

Shaken

Any Time Now, San Francisco Is Due for Another Massive Earthquake. What Might Happen When That Deadly Day Arrives?
A Worst-Case Scenario.

By Ethan Watters

1. The Time After

San Francisco's Second Great Quake came as the second big dot-com bubble was still inflating. It was an era defined by Twitter, Facebook, rising rents, and billionaires moving into the Mission and then, suddenly, by something else altogether. As with millions of others, the moments of the quake and the days and weeks following become the defining period of your life. Decades later, you still obsess over the geology that changed your life and the destiny of your city. You read all of John McPhee's rock books and then dig deeper into the journals and technical literature. You learn that the layer of the earth that humans so proudly sit atop—all the fruited plains and purple mountain majesties—is as thin and brittle as an eggshell when compared with the rest of the planet's roiling and viscous geology. You read about the remarkably young science of plate tectonics, how large sections of that outer shell spin and drift and crash into each other. On the Web you find an animation of this tectonic movement, three hundred million years of continental movement sped up to three minutes. You watch it over and over, not understanding at first why it looks so familiar. Then you see it: the spread and formation of our current continents look remarkably like cells growing and dividing under a microscope.

To comprehend the violence that was done to your life and your city by incremental movements of those continental and oceanic plates, you develop a mind that can grok geological timelines. You learn that tectonic plates interact with one another in two main ways. There are *divergent* boundaries, where plates are growing apart from each other. Because of such a fissure in the middle of the Atlantic Ocean, New York and London inch away from each other every year. Geologists describe divergent boundaries as conveyor belts moving slowly in opposite directions. Having a more personal relationship to plate tectonics, you imagine the divergent boundary differently: a long wound in the earth that never heals, endlessly bleeding and forming ever more scar tissue along its jagged border.

But it's the *convergent* boundaries, which cause such havoc and hardship for people like yourself who voluntarily choose to live near them, that really capture your interest. Amazing things can happen when plates come together. The world's most spectacular mountains were formed when relatively buoyant continental plates crashed into each other. The Himalayas grew as India rammed into Asia. The Appalachian Mountains came to be during a long-ago collision with the landmass that would eventually become Africa.

The earthquakes that happen along convergent plate boundaries come in a handful of types. You are surprisingly disappointed to learn that the earthquake you lived through, as bad as it was, is not the most powerful kind. The most dangerous scenario is when dense oceanic plates are forced under continental plates. This is what happens beneath the coast of Japan, as well as throughout much of Oregon and Washington. This more or less head-on collision of tectonic forces forms volcanoes a little way inland, as well as megathrust slips, which, at their greatest intensity, can move the earth so quickly that it can impart upward forces of two or even three times that of gravity. The movement can, in other words, throw anything not bolted down—people included—up into the air.

The great quake you lived through, technically speaking, was along a right-lateral, strike-slip fault of the San Andreas. What creates the aching tension on the San Andreas Fault system is the force of the Pacific Plate, moving in a northwesterly direction, rubbing against the North American Plate, moving in a southeasterly direction. The San Andreas Fault system runs along the entire western edge of California. When you trace the line northward on a map, your finger passes just east of Los Angeles, over the Cajon Pass, along the coastal edge of the San Joaquin Valley, through Stanford University, then parallels Highway 280 until it briefly dips into the Pacific Ocean near the Golden Gate Bridge. From there it snakes on and off the coast up through Point Reyes, where it cleaves the land to form Tomales Bay, and then to Point Arena and Cape Mendocino, where it finally turns out to sea. Taken as a whole, the San Andreas Fault system passes directly under or near some of the most populated—not to mention expensive—areas of coastline in the world. A preponderance of California's population resides within its reach. According to some estimates, the Bay Area has the highest density of faults of any urban center in the world.

Because the plates are grinding into each other, there was never a chance that California would break off and fall into the Pacific Ocean, as much of the rest of the country appears to enjoy imagining. The two plates meeting along the California coast form what is called “right-lateral faulting.” This means that if two people were facing each other on either side of the fault at the moment the earthquake struck, each would appear to the other to be transported sideways to the right as the ground broke and shifted under their feet. (During the 1906 quake, the two would have moved about twenty feet apart.) Neither would likely fall into a deep crevasse, for the same reason that California will not fall into the ocean: earthquakes happen here because plates are being pushed together, not pulled apart.

The Pacific and North American Plates move, on average, about one and a half inches each year, roughly the same speed at which your nails grow. Because L.A. sits on the Pacific Plate, it is moving northward. In an average human lifetime, L.A. will move a few feet closer to San Francisco. Some fifty million years from now, it will have long floated past the City by the Bay to become a very

large suburb of Anchorage. You like that idea: the descendants of those sun lovers shivering up there in the cold.

You knew when you moved to San Francisco, a few years after the Loma Prieta quake of 1989, that the San Andreas Fault system was active, but only after experiencing the Second Great Quake did you learn just how often it moved. Seismologists record and analyze about forty thousand earthquakes in California each year, which works out to more than three thousand each month and a hundred plus every day. Of that yearly number, about six thousand are greater than magnitude 2.0—which is about the level required for humans standing above the epicenter to feel the rumble. Only sixty-five a year top 4.0 on the scale, the point at which some damage to structures might be done.

The large earthquakes, like the one you made it through, don't come on a yearly basis, but they are always on the horizon. Andrew Lawson, the most respected geologist of his time and the central figure in documenting the immediate aftermath of the 1906 disaster (now known as “the First Great Quake”), optimistically suggested that the stress on the fault had likely been “completely and permanently relieved” by that event. It was an idea that would have appealed to a Christian population believing that the suffering and death they endured during those terrible spring days in 1906 would spare subsequent generations from such a fate. It would have been comforting to think that they had paid in full for the original sin of building on top of such perilous land.

Lawson's wishful assertion soothed people's minds for about sixty years. It was an idea that developers and politicians were only too willing to believe and promote. His mistake was laid bare in the late 1950s, when geologists started to refine their theory of plate tectonics. What they revealed is that the use of the singular to describe “the Big One” is accurate only when seen from the perspective of a human lifetime, and sometimes not even that. In a geologic time frame, Big Ones are quite frequent. The twentieth century produced about twenty quakes around the world that seismically rated above 8.0. Over the relatively young life of California, which was one of the later continental landmasses to come into existence, there have been tens of thousands of earthquakes similar to the one that hit in 1906 and the one you lived through more than a hundred years later.

“San Francisco would be a great place to live if it weren't for the earthquakes,” people from your hometown used to tell you, even before the quake struck. Now you know that the truth is more complicated, because San Francisco wouldn't be San Francisco *without* earthquakes. The bay itself is believed to be formed by a downward warping of the earth's crust between the San Andreas and Hayward Faults. Just as significant, San Francisco's turn-of-the-century charm—the Victorian and Edwardian buildings—would not have featured so prominently had the city not been basically erased from the map in 1906 and rebuilt during the next decade.

Would you take back your decision to move to San Francisco even if you knew what was coming? You ponder that question late at night when the memories of that day rob you of sleep, and you never arrive at a satisfying answer. You've come to see the massive quake as a truth serum for both you and the city. It revealed so much that previously lay hidden. It exposed secrets in the land and in the buildings and, just as important, in the population's collective psychology as well as your own. For better and worse, you know yourself so much better than you did before. Having lived through it, you can't imagine a self that wasn't defined by the experience.

2. T Minus Zero: 5:12 A.M.

It begins in the early-morning darkness while you sleep. At a spot miles deep beneath the Pacific Ocean, just offshore of San Francisco, not too far from the Golden Gate Bridge, a bit of the earth's upper crust snaps, releasing a hundred years' worth of pent-up elastic pressure. The amount of pressure increases exponentially as the break moves down a chain of subterranean rocks. The speed is spectacular. In an instant, billions of tons of rock and earth accelerate to over five thousand miles an hour, then slam to a halt as the Pacific Plate lurches twenty feet northward. While there is a hypocenter (a single spot in the earth directly beneath the surface epicenter) where the earthquake begins moving, not all of the force is generated from that point. Geologists say that faults like the San Andreas "unzip" in a fast-paced, staggered succession up and down the boundary. In rapid-fire movements, the earth speeds and stops along a plain more than ten miles deep and three hundred miles long.

The first shockwave to be sent across the Bay Area is the mildest: a compression wave similar to the short, sharp impact you'd feel if you were leaning against a cement wall when someone on the other side hit it with a sledgehammer. Traveling at more than ten thousand miles an hour, that jolt reaches shore less than a second after the quake begins. It races beneath the sandy soil of the Sunset and Richmond districts, then speeds up in the rockier center of the city before rolling downtown and out across the region. That first shock, as powerful as it is, is not the most damaging type of wave to emanate from a strike-slip fault—those will begin in a couple of heartbeats.

As light sleepers, you and your wife bolt fully awake at that first ominous jolt. You grab her arm and say (in unknowing unison with tens of thousands of other people in the Bay Area), "Did you feel that?" You hear the thundering noise of the tremor a second before it arrives. As your house starts to shake and rock, the sound becomes deafening. All 160,000 of the city's buildings groan at their joints and beat against their neighbors like bamboo in a storm. Glass shatters by the ton. The earth rumbles like a freight train as it pitches and rolls and breaks open. Brick falls away from buildings, wooden beams snap, and thousands of car alarms let loose their whoops and plaintive howls. Above the din, you hear what sound like explosions.

