be a promising ingredient for synthesized rubber; after considering some 200 other materials to co-polymerize with it, the U.S. Rubber Reserve and industry representatives ultimately decided to go with styrene, says Bohning. Beyond the two small molecules, or monomers, says Bohning, the "recipe" was fairly simple: soap, water, catalysts and a modifier. "There were three major hurdles to overcome: manufacturing large quantities of the two monomers, co-polymerizing them; and learning how to actually use the synthetic material instead of the natural one."

Thanks to the unflagging efforts of scientists at Dow Chemical, Union Carbide and other industry labs, these challenges were overcome in a remarkably short period of time, and within less than two years, U.S. industry was producing massive amounts of GR-S (Government Rubber-Styrene) synthetic rubber. In 1943, some 230,000 tons of synthetic rubber hit the market. "By the end of the war," notes Bohning, "production had reached the 1 million-ton milestone."

Since World War II, scientists have made great strides in polymer science, but the basic process for producing most synthetic rubber remains fairly straightforward. Synthetic polymers are mixed in the presence of soapsuds in a reactor, creating liquid latex. "The dry rubber in this milky liquid is then coagulated into crumbs, washed, dried and baled ready for shipment," notes the Rubber Manufacturers Association. Of course, this explanation is highly simplified.

In reality, there are thousands of different "recipes" for producing synthesized rubber, depending upon what it's needed for. DuPont's Neoprene, for

From Tree to Tire: The Manufacturing Process of Natural Rubber

Tapping: Plantation rubber trees must grow for about six years before they are ready to be "tapped." Tappers slice away a thin sliver of bark so the latex can flow down a sloping panel (think of blood oozing from a scrape on the skin) and then to a metal spike that sticks out of the tree and allows the latex to drip into the collecting cup (shown on cover). After several hours, the wound heals and the flow stops. (Repeated tapping actually stimulates more production of latex.) The gathered latex (about one fluid ounce) is then filtered, treated with acid to coagulate the colloidal particles, pressed into thin crepe sheets, then air- or smoke-dried for shipment and processing.

Mastication: The raw rubber is then put through a mechanical grinding process—known as mastication—to make it soft, plastic and sticky and easier to mix with compounding agents. Until 1920, masticators were rubber mills: steel rollers that rotated at different rates in a trough to shear and knead the rubber. The rollers were hollow, allowing cold water or steam to be circulated to control the temperature of the kneading process. In more modern times, the mill has been replaced by the Gordon plasticator, which operates like a household food chopper. The churning process heats the rubber to more than 360 degrees Fahrenheit, breaking it down.

Mixing: The masticated rubber is next mixed with compounding ingredients, using rollers rotating in opposite directions. The ingredients include fillers (calcium carbonate or barium sulfate) that stiffen the mixture but don't materially strengthen it, and fillers that do add strength (carbon black, zinc oxide, magnesium carbonate and various clays). Pigments also are added, including zinc oxide, lithopone and organic dyes. Softeners (petroleum products such as oils or waxes, pine tar or fatty acids) help the various ingredients better meld. Ground sulfur (necessary later for hot vulcanization) is also usually added at this point.

Latex is coagulated and then dried on a conveyor for use in the production of automobile and truck tires.

Calendering/Extrusion: The rubber is next either calendered or extruded, depending on what it will be used for. Calenders are machines with rolls of equal diameter that can be adjusted for clearance between the rolls and for operating at different speeds. Calendered rubber is used for sheeting, fractioning (squeezing it into the texture of fabrics or cords) or coating. With extrusion, presses force the rubber compound through dies to form flat, tubular strips that can be used for rubber tubing, hose and inner tubes, and as stripping for setting windows and sealing doors.

Vulcanization: Once fabrication is complete, the mixture is vulcanized under high temperature and pressure. Rubber is often vulcanized in molds that are placed under compression in hydraulic presses, or subjected to external or internal steam pressure during heating,

SOURCE: Adapted from The History Channel Online Encyclopedia www.historychannel.com/encyclopedia

North America generates approximately 300 million waste tires annually. Until 1985, nearly all of them were sent to landfills or collected for stockpile. In 2003, four out of five scrap tires in the U.S. were consumed in end-use markets.

example, the trade name for a family of rubbers based on polychloroprene, is particularly well-suited for insulation—from wetsuits, to electrical insulation—and is a mainstay for gaskets, hoses and corrosion-resistant coatings. Butyl rubber is impermeable to air and useful for applications requiring airtight rubber—such as adhesives, caulks and sealants. First used for the inner tubes of tires, this application remains a mainstay for butyl rubber even today.

In the manufacturing of tires, styrene-butadiene is often used to improve traction. But that's just the outer layer. Today's high-performance tires are comprised of layer after layer and the rubber recipes differ for each. The properties of the treadblock are different from the inner liner, which are different from the sidewall. Manufacturers also add a variety of chemicals to the rubber compounds (antioxidants, wax, anti-ozone materials) to improve wear and durability. During the first 50 years of the tire industry, tires were expected to last just 5,000 to 10,000 miles. Today's dealers sell some tires that are guaranteed to last up to 80,000 miles.

The downside of tire durability, of course, is the disposal problems it represents. Remember the cross-linking of rubber's molecules that vulcanization made possible? It's this same principle that makes rubber so hard to recycle. Waste tires are the most visible manifestation of this disposal problem. According to some estimates, North America generates approximately 300 million waste tires annually.

Until 1985, most scrap tires were either sent to landfills for burial or collected for stockpile. Minnesota was the first state to enact legislation and regulations to change the way scrap tires were being managed and by 1990, all states but two (Alaska and Delaware) had followed suit. Since then, progress in recycling or finding an "end use" for used tires has been marked. In 2003, approximately four out of five scrap tires in the United States were consumed in end-use markets, according to the 2003 edition of *U.S. Scrap Tire Markets 2003 Edition*, put out by the Rubber Manufacturers Association (RMA).

