Saunders Mac Lane

A MATHEMATICAL AUTOBIOGRAPHY

Saunders Mac Lane



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A Mathematical 🥭

🗢 Autobiography

Saunders Mac Lane University of Chicago, Emeritus



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Dreface

No man could so stimulate others unless, alongside an incisive intellect, he was possessed of enthusiasm and warmth, a deep interest in his fellow man, and a sympathy the more real for being unsentimental. Those who proudly call themselves his friends know these things: others will infer them in reading [his works].

—M. Kelly¹

Saunders Mac Lane has been my teacher, mentor, and model almost from the beginning of my mathematical life. It is a relationship I've cherished. He has been for me a figure of great honesty and integrity, who worked hard to advance research and to serve the mathematical community. His belief in the good, the right, and the rational, his care for the essence of mathematical ideas, his powerful enthusiasm, and his essential optimism were and are deeply attractive to me.

Nearly everything about Saunders in action was colorful, starting with the red-and-green plaid sports coat (the Mac Lane tartan, of course) and red pants that he would wear for important occasions. Perhaps a few anecdotes and reflections from my experience of him over 40 years will help the reader appreciate this color.

First Encounter

I first met Mac Lane—in a sense I'll make precise—in 1963. He was one of the most important figures in the University of Chicago

¹ From *Saunders Mac Lane: Selected Papers*, edited by I. Kaplansky, New York, Springer-Verlag, 1979.

Mathematics Department, or indeed in American mathematics: his first student, Irving Kaplansky, was Chair of the department, and two other students were on the faculty—one, John Thompson, a Fields Medalist. Mac Lane was an inventor of group cohomology, a founder of homological algebra and category theory, and known for the Eilenberg-Mac Lane spaces in topology. He was past President of the Mathematical Association of America, and he would soon be Vice President of the National Academy of Sciences, member of the Board governing the National Science Foundation, and President of the American Mathematical Society, as well.

I knew none of this. I was sixteen, an early entrant to the University, an uneven student with a great enthusiasm for mathematics. It was the beginning of my second quarter, and I was scheduled to start a basic linear algebra class that morning. I happened to arrive a little early, settled down in the first row of the class, and sank peacefully into a daydream. Being so new, I wasn't surprised not to know the other students who settled in around me, and I didn't know the teacher that I'd have. In due course, Mac Lane walked in and began lecturing. His style was lively and colorful, and I was immediately interested—but almost at once aware that I'd made a big mistake: this was not an undergraduate linear algebra course but an advanced graduate course on category theory. I'd come an hour early.

I understood nothing whatever after a few moments, but was far too embarrassed to get up and leave—instead I sank into daydreams, glassy-eyed. Mac Lane, who prided himself on paying attention to his class, later told me he thought that he could always see who was following and who was not. In a moment like a thunderclap, I looked up from my seat and found him pointing directly at me from across the room. "You!" he said peremptorily, "you don't believe this proof, do you?" Belief and disbelief were equally beyond me; I sat petrified. He advanced toward me, and I don't know what I imagined—that he would pick me up by the scruff of my neck and throw me from the room? He stopped, turned back to the board, and proceeded to explain the proof to satisfy me. Of course, I still understood nothing but I sat in rapt attention. Dreface

Fortunately the class ended soon, and as students asking questions surrounded him, it was easy for me to slip out. I didn't tell Saunders this story until many years afterwards, when I had the privilege of re-enacting it (from the other side) in a lecture at the conference in honor of his seventieth birthday. Needless to say, the event hadn't left a trace in his memory, though it remains sharp for me to this day.

Saunders and Iolerance

Saunders believes strongly in principles, in the rightness of right positions. I never once saw him personally intolerant, but he could sometimes be direct and candid to the point of offending. People whose judgment I respect have felt injured by what he said and sometimes by the bluntness of his expression. In some way perhaps he didn't appreciate the magnitude of his position in mathematics or the seriousness with which people took him. In a lesser personage some of his extreme positions might have been regarded as charming eccentricities. But given Saunders' stature, they could injure, and he might have been more cautious.

An event from late in Saunders' life may give a bit of the flavor. It was a special session run by him and Richard Askey at the Joint Mathematics Meeting in 1999, a session boldly entitled "Mathematics Education and Mistaken Philosophies of Mathematics." The audience was enormous. I found the title charming (and still find it so, even now as I become more involved with ideas in K-12 education), and I imagine that Saunders meant it to be controversial but playful. Predictably, it annoyed and needled some practitioners. Saunders began the session with introductory remarks that I found fascinating: he said that he now considered the extent of his own emphasis on category theory as a tool for learning and teaching mathematics to have been too extreme. This humbleness may have helped soften the critical tone of the session.

