Transcript: The 10 000-Mile Flush

Glenn Zorpette: The biggest base by far on Antarctica is McMurdo station. It's a U.S. installation that teems with workers and also scientists scurrying around setting up exotic experiments and field trips. But the station also has to take care of some pretty basic human needs. Like feeding everybody. And dealing with the waste that 1100 people produce. That's no small feat in Antarctica, where human habitation is governed by the strictest environmental regulations on the planet. In fact, the international Antarctic Treaty now requires that essentially every bit of waste produced in Antarctica be removed from the continent.

[sound of door opening]

John Larrabee: So this is basically what it looks like when it's raw.

Glenn Zorpette: John Larrabee is a wastewater technician at McMurdo. He oversees an innovative treatment plant that cleans up all the raw sewage and dirty water flowing from every pipe, drain, and spigot on the base. He's treating 40 000 gallons of this stuff a day. Larrabee gestured to a basin holding four days' worth of raw water.

John Larrabee: Kind of got a little gray color. Smell should be musty but not unpleasant. That's actually the technical term for raw water.

Glenn Zorpette: So this raw water coming from toilets and sinks isn't the color you might expect.

John Larrabee: No, it's not. What you see there, if you were to take a sample of that raw water and allow that to settle, if I just took a sample, set it on the counter for like an hour, you would see the brown stuff would settle to the bottom, and you'd still have clear water on the top.

Glenn Zorpette: Larrabee's job is to clean up the watery liquid part so it can be returned to the Antarctic and to dry out and pack up the solid part for shipment off the continent. But first they let a horde of natural bacteria break down the contents of the raw water as much as possible. The solids eventually settle out and are then sent to a press that squeezes the last bit of water out of them. And when that press is running, it's a heck of a thing to see and hear. And smell.

John Larrabee: The belts are moving, there's wash water going, it's pretty loud, it's pretty sloppy, whatever. The water will filter through the belt on the top, it comes around this way and another belt will meet up against it and it keeps traveling, and this is where you can see the two belts, and the solids should be between those two belts, it just keeps traveling over these rollers, just tighter and tighter as it goes, keep pushing that water out, and on the end here is where it actually gets scraped off the belt and dropped down the chute, and that's where we have the big tri-walled boxes that the solids actually go into.

Glenn Zorpette: The reason for the boxes is that this pressed solid waste—it's called a cake—is actually shipped, once a year, from Antarctica all the way to a landfill in California. It's a total of 8 to 10 tons of solid waste per year. That's a lot of human excrement.

John Larrabee: It's not called human excrement. Once it's treated, it's called a biosolid.

Glenn Zorpette: Sorry. Biosolid. That's a lot of biosolid of human origin, and a long way for it to travel. Think of it as a 10 000-mile flush. The liquid portion is filtered and disinfected with UV light.

John Larrabee: This is the final end of the treatment process itself, and the water you see right here, this is actually the treated water, which will get blended with the other two tanks and go into the UV channel. So as you can see, it's pretty good water, pretty clear water, that's what we like to see; it's what we like to have.

Glenn Zorpette: I don't think I'd want to quench my thirst with it, but I don't mind that the water is returned directly to the sound. It takes a gallon of water coming into this facility about 24 hours to swirl and swish about all the basins, filters, and presses before leaving the other end clean. It all happens so elegantly and quietly, and yet so incessantly, tucked away out of sight and out of smell.

Transcript: Science, Exploration, and the Race to the Pole

[period music, Antarctic sounds]

Glenn Zorpette: The race to the South Pole began 109 years ago with the first Antarctic expedition of Robert Falcon Scott, a British naval officer. His men built a hut on the edge of the continent. They called it the Discovery hut, named after the boat that carried the 47 men to Antarctica from England.

Donal Manahan: When you come here, you can't help but notice there's a hut just a couple hundred yards away from where we're talking that was where some of the first biologists and chemists and glaciologists and physicists worked.

Glenn Zorpette: That's Donal Manahan, a biology researcher and amateur historian who's been coming to Antarctica since 1983.

Donal Manahan: Scott came down here in January 1902, built the hut, which we can walk to after a very warm dinner here in McMurdo station.

[sounds of trekking to dinner]

Glenn Zorpette: In fact, after dinner one night at McMurdo, the main U.S. base in Antarctica, we did just that. Our hostess was Dana Topousis, a public affairs official with the National Science Foundation.

[sounds of people entering the hut]

Dana Topousis: Let's see if I can open the door…yeah. And I have flashlights because it's probably not very bright.

Glenn Zorpette: OK, so here we are opening the door to the Discovery hut.

