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Academic Genealogy of Shoshichi Kobayashi and Individuals Who Influenced Him

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1. Introduction

Professor Yoshiaki Maeda, a co-editor of this volume, kindly asked me to prepare an article on academic genealogy of my brother Shoshichi Kobayashi. In the olden times, it would have been a formidable task for any individual who is not in the same field as the subject mathematician to undertake a genealogy search. Luckily, the "Mathematics Genealogy Project" (administered by the Department of Mathematics, North Dakota State University) [1] and Wikipedia [2] which document almost all notable mathematicians, provided the necessary information for me to write this article. Before I undertook this study, I knew very little about Shoshichi's academic genealogy, except for his advisor **Kentaro Yano** at the University of Tokyo and his Ph.D. thesis advisor **Carl Allendoerfer** at the University of Washington, Seattle.

Shoshichi was well versed in the history of mathematics and wrote several tutorial books (in Japanese) (e.g., [3]) and an essay book [4]. In these writings, he emphasized the importance and necessity of studying the history of mathematics in order to really understand why and how some concepts and ideas in mathematics emerged. I am not certain whether Shoshichi was aware that one of his academic ancestors was **Leonhard Euler** (1707–1783) (see Table 1), whom he immensely admired as one of the three greatest mathematicians in human history. The other two of his choice were Carl Friedrich Gauss (1777–1855) and Archimedes (circa 287 BC–212BC).

I was pleasantly surprised to find that his academic ancestry includes not only Euler but also such a large list of celebrated mathematicians, as shown in Table 1: **Gottfried Leibniz** (1646–1716), **Jacob Bernoulli** (1655–1705), **Johann Bernoulli** (1667–1748), **Jean d'Alembert** (1717–1783), **Joseph Lagrange** (1736–1813), **Pierre-Simon Laplace** (1749–1827) and **Simeon Poisson** (1781–1840).

In Section 2, I will summarize what I have found about some of the older ancestors of Shoshichi: **Gottfried Leibniz**, **Nicolas Malebranche**, **Jacob Bernoulli**, **Johann Bernoulli** and **Leonhard Euler**. It goes without saying that we would learn a great deal also by studying **d'Alembert**, **Lagrange**, **Laplace** and **Poisson**, all of

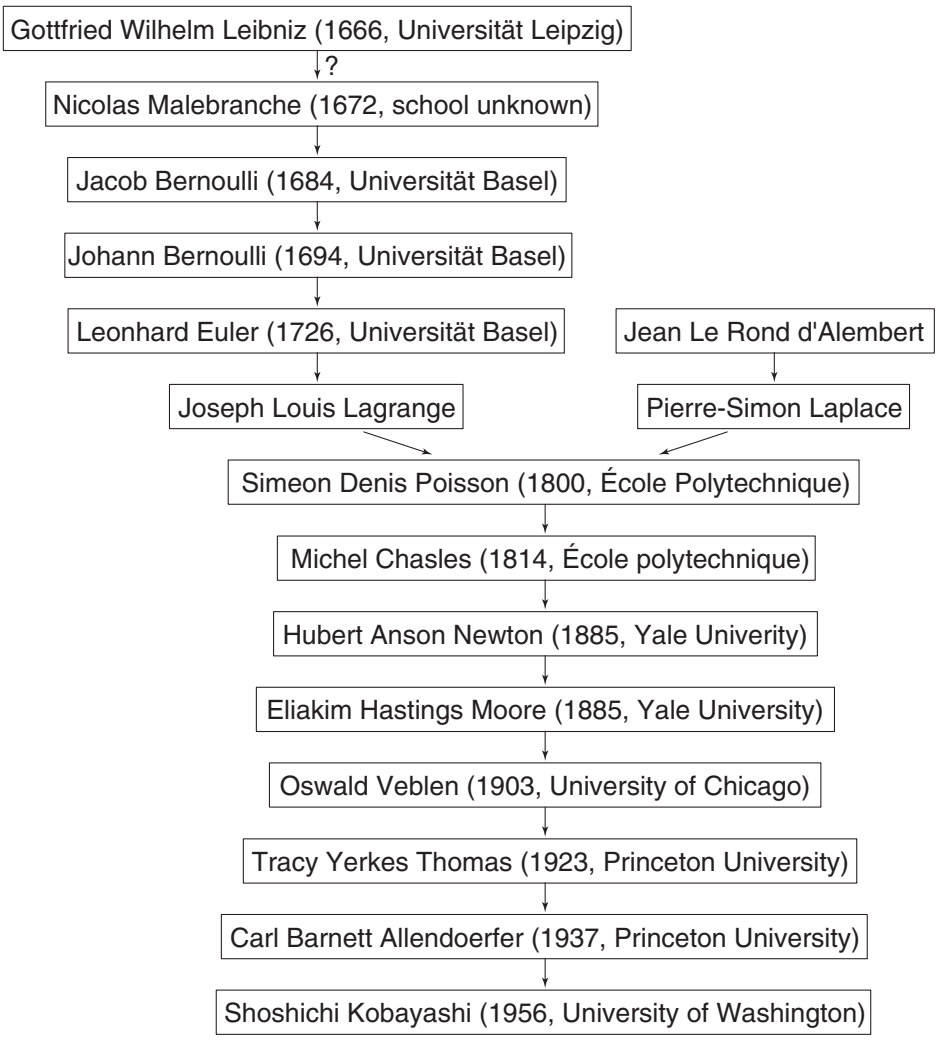


TABLE 1. Shoshichi Kobayashi's Academic Ancestry

whom are household names, so to speak, to all scientists and engineers. But in the interest of space, I should find another opportunity to discuss these mathematicians.

In Section 3, I will make another important account of various individuals with whom Shoshichi interacted directly, although they do not appear in Shoshichi's genealogical tree of Table 1.

2. Some Great Mathematicians among Shoshichi's Academic Ancestry

As stated earlier, Table 1 provides an important segment of Shoshichi Kobayashi's academic ancestry. At the top of Table 1 is **Gottfried Wilhelm Leibniz** (1646–1716), a prominent German mathematician and philosopher [5, 6].

