An Interview with Susan Friedlander

Conducted by Karen Hunger Parshall and Sergei Tabachnikov

Susan Friedlander is an English-born American mathematician whose research has focused generally on fluid dynamics and in particular on the Navier–Stokes equations. She has spent her career as an active member of the American mathematical community, teaching at the University of Illinois in Chicago and now at the University of Southern California, directing graduate students and serving in such positions as associate secretary of the American Mathematical Society (AMS), as a member of the AMS's Council, and as editor-in-chief of the *Bulletin of the AMS*. The questions for this interview were prepared by Karen Hunger Parshall and Sergei Tabachnikov, the *Mathematical Intelligencer*'s editors-in-chief, and answered by Susan Friedlander in August 2024.

Karen and Sergei: You were born in London and did your undergraduate work at University College, but a Kennedy Scholarship brought you to the United States to study at MIT. Could you describe the Kennedy Scholarship program? How would you say the scholarship that you won shaped you as a mathematician?

Susan Friedlander: In 1964, a British National Memorial was created in memory of President John F. Kennedy. The Kennedy Trust decided that there would be a "living memorial," namely a Kennedy scholarship program that sent about twelve graduate students a year to enroll at either MIT or Harvard for a year. Since 1966 there have been over 550 awards. As the British prime minister put it in 1965, "This succession of Kennedy Scholars keeps John Kennedy's memory fresh." The expectation for a scholar was not to obtain a degree but to experience a year embedded in the academic life of the United States, make contacts, and return to the UK to advance their career. This is indeed the path that many Kennedy Scholars have taken. The list of top politicians, judges, and academics who are former Kennedy Scholars is notable. In a sense, the Kennedy Scholarship can be viewed as the Rhodes Scholarship in reverse.

I was awarded a Kennedy Scholarship in the second year of the program, and I was supported at MIT from 1967 to 1969. At that time, the Kennedy family took considerable interest in the Kennedy Scholars. For example, soon after the group of us arrived in Cambridge we were invited to the "Kennedy Compound" in Hyannis, Massachusetts, and hosted by Ted Kennedy and his wife, Joan. At the time, I was 21, and I had never been in the United States before. Everything was new and exciting to me. This included my initiation into the mathematics department at MIT. The first afternoon, when I went to "tea" on the second floor of Building 2, I encountered a friendly more senior graduate student named Eric. He worked in algebraic geometry, whereas my field was fluid dynamics. However, although at that time the MIT math department had a definite split between "pure" and "applied," Eric and I became close. In the summer of 1968 we were married, and I became Susan Friedlander. My original plans were to use the Kennedy Scholarship to spend one year experiencing academic life in the US and return to the UK for a PhD program at Cambridge. But marriage changed my plans completely! (See Figure 1.)

Having brought me to the United States, the Kennedy Scholarship very definitely shaped me as a person. It shaped my academic career, which for personal reasons, turned out to be fully in the United States. My mathematical interests naturally developed over more than fifty years, but they continue to be motivated by fluid dynamics, which is the topic that I discussed in my application for a Kennedy Scholarship.

Perhaps I might do a little "advertising" to illustrate how my mathematics developed over my career. In 2021, the AMS *Notices* published an article commissioned by its editors entitled "Susan Friedlander's Contribution to Mathematical Fluid Dynamics" (March 2021, 331–343). This article was a delightful surprise to me. It was written by a group of my former graduate students, postdocs, and collaborators: Alexei Cheskidov, Nathan Glatt-Holtz, Nataša Pavlović, Roman Shvydkoy, and Vlad Vicol (see Figure 2). They all have had very successful academic careers. I am truly honored and grateful to them for writing this article about my work and for their very kind words about my mentorship.

K. P. and S. T. After earning your master's degree at MIT, you did your PhD at Princeton and had a postdoc at the Courant Institute. How did that come about?

S. F. I was very lucky in several respects. I wanted to stay with Eric, who was completing his doctoral thesis with Michael Artin at MIT. I requested a second year of funding from the Kennedy Scholarship Trust, which was granted. I also applied to the MIT Mathematics Department to become a graduate student in their PhD program, and that, too, was approved. I then started to work on a thesis with Louis Howard on the topic of waves in a rotating stratified

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Figure 1. Susan Friedlander's wedding, Cambridge, 1968.

