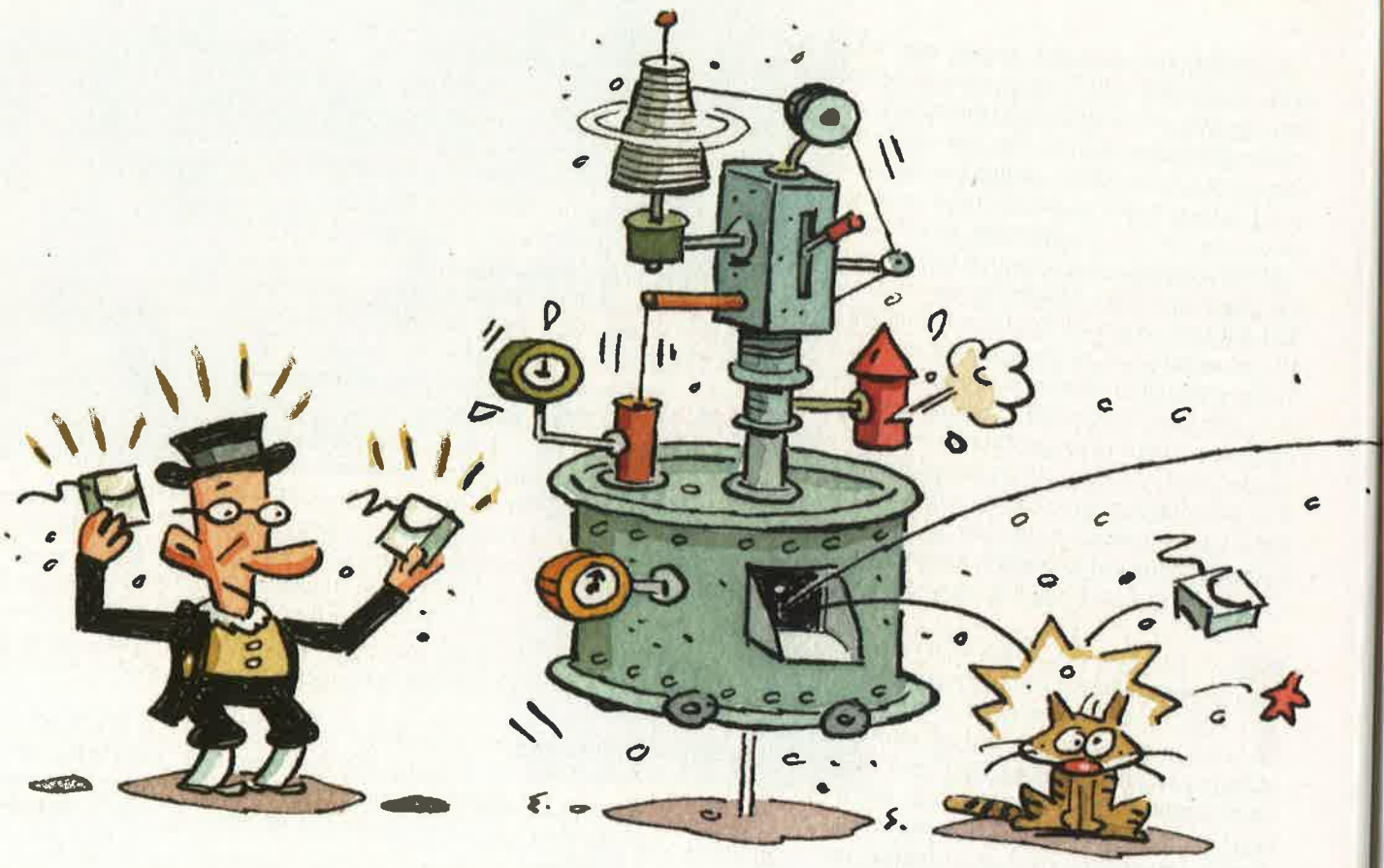


EVERY YEAR MORE THAN THREE MILLION MILES OF dental floss are sold in the United States. That's a lot, but the total should be much higher, since that amount works out to only about one flossing per week for the average American. Dentists recommend flossing at least once a day to prevent gum disease, which robs more adults of their teeth than all other oral problems combined. A recent study reported that almost half of Americans feel guilty because they don't floss their teeth, and 32 percent feel even more guilty for lying to their dentists about it.