Gottfried Leibniz developed the theory of differentiation and integration, independently of his contemporary, Isaac Newton (1642–1727) (see the Leibniz–Newton controversy on calculus [7]) and Leibniz' notation for infinitesimal calculus has been widely used ever since it was introduced [4] (pp. 46–48). His Ph.D. thesis at age 20 (in 1666) was on "Disputatio arithmetica de complexionibus (Arithmetic discussion of combinations)" under two advisors (not shown in Table 1) at the University of Leipzig: **Jakob Thomasius** (1622–1684), a philosopher, and **Erhard Weigel** (1625–1699), a mathematician and astronomer. Thomasius' advisor was **Friedrich Leibniz** (1597–1652), the father of Gottfried Leibniz, a professor of philosophy at Leipzig. Gottfried's other advisor Weigel was an academic descendant of **Nicolas Copernicus** (1473–1543) (not shown in Table 1).

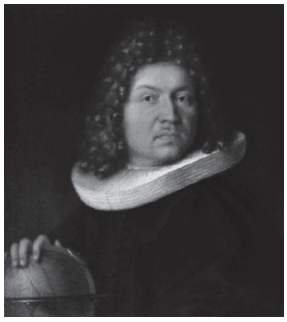
Gottfried Wilhelm von Leibniz (1646–1716) Source: http://www-history.mcs.st-and.ac.uk/. Public domain.

During his stay in France around 1670, Leibniz met the Dutch physicist and mathematician **Christian Huygens** (1629–1695). With him as mentor, Leibniz made major contributions, including the discovery of differential and integral calculus. According to the Mathematics Genealogy Project [6], Leibniz submitted another dissertation to Académie Royale des sciences de Paris in 1676 with Huygens as the advisor, although the type of degree is not given. Thus, we may claim Huygens as a mathematical ancestor of Shoshichi.

Nicolas Malebranche (1638–1715) was a French Oratorian priest and rationalist philosopher. The Mathematics Genealogy Project shows Malebranche as one of Leibniz's two students [6], but neither his dissertation title nor his university is given. In Wikipedia [8] no mention is made regarding the advisor-student relationship between Malebranche and Leibniz, but their collaboration on physics and mathematics is briefly mentioned. Considering that Malebranche was eight years senior to Leibniz, it is quite possible that Malebranche was not an official student of Leibniz, but he learned mathematics and physics from Leibniz. We need more investigation to prove the genealogy link between the two. Malebranche introduced **Guillaume de l'Hôpital** (1661–1704) to **Johann Bernoulli** (see a paragraph below regarding an unusual contract and dispute between l'Hôpital and Johann Bernoulli).

Jacob Bernoulli (1654–1705) [9] was the first mathematician in the famous Bernoulli family, of which Shoshichi gives a full account in Chapter "Mathematical families" (pp. 30–39) of [4] as well as in Section 4.1 (pp. 167–171) of

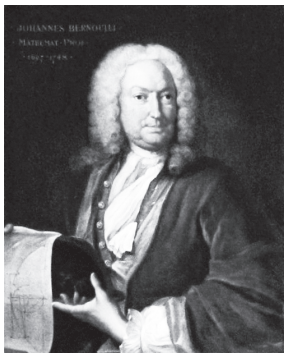
"Chapter 4: Euler" of his book on Fermat and Euler [3]. Jacob made numerous contributions, and is well known, among other things, for the calculus of variations and the Bernoulli numbers. The Bernoulli numbers appear in various mathematical fields.



Jacob Bernoulli (1654–1705) Source: Wikipedia. Public domain.

Those who study probability theory (see, e.g., [10] which I recently published) learn the work of Jacob Bernoulli through Bernoulli's Theorem (a.k.a. the weak law of large numbers), Bernoulli trials, Bernoulli distributions, etc. In 1657, the aforementioned **Christian Huygens** published the first book on probability entitled De Ratiociniis in Ludo Aleae (On Reasoning in Games of Chance), a treatise on problems associated with gambling, motivated by Pascal and Fermat's correspondence (see, e.g., [10]). Huygens' book influenced Jacob Bernoulli who worked on probability theory around 1684–1689. Much of Jacob's work is found in his book Ars Conjectandi (The Art of Conjecture), published posthumously in 1713 by his nephew Nicholas Bernoulli (1687–1759).

Johann Bernoulli (1667–1748) [11] who was 13 years younger than Jacob, studied mathematics from Jacob. Throughout Johann's education at the University of Basel, the Bernoulli brothers worked together on the newly discovered infinitesimal calculus. Shortly after the graduation of Johann, however, the two developed a jealous and competitive relationship [4, 11]. After Jacob's death, Johann's jealousy shifted towards his own talented son, Daniel Bernoulli (1700–1782).



Johann Bernoulli (1667–1748) Source: Wikipedia. Public domain.

Johann Bernoulli, introduced by **Malebranche**, was hired by l'Hôpital for tutoring in mathematics. In 1694, l'Hôpital made an unusual contract with Johann Bernoulli [4, 12] in exchange for an annual payment of 300 Francs that Johann would inform l'Hôpital of his latest mathematical discoveries. Two years later l'Hôpital authored the first textbook on infinitesimal calculus, Analyse des Infiniment Petits pour l'Intelligence des Lignes Courbes (Analysis of the infinitely small to understand curves), including what is now known as l'Hôpital's rule. After l'Hôpital's death, Johann publicly revealed their agreement and claimed credit for portions of the text of Analyse. For a long time, however, his claims were not regarded as credible by many historians and mathematicians, because Johann had been previously involved in several disputes with his brother **Jacob** and his own son Daniel. In 1921, however, Paul Schafheitlin [13] discovered a manuscript of Johann's lectures on differential calculus written during 1691–1692, substantiating Bernoulli's account of the book's origin.

