SHOW 101

EPISODE OPEN

WOODIE FLOWERS A thrill is born as engineers put a new twist into the rollercoaster. Come for a spin on Scientific American Frontiers. Also -- a dying baby gets a new heart. And an endangered woodpecker gets a new home. Can making a face change how we feel? And why doesn't this squirrel freeze solid? All coming up on Scientific American Frontiers.

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THE WORLD'S SCARIEST ROLLERCOASTER

WOODIE FLOWERS Hi, my name is Woodie Flowers. I know that sounds like the name of a cartoon character, but it's easy to remember and it's always served me well. I'm actually a professor at MIT with a lot of curiosity about the world around me and how it works -- which is why I'm standing here dressed like a skydiver. This new series is going to explore the frontiers of science, and I'm going to get to go along for the ride. I'm going to ask some questions, maybe answer a few, poke fun occasionally, -- and test some of the frontiers myself. Which brings me back to the skydiving outfit. I've always wondered what it would be like to jump out of a plane -- so I'm going to find out.

DIVE INSTRUCTOR Head up nice and high -- hard arch.

WOODIE FLOWERS This is fantastic -- I hope you guys can hear me.

DIVE INSTRUCTOR All right give me a left turn, Woodie.

WOODIE FLOWERS Okay.

DIVE INSTRUCTOR Stop -- turn left.

WOODIE FLOWERS Those are nice, swift turns. This is a 3-D sports car. Here I come!

DIVE INSTRUCTOR 3,2,1, flare. All right, good job, Woodie.

WOODIE FLOWERS Wow, I'm sure the guys with the cameras did a great job, but there's no way pictures can do justice to what I just experienced. I knew this was going to be a fun job. Actually, I spent a whole day training for this, and it cost several hundred dollars. And even though the risk associated with the jump was probably less than that of driving out here this morning, it's pretty clear that sky diving's not for everyone. But a lot of people would like to get the kind of thrill that I've just experienced without spending the time, and the money, and the nerve. And that's the reason that amusement parks are big business -- and that's the reason that the designers of rides are always trying to outdo one another. We wondered how you would design a ride that was both thrilling and safe -- so we've spent over a year tracking the designing and testing of what is -- at least for now -- the world's ultimate rollercoaster.

NARRATION Three or four major rollercoasters open up every year. And in a never-ending competition to be the best, each is bigger than the one before it. Today, coasters can be twenty stories tall and reach speeds of seventy miles an hour. The coasters are designed to be safe. But their intimidating looks are beginning to scare off less adventurous riders -according to the designer of this coaster, Ron Toomer.

TOOMER I really think a lot of people are going to walk up to that thing, look up there and say, "My gosh, that's too big for me -I'm not going to get on it."

NARRATION So five years ago, Ron began toying with a brand new concept in coasters. Here's how all existing coasters work: The twists and turns and ups and downs in the track create forces pushing and pulling on the rider. That's what makes them fun. But always the greatest force is pushing car and rider against the track -- even when you're upside down in a loop -- and that’s what keeps you from falling out. To demonstrate, we joined a high school physics class as they rode a coaster with their own homemade force meters.

TEACHER That's going to register on this. When we're standing here still, this is our one unit of force. This would mean that on your rear end, when you're in that car, you'd feel your normal weight. But as we go around the bottom of that curve, you're going to see this thing pull down to two, three, or three and a half times your normal body weight.

NARRATION For the experiment, each student was supposed to look at and remember the force holding them into the car at different points in the ride. But it proved easier said than done.

STUDENTS Too scared to look at it. We didn't look at it -- we forgot. Gonna do it again.

NARRATION We made it easier for us to see by slowing down the action. Entering a loop, there's a force three and a half times greater than normal gravity pushing them into their seats. Even when upside down at the top of the loop, they're being held into their seats by a force two times gravity. So at no point do they really feel as though they're upside down.

STUDENTS You felt like you were on Earth rather than on a rollercoaster upside down. Didn't have a sensation of being upside down. Except for the visual sensation of looking upside down, it felt like you were sitting right-side up.

NARRATION In all existing coasters, that's just as well -- otherwise car and riders would fall off the track. 0nly briefly, at the crest of a hill, does a rider feel like he's coming out of his seat. But what if a coaster could be designed that did a barrel roll -like an aerobatics plane?

TOOMER We're looking for an advancement of rollercoaster technology here that would allow us to feel more like that kind of a sensation where you're able to roll over, fly along upside down, and you really are upside down. You're hanging upside down, you look down and there's nothing below you but the ground -- and there's no tracks -- there's nothing there to hold you up.

