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CHANNEL ISLAND FOXES

WOODIE FLOWERS Tally ho and all that. I'm Woodie Flowers, and welcome to Scientific American Frontiers. Check out my outfit!

WOODIE (V.O.) This is the classic fox hunt -- except, there's no fox. The dogs are following fox scent laid down early this morning. It's the modern version of an old English tradition. Our first story takes us to the West Coast, to unearth a very different fox tradition -- -- one that links Native Americans of long ago with scientists of today. If it's a clear day on Santa Catalina you can see Los Angeles just 22 miles to the east. But to the west the view is the same as it was 2000 years ago when the Gabrielino people lived here. Native Americans disappeared from the island long ago, but their culture is not entirely lost. Today, archaeologists from the University of California are reconstructing the ancient rhythms of life on Catalina.

BILL SYNC All of this shell in here is refuse from their meals... in other words, we're looking in somebody's garbage dump.

WOODIE FLOWERS One man's garbage is Bill Howard's treasure. From these fragments, he's piecing together a mosaic of the Gabrielino lifestyle.

BILL SYNC These are what's left over from making tools. Some of them are tools. Now this is a nice flake that's very sharp and could be used for cutting vegetable material or hides or cordage or each other.

WOODIE FLOWERS As the archaeology team digs deeper they're finding out what the Gabrielinos ate and what the island ecology was like. Abalone shells are especially abundant in the 2000 year-old layer...so abalone must have been plentiful and a food staple.

NANCY SYNC I love their diet...it's good eatin'. Do you know how much abalone sells for a pound? Wonderful. A day in the life of an Islander 2000 years ago would have been like this. In the mornings, the community cast large fishing nets into the kelp beds near shore. Of course the Gabrielinos would have known the best fishing spots. While men fished offshore, women and children gathered tasty

tegula snails from the rocks. At low tide abalone was easy to find and easy to harvest. In the afternoons, when the stronger men returned from ocean fishing, the community would gather to prepare the evening meal. Here, the sharp stones were used to cut abalone or to scale and clean fish. Stone tools were also used to cut vegetables, or pound them. And it was here, around the cooking fire, that families passed on the myths that shaped their religion. Finding out about this spiritual side of life is one of the toughest jobs for an archeologist.

BILL SYNC Neato Alburito!...That's a prize...Oh that's incredible...Isn't that gorgeous? That's why finding a clue like this is so exciting. It's a hand carved pelican stone. Reverence for nature's creatures was expressed in sculptures like these. Pelicans were respected for their fishing ability. The whale was admired for its formidable size and strength. The fox was esteemed as a quick and clever survivor. But the islanders enjoyed a special relationship with the fox. Fox bones show up, not in the garbage dumps, but in ritual burial sites, where Dana Bleitz and her colleagues found this complete skeleton.

DANA SYNC One fox we found was buried in a very small hole, just large enough for its body and it was capped by a stone. Underneath the stone we found that the fox had his head up towards the top and he was tightly flexed and his tail curved right up towards his nose and his paws were crossed in front of him. And he was very carefully placed in the pit that way. The implications of finding ritually buried foxes is...it's really exciting because we do get an insight into how the Indians were perceiving these animals. Some fox rituals have survived the centuries. Tony Romero, a Chumash dancer from Santa Ynez, still performs an ancient fox dance. In this dance, Tony transforms himself into the sly, tenacious creature of Native American legend. The fox fleece on his head conceals his human form. The fox is keen, cautious and sure footed. Nothing escapes his sharp eyes. He leaves no stone unturned, no tree unexplored in his determination to survive. Thousands of years ago Chumash traders brought foxes to Catalina, where they were adopted by the Gabrielinos. Ironically, the Gabrielinos are long gone from this island.., the only living trace of their culture here is the fox, who still roams Catalina. The fox is a true survivor, but today even its presence here is being challenged.