Leonhard Euler's (1707–1783) father Paul Euler was a pastor, who studied in his youth mathematics from **Jacob Bernoulli**, and thus was a friend of the Bernoulli family. Leonhard studied mathematics from **Johann Bernoulli** and became a close friend of Johann's sons Nicholas and Daniel. In 1725 Daniel Bernoulli was appointed the chairman of the mathematics/physics division of the St. Petersburg Academy of Sciences (today's Russian Academy of Sciences), established that year by Peter the Great who had consulted with **Leibniz**. Upon Daniel's recommendation, Euler was appointed to a position of physiology at the Academy in 1727 at age 20, and became a professor of physics in 1731. In 1733, Daniel Bernoulli returned to the University of Basel and Leonhard took over Daniel's position as the head of the mathematics department at the Academy. In 1735 (age 28) he suffered a near-fatal fever and became almost blind in his right eye, but continued to be productive in his research [3, 14].

Leonhard Euler (1707–1783). Source: Wikipedia. Portrait of Leonhard Euler painted by Jakob Emanuel Handmann (1718–1781). Public domain.

Concerned about the political turmoil in Russia, triggered by the death of Empress Anna, Euler left Russia in 1741 to take up a position at Berlin Academy offered by Frederick the Great of Prussia. During the next 25 years' stay in Berlin, Euler wrote over 380 articles, a book on functions (1748), and another on differential calculus (1755). Despite his enormous productivity and contributions to the Academy's prestige, Euler was not entirely happy at Berlin [3, 14]: He did not get along well with King Frederick and his social circle of philosophers, including the likes of Voltaire (1694–1778).

In 1766 when he was 59, Euler accepted an invitation to return to the St. Petersburg Academy (whose official name had been changed to the Imperial Academy of Sciences since 1747), and spent the rest of his life in St. Petersburg. But his second stay in Russia was marred by a series of tragedies. By 1771 he had lost his left eyesight due to a cataract, he lost his home by a fire in St. Petersburg, and in 1773 he lost his wife Katharina (1707–1773) after 40 years of marriage. Despite these tragedies he remained amazingly productive. In 1775, he produced on average one mathematical paper every week [15]. He suffered a cerebral hemorrhage on Sept. 18, 1783, and died at age 76.

Euler is the only mathematician to have two numbers named after him: Euler's number e and Euler's constant γ (a.k.a. Euler–Mascheroni constant), which

is defined as the limiting difference between the harmonic series and the natural logarithm [3, pp. 223–224]. Euler's identity (which is a special case of Euler's formula) $e^{i\pi} + 1 = 0$ is said to be the most beautiful mathematical theorem, because three basic arithmetic operations (addition, multiplication, and exponentiation) occur exactly once each and the identity also links five fundamental mathematical constants (0, 1, e, i, π).

Euler's contributions ranges from differential and integral (infinitesimal calculus), to number theory, graph theory, logic, astronomy, physics and philosophy. By calculating the zeta function at integers, Euler became the father of analytic number theory [3].

3. Individuals who Influenced Young Shoshichi

In this section I will write about several individuals who directly influenced Shoshichi in his early career.

Muneo Hayashi (1916–2012). Source: Prof. Emer. Masaru Mitsuishi (Shinshu University, Nagano, Japan).

Shoshichi wrote about Mr. **Muneo Hayashi** in his essays [17, 18, 19], who was his mathematics teacher and mentor in his 4th year (academic year 1947/48) at Nozawa Middle School in Nagano Prefecture. He writes [18] "After the school hours, Mr. Hayashi taught me various mathematics. Matrices and their equations felt like magic. ... I accompanied Mr. Hayashi to a book store. We found books such as Theory of Functions by Tanzo Takeuchi. I learned that there is a field of mathematics called 'function theory.' Although it was the period when I felt hungry all the time, every day was exciting to me, thanks to Mr. Hayashi who taught me new subjects of mathematics, one after another."

Soon after Shoshichi entered Ichikoh (the Number One Higher School) in Tokyo, a new educational system came in effect. After having attended Ichikoh for just one year, Shoshichi became eligible to take the entrance examination of Todai (the University of Tokyo) because one year that he skipped in Middle school was credited to his precollege schooling years.

In his autobiographic essay [19] he fondly recalls the "**Sugaku Kenkyukai**" (Mathematics Research Group) he participated in during his freshman and sophomore years, when he primarily learned advanced mathematics through "**Rinkoh**" (in which the group members gave lectures in turn). He writes: "At Komaba, I attended seriously language classes (English and German), but skipped mathematics classes, because I was busy studying in the Rinkoh. Even after I moved to the Hongo campus in my junior and senior years, I did not attend most mathematics classes. Attending a class would be valuable in reviewing what I already knew, but I could not absorb new materials by just attending the lecture.

In order to understand new stuff, I had to pick an appropriate book myself and study it by spending enough hours. ..." The 17 text books that the math

group studied at "Rinkoh" included Topologies (by Alexandroff–Hopf), Topological Groups (by Pontryagin), Survey of Algebra (in Japanese by Kenjiro Shoda), Survey of Linear Algebra (in Japanese, by Keizo Asano), Algebraic Number Theory (in Japanese, by Teiji Takagi), and Fundamentals of Professional Geometry (in Japanese, by Hidetaka Terasaka).

Sugaku Kenkyukai. With members of Sugaku Kenkyukai. Front from left: Keijiro Yamazaki, Hideki Sakurai; Rear from left: Shuntaro Ito, Shoshichi Kobayashi. Source: Shoshichi Kobayashi, From "Elementary School until Graduation from College" (in Japanese) in "To Begin Studying Mathematics", Vol. 1, (Nippon Hyoron Sha Co. Ltd.), pp. 136–151.

Professor **Kentaro Yano** (1912–1993) [20, 21], Shoshichi's advisor in his senior year, influenced his choice of differential geometry. Their close relationship continued even after Shoshichi left Japan.