Figure 2. Working at home with Alexei Cheskidov and Roman Shvydkoy, 2008.

fluid. My third year at MIT, 1970, was Eric's fifth, in which he received his PhD and was offered an instructorship at Princeton. This was exciting for both of us. I then applied to the graduate school at Princeton, and I was once again lucky, because this was both shortly after Princeton had first begun to admit women graduate students and also when applied mathematics was developing there. I entered as the first student in a new program in geophysical fluid dynamics. My MIT thesis fit exactly in that subject. I continued to work with Louis Howard and completed my PhD thesis, which I submitted to Princeton in 1972. By this time, Eric was an assistant professor at Princeton. I looked for a job within commuting distance of Princeton and had

Figure 3. Eric and Susan Friedlander going to a British reception in Chicago, 1988.

the good luck to get a postdoc at the Courant Institute, which was an excellent place for applied mathematics. I was part of a group working in fluid dynamics including Eugene Isaacson, James Stoker, and Steven Childress. In 1975, Eric and I went on the job market with the hope of solving our personal "two-body problem." The solution was an associate professorship for Eric at Northwestern and an assistant professorship for me at the University of Illinois in Chicago (see Figure 3).

K. P. and S. T. You have been teaching at American universities for a long time. In your opinion, have students changed over the years, and if so, in what way?

S. F. From 1975 to 2008 I taught at the University of Illinois Chicago (UIC), moving up the professorial ladder from assistant to full professor. The name of the department became longer, ultimately to become the Department of Mathematics, Statistics and Computer Sciences. The interests and studies of the students also became broader along with the expertise of the faculty. However, my own undergraduate teaching stayed focused on introductions to such "standard" math topics as calculus, differential equations, and complex variables. UIC is a state university located in the center of Chicago, and its student body is very ethnically and culturally diverse. The mathematical abilities of the students are also very mixed. In my observation in over thirty years at

UIC, the only really noticeable change was the arrival of more undergraduate students with a Chinese background. In terms of graduate students, the number coming from outside the USA grew considerably. On the whole, their mathematical training and abilities were stronger than the US-born students. I suspect that such observations from UIC hold for many math departments in the United States.

In 2008 I moved to the University of Southern California (USC). This is a large private university, once again in the center of a huge city, namely Los Angeles. The student population is also very diverse, but it includes more students from wealthy families than were to be found at UIC. I became the director of the Center for Applied Mathematical Sciences at USC. Most of my teaching involves mathematical techniques for undergraduates in mathematically related subjects such as physics, engineering, computer science, and economics. Some of these students are very strong, and quite a number come from China and India.

K. P. and S. T. What is your opinion about the teaching of K-12 mathematics in American schools? In the UK? In the world in general? Do you think that one needs to fight the common "I hate math" attitude, or do you think it is just the "normal" reaction of the average person?

S. F. Eric and I do not have children, so my opinions about teaching K-12 mathematics in American schools are not informed by direct experience. But I am certainly interested in comments from friends and colleagues on the subject. One specific topic that I have followed is the so-called California Math Wars, which is both an "old battle" dating back more than twenty years and a very active "current battle." The fundamental conflicts involve math educators from schools of education versus research mathematicians. Every decade or so, the California educational establishment produces a proposal for a "California Mathematics Curriculum Framework" to be adopted in K-12 schools across the state. Such a process is happening now, and the Framework-writing committee is headed by a math educator from Stanford. The current Framework proposal is strongly opposed by various groups of research mathematicians. One point of opposition is that the Framework would discourage mathematically talented children from progressing more rapidly than their less-talented or less-accomplished classmates (i.e., tracking would be discouraged in public schools). To illustrate my opinion, in 2021 I signed, along with over one thousand other mathematicians, an open letter to Governor Newsom opposing the proposed Math Curriculum Framework. The "Math Wars" battles have received considerable publicity in the past two years. My friend Svetlana Jitomirskaya (currently a professor at UC Berkeley) and a very energetic opponent of the Framework, recently filled me in on the latest status. She and a relevant committee involved in the University of California system wrote a report concerning high-school criteria for entering the UC system that would be "dumbed down" if the Framework were to be adopted. Svetlana told me the good news that their committee's report had just been approved by the University Board of Admissions and Relations with Schools. This is a welcome victory in a battle of the California Math Wars!