A man crossing Geary Boulevard, out for an early walk with his dog, is puzzled when the traffic light he's waiting for blinks out. He looks east toward the city skyline and then west to check the traffic and is transfixed by what he sees. The street is undulating. The man watches the waves come

down Geary and can't quite put it together. The long, wide boulevard looks as though it has become an angry ocean, with peaks and troughs several feet high. All the cars parked along the street begin hopping up and down like a gathering of hydraulically tricked-out lowriders. He has a second to brace for the movement, but when the waves hit, he's knocked off his feet to groaning pavement. Crevasses burst open to reveal the street's intestines of pipes and electrical lines and snap shut just as quickly.

The dynamics of how the earth is moving have become Ph.D.-level complex. There are the "S" Waves and surface movements called Rayleigh Waves and Love Waves. Taken together, they are moving the ground and everything on it from side to side, backwards and forward, as well as up and down. These waves speed up, slow down, and amplify depending on the density and solidity of the land they are traveling through. Like rogue waves on water, these forces can, stack on top of each other, increasing the force of the earth's movement in specific spots by factors of two and three.

Within a few seconds, every object in your room (indeed, in every room in an area spreading over tens of thousands of square miles) suddenly comes alive, gyrating and bouncing as if possessed. The weight of objects is of little consequence, given the strength of the geologic forces at play. Refrigerators and televisions dance as ecstatically as flowerpots. Bookshelves and dressers lurch forward and empty their contents.

"Get out of the building" is the instinctual reaction. It's a decision that will cause many a grave injury and cost others their lives. The frontages of many buildings are waterfalls of glass, concrete, or brick. For a lucky few, running the gantlet will save their lives as they manage to make it to the street just before the building they were in collapses. (After the Mexico City earthquake of 1985, there was the tale of one man who managed to run down twenty-five flights of stairs and out into the street just before the building pancaked behind him.) Others will rush toward the purported safety of doorways. "I don't know where that idea originated from," says Mark Eisner, a longtime seismic safety expert. "Trying to move across a room is dangerous during a quake. Besides, only one person can stand in a doorway."

As your house, a three-story Victorian, shakes and lurches, you consider dashing to the stairs, but your mind flashes on a single catchy phrase you heard in some public service announcement: "Duck and cover and hold on." You yell to your wife to get on the floor, and you both huddle against a low oak dresser, the sturdiest piece of furniture in the room.

The strong motion has been going on for twenty-five seconds at this point. You wonder: When is this going to stop? Earthquakes have different characters. Walter Mooney, a geophysicist with the United States Geological Survey, says that the 2010 Haiti quake hit so hard and fast that it was "like a

Mack truck going through a plate glass window. It was ‘bang!’ ‘Kaboom!’ It began and ended in seven to nine seconds. If you were in a vulnerable building, there was no way you were going to escape.”

Large strike-slip quakes along the San Andreas can release energy equivalent to that of thousands of nuclear bombs. But unlike a bomb, that energy doesn’t get loosed in one spot at one time. To understand why faults like the San Andreas can produce such interminable earthquakes, Dan Davis, a geophysicist at Stony Brook University, has us imagine ourselves as bugs floating on a leaf in a pond. If just one pebble gets thrown into the pond, we’ll feel a set of predictable waves emanating from that one point. However, strike-slips on the San Andreas generate energy not just from one point but from thousands of places where the earth bolts forward to unimaginable speeds and then almost instantly halts in place. It’s more like a malicious teenager had thrown a bucketful of pebbles into our pond. Says Davis: “Your little floating leaf will keep shaking for a long time, because some of the ripples started at different times and some of them come from father away and take longer to reach you.”

So it keeps going: thirty seconds, forty-five seconds, with no signs of stopping. At this point, buildings around the region begin to come apart and dozens—then hundreds—of people are confronted with the ends of their lives. The largest concentration of deaths is in a six-story apartment building along Valencia Street, where thirty-four people are killed. Built from concrete, before critical changes in the building codes, the structure has support columns that crack and give way as the earth shakes. The suddenly unmoored concrete succumbs to the force of gravity, and in quick succession the upper floors tumble. Horrifyingly, even in the collapse of concrete buildings, death is not always immediate. The human body is hard to kill. The autopsies of twenty-eight of the bodies pulled from the wreckage will show only mild or moderate internal injuries. The actual cause of these deaths was slow asphyxiation. These poor people had the breath squeezed out of them.

There are other concentrations of deaths. A group of two dozen stockbrokers, getting some work done before the opening bell on Wall Street, die when their ten-story glass-and-steel building collapses across a downtown intersection. Built in 1990, the building seemed new enough that they had all assumed there was little to fear from earthquakes. The building was held together by what is called a “welded steel moment frame,” which at the time was considered the gold standard in seismic resistance. It wasn’t until several of these types of buildings failed in the 1994 Northridge earthquake, in Southern California, that engineers had to reconsider this assessment. “We never expected modern steel-frame high-rise buildings to be vulnerable until we saw the joint stress and the shearing,” said one seismic expert. “An earthquake always brings surprises.”

After Northridge, new building codes and regulations were put on the books. Unfortunately, new seismic standards are seldom retroactive. After such changes, it usually falls to the building owner

to calculate the costs and benefits of embarking on an expensive retrofit. Many owners of San Francisco welded-steel-moment buildings decided that the risks weren't yet worth the cost.

Thirteen workmen and a delivery driver are crushed to death in a warehouse in China Basin. The building is a tilt-up construction made of prefab concrete panels. The connections between the wall slabs and the ceiling are too weak to resist the movement, and the roof collapses.

Up by Twin Peaks, four multi-million-dollar homes with commanding views of the city lose their footing on the hillside, tumbling and crashing into the houses below. Eight adults and three children are killed. Hundreds of other lives are lost in smaller groups around the city. There are so many ways to die when the earth begins to move. Some are killed on the Golden Gate Bridge when they lose control of their cars in the shaking and head into oncoming traffic. Four highway overpasses collapse, crushing dozens of cars and their early-morning passengers. A single falling brick on Harrison Street south of Market takes the life of one unlucky jogger. There are hundreds who find themselves alive but trapped in collapsed buildings.

Your house almost makes it through. It lurches back and forth—a little farther toward the street with each cycle—until the fifty-five-second mark. From beneath you, in the garage, you can hear the unmistakable sound of wood snapping and shattering. On the next swing, the house doesn't right itself but begins to collapse forward into the street.

3. What Was Hidden Is Revealed

After a full minute, the ripples in the earth finally dissipate, and the land sighs and settles. The damage around the city is a puzzling patchwork. Some blocks of nearly identical houses show dramatically different results. The houses on one side of a block might have held firm because they sat at a favorable angle to the radiating forces, like boats with their prows pointed into the waves of a storm. Across the street, the houses are all off their foundations and slumped at odd angles.

The last time such a force surged through the peninsula, there were far fewer buildings and people. Much of the Sunset and Richmond districts had yet to be developed. Now there are tens of thousands of houses and apartment buildings just a stone's throw from the fault, most on concrete foundations but built over sand, and many of them low to the water table. Thousands of these houses were built quickly during postwar boom times—too quickly, in some cases. With the shaking of the earth, the decisions of countless architects, developers, policy makers, and even individual construction workers become manifest. One block, built the year after a set of building codes became available online, does well, while its sister block, built just prior, is in ruins. In those episodic building booms of the last century, many builders cut corners to save money and time. Some, for instance, used sand from Ocean Beach as part of their concrete mix. Thanks to the salt and organic matter that was not properly removed from the sand, the concrete only appeared to harden. In the quake, hundreds of these foundations crumble to dust.

Houses built close together have mostly held each other up—except for the last house in the row, the one on the corner, which absorbed the force of the others and is now scattered across the intersection. Nearly all of the houses that sat on brick foundations are tilted at odd angles or have completely collapsed.

The quake has revealed secrets hidden in the land itself. The most damage occurs where houses were built on top of unconsolidated soil or ground just above the water table. Some of these liquefaction zones are well known, but there are hundreds of soft spots in the city's landscape that had long been forgotten. There are old watering holes for livestock, filled-in mill ponds, forgotten creek beds, old garbage dumps. There are places where the water used to run aboveground that have remained damp and saturated below. A drainage path no one remembers under 7th Avenue, by Laguna Honda Hospital, liquefies in the shaking, as does an old flume path and filled-in pond in Cole Valley.

“How well a house does depends on very, very localized geologies,” warned Laurence Kornfield before the quake. Kornfield, a former building inspector and head of the city’s earthquake mitigation effort, spent much of his working life trying to wake city residents up to the danger and power of the forces they lived atop. Which buildings survive also depends on the decisions of the individual owners over the decades. Did they take care of that termite problem or the water that was pooling too close to the foundation, rotting the sills and rusting the nails? Did they perform even the most basic seismic safety work? “Sometimes the difference in a house standing and falling is a single piece of plywood and a handful of nails,” says Kornfield, who has walked cities in the aftermath of earthquake damage around the world. He remembers looking at a pair of seemingly identical houses in Kobe, Japan; one had collapsed and the other hadn’t. “You know what the difference was? Almost nothing. One house had got just a little bit extra care.”

