How I Became a Mathematician

by Steve Mitchell
September 2002

To Wendy

I'm a three-time college dropout. In fact, I don't even have an undergraduate degree. It's a long story, most of which has nothing to do with mathematics.

Child of the west

According to my birth certificate, I was born in Manhattan. Even my mother insists this improbable fact is true, and I suppose she would know. When I was six, however, we moved to the west coast, and I grew up mostly in Portland and San Diego. That would explain why the west has always seemed like home, and everything east of the Rocky Mountains like a foreign land.

My father graduated from Queens College and then from the music school at Harvard. His dream was to be a concert pianist; finding the competition too stiff, he switched to a career in electrical engineering. He continued to play, though, and I can remember falling asleep to the music of Bach, Chopin, Schubert and Beethoven cascading down the stairs into the basement bedroom my brother and I shared. My mother was an English literature major at Barnard College; in a more liberated age, she probably would have become a professional writer. One of the greatest gifts she gave to her four children was the power of imagination, imparted through her love of books, her love of writing, and the countless stories she read to us—from Farley Mowat's *The Dog Who Wouldn't Be* to *Alice Through the Looking Glass*.

My fondest memories are of our family camping trips: Mt. Lassen, Death Valley, Lake Edison, Joshua Tree National Monument, the Grand Canyon. Joshua Tree is a southern California desert studded with hundreds of enormous boulders. All children are natural climbers, and for my brother and me it was a paradise. We scrambled up rocks from dawn to dusk, sometimes getting stuck but always finding our own way down in the end. It must have been nerve-wracking for our mother. Her simple solution: "I just wouldn't look."

I have few memories of math from the first thirteen years of my life. My father had books with titles such as *Advanced Calculus* and *Differential Equations* lying around the house, but of course these meant nothing to me then. My grandest childhood ambition was to be a herpetologist. On my ninth birthday I was thrilled beyond measure to receive the beautiful volume *Living Reptiles of the World*, with its fascinating color plates of the Jeweled Lacerta, the Sudan Plated Lizard, the Black Mamba.

Belgium

The summer before eighth grade, we moved to Brussels for a year. My father spoke French, German and Italian fluently—in the war he deciphered German codes, near the Italian front—and he was determined that all four children would learn French, and learn

it well. To give us a head start, he first placed us in the International School, a British institution run with a firm hand by its stern Headmaster, Mr. Sedgwick. Jackets and ties were required for boys, and if Mr. Sedgwick caught you tie-less in the halls he would admonish you: "Young man—*where* is your necktie?" I suspect that my pathological aversion to ties dates to this period.

The math teacher, Mr. Reed, habitually tortured us at lunchtime. There was a free period afterward, and he knew that all the boys were chomping at the bit to get outside and play soccer. He would stand up and look around the room, open his mouth as though about to dismiss us, and then sit down with a self-satisfied smirk and go back to his newspaper. Nevertheless, it is to the sadistic Mr. Reed that I owe my first vivid memory of mathematics: We did old-fashioned ruler-and-compass constructions, following a tradition laid down by the Greeks over two millenia ago. I never again made any use of such constructions, even as a professional mathematician, but the combination of precise drawing and rigorous proof made quite an impression on me at the time.

We also took French, of course. To supplement our classes at the International School, my father hired a private tutor, Monsieur Classens. He was a kindly older man with a twinkle in his eye, and reminded me a little of Santa Claus. I enjoyed our sessions of French, math, and Flemish (the second official language of Belgium, very closely related to Dutch).

After about three months of this preparatory work, we were moved into the Belgian schools. Mine was for boys only, and had the imposing name Athenée Royale d'Etterbeek. I was the only American there, which made me something of a celebrity. "America," the other boys would say to me, "Les cowboys! Les gangstérs!"

Corporal punishment at the Athenée took a form I had never seen back home. In the U.S. of the early 60's, it was still commonplace for principals at all levels to keep a paddle or a rubber hose; to be "sent to the principal's office" entailed the threat—at least for boys—of getting whacked on the back of the legs a few times. But this punishment was reserved for serious infractions, such as fighting in class. In the Belgian schools, on the other hand, it was not uncommon for a teacher to slap a student for merely not knowing the answer to a question. My Flemish teacher was notorious for this; I can still picture him holding an unfortunate boy by the hair with one hand while slapping him in the face with the other: "Et bien, Philippe? C'est pour aujourd'hui, quoi?"

As an American I was immune from such treatment. In Flemish it wouldn't have mattered anyway, since—like my siblings—I quickly rose to the top of the class. Our Belgian classmates had ostensibly been studying the subject since kindergarten, as required by law, but they came from French-speaking families that looked down on "Les Flamands", and resented being forced to learn a language they associated with an inferior working class.

I don't remember a thing about my Belgian math class, except that it was easy.

High School

Measured in terms of the Beatles, my high school years ran from *Revolver* to *Sergeant Pepper* to the *White Album*. Those same years saw the assassinations of Martin Luther King and Robert Kennedy, and the riots at the Democratic National Convention in Chicago.

In tenth grade I wrote a history paper on the origins of the war in Vietnam—subliminally influenced by my parents, no doubt—and discovered that what we were hearing from our

government, and in the San Diego Union-Tribune, was very far removed from the truth. By eleventh grade several of us were refusing to stand for the pledge of allegiance, as a protest against the war. Ironically, my home period that year was math. Although the protest was sincere, I do regret putting my math teacher in a very awkward position. In twelfth grade we took to disrupting speeches by the likes of George Wallace, the racist governor of Alabama, and Max Rafferty, a bigoted reactionary who was then Superintendent of Public Education for the state of California. I have no regrets about that. We started an unauthorized school newspaper, *The Open Mind*, devoted to the war, civil rights, free speech and free love. When we were stopped from distributing it on campus, I went on television—for the first and only time in my life—to defend our actions.