Dana Topousis: It's icy…

Glenn Zorpette: It's dark and it's small and it smells…

Dana Topousis: Like old horse straw.

Lee Hotz: I believe that Scott actually never lived here…this was one of their secondary buildings.

Glenn Zorpette: Lee Hotz is a columnist for *The Wall Street Journal* and a veteran Antarctic traveler.

Lee Hotz: It's actually where they had their jollies. They used it as a theater ….So its purpose was as a kind of secondary storage area but also as a shelter.

[music]

Glenn Zorpette: Here's the race to the Pole in a nutshell. Robert Scott's Discovery expedition—between 1901 and 1904—came within 480 miles of the Pole. His main purpose was actually scientific and geographic research. Among other things, Scott and his men discovered the Dry Valleys, an ecologically remarkable area not far from present-day McMurdo base. The next expedition was Sir Ernest Shackleton's; he had been on the Discovery expedition but had had a falling out with Scott. On January 9, 1909, Shackleton got within 97 miles of the Pole before being forced to turn back.

Finally, in the greatest race of the great era of human exploration, Scott and the Norwegian Roald Amundsen raced to the Pole starting in 1911. Amundsen and his team left in October and got there first, at 3 in the afternoon on Friday, December 14, 1911. Scott and four men left in November and got there on January 18, 1912, a month after Amundsen. On the return trip, Scott and his four men all died of starvation, illness, and hypothermia. Scott and two of the men perished just 11 miles from a food depot that would have saved their lives. But a terrible blizzard confined them to their tent for nine days. Diaries found in that tent described pain and hardship and endurance almost beyond human imagining.

Donal Manahan: A typical day, if you read the diaries, are: Wake up early in the morning. Your boots are so cold that it can take you one to two hours to get your foot into your boot. You have to—Scott writes about this toward the end of his life as he was coming back—that the sweat and accumulation in your boots are such that your boots are stiff and iced up, so you put your already cold feet in an inch or so, wait for that tiny amount of heat from your foot to thaw out the boot, move in another bit. Then when you get your boots on, and the rest of your clothing, you then strap yourself to a sled that might be roughly 1000 pounds, and there's four men pulling it, and you pull that thing for maybe 12 hours a day. And at the end of that 12 hours, you stop, you put up your tent, and then even to get inside your frozen sleeping bag can also take hours, because you have to rely on the tiny amount of heat from your body to melt the sleeping bag so you can slide into the sleeping bag. Do you sleep? No. They shiver the whole night sometimes. And then the next day, you start all over again. Month after month after month.

Glenn Zorpette: Amundsen, who was first to the Pole, is regarded as a cunning, implacable competitor. Scott was until recently thought of as a courageous man whose poor judgment led four men to their deaths. More recent reviews have emphasized Scott's dedication to science and his terrible luck at the end of his trek. Shackleton will be forever remembered as a charismatic leader whose fortitude and daring led to the rescue of 24 of his men stranded on an ice floe during a failed 1914 expedition.

Donal Manahan: There's a great, great quote from the geologist who was with Shackleton and Scott, Raymond Priestley, who in the 1950s said the following, and he summed it up just beautifully: "For science, give me Scott. For rapid and efficient transport and exploration, give me Amundsen. But when things seem hopeless, get down on your knees and pray for Shackleton."

[music]

Transcript: The Fearsome Nematodes of the Dry Valleys

Glenn Zorpette: The McMurdo Dry Valleys. The name suggests the wastelands of Australia. But it's Antarctica, and it's one of the most beautiful places I've ever seen. These Dry Valleys are among the most arid places on Earth. There's very little snow, and not a lot of ice except for some scattered glaciers. And yet inside the Taylor Valley where I was standing…

[sound of water trickling]

Joseph Lee: When I came down into Taylor for the first time and heard that, it almost brought a tear to my eye. After two months of not hearing any liquid water except for what we have in the pot, and this is just—I love it.

Glenn Zorpette: Joseph Lee is a postdoctoral fellow with Portland State University and the McMurdo Long-Term Ecological Research group, also known as the LTER. Lee knew exactly where that noise of trickling water was coming from.

Joseph Lee: It's the sound of some old ice. Water deposited 4000 years ago.

[sound of water trickling]

Glenn Zorpette: Up in the accumulation zone of one of the glaciers, apparently.

Joseph Lee: And right now, when the sun shines in the peak summer, it melts, flows down…into the streams, into the ponds, and ultimately into the lakes. So that's what I'm interested in, the ground—it's this big unexplored source for water, for chemistry, for all the things that the LTER is interested in.

