"THE FRONTIERS DECADE"
- SHOW 1005

EPISODE OPEN

ALAN ALDA: On this edition of Scientific American Frontiers, you're invited to a party. We're celebrating 10 years of the series, with a high-speed trip through 200 stories, and a decade of science.

ALAN ALDA: (Narration) We'll see what science discovered, probing the oceans, the forest and the earth. We'll look at the advance of high-tech in medicine and in brain research. We'll unearth the human past, around the world. And we'll have some fun. After all, it's a party.

ALAN ALDA: Ha ha. I love it. Science! I'm Alan Alda. Join me now for The Frontiers Decade.

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WONDERS OF THE WORLD

ALAN ALDA: Hi. Come on in. It's going to be a great party. It's amazing. Scientific American Frontiers has been on the air for ten years now -- over 200 stories about scientific research on subjects ranging from the deepest recesses of our brains, to the furthest reaches of the universe. Of course, there's no way that our 200 stories can stand for all of science -- science now is enormous. Of all the Scientists who ever lived, more than 95% of them are alive today. Tonight, as we look back over our stories, we think we can see here and there a trend that's emerged. Maybe even a single thought pulls it all together -- and that's the sheer power of science to take a simple question and in answering it reveal unexpected worlds within worlds. For example -- a young biologist heard rainforest bees buzzing whenever they returned to the nest. Why do they buzz? he wondered. That's a simple question. After a series of experiments, he managed to decipher a buzz code that the bees used to direct other bees precisely to the best flowers in the forest. Bee sentences, he calls them. That revelation leads on to many other places that are fascinating -- in animal communication, animal intelligence, in evolution. All right, hold on to your seats -- this is going to be a lightning quick trip back through the Frontiers Decade of science. If you blink, you're liable to miss a new life form, or something...

ALAN ALDA: (Narration) Ancient lifeforms, but new to science, were in fact discovered in Yellowstone's boiling -- and hazardous -- volcanic pools, by microbiologists Norman Pace and Sue Barnes.

SUE BARNES: Whoa!

NORMAN PACE: Let's map around out here.

ALAN ALDA: I'm sorry.

NORMAN PACE: No, it's OK.

SUE BARNES: It's not fatal.

ALAN ALDA: Have you lost many microbiologists?

SUE BARNES: Nope.

ALAN ALDA: I saw a bleached bone up there.

ALAN ALDA: (Narration) The DNA of the lifeforms -- called archea -- is very primitive, suggesting life on earth began in hot volcanic conditions. It was a surprise to find life in hot places, and a surprise to find life in deep, dark, cold places.

ALAN ALDA: So we're just traveling through space here. It looks like we're...Whoa, whoa...

BRUCE ROBESON: Whoa. Paralia, paralia.

ALAN ALDA: What's that? What's that?

BRUCE ROBESON: These are great big brown-colored medusae.

ALAN ALDA: Oh, that's gorgeous.

ALAN ALDA: (Narration) Many of these creatures, discovered off California in the Monterey Canyon, were also unknown to science. They live in the vast, unexplored middle depths of the ocean, below about the half-mile mark. Science also revealed nature's fantastic versatility in other extreme environments.

SCIENTIST: This fellow's heart will beat about 5-10 beats per minute. Their breathing rate drops to 10-15 breaths in a row and then an hour of no breathing.

ALAN ALDA: (Narration) Alaskan ground squirrels unfreeze every few hours in winter, while Canadian wood frogs stay frozen. In spring, their first heartbeats direct blood just to the waking brain. We learned new things about animal communication when a baby killer whale named Orkid was born as Sea World in San Diego. When Orkid's mother died, the baby was adopted by another female, named Kassatka. Killer whale families have different calls, but Orkid switched to her adopted mother's calls -- she showed she could learn something new. ANN BOWLES: There's a call. Orkid. And I can hear her respon

se in there from Kassatka behind. This is super.

ALAN ALDA: (Narration) We found more terrific examples of animal communication in the Central American rainforest. There's a kind of ant which protects a kind of caterpillar by driving off parasitic wasps. The question was, how do ant and caterpillar find each other among the billions of leaves in the forest? It turned out the caterpillars use sound, produced by tiny vibrating spines which resonate as they knock against the rough skin of the caterpillar's head. Phil De Vries discovered the spines and recorded the delicate calls they broadcast to the forest.

ALAN ALDA: Now these are stingless bees.

DAVID ROUBIK: Yeah, these are the user-friendly bees.

ALAN ALDA: So this is what it looks like inside a normal hive.

ALAN ALDA: (Narration) In Panama, I made my contribution to animal communication research.

ALAN ALDA: They have little numbers on them. 78. Now we've numbered a bee. Number 78 is my bee. When this bee makes a great scientific discovery and we all go to Sweden to get the prize, number 78 is mine.

ALAN ALDA: (Narration) Listen to the buzzes. It's a code the scientists deciphered by attracting foraging bees to particular places in the forest. The buzz code is how the rest of the hive learns where to find the food. At the same institute, we joined one of the world's top bat experts, who works out how bats use sound both to locate prey -- like fish or insects -- and to get around in the dark forest.

ELISABETH KALKO: I hear the naked-backed bat; then I hear Saccopteryx balineata, the white-lined bat. In the background I hear a free-tailed bat. So it's a whole symphony of bat calls that surrounds us right now.

