SHOW 105

EPISODE OPEN

NARRATION When the world's craziest contest goes international, can Japanese and American students play on the same team? Also, how can monkey mothers make monkey babies happy? The man who brings nature into the basement--then makes it work. A good night's sleep: can we do without it but still get through the day? And the machine that's supposed to make pizza. All coming up on Scientific American Frontiers.

NARRATION GTE brings you more than the power of telecommunications, light, and precision materials. A grant from GTE also brings you the power of a new world in Scientific American Frontiers. At GTE the power is on.

WOODIE FLOWERS Hi. I'm Woodie Flowers, host of Scientific American Frontiers. This is one of the current generation of sport and utility vehicles. I think they are marvelous. As you can see, they are powerful and tough. They are also quite comfortable and reasonably economical to operate. Really good engineering. This one is called "Navajo." Must be designed for the American wilderness, right? Well, look at the name tag. It's Japanese. Have they done it again? Beaten us at our own game? Well, not exactly. Sometimes things are not the way they seem. But I'm getting ahead of myself. We'll get back to this in a little while.

back to top

TOTAL TENNIS GOES TO JAPAN

NARRATION For years, a popular course at the Massachusetts Institute of Technology has asked students to build their own game-playing machines from a kit of parts. This year, for the first time, the MIT idea has been exported to the Tokyo Institute of Technology. Japanese students received an identical kit and the same engineering challenge. At both universities the students had just six weeks to build their creations. Then at MIT there was a tournament to see who could pull the tennis balls down from a mountain and deposit the largest number in a trough on the game table. The excitement is contagious. And when the Tokyo Tech students staged their contest, it was clear that this cross-cultural transplant worked. But there's more to come. The top ten from Tokyo Tech will meet the top ten from MIT in a world series of engineering design in Tokyo. The American students take with them the machines they built and the engineering savvy they've gained. But that doesn't feel like much as they set out for the engineering capital of the world. In Tokyo they're welcomed like celebrities. After all, the Japanese students think MIT is the engineering capital of the world. Each team has just six days to design their machines. And on this modified table, the contest will be tougher. The tennis balls start out on a higher mountain. And they have to wind up in a raised area the same color as each starting square. But all that's just engineering. The real challenge is communications, because teams will consist of one American student and one Japanese. Susie draws Toshibiro's name. They can shake hands, but can they talk? For Irene and Daiki, just learning each other's names is a hint that communicating is not going to be easy. How can the teams design machines together when they have barely a few words in common? The joint contest organizer, MIT Professor Harry West, has a suggestion.

HARRY WEST Therefore we would encourage you to make full use of the pens and paper and other material that you have for communicating to try to communicate graphically.

NARRATION It looks like this scheme can work. Chris and Naoto are doing plenty of scribbling and nodding. But when Susie tries to get across her strategy, it seems there's no communication at all. Toshihiro just doesn't get it. And the awkwardness continues at the party that night. Like all college kids, they know how to eat and drink. But the American students are flustered when the evening takes a more Japanese turn. Until the traditional welcome dance begins. And then something does start to happen. The American boys, with Greg and Chris in the lead, take the first clumsy steps to join the Japanese dancing circle. Maybe rock and roll would have worked too, but in any case, the barriers between the two groups begin to come down. While nobody had known quite what to expect, the first day ends on an encouraging note. And the new camaraderie carries over to the next morning. Irene and Daiki are working together in earnest on a joint strategy.

DAIKI When it starts my big machine goes to the mountain, and then her small machine which is on top of mine gets off, beats the stack, and collects balls.

NARRATION In the original contests the students all set their sights on winning. Now they're recognizing that the goal of this international match is different.

IRENE Whoever wins, I don't think that is really the point. I think just the fact that you can produce something by working with someone and having no language in common, it's a great accomplishment.

NARRATION But some of the American students are puzzled about how to work together. Chris, for instance, is confused because Naoto seems so unassertive.

HARRY WEST I think the Japanese students seem to want to, to really blend and really try to cooperate more, rather than taking a strong leadership role.

NARRATION In Japan students learn to cooperate. It's one of the factors behind Japan's economic success. And it's especially important in engineering.

