Letter from the President

The central mission of the Clay Mathematics Institute is the support of mathematical research, internationally and at the very highest level. Our report this year contains many accounts of the Institute's work in pursuit of this, through the appointment of Clay Research Fellows, the annual Clay Research Awards, our own conferences and workshops, and by promoting mathematical activity across the globe through the Enhancement and Partnership Program. Sometimes the amounts involved are small, sometimes much larger, but the accumulative impact has been huge. The pages that follow contain ample evidence of CMI's continuing work to 'increase mathematical knowledge', in the simple and direct wording of its founding mission statement.

But that is not all with which we were tasked when Landon Clay launched the Institute in 1998. We are also to 'disseminate mathematical knowledge', 'educate mathematicians and other scientists about new discoveries in mathematics', and 'encourage gifted students to pursue mathematical careers'. The year saw the launch of two significant projects under these headings.

The first was the creation of the new Clay Award for Dissemination of Mathematical Knowledge. This is not simply an award for popularization. Rather it recognizes outstanding achievement in two intertwined strands—in the recipients' personal contributions to research at the highest level and in their distinction in explaining recent advances in mathematics. The award is intended to be a rare honor, made not on a regular schedule but only as it becomes clear that exceptional contributions should be recognized and celebrated. The first award was presented to Étienne Ghys, following a public lecture that he delivered during the 2015 Clay Research Conference.

The second was the launch of PROMYS Europe. For many years, CMI has supported PROMYS, the summer school founded by Glenn Stevens at Boston University. Each summer this brings together high school mathematicians from across America and beyond for six weeks of intense mathematical activity. Selection is highly competitive, the focus and achievements of the participants astonishing. Many of its alumni in the international community can credit PROMYS with providing the initial impetus for their careers in mathematics. As Henry Cohn explains (p 29), the goal is neither acceleration nor contest preparation, but rather to provide the deep experience of mathematical discovery. For many participants, the experience is not a single event: there are opportunities to return for a second year or later on as counselors.

The success of the Boston Program inspired CMI to develop a sister program in Oxford for European students, in partnership with Wadham College and the Mathematical Institute at the University of Oxford. After two trial years in which students were sent across the Atlantic to participate in the Boston summer school, and then return via a week of masterclasses in Oxford, PROMYS Europe ran for the first time at Wadham College in the summer of 2015. Glenn Stevens himself, together with Henry Cohn, a long-standing contributor to PROMYS, led the teaching, with Vicky Neale from the Oxford department. PROMYS Europe runs again in 2016, with a larger group and with very welcome additional support from Oxford and Wadham alumni.

Sincerely,

Nick Woodhouse

N. M. J. Woodhouse

Photo courtesy of Wadham College

PROMYS Europe

UNIVERSITY OF OXFORD

July 11 – August 22, 2015

by Henry Cohn, Microsoft Research

The summer of 2015 marked the beginning of PROMYS Europe, a residential summer program in Oxford for mathematically ambitious secondary school students, which Vicky Neale, Glenn Stevens, Nicholas Woodhouse, and I organize. Modelled after the Program in Mathematics for Young Scientists (PROMYS) at Boston University, PROMYS Europe is a partnership of PROMYS; the Clay Mathematics Institute; the Mathematical Institute at the University of Oxford; and Wadham College, University of Oxford. In this summer program, carefully selected students from around Europe gather at Wadham College for six weeks of intensive mathematical activities.

The goal of PROMYS Europe is neither acceleration nor contest preparation, but rather for each student to have a deep experience of discovering mathematics. We don't teach them mathematics, but rather welcome them to a community that will support them in doing mathematics. Each morning, the students receive a number theory problem set to guide them on their journey. The problems push them to make computations, gather data, identify patterns, formulate conjectures, and prove theorems. The problem sets are intentionally flexible and open-ended, while pointing the students in the direction of some of the highlights of 19th century mathematics, such as quadratic reciprocity.

Glenn Stevens and I also teach a morning number theory class, which intentionally stays several days behind the problem sets. By the time we reach a topic in class, the students will already have worked out the mathematics for themselves. Our role is not to teach number theory, but rather to help the students systematize and reflect on their discoveries.

For many of the students, PROMYS Europe is the first time they have ever been pushed to their limits intellectually. The problem sets are difficult, perhaps unreasonably difficult, and students cannot expect to solve all the problems. Instead, mathematics at PROMYS Europe is much like research mathematics: further insights are always possible, and there's no notion of being "done" with a topic. This can be an unsettling experience for the students, but it's a valuable shift in perspective.

In 2015, PROMYS Europe started small, with twelve first-year students, four returning students (former participants in PROMYS and the CMI-PROMYS Alliance), and five university students as counsellors. Over time we expect the program to grow, and we intend to build a community that extends beyond the bounds of any single summer and brings together participants at many different career stages, ranging from high school students to senior faculty. Everyone in the PROMYS Europe community is actively engaged in mathematics themselves; for example, the counsellors have their own seminar, which in 2015 was on elliptic curves.

Returning students are a key part of building this community. They extend their understanding of number theory, but they also need further mathematical experiences, and Vicky Neale's course plays this role. In 2015 she taught a graph theory course, which took the students from an elementary beginning to deep concepts such as Szemerédi regularity; this coming summer she will teach group theory. In addition to their target audience of returning students, these courses are also open to first-years looking for an additional challenge.

Returning students also take on mini-research projects in small groups. In 2015, they

Photos courtesy of Wadham College

explored a problem on modular representation theory proposed by Laurent Berger and Sandra Rozensztajn and a problem on graph coloring proposed by David Conlon.

As a break from the formal courses, PROMYS Europe has a program of guest lectures by well-known mathematicians, such as Andrew Wiles and Ben Green. These visits give students the opportunity to interact with a wide variety of mathematicians.

PROMYS Europe is still early in its development, but I'm excited by the start we have made in 2015, and I'm eager to see how the program grows and develops over time. This quote from a PROMYS Europe student illustrates the perspective we wish to encourage:

"PROMYS Europe is something different from how I had done mathematics before. Previously I had always learnt strategies and techniques and ideas and applied these to solving problems in order to get good marks in a test. PROMYS however is all about exploration and learning through experimentation, building the tools to ask and then tackle progressively more difficult and interesting questions. This makes the work deeply satisfying, because the results one discovers not only feel but truly are deep and meaningful mathematics."