Yano graduated from the University of Tokyo in 1934, and he studied with Élie Cartan (1869–1951) in Sorbonne, Paris from 1936 to 38 on a two-year scholarship. Shiing-Shen Chern (1911–2004) was also visiting Cartan, immediately after having earned his Ph.D. from the University of Hamburg. Chern became later instrumental in making U.C Berkeley a world center of geometry, where Shoshichi joined in 1962 upon invitation by Chern.

Shoshichi describes his encounter with Yano in [19]: "When I became a fourth year student at Todai, I had to choose a professor of "Seminar" (in which the professor and a small number of students study, discuss and give lectures in turn on some chosen topics). At the suggestion of Prof. Yukiyoshi Kawada, whom I had known since my Komaba campus days, I chose Prof. Yano's seminar to study harmonic integrals." Regarding his presentations at Yano's seminar, Shoshichi recalls [19, 22]: "... The book on harmonic integrals by Hodge was difficult to understand. It was before André Weil's 1952 paper on a simple proof of "de Rham's theorem" by use of Cech cohomology. Needless to say, it was well before de Rham published the book Variétés Différentiables. Therefore, in Professor Yano's seminar, I spoke several times concerning the 1946 paper by Bidal & de Rham [23] and other papers, by referring to the lecture note of de Rham & Kodaira given at Princeton's Institute. ...

Kentaro Yano (1912–1993). Source: http://www-history.mcs.st-andrews.ac.uk. Public domain.

"Professor Yano had studied at Princeton the method developed by Salomon Bochner (1899–1982), so in 1952, my senior year, he gave lectures on 'Curvature and Betti numbers,' based on his manuscript with Bochner under preparation. So we had an opportunity to learn the state-of-the art results on differential geometry. Furthermore, his lectures were related to my seminar topic, harmonic integrals. I could not have asked for more. His lectures also helped me get familiar with tensor analysis of, not only Riemannian manifolds, but also Kähler manifolds, and they were useful to my research in later years as well. Bochner's method gave rise to a vanishing theorem for the cross section of a vector bundle, and Kodaira's vanishing theorem is an outgrowth of Bochner's method. I had several opportunities in later years to use Bochner's method. It was 30 years later when I used this method to investigate the stability of a regular vector bundle. Professor Yano was working on transformation groups that preserve differential geometric structures (such as Riemann metric, affine connection, conformal connection), and lectured on these topics. Later, I started actively investigating transformation groups, which became one of my research topics for more than ten years."

Although Yano worked closely with Bochner while he was at Princeton, according to his biography [19], he was invited to Princeton's Institute as an assistant to **Oswald Veblen** (1880–1960). Veblen taught at Princeton University from 1905 till 1932, when he was asked to help organize the Institute for Advanced Study, and became the first professor of the Institute and remained in that position until 1950 [24]. It is to be noted Veblen was the thesis advisor of Carl Allendoerfer, Shoshichi's thesis advisor at the University of Washington in Seattle.

Upon graduating from the University of Tokyo in 1953. Shoshichi studied for one year in France, first at the University of Paris and then at the University of Strasbourg on the French Government's Scholarship. He attended a seminar by **Henri Cartan** (1904–2008) on several complex variables in 1953/1954 [25]. Henri Cartan was a son of Élie Cartan who was the thesis advisor of Kentaro Yano seventeen years earlier. During his stay in Paris, Shoshichi also listened to seminar talks by Karl Stein (1913–2000) and André Lichnerowicz (1915-1998) at Collège de France. He also interacted with Marcel Berger (1927–), Paulette Libermann (1919–2007), Warren Ambrose (1914–1995) who was on a sabbatical leave from MIT, and Katsumi Nomizu, a Japanese mathematician, eight years senior to Shoshichi.

Henri Cartan (1904–2008). Source: Oberwolfach Photo Collection. © Gerd Fischer, München, 1985. Reprinted with perm.

Katsumi Nomizu (1924–2008) [27] graduated from Osaka University with a master of science degree in 1947, and did his postgraduate study at Sorbonne, and continued his study under Shiing-Shen Chern at the University of Chicago and received his Ph.D. in 1953. He was visiting France as a post-doctoral fellow

at the Centre national de la recherche scientifique (CNRS) from 1953 to 1954. Nomizu wrote in March 2007, less than two years before his death, for the occasion when he and Shoshichi received the publication award from the Mathematical Society of Japan [28]: "... While we (Shoshichi and Nomizu) enjoyed all this (i.e., the lectures by Henri Cartan, André Lichnerowicz et al.) in Paris, we felt we should work with concentration in a small nicer environment.

We chose Strasbourg where **Charles Ehresmann** (1905–1979) and **Jean-Louis Koszul** (1921–) were teaching. We wanted to reorganize some of the classical results, for example, in the 1917 paper by Levi-Civita and Ricci, Élie Cartan's results on symmetric spaces (Riemannian or affine), classical surface theory and general submanifold theory, relations with transformations, etc. ... I want to say how Kobayashi-Nomizu was made into a book. Professor Lipman Bers (1914–1993), Editorial Board of Wiley Interscience Publishers, asked Professor Yasuo Akizuki for a suggestion on potential authors and my name came up. Bers approached me, I immediately thought "alright" if Kobayashi can help as coauthor. He said yes. We were 3,000 miles apart (note: Nomizu was with Brown University after 1960). ... Those were the days when we had an electric typewriter at best. Volume I appeared in 1963, and Volume II in 1969."

Katsumi Nomizu (1924–2008). Source: Oberwolfach Photo Collection. © Dirk Ferus, Berlin, 1982. Reprinted with permission.