HARRY WEST Design is in many ways the process of negotiation. And clearly the Japanese students are very good at doing that because they have this natural sense of trying to get together and form a consensus. And for the American students, at least to begin with, it's a little bit more of a challenge.

NARRATION Time away from the shop obviously helps. And the bright lights of Tokyo by night have a lot to offer. But it turns out that Chris and Naoto have exactly the same idea of a good time. Will they be able to bring this more comfortable companionship back into the engineering shop? Already, the few days allotted for constructing the machines are almost over. And something new is happening: the students have discovered they have a common language after all--the language of engineering. We don't have a clue what Toshibiro is actually saying, but it's perfectly clear to his fellow engineers.

HARRY WEST It's a universal language because the strength of steel is the same here as it is in the United States. The fundamental physics which describes the behavior of an electric motor is the same here as it is in the United States. So the students have this very large background that is common. All the physics and engineering and mathematics that they have learned. That makes it a truly international subject.

NARRATION A scramble to test their creations and fine tune their strategies. And suddenly it's the last day before the contest. To showcase the different machines, Harry West schedules a warm-up event. Each team gets to play a demonstration round, without any opponents. Daiki's big transporter neatly delivers Irene's harvester right to the top of the mountain. Remember, what counts is getting balls into the raised trough. This may be the most brilliant design of the lot--a tank with incredibly flexible joints. It can sweep off almost all the tennis balls, and then bulldoze a lot of them at once up into the trough. Decked out in matching headbands, Chris and Naoto have put together a true joint strategy. While Chris's huge contraption lumbers into position, Naoto scales the side of the mountain. This is real teamwork--and although it takes Chris a long time to maneuver his big machine to the other side of the table, the payoff is worth the wait.

HARRY WEST I think the teams that have been most successful have been those where the two members have sat on the same bench all the time. They've gone out drinking in the evenings together and there's been a sense of common understanding of what needs to be done.

NARRATION A former Tokyo Olympic stadium, the imposing site of the joint contest main event. And inside, an extravaganza that will be broadcast by Japanese TV. The elaborate display shows just how highly engineering is esteemed in Japan. With all the pomp that Americans normally reserve for sports heroes, each team is formally presented to the audience in the hall and at home. And although they're only teenagers, these young engineers rise to the occasion with poise and dignity. For Chris and Naoto, the first match starts just the way they planned it. But then Chris's machine is shoved away from the center of the mountain, revealing a conspicuous design flaw: now he's not perfectly lined up, so the balls aren't making it into the trough. Their opponents, the green team, are winning, 4 balls to 2. Time is running out, and Chris is jammed. But Naoto has a brainstorm--drives up the other side of the small mountain, and pushes green's balls into the red trough. Victory at the last minute--with an improvised strategy. It looks like it's going to be a great contest. But when Irene and Daiki come up, things don't go so well. They never get a chance to execute their strategy. Their opponents have one machine just for defense, and it bulldozes Irene's harvester into a corner. That's enough to take Daiki and Irene out of the contest. And it turns out this obstruction strategy knocks out team after team, including Chris and Naoto, and Susie and Toshihiro. All too soon, it's time for the finals. The flexible tank makes the first move. But this smaller machine is quicker where it counts. And then again the match turns into a defensive battle. The flexible machine is pinned, and since red has balls in already, that's all it takes to win. But winning the tournament is not what this week has been about. It's been about getting along in spite of barriers, about taking pride--"nerd pride," as the button says--in learning to work together as engineering partners. And about discovering many new ways to communicate and cooperate. As the future top engineers of the United States and Japan, these students have been building some of the most important bridges they'll ever work on. And that, says Harry West, is the point.

HARRY WEST It's very important for American engineers to learn to cooperate and to be able to work, to work together with Japanese engineers, because a lot of them are going to be doing that in the future. It's part of their job. We are going to have to learn to cooperate with other countries as well, for instance, Germany and France. The future is international. And we either recognize that or the rest of the world will just pass us by.