Dental floss is a newcomer compared with the toothbrush. The modern-style toothbrush was first mentioned in a Chinese encyclopedia of 1498. It was made with hog bristles perpendicular to a handle of bone. Floss was the invention of an American dentist, Levi Spear Parmly, who was born in Braintree, Vermont, on August 29, 1790. A member of a prominent family of dentists, he first practiced in New York City but soon moved to New Orleans.

Parmly was disturbed by the miserable teeth and poor oral hygiene of most Americans. Toothbrushes, although available, were expensive, and while tooth powders were marketed in limited quantities, they, too, were out of the reach of the typical American. Most people relied on homemade cleaners, such as gunpowder or table salt. A cloth, dipped in water and then into one of these mild abrasives, was used to scrub the teeth.

In 1819 Parmly published a book called *A Practical Guide to the Management of the Teeth*. In it he stressed the need for good oral hygiene to prevent tooth decay: "I can with confidence assert, that if the teeth and gums are regularly cleaned, no caries [decay] can possibly take place." He went on to list three tools necessary to achieve this goal: the toothbrush, the dentifrice, and what we know today as dental floss.

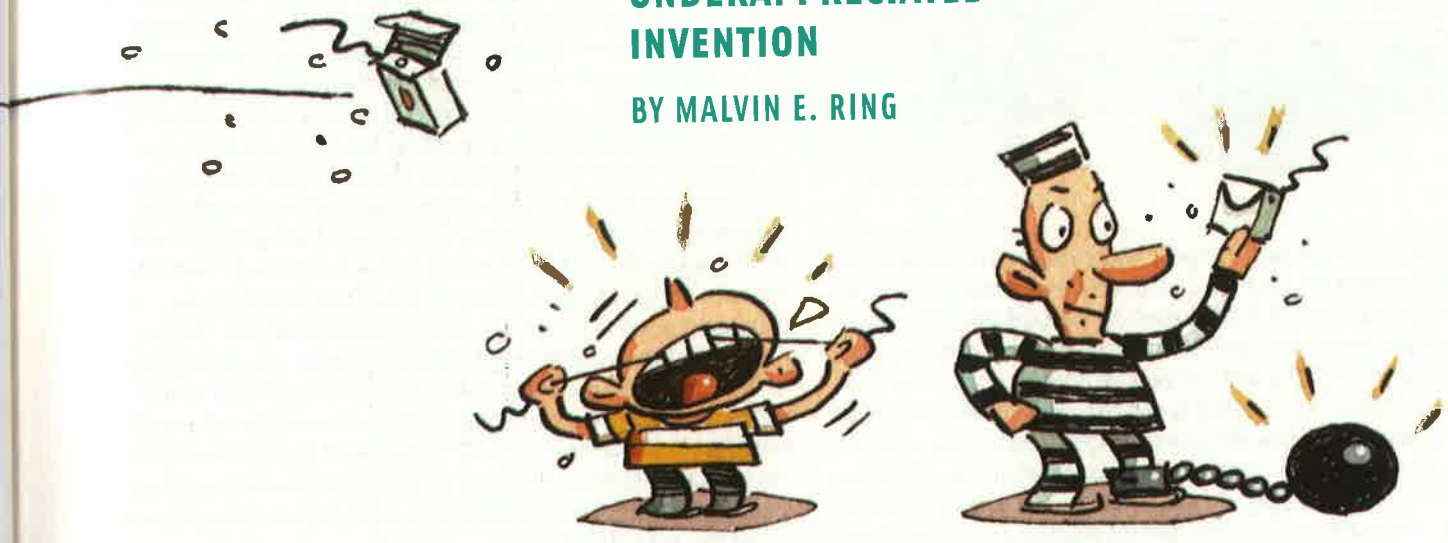
"The third part," he wrote, "is the waxed silken thread, which, though simple, is the most important. It is to be passed through the interstices of the teeth, between their necks and the arches of the gum, to dislodge that irritating matter which no brush can remove, and which is the real source of disease. With this apparatus thus regularly and daily used, the teeth and gums will be preserved free from disease." Later in the book he restated his belief that "a thread passed between the teeth after every meal will save more teeth from decay than all the brushes and powders that can be used where the waxed thread is neglected."

