Arthur Jaffe

27 Lancaster Street
Cambridge, MA 02140

Telephone: (617) 492-7227 Fax: (617) 491-1449
E-mail: jaffe@math.harvard.edu

To: Members of the Mathematical Community
From: Arthur Jaffe
Date: November 12, 2002

As you may know, the Clay Mathematics Institute (CMI) held its annual meeting in Cambridge on October 30, 2002. This meeting was a great success, including the presentation of the 2002 Research Award to Oded Schramm and to Manindra Agrawal.

For your information, I attach the remarks that I made on that occasion. During its three and a half years of operation, I believe that CMI has become an important institution within the world of mathematics through its approximately twenty programs—ranging from the employment of researchers to the encouragement of gifted young students. In addition, CMI has had an enormous positive impact in shaping the perception of mathematics by those in the general public, as well as by leaders of the scientific community and federal agencies. The CMI plays a unique role as an independent foundation, devoted entirely to mathematics. CMI has never sought outside support, but has partnered with many other organizations.

I write now to let you know that after establishing the CMI, setting it on a very positive course, and devoting the past four years to its ongoing success, I have resigned as President of the foundation. I no longer oversee the ongoing or future programs of CMI, nor do I retain any formal or informal ties to CMI. I firmly hope that the CMI will continue in a robust form.

Personally, I shall remain as a professor at Harvard University. In that capacity I look forward to our continued interaction.

Remarks at the CMI Annual Meeting
Held October 30, 2002 at the American Academy of Arts and Sciences, Cambridge, MA
Arthur Jaffe, President

Welcome:
Good afternoon, and welcome to the fourth annual meeting of the Clay Mathematics Institute! My name is Arthur Jaffe; I am a mathematician and President of the CMI. Incorporated and endowed by the Clay family at the end of 1998, this private foundation celebrated its opening in Cambridge, announced the Millennium Prize Problems in Paris during 2000, celebrating the 100th anniversary of Hilbert's historic lecture, combined its 2001 annual meeting with the closing ceremony of the International Mathematics Olympiad in Washington, an event only once before held in the United

States. I want to welcome the Clays to this meeting: Landon Clay and Lavinia Clay, whose generosity has made this institute possible.

I also want to introduce a special guest. Bill Rundell is the new Director of the Division of Mathematical Sciences of the National Science Foundation, taking over from the venerable Philippe Tondeur. This NSF division remains the major source of mathematics research funding in this country, with its annual budget of almost 150 million dollars. So Bill is a person that most of us will get to know. Let us congratulate Bill on his new position, and thank him warmly for traveling from Washington to be with us today. Bill Rundell!

This week also marks the opening of our marvelous new CMI office space on the top floor of One Bow Street, which I invite you to visit. Our space was designed by the incredibly perceptive and imaginative architect Robert Olson and his Associates, whom many of you know by his prize-winning work, both locally and around the East Coast.

The CMI charter directs it "to increase and disseminate mathematical knowledge, to educate mathematicians and other scientists about new discoveries in the field of mathematics, to encourage gifted students to pursue mathematical careers, and to recognize extraordinary achievements and advances in mathematical research. The Clay Mathematics Institute will further the beauty, power and universality of mathematical thought." The past three plus years has seen much of this activity!

Today's unique meeting is dedicated to celebrating the achievements of four Clay Institute mathematicians. We will symbolize these heights of mathematical insight and public recognition by the work of these CMI Prize Fellows. Two of these Fellows, Manindra Agrawal and Oded Schramm, will receive the Clay Research Award, the special recognition awarded annually to one or two researchers by the CMI.

The other two Prize Fellows we celebrate received Fields Medals this August in Beijing. The Clay Institute awarded Laurent Lafforgue its Research Award at the Millennium meeting held in Paris at the Collège de France on May 24, 2000. The citation recognized Lafforgue's recent results on the Langlands conjecture. Just five days after that ceremony, while preparing a series of lectures on his work, Lafforgue found a gap in his own proof. The CMI insisted that Lafforgue keep his award, with good reason. Within months Lafforgue had repaired his work to universal acclaim.

The second Fields medalist is Vladimir Voevodsky, who will speak this afternoon. Vladimir was one of the original CMI Prize Fellows in 1999. Vladimir received his award for his work in solving the Milnor conjecture, and we are honored to have John Milnor with us today, himself a CMI Scholar. Let us welcome this mathematical legend to our meeting, Jack Milnor!