WOODIE FLOWERS I think Harry West is absolutely right. The future is international. And it's already here. Take a closer look at this apparently Japanese vehicle. Although it has a Mazda nameplate and a few parts made in Japan, the engine was built in Germany, the transmission is from France, the wheels are from New Zealand, and it was designed by Ford and assembled in their plant in Kentucky. The auto industry is global nowadays, and a lot of other industries are heading that way. The kind of partnerships that we just saw formed by the students in Tokyo are already a necessity.

back to top

BRINGING UP MONKEY

NARRATION The challenges of life. We all handle them in our own way. Some of us boldly. Some, a little more timidly. Where do we get out personalities? Some of our relatives seem to have personalities too. Did these young rhesus monkeys learn to be boisterous? Or are they stuck with behavior inherited from their parents as firmly as they're stuck with their own tails? Trying to find the answer is psychologist Steve Suomi, who studies a colony of 30 monkeys set up for the purpose. When Steve started his research ten years ago, he soon found out there are two kinds of young monkeys. This six month old is typical of the bold, daring type. Whereas, this one's showing clear signs of a shy and timid personality. So's this one. He just won't leave Mom alone. In fact, Steve Suomi says, different baby personalities go along with different kinds of relationships between mothers and babies: The boldest babies have a particular kind of Mom.

STEVE SUOMI Okay, here we have an infant that's unusually bold. Well away from it's mother, and he's interacting with these older monkeys. He's playing like crazy. But for him to keep this up, he has to make sure his mother is still around. So he will be going back to his mother just for a brief period of time, just to see that she's there. And then, satisfied, he'll go back out and start the play bout again. And this is how a mother gives her infant security. That is, she is available when the infant is frightened or needs some comfort. But she doesn't interfere when he goes out to explore.

NARRATION Now here's the other extreme--a clinging baby, which goes along with a mother who's very nervous. She likes to keep her baby well out of harm's way.

KATHLYN RASMUSSEN I'll record his initial status as zero. He's awake.

NARRATION This is a newborn, just six days old. The personalities of their monkeys, right from birth, have been checked out by Steve's research team.

KATHLYN RASMUSSEN There he goes. Good. And definite, oh, look at this. Almost, give him definitely a one, and a reach and follow.

NARRATION At this age an infant hasn't really had time to learn how to behave. So if they can detect any personality, it must be genetic.

KATHLYN RASMUSSEN Okay. There they go!

NARRATION They give standard development tests, like the ones human infants might get. And all the time, they're sizing up personality. This one obviously takes life as it comes. Nothing much seems to bother him. And as he grows up, he'll probably stay that way.

KATHLYN RASMUSSEN Cuddliness. How does he react to you?

ASSISTANT Do you need to ask? No, he's cuddly. Just definitely give him a high score for that.

NARRATION His mother is the relaxed-but-available kind, and he'll be a typical bold-and-daring baby. The discovery of such early and lasting behavior patterns has convinced the researchers that monkey personality probably isn't learned from parents--it comes down in the genes. Kathlyn Rasmussen.

KATHLYN RASMUSSEN We're beginning to see differences even as early as the first week of life in terms of some infants are just much more irritable. This one is particularly calm.

NARRATION Here's another newborn. No, he's not sick. He's just very, very nervous. He's reacting to the stress of separation from his mother, who is of the nervous protective type. In fact, the stress is so overwhelming for him that Mary Schneider will find it had to administer the tests. The researchers call this type of behavior "reactive." It'll lead to the timid baby type who isn't happy exploring on his own. That's how this little fellow will turn out.

MARY SCHNEIDER So this little monkey that's reactive, if we came back tomorrow and went through this test again, he would also be reactive. If we came back in two weeks, he would still be reactive.

NARRATION So behavior is inherited. But can it ever change? Can monkeys and humans learn something different? That's what this experiment is about. Mary has picked out a very reactive newborn, to be adopted and raised by the opposite kind of mother--the relaxed type. The first hurdle, though, is getting the foster mother to accept the baby. She might not. Now here's the foster mother. Mary will be closely watching the first encounter for any signs of trouble. It's a good start. She seems perfectly happy with her new baby.

MARY SCHNEIDER This is a mother that has immediately taken this infant up and will accept this infant and provide a very nurturing climate. She's got the baby's head positioned so that the baby's head is close to the nipple for, for nursing. Cradling it. Doing all the right things. A good mom.