A large percentage of scrap tires—nearly 45 percent—were used for "tire derived fuel," "offering a cleaner and more economical alternative to coal in cement kilns, pulp and paper mills, and industrial and utility boilers," according to the report. Nearly 20 percent were consumed by the civil engineering market (shredded tires improve drainage and help prevent erosion when used in road and landfill construction and septic tank leach fields); and nearly 10 percent were ground up and used for playground and sports surfacing and rubber-modified asphalt.

The RMA also reported progress in reducing existing stockpiles of scrap tires. In 2003, some 275 million scrap tires remained in U.S. stockpiles, according to the RMA, a reduction of nearly 75 percent since 1990.

The Future of Rubber

What will the future hold for the "white blood of the jungle"?

While synthetic rubber is a multi-billion-dollar industry, countless applications demand the "real thing"—natural rubber. In the United States, in an effort to reduce dependency on foreign imports of natural rubber, particularly in the face of rising prices and uncertainty in the crude oil market, officials of the U.S. Department of Agriculture are looking for viable sources other than the rubber tree.

One candidate: the guayule (wa-YOO-leh), a small desert shrub resembling sagebrush that flourishes in the southwestern United States and Mexico. When the shrub is harvested and ground, the latex extracted has the same properties as natural rubber, with an additional benefit: It's hypoallergenic. In the medical industry, where rubber allergies are a serious problem for caregivers and patients alike, the guayule holds promise. To date, guayule has been used to produce hypoallergenic surgical gloves and catheters. Currently in production: guayule condoms.

In the years ahead, industry leaders will undoubtedly continue to explore natural rubber alternatives like the guayule, even as researchers forge ahead with innovations in polymer science, creating newer and better synthetic rubbers. Because one thing's for sure: The world's voracious consumption of the stretchy stuff will not be abating anytime soon.

Special thanks to Jeff Grau, senior hose development engineer, Parker - Industrial Hose Division, for his help with this article.

Rubber By the Numbers:

21 million tons: Amount of rubber consumed worldwide in 2005. Roughly half was consumed in Asia and islands of the Pacific.

90: Percent of worldwide natural rubber supply that comes from Southeast Asia. Thailand is the largest producer of natural rubber, Indonesia the second largest.

30 percent: Increase over the last decade in world production of rubber.

1960: Year that worldwide use of synthetic rubber surpassed natural rubber for first time.

8.8 million: Total number of tons of natural rubber produced worldwide in 2005.

12 million: Total number of tons of synthetic rubber produced worldwide in 2005.

1.3 billion: Number of tires manufactured annually around the world. (Tires account for 68 percent of worldwide rubber production.)

60: Percent used for tire manufacture of all rubber consumed in the U.S.

7: Number of gallons of oil needed to produce a single tire. (Five gallons serve as "feedstock," while the remaining two supply the energy necessary for manufacturing.)

290 million: Number of tires generated in the U.S. in 2003.

233 million: Number of tires in the U.S. that found an "end-use" in 2003 (for tire derived fuel, sports surfacing and rubber-modified asphalt, etc.); That's 80.3 percent of total tires generated.

45: Percent of total scrap tires generated in the U.S. in 2003 that were used for tire derived fuel

73 percent: Reduction of scrap tire stockpiles since 1990, in the U.S.

SOURCES: RUBBER MANUFACTURERS ASSOCIATION, U.S. SCRAP TIRE MARKETS 2003 EDITION, INTERNATIONAL INSTITUTE OF SYNTHETIC RUBBER PRODUCTS INC.

Where Does it All Come From?

Natural Rubber Production by Area

Rank	Region	2005 Production
1	Asia	8,320
2	Africa	403
3	Latin America	195

Thousands of Tons

Synthetic Rubber Production by Area

Rank	Region	2005 Production
1	Asia/Oceania	4,988
2	European Union	2,675
3	North America	2,430
4	Other European Nations	1,234
5	Latin America	653
6	Africa	78

Thousands of Tons

Where It Goes.

Rubber Consumption by Area

Rank	Region	2005 Consumption
1	Asia/Oceania	5,471
2	European Union	1,334
3	North America	1,316
4	Latin America	532
5	Other European Nations	227
6	Africa	120

Thousands of Tons

Synthetic Rubber Consumption by Area

Rank	Region	2005 Consumption
1	Asia/Oceania	5,308
2	European Union	2,565
3	North America	2,181
4	Other European Nations	976
5	Latin America	766
6	Africa	104

Thousands of Tons

BY **SARAH ACHENBACH**

CHARLES GOODYEAR

IN 2005, the world's multi-billion-dollar rubber industry produced more than 20.8 million tons of natural and synthetic rubber and, across the globe, there is one cultivated rubber tree for every two humans on earth.

With such staggering statistics, it's hard to imagine the rubber manufacturing industry ever had a shaky start. Shakier still was the life and livelihood of Charles Goodyear, the determined, sickly inventor who created the first weatherproof rubber to be manufactured from the oozing sap of the gum rubber tree.

His fanatical vision to create what he called "elastic metal" drove Goodyear in and out of prison for unpaid debts and in courts over dozens of patent battles. But

DETERMINATION FED THE INVENTIVE FIRE FOR THE ULTIMATELY PENNILESS INVENTOR

it also led him to his subsequent discovery of the vulcanization process for rubber—a process that remains nearly unchanged from 1844, when Goodyear patented it, to today. Still, when Goodyear died at the age of 59 in 1860, he was penniless.

Using their kitchen as a factory, Goodyear, his wife and small children made hundreds of rubber over-soles only to watch the entire inventory melt.