NARRATION This island paradise has attracted a wave of tourists and residents. They benefit the local economy, but they also tax the environment. For example, the land around these new luxury homes is inhabited by foxes. If the development spreads it could overrun fox habitat. If home owners bring disease, the foxes could be wiped out. So the Catalina Island Conservancy has dispatched biologists to study the fox, and to help ensure that its home here remains secure. Dave Garcelon and Gary Roemer have their own fox ritual.

BILL SYNC Mr. Fox! Each day they trap the animals. It's D5Yellow. She's also collared. This female's bark is worse than her bite. She's really a gentle creature. Bark..yes...growl...no that's my finger. Trapping allows Dave and Gary to keep track of population numbers and to perform medical check-ups. She's not missing any hair around her teats so she may not have a litter. Ok her eyes are normal. Since the island foxes have never been studied before, no one knows how long they live. I'm going to check her teeth, OK?...OK. To estimate the fox's age, Gary checks the condition of her teeth.

GARY OK upper incisors, all 6 normal. OK. Both upper canines are normal. This fox has good teeth so she's probably young.

BILL SYNC What about her age Dave, have I got her age? She's a one. She looks like a one. OK.

NARRATION Dave and Gary need to learn about fox behavior, so they plan to spy on this female. A radio collar will help them follow her in the wild. They have to pay special attention to the fit of the collar...too tight and it will hurt the fox...too loose and it will fall off. Like most check-ups, the hard part comes last...getting a blood test. Things go a little more smoothly if you can't see the needle.

DAVE Yeah, you look like little red riding hood.

NARRATION The blood sample will tell the biologists a lot about this fox's health, but it will also tell them how she is related to other island foxes and how Vulnerable she is to disease. Collecting this kind of baseline information is a critical part of protecting the species.

BILL SYNC She was barren this year or maybe she lost the litter?...bark...she's talking to us...one sync bark. Like bad tasting medicine, this ritual is good for foxes, even if they don't enjoy it.

DAVE I think that's a fox expletive to you Gary. Now Gary can track the fox he just collared. His antenna picks up her signal.

GARY Where are you little girl? There she is. She's running down through the canyon toward the vehicles. The fox knows she's being followed.., so she makes it harder. But by keeping up with her Gary finds out things...like where she hunts and what she eats. After dark, this game of hide and seek becomes more difficult, even dangerous. Foxes are nocturnal but biologists aren't, so tracking becomes a real art.

GARY Ones that are a little bit more skittish...you just have to lay off of them more, and use a lot more signal interpretation. You kind of get a feel for things

after a while, you know, you've just gotta be out there and kind of get a feel for what the signal does and what the animal does and that kind of thing. But lots of times you're wrong too."

NARRATION This is where Gary saw the fox. He marks the spot with a flag so that he can find it the next day. These are long sleepless nights. Gary's vigil continues until dawn. The next day he returns to his marker. He takes compass readings to record the exact location of last night's fox on a map. Gary knows generally where the foxes live on Santa Catalina, but tracking will pin down their habitat and range more precisely. This yellow dot is where Gary left the marker. As he follows the same female for a long time, the boundaries of her territory become clear. By tracking many foxes he begins to identify the key features of their environment. Foxes depend on these grass patches to forage for insects. They frequent burrows in search of squirrels and mice. They visit cactus patches looking for edible fruits and often resort to berries to supplement their diet. This research is teaching us what the fox needs to survive on Santa Catalina. For now the population is healthy. But will the fox continue to have what it needs? Native Americans protected and provided for the fox 2000 years ago. Now this is our responsibility.