NARRATION Two months later. Adopted baby and foster mother are getting alone fine. But is there any change in the baby? Has his mother somehow taught him her more relaxed approach to life? It seems she has. Now he's showing all the signs of being a bold young monkey, happy to play on his own. Not what you'd expect from his nervous reactive behavior as a newborn. Even more convincing evidence that the foster mother has changed the baby's behavior comes from this exploration test being set up by Kathlyn Rasmussen. The baby's living group will be enticed from its familiar cage with a trail of food. This new situation makes them all a little nervous. For the adopted baby, it'll be the first trip out of the cage. That's especially stressful. Still, bananas are a powerful inducement, so they head down the tunnel. Throughout this high stress time, the baby has been clinging firmly to his foster mother. Suddenly there's a squabble, prompting the whole group to scramble back to the security of the cage. But jut a few minutes later, the bananas reassert their power, and amazingly enough, the adopted baby is striding out boldly on his own. It's too much, even for his relaxed foster mother, so she tries to hold him back. But he's having none of it. It's a typical bold behavior patter. Transformation from timid newborn seems complete.

STEVE SUOMI With their foster mothers' backing, these patterns seem to hold as they grow older. So that, even though they may have a genetic risk for being shy or timid, they've learned how to cope with the challenges that they encounter larger through interactions with their nurturing foster mother.

NARRATION Four months later we're back with the development tests, with the same baby who started life as a nervous-reactive newborn, and then calmed down with a relaxed foster mother. But now, separated from his foster mother for the tests, he's not at all happy.

MARY SCHNEIDER This is an infant who has been with the foster mother, who is being nurturing, and he has done quite well with his foster mother. Now he is under conditions that challenge and he has reverted back to being a very highly reactive individual. He's upset. He's distraught. He's vocalizing.

NARRATION In extreme situations, the baby's genes win out. He was born nervous and reactive, and that'll always make it harder for his type to cope with a tough world.

STEVE SUOMI Highly reactive infants that grow up in benign environments won't have any problems at all. Highly reactive infants that grow in, up in environments full of stress and challenge, will need help if they want to make it through in a successful fashion.

WOODIE FLOWERS What Steve Suomi's research suggests is that a parent's behavior toward their child has a real effect--within limits--on that child's attitude about life. Does that mean that we want to take all of our very nervous and timid human babies and pair them up with carefully chosen, highly nurturing foster parents? Of course not. The thing that differentiate humans from rhesus monkeys is that we are not stuck in our behavior patterns. We can actually change if we want to. And I think the research shows something very simple: That ideal parents are always there when you need them.

back to top

NATURE IN A BOX

NARRATION A research vessel heads out into Chesapeake Bay. At the wheel, Walter Adey, who's devoted his life to a single question: how does nature work? Right here at least, the answer is, not very well.

WALTER ADEY It's going to take a great effort over many years to stabilize the Bay. And an even greater effort to bring it back to, to good condition.

NARRATION Adey's team is going fishing. MAN We're going to bring it over the port side.

NARRATION But not for the Bay's famous oysters or striped bass so sadly depleted nowadays. MAN Grab it along here. We can't see how far we can get.

NARRATION What they're looking for, most people would think of as just a water weed.

MAN Well here's a ...

NARRATION But to Adey and Matt Finn, it's a vital part of the Chesapeake, a basic building block of the Bay's ecosystem. Here's another building block, almost literally.

WALTER ADEY The idea is to prevail without, without wrecking the clump.

NARRATION How would you like to take a piece of marshland back from the shore? Water weeds and mud. That's what Walter Adey collects. Is he crazy? No, he's an enthusiast. He brings his trophies here to the basement of the Smithsonian in Washington where he reassembles them into a miniature Chesapeake Bay. Walter Adey builds model ecosystems.

WALTER ADEY This little tube here is the river actually flowing into our relatively small model. And it's sized such that that flow is about equivalent for the volume of this system for the river flow into the Bay.

NARRATION Back out on the Bay, it's time for a little night fishing, for the creatures that rise to the surface during darkness. The collecting tube comes in filled with many different kinds, from a few tiny shrimp a quarter-inch long, to thousands of microscopic plankton that just turn the water a little cloudy. They'll all go back to the basement--some as fish food.

