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## EPISODE OPEN

WOODIE FLOWERS A fish story with no fish ... a secret underwater weapon ... and a race to save a trapped whale -- on Scientific American Frontiers. Also ... planning the attack on a killer disease. Howler monkeys in Costa Rica put the bite on anthropologists. Hot wheels designed by users take the lead in the Boston Marathon. And a new concept in frozen food: taste. It's all coming up -- on Scientific American FRONTIERS.

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## WALE RESCUE

WOODIE FLOWERS (in ticket booth) Good morning. That'll be 18 dollars each for the adults, and 12 dollars for the kids.

WOMAN IN LINE What time does the boat leave?

WOODIE FLOWERS At 9:30, from the pier down there.

WOODIE FLOWERS (TO CAMERA) Boy, just look at that line! People waiting to buy tickets, boarding ship Woodie. These folks are happy to pay, and spend six hours on a boat, all in hopes of catching even a glimpse of a whale.

WOODIE FLOWERS (ON SHIP, TO CAMERA) Hi, I'm Woodie Flowers, and welcome to Scientific American Frontiers. You know, people here in New England are crazy about whales: a million people a year take one of these whale watching cruises. But less than a thousand miles from here, that way, are the Canadian maritimes -- and up there, just about the last thing folks want to see is another whale.

NARRATION The mournful cry of a humpback whale. Racing to save its life -a team of Newfoundland scientists led by Jon Lien. The whale is caught in a fishing net. If it can't reach the surface to breathe, the whale will die. When you're trying

to rescue a thirty-ton animal, the most important thing is to keep it calm. The work is cold, dangerous and most of all -- frustrating. Lien knows these whales of Newfoundland intimately. He's been face to face on over five hundred rescues. With the water temperature just a few degrees above freezing, Jon has to work from the surface. Still occupational hazards are severe -- sinus problems, pneumonia, and the constant fear of the powerful fluke. The struggle has gone on for almost three hours .... Partially free, the whale is now dangerously mobile .... Then with one final cut, freedom. But the rescue's not complete until they haul in the valuable net. For Jon Lien is saving two endangered species: the whales and the fishermen.

JON LIEN Our fishermen do not earn a lot of money, they have a big investment, they have a very short season and it's a real tough job. So when a whale comes and hits their nets right in the middle of fishing season they might lose enough time that they might lose their whole year voyage. So it's a real tough problem for the fishermen.

NARRATION Fishing is what keeps much of Newfoundland alive. Just off shore is one of the world's most historic fishing grounds-- the Grand Banks. When John Cabot discovered these waters in 1497, he reported the cod fish were so plentiful he didn't even need a net. Seeing catches from as late as the 1950s, it's almost believable. But five centuries of constant fishing by locals and foreigners have finally taken their toll. Today the cod fishermen of Newfoundland still use traditional techniques: They work from dories -- and haul their gear by hand. But now their nets are empty. Roy Careen, the skipper, is a fourth-generation fisherman struggling to stay afloat.

ROY CAREEN The fish is not as near as plenty this year as it was last year. Seems like every year it's slacking off all the time, getting scarcer and scarcer every year. You got to use more gear now to catch the same amount you did the year before. With fewer fish, the only way to eke out a living is to use more. nets - - but that brings tragic consequences for the whales.

NARRATION By the time Jon's team arrived, this whale was already dead. All they can do now is try to help the fishermen. But the \$5,000 net is so badly tangled, it may be a total loss. For Lien, it's the worst accident of the season. But the whale's death will not be in vain. Jon is determined to find out why whales collide with nets. The first step is hauling all 70,000 pounds a shore. No one's sure how these animals detect objects like nets. Eyesight is unreliable in the murky ocean. So Jon is studying the whale's hearing. Every cut releases the foul smell of decomposition gases. It's a task for only the dedicated.

JON LIEN Well, I think for a scientist it's just amazing how this huge animal works. We understand it only very poorly. And it's a rare privilege to get inside of

it like this, even though it's kind of gross. To begin to see how the parts fit together how they might make the animal work. It is a little bloody and a little wet but it's fascinating. After hours of delicate and not so delicate work, they find what they're looking for: this is an ear of a humpback whale.

