SHOW 203

EPISODE OPEN

NARRATION An Olympic champion and his raring kayak help solve the mystery of this ancient boat - and bring it back to its Aleutian home. Also - the spider says "goodbye" with silk - but it says 'hello" with flowers. Babbling babies - they can't speak, but they can tell us how we talk. And a new cure for brain tumors - it takes just twenty minutes. All coming up, on Scientific American Frontiers.

back to top

THE BAIDARKA REBORN

WOODIE FLOWERS Hi. I'm Woodie Flowers, and welcome to Scientific American Frontiers. You know, a canoe is a nice boat Lightweight, efficient, easy to paddle. But where did the canoe come from? I don't mean who manufactured it, but where did the design come from? The answer is - we really don't know! It's the same with kayaks. Although nowadays we mass produce boats like this, canoe and kayak designs were developed by Native Americans so long ago - many thousands of years - that their origins have been completely lost. This great boat building tradition flourished all across the continent. But we're just discovering that it was most refined was on the remote Aleutian Islands, halfway to Siberia, a piece of America a thousand miles from the mainland.

WOODIE FLOWERS (NARRATION) A funeral for thirty native Americans. But these remains are seven hundred years old. Ancestors of these Aleut people who live in the village of Nikolski. The nearby burial cave, discovered a year ago, contained the remains. The Aleuts decided an investigation was justified. It meant no disrespect for the dead, because the aim was so vital - to rediscover their own history. To help reveal the past, anthropologist Bill Laughlin has worked alongside the people here for the past fifty years. These 1948 home movies show one of Laughlin's earliest digs at the site of an ancient village. His discoveries have steadily revealed a way of life that has thrived here for 9000 years. The key to this achievement was not on the land - it was out at sea.

BILL LAUGHLIN "This is an especially good place to see the historical panorama of the interaction between the Aleut hunters and collectors and the sea from which all their resources came. Everything they needed came out of the ocean. And the biggest challenge of course is to go out on the open sea and harpoon a sea lion or a whale."

NARRATION The treeless tundra of these islands holds Little that sustains life. While the surrounding ocean is rich in whales, seals, fish of many kinds. But to hunt and travel year-round required an ocean-going vessel that could stand up to the roughest waters and worst weather in the world. The Aleuts developed a sophisticated boat design that met these challenges for thousands of years. Their invention was an ocean kayak, named the baidarka by Russian explorers. Fast... sea-worthy ... it was the crowning achievement of the Aleut hunters. Boat builder George Dyson is out to learn the mysteries of baidarka design and performance. Accounts by 18th century Russian colonists describe extremely fast boats - but no examples survive. To recreate how the high-speed baidarka worked, George's only guide is this tantalizing sketch, two centuries old, of an odd looking craft.

GEORGE DYSON From these sketches and from what is being discovered in burial cases and so on, archaeological evidence, how do we reconstruct the dynamics of boat budding at that time from what really is only fragmentary evidence. And the only way to do that is by reconstructing the vessels themselves.

NARRATION The original frames were made of pieces of driftwood, a scarce and precious building material. In his workshop north of Seattle, George Dyson has other choices. He's trying out aluminum tubing while colleague Joe Lubischer experiments with the same design made from wood. The flame presents some perplexing features. A bow like an open jaw - was it functional or purely decorative? The stern ends not in a point, but in a square. Why? Inset in places - bone bearings where the parts rub together. The ancient boat builders obviously didn't want a rigid structure. They used loose lashings as well. The result is a very flexible skeleton. Over this frame, Aleut Mike Lekanoff sews on a nylon covering - a substitute for the sea lion hide his ancestors used. A flexible skeleton wrapped in soft skin - just like the sea mammals the Aleuts hunted. For the first test they've chosen a calm fresh water lake, where it will be easy to measure speeds on a quarter-mile run. Recruited to paddle is Greg Barton, world record holding Olympic gold medallist. He'll run the course first in his own racing kayak. Greys strength roughly matches a typical Aleut hunter who, like Greg, kayaked every day. But his kayak is radically different from the Aleut baidarka.

GREG BARTON This kayak is designed specifically for racing on calm water in a straight line. It's very narrow, that's the main difference between this kayak and the others. This is much skinnier, it has much less resistance in the water.