NARRATION It was this new twist in rollercoaster design that Ron and his company, Arrow Dynamics, decided to explore. This is an early run of a quarter-scale model. To create the barrel roll effect, the car sits down in the tracks rather than on them, as in existing coasters -- and to hold it up when it's upside down, it hangs from a second set of wheels. These are big innovations for a rollercoaster, and when we joined Arrow in the early stages of development, there were still plenty of questions to answer -- like just how much initial energy the car would need to avoid the discomfort -- and embarrassment -- of a problem like this! The main task though, was to stop people from falling out -- the job of engineer Dahl Freeman.

FREEMAN Would you like to pull the restraint down now?

NARRATION The challenge is to come up with a restraint system that holds people comfortably and securely, no matter what their shape or size.

PASSENGER Feels great. Really secure.

FREEMAN So you feel more secure hanging onto the handles?

PASSENGER If we're going upside down.

FREEMAN We're going upside down.

PASSENGER I'll hold on.

NARRATION Ideally, the restraint system would be adjustable to fit each rider -- but the time that would take between rides would make the rollercoaster unprofitable. This system works well for Cindy, an average sized woman. But Bill, who's a little larger, would clearly have some problems. The lap bar is meant to fit snugly across his legs.

FREEMAN Obviously, this is not going to restrain his body and offer the support that he needs when this vehicle turns on its side or goes upside down.

NARRATION Bill can be accommodated only by shortening the lap bar so it can reach his lap. Now the system works fine for Bill.

FREEMAN Okay, how do you feel?

BILL I feel really secure. There's no place to go.

NARRATION But can it still do a good job on someone Dusty's size? Arrow's goal is to fit children four feet and taller. Dusty's four feet four.

FREEMAN Pull that down so it's tight. Feel good? Feel locked in? Okay.

NARRATION The shoulder restraint only keeps him from falling forward. it's up to the lap bar to hold him in.

FREEMAN Okay. Dusty, how ya doing?

DUSTY Fine.

FREEMAN Good. Things feel OK here?

DUSTY Yeah.

FREEMAN Okay, your legs are tight, look like they're good and tight, your arms -- you're holding on a little bit here, your head's clear, OK, and you're off the seat just a few inches. Let's turn him back up.

NARRATION Dahl is increasingly confident his system will hold riders as different in size as Bill and Dusty, comfortably and securely.

FREEMAN There's a partial compromise here. If I were setting it just for him, I'd probably move this lap bar another 1 or 2 inches. But the way the seat is designed in the lap bar, we got a range here, where we can lock him in securely, and as well deal with someone that probably weighs 4 or 5 times as much as he does.

NARRATION Devising an effective restraint system was a problem they'd anticipated. But the first time they put a mock-up of an entire car on the track, there was a nasty surprise in store. Because the car sits down between the rails, when it goes through its barrel roll, the rear passengers are brought within a dangerous few inches of the track.

FREEMAN Boy, look at that.

ASSISTANT That looks pretty close.

FREEMAN You know, we haven't had to deal with this before, in that the tracks have always been pretty well under the vehicle. But this track's coming right up around as we go through the spiral. We're going to have to do some shielding here, some more shielding than we normally do. One thing I don't want to do is close this in with a canopy. We've got to keep the vehicle open to maintain the thrill of the ride.

NARRATION But in the end, a small rear canopy is the only solution to making sure hair and hands don't get caught between wheels and track. At last, it's time to erect the test track -- one quarter of the finished ride. The joins must be precise to avoid dangerous lurches. But even the greatest care doesn't mean the coaster will run as predicted. While expected speeds and forces were all carefully calculated, they were based on assumptions about wheel friction. And this is the first time a coaster has alternated riding on top and bottom wheels. If the friction is less than expected, the coaster will run faster than planned -- maybe dangerously so. Which is why the first passenger won't be a person, but a machine -- an accelerometer. It's much like the student's home-made force meters, but it records front-and-back and side-to-side forces, as well as up-and-down. Three years after work began, the coaster is hoisted into position for its maiden voyage. The starting height is still something of a guess. If it's too low, the car may not pick up enough speed to make it around the track.

FREEMAN There's always that feeling inside -- you know -- what can happen that we don't know about yet? And maybe it'll end up just going back and forth right here in the dip and not make it all around or something like that.

NARRATION The moment of truth. It looks like a perfect run -- but were the forces recorded by the accelerometer in line with predictions? All seems to be well -- even in the critical region under the line when the coaster is hanging upside down. So it's safe for a human rider. Who will it be?

TOOMER I don't ride them anymore. I get sick, for one thing, and I don't like to go upside down for another; it's just not my thing.

NARRATION It's the engineers who'll take the first spin. After all, they built it!

ENGINEERS Bring lap bars down first. Tug on them a little bit. Then the windows go up. Okay?" Have a nice ride.