NARRATION Jon thinks these ears are so sensitive the animal uses them the way we use our eyes. But cod nets are silent, and that means for the whale they're invisible. To make the nets noisier, Lien is designing whale alarms. About 50 fishermen got experimental models last year. Today he's delivering a second set of alarms to Ken King. The alarms make a simple clinking sound. It's at a frequency the whales can hear -- but the cod fish can't.

KEN KING Last year when I had a cod trap in the same area it was tore up everyday, never missed a day. Had holes in the leader holes in the trap. And then I contacted Jon and I got seven of these alarms. I put four on the box and three on the leader and from the sound that they made I thought it would frighten the fish. But the best catch we had for the season for one day, 22,000, was the day after we put these things on. I knew it didn't frighten the fish. And for the six or seven days after the fish got a little less because it was getting to the end of the season. But no more whale holes, thank God. In the latest trials, the alarms are a success -- so there's hope of saving fishermen thousands of dollars and the whales their lives. But as one problem may be solved, another gets worse. The Grand Bank cod stocks have fallen to record lows. Rumor has it the government is planning drastic action. The fishermen gather for a press conference. Anticipating trouble, the minister of fisheries makes his announcement from an adjacent room.

MINISTER OF FISHERIES I have decided that effective at midnight tonight there will be a moratorium on harvesting of northern cod until the spring of 1994.

ANGRY FISHERMEN ...and if there are some men willing to go with me, we should go down and knock on that door. Rage and defiance, as the Grand Banks are closed for at least two years.

FISHERMEN Would you sit back and watch your 4 year old kid starve? I'm not going to. I'm going to keep fishing. What are you going to do, oh Jesus, lot of young fellows involved. They talk of retraining -- what are they going to retrain -- picking apples cutting firewood? Not very much to look forward to now.

NARRATION A few days later, the fishermen bring in the last nets. Some are angry; some, hopeless; but many realize that the moratorium is a last ditch effort to save their way of life.

ROY CAREEN Certainly got to be something done. If it keeps going the way it's going there be just no fish. And if there's no fish there's going to be no Newfoundland.

NARRATION It will take years for the stocks to recover -- years of pain and hardship for the 20,000 Newfoundlanders now out of work. Jon Lien will use the time to perfect his alarms, with the hope that when fishing resumes, cod nets will no longer pose a threat to the whales. For now, the whales have these waters to themselves. But with patience and proper management, the Grand Banks will again -some day -- support whales, fish and fishermen.

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## RETURN OF A KILLER: TUBERCULOSIS

NARRATION This trailer park near Ft. Myers Florida is in the grip of a public health crisis. The people who live here may have been exposed to an ancient and deadly disease called tuberculosis. Because TB is so contagious, a recent outbreak here could become an epidemic. So the Health Department has dispatched Bonnie Goyette and her TB control team...to find out who's most at risk.

BONNIE GOYETTE Someone who has infectious disease- coughs, sneezes, laughs- can spray it into the air and you inhale it and that's how it gets into your lungs. People who have been exposed to tuberculosis, if they're healthy, maintain a healthy lifestyle, their own immune system can keep this from progressing to disease. This man's immune system did not protect him. Jay Linares has advanced TB. He's lost a lot of weight, he's suffering from severe chest pain and he can't even breathe without supplemental oxygen. Jay is wasting away.

JAY LINARES I was once a Marine. I could charge up a hill. Basically I felt like I could lift a car...that strong...that well fit. And now, if I walk two blocks...or when I was very ill...I considered myself superman.

NARRATION Jay is being treated at National Jewish Hospital in Denver, a hospital that thought it got out of the TB business 30 years ago. At the turn of the century, National Jewish was completely dedicated to curing tuberculosis. The prescription was careful medical supervision, surgery, sunshine and rest. Sanatoriums like this were also intended to take infectious patients out of the community. That was the only way to stop the spread of a disease that was killing more than 150,000 Americans every year. Then research uncovered antibiotics that could cure TB. Most everyone believed the country would be rid of tuberculosis by the year 2000. But for Jay the antibiotics aren't working. That's because he has a new kind of TB, drug resistant TB. Suddenly tuberculosis is on

the rise again...and the irony is we've made it happen by abusing the very miracle drugs that were supposed to save us.