Glenn Zorpette: These little trickles of water sluicing their way through the Dry Valleys can mean the difference between dormancy and animation to some rather well-adapted creatures.

Joseph Lee: The dominant predator here in the Dry Valleys is the fearsome nematode. It's a microscopic worm that eats both algae and also other microbes.

Glenn Zorpette: Are there nematodes unique to this area?

Joseph Lee: The nematodes—most of them are endemic, so they're from here and are unique to here. They adapt to the subfreezing temperatures in the winter by drying themselves out, and as soon as the first trickle of water comes from either melting snow in the spring or a trickle of water of a glacier, or in my interest, the melting of permafrost, the wicking up of water, they snap into activity and start eating, respirating, multiplying, and living their lives in the summer.

Glenn Zorpette: Nematodes belong to a simple food web to which Lee and his team are making small experimental tweaks. They add some extra water here, some extra food there, and observe how food webs respond to a changing environment.

Joseph Lee: And given that we're part of the larger food web, seeing how the nematodes adapt tells us a little about how we adapt as a species.

Glenn Zorpette: Very few critters other than nematodes can live in the Dry Valleys. Take seals, for example. Ray Spain is a Raytheon employee who assists the scientists.

Ray Spain: We have a lot of mummified seals up and down the valley. We're not really sure why they come up here. For some reason they tend to go further and further up valley, so they're gaining altitude, and they're going over big lumpy rocks. It can't be easy travel, because they travel much better in water. And of course they die because they can't get back to sea.

Glenn Zorpette: The seals will wander as far as 10, 12 miles away from the sea, hauling their blubbery bodies over rugged mountains and hills.

Ray Spain: Long way for a seal. With little tiny flippers for feet. And then there's no bacteria here to break them down. So they just desiccate. They just dry out and become a bag of bones with beef jerky around them.

Glenn Zorpette: Goes to show just how hostile the Dry Valleys can be. Which is why Ray Spain takes the logistics and safety aspects of her job so seriously.

Ray Spain: We get people who arrive here who are graduate or undergraduate students who have never been camping before.

Glenn Zorpette: This is probably an unusual place to start camping, an arid Dry Valley in Antarctica.

Ray Spain: Yeah, but you know, if it's the first time, you can just lay out the rules and say this is how you do it. Whereas if it's somebody who's camped a lot of other places, it's probably harder, because they say, "What do you mean, I can't just pee on the ground?" It might be harder that way. Most of the people—I've never had anybody come out here and just not been able to handle it.

Glenn Zorpette: What about challenges? Have you had any unusual challenges?

Ray Spain: Challenges. I would say personalities in a small space are the biggest challenge. We spend all our time together. You have one small building to share, and you're with those people 24/7. You work with them, you eat with them, you're just with them all the time. So you can imagine being stuck with your family in a small cabin. So even people you know very well, it can be very challenging after not just weeks but months.

Glenn Zorpette: Still, Joseph Lee finds the Antarctic, and the Dry Valleys in particular, an endlessly rewarding habitat to explore.

Joseph Lee: On those few occasions when the wind dies, and you're 10 or 15 miles from camp, you're the only soul in the valley, and it's absolutely breathtaking. The opportunity, though, to really study this place, to understand it, to get an appreciation not just of its surface beauty but how it's functioning and changing with time, is really the great opportunity. It is a life-changing experience, and it's a very addictive place to do work. There's a lot of data here, and a lot of information, and as you can hear, it's critical because it's melting out every day.

[sound of water trickling]

Transcript: 5.4 Million Square Miles, One Cash Machine

[door opening and closing]

Glenn Zorpette: It's a continent of five and a half million square miles, but Antarctica has just one cash machine. It's right inside the entrance to Building 155, which houses the galley at the main U.S. base, McMurdo Station. But, come to think of it: Why is there even one cash machine here? There aren't any malls. There isn't even a Starbucks. Not yet, anyway.

[beeping]

Glenn Zorpette: How often would you say you use it?

Tony Dixon: Once a week?

Glenn Zorpette: And where do you tend to spend the money around here?

Tony Dixon: Store.

Glenn Zorpette: You mean the store in the galley?

Tony Dixon: Yeah.

Glenn Zorpette: What kinds of things do you buy?

Tony Dixon: Typically souvenirs for back home and snacks. Things like that.

Glenn Zorpette: Besides the shop here in Building 155, there are a couple bars, a coffee shop, a post office, and other consumer attractions.

Corinne Morse: People sell things. They make jewelry down here. And people knit things and sell. There's also a massage therapist here, that she does services for that. And there's also a hairdresser. She does barbershop, and tips for that.