Concerning the world in general, there is clearly overwhelming data available showing that American schools are falling behind in all subjects. We see this in mathematics, where the numbers of research mathematicians at all levels of their careers are dominated by people who were trained in secondary schools outside the United States. It is often easy to observe at a seminar dinner that most of the participants did not go to K-12 schools in the United States. Sometimes, Eric is the only person who did: he went to a school in rural Virginia, where his most positive experience was that he was left alone to study at his own pace.

I don't think I often encounter an "I hate math" attitude. I believe most people are more likely to be indifferent to math. However, I think that there is a definite community of non math users who are intrigued by math. I see an increasing trend in our math world to promote activities that popularize mathematics, from the creation of MoMath to outreach activities sponsored by United States mathematical institutes and societies. In this context, the Simons Foundation has provided extraordinary support for mathematics and related fields.

K. P. and S. T. You are an applied mathematician. What would you say are the main open problems in applied mathematics as we head into the second quarter of the twenty-first century?

S. F. Whether I am an applied mathematician might be open to debate. This is reflected in my personal choice for an important open problem that connects with both "pure" and "applied" mathematics, namely the famous Millennium Prize Problem concerning the global regularity for the system of nonlinear PDEs known as the Navier–Stokes equations. The following is a succinct statement of the problem. Prove or give a counterexample for the following statement: in three space dimensions and time, given an initial velocity field, there exist a velocity vector and a scalar pressure field that are both smooth and globally defined that solve the Navier–Stokes equations. Investigation of the properties of the Navier–Stokes equations has a very rich history that predates the Millennium Prize by centuries. There are many significant results from the viewpoint of theoretical PDEs as well as computational investigations. There is a vast literature on the Navier–Stokes equations including works by the amazing mathematician Terry Tao, whose blog post in 2007 gives reasons why this Prize problem is so hard and continues to challenge all the attempts of experts.

One reason that this problem is so important as an applied mathematical example is its close connection with the physical phenomenon of turbulence. Chaotic behavior of fluids is ubiquitous in our everyday world and has implications from weather prediction to blood flow. In turbulent flows, energy cascades through a series of scales that produce chaotic swirling changes in velocity. In the 1940s, the great Russian mathematician Andrey Kolmogorov postulated that for very high Reynolds numbers, these small-scale turbulent eddies are statistically isotropic. Furthermore, the statistics of small scales are universally and uniquely determined by parameters called the kinematic viscosity and the energy dissipation rate. Although there is considerable experimental evidence for Kolmogorov's "law of turbulence," to date, there are no known examples for which it has been proved rigorously from the Navier–Stokes equations.

Richard Feynman once described turbulence as the most important unsolved problem in classical physics. It remains so to this day.

K. P. and S. T. Vladimir Arnold once quipped, in his article "Topological Problems of the Theory of Wave Propagation," that there is no applied mathematics as such, just applications of mathematics. He went on to say, "The difference between pure and applied mathematics is not scientific but only social. A pure mathematician is paid for uncovering new mathematical facts. An applied mathematician is paid for the solution of quite specific problems." What do you think of Arnold's point of view?

S. F. As one might guess from my answer to the previous question, I prefer to view the description of "pure" versus "applied" mathematics as a continuum rather than to delineate the differences. Arnold's quip is amusing, but payment is often not the primary motivation for one's choice of research topics.

Perhaps I might use this question as a handle to discuss the importance of Russia in my mathematical career. In 1988, I went to Moscow at the invitation of the Institute of the Physics of the Earth. As Sergei knows well, it was hard for Jewish mathematicians to get positions at Moscow State University,, and quite a number of "pure" mathematicians had positions at Institutes of the USSR Academy of Sciences whose titles were very "applied." I had interests in common around the subject of instabilities in geophysical fluid dynamics with a young Russian mathematician named Misha Vishik, and he arranged for me to visit his institute in the fall of 1988 (see Figure 4). It was an amazing experience for me, both culturally and scientifically. Misha and I began a successful collaboration in which we applied concepts of geometry and topology of fluid flows initiated by Vladimir Arnold. We used pure mathematics to study instabilities in magnetohydrodynamics as it relates to large-scale motions in the Earth's fluid core.