NARRATION Resistance is created when a boat pushes water aside, forming waves at the bow and stern. The faster it goes, the larger these waves grow. The paddler has to climb up his own waves. So as the boat makes big waves, it reaches a sort of natural speed limit that's tough to beat. Greg's racing boat is more streamlined than the average kayak. You can see the small waves it's creating. Full out, he hits ten miles an hour... Olympic class sprint speed. Now the baidarka. Based on its larger hull it's bound to be slower. But how much slower, no one knows. Greg puts out all he has and hits nine miles an hour - extremely fast for a kayak this size, matching the best high performance commercial models. But the two-piece bow seems to be doing little - it's right out of the water! In fact what's happening is the boat is planing - skimming the surface. It's a way to beat the speed limit of its own waves, a trick well-known to modern boat designers. But it looks like the Aleuts got there first. The trials were revealing - but not realistic. Baidarkas were meant for different conditions.

GREG BARTON If you took these same boats and put them in some six foot swells, I'd be swimming ashore with my race boat and I'd still be paddling the other boats. And also the speeds may vary. The other boats probably wouldn't slow down nearly as much whereas the race boat would be floundering and you'd be spending a lot of time just trying to keep the boat upright.

NARRATION So for the ultimate test, Frontiers has arranged to bring the baidarka back to its roots in the Aleutian Islands. It's high summer here but the weather is still cool and the waves are still ominously large. We're going back to the village of Nikolski, ancient center of traditional Aleut boat building. They still depend on the sea for their livelihood. But no one's hunted in a baidarka for 80 years. George Dyson and Bill Laughlin are on hand for the baidarkas' arrival. The boats will have come 3000 miles from Seattle - first by commercial jet to the nearest fishing port, then three days at sea on board a fifty foot trawler. Finally, they're transferred to small boats out in the bay - and then the baidarka is home at last. For the Aleuts it's a time of rediscovery.

BILL LAUGHLIN That's marvelous. I think that's the first time now since 1910 that real baidarkas have been brought ashore here. It's a historic moment.

NARRATION The young people have never seen a baidarka before - but for the older men the memories come flooding back.

BILL ERMELOFF They had a piece of sea lion hide about this wide and about five feet long that they put in there and that's where they sat They used grass for putting under their behind.

SCOTT Did they carry a lot of stuff in the old time baidarkas?

BILL ERMELOFF Yeah, they did carry quite a bit of stuff. They carried provisions and stuff to eat. Sometimes two or three baidarkas in a group would tie together and spend the night on the open sea when they were hunting sea otters.

NARRATION For George it's the moment of truth - the water is forty degrees, and it's going to be rough out there - dangerous waters for the boat's first ocean test. But he's a skilled kayaker and this, after all, it's where the boat belongs. As it works its way onto the open sea, the mysteries of the baidarka's strange design will be mysteries no longer. The open jaw bow has an obvious sanction: the lower section pierces the surface, providing dean entry into the water. The wide upper bow gives the boat lift as it crashes into swells. Without it the baidarka would nose dive into the waves. So the ancient designers managed to combine different qualities in a single craft high speed during the hunt, safety and comfort cruising in big seas.

GEORGE DYSON It feels real nice in the rough water, feels like it was made for rough Water. The fact that it could achieve significant times on a flat water race course and also cut into this sloppy water as cleanly as it does definitely shows the real virtues of a versatile design.

NARRATION Another virtue is the flexible frame. Working in rough conditions every day, a rigid boat would wear out quickly. But with a shock-absorbing hull the baidarka can bend with the waves instead of straining against them. The Aleut designers could also turn the dangerous surf to their advantage. The wide square stern catches the energy from following waves pushing the boat on its way.

GEORGE DYSON This thing would surf like crazy if you had the power to get on top of these waves.

NARRATION With an experienced kayaker like George making it look simple, it isn't long before everyone wants a go at it.

LARRY PLETNIKOFF:: Let's try it out, eh? I'd like to try it out.

NARRATION Larry Pletnikoff has never gone kayaking before. And remember, this is an expert level boat - it's very tippy. But even a tumble into the frigid bay doesn't phase the brave at heart.

LARRY PLETNIKOFF: Oh, it was great?