Glenn Zorpette: Corinne Morse is the dispersing specialist for McMurdo Station, which means that she gets to stuff the ATM machine full of 20-dollar bills.

Corinne Morse: There's about $50 000 that goes out of that machine every week, and I fill it up every week on Saturdays.

Glenn Zorpette: So McMurdo station has its own quirky, self-contained economy. Twenty-dollar bills go out of the cash machine to the souvenir shop and the bars and the massage therapist, and then they make their way back to the cash machine. Back and forth. By the way, the bars are called Gallagher's and Southern Exposure, which is affectionately known as Southern.

Glenn Zorpette: Do the twenties pretty much, just bounce back and forth between this machine and Southern?"

Lisa Jenkins: They are all over the station. It's pretty amazing the—how the money turns around here. People write notes on their bills and they get them back eventually.

Glenn Zorpette: That's Lisa Jenkins. She tends bar at Southern Exposure.

Lisa Jenkins: There's a lot of twenties that are in cycle, that are in circulation now, that I forget what it says on it, but someone took a stack of them and just wrote their name all over them. And they're just all over the place now.

Glenn Zorpette: They're still here.

Lisa Jenkins: Yeah.

Glenn Zorpette: Months later.

Lisa Jenkins: Oh yeah. Years later.

Glenn Zorpette: Thank you very much.

Lisa Jenkins: You're welcome.

[door opening and closing, music]

Transcript: Finding Neutrinos in a Cubic Kilometer of Ice

Glenn Zorpette: Neutrinos are among the most common things in the universe—and yet they're also among the most difficult to detect. In a unique effort to see these subatomic particles, engineers are now turning a cubic kilometer of ice under the South Pole into one of the oddest telescopes in the world. By spotting some of the countless neutrinos that streak across the universe, this telescope should help scientists understand mysterious things: like black holes, exploding stars, and dark matter, the invisible stuff that makes up 23 percent of our universe.

[pump-room sound]

Glenn Zorpette: How do you make a hole two and a half kilometers down into solid ice? You melt your way down. It takes two days and 20 000 gallons of hot water. Dennis Dillings showed me how it's done.

Dennis Dillings: That's our drill water for this project.

Glenn Zorpette: So you actually use hot water to drill?

Dennis Dillings: Yes we do.

Glenn Zorpette: There's no metal bit. Just hot water.

Dennis Dillings: We use 200 gallons a minute at 90 ˚C which is boiling in the environment. And we push it out at 1000 pounds of pressure out of a three-quarter-inch nozzle. That equates up to the power of a Burlington locomotive, a big one at full power, coming out of that nozzle. That's why this drill will drill what it drills.

[pump-room sound]

Glenn Zorpette: Dillings is the drill manager for the company building the IceCube observatory. So far he's drilled 79 of these mile-and-a-half holes in a kilometer-square stretch of ice near the South Pole. He has seven more to go.

[machinery running]

Glenn Zorpette: Once a hole is drilled, technicians lower into it a string of 60 basketball-sized light detectors. By February of 2011, over 5000 detectors will lie frozen in a billion tons of ice. They're going to look for the most elusive particles in the universe: neutrinos.

Mark Krasberg: Neutrinos are really neat—they're chargeless, they're almost massless. You've actually got 10 million going through your thumb every second. They're really, really hard to detect.

Glenn Zorpette: Mark Krasberg is a physicist on the IceCube project. He explains that because neutrinos don't interact with anything, they're very hard to detect. But that same lack of interaction also means they can zip across vast stretches of the universe unimpeded. So to astronomers, neutrinos are like minuscule messengers carrying news about exploding stars, baby black holes, and other violent events that occurred unimaginably far away, and an unimaginably long time ago.

Mark Krasberg: …since neutrinos are chargeless, they go on a straight line through the universe. You basically, if you have a source, just have a straight line going back, and you can ask an astronomer, What's at that spot in the sky?

[music]

Glenn Zorpette: Neutrinos can also come from sources closer to home. In fact, neutrinos coming from the center of our Sun or our Milky Way galaxy could give physicists clues about the nature of dark matter, the mystery mass that pervades our universe but about which nothing is known. But how do you detect particles that are almost undetectable? Well, the IceCube telescope is looking for the one-in-a-million neutrino that crashes into an atom of an ice molecule and creates another particle called a muon. As that muon shoots through the ice, it gives off blue light. In the pure, incredibly clear ice of the South Pole, that tiny bit of light can travel hundreds of feet. And then it can hit those basketball-size light detectors.

Mark Krasberg: It's basically an inverse lightbulb. It collects the light and converts it into charge. There's a computer on top of here and the signals go to the surface.