JAY LINARES I became drug resistant because I just kept throwing the medicine away every time I felt better. OK, every time I got better I used to like, just let go of the medicine. And before you know it, about 2 or 3 months later, here I go again with the same pain the same symptoms.

NARRATION Here's how drug resistance happens. Regularly, a TB bacterium mutates so it can resist attack by one antibiotic. Standard treatment uses more than one antibiotic- to ensure that all bacteria, non-resistant and resistant are killed. But now suppose that after taking the first drug, the patient feels better and stops medication. The original TB bacteria and the resistant type both continue growing...that's bad...so eventually you start therapy again to cure yourself. The problem is- that's not how it happens. Remember, mutations take place. And so new resistant bacteria emerge...and even if you resume therapy, the newest mutants survive and can be passed on to the next victim. That's why Bonnie and the Ft. Myers health department have to mobilize quickly.

NORMA When are we going to X-ray these people who turn out positive?

BONNIE GOYETTE If they have any symptoms, we're going to make arrangements to have those people x-rayed tomorrow. If they are asymptomatic...If the TB in Ft. Myers is drug resistant, they could have a disaster on their hands.

WOODIE FLOWERS The crisis began a few weeks ago when this man from the trailer park came to Bonnie with a persistent cough. Tests showed that Miguel de la Madrid had infectious TB.

BONNIE GOYETTE If you would have him explain to me about how he takes his medicine, when he takes the red pills, when he takes the white ones ... Confronted with the possibility of a drug resistant case, the only safe thing Bonnie Goyette could do was to prescribe a whole array of antibiotics. Now her job is to make sure that Miguel is taking them.

BONNIE GOYETTE Norma, would you ask him if he's...how he's feeling generally. Better? No cough?

NORMA (Spanish translation of question)

MIGUEL (Spanish answer)

NORMA He feels much better now that he's taking the medication.

BONNIE GOYETTE Even though you're feeling better it's very important that you continue to take the medicine, just like you've been doing. Very important.

MIGUEL Si! Bonnie won't know for a while whether Miguel is drug resistant or not...meanwhile she's watching his wife and children closely because they're the most likely to be infected by him. Co-workers and close friends are also at risk because they spend time with Miguel in cramped quarters, sharing the air he breathes. If he comes in contact with HIV infected people, they're almost certain to get it. What makes Miguel's case so alarming is that he was recently cooped up with hundreds of people from all over Ft. Myers.

NARRATION About six weeks ago heavy rains caused a flood in Miguel's trailer park. Over 500 people had to be evacuated from their homes. Most of the flood victims were sent to the local high school, where a Red Cross shelter was set up in the gymnasium. Summer school was in session and about 150 students were sharing facilities with flood victims. For 10 days the gym was packed with evacuees, relief workers, policemen and firemen. Over 800 people were exposed to Miguel's TB.

NURSE OK Shamika, you're going to have a TB test OK?

NARRATION So Bonnie and her staff have to test everyone who spent time at the shelter.

NURSE Very still, it's not going to hurt, it's going to feel like a little mosquito bite now. Hold still. That's it. That's it. Hold still now, hold still. That is it. That's it. See this here? Look at there. Now what I want you to do is don't scratch it, don't pick at it or anything, OK?

LITTLE GIRL That hurt a little bit. I almost started to cry!

BONNIE GOYETTE Hi Carlos. Have a seat here. Let's see how your test turned out. Two days later, Bonnie returns to the high school to see who's been infected.

BONNIE GOYETTE You have a positive reaction to this test.

DAN Are you kidding me?

BONNIE GOYETTE No. If you'll take your finger and rub over it very gently you can feel that there's a little lump under the site there.

DAN Yeah, I can feel it.

BONNIE GOYETTE Feel it? This lump looks a lot like a mosquito bite. or more, If it measures 10 mm he's been infected.

BONNIE GOYETTE Ok that's right out at 10 mm. That's what we would consider a significant reaction.

DAN Significant?!