NARRATION From the sound of it, Arrow's created the new thrill it was seeking.

FREE MAN This ride concept opens up a whole new dimension to us. And we can see, instead of the horizontal spirals, we can actually see a drop, rolling. We think that'd be wonderful. We see a high speed spiral -- just exciting things in our minds and they've got to be developed and tested, but I can tell you right now they're going to work.

WOODIE FLOWERS The first time the public will have a chance to try the new coaster is in 1992. I can hardly wait. Although, now that I've skydived, and felt weightlessness for fifty seconds, even flipping upside down might seem a bit tame! But I must admit that I'm not always going to be jumping out of airplanes as part of this job. After all, I still spend most of my time teaching design engineering at MIT. That means being in this office a lot. But what I hope is that my engineer's eyes are going to help in our explorations out there along the frontiers of science. There's so much to see. Stay tuned!

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NEW HEARTS FOR NEWBORNS

NARRATION This is Colleen Barber. She's two weeks old. She and her mother are waiting -- waiting for a heart.

MOTHER Good girl. You are a pretty girl.

NARRATION Colleen's own heart is so badly deformed she's only being kept alive by medication and a respirator. Her only hope for life is getting a new heart in a transplant operation.

MOTHER The waiting is the hardest part. The not knowing what the outcome is -- just the ifs of the whole surgery. But this is her last chance, and we're going to give her that opportunity.

NARRATION Dr. Leonard Bailey has pioneered infant heart transplants here at Southern California's Loma Linda Hospital. His work hit the headlines five years ago when he attempted -- unsuccessfully -to transplant a baboon heart because of the acute shortage of donor hearts for newborns.

BAILEY These babies really don't have options. If we don't operate on them, they're going to die. And some of them will die in the next few hours; some of them will die in two or three weeks. So you search desperately for a donor to remedy that problem.

NARRATION If Colleen is to live, another baby has to have died -- and its parents agreed -- in their grief -- to donate its heart. Colleen's wait is over. A heart has been found. But even as she's prepped for surgery, the transplant team is worried. The donor heart may be too damaged to survive the transplant.

BAILEY The donor had a long resuscitation in an effort to save that baby's life. That effort failed, and the baby died, but the heart and other organs took quite a beating in the process. Had this donor been as far away as Texas or Kentucky, we would not have been able to use the heart. As it turns out, by keeping the amount of time to a minimum between donor and recipient, I think we're going to get away with it.

NARRATION If Bailey is wrong, Colleen will die. She can survive only this one transplant attempt. The gamble begins with the removal of the heart from the donor baby. Weighing barely an ounce, it's the size of a walnut. Bailey must decide instantly whether it's healthy enough to transplant.

BAILEY It's had a little trauma, but by and large it's a good heart.

NARRATION While waiting for Bailey's decision, the transplant team has been preparing Colleen to receive the heart. The process began several hours ago as bags of ice were used to chill her body. Ail her blood will be drained from her before the operation -and only if she's chilled to thirty degrees Fahrenheit below her normal temperature will her brain survive the hour or so the operation will take. Bailey carries the donor heart, itself chilled in ice water, from the donor operating room next door to Colleen's. With every moment, the heart is slowly dying. By now Colleen's body temperature has been lowered to sixty-four degrees Fahrenheit.

BAILEY Is the cooling even?

ASSISTANT Cooling nicely, sir.

NARRATION And Colleen's entire blood supply -- just eight ounces -- is drained off. Even the slightest flow of blood would make the delicate cutting and stitching of arteries and veins impossible. The clamp isolates Colleen from her blood -- and the surgery can begin. First Colleen's own, useless heart is removed.

BAILEY This baby is about to be the best it's ever been.

NARRATION The donor heart is made ready to stitch into place. Bailey connects it to Colleen's blood vessels -- and then slowly, her blood is returned. Now comes the critical moment. The ice bags are removed, allowing Colleen's body temperature to rise. Now, it's up to Colleen.

BAILEY All right. Lungs are working.

NARRATION But will the heart work in its new body? In case it needs a jolt to start it, electric paddles are standing by. But within moments, Colleen's new heart starts up by itself.

BAILEY We were a little concerned about the donor, but the little donor heart seems to have recovered quite well. So far.

NARRATION "So far" is the key phrase in infant heart transplants -- because the operation itself is only the beginning of Colleen and her new heart's attempt to live together.

BAILEY Stable this morning.

ASSISTANT Her X-ray looks remarkably good.

NARRATION Already, two days after surgery, she's had to be resuscitated once when her new heart faltered.