Shoshichi also wrote for the same occasion [29]: "In the olden days, we had to begin with an explanation of 'curvature' when we talked on differential geometry in a colloquium. 'Connection' was known to only those who specialized in differential geometry. But since around the end of the 1970s when gauge theory blossomed, those who studied topology and mathematical physics also became interested in the theory of connection of fiber bundles. Thanks to that trend, our book which emphasized the connection theory for fiber bundles by bringing that topic to the beginning of the volume came to be frequently referred to. When I was a student, there were few books on mathematics, and everyone was reading the same books. Such books had a long life, and we wanted to write books that would last for twenty to thirty years. Luckily our

Katsumi Nomizu and Shoshichi Kobayashi. Source: Shoshichi Kobayashi, "My Teachers, My Friends and My Mathematics: The Period when I studied in America" (in Japanese), Sugaku Seminar (Nippon Hyoron Sha Co. Ltd.), July 1982 21(7), pp. 55–58. (Republished in February 2013: Special Issue: Shoshichi Kobayashi).

book was selected into Wiley Classic Library Series and has survived until today, and has the honor of receiving this Award. Now I have mixed feelings: While on one hand I wish to live longer than this book by paying attention to my own health, I wish on the other hand that this book won't go out of print for another twenty to thirty years."

While they were together at Strasbourg in 1954, **Nomizu** stirred up Shoshichi, saying "Why don't you study in the U.S., instead of returning directly to Japan?" Since Shoshichi felt that he needed about a year to make a doctoral thesis out of the results he obtained at Strasbourg, he became seriously interested in following Nomizu's suggestion. He wrote to the University of Seattle in Washington, where Carl Allendoerfer (who gave the first proof of the Gauss–Bonnet theorem) was, and to the University of Chicago, where S.S. Chern (who gave a simpler proof of the same theorem) was. No sooner had the application form from a secretary of the Department Chair's office of Chicago arrived than Shoshichi received a letter from Allendoerfer (the then Department Chair) offering him an assistantship. So he jumped at this opportunity, without thinking of anything else [26].

Shoshichi left France in early September 1954 by the "Ile de France" Ocean Liner, and arrived in New York five days later. He writes in [26]: "As our ship approached the Statue of Liberty, the skyline of Manhattan, numerous automobiles on the highway along Hudson River came into sight. New York looked like a huge and advanced city, compared with Tokyo and Paris. ... With 50 dollars in my pocket, I could not afford sightseeing of New York, so after spending one night in New York, I took a Greyhound Bus straight to Seattle, where I arrived three days later."

Carl B. Allendoerfer (1911–1974). Source: Wikipedia. Public domain.

Shoshichi describes his first meeting with **Carl Allendoerfer** (1911–2004) [26]: "... Having been the department chair for a while, he was a pragmatic man. When I went to greet him upon my arrival, he surprised me by starting our conversation by asking 'Do you have enough money for now? If not, I could pay your assistantship in advance.' In truth I was short of money but felt that it would be rather disgraceful to borrow money immediately after the arrival, so I ended up with saying 'I am OK.' After we were talking for a while, he probably found that with my poor English I could not serve well as a TA (teaching assistant), so he changed my title from TA to RA (research assistantship) immediately .... The Mathematics Department of the University of Washington improved significantly during his 20 year tenure as the chair. ..."

Allendoerfer [30] graduated from Haverford College of Pennsylvania in 1932, and went to Oxford as a Rhodes scholar from 1932 to 1934. He received his Ph.D.

from Princeton in 1937, with Oswald Veblen as the advisor. He became well known for his 1943 paper with André Weil on a proof of the Gauss–Bonnet theorem [31]. He was with the Institute for Advanced Study, Princeton in 1948–49, and in 1951 he became professor and soon after the chair of the Mathematics Department at the University of Washington.

Carl Allendoerfer with Kentaro Yano in 1961. Source: Shoshichi Kobayashi, "My Teachers, My Friends and My Mathematics: The Period when I studied in America" (in Japanese), Sugaku Seminar (Nippon Hyoron Sha Co. Ltd.), July 1982 21(7), pp. 55–58. (Republished in February 2013: Special Issue: Shoshichi Kobayashi).

Shoshichi writes about his Seattle days [26] "Since I thought that if I write up what I worked on in France, that will make a Ph.D. thesis, I felt at ease after having passed the language exams (German and French) and the Ph.D. qualifying exam (which tested mathematics at the level of what we learned in the third and fourth years at undergraduate and in the first-year graduate). So I spent my time by thinking about holonomy and transformation groups that I learned from Dr. Nomizu and **Lichnerowicz** while I was in France. I also studied complex manifolds and attended Italian language classes.

There were not many interesting seminars, so I got a little bit bored. In 1955, my second year, **Hsien Chung Wang** (Ph.D. University of Manchester, 1948) [32] came from Princeton (1954–55). He became well known about two years earlier for his work on classification of simply connected compact complex homogeneous spaces. He was a very versatile mathematician working in such a wide range of fields as topology, differential geometry, and Lie groups. His lecture on complex manifolds was perspicuous . . . "

Wedding of Shoshichi with Yukiko Ashizawa, St. Mark Cathedral, Seattle, May 11, 1957. Source: Kobayashi Family Photo Album.

Shoshichi completed his Ph.D. thesis in the spring of 1956, in less than two years after his arrival at Seattle. The dissertation title was Theory of Connections. He was then appointed a post-doctoral fellow at the Institute for Advanced Study, Princeton (1956–58). Albert Einstein (1879–1955) died a year before Shoshichi moved to Princeton. Shoshichi got married to **Yukiko Ashizawa** in May 1957 after his first year at Princeton and Yukiko had completed her study at Seattle. Their first daughter Sumire was born in 1958 at Princeton. Sumire studied biochemistry at Princeton University, where she met her future husband Philip Chou, who was an electrical engineering

student. They now live outside Seattle where Phil is a Manager at Microsoft Research. Their first son Andrew got his BS and MS degrees in Computer Science from Stanford in 2013 and now works for Coursera, a major player in MOOC (Massive Open Online Course). Their second son Brendan is currently a junior in Princeton's Dept. of Mechanical & Aerospace Engineering. Sumire's younger sister Mei studied chemistry at Princeton. So there are a lot of Princetonians in the Kobayashi family, myself included.