BONNIE GOYETTE The positive test that you have now simply means that sometime during your life you have been exposed. It could have been last year it could have been even twenty years ago.

DAN What is the next step involved?

BONNIE GOYETTE The next step now is going to be for you to get a chest X ray.

NARRATION At the trailer park, more bad news...positive test results and negative attitudes. Did she take medicine?... Ok they put her on the treatment but she did not take the medication...Why? ...Because I didn't want to take it. Drug resistant tuberculosis breeds on this kind of misunderstanding and apathy. Even for dogged public health workers like Bonnie, overcoming these problems is going to be tough. Jay's doctor, Michael Iseman is one of the country's leading TB experts. He's frustrated with trying to cure not just the patients, but the system too.

ISEMAN The biggest problem with tuberculosis control today really has to do with the social disorganization in many groups in America today; minorities and immigrants whose lives are so disrupted that it's very hard for them or the health providers to sustain even a six month treatment program to cure their TB. Related to that is the fact that many of America's major cities, where TB is still dominant, that the public health infrastructure, the programs that went out to treat and cure tuberculosis patients, have been allowed to fall into a state of decay that makes it very difficult for us to arrive at successful treatments. No change in the health care system is going to save Jay. It's too late. On August 4, 1992 at the age of 34, Jay Linares died of tuberculosis.

WOODIE FLOWERS (ON STEPS OF ELEMENTARY SCHOOL) If the new wave of tuberculosis in the U.S. continues to grow, these kids may one day have to wear badges to get into school. You see, a crowded, enclosed space like this building is a perfect breeding ground for airborne infection. If someone brings TB in here, a lot of people are put at risk. And that's exactly what happened a few months ago at the New York Commodities Exchange. A few active TB cases were identified among traders on the packed exchange floor. Today, you can't

get anywhere near the trading action unless you're wearing an ID like this --with a red sticker that shows the date of your last TB test. Nobody wants us or our kids to have to wear these, and we shouldn't have to, because there is a way to beat TB -- but it means all of us getting behind a major public health effort to educate, test ... and follow up on every case.

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## ART OF SCIENCE: SPECIAL SHOWCASE

DECFACE: Hello. viewers. Welcome to Scientific American Frontiers. My name is Decface ...

WOODIE FLOWERS (NARATION) Decface is inviting us to visit a futuristic gallery at this year's computer graphics convention -- featuring some outstanding examples of the art of scientific visualization. It's a head-on fusion of human imagination and powerful computers. In this God's eye view, an earthquake creates a tidal wave sweeping over the Sea of Japan. We can follow the towering waves across the ocean surface -- and watch how they're changed by the sea floor below. Here the simulated wave is ultrasound -- destroying a kidney stone without surgery. Computer visualization can even take scientists to the stars, to see what happens when an enormous jet of gas erupts from a galaxy. Behind this swirl of flowing gases are staggeringly complex computations -- but the result is a masterpiece of the art of science.

PAUL WOODWARD As our calculations get better, as they get more realistic and they resolve more detail, they become more beautiful. Now maybe they become more beautiful just to us, but I think also other people can appreciate that having more detail, having more structure, brings out more of the true beauty of nature. We've now entered a whole imaginary world -- the CAVE -- the most popular attraction at the entire convention. People are lining up for their first taste of the new graphics technology called virtual reality ...where you get to step inside moving three-dimensional images. It's hard to convey the impact of a 3D flight through Chicago on two-dimensional television -- but sailing into a galaxy brings you closer to the full experience. The CAVE is a preview of the promise of virtual reality -- a new realm for exploration, and for the art of science.

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## TOOTH OR CONSEQUENCES: HOWLER MONKEYS

NARRATION You don't need a Ph.D. in zoology to figure out why these monkeys are called howlers. But if you are an expert on primates, beware -- this small monkey community will upset one of your most confident assumptions. We're in

Costa Rica -- not the rain forest region that lures adventurous eco-tourists, but in a dryer strip near the Pacific coast.

KEN GLANDER Have to move on the other side.

NARRATION Ken Glander is a primate expert, at Duke University -- and for 20 years he's come from Durham, North Carolina, to Costa Rica to hunt howlers.