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INTERNATIONAL DESIGN CONTEST

NARRATION 20 years ago -- the first MIT engineering contest. It started when a young professor named Woodie Flowers had his students build machines and compete head to head. Woodie is now a famous TV host, and his contest has become a world-wide phenomenon. It's spread to the Tokyo Institute of Technology where students learn the MIT hands-on approach. And it's come to universities in Germany and in Britain. Now the best, the top ten from each of the four countries, will meet in Boston for the World Series of Engineering. This will be their playing field. Each team will have a goal and a supply of ping pong balls. Their task: in ten days, build a machine that collects the balls and gets them to the goal. They can fling them, drive them, roll them, you name it. Whoever gets the most in, wins. As the students arrive, they are divided into teams. This competition doesn't pit nation against nation -- each team has one member from each country, and one of the goals is international cooperation. Right away an obstacle becomes obvious. There is a different color t-shirt for each of the ten teams -but they each get an identical kit of parts. Motors, gears, springs, pneumatic cylinders .... It's a collection of junk nobody but an engineer could love.

STUDENTS My favorite piece is the blue stuff, this stuff, because you can do anything to it. It's easy to cut. It drills nicely and it's blue... You can do a lot of

tricky things with it. Not only listen to the music... I like this and I am making like this...I like music. I don't know if I can use it but I like it...But the parts are only raw materials -- what's needed is a good idea.

NARRATION And as the gray team brainstorms, they're seeing how important communication is in engineering. Working together they're getting a taste of the future -- and that's exactly why MIT's Harry West organized the contest.

PROFESSOR HARRY WEST Today and even more so in the future, engineering is going to be an international business. Products are designed by teams of engineers and those teams are made up of engineers from all over the world. To be competitive you have to be able work together as a team. The gray team is taking an important step in developing teamwork. While it may look like they're just out having a good time, they're also learning about each other.

NARRATION Burkhard, the German member of the gray team, eagerly shares his love of classical music with his British teammate Sarah. Before college, Burk worked in a church. It was part of his two years of national service that's mandatory for all Germans. The experience means they come to America older and more mature. And for Burk, the time has helped him put his music into perspective.

BURK My favorite music, that's baroque music. You can compare with to be an engineer because order is very important in the baroque music, and also good ideas.

NARRATION For the yellow team, understanding each other's culture begins with food. Asako valiantly tries to introduce her teammates to a concoction of rice, pickled plumb and seaweed. She is a pioneer -- a woman engineer from Japan. There were just a handful of women in her class in Tokyo. And she was the only one to win a trip to America. The differences between her and her teammates go beyond food. Asako was raised in a traditional society, one that does not encourage independence, especially for women. But Japan is westernizing -- and when her college took up football, Asako became a manager. Now her trip to America is exposing her to more provocative possibilities.

ASAKO MIT women seem more independent. They can build machines by themselves. In Japan, since there are so few women in engineering, we are babied by our classmates.

NARRATION In the machine shop, where ideas come to life, the other women feel right at home -- but not Asako. In Japan, the men were always eager to help her. At MIT, she's getting the chance to develop her own skills. Her team has decided to convey the balls to the goal with a ramp. It's an obvious choice -- fast

and efficient, it's been a proven winner in this year's national contests. With this design, the yellow team is focusing on victory. But Asako is disappointed. The ramp may win, but it's not very original. Despite her growing confidence, she wasn't able to persuade her team to be more daring.

ASAKO It's an idea contest so I'd like to make a more creative machine. But it's not just my machine, so I can't just change it. In fact, throughout the shop, conformity is catching.

IDC STUDENTS We're going to make a ramp... Push them down a ramp... Down the ramp to the goal. The original strategy was a ramp.., a ramp.., an unfolding ramp...

PROFESSOR HARRY WEST When students work alone they can decide for their own personal reasons, for their own personal criteria to come up with a really outrageously creative design -- a design that probably won't win but will show off their design talents to their friends. But when they're working as part of a team, I think there is a certain pressure to conform.

NARRATION The gray team -- wrestling with exactly this dilemma -- is meeting to pin down their priorities. Masaya, the Japanese member, wants to try to win with a safe but sure design -- like the other teams. Burk argues for the opposite tack -- have fun with an innovative but risky design.

MASAYA To win is very... important

MATT But we have already won

SARAH We've all shown that we can build a ramp. Everybody's built a ramp.

