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The Richter scale of magnitude, developed in 1935 by Charles Richter and Beno Gutenberg of the California Institute of Technology and used to measure the power contained in earthquakes, references only itself; if it were human, we might call it narcissistic. We might also call Mr. Richter narcissistic, since this jointly developed scale was known by only his name, and it was not until after Gutenberg's death that Richter began to insist on sharing the credit.

The Richter (and Gutenberg) scale uses a seismograph to record the actual motion of the earth during an earthquake, taking into account the distance from the epicenter, to provide an absolute measure of an earthquake's intensity. It is a logarithmic scale; so a magnitude 6 earthquake—like the one that hit the Canterbury region of New Zealand on February 22, 2011, and destroyed the historic cathedral in downtown Christchurch, causing $30 billion in damage and killing 185 people—is ten times stronger than the magnitude 5 tremor that struck that area ten months later on December 23, 2011. That 6 is one hundred times stronger than a 4, which is roughly equivalent in force to the explosion that occurred in reactor #4 at Chernobyl in 1986, a global event I don't remember because I was only four years old, and one thousand times stronger than the magnitude 3 aftershock from the second Christchurch earthquake, which I felt while in that city on December 31, 2011.

It was my husband's first time in New Zealand, or anywhere outside of the United States, and we'd planned to finish our trip in Christchurch before flying home on New Year's Day. We'd heard about the magnitude 5 quake, but only through vague small talk we'd made with other travelers, and the extent of the destruction we found in the city was surprising.

The earthquake had been only a 5. It should have caused ten times *less* damage than the 6 had earlier that year. I had hoped to see the remains of the 132-year-old Anglican cathedral, severely damaged in February and finally toppled in December, but through the mesh of chain link surrounding the downtown perimeter, I could see only the empty skyline that had once held the church's landmark steeple.

Optimistic shop owners and determinedly cheerful residents mingled with the tourists in the temporary shopping district that had been hastily constructed out of storage containers, adjacent to the fenced-off ruins. The annual Christchurch Busker's Festival was attempting to go on as planned, and the makeshift town square was full of piano-playing children, jugglers, and slow-moving bodies painted to look like stone. We sat in our small rental car with the windows down, watching and listening, trying to decide where to go next. The 3 aftershock felt like someone was jumping up and down on the vehicle bumper and made the nearby unicycle-riding, mulleted street performer fall from his perch, midjuggle. He joked about experiencing a similar thing in a pub the night before, the crowd laughed, and we stopped poring over a city map for long enough to wonder what a force ten times that magnitude would have done to his act.

The term *magnitude* is another share of the legacy Mr. Richter left to the science of seismology. The word was traditionally used in the field of astronomy, of which Mr. Richter was a longtime enthusiast, to measure the relative brightness of a star. At the discretion of the Greek Hipparchus and the Alexandrian Ptolemy, stars were classified by their brightness, which at that time was thought to be the result merely of their distance from the earth. Under this assumption, stars were grouped into six realms of magnitude and referred to as stars of the first magnitude, second magnitude, and so on. Over time, as science progressed and telescopes were invented and improved upon, astronomers allowed the luminosity, or the electromagnetic energy emitted by a star, to factor into their calculations.

Richter (and Gutenberg) developed the scale initially to compare the size of different earthquakes. It was Gutenberg who suggested that it be a logarithmic scale; had the scale been linear, its units of measurement would have been far too small and far too numerous for common use. Perhaps we would have ranked earthquakes on a scale of 1 to

1,000,000,000. Of this decision, Mr. Richter said famously, "I was lucky because logarithmic plots are a device of the devil." I'm unsure what he meant in saying this. A mathematician friend of mine tells me that logarithms are deceptively simple and can create the feeling of getting something for nothing; the calculations are too complicated, but the solution too easy. This friend always uses a slide ruler or computer to calculate logarithms, rather than attempting to do so in his head, and says this is common among mathematicians. Perhaps the use of this scale felt a bit like a deal with the devil for Mr. Richter. Perhaps he hated being dependent on anything external to make these calculations. He was also a nudist, which is perhaps another story.

And perhaps he was less narcissistic than he initially appears. Our understanding of any one item on a scale, logarithmic or linear, is dependent on our understanding of what ranks below or above it; nothing can stand alone. I had never felt an earthquake before the magnitude 3 aftershock I felt in Christchurch, and I knew that it was a 3 only because my husband's guess, influenced by two years of living in the tectonic hotbed of California, was confirmed by news reports. The magnitude 5 quake that altered Christmas for so many Kiwis that year was bad. But it wasn't nearly as bad as what they had experienced ten months prior, and for that, many of them expressed a shaken and profound gratitude. But all of this is most certainly more complicated than my limited understanding has allowed it to be. How can impacts, magnitudes, challenges be categorized into such neat logarithmic rankings?