MAN Go back ....

NARRATION Now Adey's team has got to find the fish that'll eat the plankton. And here they are--mummychogs, minnows, silversides. They're too small to be of interest to any fisherman, but the Bay's full of them. They're yet another vital part of the ecosystem. The model has eight tanks with different levels of salt in the water. Like going down the Bay from river to ocean. This is the fully salt water tank where the waves wash over a plant and animal community that's typical of the lowest reaches of the Bay. Some creatures can choose where to settle in the model. They seek out the same habitat they'd use in the wild. Others are less mobile, but they'll thrive only in the section where they like the conditions. This turtle sticks to fresh water. Of course, it rains in the Chesapeake. That has to be reproduced, for the right length of time. So do the wind, the waves, seasonal temperatures, even varying day lengths throughout the year. And inside these boxes there's a special feature. Clear plastic gates open up connections between the tanks. It allows water to flow through the system, like in the real Bay. But Walter Adey has discovered it's not just water that moves around--living things do too. He's traced the mummychogs moving through the tanks in response to seasonal changes in salinity. Nature is doing its thing--right here in the basement.

WALTER ADEY It operates itself. It doesn't really require us at all. In fact, as you might guess, when you think of the ill effects we are having on so much of our environment, it's really much better left alone to do its own thing.

NARRATION This is not Walter Adey's basement. We're 1200 miles further south in Florida's Everglades. Like the Chesapeake, it's a unique collection of plants and animals coexisting in a complex ecosystem. From the familiar cattails to the birds, fishes, plankton, different bacteria in the marsh mud, there may be more than a thousand life forms here, although nobody knows for sure. On the fringes of the Everglades are mangroves perfectly adapted to the salty waters of the Gulf of Mexico. Inland, the water gets fresher, the plants and animals are different. It's these kinds of varying conditions that in nature always sustain an abundance of species. That's what fascinates Walter Adey. He's made the Everglades another model ecosystem. It may be pouring in these Everglades, but outside it's a beautiful day at this Smithsonian greenhouse. The Everglades model begins like the Chesapeake, with ocean waves lapping up on the beach. But it soon becomes much more elaborate. It's really a portrait of southern Florida in miniature.

WALTER ADEY Now we move into the mangrove areas. And here we have a winding tidal channel and first red mangroves. Very dense communities of red mangroves. The fish populations begin to shift from the coastal fish into the estuarine fish, the waters take on a rather reddish color as we get the tannins that are washed off of the freshwater Everglades.

NARRATION The model moves on through a series of zones of gradually changing vegetation. A fifty-mile trip in a hundred feet. And then, suddenly, there's a barrier--Florida's Tamiami Highway.

WALTER ADEY Once we cross over the trail, over the highway, then we're into full freshwater and all of the primary characteristics that we normally think of as being the Florida Everglades--small pools, freshwater pools, rich in water hyacinths, water soldier. Very large cattails, and freshwater streams that are just disappearing to the north into the prairie and hammock communities of South Florida.

NARRATION Adey's models are a kind of shorthand: They contain fewer species than the real world. But they can serve a vital function.

WALTER ADEY These models are so compact that it's very easy to demonstrate to people how an ecosystem works, what creates problems for the ecosystem, and how it's possible to actually live with it and do what we want to do as humans while the system continues to function.

NARRATION Here in Washington you can watch democracy in action, or see great paintings. But soon Walter Adey will show us how the world works. His next project? A new Chesapeake model right here on the Mall, for all to see.

WALTER ADEY In terms of living with our global environment, everybody, every person, or most every person, needs to know what an ecosystem is, how it functions, and what the ways are in which the public affects these ecosystems. Otherwise we'd have no hope of making real change.

back to top

CATCHING CATNAPS

WOODIE FLOWERS Oh, where did those fifteen minutes go? When you're sailing single-handed, you've got to do everything yourself. You've got to handle the boat, keep a lookout, navigate, cook. How can you do it? One thing that practically all lone long-distance sailors do is cut way back on their sleep. And the best way to do that seems to be take this precious sleep time and spread it out into little catnaps. That's what most successful ocean racers do. So when you know you can only get a little sleep, you break it up into tiny pieces. Does that make sense? Now there's a sleep study that aims to figure that out.