The father of modern rubber and the sole inventor of the vulcanization method, neither he nor his family were connected to the company named in his honor: the Goodyear Tire & Rubber Co., the world's largest rubber company

During the early 1830s, "rubber fever" was sweeping America. Inventors, including a bankrupt hardware merchant named Charles Goodyear, worked hard to develop a year-round rubber from natural, waterproof gum rubber. Manufacturers hurried to build factories to meet the demand for new rubber products. In the summer of 1834, the 34-year-old, typically morose Goodyear excitedly presented his rubber valve for life preservers to the Roxbury India Rubber Co. in New York, the country's first rubber manufacturer. After being shown stinking, melted products sitting useless on the factory shelves, Goodyear was shown the door. Pencil erasers notwithstanding, it turned out the new rubber goods so in demand cracked in the cold of the winter and melted into a gluey substance in the summer. Customers were livid, factories were closed, and manufacturers and investors went bankrupt. The rubber revolution, it seemed, wouldn't bounce back.

Goodyear's rejection sparked an idea about rubber's gummy properties—a curiosity that led five years later to his discovery of the vulcanization process. Eager to experiment, he returned home to Philadelphia, only to end up making an immediate and familiar detour: serving time in debtor's prison. With a batch of raw rubber and a rolling pin supplied by his wife, Clarissa, Goodyear conducted experiments in his cell. He had struck upon the idea of adding a dry powder to the naturally adhesive, raw rubber to absorb the substance's stickiness. The "magic" powder for his earliest experiments was magnesia.

After his release from jail, the bankrupt Goodyear talked a friend into investing in the promising results. Using their kitchen as a factory, Goodyear, his wife and small children made hundreds of rubber over-soles only to watch the entire inventory melt. Neighbors complained of the smell, so Goodyear moved his "factory" to a squalid, fourth-floor tenement in New York City.

Relatives and friends urged him to stop his experiments and find a venture that could feed his family, but he continued undaunted, certain that he could single-handedly rekindle the country's faith in rubber. One key to his ultimate discovery came about while trying to remove paint using nitric acid from one of his rubber product samples. The sample turned black, so Goodyear threw it away only to retrieve it days later to marvel at the smooth, dry rubber that had resulted.

With an advance from a New York investor, Goodyear began producing clothes, life preservers, shoes and other products laced with nitric acid. Once again, Goodyear's luck wouldn't hold. The financial panic of 1837 wiped out both

There is a vast contrast between how tires were produced at early Goodyear plants and today's computer-operated, highly technical plants.

investor and inventor, and Goodyear, now 37, moved his family to an abandoned rubber factory on Staten Island, scrounging for food and financial backing.

Investors in Boston offered him another chance and convinced the government to order 150 rubber mailbags made from Goodyear's nitric-acid process. So confident of his product, Goodyear stored the completed order in a warm room and took his family on a month-long vacation. Every mailbag melted, and he was now destitute. Again, the family packed up, this time moving to Woburn, Mass., so that he could continue his experiments in local factories. Farmers took pity on the inventor and his family, allowing Goodyear to dig in their fields for half-ripe potatoes.

It was in Woburn that Goodyear discovered how to vulcanize rubber during the bitter cold of a New England winter in 1939. By this point, he had abandoned adding magnesia and nitric acid and began using sulfur. Legend has it that Goodyear—now racked with gout—hobbled through the snow on crutches to the Woburn general store to show off his latest experiment. The locals around the pot-bellied stove took one look at him and laughed at the penniless, crippled inventor. Goodyear started to wave his experiment. It flew from his fist and hit the stove, resulting not in a sticky mess, but rather a charred, leathery strip with a springy edge.

Goodyear's daughter writes of a less colorful version. After an experiment, Goodyear brushed some useless rubber and sulfur from his hands onto a hot stove. His daughter observed, "As I was passing in and out of the room, I casually observed a little piece of gum which he was holding near the fire, and I also noticed that he was unusually animated by some discovery which he had made. He nailed the piece of gum outside the kitchen door in the intense cold. In the morning he brought it in, holding it up exultantly. He had found it perfectly flexible, as it was when he put it out."

Whatever the event that sparked the discovery, Goodyear was adamant that his discovery of heating the rubber mixture was due not to circumstance but to providence, that it was meant for the man "whose mind was prepared to draw an inference," and who had "applied himself most perseveringly to the subject." With renewed vigor, he now spent day and night experimenting with

Though Charles Goodyear had no connection to the tire company that bears his name, his discovery of the vulcanization process made success possible for manufacturers around the world.

different heat levels from roasting the foul-smelling rubber in hot sand to using the family oven to bake it. To finance his endeavors, he pawned his children's schoolbooks and household furniture. He even sold the dishes, making rubber dishes for the family—though there was little, if any, food to eat. When spring 1839 arrived, he traveled to Boston to find friends who might finance him and was thrown in jail for not paying a $5 hotel bill. Upon return, he found that his infant son had died, one of six of the 12 Goodyear children to die during his lifetime.

Soon, he discovered the perfect level of heat needed for his sulfur and gum mix: steam applied for up to four to six hours at around 270 degrees Fahrenheit. Ironically, for Goodyear, whose family wore rags, the textile industry would be the first to manufacture a product that introduced his discovery to the world. His wealthy brother-in-law and Springfield, Mass., textile manufacturer used Goodyear's suggestion to weave rubber threads to create a better ruffled shirt front, which was the fashion rage in the mid-1800s. Once a manufacturing and consumer nightmare, rubber was now a rousing success, and factories across the world reopened to manufacture rubber products.

Choosing not to invest in manufacturing, Goodyear returned in earnest to his experiments, envisioning uses for rubber in a variety of goods from musical instruments and jewelry to sails and even ships. He fashioned for himself rubber vests and hats and used a rubber calling card. In 1844, in what would be his last smart business move, Goodyear applied for and received a U.S. patent for his invention (#3,633). Thus began the legal battles that would plague the remaining 16 years of his life. Goodyear went to court more than 36 times for patent infringement rights. In 1852, he famously hired Secretary of State Daniel Webster to defend him in the Circuit Court of the United States. With a legal oratory that made headlines, Webster was successful in defending his client's right to be named the sole inventor of vulcanized rubber, named for Vulcan, the Roman god of fire and craftsmanship.

