Aftermath

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As every visitor to MSRI immediately discovers, the INSTITUTE occupies the brow of a steep hill, more than a thousand feet above the Berkeley campus. On my first day as MSRI's Journalist in Residence last January, I set out to climb the hill by bicycle, taking what seemed a direct and obvious route. I couldn't make the grade. Halfway up, the pedals refused to turn. It was a mortifying failure, but I kept trying, and eventually I reached the summit by a longer, more roundabout approach. The experience neatly prefigured the mathematical challenges of my residency, which also presented a steep learning curve and yielded only to an indirect attack. (And could it be significant that the successful bike route began on Euclid Avenue?)

Mountain climbing is a common metaphor for what science writers are supposed to do. As Journalist-in-Residence, my main role – as I understood it was to climb the hill, learn as much as I could of the mathematics being done up there, and then explain it to the public waiting below. But an observer from outside can serve another, more reflexive, purpose as well. Here in the pages of *The Emissary* I address a few words to the mathematical community itself, reporting back on what the world of research mathematics looks like to a visitor from another world. (I would rate myself an interested, engaged and sympathetic outsider – but an outsider all the same.)

During my six months' residency, I attended roughly a hundred talks in the MSRI lecture room. I learned quite a lot of mathematics this way, but I learned other things as well. As I took my notes on the talks, I got into the habit of reserving the left margin of each page for observations on the practice and presentation of mathematics, and on social interactions in the lecture room. The paragraphs that follow are based on my marginalia, organized under four main headings.

Chalk. Dead diatoms are becoming rare elsewhere in the academic world, but mathematicians are still expected to be masters of blackboard technique. Although the MSRI lecture room is equipped with projectors for transparencies and videos and computer displays, most speakers relied primarily or exclusively on chalk and slate. By the end of the term I had acquired a new respect for the particular virtues and versatilities of this ancient writing medium.

It's no mystery why a mathematical "talk" is almost always a visual as well as a verbal presentation. The two-dimensional notation of mathematics is hard to squeeze into one-dimensional speech. But any graphic device would satisfy this need; why is the blackboard favored over transparencies or Powerpoint? An efficiency expert would find the practice outrageously wasteful. Everyone must sit and wait for the speaker to write out equations that could have been prepared in advacne, probably more neatly and with fewer errors. But waiting for the equation to unfold is just the point: It turns out that mathematics is far easier to grasp when you can see it in the process of being written, rather than having it presented as static text. The speaker, by adjustments in timing and emphasis, directs attention to the more important parts of an expression. Indeed, an equation is seldom written in strict left-to-right order. Instead the more important terms come first, followed by less-critical constants and coefficients, with details such as ranges of integration filled in last. The sequence carries meaning; it reveals a hierarchical structure in the equation, which tends to get flattened out in a published paper.

Virtually all of the speakers during my months at MSRI performed with grace and confidence at the blackboard. Perhaps it is naive of me even to mention this, as if I were noting in astonishment that professional pianists are all comfortable sitting at the keyboard, or that chess masters know how to move the pieces. Nevertheless, blackboard mannerisms made a strong impression. Learning to wield the chalk with authority, and to deftly erase an errant symbol with the heel of the same hand, seems to be an essential step in the education (or acculturation) of a mathematician. Many go on to master the higher blackboard management, expertly juggling the six sliding panels at the front of the room, and occasionally even managing the obscure technique of using all nine boards.

Group Dynamics. Is it acceptable to talk through someone else's talk? That depends on who's talking.

Under the social contract of the lecture room, interrupting the speaker is not necessarily rude. For example, calling out a typographical correction – "I think you mean minus beta, no?" – is generally welcomed as a friendly intervention. (And it's proof that someone in the audience is awake and paying attention.) Interrupting with a question – a request for clarification – "I don't understand how you derived that partition function" – is somewhat more assertive but seldom appears hostile. Some speakers explicitly invite this kind of dialogue.

On the other hand, interrupting to dispute the speaker's results, or to argue for your own interpretation of them, is pretty clearly an act of aggression – or so it appears to a bystander like me. The issue here is not one of manners. Every group and institution evolves a style of discourse that serves its own purposes, and there's no sense in being judgmental about it. (The British Parliament and the U.S. Congress have very different rules of debate, but they are both successful bodies.) Hijacking someone else's talk may well be the best way to sweep aside needless verbiage and focus on points in contention.