Besides the surprise soft spots in the city’s geology, there are other, larger liquefaction zones that have long been known to city planners and geologists, if not always to homeowners. The entire city shore, from Fort Point to Fisherman’s Wharf and down to Bay Shore, is one long liquefaction zone. In some places, that unsteady land is just a block deep, while in others it reaches dozens of blocks into the city. The upscale Marina district is built on unconsolidated mud and loose debris from Lyon Street on the western edge to Laguna Street on the east, and south to Lombard. But the Marina is not the largest liquefaction zone in the city. That prize goes the area where you live the inner Mission.

When early San Franciscans built in this part of town, they weren’t thinking about earthquakes; they were thinking about sunshine. Living along the bay marshlands was preferable because the fog and wind coming off the Pacific was blocked or shouldered aside by Twin Peaks. With all the debris humans generate, and plentiful bay mud to dredge up, it was easy to fill acre after acre of sunny inlets, small lakes, and marsh to build another row of houses and then another. (This process was made even simpler after the 1906 quake. The millions of tons of rubble and debris had to go somewhere. Most was dumped at the edge of the bay, creating ever larger areas of shaky ground.) After a few decades, no living person had a memory of how you could once set sail in a small boat from San Francisco Bay and, at high tide, steer it along what is now right field of AT&T Park and all the way up Mission Creek to a small lake that used to exist at the corner of 17th and Valencia—a full mile into the heart of the city.

In less than a minute, square miles of seemingly solid land could turn into something with the consistency of cake mix. Through repeated shaking, particles of soil or sand lose hold of each other and the ground actually expands slightly as microscopic gaps open up. Saturated sediment held under pressure above the bedrock shoots upward toward the surface through that dilating soil as fast as

someone squeezing a sponge. When this happens, buildings lose their connection to the stability of the underlying bedrock. They are suddenly—and literally—floating on a sea of silt.

Worse yet, during protracted earthquakes, those floating buildings are being pounded by seismic waves. Some collapse or fall over, while others literally sink straight down into the muck. Your house, oscillating in wider and wider swings, finally gave way moments before you lost consciousness.

4. The First Look

You wake up with your wife calling your name and tugging on your arm. When your house slid forward into the street, the heavy dresser you had been huddled against pushed you both across the room, slamming your head into the wall beneath the bay window. It had never occurred to you to anchor a piece of furniture that was only three feet high. Your eyes focus slowly. While the bottom floor of your house gave way, the second and third floors, remarkably, held their shape. It was the cavernous space of the garage—the “soft-story,” structural engineers call it—that caused the collapse. Once you extricate yourself from the crush of the dresser, you discover that getting out onto the street isn’t going to be difficult. Staggering around in your tilted bedroom, you manage to gather some clothes and put on your shoes. Then you only have to break away the remaining glass in the bay window and battle five feet down through some wood and debris. You’re bruised, with a nasty lump on your head and some minor cuts to your arms and legs, but you are safe. A neighbor from across the street helps you and your wife through the last few feet. You stumble across the street and look at your house. It looks as if it has kneeled forward, bowing, a suppliant to the forces of the quake.

Everyone who can get out is on the street. You haven’t seen this many people since you threw a block party last spring. You surmise that you can’t have been unconscious for long—there are car alarms still going off in the distance. When they finally stop, there is a preternatural calm and silence. The air is choked with settling dust. Some people are crying, but mostly voices are hushed. People have left their buildings with what they were wearing, which was not much for some. Many have cuts on their feet and heads. People wrap themselves with whatever they have at hand: a painter’s tarp, a blanket retrieved from a car. Seeing a need, others tentatively venture back into their homes and bring out first aid kits and bundles of clothes to distribute.

As the dark gives way to dawn, people look quizzically into one another’s eyes to gauge their own reactions. *Are you experiencing this, too?* the expression asks. You all went to sleep in a functioning modern metropolis and have awoken to what looks like a war zone. In small groups, people gather around car radios. Early-morning hosts and reporters begin to relay the news. The voices have lost their radio smoothness; they sound rattled. A scientist at the California Geological Survey in Sacramento is put on the air. He gives the number that everybody is waiting for. The initial estimates, the expert reports, indicate that the area has taken a direct hit from an 8.0 magnitude quake—a worst-

case scenario for the region. He's looking at a ShakeMap, an electronic image that records seismic activity, and reports that the damage up and down the coast will be severe. On one map, the entire Northern California coastal region from San Juan Bautista to Ukiah is orange and blood red, indicating strong to severe shaking. Almost all of Central California is yellow, indicating moderate shaking. The scientist forecasts significant aftershocks. There is a 90 percent probability of multiple magnitude 5.0-plus quakes within the coming days, with a 5 to 10 percent chance of larger quakes. As if on cue, a minor aftershock, 4.2, rumbles through the region. The radio host interviewing the expert laughs nervously.

The city's emergency services are coming to life. The dozen 911 operators and police and fire dispatchers on duty in the early hours of the morning are doing their best to log the flood of calls. To the consternation of the 911 operators, many of those first calls are people reporting that there has just been an earthquake. Having only moments before crawled out from under the protection of their own desks, the operators struggle to keep their professional composure. "Yes, we know," they say. "What is your emergency?"

"The first period of a large disaster is just chaos," says Rob Dudgeon, deputy director of San Francisco's Department of Emergency Management. "You are just trying to figure out which way is up." The calls for assistance quickly stack up as the scope of the disaster becomes clearer. Soon the word comes down to fire and police dispatchers to stop sending out units. That pause in the action won't go on for very long, but it is essential for making sure that the manpower and equipment available are put to their best use. "If you just immediately react to the calls coming in, you are going to tie up everything you have and you are going to quickly run out of resources," says Dudgeon. Information comes in from a variety of sources. Firefighters from each of the city's stations will drive through their districts to assess damage. A small contingent of volunteer ham radio operators immediately begins to relay damage reports to the city's nerve center.

The traffic helicopters are soon in the air. The pilots and reporters were already at the airports, about to start their morning shifts. The first up is a KGO chopper out of Oakland. The pilot and reporter streak low and fast to the Oakland side of the Bay Bridge. The new structure, recently dedicated to former mayor Willie L. Brown Jr., has held. Two sections of the older span, already under demolition, have collapsed into the bay. More reports come in from the traffic helicopters. Nothing is moving along any major bridge or highway. Even from the air, the reporters can see major fissures and displacements of the asphalt along I-80, I-280, and Highway 101, which run almost directly over the fault for dozens of miles. Other reports come in: the pipelines running across the bay, carrying water from the Hetch Hetchy Reservoir, have ruptured.

Looking up and down your street, you see that a similar-size house, also with a garage on the first floor, has also collapsed. The street itself is unrecognizable; the sidewalk and pavement are buckled and pushed up three and four feet high in some places. You spot large boils of mud and water. An old pickup truck has sunk into the muck up to the driver's cab, with the bed pointing ridiculously upwards at the sky.

You want to say something reassuring to your wife, but she turns to you and says something first. "Where's Mike?" she asks.

Here's a part of the story you will never tell anyone, not once in the thousands of times you repeat the tale. In fact, you will omit this detail so assiduously that in a couple of decades you will forget it yourself: In the midst of these first extraordinary moments, you've forgotten about your friend Mike, who's been staying with you.

You thought you were doing him a favor; he had just broken up with his wife and had no place to go. You had an unoccupied in-law unit that you carved out of the back of the garage. You had done that construction off the books, hiring migrant labor and a friend who knew something about construction. If you told the building department that you were expanding the living space of your house, it would have triggered a whole series of mandatory upgrades. You'd have to replace the brick foundation with concrete or insert shear walls that would almost certainly turn your two-car garage into one. You had intended to do some work down there. You had even done some searching on the Web and learned that you could bolt down your foundation, even if it were brick, and that some simple T-braces and a few sheets of plywood might make the critical difference in shoring up your soft-story. But you hadn't gotten around to it. There were always dozens of more pressing items on your to-do list than preparing for an event that probably wouldn't happen for decades, if at all.

But now it has happened. And your friend Mike is paying the price for your wishful thinking. Your mind now opens up a parallel track. It is slowly processing what is happening in front of you, but it is also spinning a side narrative. In part of your mind, you are now seeing yourself as the star in your own movie. Your friend is trapped in your house and you are going to be the hero of the story. Unless it's already too late, in which case you're the villain.

You race back through a neighbor's side yard to the back of your house. You call for your friend. Your voice is tentative, almost soft; you feel strangely embarrassed. For a moment, you stupidly worry that your voice is going to wake up the neighbors. Angry at your timidity, you get bolder and start yelling his name at the top of your lungs. You pause to listen. Nothing. Maybe he's not even in there. Hadn't he gone out to the bars last night? You pray that he got lucky and went home to someone's safer bedroom.

Then you hear it. It's barely audible, but it's there: A frantic tapping of what sounds like wood against wood. You yell to him that help is on the way and then run back to the street, where your wife is gathered with a group of neighbors. The middle-aged Hispanic woman from across the street who runs a small day care center has a cell phone, but she's getting no signal. Her landline is out, too.