ALAN ALDA: (Narration) The aye-aye, from Madagascar, also uses sound to find its food. It simply hones in on every hollow sound in the wood -- even though there may be no grubs inside, as in this experiment. We looked at some wonderful work on flight. One extraordinary experiment observed a single fruit fly as it responded to changing surroundings. You could see that the fly tracks its world visually, because it tries to fly up or down in sync with the moving background. You'll be glad to know they gave their subjects time to rest. In another micro-experiment, a blowfly's muscle pulses are detected as it aims toward a moving target. Tiny counterweights that the fly uses for flight control were visible. In George Ruppell's classic studies of dragonfly flight, he's shown that their double wings, independently controlled, give them their terrific agility -- most of the time, that is. Spiders gave us a good scary time on Frontiers this decade.

RICK WEST: She's turning around. She's going to cover the entrance with silk.

ALAN ALDA: (Narration) Our cameras stalked tarantulas in the Ecuador jungle, while I scared myself just imagining spiders in Arizona.

ALAN ALDA: There's something in here...oh, oh jeez...watch out, there's something in there!

SUSAN RIECHERT: Yeah, a cricket or something.

ALAN ALDA: What? A cricket?

ALAN ALDA: (Narration) Crickets have their own problems with spiders, but scientists are endlessly fascinated, as we discovered. One study solved the problem of the mysterious zig-zag decorations on the garden spider's web. Unlike the rest of the web, the zig-zags shine brightly in ultraviolet light. So to flying insects, they look like flowers -- just the right place to land.

FRITZ VOLLRATH: Oy, hello spider! Oy, oy!

ALAN ALDA: Yeah, it's not the air. It's the sound. Oy! Oy! This is the first time I've been able to scare a spider.

ALAN ALDA: (Narration) I got back at spiders in Denmark, where Fritz Vollrath has worked out basic web-building rules, and then transferred them to a cyber spider, which now builds webs inside a computer. Ingenious high tech methods were also used here, when female jumping spiders were shown video mates with different features, to sort out what they preferred. It turns out they like the gray males -- with some hair. Then we followed the relentless portia spider as she crept across her victim's web, gently plucking it in imitation of falling leaves, to mask her approach.

STIM WILCOX: Raised up high like that, higher and higher. They're way up high ready to...jump.

ALAN ALDA: (Narration) The decade brought great revelations in animal intelligence. One surprise was that octopuses can learn from each other by observation -- by watching how to open a glass jar, for example. Here's the student watching an experienced octopus. And now, here's the student having seen it only once, succeeding in the task immediately.

ALAN ALDA: Oh look, he got in. He got it open. And he was never able to do this before?

SCIENTIST: No.

ALAN ALDA: (Narration) Just as unexpected was the creativity shown by young ravens when first confronted by an unfamiliar challenge.

SCIENTIST: What color?

ALEX: Yellow.

SCIENTIST: Yellow, that's right.

ALAN ALDA: (Narration) The multiple skills shown by Alex the parrot were simply startling...

ALEX: Two.

ALAN ALDA: (Narration) ...to our audience and scientists alike.

SCIENTIST: What matter four-corner blue?

ALAN ALDA: (Narration) The question means, what is the four-cornered blue object made of? It was a brand new question for Alex when we filmed this.

SCIENTIST: What matter four-corner blue? Wood, that's right.

ALAN ALDA: All right, give me a kiss...oh God.

ALAN ALDA: (Narration) Rio, the sea lion, showed us in another way that animals can think abstractly. He's able to sort abstract symbols -- to us, they're letters or numbers -- into two groups, and tell one from the other.

ALAN ALDA: By the way, I got that, and I wasn't getting a herring.

ALAN ALDA: (Narration) Work with chimpanzees confirmed how highly social animals can be, and how -- just like humans -- baby chimps have to learn how to behave.

ALAN ALDA: Ouch!

SCIENTIST: That's not nice.

ALAN ALDA: No.

ALAN ALDA: (Narration) Frans de Waal, in particular, has spent years dissecting relationships and personalities within natural chimp groups. Take sharing, for example. It's normal to share in the group, but some chimps, like Georgia here, can't handle it yet.

ALAN ALDA: Do you think Georgia is stingy because she hasn't learned to share yet or she's just naturally stingy?

FRANS DE WAAL: Well, in human terms, you would almost say she doesn't have the confidence yet and position yet to be generous with others. She's still very much in sort of competitive mode like, "How much can I get myself?"

ALAN ALDA: (Narration) We've checked in several times, over the years, with Sally Boysen, who gently probes the chimpanzee mind. That was three peaches in the first box. Sheba the chimp counts three more.

SALLY BOYSEN: How many peaches? How many? Show me. Yeah, six. That's the right answer. Good girl.

ALAN ALDA: (Narration) Here are Sally and Sheba three years later.

SALLY BOYSEN: That was impressive, Sheba.

ALAN ALDA: That was cute.

SALLY BOYSEN: I'm going to take this little one. You watching me? Yeah, and I'm going to put it in here. OK? Watch, I put it right in here.

ALAN ALDA: (Narration) Human kids can't manage this test of symbolic thinking until age 3.

SALLY BOYSEN: Go find the real one for me. Hurry! Hurry! See if you can find it.