When Goodyear died on July 1, 1860—emaciated and huddled over from sickness—he held more than 60 patents for rubber products. He had also perfected India rubber cloth, a mixture of fiber and rubber gum. He had lived to see his discovery result in hundreds of rubber goods and produce $8 million worth of products annually. Manufacturers were making fortunes from Goodyear's invention, yet numerous court battles over infringements on his 60-some patents cost him dearly. He owed $200,000 when he died. His family eventually became comfortable from royalties, though no Goodyear was ever connected to the company founded in 1898 that bears the family name.

The debt the world owes this disease-addled, debt-ridden inventor with unwavering curiosity and dogged perseverance is immeasurable. In his autobiography—printed on gum elastic sheets and rubber-bound—Goodyear eloquently expressed the philosophy that drove his lifelong fanaticism to create usable, modern rubber. "The writer is not disposed to repine and say that he has planted and others have gathered the fruits," Goodyear wrote. "The advantages of a career in life should not be estimated exclusively by the standard of dollars and cents, as is too often done. Man has just cause for regret when he sows and no one reaps."

Ironically, for Goodyear, whose family wore rags, the textile industry would be the first to manufacture a product that introduced his discovery to the world.

The Essence of Sportsmanship

By Michael Josephson

In 1964, an Italian named Eugenio Monti was the world champion in bobsledding and a strong favorite in the Winter Olympics. His nation expected a gold medal and after his last run it looked as if he might get it. The British team, led by Tony Nash, still had a chance to beat him, but Nash discovered a faulty axle that would require his team to withdraw. Instead, Monti removed a critical bolt from his sled and offered it to Nash.

As if to prove that no good deed goes unpunished, Nash won the gold medal and Monti was viciously criticized in the Italian press. Yet he was unshaken. "Nash didn't win because I gave him the bolt," he reportedly said. "He won because he had the fastest run."

Every real competitor wants to win, but Olympic medalist John Naber says a true sportsman, one who believes in the Olympic ideal, wants to win against his best opponent on his best day. The sportsman is not elated but disappointed when top competitors are injured or disqualified.

Monti won the gold medal at the next Winter Olympics, but it was his willingness to lose that earned him a prominent place in Olympic history. His act represents sportsmanship at its best: the pursuit of victory with zeal and passion, recognizing that there is not true victory without honor.

Today, with so many athletes willing to cheat or behave badly just to win, we need reminders of the noble potential of sports. And parents and coaches should be teaching youngsters that the real glory of sport is in the striving, not the winning.

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Try the Good Life

Explore the beaches, culture and sport of Rio de Janeiro

by Jim Duffy

LIFE IS A carnival in Rio de Janeiro—and not just during Carnival season. The annual Mardi Gras bash is the city's signature event, of course, a debaucherous affair that has been dubbed "The Biggest Party on Earth" for the way it fills two surreal and sleepless weeks of February with an astonishing array of dances, parades, concerts, costume balls and street festivals.

BUT RIO CAN be a revelation the rest of the year as well. Set between mountains and sea on Brazil's southeastern coast, this city of 6 million "cariocas" (as the locals call themselves) offers something for everyone. Like beaches? Here, you have 22 different stretches of sand to choose from, and that's just within city limits. Like music? Rio's night life swings to the beat of samba, bossa nova, reggae, jazz and more. Like sports? Surfing, climbing, fishing and sailing are all popular pastimes.

Nature lovers can hike in the rain forest one day and then stroll through impeccably designed urban parks the next. Culture lovers will find centuries-old neighborhoods dotted with gorgeous churches and interesting museums. Shoppers will discover a city famous for its adventurous fashion designers and unique jewelry shops.

So make no mistake: Come vacation time, Rio is the real deal, all year round.

The Wild Life

Rio's Carnival traditions date back a century. The famous Copacabana hotel kicked things off by holding a fancy-dress ball called "The High Life" in 1908. Two decades after that, the city's social calendar in Carnival season was crowded with more than a hundred such balls.

This year's festivities got under way in the first week of February and reached their crescendo during the weekend that stretches from the Friday through the Tuesday before Ash Wednesday. This sleepless sprint of days usually kicks off on Friday afternoon when the mayor of Rio crowns the festival's King Momo, a fat, happy, samba-stepping incarnation of the trickster god Momos of Greek mythology.

By that nightfall, streets throughout the city have been transformed into a backdrop for over-the-top costume balls, samba-school parades and raucous bandas, or street parties, in one neighborhood after another. (Overall, the best online guide to Carnival events is at www.rio-carnival.net.)

The balls vary from formal and expensive ($500 U.S. a

Historical Highlights

Officially founded in 1567 by the Portuguese, Rio de Janeiro started life as an export center for sugar before growing into the financial and cultural powerhouse of the country. When Napoleon invaded Portugal in 1808, the Portuguese king fled to Rio and the city briefly served as the capital of the Portuguese empire. The city served as the capital of Brazil from independence in 1822 until the inland city of Brasilia was established in 1960.

Among the historical highlights on display in modern-day Rio are:

- the Mosteiro de Santo Antonio, a monastery that dates to 1608 and features a spectactular 18th-century church, Capela de Sao Francisco de Penitencia;
- the Praca Tiradentes, a public square where Tiradentes, Brazil's most famous revolutionary figure in colonial days, was hanged for plotting to win independence for the country;
- the Mosteiro de Sao Bento, a monastery that dates to 1663 and features extraordinary gold-leaf carvings;
- the Nossa Senhora do Carmo, a 1761 church that was the site of the coronations of the Brazilian emperors Pedro I and Pedro II;
- the Paco Imperial, a 1743 building that once housed Brazil's colonial-era governor generals and now serves as a cultural center.

ticket) to free outdoor neighborhood affairs such as the Cinelandia Ball, which draws tens of thousands of revelers into the downtown Centro district.