"My friend is still in there. He's trapped on the ground floor," you tell the group. Again, there's that strange rush of embarrassment.

"The fire department will be here soon," says the know-it-all neighbor from a few houses down. You've never liked her—she's constantly complaining about the windblown trash that collects in your yard and reports you to the city anytime the local youth tag your garage door. "I wouldn't go near your house," she continues. "It's probably going to come down all the way." A few people nod, and for a precious few moments that seems to settle the matter. You begin to hear sirens, but none of them comes your way.

Then you see a young man walking purposefully down the street, holding a wrench. You watch him go up to the front of a house, pause, put his face to the edge of the garage door, and back away. He then pries up a concrete plate in the sidewalk and reaches down with the wrench. You realize he's turning off the emergency gas valve. Witnessing his sensible effort propels you out of your momentary stupor. You decide that you are not going to passively wait for help. The part of you that is watching the movie you are living through flashes forward to all the sleepless nights you'll have if you fail to act. You must try to get to Mike, but you can't do it alone.

5. Disaster Psychology

For the vast majority of people stumbling out of darkened buildings, the world they enter will look nothing like what is portrayed in the disaster movies. That scene is one of the most clichéd of all movie moments: the crazed hordes running through the streets, waving their hands and screaming while fleeing from fires, falling buildings, tidal waves, floods, meteors, flying saucers, zombies, triffids, and/or Godzilla. Other characters lose their minds and babble incoherently, mimicking what in the psychological literature is labeled “disaster shock.” Over the past few generations in the West, there has been a growing agreement among mental health professionals that the human mind is fragile and prone to seize up at the sight of blood, suffering, or sudden destruction. Disaster shock is reported as a state of almost infantile regression. People in this state supposedly can’t function or understand simple directions. They are prone to make the most illogical mistakes—staying in the burning building or leaving their children behind.

But what most people are witnessing in the unfolding aftermath of San Francisco’s Second Great Quake couldn’t be more different. The population of San Francisco is being let in on a secret that, for the most part, only those who personally experience disasters are privy to: people generally function well in these situations—remarkably well, in fact. Most of the stories told about panic and disaster shock turn out to be a combination of popular myth and bad or selective reporting based on preconceived beliefs.

Erik Auf der Heide, an emergency medicine physician who specializes in disaster preparedness, has spent much of his life trying to dispel the myths about human behavior during and after horrible events. Indeed, given the wealth of evidence for how well people manage in these times, he can’t understand why those myths persist. “The problem with the panic misconception is that the public, the media, and even emergency planners and public officials believe it,” he says. Even when they have personally witnessed functional, often heroic behavior after a disaster, emergency personnel tend to credit the resilience of spirit to characteristics of their own particular community, assuming that other people in other places would not fare as well. Dispelling these myths is critical, because they lead to bad disaster policy. The assumptions about easily panicked crowds, for instance, have led officials to under-inform citizens in the wake of a disaster for fear of frightening them into irrational behavior.

The truth is that many disaster victims experience a clarity of purpose that eludes them in their normal, day-to-day lives. Experiences of true catastrophe force them to push the pause button. Bills, work projects, the overdue parking tickets, the kitchen remodel (granite or stainless steel?), the kid's school applications—all of the medium- and long-term preoccupations that buzz in the brain like a bag of bees are now silent. Suddenly, you and everyone around you have encountered another way of experiencing the world—one that is more tactile, urgent, and immediately meaningful. What people find is that their brains don't rebel; they don't short out or fail to function. Indeed, they find that they have brains made for such times.

It is not uncommon to feel downright giddy. Many experience a reaction similar to that of famed psychologist William James, who was teaching at Stanford at the time of the 1906 quake. "My emotion consisted wholly of glee and admiration; glee at the vividness which such an abstract idea or verbal term such as 'earthquake' could put on when translated into sensible reality and verified concretely; and admiration at the way in which the frail wooden house could hold itself together in spite of shaking," he wrote. "I felt no trace whatever of fear; it was pure delight and welcome."

Even though you live among a privileged population that rarely witnesses calamity, you still possess an evolved brain capable of handling periods of great stress. Indeed, there is some evidence that our brains may be more at home in dire situations than they are when navigating the endless complexities and vagaries of modern life. One of the most remarkable stories in this regard came after the San Fernando earthquake of 1971 (magnitude 6.6, killing sixty-five and inspiring the 1974 film *Earthquake*). At the Los Angeles County Olive View Medical Center, the bottom floor of the mental health building collapsed, killing three patients and a staffer. The dozens of patients on the upper floor, all mentally ill to the point of needing care in a locked ward, appeared calm and cooperative after the disaster. Most striking were the deeply psychotic patients, many of whom seemed to snap out of their illness during the crisis, becoming rational and helping with the rescue of other patients. It was only later, when the modern world regained its momentum, that they lapsed back into psychosis.

True, there are those in any population who become inconsolable or who take on a victim's role right from the start. The population of San Francisco is unaccustomed to hardship. In the hours and days after the event, a few will want to know—demand to know—who is to blame for what is happening to them. Why had the city let them live in a house that wouldn't withstand such an event? The writer and futurist Steward Brand noticed, after 1989's 6.9 magnitude Loma Prieta quake, that he could sense a significant amount of free-floating rage, like an electrical charge in the air that would here and there find grounding. Small crowds verbally attacked news photographers and cameramen documenting the event. He wrote about one woman who felt it was her job to yell at a firefighter who

was desperately working to find a hydrant that had water pressure. “A woman in a jumpsuit starts haranguing the guy: ‘We need some water on the fire! Where is the water?’” as if she was telling the fireman something he didn’t already know. Brand and some fellow volunteers who were trying to help just stared at her in disbelief. Brand was also amazed to see how many people were just milling around when there was so much that needed to be done. Not all of the tasks were dangerous, either. “There was so much potential help in the Marina that was dissipated in lone tentative actions or simply never invited to help.”

Those who took Psych 101 in college likely have an overly pessimistic view of the question of whether bystanders will step in to help a stranger in peril. They might remember the case of Kitty Genovese—perhaps the most famous name in the study of bystander intervention. Genovese was a twenty-eight-year-old woman who was raped and stabbed to death in New York City in the early-morning hours of March 13, 1964. Surrounded by apartment buildings, Kitty screamed for help for more than half an hour. None of the thirty-eight witnesses who saw or heard the attack from their windows managed to do so much as call the police. While commentators of the time made much of the event (it was a sign of deteriorating social bonds and a crumbling civilization, they agreed), it took social scientists longer to get to the bottom of it. It turns out that there are two key reasons why people don’t act in a situation where they could help, and neither has much to do with a lack of caring or courage. In poor Kitty’s case, what stopped most of the bystanders from acting was that they were all operating under the reasonable but mistaken assumption that someone else had made the call. The louder she cried, the more certain they became that someone must have already acted.

In other situations, people don’t act because they are mimicking one another’s behavior. If the person next to you isn’t intervening, you unconsciously reason that that is probably the correct behavior. Because people instinctually freeze the moment a dramatic and unanticipated event begins to unfold, that state of inaction often becomes the default behavior that everyone mimics. A videotape of the bombing at the 1996 Atlanta Olympics shows this clearly. After the bomb goes off, everyone in the video freezes and then looks to someone else for cues about what to do next.

“Because of the shock and confusion, most action in a disaster is imitative,” Brand confirms. “Right after an earthquake, nobody’s in charge. You self-start or nothing happens.”

Giving your fellow bystanders another behavior to mimic, it turns out, is remarkably easy. You simply have to be the first to do something—anything. Once you have begun to act, you’ve also claimed a position of authority from which you can now request action from others. People in unfamiliar situations are highly prone to follow any semblance of leadership. Once someone has begun

to act and specifically requests help from others, it takes very little time to get a small group of people over the tipping point and into the fray.

One example of this group dynamic was videotaped after a freeway accident in the summer of 2011 near Salt Lake City. A motorcyclist had collided with and slid under a car that had then caught on fire. A group of people had already gathered when one man went up to the wheel well of the car and tried to lift it. As an individual action, the move was absurd and pointless—there was no way he was going to lift that car. But it took the crowd of onlookers no more than a couple of heartbeats to get the idea. Soon the man was joined by a dozen others, who collectively managed to lift one side of the four-thousand-pound car to knee height, enough to save Brandon Wright from burning to death. Wright was saved by a group of bystanders who were mimicking one man's quixotic behavior.

Why not take your neighbor's advice and wait for someone with real authority—a policeman or a firefighter—to arrive? Because they are not coming, at least not very soon. For regionwide catastrophes, there are not nearly enough professionals to go around. In large-scale disasters, the vast majority of rescuing is done by neighbors and strangers who arrive to help. Well-documented examples are legion. Of the five thousand victims of a massive tornado in Wichita Falls, Texas, in 1979, only 13 percent were assisted by a policeman, EMT, or firefighter. The rest were helped by other victims of the storm. Following a 1980 earthquake in southern Italy, more than 90 percent of trapped victims were extricated by untrained neighbors and strangers using mostly bare hands and garden tools. During the aftermath of Loma Prieta, an estimated 31,000 residents of the Bay Area became involved in search-and-rescue efforts in one way or another. After the Mexico City earthquake of 1985, more than 1.2 million people pitched in to locate, rescue, and give first aid; more than 130 volunteer rescuers died in the effort.