Saunders and Sammy

One of Saunders' great mathematical friendships and collaborations was with Samuel Eilenberg (widely known as Sammy, or even S²P²: "Smart Sammy the Polish Prodigy"). I got to see them in action

together only once, at the AMS Summer Research Institute on Category Theory at Bowdoin College, in 1969. They had special status at this three-week conference, not only as the senior members but also as the very founders of the subject. So, when they began discussing its origins one evening after dinner, everyone gathered around to listen.

I dearly wish I could recall the substance of their debate, but I don't; only my sense of the contrast in the two men's styles stays with me. Sammy drew Saunders out and egged him on, always slightly evasive and mocking; Saunders, whose father and grandfather were Congregational ministers, seemed to feel that since his view was right, his view would prevail. Once he had stated it, all he could do was bang his fist. The devious and sophisticated European versus the innocent but honest American? That's how it seemed to me at the time (maybe I was a little innocent myself). A loyal student, I was rooting from the beginning for Saunders' point of view, but I came away feeling that he was trounced in the contest.

Being Saunders' Student

After I flirted a while with operator theory (Paul Halmos and Felix Browder were my teachers) and group theory (learned from Jon Alperin and Otto Kegel), it was finally time for me, by now a secondyear graduate student, to settle on an area for a PhD thesis. I obsessed about how to make the choice. A close mathematical friend, Joe Neisendorfer, explained to me an algorithm: forget the topic, look around the faculty for the person you like the most. It didn't take me long to choose Saunders.

I wouldn't say I ever felt personal intimacy with Saunders, but he did go out of his way to make me and other students feel welcome in more than his office. Saunders and his late wife, Dorothy, had a small but comfortable cottage in the Indiana Dunes, a beautiful area on the shore of Lake Michigan about an hour south of Chicago, and they occasionally invited students to spend an afternoon there. Saunders was an enthusiastic sailor, and I can report, from a ride in a small sailboat on rough water, that he was ready to provide needed instruction not only in mathematics but also on how to handle the absence of a toilet—or any privacy—in that difficult situation.

If you look at the list of Saunders' 39 students, you'll see that Irving Kaplansky, who worked on valuation theory of fields, came first; I'm near the end, with a thesis on noncommutative rings. Along the way are such people as John Thompson (finite groups), Anil Nerode (logic and computation), and Robert Szczarba (algebraic topology). How did this variety come about?

Perhaps the answer lies in Saunders' hospitality to these many ideas. He wanted to learn finite groups and taught a course on them. By the end of the course, he'd decided that he'd never really understand the subject, but in Thompson he found a fabulously strong student. Saunders might have tried to turn such a student toward interests close to his own, but I think he would not, on principle: he was happy to encourage his students to do what excited them.

Saunders has followed an interesting, curving trajectory through mathematics, from logic and foundations to field theory and the beginnings of homological algebra, through topology to category theory, with smaller diversions along the way into Hamiltonian mechanics, finite groups, and many other subjects. Perhaps his students, or many of them, could be described as coming off of the tangents to this path, a kind of developable surface reaching broadly across mathematics. Altogether, Saunders has more than 1,000 mathematical descendents listed on the Mathematics Genealogy Project.²

Some other aspects of Saunders are also reflected in his students: Saunders was always active on behalf of the community, whether as Chair working to build the department at the University of Chicago or, near the end of his career, as member of the National Science Board or as manager of the elaborate system of reports for the National Academy of Sciences. Many of his students and grandstudents have followed him into this willingness for public service. When I was worrying about whether to move to my current position at MSRI, he was one of the first people I called on for advice and blessing, and he gave both.

² A service of the Department of Mathematics at North Dakota State University, available at http://www.genealogy.ams.org/.

Returning to the more fundamental matter of being Saunders' mathematical student: I tried for a while, dutifully, to find a thesis topic in category theory, Saunders' passion in that part of his life. But I failed; somehow, the things I read and learned in that domain just didn't inspire me. When I developed an interest instead in a problem on noncommutative rings posed by a visitor of Herstein, the young Chris Robson, Saunders could easily have washed his hands of the project. He did not: though it was far from his current area of interest, he welcomed what I had done, and painstakingly read draft after draft of my thesis.