BAILEY We may get away with this marginal arrangement here. I think recovery is possible. Baby Colleen was quite a challenge for us. She represented the outer margins, I think, of what we can do with transplantation, and pleasantly. She and her new heart have responded very well. I am very optimistic that she is going to be OK, and anxious, actually, to see what she's going to look like when all this is done.

NARRATION As with all transplant operations, the real barrier to success isn't the surgery, but how well Colleen and her new heart get on together. The constant danger is that Colleen's immune system, recognizing the heart as foreign tissue, will attempt to reject it. This is Garrick Tanner.

MOTHER Time for your medicine.

NARRATION He received his new heart two weeks ago, and every day since, his mother has been giving him small doses of an anti-rejection drug. He'll have to keep taking it every day for the rest of his life.

MOTHER That's a good boy.

NARRATION So far, the drug's been doing its job -- and today, the hope is that Garrick will be going home.

BAILEY Good morning.

MOTHER Hi there.

BAILEY It's a big day for you.

MOTHER I hope.

BAILEY You're actually going to take him home? How long has it been since his transplant?

MOTHER Oh, it's been two weeks and two days.

NARRATION So far, so good. But Garrick, like all transplant patients, is on a tightrope. The anti-rejection drug suppresses his immune system. Too much drug and he could die of a massive infection. Too little and his new heart will be rejected. An early warning of rejection is a fast heart beat. Till now it's been at about one hundred fifteen beats per minute.

BAILEY Well the only thing presently that's a little bit of a glitch is his heart rate. He's been traditionally down in the teens and twenties. And here resting, he's about one hundred thirty, which may not mean too much but we'll keep an eye on that. He may be beginning an immune response towards his heart. And we'll try to make a judgement call on that.

NARRATION Garrick won't be going home today. This is Amy Zuniga. She's been at home now for six months following a heart transplant operation at Loma Linda -- and still her mother checks her every day for signs she's rejecting her heart.

MOTHER I'm very afraid that we won't be able to pick up that she's having a rejection -- that I'll miss it, that I won't have been careful enough or they'll be something that I'll miss, and that she'll be in grave danger because of something I did.

NARRATION This is a home video of Amy and her twin sister immediately after they were born.

MOTHER Once she was delivered, they whisked her right away to the next room, and there they hooked her right up to some medication that would keep her heart functioning. And then they handed her back to us so we could hold her and get to know her for a moment. So for a brief moment we were able to hold both babies together and enjoy that moment together. But it's like, they tried to be very calm but you could tell -- I mean, we knew that they were waiting in the next room for Amy. And that once she was born, they were going to get right on her and make sure that she would be safe.

NARRATION Amy's transplant went well -- and ever since, her immune system has been balanced precariously between being suppressed enough to keep her heart, while potent enough to fight off infection. That such a balancing act is even possible is the most surprising -- and dramatic -- of the breakthroughs at Loma Linda's infant heart transplant program. It was a discovery made by the transplant team's immunologist, Dr. Sandra Nehlsen Cannarella.

CANNARELLA We're so used to fighting the immune system in older individuals -- constantly worrying whether they're going to get infected, or if we're too light on the immunosuppression, they're going to start to reject. Surprisingly, and very pleasantly, we have found that the infants manage most of this themselves. They've kind of taken the job away from us.

NARRATION The explanation seems to lie in the special immunological relationship that exists between mother and baby during pregnancy. Even though the fetus is foreign to the mother, each tolerates the other -- because of special cells produced by the fetus that damp down its immune response.

CANNARELLA We're finding out that this state lingers on in the post-birth period, for a period of anywhere from days to a few weeks. And we've found that if we put a heart transplant in during that time, the immune response is caught offguard, and we can kind of slip it in almost unnoticed. It wants to protect it instead of killing it.

NARRATION For baby Colleen, the battle to keep her new heart is just beginning. Little Garrick's rejection episode was soon controlled, and he'll be going home in a day or so. Amy Zuniga and her family have managed the delicate tuning of her immune system for six months now. For Colleen, Garrick and Amy, their new hearts have meant new lives -- so far.

WOODIE FLOWERS The hearts which Dr. Bailey transplants are about the size of this plum. They have to grow inside their new owners until they're about the size of my fist. I have a small research group that's been working on a new artificial leg for a long time. And we're not done yet. Because the problem of designing a machine that mimics part of a normal body is very difficult, even when you don't worry about the problem of having it grow with its user. So, artificial hearts are not the solution to the shortage of donor hearts for infants. That means that of the three thousand or so babies that are born each year that need a new heart, only a lucky few will get one. So far, the program at Loma Linda has given new lives to almost sixty babies. The oldest will soon celebrate his fifth birthday. So far, so good.