Many people who jump into action will explain later that their primary fear wasn't the danger of the situation, but facing themselves later if they failed to act. After interviewing dozens of heroes for her book *The Unthinkable: Who Survives When Disaster Strikes—and Why*, Amanda Ripley saw this pattern clearly. "The more heroes I interview, the more I realize that I've been asking them the wrong question," she says. "It is not a matter of why they did something. The better question is: 'What were you afraid would happen if you did not do what you did?'"

6. The Rescue

Standing with your group of neighbors in front of your collapsed house, you remember a story you read after Loma Prieta. It was about the collapse of the Cypress Structure, a double-deck freeway in Oakland that crushed dozens and trapped others in their cars under tons of cement, rebar, and asphalt. In the minutes after the quake, a crowd had gathered, gawking at the slumped and undulating upper deck. People looked at one another, but no one moved to help. Then, the story goes, a man named Bill McElroy, a fifty-two-year-old boilermaker, turned from the devastation and spoke to the crowd. “We better get organized,” he said in a loud and authoritative voice. “There are people up there that need us. Go home and get us some ladders and some ropes, any tools you’ve got.” And that is just what some of the people in the crowd did—not all of them, but enough to put in motion a seat-of-the-pants rescue effort that saved many lives. The Oakland Fire Department later reported: “The success of the Cypress rescue operation was due, in large measure, to the efforts of hundreds of citizen volunteers. These volunteers, coming from residences and businesses in the neighborhood or passing by on the street and freeway, performed some of the first rescues of trapped motorists. Using makeshift ladders, ropes and even the trees planted beside the freeway, these volunteers scrambled up onto the broken structure to render first aid and help the injured and dazed to safety.”

With Bill McElroy in mind, you turn to your neighbors and give your best pregame pep talk. You tell them that your friend’s name is Mike and he needs their help. “Go to your garages—go to any garage,” you say in a voice that doesn’t sound half as commanding as you’d like. “We need all the tools you can find. Bring them back here. Do it now.” A few people move purposefully away. Two men off to the side look confused, and you realize that they don’t speak English. You recognize them as the migrant laborers you walk by in the morning while they wait to be picked up for day jobs. Your neighbor from across the street translates what you’ve said, and they nod and go off. You’re doubtful whether you’ll see them again.

“Excuse me,” a man says. He’s in his mid-forties and wearing a flannel jacket. “I work construction. How can I help?”

In the next fifteen minutes, a pile of gear forms on the sidewalk in front of your house. There are a couple of ladders, crowbars, an ax, a bolt cutter. Someone has brought a gas-powered chain saw. As you try to assess what to do first, a large truck pulls up and the two migrant laborers hop out. The

truck is stacked with wood and long metal poles used for scaffolding. *That is going to be useful*, you think to yourself, although you are honestly not sure exactly how.

You look at the growing pile of tools on the sidewalk, and without much thought you grab the chain saw. You've never used one before, and it's considerably heavier than you thought it would be. You commence yanking wildly at the starter cord. One of the laborers takes the implement out of your hands. "*Tranquilo*," he says. "*No tan rápido*."

"Yeah," says the construction worker in the flannel shirt. "Let's have just a bit of a plan here."

At that moment, you demote yourself from the leadership of your impromptu rescue mission. You have some people-organizing and motivating abilities (you are the captain of your softball team), but only mediocre skills when it comes to using tools, and no experience with heavy construction.

"Okay," you say to the construction worker. "You're in charge. What now?"

He takes a breath and looks at the house. "Well, let's get these guys with the scaffolding to start bracing the walls. While they do that, I need you to tell me about the layout of the bottom floor and where you think your friend might be, um, stuck."

Within fifteen minutes, with the help of a dozen people, the scaffolding boards are braced against the sills and doorjambs of the front of your house, now leaning over the street. No one has any idea whether the scaffolding will hold the house up in the aftershocks that are certain to come, but it's better than nothing.

The construction worker has examined the back of the house and decided where to enter. He notices that the rear of the structure hadn't come down entirely. The interior wall you built to create that in-law unit may have held some weight, even if it wasn't reinforced by plywood. He decides that the only hope is to tunnel in at the spot just to the left of where you estimate that wall stands.

Watching your efforts, a few more neighbors jump in and begin clearing wood and debris to provide a path to the back of the property. Concrete is hard for humans to move without heavy machinery, but wood is another matter. Armed with nothing more than a claw hammer and some time, pretty much anyone can dismantle a wooden house. Time, unfortunately, is something you don't have in abundance.

You give yourself two jobs. You join the group of people hauling wood away from the side of the house, and from time to time you interview onlookers to see if they have any useful experience. You talk to one lanky young guy who says that he's a climber and has done some backcountry rescue training and to a young woman who is a home care nurse. You send them both up front to where the chain saw is now loudly tearing a hole in the wreckage of your house.

Then, coming down the street, you see the welcome sight of a police officer. You head for him, but before you can speak he says, “You’re going to have to clear out of here. This place isn’t safe.” You tell him that your friend is trapped and you are trying to get him out.

“It’s not safe,” he repeats, as if not understanding. For a few seconds he seems at a loss for words. It dawns on you that he is improvising in this situation as much as you are. After another beat of silence, he mumbles, “I guess do what you got to do. I’ll radio it in.”

There are similar awkward encounters playing out around the city. Police and firemen aren’t trained to work hand in hand with volunteers. Police in particular are usually tasked with getting the public safely out of harm’s way—clearing the incident area for the pros. But that tactic makes no sense in this situation, since citizens are doing more than 90 percent of the immediate rescue work. The police and fire departments have done a lot of planning for a disaster like this, but, as with a military battle, events on the ground have their own momentum and seldom conform to imagined scenarios.

Not all of the interactions are adversarial or awkward. Indeed, many of the encounters between officials and volunteers are respectful and show mutual appreciation. Although they are not trained to work with volunteers, police and firefighters who decide in the chaos of the moment to rely on this wellspring of available help are often impressed with the courage and abilities of laypeople. Back in 1989, as blocks of the Marina burned after Loma Prieta, San Francisco firefighter Joe Conway let a group of volunteers help him hold a hose. The relatively low water pressure meant that they had to get dangerously close to the inferno. He was in full protective gear, but the heat was almost unbearable. Then he looked at the volunteers on the hose, just feet behind him. Some were withstanding the blazing heat wearing only shorts and T-shirts. “It was just unbelievable,” he recalls. “I was so proud of them.”

As you get back to work, you notice a man come quickly to your pile of tools. He grabs an ax and starts jogging down the street toward the other collapsed house on your block. You are about to run after him, but your wife stops you. There is someone trapped down there, too, she tells you. It doesn’t take long to do the moral arithmetic. Your manpower and pile of tools will have to be shared.

The man has taken the ax to the house at the end of the block, where another group of people has gathered. You can see smoke rising from the roof. Looking over the tops of other houses, you now notice three additional ominous plumes. A few minutes later, you finally see your first fire truck of the morning, pulling up to the blaze down the street. The firefighters run a hose to nearby hydrants but find they are dry.

The blazes you see are just a few of the more than one hundred fires that have broken out after the quake. The South of Market and Mission districts have more than thirty separate blazes, many caused by broken gas pipes coming into contact with pilot lights on stoves and water heaters. The 325

firemen who were on duty at the time of the quake simply cannot respond to all of the fire reports coming in. They prioritize those blazes where human life is at risk. In some places, they have little or no water to work with.

Most of the crews responding to the fires discover, to their relief, that there is water pressure in the hydrants. The fires of 1906 taught San Francisco officials that they couldn't count on just one water supply system after an earthquake. In addition to the pipes that feed people's kitchens and bathrooms and many of the street hydrants, the city built an auxiliary water system, unique to San Francisco, that flows to a dedicated set of hydrants using gravity alone. Twin Peaks Reservoir, the highest point in the city, at 750 feet above sea level, is the headwater of this impressive labyrinth. Its reservoir of 10.5 million gallons is split into two smaller reservoirs; if the piping system in the city below is so damaged that one of the reservoirs gets drained, the second will serve as backup.

If that freshwater reserve from above should run dry, or if the pipes were to break too high in the system, two emergency pumping stations built at different points along the bay can pump saltwater back up the auxiliary system at a rate of ten thousand gallons per minute. If those pumping stations can't do the job, the system has connection points for the city's two fireboats, the *Phoenix* and the *Guardian*, the latter of which has the largest pumping capacity of any fireboat in the world—twenty-four thousand gallons per minute.

But the auxiliary system, as impressive as it is, still relies on 150 miles of high-pressure pipes that run below the ground. In the areas of liquefaction, those pipes have broken in dozens of places. Thanks to a sophisticated matrix of computerized valves, even this number of breaks does not take the whole auxiliary supply offline. But there are a few vulnerable areas, including the blocks surrounding your house, where the underwater mains that bring water both down from Twin Peaks and up from the pumping stations on the bay are broken. This leaves firefighting teams reliant on what the fire department describes as the “last-resort, worst-case, drop-dead scenario.” Without water from nearby hydrants, pump trucks will have to draw water from one of the 177 stand-alone cisterns hidden under intersections throughout the city. Although a few of these cisterns have a capacity of 200,000 gallons, most max out at 75,000. Setting up the trucks and then running the hoses blocks down the street to the fire takes precious time.