MATT And we wanted to do something new and challenging.

BURK Our goal is to make action

NARRATION The decision: innovation, with a flipper design. Masaya goes along, though he's not happy. Their flicker isn't working that well. But that's Okay. To be creative you have to take risks. Matt, the American member of the gray team, is no stranger to risk -- he likes zooming around at 120 mph. His grades suffer because he has a habit of spending more time in the pits than in the library. But this hands-on experience has given him a practical education in engineering.

MATT I've learned most of what I know about engineering in my garage. Most of the stuff that I do on the machines for the 2.70 contest, just common sense stuff, that I've seen on cars or something like that.

NARRATION Matt has the experience and the confidence to be creative. And it's no surprise what he contributes to his team's design. A car to disrupt the opponents. Let's just hope he's a better driver on the race track. Already it's the night before the contest. There's last minute scrambling to meet size and weight restrictions, and of course, the finishing touches. With time up, it's clear there's conformity on another issue -- neatness. It's Contest time. The yellow team is up early and Asako is nervous. Their opponents also have a ramp -- and a surprise -- an attack vehicle. But the yellow team's prepared with an impenetrable defense. They stop the attack vehicle dead in its tracks. And on the offensive side, they've designed a chopping arm to drive balls down the ramp -- it works flawlessly. For their opponents, nothing works. It's a rout -- Asako's team wins by a landslide. As the night goes on, it becomes clear why ramps are a smart choice. They're the best way to get balls to the goal. Now it's the gray team's chance to show off their design. They're up against one of the few other teams that doesn't use a ramp. Right away, there's trouble. Inexplicably, the flicker is stuck on top of the balls. Then Sarah has an idea. She tells Matt to bring the car over and give a push, but it doesn't work. Meanwhile the opponents dump truck is collecting balls and getting ready to deposit them. For Matt, it's demolition derby time as he drives the dumpster away from the goal. The defense is strong, but the offense can't score. Their experiment in creativity won't win the contest, but they're not disappointed.

SARAH It was luck. This was always touch and go. It was touch, it wasn't go.

NARRATION After three grueling rounds, the yellow team makes it to the finals. No surprise, it will bc ramp against ramp. Just before the starting buzzer, the yellow team spots a problem.

YELLOW TEAM It's okay, it's okay.

NARRATION It's not okay. Their ramp gets caught on the way. They try freeing it with the chopping arm but to no avail. The red team makes winning look easy. They are the world champions. But winning is not really the point of this contest. It's about understanding other cultures, communicating ideas, and working together as part of a team. All these students have taken a giant step into the international future of engineering.

WOODIE FLOWERS These contests are spreading like wildfire - from elementary schools to universities all over the world. That's because they work! They teach physics, math, engineering - and other things, like international cooperation. But most of all, they link teaching to the real world. Here's what I mean. This computer system is running one of the new engineering packages. And it's great! If I were in one of these contests, and wanted to scoop up balls, tip

the scoop back quickly to hold them in, then dump them out behind the machine - this looks like a winner. Designing it on this took just a few hours - and since the system automatically generates plans, I should be able to build this thing. See, it looks just like the one on screen, and it works the same way too - oops! It won't swing all the way back. Now if I take the linkage apart and reassemble it in the "dump" position, it looks like this. But it won't swing from front to back. Even using a high tech tool doesn't ensure good design. Unless you have hands-on experience that teaches you what to look for, the computer won't necessarily tell you what Mother Nature thinks of the design. Mother Nature, you see, applies all of her rules all of the time. And that's something you really learn from these contests.

