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ing into something else entirely. Scrolling may not be the ideal way to navigate a text as long and dense as Herman Melville's *Moby-Dick*, but the *New York Times*, the *Washington Post*, ESPN, and other media outlets have created beautiful, highly visual articles that could not appear in print because they blend text with movies and embedded sound clips and depend entirely on scrolling to create a cinematic experience. Robin Sloan has pioneered the tap essay, which relies on physical interaction to set the pace and tone, unveiling new words, sentences, and images only when someone taps a phone or tablet's touch screen. And some writers are pairing up with computer programmers to produce ever more sophisticated interactive fiction and nonfiction in which one's choices determine what one reads, hears, and sees next.

When it comes to intensively reading long pieces of unembellished text, paper and ink may still have the advantage. But plain text is not the only way to read.

SARAH STEWART JOHNSON

O-Rings

FROM *Harvard Review*

BENEATH THE BLINDING WHITE SKY, where glaciers calve and crash into the Ross Sea and the land surface of Antarctica begins, there are two isolated huts, the Discovery and the Terra Nova. The Discovery hut was erected in 1902 at the dawn of the age of Antarctic exploration. British Royal Navy Captain Robert F. Scott picked up the prefabricated structure in Melbourne on his way south. No one gave much thought to the wide low-angle roof and broad windows, both designed to dissipate heat in the Australian outback. No one had expected to live in the hut or, in reality, to be stranded there. In desperation, the last inhabitants took to ripping down the ceiling. They burned the rafters, still lanced with nails, in exchange for a few hours of heat. The walls are smoke-stained and jagged.

The Terra Nova hut is 12 miles farther north. It was built in a huddle over a week nine years later and was used by Scott as the staging center for his second, doomed attempt at the pole. Its walls are double-planked, stuffed with lint and seaweed. It's attached to a set of stables designed for the expedition's nineteen Manchurian ponies, though none of them lasted very long on the ice. The insides of both of these huts remain perfectly intact—not because the structures have been made into museums but because nothing decays in the frigid cold and everything was left. If you go to Antarctica's research station in McMurdo Sound and you wrangle a key and a helicopter ride to Cape Evans, you'll find everything inside the Terra Nova hut just as it was when the members of Scott's party who didn't attempt to get to the pole went running for the

ship to take them home. They left their possessions, their papers, even the dog whose skeleton you can still see, bound with a metal collar, on the floor of the doghouse.

These two huts lie near the research station where I spent the coldest summer of my life. I was twenty-six years old and in the middle of my graduate work as a planetary scientist. I went to Antarctica to probe for traces of life beneath the snow of its harsh, clean deserts. Regions of the continent were known for their similarities to Mars, which is why I had come, as an aspiring explorer of that distant planet. But I was also lured to Antarctica by something I'd once read by Edwin Mickleburgh, who wrote in *Beyond the Frozen Sea* that "its overwhelming beauty touches one so deeply that it is like a wound."

Each day in Antarctica I would rise and don the dozen layers of thermal underwear and goose down I had been issued. I was part of a program sponsored by the National Science Foundation to train young researchers. Some mornings we would snowmobile out over the windblown blue ice, a sledge of equipment fishtailing behind us. On other mornings we would head down to the helipad, hop into an A-Star or Bell 212, and zoom out over the booming pressure ridges. When the pilot reached the edge of the sea ice, one of us had to jump out, the helicopter still hovering, and bore a hole with a 4-inch bit. The ice had to be at least a meter thick; if not, it would buckle beneath us.

Everywhere I went, I lugged a gargantuan survival bag that weighed nearly as much as I did. Inside the waterproof red vinyl flaps were sleeping bags, a tent, and stakes, a WhisperLite stove, two quarts of white gas, a cookset, six freeze-dried meals, six candy bars, two bricks of Mainstay 3600 survival ration, tea bags, cocoa packets, toilet paper, candles, matches, a signal kit, and a standard-issue romance novel to read while waiting to be rescued. I practiced sawing building blocks out of the snow to construct ice walls, survival trenches, and snow caves. I studied the HF radio alphabet: *alpha, bravo, charlie, delta, echo*. I learned the geometry of crevasses and how never to step near where three cracks crossed, for the ice could give way like a trapdoor.

I also learned about the weather, which was constantly changing. A column of cold air could suddenly sink and roll over the terrain. Within seconds, a completely calm afternoon could be swallowed by katabatic winds howling off the East Antarctic ice sheet.

On overcast days, the white clouds could merge with the white snow; the light could become so diffuse that shadows disappeared, making it impossible to judge distances or distinguish the horizon.