Vladimir Voevodsky worked for three summers for the CMI in Moscow, sometimes visiting and lecturing to researchers at the Independent University of Moscow, a unique organization formed eleven years ago to foster the education of mathematicians in Russia. Leading mathematicians who now live in the West come for visits to lecture at the Independent University. The CMI not only sponsors American lecturers at the Independent University of Moscow, but through its only grant, the CMI has over the past three years paid half the operating budget of that University.

But today's specific focus on these four mathematicians remains symbolic. It represents the recognition of past and future achievements by other CMI mathematicians, ranging in seniority

from the three external members of the Scientific Advisory Board (Alain Connes, Andrew Wiles and Edward Witten), to the extraordinary, gifted students who participated in the High School Seminar Program this spring.

The CMI offers employment to young mathematicians, generally under age 30, as Long-Term Prize Fellows. This allows them to work under ideal conditions for a period of up to five years. A LTPF may work at the location that best suits his or her research; it provides traveling and research expenses, as well as provisions for collaboration, in addition to a generous salary. Present and past LTPFs have played a leading role among research mathematicians. One of the ten Long-Term Prize Fellows, Manjul Bhargava, was featured in this month's issue of *Popular Science* as one of 10 Brilliant young American scientists. A second, Alexei Borodin, was appointed full professor at the California Institute of Technology barely 6 months after receiving his Ph.D. I welcome seven of these Long-Term Prize Fellows to the meeting today. I believe that your futures will be bright. More information can be found on the CMI web site.

At the other end of the age scale, the CMI has great interest in encouraging talented young girls and boys to pursue careers in mathematics. Each year we name an American Olympiad Scholar, as the student who in the opinion of the judges gives the most original, and correct solution to a problem in the American Mathematics Competitions. Last year approximately 500,000 secondary students competed in these events, which involved a final round of 250. The 25 judges, who do their work without having the names of the authors of the papers they read, unanimously recommended Michael Hamburg as the winner. The amazing thing is that in a similar competition one year earlier, Michael Hamburg was also named the winner! Today he is a freshman at Harvard.

Aside from the myriad of these and other CMI programs, approximately 20 in number, the CMI has also had an indirect influence. It has helped shape the attitude of members of the scientific community on the role of mathematics; it has brought to the attention of the public at large the importance and the relevance of supporting mathematics; and I believe that it has positively affected the attitudes of leaders of federal funding agencies in the wisdom of supporting mathematical research. In reaching out to the public, I find it wonderful that when British mathematican Martin Dunwoody thought that he could solve the Poincaré conjecture, a 98-year old problem in topology which many persons have thought they could solve over the years—though falsely—the public took great interest. I measure this by watching how the number of hits on the CMI web site varies from day-to-day. On April 26 of this year, shortly after the work of Dunwoody was reported in the Sunday Telegraph, and also shortly after mathematicians realized that his claimed proof was incomplete, the CMI web site received ¾ million hits in a single day. The interest clearly shows that the public, not just the mathematical community is interested in the evolution of mathematical knowledge. For not only is mathematics the enabling science, at the basis of all other theoretical science and providing the foundation for practical application in every walk of our life, but also the public relishes the intellectual achievements in the most fundamental and mysterious domain of abstract research. It is fitting that public awareness of mathematics follows mathematical progress. Of course mathematics research can be justified by its practical applications to society. But these consequences in most cases come years after the fundamental insights to new areas or fields, found by inquisitive and curious mathematicians pursuing their own curiosity.

The Clay Research Award:
Let us now turn to the first major aspect of our program, the Research Awards. These awards are the greatest public recognition afforded annually by the CMI to one or more mathematicians. Today we present two such awards.

Oded Schramm:
The first award winner is Oded Schramm. Oded Schramm came to the United States in 1987 from Israel to study as a graduate student in topology under William Thurston. After this, his work evolved into the frontiers of problems in combinatorics and analysis. Schramm is an example of a person using training in one field to elucidate another one.