Bandas, too, are free, unless you count the $8 or so it will set you back to buy a T-shirt of the right color and design that will allow you to join in with the throngs of street dancers showing off their samba steps. Some of these street parties can be outrageous affairs. Banda Carmen Miranda features dozens of men dressed as the "Brazilian bombshell" of Hollywood yore, complete with the fruit-laden hats she was so famous for. Quite a few of the dancers at Bloco das Carmelitas will be decked out as Carmelite nuns. The Banda de Ipanema is older and more traditional, but this is Rio at Carnival time, so it, too, features a generous count of drag queens and over-the-top costumes.

On Sunday and Monday nights, the city's 14 best samba schools strut their stuff before paying crowds of 30,000 at the Sambodromo arena during shows running from 9 p.m. to 6 a.m. The phrase "samba school" might leave some thinking of drab dance recitals, but spectators here will see astonishingly elaborate floats (carros alegoricos) and costumes that feature gargantuan headdresses and soaring wings. The choreography is timed to music by drum corps that can run up to 400 members strong. Advance ticket purchases are the best way in, though scalpers are usually out in abundance as well.

Rio de Janeiro is known for pristine beaches and beautiful people. Perhaps its best-known beach, Ipanema, is where the most beautiful bodies congregate.

The Good Life

Come Ash Wednesday, the city returns to normal – but normal in Rio is still something of a carnival. This is, after all, a city that got its name more than five centuries ago by way of a peculiar mistake. Venturing along the South American coast in 1502, the explorer Amerigo Vespucci entered a waterway that he dubbed with the Portuguese phrase meaning "January River," perhaps not realizing that he wasn't sailing on a river at all but rather in a bay the Indians called Guanabara.

The name stuck as the city grew over the centuries that followed from an obscure colonial trading outpost into a thoroughly modern metropolis that serves as the cultural capital of Brazil. Most guidebooks divide the city into three areas—Zona Sul (South), Zona Norte (North) and Centro (downtown). Tourists are likely to spend most of their time in Zona Sul, with its abundant hotels, vibrant night life and endless beaches.

Rio's beaches are its biggest tourism draw outside of the Carnival festivities. The best known is Copacabana, a three-mile stretch of curving oceanfront that first earned its renown in the 1940s as a playground for Hollywood luminaries on the order of Lana Turner and Orson Welles. The surrounding neighborhood of the same name was a gambling mecca back then. It went into decline in the 1960s, but today the Copacabana oceanfront is lined once again with thriving, upscale hotels. A stroll along the beach leads through a fascinating series of distinct neighborhoods on the sand—soccer-playing kids in one stretch, then tourists, then older retirees and then local fishermen.

The hippest of Rio's beaches lie farther south and take their names from the surrounding neighborhoods of Ipanema and Leblon. The water is cleaner here, and so is the sand. The stretch of Ipanema known as Garota de Ipanema is where Rio's most beautiful bodies gather daily to show off their glorious tans and impeccable taste in skimpy beachwear. Elsewhere on the sands of Ipanema and Leblon, the sporting life takes center stage with games of soccer, volleyball and frescobol (a sort of beach racquetball invented in Brazil) unfolding at every turn. (Swimmers here need to be careful of the undertow; ipanema is an Indian word meaning "bad, dangerous waters.")

At the eastern end of these linked beaches is an area called Arpoador, which offers the best surfing in Rio thanks to a range of incoming waves fit for everyone from beginner to expert. Beginners should sign up for classes, of course; experts may also want to head to the less crowded Saquarema, about 60 miles outside the city, where the waves are even better.

Rio's night life is a vibrant, seven-day-a-week affair that runs the gamut from opera and ballet in lush old theaters to throbbing samba and hip-hop in darkened clubs. The city's musical scene is booming these days. While best known for the homegrown samba and bossa nova styles, Rio also boasts an abundance of reggae, rock, jazz and hip-hop music.

Futebol Fever

A traveler to Rio said "To visit Brazil without taking in a soccer game is like seeing Paris without seeing the Eiffel Tower." Soccer, or futebol as it is called here, is the passion of many Brazilians; Brazil has long been a force in the world soccer arena, taking the FIFA World Cup home five times, the last in 2002.

Rio's Maracana Stadium is one of the largest in the world and is worth a look just to say you've been there. But what better way to experience it than with thousands of true Brazilian futebol fans cheering on their team? There's no calm applause here—revelers are known to turn cartwheels and throw drinks and other objects from the upper decks in moments of frustration and exhilaration. Admission costs about $5 and, unless it's a championship match, tickets are readily available.

Side Trips

Rio may be Brazil's cultural capital, but it's hardly the country's only notable destination. Wilderness adventures abound here, and travelers can head into the rain forest along the storied Amazon River basin in the north, explore the spectacular Pantanal wildlife preserve in the western reaches of the country, and gawk at some of the world's most spectacular waterfalls at Iguacu in the south.

The teeming metropolis of Sao Paulo, located along the Atlantic coast below Rio, now ranks as the world's third largest city, with 18 million residents. Host to the Brazilian Grand Prix Formula One auto race, it's also within striking distance of numerous resorts along the coast or up in the nearby mountains.

Afro-Brazilian culture takes center stage in Salvador, the capital of the state of Bahia. Marked by winding, hilly streets with pastel-painted buildings and elaborate churches, this coastal city is constantly alive with street music. It's renowned for its seafood as well.

Inland lies Minas Gerais, the state that was founded after hordes of Brazilians arrived in the gold rush of the 1700s. Quaint, small colonial cities dot the landscape here—Ouro Preto, Tiradentes and Diamantina among them.

Brasilia, the country's capital, features a number of important architectural sites. It's also close to innumerable natural wonders, including the virgin forests and expansive deserts of Tocantins and the Emas National Park, a great place to catch a glimpse of the maned wolf and the jaguar, among other exotic creatures.