In the fall of 1958 Shoshichi moved to MIT as a Research Associate. **Warren Ambrose** (1914–1995), whom Shoshichi had met in Paris five years earlier, and his associate **Isadore M. Singer** (1924–) were Shoshichi's sponsors at MIT [33]. In the fall of 1959, he received an offer of Assistant Professorship from UC Berkeley, but because he had entered the U.S. with a J-1 visa (exchange visa) when he moved from Strasbourg to Seattle, the U.S. immigration law required him to leave the U.S. for at least two years. With help from Berkeley, he found an assistant professor position at the University of British Columbia in Vancouver, Canada, where he taught for two and half years from January 1960 until the summer of 1962.

Chern, Shiing-Shen (1911–2004). Source: Oberwolfach Photo Collection. © Gerd Fischer, München, 1985. Reprinted with perm.

In September 1962 he finally joined the faculty of Berkeley as Assistant Professor, was promoted to Associate Professor a year later, and then to Full Professor in 1966. He was attracted to Berkeley, because one of the greatest differential geometers of the 20th Century **Shiing-Shen Chern** (1911–2004) moved from the University of Chicago to Berkeley in 1960 with a mandate to build a geometry group at Berkeley.

Chern was born in China, entered Nankai University in 1926 at age 15 and received his B.Sc. in 1930, then went to teach at Tsinghua University in Beijing, while he enrolled there as a candidate for master's degree, which he obtained in 1934. That was the first master's degree in mathematics ever issued in China [34]. In 1934 he went to the University of Hamburg, Germany on a scholarship and received his Ph.D. in 1936. His thesis advisor Wilhelm Blaschke (1885–1962) recommended Chern to study with Élie Cartan in Paris, where he met Kentaro Yano from Japan, who later became Shoshichi's advisor at Tokyo. After returning to China, Chern taught in Tsinghua again from 1937 till 1943, and then he was invited by Princeton's Institute (1943–46). Chern became well known for providing a simpler proof of the Gauss–Bonnet Theorem in 1944 [35] than Allendoerfer–Weil's proof published a year earlier [31]. He introduced what is called the Chern classes, which are characteristic classes associated with complex vector bundles. Shoshichi's expository article [33] and his memoir of Chern [36] provide a rather comprehensive account of Chern's profound contributions to modern differential geometry.

Chern taught at the University of Chicago from 1949 till 1960. **Katsumi Nomizu** was his first student, and Shoshichi's longtime colleague at Berkeley **Joseph Wolf** [37] received his Ph.D. under Chern in 1959. Chern produced 31 Ph. D students at UC Berkeley, including **Alan Weinstein** in 1967 [38], another colleague of Shoshichi at Berkeley. **Shing-Tung Yau** [39], a 1982 Fields medalist, was also Chern's student (1971). Shoshichi wrote two expository articles on Yau's contributions in Japanese mathematical journals [40, 41].

4. Shoshichi's Students and Collaborators

Shoshichi produced 35 Ph.D. students, all at Berkeley. Table 2 shows his students in the chronological order of their years of Ph.D. degrees granted. Added also are their current affiliations, wherever known. The numbers of their descendants in the right-most column are based on the data obtained from the Genealogy Project. These numbers will obviously change in the future, so the numbers given here serve as lower bounds. As of this writing, Shoshichi has 71 descendants. The fact that Shoshichi produced as many as 35 Ph.D.'s during his appointment of 34 years (from 1960 to 1994) at Berkeley is a testimony of his commitment to education.

Shown on the next page is a photo taken in the fall of 1992, when several of Shoshichi's students and some of the participants in the MSRI (Mathematical Sciences Research Institute) Program on Algebraic Geometry (organized by **Shigefumi Mori** of Kyoto University, 1990 Fields medalist) got together and celebrated Shoshichi's 60th birthday at Codornices Park in Berkeley.[1]

A special volume entitled *Geometry and Analysis on Complex Manifolds: Festschrift for Professor S. Kobayashi's 60th Birthday* [43] (eds. **Toshiki Mabuchi**, **Junjiro Noguchi** and **Takushiro Ochiai**) was published in 1994, to which several of Shoshichi's former students and other mathematicians contributed their original work, like this memorial volume. The contributors were: **Marco Abate** and **Giorgio Patrizio**, **Shigetoshi Bando** & **Yum-Tong Siu**, **Ichiro Enoki**, **Zhuang-dan (Daniel) Guan**, **Yoichi Imayoshi**, **Toshiki Mabuchi**, **Hong-Jong Kim**, **Ying-chen Li**, **Junjiro Noguchi**, **Takeo Ohsawa**, **Yongbin Ruan**, **Satoru Shimizu**, and **Burt Totaro**.

Shoshichi's publication list is posted on the Shoshichi Kobayashi Memorial website [44] including his technical books, tutorial articles and essays published in journals, and an essay book. A list of his 150 plus publications, sorted in chronological order, can be found at [45]. By reviewing this list, we can find his research collaborators. **Takushiro Ochiai** (Ph.D. University of Notre Dame 1969; Advisor, Tadashi Nagano) has 14 joint papers with Shoshichi: (from 1970 to 1982). **Tadashi Nagano** (Ph.D. University of Tokyo 1959; Advisor Kentaro Yano) has 10 joint papers with Shoshichi. Nagano and Shoshichi were together in Prof. Yano's Seminar, thus they are academic siblings, so to speak, and Ochiai is an academic nephew of Shoshichi. Nagano gives a comprehensive survey (11 pages) of Shoshichi's work in [46], which he prepared for the occasion when Shoshichi received the Geometry Prize of the Mathematical Society of Japan in 1987.

[1]For more photos of the party, click on
http://mathcs.holycross.edu/~ahwang/misc/kobayashi_60th_birthday.zip

At Codornices Park in Berkeley, fall 1992. Reprinted by courtesy of Andrew D. Hwang (College of the Holy Cross). © Andrew D. Hwang. Reprinted with permission.