Each of us had our own scientific interests: penguins, ciliates, the flapping valves of Antarctic scallops. For me it was the bacterial cells eking out a living in the bleakness of inland Antarctica. I analyzed samples from the Dry Valleys, just across the sound, where no rain has fallen for two million years. There iron oxide minerals, which also tint the surface of Mars, stain the blood-red tongue of a glacier that dips down to the ice-covered surface of a salt lake. I studied Braina Island, which has all the indicators of land but isn't land at all, just a thick layer of dirt and rocks resting on a layer of ice floating, in turn, upon the sea. Slick mats of green, yellow, and orange cyanobacteria are suspended there like felt in the meltwater ponds, gashes of color against the barren terrain. I investigated all the microbial colonies I could find, trying to understand how pockets of life could survive in the hostile, Mars-like conditions.

Unexpectedly, though, it wasn't the continent's biology that most moved me, or its tumbling crevasses or poleward storms. Or even the remarkable extent to which my inner world flowed out into the landscape. It was those huts built by Scott and his two polar expedition parties. In contrast to the shimmering ice, the world inside them was dark and awful; there were reverberations from the walls, the abandoned tins and boxes, many of them still full. There were bottles of ketchup, tins of cabbage, a gramophone, test tubes, and glass vials with chemical powders. Ruined reindeer boots, man-hauling sled belts, stacked carcasses of seals, the echoes of death.

There's a small library at McMurdo, located between the laundry room and the weight room at the rear of Building 155. It has no windows and about thirty shelves of books. During the light-washed nights, when I couldn't sleep, I would sometimes find myself there, studying the faces of the men who once inhabited those huts. I would curl up on a piece of battered furniture and look through books and photographs archiving the early expeditions. One day I came across the diaries of Edward Wilson, the scientist of the crew. He last saw the Terra Nova hut in late October 1911, when he joined Scott on his final expedition. All five men in the party reached the South Pole only to discover that the Norwegian flag had been planted there a few weeks earlier, and all five men

died on the return journey. Wilson collected thirty-five pounds of geologic fossils proving that Antarctica was once covered by ferns. The consummate scientist, he hauled those fossils to the very end.

On his way back from the pole, Wilson catalogued the ambient temperatures, which remain to this day among the coldest ever recorded on the South Polar Plateau. So cold that a glass of water thrown into the air would freeze before it hit the ground. A few days later the expedition unearthed a stored cache of supplies at Middle Barrier Depot only to discover that the canisters of fuel had evaporated. It was early March 1912, just a couple of weeks before their death. They needed fuel to melt drinking water and dry out their clothes. Without it, they slowly became encased in a mantle of frozen fabric. There was nothing to treat their frostbitten toes. No heat to draw them from their reindeer-skin sleeping bags in the morning. No warmth to help their shivering bodies to sleep at night. It was a major turning point in the expedition and, as it turns out, the evaporation of the fuel can be attributed to something very small. The O-rings, the flexing gaskets that acted to seal the fuel inside the canisters, turned brittle and cracked in the extreme cold.

As a space scientist, I know something about O-rings. In 1986, seventy-four years after Scott's party met its end, Caltech professor Richard Feynman sat before an investigative panel and dropped an O-ring into a glass of ice water to demonstrate how circles of rubber lose their pliability in freezing conditions. Afterward, he placed the O-ring down on the wooden podium, looked solemnly ahead, and said, "I believe this has some significance for our problem." And indeed it did; he was part of the committee of scientists reviewing the *Challenger* shuttle disaster.

I was six years old when the *Challenger* exploded, but I remember it well. Christa McAuliffe was going to be the first schoolteacher in space, and, like schoolchildren around the United States, I was peering up at a television watching the liftoff live. After a few moments, Mrs. Schrader walked to the front of the room, her face white, and clicked off the power. It's one of my earliest memories, and yet it didn't alter my desire to become an astronaut. Even now, even with two shuttles down and NASA's human space-flight program in disarray, I still think about soaring off in a rocket.

A hundred years have passed since Scott's expedition, and the frontier is now the void of outer space. Like many other young

scientists, I have leaved my striving upon this great unknown, but I sometimes worry that my convictions about exploration are inaccurate. What if the actuality of this enterprise is horribly different from my romantic ideas?

Inside the Terra Nova hut, I lingered by the bunk of Captain L. E. G. Oates. He was the second person to die on the way back from the South Pole, and his small space remains, to this day, cluttered with cavalry equipment. In the McMurdo library, I couldn't stop looking at the pictures of Oates taken by the expedition's photographer. In one of them, Oates is standing in the stables, now empty and stained with seal blood. The light falls gently on his right shoulder, and from beneath a thick wool hat, he looks intently at the camera.