Additional scales have been designed to measure various aspects of earthquakes, such as the amplitude or size of the waves or the amount of damage done, and the majority of seismologists no longer use the actual Richter scale. However, the idea of the Richter scale has been too firmly ingrained in the minds of the general public to abandon it now. Most scales currently in use have been designed to produce results that are numerically similar to those of the Richter scale, making those results easily understood. The same earthquake may receive a ranking of 5 from three different scales, but for very different reasons. But those reasons often don't seem important if mainstream news reports can tell the general public that one earthquake received the same ranking as another one.

With similar ambiguity, the size and difficulty of whitewater on rivers throughout the world are measured on a linear scale of I–VI, with pluses and minuses thrown in for added flexibility. If there is a steady current and minor disturbances in the surface of the water, that section of the river will rank a I, while a VI ranking is given to rapids or sections of river that are considered unrunnable by anything but driftwood; these rapids are long, huge, fast, extremely technical, and seldom paddled. The VI ranking is a strangely protected entity among river runners; if more than just a lucky few people are able to safely get through a Class VI section of river, that section's ranking is dropped to a V. Many rapids or sections of river are assigned a ranking spectrum, depending on their offerings at varying water levels. Lava Falls, one of the big names in North American whitewater and one of the most difficult rapids to maneuver on the Colorado River through the Grand Canyon, is given a spectrum of IV–V on the international scale, depending on the daily fluctuation of water released from the upstream Glen Canyon Dam.

The first time I rowed a boat through Lava Falls, I was twenty-three and on an eighteen-day private river trip through the Grand Canyon. Our group had camped less than a mile upstream from Lava, knowing that the water would be lower in the morning and the rapid would consequently be less technical: more IV than V. Early the next morning we floated slowly downstream, listening to the roar of the rapid grow louder, and pulled over to hike down and scout the rapid. What I saw made my stomach heave. The water poured over a ledge that occupied most of the middle of the river, creating the infamous "ledge hole" just below, an enormous sucking hydraulic of water surging upstream and over itself, big enough to hold and crush an eighteen-foot raft, stripping it bare of frame, oars, and passengers. The runs on either side of the ledge hole were rock-strewn channels that fed into enormous lateral waves downstream. Surely, we had miscalculated our timing; this rapid, at this water level at this time of day, was a V . . . or possibly a VI. I stared at it for as long as I could stand, knowing that I'd have to row through it, then walked back to my boat on shaking legs.

I've seen video footage from this trip since then, and at this point in the recording, as I approach the brink of Lava's substantial elevation drop, I take several backstrokes with my oars before I sweep down into the rapid; I don't remember doing this, but it looks as though I'm making one final and hopeless effort to avoid doing what I'm about to do. And perhaps I was. The run itself was not the most perfectly executed that the rapid had ever seen, but I managed to keep the boat upright and pull into a downstream eddy and gradually stop shaking. Months later, a friend who had rowed Lava Falls several times watched the video of our trip and commented on how lucky we'd been to have seen the rapid at such a forgiving level.

"It was probably only about a IV-minus," he said casually.

I felt slightly stung by the dismissal of my accomplishment, however imperfect it had been. Of course, I will never know exactly what that rapid was ranked that day, because the answer will always depend on other factors. Rapid ranking is done by the elusive and powerful "they" made up of river runners, mapmakers, writers, and departments of tourism because there is no governing body in the river-running world. The system is subjective, inconsistent, and often ego-based. The link connecting the general public to these whitewater rivers is most often a paid commercial river guide, a breed prone to exaggeration and insecurity. Picture a group of guys in their early twenties sitting around a campfire or their company warehouse, drinking and describing their exploits on the Colorado, the Salmon, or the Payette.

"Dude, it was like miles and miles of solid Class V."

In most cases, it was probably just a few miles of interspersed Class III+ or IV. But individuals seeking to prove themselves will almost always claim the upper end of the spectrum, and there's nothing official to say whether they are right or wrong in doing so. A rapid's ranking, at least in the course of casual conversation, is dependent on the previous experience of the person doing the ranking, and his or her desire to impress. And no one is impressed by a III these days.

On previous trips to New Zealand, I had seen Huka Falls, perhaps the most visited section of the mineral-laden, light blue Aratiatia River on the North Island. This waterfall is tall, but not staggeringly so; the most striking feature is the enormous volume of water contained in this narrow channel, creating a cloud of mist substantial enough to dampen anything nearby. Even on sunny days, visitors wear rain jackets when they walk out to view the falls.