First row: 1. H.C. Yang, 2. Yungbin Ruan, 3. Yukiko Kobayashi, 4. Shoshichi, 5. Nina Morishige, 6. Keiji Oguiso (Osaka University).
Second row: 7. Andrew D. Huang (1993), 8. Shigefumi Mori (Kyoto University, 1990 Fields medalist), 9. Liaw Huang (1993), 10 Ying-Chen Li (1991), 11. Wang Sang Koon, 12. Zhuang-dan (Daniel) Guan (1993).
Third row: 13. Keizo Hasegawa (1987), 14. Masanori Kobayashi (Tokyo Metropolitan University), 15. Hajime Tsuji, 16. Raphael Laufer (1997).

Other joint authors include **Geneviève Avérous**, **W.M. Boothby**, **M.P. do Carmo**, **S.-S. Chern**, **Samuel I. Goldberg**, **Hsin Chu**, **Jun-ichi Hano**, **Camilla Horst**, **Masahisa Inoue**, **Peter Kiernan**, **Katsumi Nomizu**, **Yoshihiro Ohnita**, **Takeshi Sasaki**, **Eriko Shinozaki**, **Masaru Takeuchi**, **H.C. Wang**, and **Hung-Hsi Wu**.

Shoshichi's 10th Ph.D. student, **Michael Minovitch** (1970) [47] is known as a "planetary pioneer" for his gravity-assisted trajectory theory that was used by NASA in designing energy efficient trajectories of such interplanetary spacecrafts as Mariner 10 in its voyage to Venus and Mercury in 1973 and Voyager in its Planetary Grand Tour in 1976. His Ph.D. thesis under Shoshichi was entitled Mathematical Methods for the Design of Gravity Thrust Space Trajectories. "Credit for the first rigorous analysis of the concept after the start of the Space Age belongs to Michael Minovitch," writes David Portree, a spaceflight historian [48]. Minovitch's 1961 Jet Propulsion Laboratory internal document, "A method for determining

interplanetary free-fall reconnaissance trajectories," provided the first numerical solution to the **three-body problem**, one of the famous unsolved mathematical problems. His numerical solution offered the theoretical possibility of free and unlimited space travel anywhere in the entire solar system. He was interviewed in BBC's Science Program in October 2012, which can be viewed on You Tube [49].

Shoshichi's 25th Ph.D. student **Burt Totaro** (1989) [50] recently moved from the University of Cambridge, UK to UCLA. At Cambridge he was the Lowndean Professor of Astronomy and Geometry. "Burt is best known for his 1997 paper, 'The Chow ring of a classifying space.' The most impressive aspect of Burt's work is its remarkable breadth and depth, encompassing algebraic geometry, representation theory, topology, and combinatorics" says Shoshichi's academic brother, **James Carrell** (Ph.D. 1967, University of Washington; Advisor, Carl Allendoerfer), who is a professor at the University of British Columbia.

5. Shoshichi Kobayashi's Friends

Takushiro Ochiai's article in this volume "In Memory of Professor Shoshichi Kobayashi" gives a comprehensive account of Shoshichi's contributions as a researcher and a teacher. The February 2013 issue of Japanese popular mathematical journal, Sugaku Seminar, (Nippon-Hyoron-Sha) was the special issue dedicated to Shoshichi Kobayashi. The contributors were **Takushiro Ochiai**, **Hisashi Kobayashi**, **Masao Hattori**, **Ichiro Satake**, **Keizo Hasegawa**, **Yoshiaki Maeda**, **Junjiro Noguchi**, **Makiko Tanaka**, and **Toshiki Mabuchi**. Shoshichi's July 1982 essay [26] was republished in this issue.

The Shoshichi Kobayashi Memorial Website [51] provides an archival record of Shoshichi's biography, books and articles, photo gallery, and the remembrance speeches delivered at his Memorial Services held at the chapel of Sunset View Cemetery, El Cerrito, California on September 8, 2012 (**Hisashi Kobayashi**, **Mei Kobayashi**, **Alan D. Weinstein**, **Arthur E. Ogus**) [52]. The webpage also posts a condolence message from **Heisuke Hironaka** (1970 Fields medalist) & **Wakako Hironaka** [53].

On May 22–25, 2013, Geometry and Analysis of Manifolds: A Memorial Symposium for Professor Shoshichi Kobayashi was held at the Mathematical Science Building of the University of Tokyo (Komaba campus), organized by **Takushiro Ochiai**, **Yoshiaki Maeda** and others, and hosted by Dean **Takashi Tsuboi**. The symposium was attended by more than 130 mathematicians [54]. The invited speakers were: **Ichiro Enoki**, **Akito Futaki**, **Gary Jensen**, **Shinichiro Matsuo**, **Reiko Miyaoka**, **Joël Merker**, **Hiraku Nakajima**, **Junjiro Noguchi**, **Takeo Ohsawa**, **Makiko Tanaka**, **Hajime Tsuji**, **Paul Vojta** and **Shing-Tung Yau**. Programs and abstracts are found in [55]

On May 25, 2013, following the above symposium, a "Memorial Reception for Prof. Shoshichi Kobayashi," also organized by **Takushiro Ochiai** and **Yoshiaki Maeda**, was held also at the Komaba campus, with more than one hundred participants [56]. The speeches of the following individuals are also posted (in both English and Japanese) at the above website: **Takushiro Ochiai**, **Takashi Tsuboi**, **Paul**