Encountering calculus for the first time is like learning chess after a lifetime of checkers; it is much deeper conceptually, far more powerful, and infinitely more interesting than anything in mathematics that comes before it. We were fortunate that a superb community college teacher came to our school an hour each day to teach the subject. I found it fascinating. Our text was a slim paperback volume, bearing little resemblance to the back-breaking, thousand-page tomes that are the standard today. There were no glossy color photographs of ferris wheels and Olympic divers; I don't think it even *had* color, and didn't need it. On a tragic note, its author was Karel de Leeuw—the Stanford professor who, years later, was brutally murdered by one of his own graduate students.

In the fall of 1969, two months after the first moon landing, I set off to Stanford University to seek my fortune.

Stanford

Not that I had the slightest clue where my fortune would lie. I was interested in math, and good at it, but I was more interested in writing and philosophy. One day in tenth grade, idle curiosity prompted me to pick up Bertrand Russell's *History of Western Philosophy* from my father's bookshelf. Leafing through it, I was astonished at the questions considered by these strange people called philosophers. What is reality? Is there a God? My subsequent high school fascination with philosophy culminated in a pretentious senior term paper, thankfully now lost, in which I attempted to reduce all of metaphysics to a simple system of axioms. At Stanford, however, I gradually came to the conclusion that western philosophy could not, even in principle, answer any of life's Big Questions. It was naive, of course, ever to have expected that it could. In any case, this disappointment marked the end of my philosophical career.

A freshman seminar got me excited about neurochemistry for a while. Brain chemistry was a topical subject in 1969; the more powerful psychotropic drugs—mescaline, LSD, psilocybin—were still relatively new, having only become widely available in the mid-60's. Some used these hallucinogens as just another way to get high; others, rightly or wrongly, saw them as aids in a spiritual quest. In any case, it certainly added interest to the seminar, in which a dozen freshmen worked with a professor from the medical school on chemical transmission of nerve impulses across the synaptic gap (the tiny gap between adjacent nerve cells, in the brain or elsewhere). But as soon as I realized that a career in the field would involve experiments on animals, I abandoned it.

I dabbled in computer science, with the idea of writing a chess-playing program. Computers were as big as a small truck then. You had to punch Fortran code onto cards, using a special machine, and then deliver the stack of cards to the computing room for processing. It might be twenty-four hours before a printout was returned for debugging; then you went through the whole procedure again. My chess project was hopeless from the start, and never got off the ground.

That left mathematics. But I'll come back to the math later.

For a time during my first quarter at Stanford, the campus was rocked almost nightly by anti-war riots. Fifty or more riot police would be brought in from San Jose; lined up in battle formation, dressed in black with body-length plastic shields and long clubs, they were an intimidating sight to behold. I learned firsthand that tear gas is a very effective way to disperse a crowd.

In fact I was involved in the riots only as an observer, not a participant. My passionate opposition to the war notwithstanding, I could see neither the logic nor the moral basis for random destruction of university property. It disgusted me to see a legitimate protest corrupted by that greatest of all embarrassments to the human race: young men in packs. I mean the kind of mindless pack behaviour that is often fueled by alcohol or other drugs, and always by testosterone. I overheard the following exchange between two members of this miserable species, in this instance high school students from Palo Alto:

"Hey man, they're trashing windows over at the library!"

"Right on, man, let's go!"

During a lull in the confrontation one evening, several of us approached the police line and started a conversation. We discovered that the riot squad consisted mainly of young, part-time policemen, most of whom would rather have been anywhere else. One of them told us that he was working on a law degree at San Jose State; he was anxious to go home and study for an exam.

The peace march in San Francisco that year was an entirely different experience. Hundreds of thousands of people jammed the streets. Looking back from a hilltop, you could see a solid mass of humanity stretching to the horizon. Windows and balconies were packed with onlookers; some cheering, others watching in silence. There was no rioting or trashing of windows, at least not that I saw. Peace and love were in the air; and hope, and determination. For a day it seemed possible to change the world.

Inspite of all this political ferment and intellectual stimulation, by the spring of my sophomore year I was in the doldrums. I wasn't making any new friends at Stanford; worse, a relationship with a highschool girlfriend was breaking up after almost three years. I seemed to be spending more and more time alone in my dorm room, listening to melancholy Neil Young ballads and feeling sorry for myself.

Yosemite

A girl named Betty changed my life. It sounds over-dramatic, I know, but it's true. We worked together in the dorm cafeteria—bussing tables, serving chili burgers, scooping ice cream from five gallon tubs. One day she mentioned the Stanford Alpine club, and its upcoming spring trip to Yosemite. She asked me if I'd be interested in going.

Yosemite Valley is one of the most breathtakingly beautiful places in the world. It is also a rock-climbing mecca, with its towering granite walls such as El Capitan and Half Dome, and its innumerable shorter climbs on superb rock. The first climb on our agenda was Lower Cathedral Spire, a shaft of granite rising several hundred feet from the side of the valley. The trip leader asked if we had rappelling experience. Terrified that I might be excluded, I lied and said yes.

Our ascent of the spire was an adventure of mind-altering magnitude. The crux of the climb involves traversing off a flat ledge onto a vertical face with small holds and exhilirating exposure (a climber's term for steepness and height above the ground, in its psychological as well as physical aspect). Betty took one look at it, decided she couldn't do the traverse, and announced she was going to jump. Then she did, taking a smooth pendulum fall onto easier ground. Her boldness amazed me. I tried to do the moves, but slipped and went the same way as Betty. Rappelling from the summit, the exposure was phenomenal. We were using the old carabiner brake-bar system, and I had no clue what I was doing. "Say...I'm a little rusty on this; could you remind me how to set it up?" Luckily for me, our leader had all the beginners belayed on the rappels, whether they claimed experience or not.

From that day forward I was hooked. The exposure, the thrill, the incredibly satisfying feeling of moving on rock—I felt I had found my calling at last. At the end of spring term I dropped out of school, and spent the next four years hitchhiking around the west, climbing, working odd jobs, and occasionally—when the spirit moved me, and finances permitted—giving college another try.