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WOODPECKER HOUSING CRUNCH

NARRATION In the summer of 1989, the Francis Marion National Forest in South Carolina was a haven for one of America's rarest birds, the red-cockade woodpecker. The woodpecker is an endangered species because old growth pine forests like this, once common in the south, are themselves disappearing. The Francis Marion National Forest was special because here the population of the red-cockade woodpecker was actually on the increase. Then came the night of September 21st. 1989's killer Hurricane Hugo struck South Carolina with almost unparalleled fury -- record high seas and one hundred fifty mile an hour winds. Watching the news reports with mounting horror was ornithologist Jerry Jackson.

JACKSON I was keeping a very close eye on where it was headed. I had been on the Francis Marion National Forest only about two weeks before the hurricane hit and I knew what was in store and it was disaster, I mean absolute disaster.

NARRATION In just a few hours, most of the Francis Marion was leveled. Of the forest's one thousand seven hundred red-cockade woodpeckers, one thousand were dead or missing. Many trees snapped where the woodpeckers had drilled their holes, crushing the birds sheltering inside. It's this destruction of the woodpeckers' homes -- even more than the loss of the birds themselves -- that was the most devastating of Hugo's blows to the species. Because the red-cockade woodpecker's home is definitely not just a hole in a tree. To find out why the red-cockade woodpecker's nest is so special, Frontiers came here, to Mississippi's Noxubee Wildlife Refuge. It's early in the morning -- the best time to catch a woodpecker. Noxubee -- another of the few scattered old growth pine forests of the south -- currently is home to just forty-one woodpeckers. White bands mark trees with woodpecker holes. The question for Jerry Jackson is whether the bird in this tree is sleeping late.

JACKSON Hey! We got one!

NARRATION If this is a female, then she's the only one at home. That's because males and females keep separate living quarters -- and it's the father who nests with the babies, while the mother sleeps off by herself.

JACKSON Oh, this is a bird that has bands on it, so we've got us a recapture. We'll be able to tell how old this bird is and when it was banded.

NARRATION And its sex -- because only the males have the red cockade.

JACKSON They only show these red-cockades when the birds are aggressive or courting. This bird's a little aggressive right now because he doesn't really like being caught.

NARRATION Because it's a male, there are probably babies in the tree - and their hungry cheeps give them away Both male and female share the feeding chores during the day.

JACKSON Well, get back to your nest, fella.

NARRATION So here's the first reason the holes are valuable -- each family needs two. The second reason is visible around the hole itself - sticky sap, looking like candle wax. The sap is there because, unlike other woodpeckers, red-cockade woodpeckers choose to make their holes in live trees, not dead ones. And making a hole in a living tree is hard -- very hard.

JACKSON The average length of time that it takes for a red-cockade woodpecker to excavate a cavity is four point seven years. As a result, those cavities are extremely valuable pieces of property, and they're passed down from generation to generation, and the males inherit them.

NARRATION Four point seven years' work per cavity is quite a mortgage to pay off -- and it raises the question: Why? Why do red-cockade woodpeckers drill through live sapwood, while other woodpeckers just peck their way through dead wood? And here's the answer -- the gray rat snake. It's a superb tree climber, its scales giving it an excellent grip on the bark. But around the nest hole, the woodpecker has pecked the bark to keep the sap flowing. As the snake approaches its goal -- a succulent meal of eggs or nestling -- the waxy sap gets thicker and thicker. The sap works its way between the snake's scales, sticking them together. But if the sap protects against snakes, it doesn't keep biologists away. Fortunately, Jerry Jackson's motives for climbing the tree are more benevolent. While the parents are away gathering food, Jerry plans to check on the nestling. This is a three-week old female. She's banded, then weighed -- during which she gets her first real look at the world she'll soon be joining. Jackson's work is part of a detailed monitoring of the birds here in Noxubee from birth to death.

JACKSON That about has it -- forty-five point three grams. This bird is very close to fledging. You can see it has very well-developed wing feathers, but that the wing feathers are still growing. And those feathers will be completely grown probably within the next week, and this bird will be out of the nest by then.

NARRATION Out of the nest -- and needing one of her own. Her home nest will be inherited by a brother. Fortunately, in Noxubee, there are still a few trees to be drilled, a few homes to be had. But back in the Francis Marion National Forest, Hurricane Hugo crushed hundreds of woodpecker homes. With so many trees destroyed -- ironically, snapped in two often because they contained woodpecker holes -- the shortage of homes is acute. And because it takes so long to make new cavities, wildlife managers here feared that the seven hundred birds surviving the hurricane would die homeless. So in the spring of 1990, they went into the construction business. Biologist Carolyn Bachler first drills a horizontal hole, just as the bird does. Then she drills a second hole at an angle from above, to create a vertical cavity down through the middle of the tree. The idea is to reproduce in a few hours what it takes a bird over four and a half years to make. BOB

HOOPER Here's the entrance, here, and it's about nine or ten inches deep. The light-colored wood here is sap wood, and it is living wood and the resin actively flows through it. The reddish-colored wood here is heartwood and it is essentially dead -there's no resin movement through it. The bird needs the heartwood into which to put its cavity so that it doesn't have to contend with resin within its cavity.