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ART OF SCIENCE: WALKIN' AFTER MIDNIGHT

WOODIE FLOWERS This time on the "Art of Science" we have something a little different: a dance, by choreographer Thecla Schiphorst. What's the science connection? Well, the dancers are animated on a computer - but what really caught our eye is the way it's done. Thecla and her colleagues at Simon Fraser University. The dancers developed their own software, called "Life Forms", that makes it easy to program the individual steps ... put several figures on stage at the same time ... and even change their relative movements in time and space. Now, for the first time, a choreographer can see a dance before calling the first rehearsal. And sometimes the animation itself can be a work of art. So sit back and enjoy "Walkin' After Midnight"

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MIND READING: DYSLEXIA

TEACHER Where was Uncle Somebody going to come from? Does anybody remember? What state in the United States? ... Alex?

ALEX Washington.

TEACHER Washington. Now there are two Washingtons. Do you know the difference between the two Washingtons?

ALEX Ah yes ... the one farthest away. Third grade ... and there's so much to learn. Geography is just one of the subjects ten year-olds have to master. And Alex is pretty good at it -- as he is at most things in school, from art to arithmetic.

TEACHER Okay and what's that one?

ALEX Washington.

TEACHER Just Washington. Okay, if I pulled down the map of the United States, could you come show me? First of all, Uncle Somebody is coming from which Washington? Way up there - that is Washington State. He's also got a knack for how things work -- so he can help eight year-old Jimmy get the hang of driving. But it's not geography or mechanics that's brought these kids to Newark, New Jersey.

ALEX You press reverse down there and forward's there. And you have to make a straight ... there ... and then press forwards.

JIMMY Nowadays soccer balls -- as well as the balls used in some other sports -- are made from synthetic materials molded into the correct shape. However, the balls used by professional teams have always been made from leather panels stitched together around a rubber bladder. They've come to take part in a reading study in this laboratory at Rutgers University. Jimmy is flying through a standardized passage from a first-grade storybook.

ALEX The balls used by professionals ...

STEVE Wow! Okay ...

ALEX ?????????

STEVE Close -- What's that letter? That one after the “l”?

ALEX That’s "a".

STEVE Bla.

ALEX Bla - dder.

STEVE What's that word? Do you know that word?

ALEX Add. Ladder.

STEVE Great! But Alex is not having such an easy time.

NARRATION Though two years older, Alex can't keep up with Jimmy in reading. When an otherwise intelligent child falls two or more years behind in reading level, most specialists agree on a possible diagnosis: dyslexia.

STEVE Now I want you to read some words that are not real words, okay? Instead, just tell me how they sound. How does this first word sound?

ALEX Cat.

STEVE Good. Now this one.

ALEX Op.

STEVE Great !

NARRATION Now we're just going to do some more. One strategy dyslexic kids often use is guessing at words. Watch Alex try that in this non-sense test.

ALEX See. Scattered. Chad.

STEVE Ah, you made that into a real word. one a little closer, okay?

NARRATION Let's look at that.

ALEX S - s - scratched.

NARRATION "Scattered" and "scratched" are shrewd guesses -- Alex is playing off the consonants in the non-sense word. And he gamely keeps trying.

ALEX Stretched? ... Stressed.

NARRATION Exactly what dyslexia really is has been fiercely debated. Paula Tallal's work here at Rutgers is helping make this murky label more precise.

PAULA TALLEL What they're having trouble with many times is reversals of letters -- what appears to be reversals of letters, like "B's" for "D's" or "g's" for "P's". Well, it's really interesting; it turns out that those are also the same letters that are the most acoustically confusable along a very important dimension. And that has to do with how rapidly the acoustics are changing inside that individual speech sound.

NARRATION When we speak we create sound waves -- and a computer can convert them into pictures. "Puh" looks like this; "buh," like this. You can see they're the same except for this short stretch at the beginning -- a few hundred milliseconds of sound. Paula's theory is that sound changes this brief are too fast for dyslexic people to pick up on. So she's testing kids' ability to recognize sound changes.

PAULA Okay? Then it's your turn ... Okay, good.

NARRATION Jimmy can remember four tones and press the corresponding buttons -- even when the beeps are played quickly. But with just two tones, Alex is uncertain.