KEN GLANDER Got 'em.

NARRATION Of course, Ken's bullet is just a tranquilizer dart. His aim is to find out exactly what these monkeys are eating.

KEN GLANDER OK -- heads up! You're all right -- all right-- to your left -- your right. Back a little bit that way. Here she comes! Good catch! Good catch. She's a nice young animal. She's in excellent condition.

NARRATION She's still awake, but this monkey will stay comfortably numb for about an hour -- more than long enough for a complete medical examination in the field laboratory, just a few dusty miles away.

KEN GLANDER This is the same way the police take fingerprints. In fact I got this from the Cary, North Carolina, Police Department.

NARRATION Ken's adopted a foolproof method for keeping track of his patients.

KEN GLANDER OK. You've got a good one. Let me see what you got. Now pull it off, from the heel first.

NARRATION Remember -- Ken really wants to find out what monkeys eat. So he turns into a dentist.

KEN GLANDER His teeth are actually quite dirty. He hasn't flossed between meals. We have never found a cavity in 21 years, in some 800 monkeys. It's been shown that some of the food that they eat contains natural anti-bacterial, and that prevents the bacteria that cause tooth decay from growing in the mouth. Now let's put the cast material in.

NARRATION These casts are helping Ken overturn a long-standing idea in anthropology.

KEN GLANDER OK. Here we go. Good cast ...very sharp points.

NARRATION Young howlers set out in life with nice sharp teeth like this. But a steady menu of stems and buds is tough on enamel. In fact, researchers have always used tooth wear to estimate a primate's age: the more worn down the teeth, the older the animal. It seemed like a reliable method -- and Ken used it too -- until one day ...

KEN GLANDER Ten years ago, I captured two females, and gave one an age of 13 years, and the other an age of 23 years, based on the wear on their teeth. And it was only when I got back to Durham that, in looking at my records, I realized that those animals were the same age, in fact -- I had captured them as babies, and they were in fact 13 years of age. But one had almost no teeth -- she had the teeth of a 23 or a 25 year-old animal.

NARRATION The mystery led Ken to this spot. Piercing the dry forest range of the howler troupe is the Corobici River, flowing lustily even in the winter dry season. Lined with lush vegetation, this narrow green corridor is home to another howler colony. Here, just yards from the dry forest, monkeys feast on soft leaves and gentle flowers -- food that's kinder to the teeth than the dry forest menu. As Ken tracked down these diet differences more closely, he realized that even the leaves in the dry forest are rough on a monkey's molars.

KEN GLANDER If you look closely you can see that there's a fine coating of dust on these leaves, from all the dust that's in the air. And when howlers come and eat this, they're ingesting the leaves as well as the dust. And this grit is very hard on their teeth, because it causes rapid wear. It would be the same thing as if I were to eat sandpaper.

NARRATION Anthropologist Mark Teaford is taking an even closer look at diet and tooth wear. He's putting gold-plated molds, made from Ken's howler casts, under an electron microscope to magnify the surface two or three hundred times. Here, on a river monkey's teeth, you can read the results of a soft-food diet: the enamel is even, and there a just a few scratches. Now the teeth of a dry forest monkey.

MARK TEAFORD Initially, it might look like it's fairly similar to one of the river ones, but as we come into higher and higher magnification, you can see that the wear pattern is very different. There's much more microwear, far more scratches, and a fair number of pits -- these short wide features. So in the dry region monkeys eat gritty leaves from hardy plants, while in the river area just next door other monkeys eat soft food. And under the microscope, it's this difference in diet, not simply age, that shows up on their teeth.

NARRATION Meanwhile, the howlers in Costa Rica confronted Ken Glander with another puzzle. Why do the dry forest monkeys prowl the barren trees, in search

of food that's hard to find -- and tough to chew when they do find it? After all, the leafy banks of the river are not far away -- a much more inviting prospect than their own dusty precincts. But the river monkeys don't look fondly on scroungers from the dry forest troupe -- in fact, they guard their abundant greenery with a surprising fierceness. And when you watch the feeding pattern closely, as Ken does, you see that the river monkeys travel far between bites -- passing up many branches, then stuffing their faces on one judiciously selected bough.