ALAN ALDA: (Narration) But to Sheba, it's child's play.

SALLY BOYSEN: Oho. Good work!

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CYBERDECADE

[Music Segment, No Narration]

ALAN ALDA: Let's say you can get a machine to give every indication that it's feeling stuff. So what? How will that change the world?

RODNEY BROOKS: I'm interested in understanding what it is about us that makes us human. This is my attempt at trying to break down what it is that makes us human into simpler components, to therefore understand it.

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MEDICAL DECADE

ALAN ALDA: Our next segment is about medicine. I love discussing medical problems at dinner. During our decade, two important and contrasting trends became clear. In the first, we've seen computers and high-tech methods really take hold in almost every branch of medicine. We now routinely image and map the body with unprecedented accuracy, for example, and I don't think there's a lab I've visited that hasn't made some kind of computer analysis a crucial part of its work. The second trend is ominous. Disease organisms are fighting back, developing resistance to once reliable therapies. As we saw in stories on TB and malaria, this is an extremely serious worldwide threat. So there was a lot of action in medicine. Let's take a look.

ALAN ALDA: (Narration) In a recent story on high-tech medicine, I was in the operating room as Linda Tolve had a large tumor removed from her brain -- a tumor that some doctors had judged to be inaccessible. A 3-D computer graphic image was superimposed on Linda's brain to guide the surgery.

DR. BALCK: I think we're pretty happy with that in term of the resection. I think now it's just a matter of making sure everything's nice and dry. But we are essentially done.

ALAN ALDA: Congratulations.

LINDA TOLVE: Great doctor, huh?

ALAN ALDA: (Narration) Sophisticated image processing was also behind this prototype aid for the partially sighted that Leonard Perra tested, with his grandson helping out.

LEONARD PERRA: All I've ever seen was shapes, not faces. No features. And now I can see their faces again.

ALAN ALDA: (Narration) The program's long-term goal is to continuously track an eye's defect, and then have a wearable computer literally fill in the blank. We saw

the same idea -- using high tech to compensate for problems -- as we continued to follow the story of Kara, a vibrant young victim of cerebral palsy. Here, infrared lasers surreptitiously track Kara's eye so she can select messages on a screen, simply by looking at them.

KARA: It's great to see you again.

ALAN ALDA: Hey, what a nice reception! Hi ya, Kara. It's great to see you again, too!

ALAN ALDA: (Narration) In this extraordinary research program, computer control of muscles through implanted electrodes brought paralyzed limbs back to life. Right now it's a crude simulation of natural nerves, but it enabled Dan to stand on his own for the first time.

TECHNICIAN: How's it feel, Dan?

DAN: It feels vertical.

DAN'S WIFE: It's been a long time since I've seen him that tall.

DOCTOR: There's about an inch-long hole...

ALAN ALDA: (Narration) In one high-tech operating room, the patient was a dummy with pig's intestines, dyed bright red. Being developed as a way to rapidly apply the best care on the battlefield, it's a prototype for remote surgery, in which doctor and patient are in different places, linked only electronically.

ALAN ALDA: Do I have too little of it?

TECHINICIAN: No, that's just fine.

ALAN ALDA: (Narration) In Russia, surgeons displayed a special alloy for the wire supports -- called stents -- commonly used to keep clogged arteries open. The collapsed stent is easy to insert with a catheter, into a leg artery in this case. Then the alloy springs into shape as it warms up, opening the artery and allowing blood to flow. Our cameras filmed an important milestone in the treatment of heart disease when an implantable pump was placed alongside a failing heart.

MIKE DORSEY: Just drop them into the pouch like this and pull the flap down.

ALAN ALDA: (Narration) Mike Dorsey demonstrated how he carried the pump's batteries.

MIKE DORSEY: Now I'm ready for traveling.

ALAN ALDA: (Narration) After seven months, Mike got a heart transplant, and the program has been a key step toward the eventual goal of permanent artificial hearts.

NURSE: Hi, Michael.

ALAN ALDA: Wait, what is this?

RESEARCHER: This is cartilage. It's a scaffold of...

BOB LANGER: You see the nostrils?

ALAN ALDA: Yuck! Wait a minute!

ALAN ALDA: (Narration) Well, it may have looked gross to me, but that nose represents a big part of medicine's future -- spare parts, grown to order in the lab, like these heart muscle cells, alive and beating. This is the next revolution in medicine in the making. This story was about another potential revolution, gene therapy. Lillian Cooper took part in a trial which inserted into her leg the genes for blood vessels, to see if she could actually grow new ones, bypassing a blocked artery. This trial was an unprecedented success, but other gene therapy trials have since gone badly wrong, so the future of gene therapy is right now uncertain. But alongside the promise of new ideas, old diseases we thought we'd defeated -- like TB or simple infections -- made a comeback.

MAN: Buenos tardes...

ALAN ALDA: (Narration) The problem is resistance to antibiotics. It develops when drugs are misused or over-prescribed or not taken correctly. Some resistance is almost inevitable, though, as we found out in Africa, where the malaria parasite is now resistant to some drugs, and malaria-carrying mosquitoes have developed resistance to insecticides. The decade saw, in the West, an increase in interest in traditional medicine. On our trip to China, we showed how ancient herbal remedies are prescribed on a large scale. Western drug companies are now systematically screening those remedies for useful compounds. Traditional medicine is used by most people in the world, and wild raw materials are getting scarce. In a South African township, I visited a traditional healer who has had to start growing his own rather mysterious supplies.