On the road

It was the Golden Age of hitchhiking. Thousands of people were on the road, thumbs out, cardboard signs hopefully displayed: Boulder. Fairbanks. North. Anywhere! You could get a ride in five minutes at some locations—if you were lucky, that is, or female. I once read *Catcher in the Rye* in its entirety at a godforsaken crossroads in the Nevada desert, so desperate to get out in any direction that I would change corners whenever a car appeared on the horizon. The best bet was always a hippie van, painted in pyschedelic colors; the worst, an elderly couple in a Cadillac or Lincoln Continental. I developed a 10-point rating system—9 points for the hippie van, 6 for a beat-up pickup truck, zero for the Cadillac. Some combinations were so improbable that I gave them a negative rating—for example, a family on vacation in a Chrysler sedan, pulling a small trailer.

So I was astonished when, on another epic crossing of Nevada, I was picked up by a family on vacation in a Chrysler sedan, pulling a small trailer. Central casting at Disney studios could not have come up with a more wholesome, All-American cast of characters: Mom, Dad, four kids and the mother-in-law; only the family dog was missing. I was utterly amazed that a vacationing family from Kansas would stop for a long-haired, rather disreputable-looking climbing bum. The previous day I had spoken briefly with the father at a hamburger stand in Winnemucca, a hundred miles up the road. He was curious about my climbing gear, and where I was headed, and apologized for not offering me a ride—on the grounds that his car was already full, which it was. He later told me that when he saw me the next day in Elko, he was going to drive on by until the kids intervened: "Dad! Dad! Pick up the hippie!!" How all eight of us fit in that car is a mystery to me now; certainly attitudes about seatbelts

were more casual then. I rode with them for three days and six hundred miles, from Elko to Boulder, Colorado. I played games with the kids; we toured the Great Salt Lake and the Mormon Tabernacle; we camped at Dinosaur on the Utah-Colorado border. They were wonderful people, and I will never forget their generosity.

The dark side

Hitchhiking also had its dark side. As a rule of thumb, one should avoid accepting rides from ex-convicts. I inadvertently broke this rule twice, with unpleasant consequences.

On the first occasion it was a recent parolee from the Nevada State Penitentiary, in for burglary as I recall. He wanted five dollars for gas money, shop-lifted a box of cookies at the gas station, later threw the empty box out the window, and finally contrived to leave me stranded in the middle of the desert with no water. Oddly, it was the littering that shocked me the most. At any rate, when we pulled off the road to spend the night, I rolled out my sleeping bag far from his, and took the precaution of tying my pack to my wrist with a piece of thread. When he drove off abruptly at dawn, all he got was my five bucks. The worst part, however, was that I had foolishly neglected to stock up on water in Winnemucca, and the temperature would reach one hundred degrees by noon. A long and thirsty wait was averted only because a young couple moving to Massachusetts had chosen the same pullout for the night. After some hesitation they agreed to stuff me into the back of their station wagon, between a mattress and an end-table. They were only willing to take me to the next town—which was Elko, where I was picked up by that wonderful family from Kansas. So I guess things do happen for a reason; praise be to the Parole Board of Nevada!

On the second occasion I was hitching to Bellingham at a freeway entrance in Seattle. There was a certain strategy involved in hitch-hiking; for instance, there was no point in taking a ride to an exit just out of town, and even a ride half-way to your destination could backfire if it left you in Podunksville, where no one went for a drive except on alternate Sundays, and hippies were lumped in the same category with Communists and axe-murderers. (Near Shasta, California, a little girl on a bicycle asked me from a safe distance whether I had ever killed anyone; I was tempted to reply "not yet", but thought better of it and assured her that we long-haired folk were actually nice people, once you got to know us). So you'd ask: Where ya headin'? Bellingham? Far out! Having hit the jackpot, I didn't mind that the car was a rusting old hulk, badly in need of a new muffler. Nor did it seem to matter that the driver had just gotten out of jail that morning, a fact he volunteered with some pride as we entered the freeway. But I began to worry as he guzzled a six-pack of beer at an alarming rate, chased down with sips from a plain brown flask, all the while driving erratically at speeds up to ninety miles an hour. Even more terrifying was that at random intervals he would come to a complete stop in the fast lane. The third time this happened I checked quickly to see the road was clear, thanked him for the ride, and ran for the nearest offramp.

Riding the rails

I met Jay on a climb near Leavenworth, Washington, early in my transient period. He was a student at Washington State University at the time. He also was, and is, one of the

most generous people I have ever known. Jay and his girlfriend Pats more or less adopted me; I spent many a night on the living room couch of their basement apartment in Pullman, sometimes staying for weeks. We became close friends, and shared countless adventures on and off the rock.

It must have been Jay's idea to hop a freight train. One spring in Missoula, Montana, we volunteered to deliver a goat to some friends in Bellingham. Jay had a pick-up truck, but for reasons now forgotten it was parked in Pullman at the time. So the plan was to take the train to Spokane and then hitchhike to Pullman. We waited for the dead of night, then snuck into an empty boxcar with the goat. Minutes later, we realized to our horror that several men with flashlights were moving up the line, peering into every car. Having read too many depression-era stories about the railroad "bulls" beating up hobos, I was preparing for the worst when they reached our boxcar. They did a double-take:

"Is that a *goat*?"

"Yep."

Laughter.

"Well, if you guys want to get to Spokane, you better move up a few cars. We're cutting the last ten to a siding."

Travel by freight train leaves much to be desired. They are maddeningly slow, and an empty boxcar makes an ear-splitting racket. When we arrived in East Spokane, nearly deaf and with a severely traumatized goat in tow, we decided to take a city bus across town. The driver was reluctant to let us on until we pointed out that the sign on the door said "No Dogs". This seemed to satisfy him, and we soon arrived with our goat on the road to Pullman. We split up to improve the odds, flipping a coin to see who got the goat. I lost. In the farm country of Eastern Washington, though, my furry horned companion proved more an asset than a liability; we got a ride in surprisingly short order.