Figure 4. Susan Friedlander and Misha Vishik at the Peterhof Gardens, Leningrad, 1989.

I discovered that the mathematical community in Moscow was very interconnected. Through Misha, who was initially a number theorist, and his father, Mark Vishik, who was a distinguished analyst, I met many mathematicians whom I had known before only by reputation. The list included the famous PDE women Olga Oleinik in Moscow and Olga Ladyzhenskaya in Leningrad. I went back to Moscow again in 1989 as the Soviet Union was collapsing. The mathematical environment continued to be stimulating and exciting but very unsettled. It was even a challenge to find food and basic necessities. Friends that I had made in Moscow were beginning to discuss emigration, which at the time was difficult.

There were plans made in the American mathematical community to try to help the Russian mathematical community in practical ways. In the 1990s I became involved in such activities organized by the AMS. For example, we raised money whose actual delivery to people in Russia needed to be done by "creative" methods. After the fall of the Soviet Union in December 1991, the chaos that ensued made academic life difficult, so even math books and journals were limited. In the years 1992–1997, I was chair of an AMS committee to help mathematical libraries in the former Soviet Union, and I was the cochair of the International Studies Fund Russian Grant selection panel. I am honored that in 1995 I was elected an honorary member of the Moscow Mathematical Society in recognition of my help in difficult times.

K. P. and S. T. The *Bulletin of the American Mathematical Society*, founded in 1891 under the title *Bulletin of the New York Mathematical Society*, was the first journal supported by the society. When you became its editor more than a century later in 2005, you were the journal's first female editor. When you stepped down as editor earlier this year, you became one of the journal's longest serving editors, surpassed only by Frank Nelson Cole. Could you describe the challenges you faced guiding this major publication? What were the main rewards of the job? The primary headaches?

S. F. As Karen knows, the first issue of the *Bulletin of the American Mathematical Society* was published in 1891, which makes it not only the original journal of the AMS but also one of the oldest prestigious journals covering a broad range of mathematics in the world. I was therefore a little overwhelmed when John Ewing approached me with the suggestion that I become the chief editor at the retirement of Donald Saari in 2005. Don was an excellent chief editor who admirably fulfilled the main goal of the *Bulletin* to inform the general mathematical community about current advances, directions, and ideas in mathematics. I had extensive editorial experience with the AMS as a member of the Editorial Committee of the *AMS Notices* (1993–2016) and chair of the *AMS Colloquium Publications* (1996–2005). On thinking it over, I told John Ewing that it would be an honor and a challenge to do my best to guide the *Bulletin* and continue the tradition of excellent expository articles while introducing innovations.

One of my first innovations concerned the covers. The venerable green *Bulletin* of the twentieth century made way for a new type of cover for the new millennium. I introduced the purple trim surrounding a pale cream background, which allowed a "wash" for the reproduction of a background photograph. Each issue had a different wash of an image that has a connection with material inside. Often this material reflected historical documents, objects, and photographs from the mathematical world. A clear copy of the image was printed inside each issue. For many years, between 2006 and 2019, the covers and short, erudite "about the cover" articles were created by Gerald (Jerry) Alexanderson. He generously allowed us to use material from his extensive collection of antiquarian mathematical books, documents, and objects. In total, Jerry produced about fifty wonderful cover images and articles for the readers of the *Bulletin* to enjoy.

During my term as chief editor, the *Bulletin* published a number of memorial issues featuring the work of distinguished mathematicians who had recently died. The cover of each of these issues shows a photograph of the mathematician to whom the memorial issue is dedicated. For me, three of these memorials were particularly poignant, namely those for Vladimir Voevodsky, Andrei Suslin, and Yuri Manin (see Figure 5). I first encountered these brilliant mathematicians during my trips to Russia at the dissolution of the Soviet Union. In the 1990s, Eric Friedlander arranged to bring all three to various positions at Northwestern (Eric was chair of the Mathematics Department). We became good personal friends with all three, who were not only exceptional as mathematicians but were also remarkable people. We mourned their deaths.