NARRATION Meet Francesco Jost. He's Swiss, he's an artist--and he's a guinea pig. For the next seven weeks he's going to try sleeping for just six half-hour naps per day. Why would he want to do that?

FRANCESCO JOST It's difficult to explain. I want to be more productive. And do a job in greater depth. Many times when I produce a painting, I don't really have a lot of time to reflect. Here I will have a lot of time to reflect.

NARRATION Running the experiment at a Boston sleep research institute will be Claudio Stampi. Of course, sleep researchers have to sleep, too, so Francesco's brain waves will be recorded 24 hours a day.

CLAUDIO STAMPI Buona notte. Chiao.

NARRATION The first thing to do is measure Francesco's brain waves during a normal 8-hour night's sleep to compare with what happens when he goes on the reduced schedule. Like most people, Francesco sleeps in cycles. First light sleep with small, rapid brain waves. Then deep or slow wave sleep takes over. And finally we reach "rapid eye movement" or REM sleep when we usually dream. Cycles are repeated through the night, each lasting at least 90 minutes. So one key question is: What type of sleep will Francesco's body choose if he never sleeps longer than 30 minutes?

CLAUDIO STAMPI Probably what will happen is that the body will automatically prefer to concentrate on the sleep stages or the sleep parts that are most important and most necessary. And maybe by this experiment we will be able to select and filter out what are the physiological aspects of sleep that are more necessary.

NARRATION As the 49-day experiment gets under way, Francesco takes advantage of the extra work time. By Day 12 he's getting used to the schedule: Three and a half hours work, a half hour sleep. Throughout each day he has to record in his computer how he thinks he's doing. So far, everything is on the plus side: He can concentrate, he feels alert. There are regular performance tests too. Here he has to subtract 9 from 691. The right answer is 682. Now it's 8 from 682. Should be 674. Some stakes, but overall he's doing almost as well as before the experiment began.

CLAUDIO STAMPI I was surprised myself to see that the decreasing performance was so modest. Francesco was able to adapt to this schedule reasonably well in terms of performance.

NARRATION But what about his type of sleep? Is he getting the three different kinds? He's been asked to note down his dreams and he's still doing so. So he's probably getting REM Sleep, the type that goes with dreams, but normally comes at the end of a 90-minute cycle. Claudio searches Francesco's brain wave records for the telltale signs of REM sleep. And he finds them. On the top the fast brain waves typical of REM sleep. In the middle the sudden busts of rapid eye movements. And below the characteristic low muscle activity. Francesco's REM sleep is normal. What's not normal is how quickly it starts.

CLAUDIO STAMPI A few minutes after sleep onset, REM sleep starts. Whereas, in a normal night's sleep, the REM takes at least 90 minutes, two hours sometimes, or maybe sometimes even three hours to appear initially. So the whole architecture of sleep is changed.

NARRATION Now look at the next nap Francesco took after the REM sleep one. It's mostly deep sleep, characterized by these big slow brain waves. Francesco seems to be making an extraordinary adaptation to get the three different sleep types. Although his sleep quantity has been cut by more than half, the composition is unchanged.

CLAUDIO STAMPI Percentages of sleep stages in the nightly schedule are very similar to baseline normal night's sleep percentages, which suggests that all sleep stages may be equally important in the function of sleep.

NARRATION It's now Day 33 of the experiment. Francesco is spending a week at the beach. Both mood and performance are slightly below normal--but they're stable. This really seems to be working.

FRANCESCO I am really surprised that I can live like this, that I can adjust to this new schedule without having more difficulties

NARRATION The experiment's now two-thirds done, and Claudio springs a surprise.

CLAUDIO STAMPI Hello Francesco, how are you?

FRANCISCO I am fine.

NARRATION For one night only, Francesco's allowed to sleep all he wants. Claudio wants to know if a sudden sleep bonus can affect performance, but he'd kept quiet about the idea so as not to affect Francesco's mood during the first thirty days. Francesco sleeps for ten hours. But once he's back on his reduced schedule, his mood and performance improve dramatically--and stay that way--even exceeding his pre-experiment scores! Claudio isn't sure why Francesco benefited so much, but he thinks sleep bonuses could have practical applications.