NARRATION Carolyn Bachlet scrapes off some bark to set the sap flowing. The tree is in move-in condition -- but it took half a day's work. Here's a pre-fab option. This time, the tree is excavated by chain saw. A little putty -- and a bird house is slipped into place. Even sap holes are started for the hoped-for tenants. A little paint gives the impression that the sap is already flowing. In all, over six hundred artificial cavities were built in the Francis Marion Forest over the winter. With spring -- and nesting season -- came the chance to find out if they worked. Eddie Taylor checks one of the bird house implants with a light and a dentist's mirror.

TAYLOR Bob, we've got some eggs.

HOOPER Is that right? How many?

TAYLOR Got two.

HOOPER That's the very first nest.

NARRATION The same nest, three weeks later -- and hungry chirping signals that the eggs have hatched.

TAYLOR What I'm gonna do is fixing to pull the nestling out of the nest so we can band them. What I'm gonna use is this little instrument right here. It makes little nooses, and then I'll pull it tight and it'll grab them and I'll pull them out gently. It doesn't hurt the young because their bones have not calcified at this age, and so they're still malleable. And we can handle them gently without hurting them.

NARRATION The chicks' eyes aren't open yet -- but they can tell the difference between light and dark. And dark means their hole is covered by Mom or Dad arriving with food. At least that's usually how it is. A nest-by-nest inspection of the trees that remain in the Francis Marion National Forest this spring showed that sixty-five percent of all the new birds were born in the artificial cavities A band on the bird will help keep track of it in the future. The man-made nests appear to have given the woodpeckers here a new lease on life. But even as this most important population of red-cockade woodpeckers has been rescued from a rare natural disaster, the erosion of their habitat all over the south continues. The real threat to the species' survival remains man, not nature.

JACKSON There's a lesson to be learned from Hurricane Hugo, and we're very fortunate we have the opportunity to learn that lesson. And that lesson is that every population is important. And that we can't count on having a few large populations. This probably the best-known woodpecker in the world. We know what it requires -we know what it needs. We've just got to make up our minds to do what it needs to protect the remaining populations.

WOODIE FLOWERS It's lunch time in the city -- a great time and place for people watching. It's a lovely day -- there's just about any kind of food available -- and the company's congenial -- and judging from people's faces, most folks are relaxed and happy. Now, we're pretty used to reading people's mood from their faces. When people are happy they look happy. When people are sad, both their posture and facial expression reflect that sadness. And I for one had always assumed that the feeling comes first, and the facial expression follows. I'm happy, so I smile. I'm angry, so I frown. It's pretty obvious, right? Well, one thing scientists love to do is challenge the obvious...

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FACING FEELINGS

LAIRD What most people believe -- everyone sort of believes as a lay person -- is that the face expresses the emotion that already exists inside. And what I believe is that that is backwards -that rather than the feeling coming first and then the expression, that first you have the expression, and the feeling of the expression as it's happening is what the feeling of an emotion is.

NARRATION Dr. Jim Laird is a research psychologist at Clark University in Worcester, Massachusetts. His experiments depend upon people being deceived -- and part of the deception is that Laird should look like a laboratory scientist and use impressive equipment -- even if it doesn't really work, and its data are faked.

LAIRD This machine used to measure physiological data years ago, but it's old and obsolete now. We use it now just because it looks like real science.

NARRATION Beth is a student volunteer who doesn't know the electrodes, like the machine, are fake. She's been told they'll measure her face muscles as she sets them according to Laird's instructions.

LAIRD OK, great. Now there's one other thing I should have mentioned. There's another source of error in our measurements which is variations in mood. We all have these almost random moment-to moment fluctuations in mood which we don't pay attention to often times, but in this case I want you to be aware of those kinds of changes. OK? Good. So that's it. Ail you have to do then is sit there and let the machine do the work.

NARRATION It's these mood changes that Laird is really interested in. He gets Beth to move her face muscles one by one.

LAIRD Narrow your eyes a little bit. And now I want you to contract the muscles along the center line of your nose by flaring your nostrils and pulling your upper lip up towards your nose.

NARRATION She's never told what expression to make, but eventually an expression of disgust is molded on her face.

LAIRD Now look at this.

NARRATION Beth thinks she'll be asked questions about this picture later -but it's all part of Jim Laird's elaborate charade. The real test comes when she fills in a questionnaire asking her what her mood was during the experiment. The answer -- disgusted.