The Sporting Life

By day, Rio is a city of endless diversions. The active life here isn't simply a matter of abundant bicycle trails and jogging paths. There are more than 300 rock-climbing options within a short drive and a number of outfitters and guides available to choose from. One of the more intriguing climbs is tackling Pao de Acucar. While most tourists take a cable car to this summit to take in spectacular views of the city, some opt to sign on for a six-hour hiking and climbing excursion (open to beginners) organized by an outfit called Animus Kon-Tikis. Don't bother with climbing in the summer months, however, as the rocks tend to get ridiculously hot under the Brazilian sun.

Hang gliding is another option for the daring adventurer. The most popular route for beginners takes off from the 1,600-foot-tall Pedro Bonita and heads down onto the Pepino beach below. Experienced gliders can take excursions run by any of half a dozen reputable clubs and companies that arrange trips for tourists. Several scuba diving outfitters are available as well. Anglers looking to do some deep-sea fishing can rent their own boat or take one of the guided trips offered by Universidade de Pesca.

When You Go

Climate: Rio is a tropical city. The months between December and February are hot and humid, with highs often reaching 100 degrees Fahrenheit. The rest of the year, daytime temperatures tend to be in the 70s and 80s.

Accommodations and Transportation: Hotel rooms in Rio run the gamut from luxurious to rough-and-tumble. A nice double room with bath in a quality hotel will likely run $100 U.S. a night or more. The rates will double during Carnival and around the New Year's holiday. Rooms at Rio's most famous hotel, the Copacabana Palace, can run upward of $500 U.S. a night.

Traffic in Rio is a confusing, congested nightmare, so it's probably best to rely on the city's public transportation system. Two main subway lines run until midnight six days a week and until 11 p.m. on Sundays. (Needless to say, they run 24 hours a day during Carnival.) The city's numerous bus lines are reasonably safe by day but should be avoided in favor of taxis at night. Taxi riders should make an effort to understand fare structures in advance, as some drivers are known to inflate rates for tourists.

Spectator sports also abound in Rio. Soccer fans should keep their eye on the local futebol schedules in order to take in a match at the magnificent Maracana Stadium in Zona Norte, which accommodates rowdy crowds of more than 100,000. (See Futebol Fever on page 27.) Auto racing is big in Rio as well; more Brazilians have won Formula One world championships than any other nationality. Check on the race schedule at the Autodromo Nelson Piquet in Zona Sul. Olympic-style sports will take center stage in Rio during July of 2007 when the city hosts the quadrennial Pan American Games (www.rio2007.org.br).

Sports-minded travelers also would do well to get a taste of capoeira, the martial art form invented centuries ago by Brazilian slaves. After its practice was outlawed by slave-owners, capoeira went underground, eventually emerging again as a dance form accompanied by drums and tambourines. Imagine putting a fight from a martial arts film to a rhythm of drums and having the combatants narrowly miss each other with every kick and punch—that'll give you an idea of this uniquely Brazilian mix of sports and art. The Fiera Nordestina fair and marketplace held every weekend in the Sao Cristovao neighborhood west of the Centro business district often features capoeira displays.

As renowned as Rio is for its fast-paced night life and sporting diversions, the city is also something of a strollers' paradise as well. It's loaded with notable museums, lovely gardens, gorgeous churches and quaint streetscapes. The streets through the expansive Parque do Flamengo in the Flamengo neighborhood are closed on Sundays, making way for waves of cyclists, rollerbladers and joggers; the park was designed by Burle Marx, a Brazilian landscape architect famous the world over.

Perhaps Rio's most intriguing natural destination is the Floresta da Tijica, a sliver of rain forest located just 15 minutes away from the city. It's got well-marked trails, several waterfalls and caves, abundant iguanas and monkeys—and even a restaurant.

Finally, no trip to Rio would be complete without a visit to the top of Corcovado (Hunchback Mountain). There, arms outstretched over the city, stands the famous statue of Cristo Redentor (Christ the Redeemer), shown above. Trains climbing the mountain leave every 30 minutes from the Cosme Velho neighborhood not far from Copacabana. The statue, which rises to 125 feet tall, is a symbol of Rio known the world over.

Inspecting Hose Assemblies Keeps Personnel and Equipment Safe

By Phil Kimble

A vacation on a cruise ship is full of fun and adventure. Exploring exotic ports of call, making new friends, eating more food than you ever thought possible and lots of entertainment is just part of the experience. With nearly one crew member for every two passengers, the level of service and attention to detail is unparalleled. It is a whole new world.

However, there is another, practically unseen, world on a cruise ship. When a ship comes back to its port of origin, there are only a few hours between the current passengers disembarking and the arrival of new guests. Hundreds of staterooms have to be thoroughly cleaned. Huge amounts of luggage must be unloaded while the luggage of the arriving guests must be loaded and delivered to the appropriate room. Tons of food, water, beverages and other supplies must be loaded and properly stowed. All of this is orchestrated and choreographed with the precision of a Broadway musical. In addition to loading the creature comfort items, diesel fuel is loaded either from the dock or from a barge in the harbor. Thousands of gallons of diesel are pumped into the fuel tanks of a ship after every trip. Big diesels, some with as many as 14 cylinders and pistons the size of 55-gallon drums, power the ship.

The Coast Guard has very strict rules and regulations about hoses going from shore to ship and ship to ship. Fuel loading hoses, and many other "over water" hoses, must have the fittings built into the hose or the hose must have permanently attached couplings. Personnel aboard the ship receive the fuel hose through a doorway in the side of the ship and connect the hose to a pipe that fills the tanks. The compartment where the fuel hose is connected is small. Because it is relatively close to the water and near the engine room, it is a sealed compartment. The assigned crew is to stay at this post during the entire loading process, disconnect the hose when loading is complete, and seal the door back up when the loading hose is back on the barge.