Saunders' mode of instruction in thesis writing bears mention. I had written a couple of papers, jointly with Robson, of which my thesis results were partially an extract. Robson cared a lot about exposition, and so (learning from Saunders among others) did I. We'd gone through many drafts, and I thought the writing pretty polished. Saunders did not. He began at the beginning and worked his way through the thesis until he'd compiled a list of exactly 25 substantive suggestions. Then he stopped and returned the document to me for an overhaul. When I had finished making the corrections he'd flagged and all their analogues, I gave it back to him, eager to be done. But...after a week or so I got a second list of exactly 25 more suggestions. The third list was a bit shorter, and Saunders allowed the process to converge before I got too frustrated.

It must be clear by now: over these forty years I've learned many lessons from Saunders. I'm deeply grateful to him.

David Eisenbud, Berkeley, California

Acknowledgments

When Saunders Mac Lane asked me, a few years ago, if I would publish his autobiography, I was honored and very pleased because I knew that he has been witness to so many interesting, diverse, and important events of which he had been an astute and formative observer. I first met Saunders when I joined Springer Verlag as the first in-house mathematics editor in 1964 and he was an author and one of the editors of the series Grundlehren der Mathematischen Wissenschaften. Over the years I received much valuable advice and shared many stories with Saunders, but when I read the first draft of his autobiography, I found so much that I had not known and insights that I am sure will be educational and inspirational to young mathematicians and colleagues of many years.

It is my duty and pleasure to thank those who have assisted, contributed to, and enhanced this manuscript; I do so also on behalf of Saunders whose health does not allow him to express all the thanks that are due at this time.

The first person I want to thank is Dr. Janet Beissinger, a mathematician at the University of Illinois at Chicago who answered our request to read and develop the draft of the manuscript that Saunders had mostly completed. Our first meeting with the author led to an extended series of regular meetings and conversations that gave Janet an understanding of the motivation for the project and Saunders' goals and led to her extensive development of the manuscript in close cooperation with Saunders. These meetings gave Saunders

Acknowledgments

the opportunity to test and expand his narrative with a sympathetic yet independently minded reader/listener and to approve her edits. We cannot thank Janet enough for her selfless service. She graciously acknowledges that the project expanded her perspective and taught her many things.

Thanks are due to Greta Schuessler, who was the Assistant Executive Officer of the Report Review Committee of the National Academy of Science during Saunders' tenure in that position. Her reading of and commenting on the relevant sections of the book were invaluable, yet all responsibility for the final manuscript rests with the author.

Gretchen Mac Lane, a professional editor in her own right, read the manuscript and amended and clarified memories while leaving the original narrative and voice intact; her younger sister, Cynthia Hay, added comments and corrections.

Osa Mac Lane encouraged the project and served as diplomatic guardian during the many sessions and conversations we all had with Saunders, assuring his patience with our repeated questions. She helped collect the wonderful pictures that are included in the book and, I am sure, was a strong support behind Saunders' efforts to collect and put down his memories.

Irving Kaplansky and David Eisenbud, two of Saunders' many students, encouraged the project from the very beginning and have been helpful along the way with advice and encouragement. Two other students of Saunders, Paul Palmquist and John MacDonald, have carefully read the manuscript and made suggestions that have been implemented.

My thanks extend to all of the above and to those who have helped without my awareness.

With this I turn the manuscript into the hands of the reading public and hope that it will be received with interest, pleasure, and appreciation for a life of creativity and service.

> Klaus Peters Publisher

Part One Early Years





Chapter One (=) (Steresy)

astle Duart rises grim and foreboding over the Straits of Mull in the Highlands of Scotland, the former center of the clan MacLean. The MacLeans conceded victory to the British in the last battle of the Forty-Five Rebellion, the Battle of Culloden and later suffered the fate of many other Highlanders who were evicted from their homes to make way for sheep farms during the "Highland Clearances" of the early 1800s. Thus, in the early 19th century, my MacLean ancestors sought new beginnings in western Pennsylvania and Ohio.

My grandfather, William Ward McLane—son of John and Julia McLane—was born on November 18, 1846, in Lewisville, Indiana County, Pennsylvania. William graduated from Blackburn College in 1871, and from the Western Theological Seminary in 1874. He was then ordained to the Presbyterian ministry, and served as pastor of the Second Presbyterian Church in Stuebenville, Ohio until 1883. That year, William was officially charged with heresy for preaching on the writings of Charles Darwin. Evolution was widely unaccepted among the faithful of the time, and at the annual meeting of the Presbyterian Synod it became clear to my grandfather that he would be convicted of his charge.