GEORGE DYSON I couldn't believe he stayed up as long as he did! I've never found anybody who's never kayaked before who stayed up that long!

LARRY PLETNIKOFF: I did it today, ehhh?

NARRATION In the hands of its inventors, the baidarka is back in home waters.

WOODIE FLOWERS Now that the baidarka has returned to the Aleutians, the local people are determined to revive their boating traditions. And it's not too late. As we just saw, there are still a few older people who remember what it took, especially the extraordinary physical skill and stamina. Young boys started training from their earliest years - at age four or so. They played with model baidarkas... They even had miniature harpoons like this to get ready for the real thing. And all the time they did exercises .... Like hanging by your fingers to develop the muscles that hold the paddle.., and sitting with legs straight out - like you would in a baidarka - and leaning forward, to develop flexibility.., or stretching exercises like this... All designed to ensure that the abilities of the Aleut paddler matched the abilities of their wonderful boat, which is now back in its original home.

back to top

FATAL ATTRACTION

NARRATION 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? 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. 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. 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.

back to top

ART OF SCIENCE

WOODIE FLOWERS (NARRATION) This is an example of the art of science. This is not. It's a little drawing I made of a beach in California. There's something funny about this drawing- aside from the fact that I'm no artist. It might show a few yards along the shore, or it might show the whole coast from Monterey to San Diego. Without knowing the scale, you just can't tell. Realizing that something can look. The same at different scales is one of the key ideas behind a hot topic in math called fractals. This is a fractal, and so is this. Actually, fractals are mining up everywhere, from the patterns in clouds to the linings of our lungs. And the study of fractals is also generating something else - dazzling animation. Heinz Otto Peitgen and Spektrum Videothek produced the hypnotic images you're about to see. Keep an eye out for change of scale - but as always on the "Art of Science," the main thing is just to sit back and enjoy.

back to top

BABBLING BABIES

WOODIE FLOWERS This is Corey Rae, age 12 months. She's learning to speak, and so far, she has one major accomplishment: "Hi." But researchers at McGill University in Montreal are paying less attention to her first word than to this:

MOTHER Mamamamama.

NARRATION Listen to that again.

MOTHER Mamamamama. Mamamama.

NARRATION This is babbling, when a baby repeats a syllable over and over. All babies do it - it's part of learning to communicate. But according to psychologist

Laura Petitto, babbling is not language as we know it - as meaning and content - it's language as a baby knows it- as forms and sounds.

LAURA The important thing about the way children use these forms is that they don't mean anything. There's nothing in the world that they're referring to. It is a stage of human development where the child is simply playing with the raw form of human language. How did you know when was babbling. What was different about it?

MOTHER Babababababa. She just started...

COREY RAE: Bababababa...Babababa.

MOTHER Babababababa.

NARRATION If Corey Rae doesn't mean anything when she babbles, then why does she do it? Most linguists think that a baby like Corey Rae babbles because she is establishing control over the muscles that produce speech. Laura has a much more radical idea. She thinks Corey Rae is babbling, not because her vocal tract is maturing, but because her language ability is maturing. This disagreement is fueling an intense debate about the nature of language itself.

WOODIE FLOWERS Here's the central question: Are language and speech as intimately connected as they seem? We've evolved so that our brains work together with our vocal tract to produce language in the form of speech. But if our vocal tract hadn't evolved this way, would we still have language? Many linguists say no. Laura says yes - language is an independent part of the brain which would find some way to come out, even in the absence of sound. But in a world where language is expressed through speech, how would you study that question?

NARRATION Here's how: This is Rainy, 18 months old. Rainy is profoundly deaf, and so are his parents. From birth, he's been exposed to a language based not on speech but on signs, produced not with the vocal tract, but with the hands. Both Rainy's parents communicate to him in sign language. Children like Rainy are a unique opportunity to test Laura's theory.

LAURA If you want to understand whether language is involved in the production of babbling, or speech is involved in the production of babbling, sign languages are the test case because they're not based on speech.