Although his claim that flossing would infallibly prevent tooth decay was too simplistic—other factors are at work besides trapped food particles—his was an impressive discovery. Gum disease results from an accumulation of a harmful substance known as plaque, which is produced by oral bacteria. It can be successfully removed from between the teeth by assiduous at-

OUR DAILY THREAD

DENTAL FLOSS IS A GREAT UNDERAPPRECIATED INVENTION

BY MALVIN E. RING



ILLUSTRATED BY ELWOOD SMITH

tention to flossing. Because of his pioneering writings, Parmly is sometimes called "The Apostle of Oral Hygiene."

In 1836 a renowned New York City dentist (and, like Spear, a Vermont native) with the quaint name of Shearjashub Spooner wrote *Guide to Sound Teeth*. He, too, recommended that the "front teeth may be polished on their sides by running a silk thread with powdered pumice stone between them." Yet in spite of the obvious benefit to be obtained from the use of floss, it was not readily adopted by the public. Even brushing was still practiced primarily by the upper classes. In the first half of the nineteenth century there were few trained dentists in America to spread the word about flossing. The first dental school in the world, the Baltimore College of Dental Surgery, wasn't established until 1839. And advertising of consumer products did not become pervasive until near the end of that century.

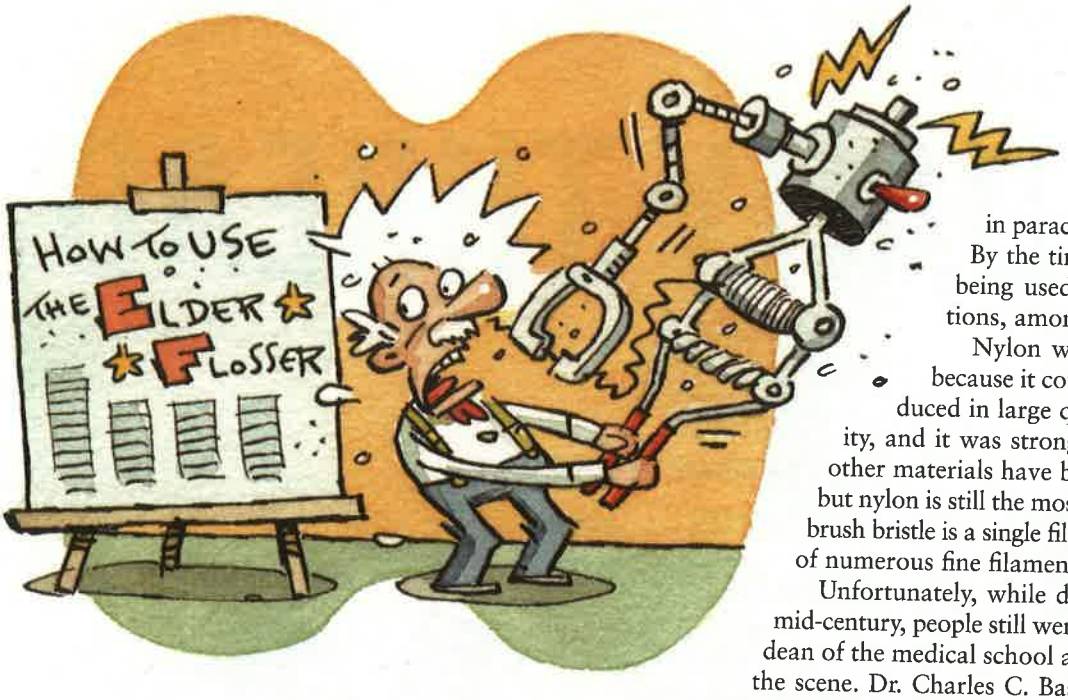
A good indication of the limited use of floss can be found in the 1856 *Lady's Guide to Perfect Gentility*. This widely circulated book, teaching young women the niceties of grooming and demeanor, devoted 15 pages to the care of the teeth, even recommending a "quill toothpick to remove food particles." Yet it didn't mention flossing, although this was nearly 40 years after floss had been introduced.