As far as I know, the goat lived out the rest of its life quietly on a farm near Bellingham.

Making a buck

Meanwhile, there was always the question of money; "Professional Hitchhiker" is not the most lucrative of occupations. I changed irrigation pipe in Missoula, Montana, tarred roofs in Richland, Washington, and was a night janitor at the Keyport Naval Base. Some jobs lasted for a few months; others for less than a week. Jay and I held out for only five days at the irrigation pipe job, which required moving twenty-foot sections of pipe in a field populated by hordes of mosquitos and a small herd of hostile bulls. It was about a hundred degrees in the shade, and we were getting paid by the pipe, which worked out to about one dollar an hour (minimum wage then being a buck sixty-five). Our boss lived in a fancy ranch house with a swimming pool and a lighted tennis court. I remember standing in the kitchen waiting for him to write out our measly paycheck, hungrily eyeing the package of whole-wheat fig bars on the counter. He ignored the hint. I've never forgiven him for that.

I taught rock-climbing in Bellingham for a while, where I acquired the nickname "Mad Dog" because it was said that I would snap and foam at the rope when beginners were slow to learn. This was utterly untrue, I can assure you, but the silly nickname stuck. I discovered that I enjoyed teaching: "Try putting your left foot on that sloping hold...good,

good...now pull off on the flake with your right hand—go for it...don't bail...you've got it!" Looking back, though, it is appalling to think that I was just twenty years old and had only been climbing myself for a year. The rock-climbing instruction was safe enough, at a small bouldering area near the college. But I had no business co-guiding a large party on the North Face of Mt. Shuksan. The man who hired me spent more time in the taverns than he did on the peaks, and I was barely more experienced than our clients. It's a wonder that nobody died.

When I was really broke, I would retreat to San Diego and my long-suffering parents, who, surprisingly, never disowned me. In fact I lived with my mother, my parents by then having divorced. While living at home I worked more conventional 8-to-5 jobs—material control clerk at an electronics company, department store warehouse worker—and learned two important lessons: First, when training for rockclimbing it is best to avoid a steady diet of vending-machine donuts. Second, the thrill of punching a time-clock wears off in about three days. There had to be a better way to make a living. It had to be more interesting than counting resistors, or unloading crates of underwear. It could not involve wearing a tie. But what?

Bellingham days

Mathematics was always near the top of the list, although I had no clear picture of what a career in the field would entail. At Stanford I had my first introduction to real mathematics, and was fascinated. For instance, I refused to believe my instructor's claim that the real numbers are uncountable, and engaged him in a heated argument on the point. Needless to say, I lost. Not long thereafter I learned how to rigorously construct the real numbers as Dedekind cuts. That was quite an eye-opener; it had never occurred to me that the real number system was in any need of construction. I took an independent study course on number theory with Paul Cohen, who won the Fields Medal in 1966 for his work on the Continuum Hypothesis. I had never heard of Cohen or the Fields Medal, however; to me he was just another math professor, an abrasive type given to interrupting with unhelpful remarks such as "You've completely missed the point!" Complex analysis baffled me at first, and I flunked the midterm badly. The subject can be described as "calculus in the complex number system", but this is misleading because surprising new phenomena appear (for example, the beautiful Cauchy residue theorem) that have no analogue in ordinary calculus over the reals. It was not until the night before the final exam that enlightenment dawned—slowly at first, and then in a flood of excitement as all became clear at last.

Thus when I enrolled at Western Washington State in Bellingham, chosen for its combination of nearby mountains and cheap tuition, it was only natural that I gravitated to math courses. The most interesting of these could have been titled "Discovery Method Hilbert Spaces". Taught by a very enthusiastic professor from Louisiana, it had only three students and no textbook. We had to prove the theorems ourselves—with hints, of course—and as a result didn't get very far, covering perhaps a fourth of what might be done in a conventional lecture. But so what? The most persistent myth of mathematics education is that what is covered is the same as what is learned. We didn't cover much, but we sure did learn.

Alas, my student career in Bellingham lasted only one quarter. Climbing beckoned, tuition funds were evaporating, and I still didn't know what I wanted to be when I grew up.

It didn't help that I discovered downhill skiing that winter. Lift tickets at Mt. Baker were six dollars (five-fifty for Thursday night-skiing at Grouse Mountain!), but that was still too much to maintain the habit for long. For a time I entertained the absurd idea that I could be a ski instructor in the winter, and rock-climbing instructor in the summer—absurd because I was, and still am, a thoroughly mediocre intermediate skier. So I gave up on skiing, but still had hopes for a career in rockclimbing. This too was unrealistic, for although I was a much better climber than skier, I was still nowhere near good enough to make a living at it. A friend who was more talented than I went on to become a professional climber and photographer, and has managed to eke out a living but not much more. My fifteen minutes of fame came about from climbing with him: I often ended up in the photos, and you can find me for example in "Fifty Classic Climbs", by Roper and Steck (look under Liberty Bell).

Taking a fall

A trip to Yosemite that summer ended in near disaster. Jay, our friend Bob and I were two hundred feet off the ground when a slab of rock the size of a large bed came loose, with me on it. I was climbing third at the time, and had almost reached the ledge where my companions were anchored. In theory, what should happen next is (a) rope stops falling climber immediately; (b) two-ton slab crashes to the ground, exploding into a hundred pieces; and therefore (c) the only danger is to anyone who happens to be at the base of the cliff below (no one was, thank God). But we were young and reckless, and we were using a very poor belaying technique. Bob somehow lost control of the rope, and I fell for its full length of 150 feet before the anchors stopped me. I don't blame him in the least. We were all using the same careless technique, and our roles could easily have been reversed.