ALAN ALDA: What is this? Do you eat this?

MR. CELE: In English, I don't know how to call it.

ALAN ALDA: I've never seen anything like this.

MR. CELE: But it's poisonous.

ALAN ALDA: It's poisonous -- thank you. I'm sorry I picked it up. I had to put my hand on it now. I'll never...

MR. CELE: When you eat it.

ALAN ALDA: Not the skin, huh? You sure about that?

MR. CELE: Sure.

ALAN ALDA: Otherwise you may have to give me another plant to get rid of that.

MR. CELE: To get rid of it, yes.

ALAN ALDA: What does this do? Why would you sell a poison plant?

MR. CELE: Well, it's for those who know how to control it.

ALAN ALDA: What does it do for you if you take just the right amount.

MR. CELE: An enema.

ALAN ALDA: An enema. Oh great. I'm glad, good.

ALAN ALDA: (Narration) In the forests of the Pacific Northwest, Taxol was discovered. We showed some of the first trials of this promising new cancer drug. Taxol was found in the bark of scarce yew trees, so the aim was to synthesize the drug, starting with yew needles. The trials and the synthesis were successful, and now Taxol is an important weapon against many different cancers. We showed Chinese medicine's direct influence on the West in a story on Therapeutic Touch, in which practitioners claim to manipulate the patient's so-called energy field. Then, in an exclusive report, we showed how 11-year-old Emily Rosa proved that the practitioners could not detect the energy field they claimed existed. Emily used a rigorous experimental design.

EMILY: I got 4.1 for an average of correct guesses. 5 is chance and they got below chance.

ALAN ALDA: (Narration) Emily's paper on the experiment ended up in a peer-reviewed medical journal. Eating much less was one story in an episode about living longer that ended our medical decade. Low-calorie, high-nutrition diets seem to be one way to extend life. Results of monkey studies, still in progress, are pointing in that direction. Then we saw mice with cells genetically engineered to age more rapidly than normal, opening up ways to possibly slow the process in humans. And we saw tiny nematode worms with genetic mutations, induced in the lab, which multiply the worms' life span up to four times.

ALAN ALDA: Oh my God, that really is...

CYNTHIA KENYON: ...this is a mutant worm. This is the exact same age.

ALAN ALDA: The same age!

CYNTHIA KENYON: It's the same age -- I'm not kidding you. Isn't that amazing?

ALAN ALDA: It is amazing.

CYNTHIA KENYON: I mean it's just unbelievable -- you change one gene and essentially you cure this disease of aging.

ALAN ALDA: (Narration) Extended human lifespans really are around the corner, and that seemed a pretty good idea to me...

ALAN ALDA: It's very good.

ALAN ALDA: (Narration) ...although very low-cal diets didn't look so easy.

ALAN ALDA: This wouldn't be bad for a dessert, or am I denied dessert now?

ROY WALFORD: No, that would be fine, sure -- an apple is a good dessert.

ALAN ALDA: Your heart would sink if I took out the frozen yogurt probably.

ROY WALFORD: Well no, yours would.

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ARCHAEOLOGY DECADE

ALAN ALDA: Some of our most fascinating stories on Frontiers have been about the past. Increasingly in recent years, history and archeology have benefited from the use of scientific methods -- like DNA analysis, accurate dating techniques, remote sensing. And experimental archeology is getting to be a big thing -- why not make the boat or the machine, the way they made it then, and see how it actually worked? But you know, there's something different about this field. It does seem to attract more than its fair share of people who are really passionate about what they do. Maybe you have to be that way to put up with the often rotten conditions, in out of the way places; or maybe it's just the subject -- it's exciting to dig in the sand and reveal our own past.

ALAN ALDA: (Narration) During the decade, human origins in Africa continued to be teased out. Our cameras witnessed one team uncovering the first piece of an archaic human's skull, 300,000 years old.

ARCHAEOLOGIST: There she comes.

LEE BURGER: Hopefully, eventually, with a lot of little pieces, we'll be able to put him back together, but that's a fantastic find, huh?

ALAN ALDA: (Narration) This hilltop excavation revealed a rich native African past, which suddenly, with the end of Apartheid, it was alright to study. It was the first royal burial found in the region -- a king and queen who were probably ancestors of the present king of Venda, who invited me to join in the celebration dance. In northwest China, after protracted negotiations, ours was the first TV crew allowed to film 4,000-year-old mummies, preserved in the dry desert. The mummies' appearance suggested Caucasians reached China much earlier than had been thought. In Egypt, new finds were also forcing new thinking, as excavation got underway of a cemetery for workers on the Giza Plateau. The conventional wisdom was that slaves had built the pyramids, but here were hundreds of respectful and costly tombs, even a fine statue of one site foreman. It was a revelation to archaeologists.

ARCHAEOLOGIST: They were treated and respected by the king because those are the people who built the pyramids and the tombs. Those are the people who make the king eternal. Without them the king would never be a god.

ARCHAEOLOGIST: [Danish]

ALAN ALDA: (Narration) In Denmark, I experienced one of the best examples of a new trend -- experimental archaeology.