In one instance, the crew members assigned this task had been through the process many times without an incident. Because they knew the routine so well, they decided during a recent refueling to connect the hose to the tank fill pipe, and then attend to some other business. They thought they knew exactly how long the fuel loading process took and would be back in plenty of time.

The crew on the fuel barge was unaware that the hose connecting the barge to the ship was damaged while in storage. When the barge began loading fuel onto the ship, the damaged hose began to leak near its connection to the fuel tank. Even though the leak was small, the diesel fuel began collecting in the compartment. When the crew members returned and opened the door to the fuel-filling compartment, many gallons of diesel fuel rushed by them. The fuel found its way to the engine compartment coming in contact with hot pipes then bursting into flames. Luckily, no one was injured and the fire did not damage any equipment.

Although it took only a few minutes to put out the fire, thick heavy smoke permeated the entire ship. The damage cost the cruise line millions of dollars in revenue because the ship was out of service for almost a year.

To avoid potential harm to personnel and equipment, Dixon stresses the importance of inspecting all hose assemblies prior to each use. Worn out fittings, attachment devices, hose and accessory items must be replaced. Retaining devices (safety devices) such as clips, cables or chains must be used. Continually educate your employees about the proper use, care and potential hazards of hose assemblies. Take advantage of Dixon's free Hose Assembly Safety Program and the follow-up training seminar to aid you in setting up your own inspection program. If you have any questions about applications, use or assemblies, call Dixon at 1-800-355-1991.

Boss Ground-Joint Fittings:

- Also known as Bull Hose Fitting
- Primary use is steam and heavy duty air transfer
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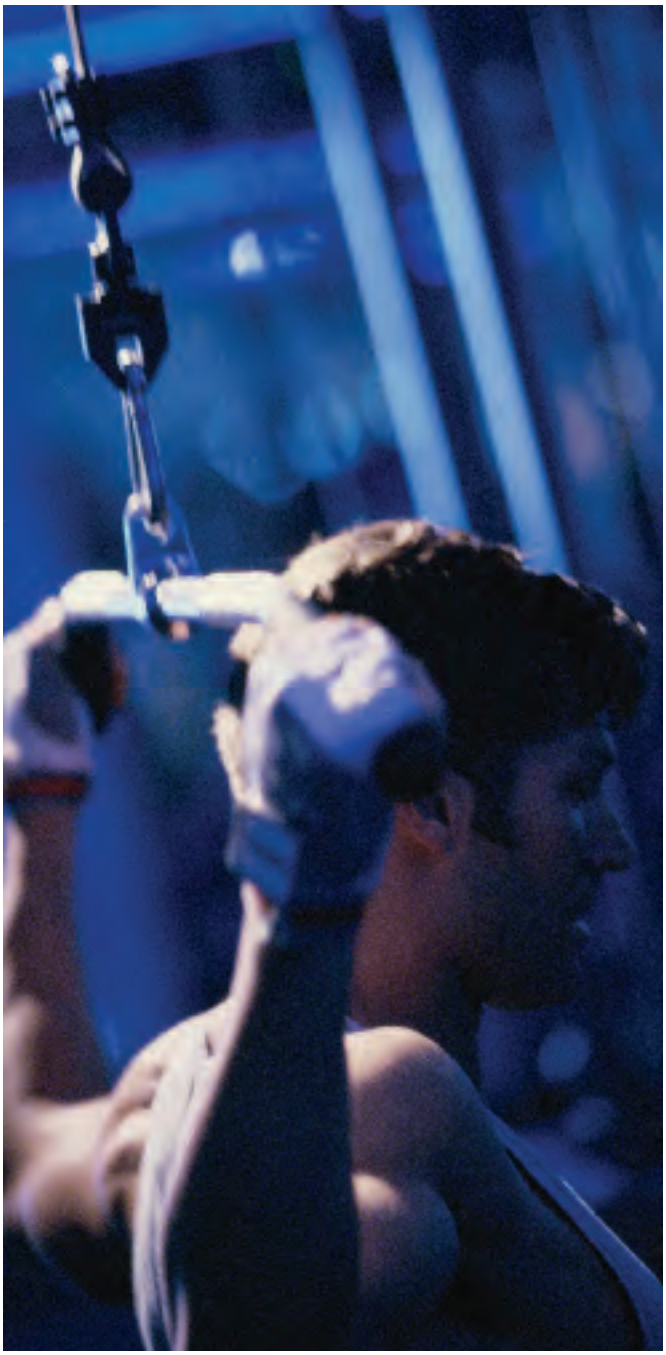
- Look for these features:



Pump Up to Stay Fit

Strength training boasts many fitness benefits without the bulk

By Sue De Pasquale

When most of us think of cardiovascular exercise, our thoughts turn to sports like running, swimming or tennis. Neal Pire would like to put another option on our heart-healthy radar: strength training.

"Resistance training has been shown not just to make you stronger and more able to take on the physical stresses of mowing the lawn and lifting your kids. It's also been shown to enhance and maintain cardiovascular health," notes Pire, a fellow of the American College of Sports Medicine (ACSM) who has worked as a personal trainer for 27 years.

Indeed, he says, the latest scientific evidence points to strength training as an important weapon in our battle to slow the effects of aging. In addition to strengthening the heart, regular workouts help build and maintain bone mass, preventing osteoporosis; increase metabolism, which can help with weight maintenance and loss; and improve strength and body tone, making it easier to stay active and perform our daily activities.

Strength training is often referred to as "resistance training" because it involves loading a muscle group with some form of resistance—provided by free weights, machines, bands/tubes or your own body weight (think pull-up). The goal, surprisingly enough, is to cause muscle overload—to actually damage muscle fiber, according to the ACSM. The damaged fibers send out substances that call for the arrival of cells to clean up the damage and then signal the production of new proteins to repair the muscles. This cycle of muscle damage/muscle repair over time leads to a buildup of muscle protein, which makes muscles bigger and stronger and able to handle more resistance.