Table 2a. Academic Descendants of Shoshichi Kobayashi, part 1

	Name Current Affiliation	Year of Ph.D. Nr. of Descendants
1.	Sebastian Su Koh West Chester University (Retired)	1964
2.	Francis Joseph Flaherty Oregon State University (Emeritus)	1965 5
3.	Vivian Yoh Kraines Meredith College	1965
4.	Gary Richard Jensen Washington Univ. St. Louis (Emeritus)	1968 10
5.	Myung He-Son Kwack Howard University (Emeritus)	1968 1
6.	John Robert Zumbrunn Equinox Fund Management LLC	1968
7.	Carlos Edgard Harle University of São Paulo, Brazil (Emeritus)	1969
8.	Peter Kiernan University of British Columbia (Emeritus)	1969
9.	John Douglas Moore University of California, Santa Barbara	1969 3
10.	Michael Andrew Minovitch Phaser Telepulsion Inc., Los Angeles	1970
11.	Roy Hiroshi Ogawa University of Nevada, Las Vegas (Retired)	1971
12.	Geneviève Maynadier Avérous CNAM (Conservatoire national des arts et métiers)	1974
13.	Rune Zelow Lundquist In Oslo, Norway	1977
14.	Toshiki Mabuchi Osaka University, Japan	1977
15.	Michael Jay Markowitz Information Security Corporation	1979
16.	Andrew Joseph Balas University of Wisconsin-Eau Claire (Deceased in 2003)	1980
17.	Blaise Grayson Morton University of Minnesota & Whitebox Advisors LLC	1981
18.	Jay Alan Wood Western Michigan University	1982

Table 2b. Academic Descendants of Shoshichi Kobayashi, part 2

	Name Current Affiliation	Year of Ph.D. Nr. of Descendants
19.	Jae-Hyun Yang Inha University, Korea	1984 8
20.	Ahmad Zandi-Bami Ulysses Strategic Services	1984
21.	Hong-Jong Kim Seoul National University	1985
22.	Ricardo Francisco Vila-Freyer Centro de Investigación en Matemáticas, Mexico	1986
23.	Keizo Hasegawa Niigata University, Japan	1987
24.	Alexander John Smith University of Wisconsin, Eau Claire	1987
25.	William Charles Jagy University of Texas at Austin (formerly)	1988
26.	Burt James Totaro University of California at Los Angeles	1989 9
27.	Ivona Maria Grzegorczyk California State University, Channel Islands	1990
28.	Janis Marie Oldham Agricultural and Technical College of North Carolina	1990
29.	Ying-Chen Li JP Morgan Chase	1991
30.	David Warren Gomprecht The Dalton School, New York City	1993
31.	Zhuang-dan (Daniel) Guan University of California, Riverside	1993
32.	Liaw Huang Terry Consulting	1993
33.	Andrew David Hwang College of the Holy Cross	1993
34.	Dae Yeon Won Duksung Women's University, Korea	1995
35.	Raphael Laufer Systems Planning and Analysis, Inc.	1997

Vojta, **Nobuo Naito**, **Yutaka Katase**, **Shigetoshi Kuroda**, **Gary Jensen**, **Shing-Tung Yau**, **Shuji Hosoki**, **Eriko Shinozaki**, **Toshiki Mabuchi**, **Akiko Ashizawa**, **Hisashi Kobayashi** and **Yukiko Kobayashi**. **Gary Jensen** (Ph.D. Berkeley 1968), Shoshichi's fourth student and a professor emeritus at Washington University, St. Louis, gave a very touching story about his relation with Shoshichi [57]. **Shing-Tung Yau** (Ph.D. Berkeley 1971; Advisor, S.-S. Chern) also gave a very moving speech [58] and composed a Chinese poem in honor of Shoshichi [59]. A memoir by **Yoshihiko Suyama** (in Japanese only), and a memoir by **Noboru Naito** (Shoshichi's classmate at Nozawa Middle School) are also found in [53].

The December 2013 issue of *ICCM Notices* [60] devotes 21 pages to "In Memory of Shoshichi Kobayashi," contributed by **Shing-Tung Yau**, **Hisashi Kobayashi**, **Noboru Naito**, **Takushiro Ochiai**, **Hung-Hsi Wu**, **Blaine Lawson** and **Joseph A. Wolf**. The December 2014 issue of *Notices of AMS* [61] will carry "Remembering Shoshichi Kobayashi," (**Gary R. Jensen**, coordinating editor). The contributors are **Toshiki Mabuchi**, **Takushiro Ochiai**, **Joseph A. Wolf**, **Hung-Hsi Wu**, **Robert Greene**, **Gary R. Jensen**, **Myung H. Kwack**, **Eriko Shinozaki**, **Hisashi Kobayashi**, and **Mei & Yukiko Kobayashi**.

Acknowledgment

A number of individuals helped me locate Shoshichi's 35 students. My special thanks go to Professors James Carrell, Keizo Hasegawa, Andrew Hwang, Gary Jensen, Ivona Grzegorczyk, Zhuang-dan Guan, Toshiki Mabuchi, Shigefumi Mori and Arthur Ogus. The author also thanks Brian L. Mark, Phil Chou and Sebastian Koh for their careful reading of the manuscript and editorial suggestions. Finally, this work would have been impossible, were it not for the "Mathematics Genealogy Project" and Wikipedia.

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Post Script

With the assistance of my academic sibling Prof. Vince Poor of Princeton University, I have found that we are academic descendants of Carl Friedrich Gauss (1777–1855): Our Ph.D. thesis advisor at Princeton was Prof. John Bowman Thomas:

John Bowman Thomas (1955, Stanford University)
Willis W. Harman (1948, Stanford University)
Karl Ralph Spangenberg (1937, Ohio State University)
William Littell Everitt (1933, Ohio State University)
Frederick Columbus Blake (1906, Columbia University)
Ernest Fox Nichols (1897, Cornell University)
Edward Leamington Nichols (1879, Universität Göttingen)
Johann Benedict Listing (1834, Universität Göttingen)
Carl Friedrich Gauss (1799, Universität Helmstedt)

Dr. Michael Gerver of Technion confirmed through the archival office of the Universität Göttingen that Johann Listing was the thesis advisor of the American physicist Edward Nichols. Both the Wikipedia and the Mathematics Genealogy project incorrectly record Hermann von Helmholtz (1821–1894) as Nichols' advisor. Helmholtz was a professor of Universität Berlin, not Göttingen. Nichols worked

with Helmholtz at Berlin before he moved to Göttingen, where he submitted his doctoral dissertation with Listing as the advisor.

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