**KEN GLANDER** In one case I had 149 individual trees of the same species in the range, and they ate mature leaves from only 12 of those 149 trees. And I was wondering why. So Ken collected leaf samples to analyze in his lab. And he found out why the howlers are so particular: most trees along the river are poisonous. His conclusions: Life for the howlers is hard, even where it looks sumptuous. And differences in diet show up as dental data on monkeys' teeth. But that's not the end of the story.

**WOODIE FLOWERS (IN MUSEUM, HOLDING SKULL)** In fact, it's just the beginning -- of a whole new story -- a story about ancient animals, including our own ancestors. It's really tough to make deductions about behavior and lifestyle from a fossil bone like this. For instance, what about the wear on these teeth? Is that telling us this two-and-a-half-million year old human ate roots, or nuts ... or maybe just lived in a dusty place? So far, we've only been able to guess. But now, for the first time, thanks to the painstaking work of researchers like Ken Glander and Mark Teaford, we're learning how to correlate tooth wear and diet in a reliable way. Ken set out to discover what howler monkey's eat, but he's come back with clues that will help us to read our own prehistoric past.

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## WHEELCHAIR RACERS

**NARRATION** The starting gun of the Boston Marathon -- one of the world's premier sporting events. Just to make this field, you need legs of steel. But some competitors can't use their legs at all. Paralyzed by injury or disease, these racers will pull themselves through 26 miles in wheelchairs. Like every runner here, they have to be in top physical form. But to win in this division, they also need hot wheels. Fast chairs are part of a design revolution -- a profound change that's been engineered by wheelchair users themselves. One of these user-designers is Rainer Kueschall. He didn't set out to be an engineer -- but life left him no alternative.

**RAINER KUESCHALL** When you are very limited you only have 2 choice to go forward or stay where you are and suddenly one day comes and you say 'I have

to do something with my life. Which way shall I go? And I went a positive thinking way.

NARRATION Watching Rainer work out in his native Switzerland today, it's hard to believe that a diving accident 26 years ago left him virtually paralyzed. His long recovery was made even more difficult by the wheelchair he was given. It's tough to push that conventional wheelchair, even up a ramp, as Rainer's associate demonstrates. As for climbing over curbs - forget it -- at fifty pounds, the chair's too heavy. And the main wheels are so far back that steering and maneuvering are really tricky. For FRONTIERS, Rainer reluctantly agreed to get back into the old standard wheelchair. All the discomfort and dissatisfaction he experienced years ago came back as forcefully as ever.

RAINER KUESCHALL My seat position is not good enough. My legs are much forward. The mobility is absolutely eliminated so I feel real disabled. Rainer refused to endure these limitations. decided there was only one thing to do: Ten years ago, he design his own wheelchair. RAINER I feel free., maneuverable., only like that am I able to be active. I think as you saw me before I never have a chance to survive outside.

NARRATION The standard wheelchair is heavy and high off the ground. Rainer's chair is lighter, lower to the ground, and most important -- the back wheels are directly beneath the seat. That makes it easier to maneuver the chair and to get more power into each push. Today Rainer is a world leader in wheelchair design, and he operates a factory in Basel. The engineering changes he made are simple enough -- but they make a big difference because they come from a personal understanding of wheelchair riders' needs.

RAINER KUESCHALL We are wheelchair users and it is in our interest to squeeze the maximum out of it. That's why I think we found all these technical improvements in a short period of time that nobody saw before.

NARRATION Thanks to Rainer, and a handful of other user-designers, wheelchair riders can now tackle just about any sport they choose. One athlete who's made the most of the new mobility is Bob Hall. Like Rainer, Bob rejected the limitations of the standard wheelchair.

BOB HALL I found that the wheelchair was the most disabling aspect of my being and that really held me back. It was made for not really any other purpose than to sit there and I wanted to move and move fast.