PAULA Okay, this one's a little tough ... your turn.

ALEX Oh no ... Oops!

NARRATION That was supposed to be that one. Trouble ... and to prove that Alex's problem isn't just hearing, Paula switches to another medium: visual symbols. Alex still can't do it -- the relationship between this string of symbols and his button pushing is almost random. Paula's results are clear and consistent: When information is presented too quickly, her dyslexic subjects just can't keep up.

PAULA The language and learning impaired kids had just as much trouble visually as they did auditorally. So the problem seems to be a specific problem that has to do with the rate at which the nervous system can transmit information that keeps coming at it, one after the other.

NARRATION At the National Institutes of Health in Bethesda, Judy Rumsey is investigating the physical side of this brain processing problem. Charles is about to undergo a positron scan. It's a painless procedure that allows Judy to study what goes on inside his brain while he listens and responds to a quiz.

JUDY RUMSEY Want to just go into the room and just try to watch the IV, but sit down on the bed. Okay, now go ahead and sit down and you're gonna lie down and put your head on this. And let's see if we can get your head positioned.

PAUL Okay. I want you to just hold still and close your eyes for the next couple of minutes. I'll be molding this to your face. Should not be uncomfortable for you at all. If it is, let me know right away and I'll adjust it.

CHARLES Okay.

JUDY This feels a little funny at first but it will be comfortable after a second or two. Instead of tones or symbols, Judy uses actual words -- but she's still testing how information is processed.

JUDY Okay, we'll begin the scan in just a minute. Now you'll be hearing pairs of unrelated words and if the two words within a pair rhyme, you should press the button as soon as you know that they rhyme. Paul, ready for the injection.

NARRATION As the scan begins, a radioactive tracer in this solution will make things more visible. Rhyming test words: Debate / relate, Iodine / serpentine, Improvement / percolate, Degrade / cascade, Bent / wheat, Vindicate / penetrate, Hesitate / dissipate, Deviate / permanent, Lace / pace, Salivate / cabinet, Lake / break, Sweet / treat, Calibrate / caliber, Deplete / sustain, Wade / made, Frustrate / translate, Went / ray, Defeat / concrete, Negligee / matinee, Dental / angry, Bent / lament It's not poetry, but it does the job. As Charles listens to each pair and responds to rhymes, the scanner captures successive pictures of the blood flow through his brain. Judy zeroes in on the areas responsible for language processing. It turns out that some of these brain areas are not active in dyslexic people.

JUDY RUMSEY This is an area in the left parietal lobe important for language processing. And as you can see here, on the right in our normal control, there's considerable blood flow and considerable neuronal activity. On this scan we see the same slice through the brain of one of our dyslexic subjects. There's less activity, as indicated by the ... ah ... cooler colors here and the fact that there's less of the warm colors -- the red and orange in particular -- in this dyslexic brain. This means that dyslexics are unable to actually activate this region that normals activate in order to do the rhyme detection task.

NARRATION So the evidence is mounting: dyslexia may be an organic -- even perhaps a genetic -- disability. That's why the Rutgers lab is now exploring early detection: playing tone cues to babies, and measuring their response time.

TEACHER Scene one says the setting is the Imperial Garden of Japan. Up to second messenger. Early diagnosis will help -- but if dyslexia really is a physical disability, sustained and supportive teaching will remain the only way to help these bright kids become successful readers.

ALEX This tree will have to be cut ... cut down. My perfect garden will be perfect no long ... longer. How... how trouble.

TEACHER How terrible!

ALEX How terrible.

WOODIE FLOWERS You know, I really identify with Alex, 'cause ! think I'm at least mildly dyslexia. When I was growing up, everyone else in my family really enjoyed reading, while I was struggling with it. The reason that struggle was so frustrating is that we just didn't understand it.

WOODIE (V.O.) If I'd been trying to learn something visible - like how to juggle - everyone would have understood that I could get one toss at a time, but I just couldn't put it all together. But if you have a good teacher, and supportive people around you -- even things that seem impossible - can happen!