ALAN ALDA: A cinch.

ALAN ALDA: (Narration) These exact replicas of Viking warships were based on wrecks excavated from the bottom of the fjord. Their superb sailing qualities showed why the Vikings ruled the waves around the ninth century. In Italy, we saw how they're trying to avoid a wreck of historic proportions.

ALAN ALDA: Andiamo.

ALAN ALDA: (Narration) There's an elaborate rescue plan in the works, but as a first step, steel bands now hold the Leaning Tower together at the point of maximum stress. Paolo Heiniger They are embracing actually the external wall of the structure, and they are meant to contain the risk of local explosion of material.

ALAN ALDA: That's nice. So glad to hear that. Embracing the structure so it doesn't explode.

PAOLO HEINIGER: Yes.

ALAN ALDA: (Narration) Here in America, experimental archaeology returned a gift to Native Americans. It's a baidarka -- the traditional Aleut boat. They were all gone, but a reconstructed model, based on old drawings and memories, was tried out in rough Aleutian seas. The mysterious double bow, combined with a flexible frame, gave speed and buoyancy in the waves.

GEORGE DYSON: Feels real nice in the rough water. It feels like it was made for rough water.

ALAN ALDA: (Narration) They were perfect hunting boats for these conditions. Finally, we showed how modern methods helped clear up a lingering mystery from Custer's Last Stand. The problem was to identify an unknown soldier from his remains. Using video technology, historians were able to successfully match the skull to a specific 19th-century army photograph.

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ENVIRONMENT DECADE

ALAN ALDA: This has been a decade that at least one group of scientists would rather not have witnessed. They are the people who study the wild places of the Earth -- the coral reefs, the forests, the deserts and mountains which are home to an enormous, and still uncounted, diversity of creatures. Of course, we all know that those places are coming under increasing pressure from us -- from humans -- but as we've reported, in many parts of the world, a few humans are trying to do something about it...

ALAN ALDA: (Narration) In 1989, Hurricane Hugo slammed into South Carolina. It destroyed almost every nest site of the rare red-cockaded woodpecker, which nests only in mature pines. There was an emergency program to make artificial sites for the 700 birds left alive. It was a classic demonstration of how vulnerable species become once human pressure has hemmed them in. In St. John, I saw some of the coral diseases that are appearing with increasing frequency around the world. These white patches are one symptom.

ALAN ALDA: When I see the white stuff down there, what am I looking at?

GINGER GARRISON: It's as if we lost everything except for our bones, so that we wouldn't have any flesh left.

ALAN ALDA: (Narration) An inspired piece of scientific detective work traced the die-back of coral sea fans to a soil fungus, blown across the Atlantic from newly created African farmland. The sea fans were depressing, but the science was wonderful.

ALAN ALDA: Ha, ha, ha. I love it! Science!

ALAN ALDA: (Narration) In the booming resort town of Eilat on the Red Sea, our story showed how direct wear and tear from thousands of tourists' feet is destroying the shallow reef. But to compensate, just down the coast, biologists have submerged large steel frames as the basis for artificial reefs. The first colonies of marine life have moved in. In Newfoundland, the sad spectacle of a rare humpback whale that had died trapped in a fishing net was tempered by the dedication of the biologists.

JON LIEN: Oh jeez, watch out. I'm going in. Oh, OK, is that coming out? Well, I think for a scientist, it's just amazing how this huge animal works. We only understand it very poorly. And it's a rare privilege to be able to get inside of it.

ALAN ALDA: (Narration) Jon Lien, one of the world's leading whale rescue experts, has released hundreds of trapped whales in these dangerous, near-freezing waters, at considerable personal risk. In St. Thomas, I met another dedicated biologist who works with sea turtles. Zandy Hillis patrols nesting

beaches, protects nests and regularly checks up on every one of the adolescent turtles that hang out on the reef in her area.

ALAN ALDA: Ha, ha, ha.

ALAN ALDA: (Narration) In China, I met a lone Yangtze river-dolphin.

ALAN ALDA: Chi Chi is the only dolphin, river dolphin in captivity anywhere in the world?

WANG DING: Chi Chi is the only baiji in captivity in the world.

ALAN ALDA: The only baiji, I see. OK.

WANG DING: Yes, that's true.

ALAN ALDA: OK, wait a minute. Wait a minute, don't go away. Wait, I got it here, here, here.

ALAN ALDA: (Narration) It's touch and go now for these animals, although species can be brought back from the brink -- as has happened with the great bustard. Its grassland habitat has given way to farmland, but once again, a campaign run by a few dedicated enthusiasts has made all the difference, with young birds now regularly released back into the wild.

ALAN ALDA: You grab him by the wings and then you grab him by the neck?

SCIENTIST: If it's close to the fence and it's standing, more or less, then it's best you first go...

ALAN ALDA: (Narration) I'm discussing how to catch a stork, with another of those enthusiasts.

SCIENTIST: If it's flying against you, the best is you take it as you normally take your woman in the early morning and then you have it. That's all, no problem.

ALAN ALDA: Ha, ha, ha.