He therefore resigned his position from the church in 1884 and set off with his family to New Haven, where he became pastor of the College Street Congregational Church. At this time, William had three sons, John F. and Paul from his first marriage, and baby Donald

Early Years



Reverend William Ward MacLane

(my father), the eldest son of his second marriage to Frances Robinson. Frances was an enthusiastic poet and descendant of William Bradford, who had sailed on the Mayflower and had become one of the first governors of the Massachusetts Bay Colony.

Once settled in New Haven, William moved the church from its traditional location on the New Haven Green to a more outlying location and continued his scholarly work, eventually earning a Doctor of Divinity at Yale.

The family lived near the Yale campus at 85 Howe Street for a considerable amount of time. The address is noteworthy because Josiah Willard Gibbs, the theoretical physicist and chemist who became one of the greatest American scientists of the 19th century, lived on the same block. The eminence of this neighbor undoubtedly contributes to the persistence of a family legend that Gibbs, while taking refuge from a thunderstorm in a doorway, came upon my grandfather and asked, "Young man, have not I seen you before?" Of course, Gibbs had seen my grandfather on many previous occasions, only without the dubious benefit of rain to inspire conversation.

After many years in New Haven, William was retired from his pastorate, probably because the congregants wanted a younger pastor. He moved to North Leominster, Massachusetts, and became pastor Chapter One 🗢 Heresy



The Saunders family in Newport, RI, 1913 (top row from left to right: Donald, George holding Lois, Isabel holding Tom Jr., Tom Powell, Sr.; front row from left to right: Saunders, Winifred, Aretas, Priscilla, Dorothea)

of the Congregational Church. We will return to him there later in my story.

My father, Donald Bradford McLane, was born January 19, 1882, and was a year old on the journey from Stuebenville to New Haven when his parents fled their parish to avoid charges of heresy. In New Haven, he graduated from the well-known Hill House High School in 1899. He was a bright and well-liked member of his school; in his senior class book he wrote the essay covering junior year, and was voted the wittiest and most eccentric member of his class. He studied at Yale, where he graduated in 1903, and went on to the Union Theological Seminary in New York City. After his graduation there, he served for a year as an assistant pastor of the Church of the Sea and Land.

The next-door neighbor, George Aretas Saunders was a parishioner of his father's church in New Haven. He had moved from Newport, Rhode Island, where his father, Aretas Saunders, was a prominent dentist. He attended the Sheffield Scientific School at Yale as an engineering student, but gave up school to marry Isabel Andrews. They remained in New Haven and raised three children: Winifred,

Early Years



Saunders as a young child with his parents, Donald McLane and Winifred Saunders

Dorothea, and Aretas. Winifred, the eldest, was beautiful and talented. She graduated Phi Beta Kappa from Mount Holyoke College and briefly taught high-school English and mathematics. Though the Saunders and McLane families lived next door from one another, my father was shy about approaching Winifred. But we know he must have followed family advice that "faint heart never won fair lady," as he and Winifred were married in 1908.

After their marriage, Donald took up his first regular pastorate at the Congregational Church in Taftville, Connecticut. Taftville was a New England mill town, dominated by a cotton mill and surrounded by simple workers' houses.

I was born nearby in Norwich on August 4, 1909, christened Leslie Saunders MacLane. My father and his brothers had changed the spelling of the family name from MacLean to MacLane so as not to be considered Irish. It was my nurse who suggested the name Leslie, but a month later, my parents agreed that they didn't like the name. My father put his hand on my head, looked up to God, and said, "Leslie forget." I have gone by two last names ever since. The space in Mac Lane was added years later by me, when my first wife, Dorothy, found it difficult to type our name without a space.

Chapter One 🗢 Heresy

In Taftville we lived on top of a hill with a good view of the town, and life there remains idyllic in my memory—I was quite unaware of the life of the workers in the mill and their connection to my father's church. I remember vividly sliding down our hill with my father, and I subsequently loved slides and sliding forever. I still have a Flexible Flyer in my basement, and in Cambridge I once built a backyard snow slide, slanted 60 degrees, for my three-year-old daughter, Gretchen, who reminds me how I systematically iced the surface for a slick slide down.

In the back of the Taftville house there were extensive woods. My father took me on walks from an early age, and I fondly remember that he encouraged me to find my own way home. I developed a good sense of direction and later encouraged the same for my own daughters by pointing out "markers" and the direction of the sun on the walk out, letting the girls find the way back using these clues.