NARRATION If Laura's theory is right - if babbling is tied to language and not to speech - then deaf kids like Rainy should babble. Of course they wouldn't babble with their voices, they would babble with their hands. Do they? And how would

we know if they did? student Paula Marentette are trying to figure out. That's what Laura and graduate. Each hour of videotape that she shoots takes Paula hundreds of hours to analyze it's hard work to determine if Rainy is using his hands to babble. That's because kids use their hands in a lot of different ways - to point to things, to scratch themselves, to handle objects, to express anger. And all kids do a lot of this kind of gesturing when they're excited. To filter these out, Paula and Laura study hearing children's hand movements as closely as they study deaf children.

PAULA Given that Corey Rae is producing this open-close gesture we sort of store that knowledge and when we see that in a deaf child, we think - okay, this is a form that occurs, we've observed this in hearing children. So it's probably a gesture rather than a sign or a babble.

NARRATION But even when Paula throws out all the gestures, and points, and scratches that she knows are not babbles, there's still a lot of hand activity left. This is Isabelle. Watch her hands closely. This gesture has never been seen in hearing children, and it doesn't refer to anything. Now Paula can move to a new level of analysis. Is the hand shape and hand movement that the baby is using commonly seen in adult sign language? Watch as this adult makes the sign for "angry," and for "curly." Notice the hand shape - an open hand with curved fingers. The same as Isabelle's. And the movement, a kind of flapping at the wrist. Reminiscent of this movement, a sign that means "don't want," as in "I don't want an apple." Now, how does what Isabelle is doing with her hands compare with this?

OLIVIER Dun, dun, dun, dun, dun.

NARRATION For Laura, all the hours of screening and studying come down to this question: Is what the deaf children do with their hands the same as what this hearing child does with his voice?

OLIVIER Dun, dun, dun, dun, dun.

LAURA What the child did is he extracted out a sign that he heard in his environment, a sound that's in world languages. It's organized in relation to another sound, so there's a consonant and a vowel. It's organized in a syllable and this syllable is repeated again and again and again.

NARRATION Now Laura turns to a tape of Vance, a 9 month old deaf child. His sister and his mother are signing about what they did earlier that day. Trying to get into the conversation, but not yet able to sign, Vance puts his hand directly in their line of sight and makes this gesture. Here they are - all the same features of babbling that Laura has observed in hearing children. And of course, this time the

repeated syllable consists not of a consonant and vowel, but of a hand shape and hand movement. Vance is babbling. He's not actually signing, the way his mother and sister are, but he's taking the first step.

LAURA None of these forms are the identical forms that a parent produces. In the same way in vocal babbling. Not many parents walk around the house going "dadada". Nonetheless, children produce these forms. So the babbling is the child's active attempt to master the form of language. To listen to the environment, to look at the environment, and in little baby steps play with these the forms of language in an attempt to build and master a target language.

NARRATION After analyzing hundreds of hours of tape, Laura has concluded that deaf babies babble, just like hearing babies. And that's vital evidence for the theory that language does not need speech to express itself. It will find a way out, by whatever means are available. But does this mean that sign language is just a substitute for speech, something that the brain turns to when speech is not possible? Here's a way to find out. Simon is almost 2 years old. He's signing...

FATHER Et qu'est-ce qu'il fait?

SIMON Woof.

NARRATION ...and he's speaking.

SIMON Ah oui. Et la, et la.

NARRATION His mother is profoundly deaf and signs to him.

FATHER C'est quoi, ca?

NARRATION His father is partially deaf, and speaks to him, in French.

FATHER Pour fair quoi?

NARRATION Simon, who has normal hearing, seems perfectly comfortable with this arrangement.

FATHER For Simon, it's very natural. He never gets frustrated with it. He doesn't really make a distinction between the hearing and the deaf. People are very surprised that he can sign. He's like a model to the world.

NARRATION Simon is learning both to sign and to speak. But does he find speech more natural, easier to learn? Paula and Laura have been videotaping Simon since he was 4 months old. And here's what they've discovered: Simon is

passing every major milestone in language learning - in both sign and speech - at exactly the same time. One of these milestones is putting 2 words together.

SIMON Parth' l'eau, l'eau.

NARRATION "Partir l'eau, l'eau," he says in French. "The water's all gone." A few minutes later in the tape, he's putting two signs together. He signs "monkey" and then "same", meaning the monkey in the room is the same as the one in the book.