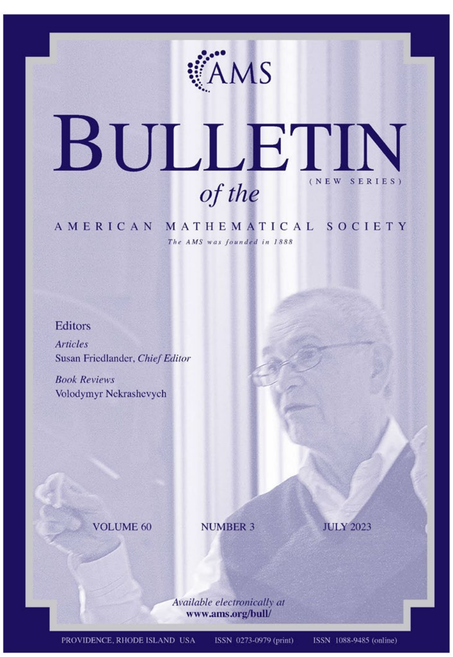

Figure 5. Yuri Manin on the cover of the AMS Bulletin, Vol. 60, no. 3, 2023. Photo courtesy of IHES.

In terms of "headaches," there was really only the perennial problem that all editors face, namely ensuring that authors produce their promised articles on time. For example, each January issue was dedicated to publishing the articles by the four lecturers at the Current Events Session at the preceding January's Joint Math Meeting. This concept was initiated and organized by David Eisenbud and modeled after the Bourbaki seminars in Paris. Most of the speakers honored their promise to send me their articles in good time for the scheduled January issue. However, a few tardy mathematicians needed many reminders.

K. P. and S. T. In addition to your service as the chief editor of the *Bulletin*, you were also very active in the American Mathematical Society (AMS) more generally, serving, for example, as associate secretary from 1996 to 2010 and serving on the Council from 1996 to 2024. Over the course of those years, what sorts of changes did you witness in the AMS?

S. F. If I might, I will first tell you a little about my experiences as an AMS associate secretary. There are four AMS associate secretaries, who are responsible for overseeing the AMS Sectional Meetings. I was the associate secretary for the Central Section until I moved from Chicago to Los Angeles. I found the position interesting and on the whole enjoyable. The main work is to coordinate the components of the meeting: the host department, the speaker selection committee, and the AMS professional staff. The Sectional Meetings occur twice a year, so in the period 1996 to 2010 I became acquainted with quite a number of mathematics departments throughout the "center" of the United States. Every fourth year, each associate secretary works with the AMS secretary and staff to "create" the Joint Mathematics Meeting (JMM) in January. The number of participants at the JMMs increased during my years as an associate secretary to over six thousand, making the JMM the largest mathematical meetings in the world.

For me, the most interesting part of being an associate secretary was serving on the program committees for joint AMS foreign conferences, namely in South Africa (1996–1997), Australia (1998–1999), Spain (2001–2003), India (2001–2003), Germany/Austria (2002–2005), Poland (2005–2007), Shanghai (2006–2008), and Mexico (2009–2010). These AMS Joint Conferences grew in number and frequency during my time as an associate secretary. I found each fascinating, enjoyable, and with its own unique challenges.

At the AMS–Mexican conference in 2010, a group of us from various countries in the Americas laid the foundation for an Americas-wide quadrennial conference called the Mathematical Congress of the Americas (MCA).

I put my AMS associate secretary experiences to good use as a member of the steering committees for the MCAs held in Mexico (2013), Canada (2017), and Argentina (2021). I am currently busy helping with the first MCA to be held in the United States, which will be in Miami in July 2025. Since their inception, the trustees of the AMS have been very supportive of these hemisphere-wide congresses.

Now a few comments concerning changes in the AMS over "my" decades. This actually stretches from 1983, when I was a "young" elected member of the AMS Council, to the present year. AMS membership grew, the number of committees grew, and the membership of the Council grew. Activities and outreach grew. The organizational chart for governance of the Society and associated staff grew. Of course this is usually considered a positive evolution for most organizations. However, over the past few years, membership has actually declined, and many early-career mathematicians don't see the point of joining. From my point of view, one reason for this decline is that the AMS increased its involvement in controversial political issues with a bias to the "left." For example, in about 2017, the AMS hosted a controversial "inclusion/exclusion" blog until, following a change in AMS leadership, the blog was retired in 2021. The frequency of statements "in the name of the Society" voted by the Council increased over the years and became more focused on politics than mathematics. But this is not to say that in my early days the AMS did not have strong political voices expressing their opinions. I remember hearing Mary Gray speaking passionately at the Council concerning the Association for Women in Mathematics, of which she became the first president. Chandler Davis, famous for both his mathematics and his political stands in the McCarthy era, was an outspoken voice at Council meetings. As Sergei and Karen are well aware, Chandler Davis was for many years the editor and then the coeditor of the *Mathematical Intelligencer*.