After four years in the mill town, my family moved to Boston, where my father became pastor of a Congregational church in Roxbury/Jamaica Plain. This stands in my memory as a great change, and many events impressed on me an alienation and anonymity of city life that contrasted with my experience in a small town. Our family walks now took place in a park around a lake instead of in the woods, and our backyard was paved over. My father had helped me construct a playhouse out of a wooden crate, but older boys in the neighborhood destroyed it. I also remember social tensions that were frightening and unfamiliar to me—there were race riots nearby that ended in stonings.

My family suffered a loss during this time—the birth of my sister Lois had happily completed the family, but she died of heart failure at the age of 4. My parents were devastated, and my father celebrated her brief life in poetry, a talent that he had inherited from his mother. The loss was difficult to accept, and my parents attempted to overcome it through the adoption of another daughter, but she didn't settle well into the family, and the adoption was not completed.

In the meantime, I did start attending school. There is little I recall. On one occasion, I did not return directly home from school, but wandered about instead. I was suitably lectured when I finally

Early Years



Saunders and his sister Lois, soon before she died

arrived at home. I do specifically remember learning fractions in the third grade. My teacher used cut-up strips of paper to demonstrate their meaning, which impressed me. I like to think of that lesson in today's terminology—the activity would be called "hands-on learning," and the strips "manipulatives"—and know that my teacher used these "modern" methods in 1917.

Politics mattered then, and I closely followed my father's views. In 1916 he favored the reelection of President Wilson, who at that time had "kept us out of the war." I was impressed with this slogan and put on a campaign for Wilson. I apparently felt that at age 7, I had sound political judgment, and left VOTE FOR WILSON slips all around the neighborhood.

When the United States entered the war in 1917, political issues became more serious. My father maintained his pacifism, which resulted in tensions with many of his parishioners. Hence, we moved to North Wilbraham, Massachusetts, a small farm village outside Springfield, where my father became pastor of a combined church. Previously, there was a Methodist and Congregational church, perhaps too many for a small town, and so they united, but there was considerable doctrinal tension in the combined church.

Chapter One 🗢 Heresy



Saunders, age 5, and Lois, age 2, with their parents

I was happy to be in a small country town again. There was a pond nearby, and a dump full of wonderful, old discarded objects. The parsonage had a big backyard with a fine sand pile where I played at soldiers. Our neighbor was a Civil War veteran, which I found very impressive. We had a garden in the yard that had more space than we needed for planting, and I took over one row and constructed a mock trench. I could not have understood the horrors of warfare, but the war, though taking place at a great distance, had influence.

The grade school in Wilbraham was in a three-room building, though I remember using only two of them; one for grades one to five, and the other for grades six to eight. Many years later, I returned to Wilbraham to find that my old school had been preserved as an example of how education used to be. I recall little of the subject matter I learned there; life outside of school was much more exciting. I played with my friends at the dump, and in the bushes of the pond. We sometimes broke into an abandoned hardware store, and in the winter, I delighted in riding my sled down the town hills. Once, I even rode in an automobile, which was a complete wonder to me at the time. My brother Gerald was born at the hospital in Springfield in 1918, which finally filled the void in the family left by Lois's death.

Well before completion of the expected six-year pastorate in Wilbraham, my family moved to a new parish. The reason for the move could well have been doctrinal disputes with Methodists, or possibly my father's part-time job. The Wilbraham Academy was a boarding school for boys just down the street, and the headmaster

Early Years

was a prominent Methodist parishioner. At the start of the school year, a faculty member abruptly resigned, and my father was recruited to fill his place as the Latin teacher at the Academy. My father knew many languages, including Latin; he once wrote an article about the Lord's Prayer in 27 languages. But teaching was a distraction for my father. He preferred to write sermons and visit his parishioners; he felt that visitations were an essential aspect of his ministry.

My father's new parish was in Utica, New York. Utica was a growing city that had expanded southward along Genesee Street. The Congregationalists set up a brand new church there, and my father was the founding pastor. This presented a challenge for him: building the church, recruiting new members, preaching and comforting parishioners sermons, were daunting responsibilities. Because the church was brand-new, there was no existing parsonage. My father had to buy one of the new jerrybuilt houses that had a then-considerable mortgage of \$6,500. At this time I was only 12 years old, but I was concerned by the troubles of my family's finances.

The local grammar school was just around the corner from our house. I attended and found it very different from my previous tworoom schoolhouse. At the end of the seventh grade, all students had to take the New York State Regents examination in arithmetic. The requirements involved quickly adding up long columns of four-digit numbers, a skill that my fellow students had practiced much more than me. It is my recollection that I flunked this exam, but apparently there were no resulting sanctions, as I went on to the eighth grade.