PAULA It suggests that the brain doesn't care if one is a signed language and one is a spoken language. That it can take input from signor from speech equally wel and do what it needs to make a fully productive language

NARRATION Years of painstaking work on babbling and language learning are bringing Laura closer and closer to the ultimate goal: understanding that highly inaccessible par tof the brain which is language itself.

KATIE (SIGNING) "Communicating with your hands works fine -- as long as other people know the language."

WOODIE FLOWERS "Communicating with your hands works fine - as long as other people know the language." That's what Katie just said in sign language, and it points to the practical follow-up to this story. If Laura Petitto is right, then using your hands is just as natural a way to communicate as using your voice. But evolution has created a world in which hearing is a given and speech is the norm. And that creates obstacles for deaf people. For example, think how much you'd miss watching television without sound. Actually, thousands of deaf people see Frontiers and many other TV programs this way. These captions are broadcast along with the regular TV signal, but you normally don't see them unless you have a decoder. Captions help bridge the language gap - and they're a great example of the way technology should work: it doesn't get in the way if you don't need it, but if you do, it's right there.

back to top

3-D THERAPY

NARRATION Ken Walker has a brain tumor. But the chances are that by the end of tomorrow a new kind of radiation therapy will have killed the tumor - in a single treatment.

WALKER Initially when the doctor said, would you like to try it, I said "Absolutely!" The traditional radiation would probably be every day for six to seven weeks,

which is a couple months from a life, going on with your life, difficult to work in. This has the possibility of being a one-on-done, so it sounds great to me. I'm ail for it.

NARRATION Eight A.M. the next day, at Boston's Brigham and Women's Hospital. It's a startling scene as doctors prepare to attach a metal ring to Ken's head. Itís essential for the ring to stay in position throughout the day, so they'll use blunt plastic pins to clamp the supports tightly to his skull.

DOCTOR Mr. Walker, right?

NARRATION This is the worst part of the day.

KEN WALKER It may look like medieval torture, but Ken feels no pain. In fact, the little lumps on his forehead are filled with a liquid pain killer. Neurosurgeon Eben Alexander developed this treatment, along with radiation therapist Jay Loeffer on the right. They will use the ring and this metal cage which fits onto it to find the exact position of the tumor. Eight-fifteen A.M. Ken is going to have an x-ray called a CAT-scan.

DOCTOR Ken, now don't hold your head. Relax. Relax your neck.

NARRATION It's routine for most large hospitals, but here the team will add a special feature. As Ken's wife, Gloria, looks on nervously, the metal cage has been fastened securely to the ring. Now it will show up on the x-ray, and provide fixed reference points for precisely locating the tumor. It's like putting a grid of lines on a map to allow a map reference to be read off. The x-ray procedure begins. In twenty minutes the machine will take a series of pictures through the head. The pictures are arranged in slices an eighth of an inch thick, piled one above the other, Like the floors of a building. The tumor shows up as a dark shadow just behind the left eye. It's clear to the doctors, and to Ken's wife.

DOCTOR We'll probably target a little bit off center.

NARRATION With these pictures the team will work out the exact shape, size, and location of the tumor, and then plan the therapy. The planning is going to take several hours so now for Ken comes the most difficult part - just sit and wait, with the ring still in place. It's the vital reference point needed for the treatment later today. The team moves over to the computer system at the nearby Dana Farber Cancer Institute. Eben Alexander begins work.

EBEN ALEXANDER Right now what we're doing is just marking in the contours as we see them here, of the tumor itself. What this enables us to do is to come up with a three-dimensional reconstruction in space.

NARRATION Eventually the computer will have a complete picture, not only of the tumor but also of the eyes and other critical structures nearby that the treatment must avoid. Here the optic chiasma - the delicate structure where nerves from the eyes join together - is being mapped. And here they are marking out one of the optic nerves, another critical structure. After three hours spent marking out every x-ray picture, it's clear that the tumor is dangerously dose to two crucial structures. They have got to be left unharmed by the treatment.

EBEN ALEXANDER So here is our real challenge. It's right here. Because here we have the hu'nor itself and then immediately within four to five millimeters away is something that we don't want to give any radiation dose to. The tumor we will get maximum dose to. And the optic nerve and chiasma, very low dose.