Currently, Schramm is a Senior Researcher in the mathematics group at Microsoft in Redmond, Washington. This remarkable and extraordinary research group brings together a unique set of mathematicians to work outside a university environment. It began with the vision of Nathan Myhrvold. Christian Borgs and his wife Jennifer Chayes formed this group and lead it. Christian is in the audience, although personal reasons beyond her control prevent Jennifer from celebrating with us today.

Schramm this year is 41 years old. Most American universities would like Schramm on their faculties, however he finds Microsoft an appealing environment. While he is known in many fields, he is perhaps most widely recognized for his ground-breaking proposal of stochastic Loewner evolution, or SLE. This work led to the solution of many problems by him, many together with his collaborators Greg Lawler now at Cornell University, and Wendelin Werner in Strasbourg, France, as well as by many other mathematical researchers. His work in a spectacular series of papers has led to major progress in probability theory, in the theory of percolation and of random walks, as well as in related topics of conformal field theory. Schramm presented a wonderful series of lectures about his work barely a year ago here in Cambridge. He has over 50 publications, many of which are regarded by experts as breaking important new ground.

Today we present the **Clay Research Award to Oded Schramm**, citing his "Work in combining analytic power with geometric insight in the field of random walks, percolation, and probability theory in general, especially for formulating stochastic Loewner evolution. His work opens new doors and reinvigorates research in these fields."

PRESENTATION BY LANDON AND LAVINIA CLAY
RESPONSE

Manindra Agrawal:
The second research award goes to 36-year old Manindra Agrawal of the Indian Institute of Technology in Kanpur. Located about 250 miles from Dehli on the train line to Calcutta, Kanpur might be described as "in the middle of nowhere," and the phenomenal success of Agrawal brings glory to this new university whose strength is in computer science and engineering. An expert in decision theory and complexity, especially on the relation between the geometry of sets and their information content, Manindra Agrawal turned his attention some years ago to computational algorithms. Fascinated with the problem of testing for primes, he worked on this problem with a colleague Biswas, and recently with two undergraduate students: Neeraj Kayal and Nitin Saxena.

To the great surprise of the experts, the Agrawal-Kayal-Saxena algorithm announced in August 2002 shows that the time necessary increases only as a twelfth power of the length of the number.

It is interesting that the breakthrough that eluded the experts is described in a paper only 9 pages long. This gives us pause that other deep results, which elude the experts, may have a simple and elegant solution waiting to be found by extraordinary researchers working far from the most active research centers.

When the Scientific Advisory Board of CMI decided to recommend that Agrawal receive the Research Award, I invited his students (now in the first few months of their graduate study, but already world-famous) to accompany Agrawal to this meeting. Unfortunately, about three weeks ago, the US State Department denied their visa application, stating that "they gave insufficient proof that after their one-week visit to the United States, they would return to India!" It is not clear that this is really the outcome best for the US!

I am extremely grateful for the help Kate Auspitz afforded to the CMI in attempting to reverse this decision. Kate is the aide of our local Congressman, the Honorable Michael Capuano. Kate was also generous with her time and effort with other visa questions, which would have been impossible to solve without the assistance of Capuano's office.

Today we present the **Clay Research Award to Manindra Agrawal**, "For finding, jointly with two undergraduate students, an algorithm that solves a modern version of a problem going back to the ancient Chinese and Greeks: how can one determine whether a number is prime in a time that increases polynomially with the size of the number?"

PRESENTATION BY LANDON AND LAVINIA CLAY
RESPONSE

Introduction of Speaker:
Maindra Agrawal introduced by Madhu Sudan (MIT)
Madhu Sudan is a leading computer scientist and professor at MIT. At the International Congress of Mathematicians this August in Beijing, Sudan received the Nevalinna Prize—the computer science analog of the Fields Medal, that has been awarded to one individual every four years.

BREAK AND RECEPTION

Introduction of Speaker:
Vladimir Voevodsky introduced by John Milnor (SUNY at Stony Brook)
Jack Milnor is a mathematical legend. He already became famous for his mathematical research as an undergraduate, by solving a major open problem in knot theory: he showed that the integral of the curvature of a knot is at least 4π. He later posed what is known as the "Milnor conjecture" which Voevodsky has proved. Milnor has been professor at Princeton University, the Institute for Advanced Study, and is currently the Director of the Institute for Mathematical Sciences at the State University of New York at Stony Brook. He has received many honors, including the Fields Medal at age 31 and the National Medal of Science.