Glenn Zorpette: Researchers hope these ghostly particles will help them solve some of the biggest mysteries of the universe. If they do, then one day this strange telescope under the ice might not seem so strange after all.

Transcript: The Big Bang, the South Pole, and Everything

Glenn Zorpette: The South Pole is a great place to study origins of the universe. Here's why. One of the main things that cosmologists do is analyze the microwave radiation that permeates the universe. That radiation is called the cosmic microwave background, and you can think of it as an echo of the big bang that launched the universe into the glorious spectacle that we see today. With its dry, stable atmosphere, the South Pole offers outstanding viewing conditions for two microwave telescopes that could unravel the deepest mysteries of the universe.

[clanking/talking sounds]

Glenn Zorpette: Physicist John Carlstrom of the University of Chicago leads the way up to the roof of the South Pole Telescope. It towers five stories above the powdery white snow.

[clanking sound up for 1 to 2 seconds then fade]

John Carlstrom: This is a 10-meter diameter—it's actually a little larger, but 10 meters as it's projected toward the sky—telescope for looking at radiation from the big bang, what we call the cosmic microwave background radiation.

Glenn Zorpette: Carlstrom is the mastermind behind this [US] $19 million telescope. He explains that the cosmic microwave background radiation is like an echo reaching us from 13.7 billion years ago.

John Carlstrom: And it allows us to take a snapshot, see what the universe was like. So we can take telescopes like this and develop images of what this radiation looks like where it's a little more intense and less intense, hot spots and cold spots. And when we develop these pictures and look at them, what we're seeing is the baby infant picture of what our universe looked like.

Glenn Zorpette: Carlstrom's studying these maps for clues to dark energy, the utterly mysterious force that makes up 70 percent of our universe. Astronomers know very little about dark energy, but they do know that it counteracts gravity and causes the universe to expand at an ever-increasing rate. One of the major mysteries of dark energy is that it can't account for the formation of the largest structures in the universe, which are clusters of galaxies. Studying when these galactic clusters formed and how they've changed could answer some basic questions about the origins of our universe, such as: How important was dark energy in the early universe? When did it kick in? How has it evolved? In its search for answers, the South Pole Telescope scans the skies for galaxy clusters.

John Carlstrom: There's a little shadow against the cosmic microwave background, and that shadow is because you've just detected a cluster of galaxies. So you're looking at the largest object the universe has ever created, and you're going to see it as a hole, a depression in the intensity of the cosmic microwave background. Fewer photons.

Glenn Zorpette: To detect those tiny temperature dips, the telescope's photon detectors and one of its mirrors are kept extremely cold.

Glenn Zorpette: In a round chamber beneath the South Pole Telescope, superadvanced refrigerators keep the telescope's mirror at 10 degrees kelvin. That's about –450 degrees Fahrenheit—even the South Pole is blisteringly hot by comparison.

[sounds of helium pulsing]

John Carlstrom: It's helium rushing through these lines—helium for our refrigerators. The refrigerators have this pulse of helium that goes in to cool the detectors.

Glenn Zorpette: In 2011, Carlstrom and his colleagues will move on to another huge cosmology topic—the theory of inflation, which says that the universe began expanding exponentially right after the big bang, when the entire universe that we see today was about the size of a grapefruit. Down the hall from the South Pole Telescope, another telescope, called BICEP, is already trying to test the theory. Harvard astronomer John Kovac leads the BICEP team.

John Kovac: There's a specific pattern that would be characteristic of gravity waves that would have been created by an initial epic inflation in the first tiny fraction of a second if the universe underwent an inflationary expansion.

Glenn Zorpette: Translation? Okay. Inflation theory says that the explosive expansion of the universe would've created gravitational waves. And these waves would've left a signature, kind of like its own graffiti, in the cosmic microwave background. What would that graffiti look like? Well, think of it as a slight swirl in the radio signal. Graduate student Justus Brevik helped build the BICEP detectors that sense that swirling pattern.

Justus Brevik: What we do is we sit there and we scan the sky with these detector arrays and build up maps. And we have about an 800-square-degree field that we look at, and we scan over that for about a year and half to create a map of the polarization signal.

Glenn Zorpette: By studying the polarization of the microwave background, Carlstrom and his team may finally find hard evidence not only of gravity waves but also of inflation. Even in cosmological terms, that would be big.

John Carlstrom: What we would detect is what I think is, effectively, a smoking gun for inflation, for this incredible theory that the universe inflated from a subatomic region of space-time.

Glenn Zorpette: In other words, we'd have proof that the whole universe expanded from something much smaller than an atom. It would be the biggest news ever from the bottom of the world.