But as I sat in the lecture room meekly observing these sometimes-heated exchanges, one aspect of the interactions began to disturb me. I could not help noting that a speaker's likelihood of being challenged in the middle of a talk depends to some extent on the speaker's seniority, or perhaps on some similar measure of stature

within the community. A distinguished professor seldom has to fend off a hostile interruption, but a young postdoc is more likely to face at least one challenge from the floor. And being interrupted by abelligerent question is not the end of it. Someone else may interrupt the speaker again to give the answer!

Boundaries and Rivalries. A whole genre of wan academic humor thrives on the friction between scientific disciplines. "A mathematician, a physicist and an engineer walk into a bar...," the joke begins. As a professional observer of mathematics, physics and engineering, I have certainly been aware of differences in style and philosophy. But my few months of total immersion at MSRI, in a group that had strong representation from both physics and mathematics, altered my view of the issue. The problem of working together across disciplinary boundaries is no joke.

Physics and mathematics have the closest possible family ties, with a number of major founding figures (Newton, Lagrange, Laplace) claimed by both tribes. It's therefore a little unsettling to realize that the two disciplines have deep disagreements not only about formalities such as notation and terminology but also about fundamentals, including what constitutes a valid proof. Problems considered settled by (some) physicists are still classified as open questions by (some) mathematicians. With that deep a dispute, communication is sometimes reduced to shouting across the barricades.

Of course mathematics itself has its own internal divisions into specialties and subspecialties, whose intricacies can baffle an outsider. ("A differential geometer, an algebraic geometer and a symplectic geometer walk into a bar....") Apparently the divisions can even baffle an insider. At many of the talks I attended, I was not the only member of the audience struggling to follow the argument. Maintaining open lines of communication appears to be a challenge even within mathematics.

Bridging such inter- and intradisciplinary chasms is one of the principal goals of MSRI (and of various other institutions). Creating a true meeting of the minds looks to be a harder problem than I ever imagined. Bringing people together in the same room is often not enough. But bridges can be built. It does happen. I saw it happen repeatedly in the lecture hall at MSRI. Although the dialogue sometimes failed, it was more often successful.

Intensity. If we can't always count on everyone playing peacefully in the sandbox, the reason is not hard to find. Mathematical gatherings get intense because people doing mathematics care passionately about it. The emotional tension is a gauge of intellectual commitment. You don't tell a football player who just lost the World Cup final, "It's only a game," and you don't tell a mathematician hot on the trail of a new result, "It's only mathematics."

Personal ambition is surely a factor here, as it is in any other discipline, but there is more. Lewis Thomas, in his essay *Natural Science* (in "Lives of a Cell", Viking, 1974) described the phenomenon eloquently:

"Scientists at work have the look of creatures following genetic instructions; they seem to be under the influence of a deeply placed human instinct. They are, despite their efforts at dignity, rather like young animals engaged in savage play. When they are near to an answer their hair stands on end, they sweat, they are awash in their own adrenaline. To grab the answer, and grab it first, is for them a more powerful drive than feeding or breeding or protecting themselves against the elements."

The nature of the mathematical enterprise may raise the stakes even higher than they are elsewhere in the world of science and scholarship. In other fields, an idea that proves fruitful for a time but eventually has to be discarded is counted a partial success. In mathematics, a proof that turns out to have a serious flaw is nothing but an embarrassment. Even though Hilbert's dream of a complete and consistent formal system has been set aside, the collected literature of mathematics is treated as a sacred text to be guarded against corruption and dilution. Shoddy or trivial work is positively offensive; the emotion it evokes is something akin to disgust. By the same token, a result that provides illumination is greeted with a powerful sense of joy.

Strong feelings appear to be intrinsic to the practice of mathematics. They are not to be blunted or softened. Anyone who imagines that this is a purely cerebral, intellectual and emotionlessenterprise has missed the point entirely.

In June I came back down the hill – the descent was a challenge to the nerves rather than the muscles, and went by entirely too fast – and now I find myself in the aftermath of my residency at MSRI. "Aftermath" is one of those words that seem to have lost their roots. In newspapers today it usually refers to the events following a tornado or an earthquake or some such natural disaster. Originally, though, an aftermath was a second mowing – a bonus crop that a lucky farmer might squeeze into the growing season after the first harvest.

My aftermath, happily, falls into the bonus category. The first harvest was learning the mathematics itself, reaping all I could in the time allotted. The bonus was getting a clearer view of how mathematics is done.

MSRI, second and third floors