One reason for the limited use of flossing was that thread suitable for use as floss was expensive. In a normal, healthy mouth, the teeth are in tight contact with one another. Consequently, anything that is pulled between them must be strong enough to withstand shearing. Ordinary cotton thread is too weak for this, but silk thread has great strength and can be passed repeatedly between the teeth before it frays and eventually tears.

Silk was discovered in China around 3000 B.C., but by A.D. 200 the secret of its manufacture had spread to other countries. The Chinese lost their monopoly, and Japan became the leading producer of silk, though during the nineteenth century many Western countries also started manufacturing it. For all their famed inventiveness, the Chinese never thought of using silk to clean their teeth, and to this day floss is very hard to find in China. But in America, Parmly realized that silk was just what he was looking for—especially when it was waxed, allowing it to slide more easily. Silk continued as the desired material for floss until the introduction of nylon in the 1940s.

The first patent relating to floss was issued in 1874 to Asahel M. Shurtleff of the dental-supply company Codman & Shurtleff, of Randolph, Massachusetts. It described "An Improved Pocket Thread Carrier and Cutter," which was not much different from today's packages of floss. The company did not begin actively marketing floss until 1882.

Widespread distribution of dental floss was first accomplished by the Johnson & Johnson Company. Robert Wood



Johnson had been very strongly impressed by the work of the English physician Joseph Lister, who introduced antiseptic surgery in the late 1870s. Johnson recognized that there was a market for ready-packaged sterile bandages and surgical dressings, and in 1885 he and his two brothers started their company on a shoestring, renting a small fourth-floor loft in an empty factory in New Brunswick, New Jersey. They sold not only dressings but surgical sutures made out of silk. This gave them the idea to produce dental floss from the same material. It was trial-marketed in 1896, and the product apparently found its niche. Other brands, such as Red Cross, Brunswick, and Salter Sill, began to appear, and around 1900 Johnson & Johnson bought the Codman & Shurtleff Company, the first commercial floss producer. Today Codman & Shurtleff is still an active division of Johnson & Johnson.

Making floss available was one thing; getting people to use it was another. In March 1907 Dr. C. O. Kimball sent a questionnaire to boarding schools in New Jersey, Massachusetts, and Connecticut, asking about their students' oral-hygiene practices. More than two-thirds of the schools said they did nothing to improve the care of their pupils' teeth. Only one all-girls school required pupils to clean their teeth with brush and silk thread after each meal, with "a trained nurse standing by to see that they do it."

As in so many areas of technology, a major advance came out of World War II. By the early years of the twentieth century the manufacture of silk in this country had almost disappeared, since it was cheaper and easier to import from Japan. So when the supply of silk was cut off by the Japanese, America had to find a substitute. The DuPont Company had already offered its newly invented textile, nylon, as a substitute for silk in parachutes for the Army Air Corps. By the time the war ended, nylon was being used in dozens of other applications, among them dental floss.

Nylon was an ideal material for this because it could be easily and cheaply produced in large quantities with uniform quality, and it was stronger than silk. In recent years other materials have been adapted for dental floss, but nylon is still the most widely used. A nylon toothbrush bristle is a single filament, but nylon floss is made of numerous fine filaments twisted together.

Unfortunately, while dental floss had improved by mid-century, people still weren't using it. Then the former dean of the medical school at Tulane University came on the scene. Dr. Charles C. Bass was a physician who had specialized in infectious diseases. He was shocked by the terrible oral health of his patients, which he thought contributed to their poor general health. In the late 1940s he set out on a one-man crusade to educate the public. But first he produced his own specially designed floss—unwaxed nylon yarn composed of loosely wound filaments. He sold his floss only to dentists who were willing to come to his office, where he would teach them the "correct" technique. Recent studies have contradicted Dr. Bass, showing no difference in effective cleaning between waxed and unwaxed floss and finding that patients prefer the waxed type.

Our understanding of dental processes has improved greatly since Levi Parmly published his pioneering book, but what he said then remains true: Flossing is still the most important preventive measure to preserve one's teeth, and not nearly enough people practice it. The 1980 *American Yearbook of Dentistry* said that "less than 15% of people receiving regular dental care use some form of interdental cleansing daily. This is due to several factors [among which] is the lack of an easy way to accomplish this task."