Oates developed a savage case of frostbite on the return journey. With the winter cold and darkness descending, Scott described how Oates stepped from his tent into a minus-40-degree blizzard, simply remarking to the others, "I am just going outside and may be some time." Scott's description of the young captain disappearing into the whiteness, sock-footed and alone, offering up his life to save his comrades, echoed throughout Britain. After the world learned of the tragedy, the *Evening News* called for the story to be read to children across the nation.

Scott's account, however, is in marked contrast to Wilson's blunt and matter-of-fact telling of the grim narrative. Wilson writes on November 2, 1911, "Efforts were absurd . . .," on December 18, "Our hunger is very excessive . . ." And when he writes about Oates, there is nothing to suggest that he died in a whirl of gallantry. In a letter Wilson wrote to Oates's mother describing the death of her son there's no mention of any heroic last acts. In fact, that story is only found in Scott's journal entry some days later. It appears, in fact, that Oates did nothing to mark the occasion. Captain Oates, Captain L. E. G. Oates, his cankered legs rotting, just stumbled outside, and no one tried to stop him. He wasn't a man preciously composed in his suffering, inviolable as he faced oblivion. In all likelihood, he was a desperate ghost, seething with anger toward Scott, cut loose by pain, and on the verge of insanity.

The account of what happened to the crew of the *Challenger* has similar discrepancies. The spacecraft was launched on a cloudless day from Cape Canaveral in January 1986. Liftoff time was 11:38 a.m. Shortly after, a brittle O-ring turned the shuttle into

an inferno of flaming liquid oxygen. The *New York Times* headline the next day reported: "Challenger Shuttle Explodes Seventy-Four Seconds Into Launch: Seven Astronauts Killed Instantly."

But in late February, divers located the crew module, which had barreled into the sea floor. An NBC report indicates that as cables pulled the wreckage onto the deck of a ship, a blue protrusion slipped out, bobbed along, and then disappeared back into the sea. It was the waterlogged body of astronaut Gregory Jarvis, and it was another five weeks before divers relocated his corpse.

Slowly, the true story was pieced together from images, debris, and the recovered wreckage. It was determined that just over a minute after liftoff, the booster stack of the shuttle had exploded, some 48,000 feet above the earth. The forward fuselage, the small tip of the shuttle harboring the crew module, separated from the tanks. Chillingly, it did not explode. Propelled by its own momentum, it rose away from the fireball, carrying its seven passengers. It streaked across the sky along a ballistic trajectory, arcing in the tender thread of a parabola. What the astronauts would have noticed in the moments after the explosion was actually the quietness, the roar of the engines ceasing as the fuel tanks ripped apart and the fuselage broke away.

In the hush, the crew module continued to rise above the smoke, which blossomed like a white geranium. Twenty-five seconds after the O-ring gave way, the crew module crested at 65,000 feet, and then it began to fall. It fell for two minutes and forty-five seconds before impacting into the ocean. To the experts who sifted through the pixelated images, nothing suggested that it was erratically pitching or yawing. Among the most haunting pieces of wreckage discovered were four personal egress air packs designed to provide breathable air in the event of emergencies. Three of them had been activated, and the official report determined that they had been activated manually, not as part of the impact. For how many of those two minutes and forty-five seconds did the seven astronauts remain conscious? On the investigation committee, some scientists and fellow astronauts thought they were conscious for all of it, but we'll never really know.

That "we'll never really know" was the overriding message of the official report as it was released. Much of the hardware was mangled beyond recognition, and many pieces were not found. The section of the report dealing with what happened to the as-

tronauts seems nebulous, buried in the middle, as the reader's attention is swept off to the fact of brittle rubber. The bobbing, waterlogged corpse of Gregory Jarvis is never discussed, nor are those two minutes and forty-five seconds and what they might have been like. They are seldom mentioned, out of what I take to be respect and reverence at the heart of our collective American narrative about what it was to lose the *Challenger*.

I have spent a lot of time trying not to think about those last couple of minutes. I'm not sure I want to know that Mike Smith saw the flames ripple over his window, or what he imagined in his last two minutes and forty-five seconds of thought. I think of all of the things I can think of in that amount of time. I don't want to dwell on that sudden, serene silence or let myself envision Judy Resnik frantically searching for her accessory oxygen tank. I don't want to know that Captain Oates died in a state of psychosis either. I try to reason with myself that the details of these particular narratives are in the end inconsequential. They died: that is the sad fact of it, let it be.