Often it is too late. Many of these old wooden houses sitting shoulder to shoulder just go up too quickly, especially when the fires are started by the blowtorch of a broken gas pipe. The wooden lath in the plaster walls acts like kindling that easily ignites the buildings' more substantial skeletons—thick slabs of redwood that have had decades to dry. Within fifteen minutes of the time you noticed the smoke down the street, the cars in front of that house are melting in the heat. The firefighters are now

using the water from the cistern to keep the smoldering houses across the street from catching fire. It doesn't take long for you to realize that no house on your block will be standing at sundown.

You go to inform the construction worker of the approaching conflagration and discover that they have managed to reach Mike through a narrow tunnel. The construction worker, who has had some experience replacing the foundations of houses, has buttressed the passage using a simple box-crib shoring technique. He's simply cut three-foot sections of four-by-fours and stacked them in a hashmark pattern.

Wriggling into the opening, you find Mike unconscious, with his legs pinned under a four-by-four beam. His upper body, fortunately, is in a small triangular opening. Lighter and more flexible than concrete, wood-frame structures usually collapse less completely. Even on the bottom floors of wooden buildings, there are often "voids" created, little pockets of space. There are disreputable self-proclaimed "experts" who claim to know how you can anticipate where a void will be created in a room, but actual engineers know that they are full of shit. Finding yourself still breathing after the building around you has collapsed is mostly a matter of luck. Marla Petal, a disaster expert from Bogaziçi University, in Istanbul, who did her doctoral thesis on the causes of death in the 1999 Kocaeli earthquake, puts it this way: "We don't know a.) whether it is possible to anticipate where the life safe voids will be before the collapse, and b.) whether it is possible to get there during the strong shaking of an earthquake." Your friend Mike simply lucked out when his legs ended up under the beam, rather than his head.

Using two car jacks, you and the construction worker are able to raise the beam just an inch or two, but it's enough. When you get Mike out to the sidewalk, there isn't as much blood as expected. His legs are mangled and at odd angles, but during the time he was trapped, his body has already stemmed the loss of blood.

The home care nurse looks him over and says the obvious: "You need to get him to S.F. General as fast as possible." Using a camping cot, you, the construction worker, and the migrant laborers hustle Mike the four blocks to the hospital. You know that it is critical to get him medical attention immediately, but you don't know the full extent of the emergency. Mike is facing the potentially deadly consequences of what is called crush-injury syndrome. After the blood flow was constricted in his legs, the blood cells and muscle tissue in the limbs began to die and started leaking their component chemicals: amino acids, creatine phosphokinase enzymes, peroxides, lactic acid, and potassium, among others. The moment you lifted the beam off his legs, all the substances released from his dying or injured cells surged into his circulatory system. Mike's kidneys are already struggling

under the stress of trying to process this multitude of potentially toxic chemicals. With crush-injury syndrome, the body can literally poison itself.

At the doors of San Francisco General Hospital, the city's only Level 1 trauma center, you are directed to triage areas in the parking lot. Much of the actual hospital is out of commission: the functioning buildings can take in only 10 percent of their normal capacity of patients in the first days after the quake. It will take two months to get it up to 60 percent. So the nurses and doctors have to treat many patients in the open air. Fortunately for those coming in with the onset of crush-injury syndrome, the first-line treatment is straightforward: Insert multiple IV lines and a urinary tract catheter so that the victim can pee out as many of the toxins as possible. A nurse and an EMT take Mike into the maw of activity. You and your small crew of rescuers sit down on a nearby curb and stare blankly at the activity. For minutes, no one says a word.

7. The First Night

By midday, the city's Emergency Operations Center is fully up and running. A few blocks from City Hall, the EOC is a stand-alone building on the 1000 block of Turk Street. The mayor and his key staff, along with representatives from every city service, are on hand. Representatives from PG&E and the Red Cross are also present. A large open room on the second floor of the building is the nerve center. Across the room are a dozen groupings of tables, each with a phone and a small flag indicating the focus of the people gathered there. There are tables for fire and rescue, for human services, for transportation, planning, infrastructure, law enforcement, logistics, and so on. Powered by its own generator, the place is tricked out with technology and communications equipment. Maps of the city are projected onto whiteboards that can then be hand-annotated. Television and oversize computer screens light up the room. The phones are old-school, reliably nondigital and hardwired. The place is as busy as a trading floor, which, in some ways, it is.

These tables are not the center of activity for these arms of the local government, but rather a place where cooperation *between* the services can be facilitated. When a Red Cross staffer gets word that a rescue truck is blocked by downed power lines in the road, she hustles over to the people at the Public Works table to ask if they have the manpower and equipment to clear the area. When help is not available from any of the departments represented in the room, requests get sent up the line to the state and federal government. The need for such a local-services trading floor became clear after other major disasters, including Hurricane Katrina in New Orleans. "Each service tends to think about their own specialty, especially the first responders: fire, police, and medical," says Rob Dudgeon, of the Department of Emergency Management. "But in a major disaster, you have to immediately start thinking about things like public works, sanitation, and reconstruction. It's much bigger than just putting the fires out."

While this nerve center is busy, the city has made sure not to overly centralize the decision-making process. Top-down command structures were seen as critical mistakes after both Katrina and the 1995 Kobe earthquake, in Japan. Given the unpredictable and quickly changing situation, the city has authorized a battalion of fire chiefs from ten emergency response districts across the city to make critical decisions for their territories. In effect, these chiefs become incident commanders for whole neighborhoods. Briefed at the EOC, it doesn't take long for the mayor to declare a state of emergency.

He gives orders to begin the process of requesting resources from FEMA, state emergency services, and the military.

As evening comes, thousands of families have to make a choice about where they are going to bed down for the night. People become seat-of-the-pants building engineers, trying to assess the damage to their homes. Will it withstand more aftershocks? Everyone has a strong desire to stay in their own homes, and most will look past the cracked plaster, broken windows, and fallen chimneys and spend a nervous night in their own beds. In the vast majority of cases, it's a good decision. The houses that made it through the first quake will for the most part not be brought down by the aftershocks.

But you and your wife, with your home now engulfed in flames, are part of a quarter-million people across the region who cannot or will not stay in their homes. Some find shelter with friends or neighbors or at the few relatively undamaged hotels, but tens of thousands have no place to bed down. Even though you've witnessed firsthand the remarkable courage of strangers, you still worry that at any moment there will be a breakdown of social codes of behavior. Watching CNN coverage of other disasters, you remember television reports of wild-eyed looters. With such a collapse of the physical structure of a city, how long will it take for social constraints to become as vulnerable? What's to stop people from behaving badly?

Yet again, what you thought you knew about post-disaster human nature turns out to be mostly myth. Walking with your wife toward the Civic Center, where you've been told there will be accommodations for homeless like yourself, you come across a large three-acre vacant lot at the bottom of Portrero Hill where a few hundred people have set up a makeshift camp. Tentatively, you walk among the tents. Within a few minutes you have been offered a place to sleep and given some food and water. You didn't even have to ask.

In the immediate hours and days after a cataclysmic event, community spirit and cohesiveness tend to rise, not dissipate. "Researchers have found—at least in the first seventy-two hours after a disaster—that community resilience and unity, strengthening of social ties, self-help, heightened initiative, altruism and prosocial behavior more often prevail," says Erik Auf der Heide. "In short, when things are at their worst, disaster-stricken communities tend to rise to the occasion."

The author Jack London noticed this back in 1906—the strange calm and pervasive feeling of community spirit after the first Big One. "Remarkable as it may seem," he wrote, "Wednesday night while the whole city crashed and roared into ruin, was a quiet night. There were no crowds. There was no shouting and yelling. There was no hysteria, no disorder . . . I saw not one woman who wept, not

one man who was excited, not one person who was in the slightest degree panic stricken . . . Never, in all San Francisco's history, were her people so kind and courteous as on this night of terror."

Interestingly, not all groups of people react in the same way. One's culture—in particular, the shared beliefs about the human self—matter a great deal. Social scientists have studied, for instance, the fascinating difference between how the Japanese react to earthquakes and how Californians do. Californians are among the most optimistic of overly optimistic Americans. This optimism, combined with belief in an internally motivated independent self (not to mention a willingness to question or buck authority), makes them a proactive population in the wake of disasters. The Japanese, who are more fatalistic and deferential to authority, are somewhat less likely to independently assist with rescues or provide assistance to strangers without specific instructions from on high. The Japanese are not necessarily selfish in this regard—they are tightly bonded and remarkably giving to their families and smaller social groups—but they are more apt to believe that people they don't know are someone else's responsibility.

Subcultures matter also. San Francisco is a patchwork of strong immigrant communities, with nearly 50 percent of residents speaking a primary language other than English. Bound together by religion, language, and neighborhood, these first- and second-generation immigrant pockets treat one another with remarkable generosity and goodwill.