LAIRD Great. Now for the next one, what I'd like you to do is to open your eyes wide.

NARRATION Again, Beth is told to move her face bit by bit.

LAIRD Eyes open wide and let your mouth relax open a little. these are often hard. Just relax. I know.

NARRATION Laird is trying to mold an expression of fear. Beth's having problems because she doesn't know her face is meant to show fear, but she gets it in the end. As well as a happy face. And a sad one. In every case, when she's asked how she felt during the test, the answer matches the face she's been wearing like a mask.

LAIRD On this one, Kim, what I'd like you to do is to scoot to the front edge of your chair, put your feet together and under the chair.

NARRATION Jim Laird does a similar experiment molding people's postures.

LAIRD Now turn your upper body towards the left. Good, twisting a little at the waist. Keep your head facing front.

NARRATION Again, if coached into an exaggerated pose, the subject feels the appropriate emotion.

LAIRD Bring your hands up about to mouth level with your palms forward and lean back just a little. OK. Stop. Now if you could just use this to describe how you're feeling.

NARRATION So in all Laird's experiments, the feeling follows the facial or bodily expression of the feeling, not the other way around. In fact, he argues, what we call feelings are our interpretations of what our bodies and faces express.

LAIRD The major premise of my work is that we are observers of ourselves in the same way that we're observers of others. That is, we don't have any special way of knowing about ourselves; instead we have to, in an unconscious way, observe ourselves. So that what we know about ourselves comes from essentially public activity.

NARRATION If Laird is right, then appearing to feel something should generate the feeling itself. Testing that idea involves another deception.

LAIRD Well, let me explain what this is all about. I'm sure you know that ESP doesn't work. But, we have some ideas about ways that might improve ESP performance -- kind of tuning exercises, in effect. First of all, could you lean forward and put your arms on the table in front of you.

NARRATION The ESP talk is a smokescreen for the real experiment.

LAIRD And then what I'd like you to do is to gaze into each other's eyes for two minutes. You don't need to think about anything, and you shouldn't talk.

NARRATION The idea for this experiment came when Laird saw two people in a cafeteria gazing into each other's eyes as if they were in love. These two subjects have never set eyes on each other before.

LAIRD If you can get people to express an emotion, they will then feel the emotion. And in this case, gazing into someone's eyes is an expression of love. So we're hoping they will then feel love.

NARRATION After answering questions that included how they felt about each other, the subjects are told the real purpose of the experiment.

WOMAN I was kind of surprised that the experiment was about emotions and gazing into people's eyes and seeing if that actually made you feel the emotion of love, because I kind of have to admit that I thought I did, a little bit. And I thought maybe, you know, it was just this person.

MAN As I was filling out the questionnaire, most of the responses that I made about her were more on the positive side than on the negative side. Whether that means that it worked or not, I don't know. But, there might be something to it.

NARRATION If it all sounds a little too simple to be true, Jim Laird is the first to agree -- but only, he argues, because feelings are complicated things.

LAIRD The effect is consistent and real. It's not gigantic -- I mean it's not like these people leave the experiment enraptured forever. But then, remember that we're only manipulating in a tiny part of the real-life pattern of love. When people are beginning to fall into love, they do all sorts of things: They touch, they look, they share confidences, the heart pounds, all of those things. And they must all contribute to the full-fledged feeling.

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SUPERCOOL SQUIRRELS

NARRATION Early May, two hundred and fifty miles inside the Arctic Circle. On the shores of frozen Lake Toolik in Alaska, the first signs of spring. Nibbling at the melting tundra, the caribou have returned. Ptarmigan, too, have come back from a winter spent five hundred miles to the south. But another creature just putting in his first appearance for the year has spent the whole winter right here, a few feet underground. Today he has a visitor. University of Alaska biologist Brian Barnes is trying to discover just how the Arctic ground squirrel makes it through the Arctic winter.

BARNES It's a long winter here. It begins to freeze in late August and stays cold like this into late May. We've measured soil temperatures here, where the ground squirrels hibernate and they drop to minus ten to minus twenty degrees Celsius for much of that winter. And it's during that time that these animals stay curled in a ball, underground, in hibernation.

NARRATION The problem for an animal as small as the ground squirrel is making the few ounces of fat it can put on in the brief Arctic summer last through eight months of twenty degrees below. Brian Barnes and graduate student Mark Reed take advantage of the spring sunshine to check baited traps set out near ground squirrel burrows.

BARNES We've got one. She looks in good shape. I think she's one we'll take back for hibernation experiments.

NARRATION This female will accompany them back to their lab in Fairbanks... where she'll have plenty of company in a room maintained at five degrees

Celsius -- warm when compared to twenty degrees below, but cold enough to induce hibernation.