But somehow I can't stop wondering about them. Five people perished on their way back from the pole, and another seven on their way to orbit; they fell against the terrifying whiteness of the ice and the burning sky. All twelve of those lives ended in blackened flesh, horror, and numbness, and all because of the tiny, tragic fact of a brittle O-ring.

That summer when I was twenty-six, I was in Antarctica long enough to notice changes in the light. By the end of my field season, the midnight sun was beginning to dip down lower and lower toward the horizon, glowing with a faint, creamy incandescence. Before I boarded the cargo flight home, I was determined to hike out and see the view from Castle Rock, a distant volcanic outcrop jutting through a glacier.

Early one morning, I stopped by the firehouse at McMurdo Station to pick up a radio, file a foot plan, and check out with the responder on duty. I stuck close to the wind-frayed flags planted every 20 feet along the route. The day was staggeringly bright and, like everywhere in Antarctica, devoid of smell. There were snowfields in every direction, and I could hear my boots with each step, pressing into snow so cold and dry it squeaked like Styrofoam. When I reached the end of the ice, I began climbing, pulling my-

self up along the twisted preset ropes. My boots gripped the cold igneous rock below me, once lava in the vent of an ancient volcano. As I ascended onto the peak, I fell on my knees, exhausted and sweating inside my big red coat. I gazed across the Ross Ice Shelf toward the South Pole. Behind me towered Mount Erebus and Mount Terror. In front soared the Royal Society Range, and to the east, the open sea, riddled with tabular icebergs.

The whole of the sprawling base—the labs, the dorms, the helicopter pads—had disappeared into a bewildering sea of white. I thought of the photograph of Earth taken by *Voyager 1* from the edge of the solar system. From 3.7 billion miles away, the whole of our world—everything human—was less than a pixel across. After a while, I spotted the trail leading back to McMurdo Station, just a faint strand tracking toward the horizon. The same year as the *Challenger* accident, two Americans fell into a fissure of ice 75 feet below. A search and rescue team tried frantically to pulley them to the surface, but they were wedged in too tightly to budge. The team heard them crying as the hours passed, then waiting and screaming until their voices finally stopped.

What is it that drives us to places like these—to the nothingness of the poles, the vast void of outer space? At the edge our world recedes, but we can't escape the brittle cold, the throbbing legs, the grating of mechanical parts, the absurdity of those O-rings. But perhaps this is why we strive. Perhaps, in the midst of such immensity, when we are faced with the irreducible fact of us, the firmities of reason and rationality give way. In the muscle of this great paradox, even a scientist is capable of believing in bigger things. The stronger the contradiction, the tauter the bow, the farther we can shoot.

Standing in the piercing air, I began to feel incredibly cold. My skin was damp, and snow had found its way into the crevices of my wrists. On top of Castle Rock, with my breath tumbling down the peak, I took one last look at the vast expanse that surrounded me. There was total stillness except for the faint whirr of a distant helicopter. The Terra Nova and Discovery huts were out there somewhere, frozen and timeless, holding steady against the winds. I took hold of the fraying rope at my feet and began my descent.

BARBARA J. KING

When Animals Mourn

FROM *Scientific American*

ON A RESEARCH VESSEL in the waters off Greece's Amvrakikos Gulf, Joan Gonzalvo watched a female bottlenose dolphin in obvious distress. Over and over again, the dolphin pushed a newborn calf, almost certainly her own, away from the observers' boat and against the current with her snout and pectoral fins. It was as if she wanted to nudge her baby into motion—but to no avail. The baby was dead. Floating under direct sunlight on a hot day, its body quickly began to decay; occasionally the mother removed pieces of dead skin and loose tissue from the corpse.

When the female dolphin continued to behave in this way into a second day, Gonzalvo and his colleagues on the boat grew concerned: in addition to fussing with the calf, she was not eating normally, behavior that could be risky for her health, given dolphins' high metabolism. Three other dolphins from the Amvrakikos population of about 150 approached the pair, but none disrupted the mother's behavior or followed suit.

As he watched the event unfold in 2007, Gonzalvo, a marine biologist at the Tethys Research Institute in Milian, Italy, decided he would not collect the infant's body to perform a necropsy, as he would usually have done for research purposes. "What prompted me not to interfere was respect," he told me earlier this year. "We were privileged to be able to witness such clear evidence of the mother-calf bond in bottlenose dolphins, a species that I have been studying for over a decade. I was more interested in observing that natural behavior than interrupting it by abruptly interfer-