My two friends had the worst of it. They suffered severe rope burns to their hands, and for a short time thought I was dead. For me it wasn't scary at all. I was knocked out at the beginning of the fall, and the next thing I remember is dimly regaining consciousness at the bottom, with no idea what had happened or where I was. Miraculously, I suffered only a concussion, multiple lacerations and a broken nose. Days later, I was disappointed to learn that the rescue team had included Bev Johnson, a Yosemite regular famous for her figure as well as her climbing ability. To be rescued by Bev must have been many a young male's fantasy, but in my barely conscious state, eyes encrusted with drying blood, I missed the experience completely.

A brave new world

Two years after Bellingham, I decided to try college a third time. I was back in San Diego, living at home and working at a Walker-Scott department store warehouse. My plan, if it could be called a plan, was to enroll at UC San Diego and take a few math courses.

On the road I'd been keeping a notebook that I titled "Lunatic Projects". During rainy spells in Yosemite I worked on a number of these lunatic projects: proving the 4-color conjecture (at that time still an open problem); proving the Jordan curve theorem from scratch; a study of Riemann versus Lebesgue integration. None of them got very far, but it was an amusing way to pass the time. At home, or anywhere that I had access to math books, I made occasional forays into algebra, analysis, and point-set topology. Along the

way I learned that studying mathematics on your own has two decisive advantages: You can proceed at your own pace, and you can follow your own interests.

So I felt that I was ready for graduate courses at UCSD, at least in analysis. The only obstacle was the usual one, namely money; I decided to learn the Fall quarter material on my own, while earning money to pay tuition for the Winter quarter. When things were slow at Walker-Scott, I would disappear into the cavernous depths of the warehouse, hide amidst the towering stacks of sheets and towels, and contemplate the mysteries of Borel measures and Banach spaces. In December I signed up for Real Analysis and a course in religion. But I needed one more class.

While perusing the stacks in the math library, I stumbled on a book entitled *Algebraic Topology*. It was incomprehensible, and yet strangely alluring. Its author used some mystical process to attach algebraic invariants to geometric objects—spheres, donuts and the like—which could then be used to distinguish topological types. I somehow managed to convince a reluctant professor to take me on as an independent study student. It is embarassing to recall my nervous answers to the on-the-spot algebra quiz he gave me:

Professor: How many homomorphisms are there from Z/2 to Z?
Me: Well...there's the zero homomorphism...
Professor: Are there any others?
Me: Uh..I can't think of any...

For those who aren't familiar with the algebra: It's not that my answers were wrong, but they were lame in the extreme. A comparable dialogue might go like this:

Professor: How many continents are there south of Patagonia?
Me: Well...there's Antarctica...
Professor: Are there any others?
Me: Uh..I can't think of any...

After this unpromising audition, I'm surprised that he was willing to work with me at all. But he agreed to give it a try.

Algebraic topology opened up for me a whole new universe. Mathematics was transformed overnight from a dead subject, in which everything interesting was finished a century ago, to a living, exciting, brave new world, limited only by the imagination and with vast tracts of wilderness waiting to be explored. At the time I already knew of a few unsolved problems in mathematics, but they were isolated curiosities such as Fermat's Last Theorem and the Goldbach conjecture. In topology I discovered that many of the most fundamental problems were wide open—the Poincaré conjecture, for example, and the baffling mystery of the homotopy groups of spheres. (Indeed the latter two problems are still open as of this writing; a solution to the Poincaré conjecture will win you not only a Fields medal but also a million dollars from the Clay Foundation. Good luck!)

I had the best of intentions to continue my studies Spring Quarter. Honest. But in March the postcards started arriving from the Northwest: We'll be in The Valley [i.e., Yosemite] this spring...Why don't you join us? The temptation proved too great; I dropped out for the third time. What my parents thought at this point I can only imagine, as they hardly said a word. That they should be nominated for sainthood is beyond dispute.

A half-baked scheme

With a treasured copy of C.R.F. Maunder's *Algebraic Topology* in my backpack, I wandered from Yosemite to Zion to Montana and finally to Priest Lake in the Idaho panhandle. In Montana I hooked up with Jay again, and we stayed with two friends, John and Donna, who lived in a boxcar that they bought at an auction for one dollar. John took perverse delight in frustrating home-insurance salesmen. What if your house burns down, they'd say. I'll just buy another one for a dollar, he'd reply. They never had a good answer to that.

This was the summer of our irrigation-pipe experiment, and we were always broke. At the nadir of our financial fortunes, we resorted to frequenting bingo halls that advertised free sandwiches. We should have known that "sandwich" meant two tiny triangles of Wonder Bread, glued together with a spam-like substance of indeterminate origin.

Finally, Jay got a job in Montana working for the railroad—all the live-long day, or so he claimed—while I ended up at his parents' small cabin in Priest Lake, where I spent most of the summer working odd jobs. The work was outdoors and would be called off when it rained. I loved those rainy days—sitting at the kitchen table of the tiny cabin, with Maunder close at hand and lightning striking over the lake, pondering the homology groups of the torus. I knew then that I wanted to be a mathematician.

The trouble was that I lacked a degree; according to my calculations it might take two years to meet the non-mathematical requirements. That was very discouraging. But a few months earlier, a possible way out had already occurred to me.

I was on a remote highway somewhere near Zion National Park, waiting for a ride and watching the clouds float by over the red sandstone cliffs. It was a glorious spring day, the kind of day when all the pent-up loneliness of the night dissipates into the beautiful blue vastness of the desert sky, when the mind is free to wander or dream or think of nothing at all, when one is happy just to be alive and it really doesn't matter whether the next car stops or not. Into this reverie one practical thought intruded: Why did I need a degree?

In recently rediscovered letters to my mother—reading them over 25 years later has been a strange experience, almost like going back in a time-machine—I put it like this:

> ...sometime last spring, an absurd, rather half-baked scheme suddenly emerged from somewhere in the vast and largely vacuous subterranean caverns of my brain—namely, to get into graduate school without a bachelor's degree.