The city of Utica offered some rural aspects: a creek passed through the wrecked site of an amusement park nearby, continued through a stretch of woods, and then flowed under the main street by a culvert. Together with my friend Bill Schmidt we explored the culvert and, probably recklessly, waded through it under the street. We used abandoned lumber from the amusement park to build a splendid tree house eight feet up, which we accessed by ladder. We even included a fireplace in the tree house, though its design left something to be desired—we were evidently unaware that proper construction of a fireplace included a draft, and when we lighted our

Chapter One 🗢 Heresy



Saunders with his brothers Gerald and David in a homebuilt cart, Utica, NY, 1922

fire, smoke promptly filled the tree house. We then built a second tree house, this time without a fireplace.

I engaged in other constructions; in the backyard of our house I put together a mock sailboat, and I also used an old set of wheels to build a cart in which my brother Gerald could ride—he did not seem to mind that I volunteered him for this activity. My family bought me a bicycle, which I used to earn some money by delivering baked goods from the home of Mrs. Crippen on the next block. My delivery was not, apparently, always careful; a customer complained that the meringue on her lemon meringue pie had suffered slippage. I tried to do better after that, as I was quite happy to be earning money.

In the winter, the town hills provided ample opportunity for sledding. My old Flexible Flyer had grown too small, and so I used the money from my delivery to buy a wonderful new sled—a Flexible Flyer Racer. Misfortune soon ensued. I took my new sled down a toboggan slide on a big hill, lost control, and badly bent a runner. Disappointed, I took it back to the department store, where, to my surprise (still today), they willingly replaced it with a new sled. I still have that fine Flexible Flyer Racer; it provides a small link to my boyhood.

I also joined a troop of Boy Scouts that met in a church downtown, where we enjoyed games such as shuffleboard. I took seriously to scouting, enough to spend my money on a uniform, which I proudly

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wore to the hospital where my mother had given birth to my youngest brother, David. As a Scout, I enjoyed two weeks of summer camp, though I did fail badly at some of the athletic tests.

I began high school in the center of the city, at the Utica Free Academy. Though I must have taken the usual courses for freshmen, I remember only algebra, which was taught by a veteran teacher who was also the football coach. And of algebra, I remember only my pleasure at learning that it was indeed possible; before then, I had only known arithmetic.

By the time I entered high school, my father's health had become unstable; it was unclear whether the cause was overwork or if it was residual of a case of influenza he caught during the 1917 epidemic. On one occasion, his doctor sent him off for treatment at a rest home. He returned looking much healthier, but his recovery was not permanent. In 1923, when I was a sophomore, he was diagnosed with tuberculosis, so he resigned his pastorate and went to a sanitarium in the Adirondack Mountains. From his bed he wrote me several thoughtful letters about my growing up. My mother and I went up to visit him and he seemed to be cheerful and improving, but I could not have realized that I would not see him again.

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hen my father became ill, my grandfather, William Ward McLane, still held his pastorate in North Leominster. His wife Frances, who suffered from what may have been Alzheimer's disease, had recently died, leaving him alone with a maid in a large parsonage. He offered to take in my mother and her three boys, and she gladly accepted since there was no disability pay or pension to replace my father's lost salary. I helped to pack up our possessions, which included many books; among them I remember specifically the 11th edition of the Encyclopaedia Britannica, with its splendidly accurate and comprehensive information—I still use it to this day.

After we settled with my grandfather, my mother found a job teaching English at North Leominster High-school, and raised Gerald and David as well as she could under the gaze of a father-in-law not attuned to the needs and ideas of little boys. I began to feel a little more independent, and admired the way my mother managed her difficulties. I joined a troop of Boy Scouts, attended a group for young men in Sunday school at my grandfather's church, and entered school as a sophomore.

North Leominster High School was an exciting place for me. As a sophomore, I learned Euclidean geometry. However, the school evidently considered this subject a bit too difficult for most students— as juniors we all reviewed and repeated the course in geometry. Our teacher, a young woman, chose to send the students to the blackboard

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Sunday school class, Leominster, MA: Saunders is in the third row, second from the right

to present the theorems of the day. I recall one occasion involving a theorem about a triangle: I knew that the specific shape of the triangle did not matter, and that its vertices could be lettered at will. So when I went to the board, I drew the triangle upside down, changed the letters labeling the vertices, and presented the proof at flank speed, all to the evident distress of my teacher, as some of the students (my friends) egged me on. In retrospect, it is apparent that I understood the proof from my first geometry class, but that I did not at all see how to communicate the proof to my fellow students; I must have been a real nuisance to the young teacher.