NARRATION It's two in the afternoon. The planning session is now being led by physicist Hannah Kooey. It's his job to work out how to direct the radiation at the tumor safely, using this three-dimensional computer map. It shows the tumor in blue, and close by, the crucial structures, all precisely located above the circular metal ring which Ken is still wearing. If Ken were going to have conventional radiation treatment, his entire head would be given a small but damaging dose every day for a couple of months. It only works because the healthy parts recover more quickly than the tumor, which gradually dies. In contrast, the new treatment is a single, concentrated dose. But the radiation is continuously moving, so most of the brain gets just a small exposure - the tumor is the only constant target. In the planning session they are now trying out different pathways for directing the radiation beams at the tumor. The computer keeps track of places where a beam would pass through a critical structure. And it becomes dear that getting enough radiation in to kill the tumor will inevitably mean some exposure of the optic nerve.

HANNE KOOE At this point we have to decide, given those set of beams and placement of those targets, what is the actual dose we will be delivering to the tumor, and what is the actual dose that we will be delivering to a critical structure.

NARRATION Here the computer shows in red the high-radiation dose area. The tumor is covered but so is a small part of the optic nerve. There will be some damage - but not enough, it's judged, to harm Ken's vision. It's now late afternoon. excruciating headache. And the constant pressure of the ring has given Ken an It's turning into a very long day.

GLORIA WALKER Well it's real hard to look at him like that with the lights on. I'm not real good with needles or anything like that, so I always have to look away with IV's or anything. So this is not a real pleasant visual appearance.

KEN WALKER This morning I, the anxiety had to do with putting this contraption on. And I'm not at all anxious about getting the radiation treatment. I'm just anxious about getting this thing off.

NARRATION Finally, at six o'clock, it's time for the treatment. The ring is locked into position. Now the tumor inside Ken's head has become a precisely located target, that the beam from the radiation machine will be able to reach with pin-point accuracy. There's a quick run through of the moves which the team spent the day planning. Then it's back to the control room for the real thing. There'll be just twenty, minutes of exposure.

WOMAN 2.91 going to the ....

NARRATION Ken will avoid entirely the unpleasant side effects which would go with conventional, long-term radiation treatment.

EBEN ALEXANDER When he leaves the room, the tumor has been altered in such a way that it is now essentially dead. So this has a very dramatic effect on the tumor, and just with this one twenty-minute trip into that room, we are going to kill the tumor. The treatment itself is virtually automatic except for the tumor, nothing is going to change now. But somehow it doesn't seem that way.

GLORIA WALKER It's probably just that nerves are a part of the whole thing. Just waiting and knowing that it's really going on. That this is the whole reason why we came here. So, I'll be glad when it's all over.

NARRATION It quickly is. Now the moment Ken's been longing for.

EBEN ALEXANDER Take it easy for a moment. O.K.

NARRATION Relief, though, is not immediate. He's got the worst headache he's ever known.

KEN WALKER One of the problems with the flame when it's on all day is that you get used to it being on. And when you release the tension of it, it's, that's the worst time for the headache. And this kind of pressure headache will go away very quickly.

NARRATION And the next day Ken had no problem keeping an appointment with our cameras.

KEN WALKER Just after I got the ring off I was feeling pretty poor, but within, I guess the doctors said within an hour or so, most of it would go away. By the

time we got down and got the taxi, got back to the hotel, I felt good enough to go downstairs and eat dinner.

GLORIA WALKER It's a good feeling to know it's all over and done with and it was successful and he's feeling better and all one piece. And it's great.

NARRATION There are just a few places in the world where this kind of high accuracy treatment is possible. But for Jay Loeffler, that won't last long.

JAY LOEFFLER We're tired of having long-term complications to radiation. 'You have to be more specific - get in the radiation to where tumors are, and avoid normal structures on the way in and out. I think this is just the beginning of a lot of changes in radiation therapy.

WOODIE FLOWERS It was a year ago that Ken Walker sat here and talked to us about his radiation therapy. Today he's in perfect health. That single treatment completely destroyed his brain tumor. The technology that helped Ken survive is another advance driven by the application of computers. And its now spreading to hospitals all over the country. But, that wonderful innovation is not a universal cure. If you get sick the best treatment is one you and your doctor decide on for your individual case. Next time on Scientific American Frontiers science meets the good life in our spedal from France. Please come on back and watch.

back to top