K. P. and S. T. In 2021, you were one of the founding members of the Association for Mathematical Research (AMR). Could you describe the goals of the AMR? How do they differ from the goals of the AMS?

S. F. Eric and I were very pleased to be invited by AMR president Joel Hass to join the board of a new organization that he and several mathematicians were creating. The mission of the Association for Mathematical Research is simple, namely to support mathematical research and scholarship. This is prominently stated on the AMR web site www.amathr.org.

We strongly support such goals, and we respect the mathematicians who were organizing the AMR, so we agreed to be founding members of the board. As I have mentioned, I have had extensive service in the AMS, and I continue to appreciate its work in the context of supporting mathematical research and scholarship. However, as I have also observed, the AMS is a huge organization with many committees and very varied activities. The concept of a small, more focused association with expertise in communicating via the latest web technology appealed to me. I believe that my AMS editorial experience and my international conference organization brings a useful perspective to the AMR board. I note that in addition to Eric, two other former AMS presidents, James Arthur and George Andrews, agreed to join the original AMR board. This new organization definitely has roots in the AMS.

As our initial step to test the interest of the mathematical community, the board drafted a letter that we sent to about two hundred mathematicians informing them of our project and inviting them to become founding members of AMR. We were quite pleased with the positive response rate. With their permission, we then posted their names on our website, and the AMR went public.

Currently, the AMR is thriving, with about eight hundred members. It is open to all who wish to join. To remove financial barriers and encourage participation of all who are interested in supporting mathematical research and scholarship, there are no fees or dues. I urge readers of the *Intelligencer* to investigate the AMR web site and see the many ongoing AMR initiatives, including new "diamond open access journals," the AMR open access monographs, virtual distinguished lecture series, AMR mathematical prizes, and numerous lists of web-based resources for the mathematical world.

K. P. and S. T. In the January 11, 2022, issue of *Scientific American*, the AMR was described as reflective of a "schism in the field of mathematics." What is your take on why the AMR's founding generated controversy?

S. F. When AMR went public in 2021, the fact that its web site made no statement concerning the words "diversity, equity, and inclusion" and the broader politics of racial and social justice was interpreted by some mathematicians as implying that AMR was in opposition to other mathematical organizations that were prominently displaying their political opinions.

The invitation letter to become a founding AMR member stated, "Though individual members may be active in educational, social or political issues related to the profession, the AMR intends to focus exclusively on matters of research and scholarship."

Sadly, there are mathematicians who took exception to a mathematical society with the founding principle that the organization itself would be apolitical. There was a backlash, and certain members of the mathematical community sent aggressive e-mails to the publicly listed founding members urging them to resign from the AMR. Comments I received indicated that some of these e-mails particularly targeted women. A few of the initial founding members did indeed resign.

The 2022 *Scientific American* article publicized criticism of the AMR through the lens of a journalist, who discussed controversial opinions, articles, and letters that had appeared in AMS publications and various items posted on social media. Her article tilted towards progressive politics. However, people continued to join the AMR, look at the website, read the newsletter, and participate in AMR activities. Many of them liked what they saw.

Far from being reflective of a "schism in the field of mathematics," the AMR is happy to cooperate with other mathematical societies where common interests overlap. For example, there are many mathematicians worldwide who feel strongly that the future of mathematical publication and dissemination requires open access. AMR's publications are fully diamond open access. AMR membership is available to all without dues or fees. I am delighted to report that in 2024, AMR is on a roll!

K. P. and S. T. Thank you for agreeing to this interview and for sharing some photos with us. Let us close with a picture of you at your seventieth birthday party (Figure 6).

Figure 6. Susan Friedlander's seventieth birthday party, Los Angeles, 2016.

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