For years it was thought that these falls were too dangerous to kayak over and no one ever tried. Then in the early 1980s, a woman from the nearby town of Taupo threw herself over the protective railing at an upstream lookout and despondently propelled herself downstream and over the falls toward what she hoped would be the end of her life. Rather than being caught and held in the circulating hydraulic, she instead bobbed gently over the thousands of cubic feet of water that had been so feared for so long and emerged unscathed downstream from the waterfall. She swam to shore and—unwilling to abandon her fear of and confidence in the destructive power of the waterfall—walked back upstream and jumped over the guard rail again, only to experience the same thing. She went over the falls four times before giving up. I've heard this story each of the three times I've visited Huka Falls, in variations consistent enough that I don't question at least the basic truthfulness. I don't know if she later sought another method of ending her life or if she interpreted this failed attempt as an indication that she was meant to continue living; I hope for the latter but wonder—if that were the case—if her interpretation may have been challenged by the fact that Huka Falls has now been downgraded from a Class VI to a Class IV–V, depending on water level, and people kayak it often. One New Zealand whitewater webpage refers to it as a "fun outing" and claims that it is possible to maintain a dry face when kayaking over the falls. This is obviously an exaggeration in true Kiwi "No worries, mate!" fashion, but it illustrates the degree to which public perception of this waterfall has changed due to the evolving boldness of kayakers.

In a long conversation over lunch, in which I tried to understand the nuances of logarithms and my own thoughts, my mathematician friend tried to articulate my problem with the whitewater ranking system in his own terms.

"It's like redefining the length of a mile every time someone beats the existing running record."

And what if we did? What if, when the first precisely measured running tracks were built in England in the 1850s and Charles Westhall set the first world record in the one-mile run with a time of 4:28, the definition of a mile was adjusted to whatever distance Westhall could run in that length of time? What if his gait slowed as he aged? What if that British sense of nationalism, so prevalent in the mid-nineteenth century, had relaxed enough to acknowledge greater, though less official, speeds being run by individuals in South America or Africa? Would our mile now be something closer to the length of the modern kilometer? If so, it may have helped me better visualize the layout and dimensions of New Zealand when I first visited it as a naïve and unprepared nineteen-year-old.

Richter (and Gutenberg) devised their scale to replace the Mercalli scale, developed by and named after Father Giuseppe Mercalli, Italian priest and geologist, which ranked earthquakes on a scale of 1 to 12, based on the reactions of people and buildings. A collapsed building and panic in a crowd led to a high ranking, while levelheaded citizens and a moderate tremor in the floor earned very little attention. The difficulty, obviously, was the subjectivity: the severity of an earthquake may depend entirely on Mercalli's light fixtures—did he have stationary light bulbs or chandeliers capable of swinging? As construction methods became sounder, the strength of an earthquake decreased; as populations swelled, earthquakes in that area became stronger. I wonder if all science is destined to become amusing for the generations that follow.

There is a heated debate over plans for the Christchurch Cathedral. The city itself is changing as it rebuilds; what was once the most "English" city in New Zealand is becoming more artistic and relaxed, and leaders of the church would like to see the cathedral replaced with a contemporary new building, one safer, less expensive, and more in tune with the times. Countering this (and filing lawsuits to prove their point) is the Christchurch Buildings Trust, a group of American supporters and local activists who hope to restore all the significant buildings in the city, specifically the cathedral. Supported by artisans and craftsmen from around the world, the trust has offered to do pro-bono work to begin reconstruction. Meanwhile, the cordoned-off wreckage of the church sits untouched in the town square.

A short distance away lies a representation of another controversy, Christchurch's transitional "Cardboard Cathedral." This memorial church, built from nearly one hundred twenty-four-inch cardboard tubes coated with waterproof polyurethane on an A-frame of timber beams and structural steel, was dedicated in August 2013. The building was designed by Japanese architect Shigeru Ban, known for his temporary structures in the wake of natural disasters, who said, "The strength of the building has nothing to do with the strength of the material. Even concrete buildings can be destroyed by earthquakes very easily. But paper buildings cannot."[1] Kiwis were, and continue to be, divided over this church; many appreciate the swift answer to the loss of their cathedral and admire the innovation and modern design, while many are repelled by the idea of a temporary structure; a church, after all, is

1. Quoted in Matt Hickman, "Shigeru Ban's Cardboard Cathedral Opens after Ungodly Delay," *Mother Nature Network*, August 7, 2013, http://www.mnn.com/lifestyle/arts-culture/blogs/shigeru-bans-cardboard-cathedral-opens-after-ungodly-delay.

representative of the faith of its congregation, the rock upon which their devotion is founded.

But doesn't rock crumble and turn to sand eventually? Don't all of our estimations erode and change? A river will continue to run its course through a rocky rapid, despite the numerical ranking we assign to it, and an earthquake of high magnitude will still crumble a church, no matter what it's made of. I can't help but feel that a temporary church somehow makes a virtue out of acknowledging the unpredictability and impermanence of this world.

This essay by Elizabeth Knight received an honorable mention in the BYU Studies 2014 personal essay contest.