BARNES This fellow is in hibernation, you can see tell by his curled posture and his pylo-erected hair. And this is the typical posture for a hibernator, with his nose tucked beneath his tail. He's very cold to the touch, I can tell. These animals, when they're awake, their hearts will beat two hundred to two hundred and fifty times a minute. This fellow's heart, at its lowest frequency, will only be about five to ten beats per minute; their breathing then drops to typically only ten to fifteen breaths in a row and then an hour of no breathing, followed by another ten to fifteen breaths.

NARRATION This drastic slowing down of the squirrel's system is like what occurs in other hibernating animals. But what's different about the squirrels is that they appear to let themselves get much colder that other creatures -- here down close to the room temperature of the lab. They stay at this temperature for about three weeks, then slowly begin shivering. The shivering becomes more violent as they burn fat to warm themselves up. This one has been shivering for a couple of hours now. In a few more hours it will be fully awake with a temperature of thirty-seven degrees Celsius.

BARNES Once fully re-warmed, they remain that way for only about ten hours, twelve hours; and then re-cool back to normal torpid levels. Takes about two days to re-cool.

NARRATION This cycle of three weeks dormancy, followed by a few hours of shivering and a few more hours fully awake, is repeated some ten times over the length of the winter. The lab environment has allowed Brian Barnes to watch his squirrels hibernate. But to answer the central question -- how they survive months of temperatures far below that of the laboratory -- he has to wait for winter. A few months earlier, he put several of the squirrels captured in Toolik out in large underground cages, and let them dig their own hibernation burrows.

BARNES To determine what they're doing inside their burrows, we use these radio transmitters that are implanted inside their bodies and send out a signal that varies according to their body temperatures. You can hear a high tone because the transmitter's been warmed with my body. But if I drop it into the ice water here, you can hear the tone slowly fall as the temperature of the transmitter falls. (tone) Well, from the low tone, you can tell that one's down hibernating. (tone) really cold. (tone) Still colder. (tone) Hibernating. (tone) He' s (tone) And there you have an aroused one, an awake one. That guy's really down.

NARRATION Using this system, Brian Barnes made the astonishing discovery that unlike any other known warm-blooded animal, Arctic ground squirrels actually allow their body temperatures to drop below freezing.

BARNES Water freezes at thirty-two degrees Fahrenheit and our bodies are seventy percent water. And so are the squirrels'. So you'd expect that as the squirrels' temperatures fell below freezing that water within their cells and tissues would begin to crystallize into ice and they'd suffer lethal damage -- frostbite and freezing can occur. In these squirrels, that doesn't happen. They drop to twenty-nine, twenty-eight degrees Fahrenheit, and no freezing occurs.

NARRATION How do the squirrels do it? Barnes has tested blood plasma from the squirrels to check the most likely explanation -- that the plasma contains an antifreeze, preventing ice crystals from forming in the blood. Some Arctic fish avoid freezing this way. But the squirrels' plasma behaves no differently than any other mammals', freezing just below zero degrees Celsius.

BARNES So far, we've measured freezing points that are typical for mammals -- around minus point six degrees Celsius. So from this procedure, we've determined that there is no antifreeze in these ground squirrels, even though their body temperatures are below the freezing point.

NARRATION In the lab, the squirrels' blood freezes. In the animal, it doesn't. Just now, there's no good explanation for how the squirrels allow their hibernation temperatures to drop below freezing. But the fact that they can means that they save a lot of energy over the winter -- energy they'd otherwise be spending keeping warm. Without being able to go stone cold during hibernation, the Arctic ground squirrel just wouldn't be able to eat enough during the summer to survive the long freezing winter.

WOODIE FLOWERS What a great mystery! The blood freezes in the lab, but not in the living squirrel. Now, Brian Barnes published his research a few months ago, and suggested that the explanation might lie in the phenomenon called supercooling. I've got a supercooling demonstration here. Rather than squirrel's blood, we've got tap water in this glass, in the middle. And there's an ice water slurry around the outside, to which I've added quite a lot of salt. The temperature of the slurry is now at minus twelve degrees Celsius. The tap water is still liquid -- and its temperature is now minus three degrees Celsius. Now that's three degrees below its freezing point. This supercooled state is quite unstable. The question is, can the squirrel's blood exist in that state for up to three weeks at a time? I must admit that I'm quite skeptical. For one thing, the squirrel's heart is beating -- barely -- and its blood is moving around in its body. Now even the slightest motion -- like this -- causes the supercooled liquid to freeze immediately. So, in my opinion, the mystery remains, and that's often the way it is on the frontiers of science. Every answer creates new questions. Join us next time, and we'll ask a few more.