ALAN ALDA: (Narration) You'll notice how I stayed out of that one -- storks have big beaks. But there's a serious problem with Europe's storks. Many become exhausted on their migration south to Africa, because intensive farming in Europe has reduced the frogs and mice they eat. A few people run this rescue station along the way, but it's not a long-term solution. It was remarkable to see people

everywhere waking up to the fact that so much wildlife -- like Europe's brown bears -- must be conserved before it's too late.

ALAN ALDA: Mangia, mangia.

ALAN ALDA: (Narration) Brown bears, once common, are now confined to a few mountain strongholds. There's a captive breeding program here, but inbreeding's a danger, so genetic analysis is essential.

ALAN ALDA: Where is he taking the blood from? Is it from this vein here?

SCIENTIST: Yes, the jugular, jugular vein.

ALAN ALDA: Jugular vein.

SCIENTIST: Jugular.

ALAN ALDA: (Narration) These Chamois mountain goats are to form the nucleus of a new herd, to avoid the kind of vulnerability that almost wiped out South Carolina's woodpeckers. Occasionally, one of these nervous animals doesn't make it, but biologists believe it's a price worth paying for future security. Our story on white rhino showed how intensive management of endangered species really can work. There were once 50 white rhino left, all in this park. Now there are 2,000 here, and 5,000 more worldwide. They're out of danger. In many places, we found a new understanding of the needs of entire habitats.

ALAN ALDA: I can't believe how fast that's going.

ALAN ALDA: (Narration) Fire is essential in many ecosystems -- to promote seed germination, for example -- so more and more ecologists were starting fires. In this project, simulated lightning strikes were just the start.

SCIENTIST: What you'll be doing is simulating a cow's stomach, maybe a buffalo's stomach.

ALAN ALDA: (Narration) It takes buffalo and fire for some prairie plants to germinate. Our cameras were here nine years ago, and now there are just 10 precious acres of prairie restored to original condition. An artificial prairie dog town was the setting for one of America's best-known restoration projects. Prairie dogs are brought in so that the young black-footed ferrets bred here can learn to hunt, under the biologists' watchful eye. Over 1,000 of the once-endangered ferrets have since been released, near natural prairie dog towns. Prairie dogs -- once regarded as pests -- are essential to the future of the ferrets, and in many stories, we found biologists eager advocates of the need to conserve the least

popular wildlife. Yes, scorpions have their place, we were told, and so has everything else -- even if it does attack microphones.

STEVE BEAUPRE: Grab that tail for me.

ALAN ALDA: Grab the tail. Do you have the head? Oh, the tail, the shaking!

ALAN ALDA: (Narration) In this story, I learned that every square mile of Arizona desert shelters over 2,000 rattlesnakes -- and they just want to get away. And after rattlesnakes...

ALAN ALDA: It's a gigantic head on this.

ALAN ALDA: (Narration) ...the producers thought I should try sharks.

ALAN ALDA: It's biting the boat. That doesn't sound like what you said before about not biting things that aren't food.

KIM HOLLAND: Well, that's the great thing about science, it's a world of discovery.

ALAN ALDA: Does it make any difference if you rub her tummy? I mean, does that help her quiet down?

KIM HOLLAND: I don't know. But you know, it's a very, very common phenomenon in all vertebrates that...

ALAN ALDA: Oh gee. Oh boy. That's why I'm...now I'm playing the part of Richard Dreyfus. What, was he busy today?

ALAN ALDA: (Narration) Implanted radios allowed the scientists to find out the sharks traveled routes extending hundreds of miles.

SCIENTIST: Arriva...rapido.

ALAN ALDA: (Narration) In our stories on undisturbed ecosystems, we showed what's been discovered in recent years about the astonishing diversity of nature. Rainforest studies like these now have scientists convinced there maybe 30 million different species on the planet. In our most recent episode about this aspect of nature, we visited the Galapagos Islands. It's one of the least disturbed places on Earth, still little changed from Darwin's time. The Galapagos are an important natural laboratory where fundamental research on evolution is continuing -- tracing the adaptation of finches' beaks to changing food supplies, for example. The islands are a natural paradise.

ALAN ALDA: Hello. My problem is I not only saw ET, I also saw Jurassic Park!

ALAN ALDA: (Narration) We told the story of the marine iguanas. They were devastated in 1997 and '98, when El Nino brought warm waters to the shores. 90% of the iguanas perished when the algae they eat died off. The food supply has since recovered. It was evolutionary pressure that the species must have gone through many times before.

ALAN ALDA: Why do we see so many smallish iguanas here?

MARTIN WIKELSKI: They sometimes have these huge algae pastures, and they just get a mouthful of algae every bite. But here they only have a tiny little carpet of algae and they constantly have to scrape it off.

ALAN ALDA: So that has selected out the big ones.

MARTIN WIKELSKI: Right.

ALAN ALDA: So there they are. That's the product of natural selection right there.

MARTIN WIKELSKI: Right.

ALAN ALDA: (Narration) We filmed another famous story of unvarnished nature here in a masked booby colony. One chick violently expels the other from the nest. Although it seems inexplicable, it makes sense, because the female can only adequately feed one. In the future, are we going to be able to protect places like this from the powerful human pressures that take their toll in so many other places?