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FATAL ATTRACTION

WOODIE FLOWERS In this tropical paradise, animals play.., raise their young.., and wage the daffy battle of survival. Take argiope argentata, more commonly known as the garden spider. Every morning, in the hours just before dawn, she spins a new web. The raw material emerges from silk glands inside her body. She is both architect and master builder, as she weaves the silk into this stunning tapestry. Its sole purpose: to snare insects for her to eat. At daybreak, Yale biologist Cay Craig and her graduate student, Cheryl Hayashi, track down the busy spiders. A mystery spun into the webs has lured them to Panama: Why do these spiders weave decorations, like this zigzag flourish? Usually, there's just a single decoration, but occasionally there are fancier patterns like this. How could decorations help in the spider's struggle to survive?

CAY Okay, this one's here from yesterday.

NARRATION That's what Cay and Cheryl are here to investigate. They want to find out if decorations catch more insects.

CHERYL Oh, there's no decoration today.

NARRATION To start they have to inspect an undecorated web. This one has some holes. Cheryl sketches the damage onto what will become a sort of baseline map of the web. Now Cay and Cheryl can spend the next hour finding and mapping new webs, while everything that goes on back at the original site will be recorded in the web itself. A lot of bees fly into the sticky net and then escape, musing only slight damage to the web. But this bee is not so lucky. The spider wraps her prey with fleshly made silk so it can't escape. Then she snips the strands of the web that originally trapped the bee, and carries her bundle back to the hub - she leaves a tell-tale trail of web damage in her wake. The meal takes a long one - she has to break down the bee with regurgitated digestive juices before she can eat it. While she's busy digesting, a lot of bees get a second chance. When Cheryl returns an hour later, she can reconstruct the events of the hour by examining the web and comparing it to her baseline map.

CHERYL Looks like about three interceptions occurred. That the spider actually caught the prey because they're cut out. There's also a bee that's been caught

and wrapped here, and you can see that the spider went out along this line and came back in. There are also a lot of other small line damages here which are probably insects hitting the web and then fleeing themselves.

NARRATION Now they're ready to tackle the mystery of the decorations.

CHERYL Okay. I think it is from yesterday, right. I think this is R - 24.

NARRATION The small spider has spun a small decoration.

CAY It probably has some growing to do.

NARRATION Will it help her trap bees?

NARRATION During the hour, this spider catches several bees.., and an unusual delicacy: a large grasshopper, still alive, struggling to breathe through the thick silk. This bee has been trying to escape for several minutes. Finally, it's bound by just a single strand. NARRATION The spider is not responding. Then the bee gets entangled again. The struggle is over.

CAY Oh my Gosh. What a mess. Look at this.

CHERYL Big interception here.

NARRATION The verdict that emerges from hundreds of these maps is unmistakable: decorated webs catch more insects.

CAY What these studies are showing is that they're really doing fantastic things, that they're decorating their webs with brightly-colored will to lure insects to them, to attract insects to the web.

NARRATION What is it about these decorations that make them so attractive - and so fatal - to insects?

CAY Stand by for a minute

NARRATION Cay has a hunch - and to test it, she's going to take some pictures.

CAY Ooh, perfect. Now perfect.

NARRATION She photographs the web once in normal light, and once with a special filter that blocks out all light except ultraviolet light. Ultraviolet, or UV light, is invisible to humans. But insects not only see UV light;, they see it as extremely bright. The flowers of many plants, including these grasses, reflect UV light, so

the flowers look even brighter to bees than they do to us. In fact, LTV light is a kind of beacon for bees, drawing them to their food sources. So as they fly through the air, the bees are looking for any surfaces that reflect UV light. Maybe the silk the spider uses to fashion her decoration also reflects UV light, just like a flower.

CHERYL All the visible light has been cut out.