At that time, students who had study periods were assigned to sit in the back of active classrooms. After one of my impetuous performances, an older student with a study period in my class came by my desk to leave a brief note that said, "Keep it up," signed, "A math tutor." The note was written by Earl D. Rainville, who was eventually a mathematician on the faculty of the University of Michigan, where he prepared textbooks on differential equations and special functions. In subsequent years, we were acquainted only distantly, and I regret this loss of contact.

The Boy Scout troop provided good fun with hikes and cookouts, and there was also an annual competition between the troops in the neighborhood—this I enjoyed. There was one competition about

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Saunders with his brothers Gerald and David, Norwalk, CT, 1927

knots, in which each contestant carried four short ropes and ran across the room to a log, tied on the ropes using different knots in a specified order, and ended with a bowline that he used to pull the logs across the room. I can't recall that I ever won, but I did learn those knots. However, I did not yet know of the many mathematical questions associated with knots.

We also competed in Morse code signaling: The signalers stood on one side of the room, sending the prescribed message by the usual successive position of the flags. My signaler was athletic—he signaled fast. I sat on the opposite side and quickly read off the letters to my scribe. We won often. As I recall, we even floated a rumor that we had set a world record. Of course, we never really pressed this issue; it served mostly to bolster our self-esteem.

In later years, I returned to Leominster for a class reunion. I found that my signaling companion ran a summer camp for youngsters, and so had realized his remarkable athletic capabilities; however, we did not keep in touch further. I did manage to keep up with other friends: John and Bill Grubb; Wallace Gove; and Ralph Kirkpatrick, who became a musicologist and a famous performer on the harpsichord. He was most famous in the 1950s and 1960s for his reinterpretations of Dominico Scarlatti. Ralph and his sister, Annis, were great friends with my mother; Ralph kept a harpsichord at her house for practice.

During my high-school years, the Ku Klux Klan was active and apparently critical of Catholic doctrines. A Congregational church downtown received and praised Klan members with these views, and the excessive attacks on Catholicism displeased my grandfather. He proceeded to open his church on a weekday to give a two-hour lecture on the origins of the Protestant/Catholic divide, which was wellattended and impressively done. I admired his devotion and vigor in defense of tolerance, and marveled at his decisive activity at nearly 80 years of age.

This does not mean, however, that I understood his ideas. I did join his church, and in the process of doing so, remember being questioned carefully by an elderly member about my beliefs. I answered seriously, but at the same time, kept some reservations about certain points of doctrine. I struggled with aspects of my ministerial heritage, but I did not often approach my grandfather for advice and wisdom. On one occasion, I asked him about the purpose of individual life. He responded that we were there to exhibit the glory of God; this conclusion stopped me cold—God's glory was not visible to me.

At the high school, my English teacher was Olive Greensfelder, a native of Hyde Park in Chicago, who had come east to do graduate study in education. She took much care in reading and criticizing my writing; I specifically remember an enthusiastic essay I wrote about Abraham Lincoln. I consider her guidance in writing to have helped me later in the exposition of mathematics for students. She established a high-school newspaper and named me the editor. The first assistant editor was a beautiful blond named Helen Wolcott, whom I admired, but only at a distance. I did learn to dance, and had occasional dates, but not with Helen, as she was dating my best friend, Merrill Bush.

The high-school boys were organized into companies for required military drills, which we carried out on the football field in uniforms that echoed Civil War style, caps and all. The drilling, I suppose, was

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good for our discipline. We learned the manual of arms, and I even rose to be second lieutenant of my company. Each spring, at the town exercises for Memorial Day, the four student companies paraded, and there was an annual competition for "best company."

My father's pacifism during World War I was still on my mind: One year, on the day of the annual drill, the high-school newspaper carried my editorial criticizing the whole military drill requirement. It caused considerable discussion. The faculty member in charge of the drill, however, responded only mildly, pointing out that I had split an infinitive. The drill continued despite my editorial, but I imagine I felt that I had supported my father's views.

Early in 1924, we received the devastating news of my father's death at the hospital in the Adirondacks. At first, we did not tell my brothers. David was only 2 or 3, and Gerald was about 7. As I mentioned, my father had kept in careful touch during his hospitalization, writing me thoughtful letters about the challenges of growing up. I tried, in small ways, to express his influence to my brothers, but did so imperfectly. Gerald finally asked me when father would come home, and at the age of 16, I did not know how to explain such things to him. I only said, "He's not coming home. He's dead." Learning the truth in that way from me was very traumatic for him. I did realize that his death was a terrible blow for my mother, but I was not always adequately helpful. For example, one Halloween I rang too many doorbells and a policeman called at the parsonage to explain my misbehavior to my grandfather. He must have found these times troublesome, but he managed to accept me.