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DECADE OF THE BRAIN

ALAN ALDA: The 1990s was the official Decade of the Brain, and on Frontiers, we did a lot of stories on brain research -- on sleep, on memory, language, phobias, how babies and kids think and learn. We're still a long way from being able to say how the brain works in any comprehensive way. But what has emerged is a new appreciation for how tremendously complex the brain is, while at the same time being flexible and changeable. It doesn't seem to be like a computer program in there, the way we once thought it did. Although, maybe

that's just because we don't understand it all yet. Here's just a sampling of what we found out when we had our heads examined during the Frontiers Decade.

ALAN ALDA: (Narration) Asking the question, how do kids think about magic, or illogical things, yielded some revealing answers.

ALAN ALDA: Is that high enough?

MAGICIAN'S ASSISTANT: A little higher up above your head.

MAGICIAN: How's that?

ALAN ALDA: (Narration) In one notable series of experiments, babies under one year old were shown illogical events. Even minds this young seem to have mastered how the physical world should work, as shown by an analysis of their reactions.

SCIENTIST: What's in the box?

ALAN ALDA: (Narration) In contrast, kids as old as three can't yet recognize how their own minds work.

SCIENTIST: Look at that. What are they? JACOB: Ropes.

ALAN ALDA: (Narration) Jacob calls them ropes, but the point is, he's now sure he always knew they were there.

SCIENTIST: What did you think was inside the box before I turned it over?

JACOB: Ropes.

SCIENTIST: Ropes!

TECHNICIAN: Paul, ready for the injection.

ALAN ALDA: (Narration) The decade saw tremendous advances in ways to look directly at the brain's activity. PET scans were used widely, revealing here, for example, lower blood flow in the language area of a dyslexic's brain, on the left. I tried out the latest of these brain examination methods, a functional MRI, in a study looking at memory and age.

ALAN ALDA: How was my brain?

MARILYN ALBERT: It actually looks very young.

ALAN ALDA: Yes? What could you see? Marilyn Albert Yes, we were admiring it.

ALAN ALDA: Yeah?

ALAN ALDA: (Narration) They identified an area that's active in memory with young people, but not old. Drawing two shapes was the task in a less high-tech, but no less revealing, study.

ALAN ALDA: Nothing wrong with that!

ALAN ALDA: (Narration) Normal brains can't do this because signals to the two hands get mixed up.

MIKE GAZZANIGA: Well, we're seeing the fact that Alan's hemispheres are connected.

ALAN ALDA: (Narration) But a subject whose hemispheres had been surgically separated to treat epilepsy can draw as if he has two brains. We put on this piece of theater to illustrate some important research on the unreliability of memory. When later I was shown pictures of the picnic, I couldn't remember what I'd really seen.

DAN SCHACTER: Umbrella.

ALAN ALDA: No umbrella, no.

ALAN ALDA: (Narration) I got that right...

DAN SCHACTER: Nail file.

ALAN ALDA: Yes, I think I remember her filing her nails, although...

ALAN ALDA: (Narration) But I got that wrong.

ALAN ALDA: ...the picture is also vivid in my mind. But I think I remember her filing her nails, too.

ALAN ALDA: (Narration) I had a largely sleepless night in a sleep lab so we could report on a study of dreams. I finally settled down at six in the morning.

DR. STICKGOLD: These are really good eye movements. These are fast and they're big.

ALAN ALDA: (Narration) The rapid eye movements showed I was dreaming, so of course they woke me up to take a word association test. It turns out we're really fast at associations during dreaming, suggesting that's how we make dreams, in response to random signals in the brain. Receiving direct signals into the brain was how dowsers claimed they were able to find water.

DOWSER: Coming up on something. Here we are. 342 feet deep. 26 gallons per minute.

ALAN ALDA: (Narration) We challenged several dowsers with scientifically based tests of their abilities, but in our limited sample at least, nothing worked out. Yet something that seemed equally far-fetched appeared to work pretty well -- using brain waves picked up by electrodes to steer a sailboat. And in perhaps the most unexpected story of the Frontiers Decade, it turned out the Air Force was looking at the same method to control fighter jets.

PILOT: It's simply a matter of desiring this thing the go to the right or desiring it to go to the left. And then my brain automatically produces the signals necessary in order to make it happen for me.

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DECADE IN SPACE

ALAN ALDA: Next we're going to look back at the stories we did on earth science, planetary science and space science. It was kind of exciting -- our film crews landed on a brand new volcanic island here on Earth, we discussed ways to get to Mars cheap and soon, we analyzed some of the first pictures from the newly fixed-up Hubble telescope, and I got to talk to a genuine spaceman. There was one very sad event in this field -- Carl Sagan died in 1996 at the age of 62. He had been a tireless advocate for space and planetary exploration, a teacher, a TV star, a prolific author -- especially of books that interpreted science for the non-scientist. He was insistent on the importance of rational scientific thinking, and above all, he wanted us to understand our human place in the universe. Here's what he said when I visited him...

ALAN ALDA: The question is, if there are planets that could possibly support life, are we alone here? I imagine you feel passionately about the answer to that.

CARL SAGAN: I don't know the answer, but I do feel passionately about it.

ALAN ALDA: That's a great combination. Explain that.

CARL SAGAN: Well, we have not found extra-terrestrial life. We are just at the very earliest stages of the beginning. You haven't found it yet, so it would be foolish for anyone to say that he or she is absolutely certain that there is life elsewhere. At the same time, we have a fairly good idea of the number of stars in the Milky Way galaxy. It's about 400 billion.