FLOSS IS USED IN HUNDREDS OF WAYS NEVER DREAMED OF BY ITS

To remedy this problem, many minds have gone to work creating new types of floss and new varieties of floss holders and utensils. Since 1975 more than 1,300 U.S. patents have been issued for changes or improvements in floss and floss peripherals. Many of these were for holders intended to make flossing easier or more fun, especially for children. One holder takes the form of a modernistic shark, with the floss drawn out between its teeth. Another is a little plastic man that children can hold in their hands while he pushes the floss between their teeth.

There is still a great need for a holder that is easy for the elderly and disabled to handle. One such device is so complicated that three pages of pictures and text are required to ex-

plain how to refill and use it. Some simple holders are available, however. Made of plastic, they resemble a pair of pliers, with the floss stretching across the jaws of the instrument. When the handles are squeezed, the tension on the floss increases, allowing the user to manipulate it between the teeth without winding the floss around the fingers.

CHANGES HAVE ALSO BEEN MADE IN THE SURFACE CHARacteristics of floss. One recent patent is for "floss having spaced, spherical protuberances along its length that improve the ability to remove unwanted material trapped between teeth," while another is for a ribbon of biodegradable polymer with loose frills on each side to aid in scouring the teeth.

Oral-B produces a Super Floss, which is made of three components in series: regular nylon filament, then a loose mesh of finer nylon, and finally a stiff, thicker filament. As the floss is drawn between the teeth, each component does a different job. In 1998 Moll Industries, of Knoxville, Tennessee, brought out a braided floss that it said had greater tensile strength than unbraided. Gillette Canada, pursuing a different route, is coating ordinary nylon with a resin to improve its abrasivity.

One of the most successful floss newcomers was introduced in 1992 by W. L. Gore & Associates under the name Glide. In 1969 Robert Gore, son of the company's founder, had found that if Teflon (or PTFE, for polytetrafluoroethylene) was heated, cooled, and then stretched, it formed a strong, porous material, which Gore dubbed ePTFE, for expanded Teflon. When woven into fabric, this fiber had nine million microscopic holes per square inch, allowing molecules of water vapor to escape but preventing their entry. This became the basis of the "breathing" fabric Gore-Tex.

Company engineers realized that ePTFE could also be used to make an improved type of floss. Glide, which is now marketed by Procter & Gamble, has captured a large share of the market because of the ease with which it passes through tooth contacts without tearing. A study in 2001 at the University of Heidelberg, Germany, used sophisticated measuring devices to determine the amount of force needed to pull different types of floss between the teeth. Glide was significantly easier to use and was favored by most of the study's participants. In 1992 the noted dental scientist Dr. Sebastian Ciancio, of the School of Dental Medicine at the SUNY Buffalo campus, found no significant difference in plaque removal among waxed, nylon, and Glide, yet 74 percent of the study's members preferred Glide, saying it was easier to use.

The idea of impregnating floss with a flavoring or performance-enhancing agent is nearly as old as floss itself. The earliest mention can be found in an 1876 patent by a New York dentist named Eleazar Parmly Brown, the godson of the discoverer of floss. He soaked strands of silk floss in carbolic acid to disinfect it before putting it on a spool. Today companies are impregnating their floss with a variety of materials, some therapeutic and some not. One uses a patented breath freshener; a Korean company adds xylitol, a noncariogenic sweetener; and another company, Desert Essence, pushing the exotic, sells a floss that is impregnated with tea tree oil.

Most such additives are essentially marketing devices, but a few have proved beneficial. A group of researchers in Boston impregnated unwaxed floss with enzymes that destroy the bacteria that cause dental caries and periodontal disease. This process is now starting to show up in commercial products. Other additives aid in whitening or react with saliva to release a substance that helps sensitive teeth. In 1990 an inventor patented a floss impregnated with nicotine, to help smokers quit the habit. So far no studies have proved its efficacy. What seems to be the ultimate floss is designed to appeal to vegetarians as well as those who want organic and nonpolluting materials. The product, Gentle Floss by Eco-Dent, is advertised as biodegradable, recyclable, and 100 percent vegan, containing no beeswax or mineral wax and impregnated with menthol, anethole, orange, fennel, anise, geranium oil, oil of bergamot, basil, lavender, rosemary, rose, potassium thiocyanate, lactoferrin, lactoperoxidase and glucose oxidase.