NARRATION In 1975 Bob became the first athlete to complete the Boston Marathon in a wheelchair. That first ride was in this conventional chair. But he too became a user-designer -- and built this racing chair. The back wheels are

angled -- that puts the tops within reach for a power push, while providing maximum stability at the bottom. Bob's latest is this three-wheeler. A mere 17 pounds, it's been clocked at 40 miles per hour. Three weeks before the Marathon, Bob is struggling to come up with the extra edge of speed that could make him the winner. To give the chair sleeker lines, he's considering an idea from auto racing: taper the squared off back, so the whole frame becomes a streamlined diamond. And to reduce the weight, Bob's got another trick. For the first time ever, he's fashioning a wheelchair frame from titanium. It's an idea he got from racing bikes, which use titanium because it's light but extremely strong. With some delicate finishing work, the diamond frame is completed. And to get the most out of the new design, Bob's bringing in a top young racer. He's Craig Blanchette -- featured in this Nike commercial. The designers have opened new possibilities for disabled athletes. Craig is a genuine sports star who's making it big. Three days before the Marathon, Craig flies in from Oregon to take on Bob's new machine.

CRAIG BLANCHETTE How light is it?

BOB HALL What do you think?

CRAIG BLANCHETTE It's awesome. It's awesome.

BOB HALL I think it's about 12 1/2 pounds.

CRAIG BLANCHETTE Really...pretty amazing.

NARRATION Craig's usual event is sprinting -- and he discovers he can really fly in this chair. Now he wants to check out a key racing strategy -- drafting. With the old three-wheeler up front, Craig gets close in -- then he can ride the draft of reduced air resistance, and work less hard. Bob's design is shaping up as a real contender. Back in Switzerland, Rainer is also making final preparations for the coming race. As a quadriplegic, he won't compete directly with Craig, or with paraplegics who have full upper body strength. But just being in the same race is a personal victory.

RAINER KUESCHALL I think it's natural when you are slow you want to be fast. And when you see the big boys, the paraplegics, and so on you saw the possibility they could move and so ... I think it always a little dream of a quad, 'Wow, if I could just do that'. Race day in Boston... the preparations are over... time to warm up... for runners... and for wheelchair racers.

NARRATION Craig's new chair is ready to roll. Now the pressure's squarely on him: Can a sprint racer really cut it over the marathon distance?

CRAIG BLANCHETTE I'm feeling anxious and nervous actually. I'm ...I really don't know what I'm feeling actually.

NARRATION Fifteen minutes before the foot racers, the wheelchair racers take off on a rolling start. That's Craig in the blue helmet. The official whistle, and they're off. After just a few minutes, the field thins out, with Craig up front. Two miles later ... this trio makes a break from the pack ... with Craig hanging onto third. Jim Knaub, the 1982 and '83 winner, pulls ahead. Craig -already a little winded -- remains behind to ride the draft. Then, with a sprinter's spurt, Craig makes his bid for first place. Soon it's just a two-man race, with Jim and Craig trading first place. But behind the leaders ... ..the infamous Heartbreak Hill takes its toll. And for Rainer it's especially grueling. He's completely exhausted -- he can't push anymore -- but the crowd keeps cheering him on, and he pulls himself up the hill. Meanwhile, at the front, Jim Knaub begins to pull away from Craig. In a distance event, you've got to know how to pace yourself... Craig's fast chair can't make up for his inexperience. And the veteran wins his third race. He's wheeled 26 miles in one hour, thirty minutes. Four minutes later, Craig comes in second ... an outstanding finish for his first shot at a major marathon.

CRAIG BLANCHETTE Basically, all I did was try to hold onto second. tried to dial 911. Rainer finishes in a respectable three hours -- his bravery and persistence paid off.

RAINER KUESCHALL It's the hardest race I ever did. These hills take everything out of you. It was unbelievable ... the crowds. These people are absolutely crazy so I never could allow me to give up.

NARRATION The new mobility has progressed so far that a hundred-year-old foot race now has two winners. And as user-designed technology becomes available to all disabled people, everybody wins.