I enjoyed relationships with my father's full brothers: my Uncle Stanley was an engineer who worked at General Electric, and my Uncle William was an enthusiastic salesman. I had yet to develop relationships with my father's half brothers, Uncle John and Uncle Paul, who were sons of my grandfather's first marriage. But during a visit, in 1924, Uncle John turned to me and said, "Saunders, I will send you to Yale." Yale was a natural choice since our family had a history of attending school there, including all five uncles and both of my grandfathers, as well as earlier relatives, such as a distant cousin Ami Ruhami Robbins. I eagerly accepted Uncle John's offer, of course. As will soon appear, I profited much from my undergraduate years at Yale.

At this time, Uncle John was a senior partner of the Wall Street firm Simpson, Thatcher, and Bartlett; he was married, but with only one child, an adopted daughter. His generosity in providing higher education for me, for my brothers and for others as well was remarkable. Most of my college-bound high-school classmates were headed for Harvard, but I was happy to apply to Yale. I assume that my English teacher, Miss Greensfelder, wrote well about me, but presumably I would have been admitted anyhow as a "legacy," an idea then and now popular in the Ivy League.

Uncle John also observed, and correctly so, that I was a naive and inexperienced young man. After my junior year, he arranged surveying work for me during the summer with one of his clients, the Pennsylvania Power and Light Company. The company had recently established a dam for water power, creating Lake Wallenpaupack, and they needed to survey its boundaries. I was a rodman in the survey gang. Each morning we drove out to the site of the new lake and proceeded to survey more of the resulting property lines. I dressed in high boots for protection against rattlesnakes, and carried a brush hook-an ax with a hooked blade. I cleared away all of the brush in the line of sight so that the surveyor could see the next stake from his transit. I learned to whack brush and to hold a pole steady for sighting on the true vertical over a stake. I was fascinated by the way the surveyors used trigonometry, which I had not yet studied thoroughly at school. The transit, which is a telescope mounted to swivel both horizontally and vertically on a tripod, is a wonderful instrument for measuring angles.

However, I was alone in the company of older men and their raucous view of life. When the day was over, we congregated in the bar of the local hotel, in the town of Hawley. I had been trained that drink was evil, so I found myself in an uncomfortable new experience. My friends—the survey gang—kidded me mercilessly. I was 16 and homesick, and I almost gave up. But a wiser, older man listened to my troubles and made some useful adjustments. I was moved from

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the rowdy hotel to a room in a private home where I had more freedom—I was able to do things like play records. I seem to recall playing the record "Forsaken" over and over again. That was how I viewed myself. Somehow, I stuck it out for the summer, finally returning to my grandfather's house. I constructed a partly working model of a transit so that I could explain to my brothers what I had been doing. I do not recall trying to explain my homesickness; this was my private trouble.

The following summer, I did not return to surveying in Pennsylvania. Instead, I got a job in a local celluloid factory, where I spent most of my time beveling the tongues on barrettes for ladies. Since I stayed at home, there was no problem of homesickness, and I did earn a bit of money; I also learned how dull and repetitive work in a factory could be—a useful bit of information, to be sure.



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n the fall of 1926, at 17, I went off to Yale. My mother arranged for me to room with Harvey Morrison, whose family we knew. I was initially startled by some aspects of student life, which was dominated by students who had come from famous prep schools such as Exeter, Andover, and Kent. I quickly learned that a proper Yale man should be active; he went out for football, managed an athletic team, or "heeled" the *Yale Daily News*. I did not even try to go out for the *Daily News*; I concluded that my experience with a minor high-school newspaper would be of little help. I did once try out for track with no success—I was not fast enough. In general, I avoided the sanctioned activities for students and concentrated on the excitement of the ideas that came up in my courses.

Shortly after arriving, a representative from the well-known New Haven department store J. Press called on us in our rooms to offer a "Pressing Contract." I did not think I had enough money for this, and regardless, the idea of freshly pressed pants for each day did not seem necessary to me. I did, however, follow the common practice of packing up my dirty laundry every week and mailing it home to my mother to be washed. As for money, my Uncle John provided me with \$1,200 each of my four college years to cover my tuition and other expenses. This amount sufficed, but I am struck by how ridiculously small it seems today.

Before coming to college I had considered my financial future—it was clear to me that my family had experienced difficult financial