CLAUDIO STAMPI This suggests that if a person is under an emergency, and the emergency is very prolonged and has the possibility of taking one day off and sleeping as much as a person wants, this will be positive, would give good results. And then, after that the person can start again a multiple-napping schedule, more refreshed than he was before.

NARRATION Day 48. Just one day to go. During the last week Francesco's been living at the sleep lab. He's under constant observation because experiments running this long are extremely rare. Anything might happen. But the real problem is nothing's happening. He often finds it a little tough to, well...really get moving after his half-hour nap periods.

CLAUDIO STAMPI Francesco, it is time to wake up. No signs. Still sleeping.

NARRATION Francesco's girlfriend Magda has a turn.

CLAUDIO STAMPI He has been two months sleeping only three hours per day so he has built a tremendous sleep pressure. Now his sleep pressure manifests mostly in a difficulty to wake up rather than sleepiness when he's awake.

NARRATION So although Francesco's been showing sleep pressure for some time, once he wakes up, he does just fine on his test scores. Right now, though, it looks like he'll be scoring a zero. Magda gets him to at least sit at the computer--but somehow the questions just don't make sense. And finally, he figures, if they really want me to stick with the computer, there's only one way to do it. It took half an hour but he's finally awake, and amazingly enough his test scores are right on. He answers "No" to the question "Do you feel tired?" and "Yes," he can concentrate. After nearly two months with only three hours sleep a day, it's an extraordinary performance. Could anybody do it?

CLAUDIO STAMPI Francesco's a normal person, a normal young person, and he's very representative, if you wish, of the human species, adult human species. So it is possible to suspect that individuals like Francesco would be able to adapt to this, relatively easily, to this multiple napping pattern.

NARRATION Multiple naps seem to work, although, left to itself, the body might prevent their use through sleep pressure. They'll pursue this and other questions at the lab. Francesco will be coming back as a subject, although, considering his feelings right now, it's a little hard to see why!

FRANCESCO I am free! I am happy that I won't have to take any more tests. And I will be able to go out now and live normally. I am ready for a little vacation.

back to top

PIZZABOT

WOODIE FLOWERS Some cheese. A few green peppers. And finally, the anchovies. Making pizza. It's the kind of thing that really needs a human touch. Right? Well maybe not for much longer. Take a look at this.

NARRATION Sandy Blatt is going out for pizza. But that's not so easy. But that's not so easy. He was paralyzed in an accident ten years ago, and he's here today not to order a pizza, but to make one himself. At Fox's pizza in Pittsburgh, Sandy is helping to unveil Pizzabot, a system that could help re-employ the disabled. At its heart is a voice-activated robot arm, programmed to do the manual work. It's a concept Sandy thinks has real potential.

SANDY BLATT I'm disabled from the neck down. I'm not disabled from the neck up. So I have the mental capacities I have, wherewithal to go back to work. The technology allows me to use that mental ability and get the assistance from what I call my extended arms, my extended hands.

NARRATION The project started six months ago at Carnegie Mellon University, with the help of Sandy and automation expert K.G. Englehardt. Their aim--take this off-the-shelf robot arm normally used in factories and create a low-cost, functioning prototype.

SANDY BLATT It's going to be the workhorse. We're going to have it in the front window just like the old pizza shops where the guys stood in the front window and flipped the pizza up in the air, although we haven't quite configured how to do that.

NARRATION Instead, they start out with pre-packaged dough. The first trick, spread the sauce on the crust. They start out with a low-tech ladle. Cutting edge it's not. But that's the point. The simpler the tools, the lower the cost. Next, the spices. Even a simple shaking motion isn't easy to duplicate. Manipulating the toppings is the big job. The human hand makes it look easy, but it's actually a complex maneuver.

K.G. ENGLEHARDT Now this is the part that is really, really giving you some trouble. We're shaking cheese on here. We will show you ....

NARRATION And trying to sprinkle cheese is a nightmare.

K.G. ENGLEHARDT Again, you know, you see it, this is not going to work. You are just going to just dump it all on one spot, I'm afraid, and not be able to ...

SANDY BLATT It's not running it fast enough and the cheese is never going to come out consistently.