As you eat your dinner of stew and bread with other survivors on the evening of the quake, you discover that you belong to a subculture of your own. At first it's hard to define, just a gut feeling. There is something familiar about the vibe of your encampment that you can't quite put your finger on. Across the empty lot, most people are putting up small camping tents, but others are constructing larger shade structures and rolling out carpet. People are cooking food in large vats and inviting others to eat with them. Someone has started a generator. Using the electricity, someone else has strung a long series of Christmas lights from tent to tent. Another person has hooked up powerful speakers and is blasting news reports from an AM station. It feels weirdly as though everyone here was prepared for this sort of event, as if they had all done this before.

Standing and looking out at the growing sea of tents, your wife finally makes the connection. "My God," she says, "it's like Burning Man."

Burning Man, the desert bacchanalia in Nevada, draws most of its participants from the Bay Area and in particular from hipster neighborhoods like the Mission and Portrero Hill. Thanks to this now twenty-five-year-old annual event, thousands of San Franciscans have had the experience of going out into the desert for multiple days and surviving without access to stores, running water, or telephone communication. The building of Black Rock City, the name given to the community that rises from the

sand over the course of several weeks and then vanishes, requires a willingness not only to suffer the punishing climate but to be prepared to meet your own needs and to assist others.

Out of garages and storage units all over the city has come the stored Burning Man equipment gathered for do-it-yourself survival. Out come the large tents, sleeping bags, first aid kits, five-gallon buckets for makeshift toilets, walkie-talkies, dust masks, cooking stoves, headlamps, portable radios, rope, duct tape, fire extinguishers, sledgehammers, rope, rebar for staking things into the ground, parachute canopies, and plastic blue tarps by the acre.

Also evident is an ethos learned at Burning Man: *no spectators*. Everyone pitches in and helps. The effect of that spirit is hard to quantify, but you can feel it as you walk the encampment. These are people not only intent on surviving and protecting their own but also showing an openness about sharing. Through their actions they broadcast a moral duty. What was seen by the larger culture as a self-centered lark—a self-indulgent art festival in the desert—turns out to have been a remarkably effective training ground for a post-apocalypse San Francisco.

And it's not just the Burners who are coming together to make an effort to help. The disaster reveals San Francisco as a complicated quilt of connection and solidarity. People who have worked together on community gardens or volunteered on the same PTA board or organized a local neighborhood watch are now discovering that they've been storing what sociologist Robert Putnam calls "social capital." Through these unrelated activities, they have banked a measure of trust and a network of reciprocity that can now be put to critical use.

These networks, rich in social capital, are also formed at work. Companies like Google make a policy of encouraging employees to work 20 percent of their time on projects outside of their normal job descriptions. One of the benefits of this policy has an immediate impact during the crisis. In the hours after the earthquake, Google launches a California version of its Person Finder, already deployed after the earthquakes in Haiti and Japan. It's a simple interface, allowing people to share information about the status and whereabouts of others. It is also connected to Google's photo-sharing service, Picasa, so that photos—including snapshots of the lists of people who have signed in at shelters—can be accessed by anyone who has a Web connection. As cell phone service resumes in the coming days, the Person Finder will come to life.

8. The World Comes to San Francisco

The morning after the quake, the great convergence begins. The entire world's attention has turned to the Bay Area, and the region begins to feel the effects. The federal government activates FEMA resources from as far away as Utah. Handling the 11,012 dead bodies is no small task in itself. There is a critical shortage of body bags, staff to oversee the remains, and places to put the bodies. Among the aid requests sent to inland counties of California is one for more coroners.

On their own initiative, tens of thousands of individuals jump in their cars and begin to make their way to the Bay Area. Among this influx are local residents who happened to be away on business or vacation when the quake struck. They are anxious to get home to survey the damage and check on relatives and friends. More numerous are the curious, those who have an insatiable itch to be on the scene and part of the action. Mostly they hide their voyeuristic motives—even to themselves—by claiming that they are going to help the victims or to document the disaster. But while the Bay Area needs a great deal of assistance, especially from those with expertise in medical care and infrastructure repair, it most decidedly does not need additional volunteers. As with most disasters, the vast majority of the population is uninjured and more than willing to help their neighbors. Those who show up with only good intentions just add to the burden on already stretched local services.

Reporters and camera crews also descend on the region. All the stars of the major news outlets chopper in and begin to report more or less continuously in front of the most picturesquely damaged structures. Everywhere there are camera crews, photographers, and scribes looking for fresh angles. At the end of the first week, the last unrescued survivor, a fourteen-year-old girl, is miraculously pulled from the basement of a collapsed apartment building in SoMa. It is a search-and-rescue dog flown in from Montana that finds her. All the national media lead with the story. In many people's memories of the quake, these selfless animals have played a pivotal role in saving those trapped. The truth is that this is their single success. Rescue dogs get great press, but in actuality they rarely make a meaningful difference.

Reporters also dig for dirt. In front of national audiences, they repeat rumors about people panicking during the quake. Finally, a video crew scores some footage of people in the Inner Richmond prying open the door of a grocery store and taking food and supplies. The footage is repeated so often

that the nation gets the impression that San Francisco has reverted to its mythical Wild West days—a place without laws.

Also converging on the region are hundreds of self-proclaimed trauma counselors. They are all well-meaning and certain of the importance of their ministrations to the suffering population. Their mission is simple, as many of them explain at every chance they get: they are the mental health equivalent of emergency medical personnel. Unless they get to the scene and start treatment soon, the psychological damage to the region will be devastating and long-lasting. The consequences of PTSD, some even suggest, will be multi-generational.

It is clear that the psychological fallout from the event is significant. Thousands have lost spouses, children, best friends. The constant aftershocks—a dozen in the first two days alone—have kept everyone on edge. The pressure that the event places on the human psyche will lead to some inexplicable and inexcusable behavior. Repeating a scenario that occurred after 9/11, one woman, on the third day after the quake, will claim to have received a cell phone call from her son, trapped under a collapsed apartment building in the Sunset district. Rescuers are diverted to the scene, where they work frantically but find no one. Only days later does it come to light that the woman has no children.

To begin to treat the psychologically damaged, teams of trauma counselors set up tents near encampments of the homeless. They come in a breathtaking variety. There are psychotherapists, thought-field therapists, eye-movement-desensitization-and-reprocessing experts, trauma masseuses, even trauma acupuncturists. In addition, there are Christian counselors and Scientologists doing “touch assist.” They walk among the population with the air of doctors assessing the situation. To anyone who will listen, they encourage a visit to their treatment tent to receive counseling or bodywork. Soon, bad feelings break out between camps of counselors. Those who were first to set up at a location try to lay claim to a population of survivors.

Along with the counselors, there are PTSD researchers who have seen an easy opportunity to advance the science of understanding trauma by surveying, testing, and otherwise monitoring the population of the Bay Area. A chance to study such a large population of Americans under duress presents itself only rarely in the active life of PTSD researchers, and the event becomes something of a research gold rush.

Earthquakes begin in the world of physics, but their longest-lasting effect is certainly in the minds of the survivors. The meaning each individual brings to the event matters a great deal to the experience. For those who have studied psychological trauma in depth know something that most people don't: What your particular culture believes about how one will react shapes the reality of that reaction. Put another way, the meaning that we collectively bring to these events matters.

Looked at over the long sweep of history and across cultures, the psychological reactions to trauma are varied. Those suffering psychologically after the 1906 quake likely would not have recognized the symptoms on the PTSD assessment list. They lived in a time when trauma was viewed in purely physical terms. Chest pains and neurological tics and muscle spasms were accepted as unavoidable consequences of stress—as was the case with “shell-shocked” soldiers from the First World War. This is not a matter of that generation’s being psychologically unsophisticated; physical symptoms were merely the known language of suffering for that time and culture.

When it comes to one’s reaction to horrible events, context is crucial. As the influx of trauma counselors to post-quake San Francisco suggests, you now live in a time that has largely lost the belief in human resiliency. “In a momentous shift, contemporary Western culture now emphasizes not resilience but vulnerability,” says Derek Summerfield, a psychiatrist who lectures at King’s College, in London. “We’ve invited people to see a widening range of experiences as liable to make them ill.”

Central to that assumption of vulnerability is the diagnosis of post-traumatic stress disorder. The inevitability of PTSD development if psychological trauma was not treated quickly became common wisdom in the years after the Loma Prieta quake of 1989. PTSD researchers and trauma counselors flattered themselves with the idea that they were the first brave souls to face the true aftereffects of psychological trauma. As one leading researcher put it in her history of the movement, they had fought nefarious forces intent on “denying the profound and long-term effects of trauma.” Admitted to the official lexicon in the mid-eighties, PTSD had quickly become conventional wisdom.

“PTSD is a normal reaction to an abnormal event,” trauma counselors tell survivors of the quake. But hidden within the various types of ministrations are elements of indoctrination. Counselors “educate” their patients about which symptoms they should expect to experience. Those who claim to be doing fine are treated with suspicion.

In the days after the quake, you feel a deep unease. At first it’s hard to describe—a free-floating disquiet. You’re finding it hard to sit still. You relive in your mind your behavior on the morning of the quake and wonder whether you could have done better. Word from the hospital is that Mike will survive, but without most of his left leg. The image of your injured friend is hard to shake from your thoughts. There is another thing that you don’t admit even to your wife: You miss the excitement of those hours after the quake, when every action and decision was so meaningful. Now your life is filled with so much waiting and thinking.