Getting started on a resistance-training program is simple, says Pire, and it needn't be an expensive undertaking. While many people opt to start working out at a gym or with machines at home, "gym membership isn't mandatory," he says. All you need is a few hand weights—even some weighted juice cans will do.

"The basic guidelines call for a minimum of one resistance-training exercise per major muscle group"—arms, shoulders, chest, abdomen, back, hips and legs, says Pire. But

one exercise can impact multiple muscle groups. Thus, an effective workout can be as simple as doing squats (for the quadriceps), push-ups (for the pectorals and triceps), arm raises (for the shoulder muscles), lunges (for the backs of thighs) and a curl movement (to flex the elbows).

Many novices, however, prefer to start their training at a gym or health club, where a trainer can create a personalized training regimen that utilizes the wide array of machines and free weights available.

A cautionary note from Pire. "It's important to be able to discern whether you're getting the right information and guidance." The surest way? "Look for a certified personal trainer."

Wherever you decide to train, and whatever "recipe" of exercises you decide to follow (and these are as varied as the experts who create them), there are general recommendations from the American College of Sports Medicine that can help you improve and maintain your health.

- Plan to work out two to three days per week, allowing a day between each workout to give muscles time to repair.
- Do a minimum of eight to 10 repetitions of an exercise (known as a "set") per muscle group. With each set, you want to push yourself to "volitional fatigue," the point where "you can't do the exercise correctly any more; your muscles are tired," Pire explains.
- As your muscles adapt and it becomes easier to do an exercise, "it's time to grab a heavier can of corn," says Pire. Adjust the level of resistance and add a set.
- Plan to rest one to two minutes between each set, or until your breathing has returned to normal.
- Cold muscles are more prone to injury than warm ones. Get the blood flowing by starting with five to 10 minutes of light aerobic exercise, then doing some warm-up sets, using lighter-than-usual resistance.

Worried about turning into an Arnold Schwarzenegger? You needn't be. The bulging muscles and rippling tendons you see on bodybuilders are the result of years spent lifting ever increasing loads of weight.

Studies have shown that most people are apt to stick with a resistance-training program if they limit workouts to 20 to 30 minutes, several times a week.

In his nearly three decades of experience as a personal trainer, Pire has found that novices begin to feel results within just two weeks. "Everything starts feeling a little tighter," he says. The visual payoff takes a little longer. But within six weeks, says Pire, you should be able to look in the mirror and see a new, toner you.

The X-ray

A look inside—the X-ray illuminates a world never seen before

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A potentially broken arm, a toothache that just won't quit, structural soundness of a bridge or a building, and even security on the world's airplanes. All of this depends on one ubiquitous tool—the X-ray. In fact, X marks the spot in so many places in today's world that we take the innovative scan for granted, forgetting the X-ray's origins. It goes back more than a century.

The X-ray has been a part of the vernacular since its 1895 discovery by German physicist Wilhelm Röntgen. For some 20 years prior to Röntgen's discovery, his fellow scientists had been experimenting with energy and the light it produces. Johann Hittorf had, in 1876, discovered a fluorescence emanating from glass electron tubes, and named that light "cathode rays." Later, William Crookes created a glass vacuum cylinder containing electrons that discharged a high electric current. In his laboratory, Röntgen combined Hittorf's cathode rays with Crookes' tubes and got an unexpected result.

The enlightening combination of these two inventions produced a faint green light against the lab's far wall—and, to Röntgen's astonishment, traveled on its way through books and other objects. While switching the items in the ray's path, Röntgen saw the outline of his hand bones projected on the wall. He called this strange, new ray "X" for "unknown."

Röntgen hurriedly published a report titled "On a New Kind of Ray: A Preliminary Communication" in a German medical journal and was awarded the first Nobel Prize for Physics.

X-rays (or "Röntgen rays," as they are known in some parts of the world) are, like normal light rays, produced by atomic activity. Wavelike forms of electromagnetic energy are released at varying speeds by atoms in the form of light photons. While normal, visible light travels on a long wavelength of low energy, X-rays travel on a short wavelength of incredibly high energy. Items constructed of large, high-energy atoms, such as bone, are easily illuminated by X-rays, whereas skin, which is composed of small, low-energy atoms, allows X-rays to pass through.

Röntgen's discovery wowed the scientific world, and soon his peers were working to develop new uses and technologies for the X-ray. The public was wowed, as well. Scores turned out as audiences for X-ray exhibitions, where the machine's capabilities were displayed on stage. But as one scientist after another suffered arm amputations as a result of "radiation sickness"—it would later be known as a form of cancer—it became clear that the intensity of X-rays was harmful to humans. Despite the hazards, the potential benefits of Röntgen's new invention could not be ignored.

Doctors could now diagnose broken bones without having to resort to surgery as they had before, and dentists had been given perhaps their most valuable tool for identifying cavities and other dental problems. Another early use of X-rays was in fitting shoes; many shoe stores in the 1940s and 1950s had machines in which customers could confirm that shoes fit their feet. As many as 10,000 machines were thought to be in use and the practice continued for years until the danger of exposure was considered unacceptable.

Precautions including the protective aprons worn during many types of X-rays have reduced risks to patients, and continued developments in the scientific community have created uses for the X-ray that Röntgen never could have imagined.

X-rays are now used to determine the authenticity of works of art and museum artifacts and for art restoration. They also can detect fake gems, smuggled goods at customs, and were an integral part of former President Ronald Reagan's Cold War defense planning strategy. Reagan's Strategic Defense Initiative included the use of an X-ray laser device; a blaster of sorts powered by a thermonuclear explosion. In recent years, the widespread use of X-rays has also contributed to airport security, slowing down lines but (hopefully) making airports more safe.

Röntgen's accidental discovery continues to illuminate and reveal secrets that would otherwise be hidden.

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