NARRATION A test, fully loaded, reveals another problem. The weight of cheese affects the grip of the jaws.

SANDY BLATT I'm to come back and dump most of it on the way over. And it's going to miss.

K.G. ENGLEHARDT That's exactly the problem, right there.

NARRATION Solving these kinds of problems is a question of reprogramming and lots of it. Firm up the grip, adjust positions, change speeds. Try it out. Re-adjust positions, and so on.

K.G. ENGLEHARDT It needs to go all the way over.

SANDY BLATT That's it.

K.G. ENGLEHARDT That's it! Perfect. The angle of the approach is different. See, it picks it up here and it holds it carefully. And now you're getting a better...

NARRATION The robot system has got to succeed every time.

K.G. ENGLEHARDT We've got to work towards reliability, that is, it's got to be able to do the chores consistently that we detailed for it to do. One of the most important chores is of course the manipulation task as we've been looking at today. The other progress that we need to make is the voice interface portion that really allows hands-off interfacing with the system.

NARRATION Here, "hands off" means ordering just by talking. Using computerized voice recognition, the robot can be trained to respond to anyone's speech.

SANDY BLATT And mushrooms. Onions.

NARRATION And it talks back too. Just to confirm the order.

ROBOT Sausage.

SANDY BLATT Skip the onions.

ROBOT Hold the onions?

SANDY BLATT That's right. Go ahead. That's good. That's it.

ROBOT Pizza with mushrooms, sausage.

NARRATION A month has passed. They are trying the arm with real ingredients. Surprisingly, getting a machine to follow human speech is not as hard a mastering simple physical motions. To spread the sauce, a flat scraper is being tested. Time to reprogram.

K.G. ENGLEHARDT Well now, see, that works too All right, now ....

NARRATION The scraper could work, but an extra tool really complicates the process. They go back to the ladle, and try using it for double-duty--ladle and spreader. Getting the cheese on evenly is still a problem.

K.G. ENGLEHARDT It works but not well.

NARRATION What K.G. is after is a motion that mimics how human fingers sift cheese. How about this tool?

K.G. ENGLEHARDT It's almost like it's straining.

NARRATION Somewhere between motion and sticky cheese, it's not working out. It's just weeks to go to the premier, and still nothing seems to work perfectly.

SANDY BLATT Bring that down a little lower.

NARRATION Everything turns out to be just a bit more complicated than at first sight.

K.G. ENGLEHARDT Now this is a problem! Ah, no!

NARRATION Demonstration day. With the prototype set up for the day in the local shop, Sandy's ready to make some pizza. But first, he reminds the computer what his voice sounds like.

SANDY BLATT Hamburger. Hamburger. Hamburger Make Medium. Always. Sausage. Make it.

ROBOT You have ordered a medium pizza with sausage.

NARRATION First pizza, coming up. The ladle's been lengthened into a scoop, and its edge makes a pretty good spreader. The scoop's a multi-purpose tool. For the sticky cheese, there's a delicate shaking motion. The only other tool they need is a spice shaker. They've even got a handle on the rather unwieldy olives. Finally, for this order, a heavy load of sausage bits. One misstep here could ruin the pie. Not perfect, but not bad. Now, it's into the oven. Sorry, they'll work on that later. It looks like a winner, and though this is just a trial run, the first pizza robot franchise could open its doors within a year.

K.G. ENGLEHARDT Here is your first robot pizza in the world.

NARRATION For the design team, it's been an important first step in lending a hand where it's needed.

SANDY BLATT The bottom line is being able to put anybody to work who wants to go to work. Actually the bottom line is the fact that the pizza tastes great.

WOODIE FLOWERS Like some of my research, the pizza robot involves high-tech devices applied to human rehabilitation. And therefore, it triggers questions about cost, especially since health care resources are so limited. The thing I like about the robot pizza idea is that it avoids that resource question entirely, because it's meant to be a commercial venture. If they can make it work, everybody wins-the company makes money, we get pizzas, and Sandy gets a job. hope they are outrageously successful!

VOICE Hey Woodie. A large pepperoni, no anchovies.

WOODIE FLOWERS Coming up! That's all for this edition of Scientific American Frontiers. See you next time.

back to top