Finally, you decide to confide your feelings to a volunteer counselor. You go to one of the aid tents and wait in line. Then, for an hour you sit in a group session led by a young woman who identifies herself as a “critical-incident debriefer.” She lists the symptoms of PTSD—the

hypervigilance, flashbacks, mood swings—that survivors commonly experience. Then she asks the ten people in the tent to retell their stories of the quake. She prods for emotional details. Like you, almost everyone finds themselves crying at the retelling. This is the point, she says, to emotionally re-experience the event.

Much later, you will identify this meeting as the start of your personal downturn. It's only after years of therapy that you look into the studies surrounding the application of critical-incident debriefing. What you find infuriates you. Study after study shows that these sorts of early psychological interventions either are ineffective or actually cause people to do worse over time. One study followed several hundred car accident victims over a three-year period. At random, some were given early trauma debriefings, while others were given no psychological treatment. At the end of three years, interviews showed that the people who had been given the early psychological counseling were more anxious and depressed than the other study subjects, and more fearful of riding in cars. A study with burn victims showed similar negative trends. You wonder how these critical-incident debriefers were allowed to practice their pseudo-science on such a vulnerable population.

9. Anatomy of a Super Cat

For a few weeks, the whole region runs on the adrenaline of the event, but then things get tough. You can live without a houseful of creature comforts for a while—it's invigorating, actually, like camping. But, as with camping, the physical discomforts begin to weigh on you after only a few days. Crapping into a bucket loses its novelty immediately. Finding a way to dispose of that waste is no fun, either. At least no one goes hungry. There are plenty of calories to go around: FEMA and the National Guard hand out MREs. You've heard so much about these military meals in war stories that you actually look forward to trying them. You spit out the first bite of some god-awful concoction carrying the label "Cheese Omelet."

The populations of the fifty-five makeshift homeless shelters all across the city decline a bit in the first few days after the quake as people find couches of friends to crash on or make their way out of town on ferries running across the bay. But those who leave the shelters are soon replaced by people who find they can no longer live in their homes without working sewers, water, or gas. The social fabric of the shelters become frayed. On the third night, in a shelter at the Civic Center, near City Hall, there is a stabbing when someone is caught stealing a cell phone. It's the sort of story the media has been waiting for, and the incident is instantly reported in the national news and on the Internet.

By the third week, community spirit flags as the population begins to understand how long it will be until their lives return to anything approaching normal. The tallies come in from building inspectors across the Bay Area. The numbers are breathtaking. More than 100,000 residential buildings have been destroyed or damaged to the point that they are not safe to enter. Nearly 10,000 commercial structures are similarly useless. Almost two hundred hospital buildings are damaged or destroyed. In San Francisco itself, fully two-thirds of the buildings have sustained significant damage—23,000 of which are not safe to occupy. Nearly 4,000 will have to be completely demolished. The total estimate of this damage nears \$50 billion.

That \$50 billion is just the beginning of the cost of this quake. Certain disasters are of such magnitude that they have what specialists in business call "cascading consequences." Over a period of years, the cost of those consequences often proves to be greater than the initial damage. Such disasters, it is said, give rise to a "nonlinear loss amplification." The researchers at Risk Management Solutions,

which provides disaster analytics for insurers, have a name for such an event. They call it a “super cat,” short for “super catastrophe.”

Of course, every significant disaster has some post-disaster costs. If a store is damaged, the losses to that business continue until it can reopen. People waiting for their homes to be repaired have to lay out money to live elsewhere in the meantime. The cost in these cases is simply the sum of all these specific, individual expenses.

To calculate the damage from a super catastrophe, you can’t simply total up the losses to the buildings, infrastructure, and the like and call it a day. “As catastrophes increase in magnitude, some of the simple assumptions of independent loss generation start to break down,” says the Risk Management Solutions literature. Businesses are so interconnected to the local infrastructure and with one another that they have a difficult time restarting without the other components up and running. Even if the electricity is on, you can’t get back to work in a building without water. Roads and commuter pathways have to be fixed before you can even get employees to the building. Work is slowed by equipment and material shortages and a limited skilled labor market. The longer the delay, the greater the cost to the local economy in lost earnings and wages. Damaged buildings will quickly deteriorate as they await attention. When the first significant rain comes, a month after the quake, thousands of roofs let the water in, spiking the cost of future repairs, including mold removal. Most of the major highways, built as they were over bay fill and wetlands, require major retrofits and repaving. A few will be open in weeks, some will take months.

With the dock and cargo facilities in Oakland damaged, container ships headed to the United States are redirected north to Seattle and south to L.A. The eastern span of the Bay Bridge is deemed beyond repair. The region will have to await the opening of the new span, already under construction but years away from opening. Even the restaurants and businesses that get back on their feet find that they have few customers. Tourists book their vacations elsewhere. Negative feedback loops begin to emerge. As delays lead to more delays, businesses run out of money to stay afloat. More people find themselves out of work, with increasing consequences for the local economy. The Bureau of Labor Statistics estimates that the quake has cost workers more than \$9 billion in lost wages in just the first quarter after the event and a loss of more than 700,000 jobs. The engine of the local economy begins to sputter and threatens to stall.

San Francisco’s economy in 1906 relied on skilled craftsmen and the natural resources of the region. Modern San Francisco, by contrast, is dependent on something much more ethereal and transplantable. The Bay Area’s economy is driven by the so-called creative class—scientists, engineers, researchers, computer programmers, artists, designers, and media workers. So many jobs in the region

can be done elsewhere—in Denver, say, or North Carolina. Startup money in the tech sector begins to flow to other regions of the country. As a result, there is a brain drain on the community.

Thankfully, one of the reasons that the Bay Area has a surfeit of the creative class is its local institutions, in particular Stanford and UC–Berkeley. Both schools were insured and relatively well prepared for the quake. After a semester pause, they are back in the business of drawing the best and brightest students and professors to the Bay Area. The brain drain will not last forever.

The majority of the damage to the long-term economic stability of the region turns out to be not in the business sector but in the private housing market. Remarkably, only 12 percent of Californians have earthquake insurance on their homes.

Adding to this problem is the fact that, even before the earthquake, many Bay Area homes were already significantly underwater, their values well below the mortgages owed. Even minor damage to these homes pushes the owners beyond the tipping point. A \$10,000 or \$20,000 repair to a roof or a plumbing system is simply money that they don't have. With home equity loans out of the question, houses all around the bay are abandoned as owners walk away from their mortgages. Another cascade of economic consequences begins: Every abandoned and blighted house brings down the value of the houses next door, which, in turn, increases the likelihood of more defaults. The growing blight seen in Bay Area cities like Milpitas, Richmond, and the flatlands of Oakland is not as significant in San Francisco proper, where banks find willing buyers betting that the city will eventually pull through.

You were one of the lucky few in a couple of ways. The biotech firm you worked for decided to stay put, and within three months you are back at work. You also had a mortgage deal that required you to purchase earthquake insurance. Within six months you are given the money to rebuild. It takes more than two years to get the house finished, and it has none of the charm of the old Victorian.

Your neighborhood is never the same. Some owners of apartment buildings are only too happy to demolish their damaged structures and rebuild. The rents they previously could charge had been held in place by what they felt were onerous rent control laws. Happily for them, the rules state that any rental building that is torn down and rebuilt can go at market rates. As a result, some owners engage in legal fights with the city's Department of Building Inspection, insisting that their buildings are damaged beyond repair.

Adding to this problem, landlords are often painfully slow to repair rental property. They have little incentive, knowing that they'll receive only the previous rent-stabilized payments for doing so. This was the case after Loma Prieta. Fully 90 percent of the multifamily buildings uninhabitable after the quake were still vacant a year later. The more affordable the housing, the longer it takes to be repaired. Hundreds of owners of apartment buildings that have to be demolished elect to rebuild not

rental units but condominiums and lofts. While in other times these landlords would have had to submit to the city's condominium conversion lottery, the ordinance doesn't apply to empty lots. The net effect is that San Francisco loses thousands of units of its low- and middle-income housing.

The city never looks the same. In 1906, San Francisco had the good fortune of being leveled during a time when much of the population were still craftsmen. Victorian and Edwardian houses—with their bay windows, wood floors, cornices, and built-in cabinetry—sprang up even in working-class neighborhoods. After the conflagration in your Mission neighborhood, that charm was wiped away and was too costly to replicate. The buildings that go up in place of those old Victorians are much more efficient, and certainly much sturdier, but they have no sense of being made by hand. Their components are modular, built somewhere else and assembled on-site. These new lofts and condominiums have all the heart and charm of Lego structures.

Two and a half years after the disaster, you glance out the window and recognize the man standing across the street, looking at your house. He's not wearing the flannel shirt that came to symbolize him in your mind. You go out and shake his hand. You never got to properly thank him for the day he helped save your friend's life. He tells you that after the quake he retrained as a fireman and now works with a small department in a Central Valley town. "It was tough afterwards," he admits. "That day was so intense, it made everything else in my life seem kind of pale for a long time after."

You sit down on the sidewalk, right where you had piled the tools that day, and talk about the experience. Then you sit in silence, looking at your new house but seeing in your mind's eye your old doomed Victorian leaning over the street. "I have a question," you say finally. "What is your name?"