The great strength and almost unbreakable nature of modern dental floss has led to its being used in hundreds of ways never dreamed of by its inventor. As one article puts it, "Dental floss is the new duct tape." A clever scam occurred in April 2002, when an offender sentenced to 64 days in the Okanogan, Washington, county jail told the sheriff that he was claustrophobic and needed more time in the exercise yard. He used the time to cut through the steel of a wire-link fence using floss and toothpaste. He then pried the links apart and made his escape. A prison official said, "I couldn't believe it until I did it myself." Two years earlier a Texas inmate had used the same method to cut through the bars of his cell, then burst out at an opportune time and stabbed a member of a rival prison gang to death. The prison was put in lockdown, with all cells searched for dental floss.

A West Virginia convict traded cigarettes for floss and wove a rope long enough to climb over the prison's 18-foot wall, only to be captured and sentenced to an additional five years. The state of Maine then prohibited the possession of floss by inmates, leading one to sue for "stress and anxiety over the inability to fight tooth decay." One of the most daring floss-driven escape attempts came in November 1988, when three prisoners in New York City's Metropolitan Correction Center

INVENTOR. ONE ARTICLE SAYS, "DENTAL FLOSS IS THE NEW DUCT TAPE."

DR. MAYO SAID FLOSSING "CAN ADD TEN YEARS TO YOUR LIFE."

climbed out a window and slid down six stories on a dental-floss rope thinner than a pencil. They were caught, and the floss cut into the hands of one inmate deeply enough to sever some tendons.

Such a strong fiber was certain to find medical uses. A few years ago a spearfisher off the Bahamas was attacked by a shark that severely tore his right arm. He would have bled to death if not for his fiancée, a nurse, who pulled him into their boat, found some dental floss, and tied off his severed arteries. Less dramatically, it is common practice for anesthetists to secure an endotracheal tube during surgery by tying it to the patient's teeth with floss.

Floss comes to the rescue in many emergency situations. In 2002 Terry Watson, a Florida sailor, ran into a severe storm en route to Denmark. For more than two months he was missing at sea, but he managed to keep his vessel seaworthy with tape and dental floss, which he used to mend his torn sails. Survival kits for hunters often contain floss, which can be used to catch fish, make a net, trap small animals, and repair backpacks, tents, or clothing.

In the home, floss can be used for cleaning the crevices in wooden furniture legs, hanging pictures (floss does not stain the wall, as wire does), separating photographs that have become stuck to one another, and sewing buttons on coats. Even animals benefit. There is a chew toy for dogs made of strands of floss tied together in the shape of a bone. As Fido gnaws on it, the nylon strands remove plaque and tartar. Scientific uses include strapping tiny transmitters to the backs of snowy owls to study their migration patterns. In law enforcement, saliva adhering to floss has been used for DNA testing.

THE LATE FRANK ZAPPA HAD A HIT SONG WITH "MONtana," in which he fantasized about becoming a "dental floss tycoon": "I might be movin' to Montana soon / Just to raise me up a crop of dental floss / Raisin' it up / Waxin' it down / In a little white box / I can sell uptown." In a song called "I've Got Gingivitis," the Canadian band Show Business Giants laments contracting the title illness "because I wouldn't go out of my way / to brush and floss three times a day." The Netherlands boasts a rock band called Dental Floss, and the American group Carbon Leaf includes a song about floss in its repertoire. The song was composed spontaneously onstage while waiting for technicians to fix a problem with the microphones.

"Floss or die!" That was the message Dr. Raul Garcia, a periodontist from Boston, brought to a conference of dental researchers in 1998. The phrase was picked up by the Associated Press and received wide coverage, with stories on the relationship of gum disease to life-threatening disorders such as heart attacks. Extensive research in America and abroad has shown that diligent use of dental floss is an excellent way to help avert these threats. Even Dr. William Mayo of the famed Mayo Clinic once said, "Daily plaque control can add ten years to your life." Yet with all this evidence, only about 15 percent of the population flosses regularly. Here, as is true with so many medical problems, a simple and inexpensive remedy can do more than the most advanced techniques and most high-tech drugs in the world—if only people would take advantage of it. ★

DR. MALVIN E. RING *is a dentist in Rochester, New York. He is the former editor of* Bulletin of the History of Dentistry *and the author of* Dentistry: An Illustrated History *(1985).*