I chose the University of Washington for my half-baked scheme because of the mountains, and because I knew there were several algebraic topologists on the faculty.

Well...that's not the whole truth. There was also a certain young woman named Wendy residing at Houseboat H, Lake Union, at that time a low-rent artists' district.

Houseboat H

Stepping off the dock onto the narrow outer deck of the houseboat, you could feel it move slightly in response. On a sunny summer morning the door would be open, with the voice of Joni Mitchell pouring out over the lake—*Ladies of the Canyon*, perhaps, or *Morning Morgantown*—and the tantalizing smell of fresh-baked bread wafting forth on the breeze. The house itself was a rectangular box about 20 feet by 12, consisting of a single room plus

the closet-like bathroom. Upon entering you would find the bed immediately past the door on the right. But you would probably first notice the loom, beautifully handcrafted from wood and about the size of a small upright piano. Foot pedals operated a set of metal frames that raised and lowered the appropriate warp threads—that is, the threads running vertically as seen from above—allowing a wooden shuttle trailing the weft, or horizontal, thread to be passed through. The rhythmic rise and fall of the frames, accompanied by the clickety-clack of the shuttle, could often be heard late into the night, seemingly in time with the gentle rocking of the boat.

There was just enough room to walk between the bed and the loom. Partly hidden in a small jungle of houseplants you would find the spinning wheel, where Wendy hand-spun the wool used in her weaving, and the warping board, a rotating wooden structure used to measure out the warp threads to their proper length. From these three tools an astonishing variety of art was created, at once beautiful and practical: wall hangings, decorative pillows, skirts, shirts, baby blankets... As a birthday present Wendy once made me a chess set, with its board woven from gray and white yarn, its pieces fired from sculpted clay.

Indonesian batiks provided a background for the warping board. A step or two past it, and you were in the kitchen. Or more precisely, at the kitchen counter, whose surface was a slab of some exotic wood brought back from Africa. A fresh loaf of elf-bread, made from a secret recipe handed down by hobbits, might be cooling on the counter. The dishes on the kitchen shelves—plates, bowls, mugs, wine goblets—were all original ceramics, many of them made by Wendy, others by amazing artist friends: Pats, and Jamie Wood and Greg Federighi. Beyond the shelves—but there was nothing beyond; you would have reached the end of the boat.

At the time of that Priest Lake summer, I'd already known Wendy as a friend for two years, through Jay and the Pullman connection. She was an art major at Washington State, specializing in ceramics and weaving. When I first met her, she was just back from a trip around the world with World Campus Afloat. It was typical of Wendy that she paid for this trip herself; she paid all her college expenses with no help from anyone, including her parents. In those days you'd usually find her wearing work boots, overalls and a flannel shirt, with a ceramic button affixed bearing the slogan "Not Insane". You probably wouldn't guess that she started off as a math major; she switched because, and I quote, "the math people were boring". When I wrote to Wendy from Priest Lake—hey, I'm coming to Seattle for a few days (hint, hint) to check out the graduate program at the UW—I was not surprised to get a reply inviting me to stay at her place. In fact, knowing Wendy, I would have been shocked at anything less.

What I didn't realize, however, was that the houseboat was so small. One thing led to another, and I stayed for two months. Later we would joke that it was a textbook case of love at three hundredth sight. The three hundredth time was the charm, however, and four years later we were married. But that's getting ahead of the story.

Getting in

"And you are...?" Professor Bob Warfield fixed me with his penetrating stare. I was sitting quietly in the back row in his graduate algebra class, not expecting to be noticed. I told him that I was thinking about graduate school and wanted to see what it was like at the UW. If that was all right with him, of course.

"Oh, so you're just spectator-sporting," he said, and went back to his lecture. Spectator sporting? Me? I felt mildly insulted. When I spoke with him later at his office, however, he encouraged me to apply. In fact, I was surprised and delighted to discover that no one in the math department seemed to put much stock in formalities. Ed Curtis, the senior resident topologist, put it this way: "If someone wants to study mathematics, I say more power to 'em. I don't care if you have a high school diploma." I made an appointment with an Associate Dean, who assured me—without making any promises—that it was theoretically possible to be admitted without a degree. It began to look like my dream was not so far-fetched after all.

A few months later, back in San Diego, I received an electrifying letter from Warfield. We can't offer you financial support, he began, because we don't know enough about you. But if you want to come anyway, "I will break the Dean's door down if necessary to get you admitted". If those words were calculated to inspire a young would-be mathematician, still uncertain of his abilities and his future, they certainly had the desired effect. I immediately redoubled my efforts to prepare for graduate school, embarking on an intensive study of Galois theory (one of the most beautiful subjects in mathematics), and forging ahead with my beloved fibre bundles (a topic from algebraic topology).

Shortly thereafter, I was admitted. Whether the Dean's door was still standing, I can't say.

Having a party

Graduate school was an adventure in its own right—the intellectual equivalent of climbing, if you will. This is not to say that the climbing was easy. I agonized as much as anyone over passing the preliminary exams, writing a thesis, and getting a job. But most of the time I simply reveled in the beauty of modern mathematics, with all of its mystery and endless surprise. Shortly after liberating myself from the tyranny of the prelims, I cornered Linda Ness (then an Assistant Professor at the UW) in the halls, and proceeded to bend her ears about all the exciting new realms I planned to explore. She looked at me and laughed. "You're just having a party!"

Thanks to Wendy's support, I was able to get through that first quarter without a Teaching Assistantship. The math department helped too, through an arrangement of questionable legality whereby I took three courses but only registered for one. If the Graduate School objects, one professor assured me, "we'll tell them to go jump." This remark evidently reflected some ongoing dispute. At about the same time, Warfield posted a note on a public bulletin board that began "Due to nonsensical regulations imposed by the otherwise useless Graduate School..." I felt right at home.

From the next quarter on I had a T.A. position, with one exception. In the summer after my first year, either there weren't enough teaching positions to go around, or they weren't

ready to trust me with my own class. In any event, I found myself once again in need of alternative employment.