ALAN ALDA: 400 billion.

CARL SAGAN: Right. So that's roughly speaking 100 times more than the number of people on earth. Imagine every person had 100 stars...

ALAN ALDA: And every one of those stars had an unknown number of planets...

CARL SAGAN: And that's just in this galaxy, and there are tens or hundreds of billions of other galaxies. Put that all together and it seems laughable arrogance for humans to pretend that they're the only life and the only intelligence.

ALAN ALDA: (Narration) Scientists said they'd found life in this meteorite.

KATHIE KEPRTA: Now is this your first look, this is your first look at Mars?

ALAN ALDA: I can't believe I'm this close to it.

KATHIE KEPRTA: That's right.

ALAN ALDA: How long ago did that get knocked off Mars?

KATHIE KEPRTA: About 16 million years ago.

ALAN ALDA: Well, I see a dark crack.

ALAN ALDA: (Narration) People still don't agree if the suggestive shapes in the rock had been alive or not. We looked extensively at how humans can live in space.

ALAN ALDA: Hello, Andy, it's Alan Alda. Can you hear me up there?

ANDY THOMAS: I can hear you loud and clear. Welcome aboard Mir.

ALAN ALDA: Tell me about the effect of this weightlessness on your body and what you're doing about that.

ANDY THOMAS: We use a regime of exercise up here. We actually put on a harness which has bungies which simulate the load and ties us down to the treadmill.

ALAN ALDA: (Narration) It was the Russian space program that discovered how long-term weightlessness causes muscles and bones to waste away. Our cameras were in what was then the Soviet Union 10 years ago, to film pioneering research on counter-measures. Today, the Russians still have the most experience of living in space.

TECHNICIAN: Do you want blindfolds?

ALAN ALDA: I don't know, do I?

JOHN GREENLEAF: Yes.

ALAN ALDA: Maybe a blindfold and a last cigarette? I don't know.

ALAN ALDA: (Narration) With trepidation I tried out the latest space exercises.

ALAN ALDA: What's going to happen to me? I don't know what this does.

ALAN ALDA: (Narration) In orbit, it would provide exercise while also forcing blood down into the legs, simulating gravity. It's part of NASA's program preparing for a long flight to Mars. Space exercises is one area, another is maintaining muscle control during a landing. They put me in a centrifuge to try that out.

ALAN ALDA: It's as though my arm has some magnetic force pulling it down.

SCIENTIST: Well, that's G-forces.

ALAN ALDA: Unbelievable. Unbelievable feeling.

ALAN ALDA: (Narration) We also checked in with volunteers sealed in a chamber for three months to test recycling systems that could be used in space. The water just went round and round.

ALAN ALDA: Let me see you drink a glass of water, if you don't mind.

ALAN ALDA: (Narration) And the bread was made from wheat that grew with CO_2 that the volunteers breathed out. In our story on travel to Mars, Bob Zubrin

explained his scheme to produce fuel on Mars itself for the return journey. The fuel is made from the Martian atmosphere in a machine like this.

BOB ZUBRIN: This is a general purpose Martian still. It makes oxygen, water, methane, methanol, kerosene, ethylene, anything you want.

ALAN ALDA: Blast off. Oh, look at that. Whoa.

TECHNICIAN: 1,2,3,4.

ALAN ALDA: (Narration) Bob's fuel seemed to work pretty well in a test run.

ALAN ALDA: So now are we in orbit now, is that it?

ALAN ALDA: (Narration) Bob wants to go to Mars to look for life, but some people believe a film like this proves that alien life has already found us. We made our own alien film in a Hollywood special effects house to show how easy it is to be fooled. We also explored the universe's history, back in time, with the aid of the sharp pictures that the newly repaired Hubble Telescope began to produce in 1993. The pictures showed galaxies so distant that they revealed processes going on 4 billion years ago, when galaxies were crashing together, merging into the kinds of galaxies we see today. We're still living with the heat left over from the formation of our solar system. It causes volcanoes. In our story on Vesuvius, we showed how the next eruption threatens residential areas and highways. A dramatic computer simulation modeled pyroclastic flow, as it's called, sweeping down the volcano's slopes. Unless, that is, this barrier system is built. Montserrat, in the Caribbean, showed graphically how destructive the hot gas and rocks in pyroclastic flow can be. Whole towns were destroyed, and left abandoned. Our cameras accompanied volcano scientists when they went in after each new eruption. The long-term aim is to be able to predict the volcano's behavior.

SCIENTIST: The houses which were standing in this location beforehand are now out in the Caribbean Sea.

ALAN ALDA: (Narration) Then in our story about Surtsey, we were reminded how creative the Earth's activity can be. The island, south of Iceland, was formed in 1963, and one scientist has been watching it since his first visit in 1965. Seeds soon arrived on Surtsey, he found, attached to floating fish egg cases, for example. Within a few years, there was a new piece of living Earth.

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SHOW CLOSE

ALAN ALDA: (Narration) Well, it's been an exciting decade for science and a fascinating 10 years for Frontiers.

[Fireworks.]

We'll be back next season to begin a new decade of stories. Hope to see you then. Don't go away -- Trinidad's champion steel band, the Renegades, is going to play us out.

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