NARRATION And it's this hunch that led Cay to take these pictures. Here is a high contrast black and white version of how we see the web. The decorations stand out, but so do the spider, the leafy background behind the web, and the entire blade of grass in the bottom center - both stem and flower are extremely bright. But in UV light only, the kind of Light that bees are attracted to, almost everything fades away, EXCEPT the decoration and the grass flower. This means that they both reflect UV light. In fact in this light, the zigzag decoration bears an uncanny resemblance to the flower. Viewed through a video camera which has been speedily adapted to read only ultraviolet light, the spider's strategy becomes dear: she is decorating her web to look like a flower, trying to fool hungry bees. But one more mystery remains. We know that spiders are meticulous builders. Day after day, they weave their webs, never varying the basic structure. But the decorations change all the time. Sometimes a single arm pointed this way, sometimes that way. Sometimes 2 arms, or even 4. Even more baffling, on some days the spiders don't decorate at all. That makes no sense, since decorated webs attract far more insects than undecorated ones. Is this just random behavior? Or are the spiders up to something? To fred out, Cay has devised an experiment to ask the bees. Assisted by Jennifer Maas, Cay lures the bees to the site of the experiment with a dish of sugar water. Once the experiment begins, Cay needs to track the behavior of each individual bee. That's a Problem. They all look kind of similar. Solution: nail polish. Fortunately, these bees don't sting.

JENNIFER Gold top, dark blue bottom. We haven't had one of those yet.

NARRATION Each bee gets its own individual marking, so it can be recognized later. Then Jennifer heads into the wild, to find the decorations they need for the experiment. She carefully lays the decoration onto a piece of sticky acetate. A web strung across this hoop goes directly in front of the sugar water dish.

CAY Are you ready, Jennifer?

NARRATION Then it's decorated. The bees still want to get to the sugar water. But now there's a decorated web in their way. How will they respond?

JENNIFER Gold top, pink bottom.

NARRATION Cay looks for the individual bees that she's marked. Here's the gold one.

CAY Gold caught

NARRATION Jennifer keeps track of what the marked bees do. Most of them are getting caught. But since there's no spider to finish them off, they always eventually escape. Do the bees learn something from this experience?

JENNIFER We think that flying into a web is pretty traumatic. It's kind of like if you slam your hand in a car door you're not likely to do it again, because it's just a really strong signal that will help you remember in the future.

CAY Yeah, avoid, around, you're right.

NARRATION After getting caught a few times, the bees do learn to avoid the web and fly around it. Here's a slow motion replay. The gold bee, who's gotten caught several times in the past, now flies around the web. So the bees have learned to avoid a web that's decorated like this. But what happens when Cay changes the decoration by pointing it in a new direction, like this?

CAY Blue top, pink bottom. Caught.

NARRATION Cay will have to repeat this experiment many times, to make sure, but it looks like the bees are now flying right into the web, as if they'd learned nothing at all.

CAY Caught, caught. Maybe changing the decoration confused them.

CAY Well the idea is that if the bees see the same decoration day after day, they may be able to learn to avoid the web more easily, then if the decorations constantly changing. So that could explain why the spiders have evolved to spin variable decorations, why every individual spins a different decoration, and its unpredictable.

NARRATION The spider and the bee are locked in a life and death struggle. The spider comes up with a trick to trap the bee; the bee either catches on or ends up as spider food. And when enough bees catch on, it's time for a new trick, or the spider goes hungry. This is the battle of the hunter and the hunted - played out by individuals, but evolving over thousands of generations. New moves keep the hunters ahead, new countermoves keep the hunted alive.

WOODIE FLOWERS That's it for this edition of Scientific American Frontiers. Be sure to join us next time, for a rare and exciting look at science in the Middle East. From the Pyramids near Cairo to the Bible lands around Jerusalem - from the rediscovery of ancient music to the latest research on newborn babies -- you won't want to miss Frontiers in Egypt and Israel. So please, come on back and watch.

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