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## THE CUTTING VEG: SMART FOOD

WOODIE FLOWERS These days most farmers do this with machines -- but here at Old Sturbridge Village, they're dedicated to the faithful re-creation of life in nineteenth-century America. Even the vegetables are harvested and preserved just the way they were in the early 1800s. Stringing the pumpkin this way dried it out ... and hanging it kept it away from pests. There was a proper technique for storing each kind of food -- maintaining a good winter diet took a lot of work. Seeing what our ancestors had to do really makes you appreciate freezing and vacuum packing and all the other modern technology for preserving food... OK, so canned vegetables aren't exactly mouth watering -- but science is working on

that. Snap beans -- fresh from the harvest, now about to be canned. That way these vegetables will be available in a convenient form year round. But their snap won't. Malcolm Bourne, a food scientist at Cornell University, can show you exactly how bad these beans become. His lab is equipped with a machine that measures the curse of canned vegetables -mushiness. A heavy-fisted robot arm is about to make these beans history. This pathetic score -- point 3 -- ranks beans in the same mush league as stewed tomatoes ... and mashed potatoes. Fresh beans are much snappier -- and score 15 times better. What turns today's firm beans into tomorrow's mush? Heat. The first step in preparing canned beans is blanching -- a scalding shower in 200-degree water. Why this ordeal? Because the chemical reaction that makes beans ripen in the field just keeps on going even after they're picked. Beans will merrily ripen 'til they rot. Heat stops that reaction but causes mush. What Malcolm's discovered is a way around this bind.

MALCOLM BOURNE You put a vegetable in a pot, it might be a carrot, a green bean, a potato, or whatever, and you cook it and it gets soft. Everybody knows about that. But what my research showed is that there are two kinds of firmness in vegetables.

NARRATION The first kind of firmness is already there, inside the bean. Gases that form between plant cells keep the cell walls rigid. Heat makes these gases escape. But a second kind of firmness can be activated -- if the bean is processed the right way.

MALCOLM BOURNE We're still using a three and a half minute blanch time, but we've lowered the temperature to 145 degrees Fahrenheit. That's 55 degrees cooler than the standard blancher -- still warm enough to prevent rotting in the can, but cool enough to release the second type of firmness.

NARRATION Heat activates a protein called pectin, which turns into a sort of edible cement. Pectin is what makes jelly firm -- but it only forms at about 150 degrees -- just the temperature Malcolm has selected for blanching. A few hours later the pectin cement is set. Is it strong enough to keep the beans firm? Malcolm's plunger is the ultimate test. It's a success -- Malcolm's canned beans are ten times firmer than the mushy ones. Lowering the temperature works wonders for green beans. But for some cooked vegetables, it's not how hot but how long. For instance, how long does corn on the cob need to be boiled before it's frozen? That's an issue because boiling time affects flavor. And the effects get worse as the storage time gets longer. A lot of commercial frozen corn is stored for as much as a year before you bring it home. When you finally cook it, there's a problem. And if you can't put your finger on it, some professional tasters will help. First, corn boiled for 12 minutes before it was frozen.

TASTER #1 It's quite soft and mushy.

TASTER #2 Very bland.

TASTER #3 It really sticks to my teeth. I don't like it at all.

NARRATION All the symptoms of an overcooked vegetable. But how about corn boiled for just six minutes before it goes into the freezer?

TASTER #4 Crispier, but it tastes kind of like grass or hay.

TASTER #2 Doesn't taste like sweet corn at all.

NARRATION Professor C.Y. Lee knows that corn boiled for just six minutes is crispier. But that's not long enough to stop the ripening reaction. For corn, as for green beans, the result is lousy taste. There's only one way to stop the ripening: heat. It works in corn, just like in green beans. But there's a catch -- to get the entire cob hot enough, it has to be cooked for 12 minutes. And that's when the mush starts. Or when it used to, until C.Y. Lee engineered a solution. The hole lets heat reach inside and outside at the same time. So, in just six minutes, the cob gets hot enough to halt the ripening that spoils the flavor. Now, with a shorter boiling time, frozen corn stays firmer and tastes better. Well, they're making progress..., but if you really want the firmest, tastiest corn you can get, this is still the place to look. Next time on FRONTIERS, teams from England, Germany, the U.S. and Japan will compete in a world series of engineering. We'll track down foxes -- and fox people -- on the Channel Islands off California. And we'll find out why some smart kids have such a tough time with reading. So please, come on back and watch.

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