It's funny the way fate works. If it hadn't been for my brief acquaintance with Betty, I might not have dropped out of Stanford to go climbing. If it wasn't for rockclimbing, I wouldn't have met Jay, and if it wasn't for Jay, I wouldn't have met Wendy. And if it wasn't for Wendy, I would never have met Chris and Jeff Gentes. I knew right away that they were special. After breakfast on the houseboat one Sunday morning, they listened attentively to my lecture on the importance of sorting dishes by topological type; clearly, this was a couple with exceptionally good taste. At the time Chris was a teacher at a Montessori school; I visited her class and came away very impressed with the Montessori method and its innovative math toys. Unfortunately, however, they had no openings for a topologist. Jeff later became a producer for KCTS, the local PBS station; his many credits include the stunning, aerially photographed "Over" series: *Over Washington*, *Over Ireland*, etc. But that summer he was in the same boat as me, and was working as a laborer building a condominium complex at Alki Beach. More victims were needed, and I signed up. We spent the rest of the summer hauling sheetrock and lumber, and moving refrigerators up four flights of stairs.

The men we worked with were an interesting breed. They were incapable of uttering a single sentence without including multiple obscenities, and if any comment or situation could be given a crude sexual interpretation, it was obligatory to do so. I will refrain from giving examples. Every woman under fifty who passed by was scrutinized and rated in the lewdest, most disgusting manner imaginable. Our boss, an ex-convict, called Jeff "college boy" and seemed to get his kicks from ordering us around. We survived only by keeping a sense of humor, pretending we were undercover anthropologists studying a tribe of degenerate savages.

At the midpoint of my graduate career, Wendy and I got married. No one could accuse us of having a traditional wedding. We wrote our own vows, did not exchange rings, and had neither minister nor even justice of the peace. A dear friend and fellow grad student, Fran Berman, presided over the ceremony. Afterwards, more than one person whispered to my mother, "Are they really married?" We were.

Wendy made all of our wedding clothes—everything but the shoes. She finished the wedding dress with less than an hour to spare, having spent much of the afternoon baking the bread to be served at the reception. Elf-bread, of course. Wine flowed freely from carafes made by Greg into cups made by Jamie; fittingly, these two wonderful friends and artists were engaged to be married that same summer. Chris and Jeff's first child, Katy, thoughtfully timed her birth so that she could attend the festivities, age three weeks. To have my far-flung family—Mom and Dad, Janet, Ken and Victoria—all assembled in one spot was nothing less than a miracle. Wendy was beautiful, radiant, perfect. It was, in my humble opinion, the greatest party of all time.

The great game

I continued to devour new mathematics at a frenetic pace. My heroes then included John Milnor, Michael Atiyah, Jean-Pierre Serre, Raoul Bott, Dennis Sullivan, Frank Adams and

Dan Quillen; no one outside of mathematics will have heard of them, even though by rights they should be household names. For a time I became obsessed with a famous, still unsolved problem in algebraic topology called the Kervaire invariant problem, even travelling to the east coast to consult several experts: Frank Peterson at M.I.T., Ed Brown at Brandeis, and Bill Browder at Princeton. It was thrilling to finally meet these legends of topology, whose papers I had been reading for years. Their kindness and hospitality will not be forgotten.

That was another thing that drew me into mathematics, and in particular into topology: the people. The shortage of women in the profession was disturbing, but that seems to be slowly improving. Later when I started going to conferences, I began to especially appreciate that no one cared how you dressed, or what kind of car you drove. There was a topologist from Oxford whose conference attire consisted of grey sweatpants and sweatshirt. There was a topologist from Scotland who wore only three-piece suits, even in the Swiss alps in the middle of summer. A topologist might have hair down to his waist, or he might be an ex-marine still sporting a regulation crewcut. If you wanted to wear a jacket and tie, that was fine. If you wanted to dress only in black, or in tie-dyed T-shirts left over from the sixties, that was fine too. All that mattered, apart from being a decent human being, was that you played the game—the great game, pure mathematics.

I played the game with wild-eyed enthusiasm, wandering all over the mathematical map and wanting to know everything. As a result I took rather a long time to finish my thesis. When Mt. St. Helens erupted in the spring of my fifth year, I took it as a sign that the gods of mathematics were displeased at my procrastination. As if to confirm their displeasure, my thesis advisor, Doug Ravenel, returned from England and told me bluntly, "I'm concerned that you don't have a marketable result." Doug was a fantastic advisor, and he went on to suggest: "Why don't you try to stably split the classifying space of Z/2 cross Z/2? Here's how I think it goes..." On the face of it this was a very narrow, specialized sort of problem, but—and this is a great tribute to Doug's intuition—in the long run it led to a whole series of completely unexpected connections with other problems in topology, beautiful connections that kept me busy for several years after graduation. In the short run, it led me to a very marketable result indeed.

In 1981 I finally received my first college degree, a Ph.D. And that, for whatever it's worth, is how I became a mathematician.

Epilogue

Wendy and I spent three years on the East Coast, first in Boston at M.I.T., where I had a two-year postdoctoral position and then in Princeton, where I had a National Science Foundation fellowship. Those years were productive in other ways too: Jessica Linnie Mitchell was born in Boston, in 1982. Abigail Mary Mitchell came into the world in Princeton, in 1984.

We returned to Seattle for the second year of my NSF fellowship. In the meantime, Wendy's career had taken an unexpected turn. Around the time we got married, Wendy applied for a temporary job at Boeing, just to pay the bills. To her surprise they offered her a job as a systems analyst; it turns out that Boeing had a policy of periodically throwing a few artists into the mix. In Wendy's case this unlikely sounding idea turned into a spectacular

success, and when we got back from the east coast Boeing practically begged Wendy to return to her old job. She's been a highly successful analyst and manager at Boeing ever since.

In a stroke of phenomenal good fortune, I was hired as a tenure-track assistant professor at the University of Washington. That was our first choice, and not just for mathematical reasons—for friends, for family, and of course for the mountains. I'm sure Bob Warfield played a key role in the hiring decision. I know for certain that as chairman he was the one who battled the Dean and the College Council to push through my early tenure. (In fact, my promotion with tenure was not that early by math department standards; but the college at large has a different culture, and sees things quite differently.)

Not long after that, Robert Warfield died of cancer. He was 49. It was a terrible personal blow to many, and a great loss to the department.

In 1985 I started climbing again after a six year hiatus, and was at a loss to explain why I had ever stopped. Over the next decade I did some of the best and most enjoyable climbing of my life, mostly on cliffs in the Pacific Northwest but also in Yosemite, England, and the spectacular Wind River Mountains of Wyoming. In more recent years various joints have been less cooperative, but I still climb a little. More often I'm hiking up in the high alpine regions, where snow-capped peaks soar into the azure sky, where sparkling waterfalls pour over polished white granite, where steep hillsides of dazzling green heather intertwine with riotous fields of flowers, and where, to mildly paraphrase John Muir, who in turn was paraphrasing a higher authority (*Job 38:6-7*):

> It is still the morning of Creation
> all the morning stars are singing together
> and all the children of God are shouting for joy!

Although Wendy stopped weaving long ago, her creative artistry has blossomed in new channels, notably dressmaking. As a rule, recital dresses are finished within thirty minutes of curtain time; with prom dresses and the like, I've often had to stall for a few minutes when the date knocks on the door. Her track record is amazing, though; she always finishes these stunning creations in the nick of time. Everyone wonders what's going to happen with the first wedding dress. But we'll cross that bridge when we get to it.

Our two beautiful little girls grew up into beautiful and talented young women. Jessie is a junior at the University of Washington, majoring in International Studies. Abby is just starting at the Indiana University School of Music, planning a career in opera. Don't even get me started bragging about my daughters. As any of my recent students could tell you, I'll go on and on and on.

As for mathematics, it's as much of a joy as ever. Someday, when you have a few spare years to kill, I'll tell you all about it.

In gratitude

There are so many people I would like to thank. Family, friends, teachers, mentors—what modest success I've had as a mathematician I owe to them. More importantly, what joy and fulfillment I've had in life I owe to the same wonderful people. I can't possibly mention everyone that I'd like to, and nothing that I can say will be adequate. But here goes. I want to express my heartfelt gratitude to:

My mother, for her constant love and support, for her creativity and imagination and for reading us all those stories, and for having the patience of a saint during my transient days;

My father, who introduced me to music, languages, mathematics and camping, and wouldn't allow a TV in the house;

My siblings, Janet, Kenneth and Victoria, for their friendship, support, and acceptance of my innumerable eccentricities, and for inspiring me in more ways than they know;

My brother-in-law Jerry, who is willing to be seen with me in public despite my C in Economics, and who taught me more about Archimedes than I ever learned from mathematicians;

Jan and Jerry and their children, Alex and Genny, who floated the middle fork of the Salmon river with us, and explored behind the waterfalls and into the deep underground lava tubes of Eastern Oregon;

My grandmother, Miriam Brennan, who sent me tuition money at a time when I surely didn't deserve it, although that only gives you a hint of this remarkable woman;

My Uncle Ken and Aunt Joan, who found me a job and so kindly gave me a place to stay in those critical few months before grad school.

Of the many teachers and mentors who have helped me along the way, I want to single out two:

Bob Warfield, who got me into graduate school, taught me abstract algebra, and supported my career in so many other ways;

and

Doug Ravenel, my thesis advisor, whose support, guidance, expertise and friendship have made all the difference.

Thanks also to all my fellow grad students and their significant others, especially *David and Pat*, *Fran*, and *Jane*;

And to all the students in my classes, who have made teaching always interesting, usually fun, and sometimes a joy.

No words are adequate to thank my cherished friends in the northwest; in those transient days, they truly transformed my life, more than they can ever know.

Jay–I can't say enough about Jay. Without him, I'd have missed some of the best times, and best friendship, of my life. Let's face it—without Jay, I'd probably still be homeless, unmarried and unemployed, peddling used theorems on a street corner in Bozeman;

Jamie and Greg, dearest friends, artists par excellence, parents extraordinaire of beautiful daughters Sophia and Diana;

Chris and Jeff, dearest friends and the parenting pioneers among us. It's been said that every math talk should include at least one proof, so here's mine: *Theorem:* Chris and Jeff have set a standard for parenting unsurpassed in the known world. *Proof:* Katy, Kerry, Conor. Q.E.D.!;

Greg and Vicki, who, although they may not know it, were my first real friends in the northwest. Their kindness, giving spirit, and love for each other set an example that has inspired me ever since—a spirit and love that shines brilliantly in their incredibly talented, wonderful daughter Jamie Ann;

Jeff Weismann and amazing daughters Rebecca and Mikayla, who shared with us the greatest vacation ever on the Rogue River;

Pats, who took me in to her home, and showed me how to lie in the sun like a lizard;

Julie, for just being her wonderful self.

And thanks to Jay's parents, Charlie and Louise, who generously loaned out their Priest Lake cabin to an unending procession of climbers, hippies and vagabonds;

to Jamie's parents, Jack and Kay, who never failed to welcome Jay and me when we turned up on their doorstep in Richland—always, by some inexplicable coincidence, precisely at dinner time;

to Wendy's parents, Viola and Gene—and especially Vi, for raising so remarkable a daughter.

Last, and most of all, I want to thank my wife Wendy. Without her love and support, I could never have made it as a mathematician. Without her love and support, my soul would be the poorer, my life incomplete. Friend, artist, wife, mother of our incredibly fabulously wonderful daughters, Abby and Jessie, I can't thank her enough. I've been so fortunate in life—and Wendy, the luckiest part of all was finding you.