From Samos to SAMSI: The Mathematical Science Institutes

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Writing in the third century AD, Iamblichus tells us that

> "…Pythagoras formed a school in the city of Samos,…. Outside the city he made a cave the private site of his own philosophical teaching, spending most of the night and daytime there and doing research into the uses of mathematics.…"

While this was undoubtedly not the first mathematics institute, it is perhaps the earliest one of note and, of course, has left us with a solid legacy of achievement. Pythagoras's "institute" was relatively short lived, although its demise was probably not due to funding cuts. The modern mathematics institute is much less centered around an individual and the participants certainly enjoy superior accommodations.

Despite such a long history, the mathematical institutes as we know them are quite recent in origin. As mathematicians, we love to categorise, and following this indulgence would identify at least three distinct mission types. In the Pythagorean mode, the Institute for Advanced Study was founded in 1930 as a community of scholars and included Albert Einstein as one of the initial appointments. The institute has a core of permanent members plus a sizeable number of visitors who explore semester- or year-long topics primarily within the interest of the core faculty. The institute has considerable infrastructure resources including an extensive library. Mathematics is only one of the subjects studied but was, along with theoretical physics, one of the founding disciplines. The model has been copied often with the Institut des Hautes Études Scientifiques (IHÉS) in the Paris suburbs perhaps the best-known example. In a very different structural direction there is Oberwolfach, where there are no permament faculty and no long-term topics—just the exceedingly simple model of fifty week-long workshops per year that encompass the entire range of the discipline. Again, there have been many disciples; one of the most recent is the Banff International Research Station in the eponymous town in Canada. The third model, and by far the most prevalent, probably, at least as far as the modern era is concerned, was initiated by the Institute for Theoretical Physics in Santa Barbara. In this model there are no permanent faculty, but the focus is on long-term workshops that range over a broad spectrum. The participants come for as long as a year or as short as a few days. This was the model that the initial Division of Mathematical Sciences (DMS) institute solicitation used in 1980 that resulted in the founding of both the Mathematical Sciences Research Institute (MSRI at Berkeley) and the Institute for Mathematics and its Applications (IMA at Minneapolis) in 1982. It is also the working model of the subsequent DMS institutes: Institute for Pure and Applied Mathematics (IPAM at UCLA in 1999), Mathematical Biology Institute (MBI at Ohio State in 2002), and Statistical and Applied Mathematical

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Sciences Institute (SAMSI at Research Triangle Park in 2002) as well as a host of others worldwide, such as the Newton Institute in Cambridge. Indeed, there is hardly a major research nation that has not initiated at least one mathematics institute. Many of these are still local in flavour, but a significant number contribute heavily to the global mathematics communications network. The U.S. is not the leader here; on a per capita basis Canada has invested much more heavily with the Fields Institute for Research in Mathematical Sciences in Toronto, the Centre de Recherches Mathématiques in Montreal, the distributed Pacific Institute for the Mathematical Sciences and, of course, Banff International Research Station.

Why has there been an explosion in such institutes and, in particular, why has DMS felt they were so important?

Certainly the ubiquity and ease of travel has been a major factor. Mathematicians have always collaborated and are among the few scientists who work to get colleagues hired in exactly the same area; such individuals are viewed as potential collaborators rather than competitors. Despite modern telecommunications, the need for face-to-face meetings persists, particularly for younger mathematicians. In fact, as a general rule, in order to stay abreast of developments, it is almost imperative to get out into the community in which one works. The importance of this has been the driving force behind institute expansion. From the DMS perspective, one of the goals has been to provide essential support for as many mathematicians as possible. We simply aren't able to provide small travel grants to thousands of people, and besides, the institutes are extremely efficient and a very cost-effective way for us to meet this target.

What exactly does DMS support? Well, we have a myriad of programs, but in reality we fund only three items: summer salaries for researchers on "single investigator" grants; funding for young people—postdocs, undergraduate, and graduate students; and travel. Of course many "single investigator" grants contain all three of these, but there are programs that are dedicated to just funding students and those that only, or primarily, fund travel; our support for conferences and the institute portfolio are examples. We are currently spending about US$20M or 10% of our budget on institute, conference, and workshop activities. This is only slightly more than at any time in the last twenty years, but the trend is unmistakably going up. The institutes are collectively doing a superb job, and we view them as the most effective means of meeting several goals. The next paragraphs will expand on the word "several" and also indicate some of the changes that are taking place within the institutes themselves.

"Connecting" mathematicians, whether this is with other scientists or other mathematicians, is viewed as a priority, and over the years DMS has looked at various mechanisms to achieve this end. This was the rationale for both the original institutes competition and the two subsequent ones. It is also imperative that we broaden our participant base to be more inclusive. With existing funds, there is a limit to the number of mathematicians we can support directly—to provide one month's summer support and some travel—the most basic single investigator award costs at least US$30K per year (we must include fringe benefits and indirect cost return). For the same amount, we can pay travel and accommodations for a month at one of our institutes for six mathematicians.

In an ideal world we would offer support to every research-active mathematician in the U.S. and invest in every active topic. If by support one means paying part of the salary, then expecting ideal to meet reality isn't ever going to happen, and we are going to fall short by a substantial amount. However, if we mean the ability to potentially offer every research-active mathematician access to conference/workshop support, then this can be realised. In making the dollars stretch, we have to be efficient and ensure the workshop programs we are funding are of the highest quality and encompass a broad spectrum of the mathematical sciences.

We also have to worry about broadening the list of participants: one half of DMS funds goes to about twenty-two departments, three quarters to about forty-five departments—a typical power law effect that covers many events. I view this not as right or wrong but simply as the reality of the current university system, and to attempt to torque it would be intellectually dishonest. However, this doesn't mean that we cannot do anything for mathematicians not at the "top" institutions. We might not have the resources to make that single investigator award, but we should be able to make some places available at the institutes' tables. Thus in our quest for broader participation we mean by this term not just to cover underrepresented minority groups or women, but geographical and institutional broadening. The institutes have been asked to meet this challenge, and we have increased their funding to enable them to do so. This year, by pure coincidence, all of the institutes we fund had either a major midterm review or had submitted a renewal proposal. This provided DMS with a unique opportunity to evaluate and hence assess the combined capabilities.

In order to meet the multiple challenges, a far-reaching strategy has been developed. The institutes have agreed to cooperate on a variety of key issues: the selection of programs to minimize overlap and to obtain intellectual diversity; the building and maintenance of a common Web page

that will allow the user to see very clearly current and future events at all of the institutes as well as a common application page for admission and support to any program. In the longer term there are plans to disseminate future and past workshop material for the benefit of the research community. In addition, institute annual report summaries would be made available that would let the community judge the success in meeting the stated goals. Thus we are not viewing the institutes as being under a sunset clause but rather a sunshine clause. This is not to say that individual institutes will not come and go—there will be periodic recompetitions, renewal proposals, and ongoing evaluation—but that the *collection of institutes* is the primary way to view the portfolio. This is an important development for it allows the whole to far exceed the sum of the individual institutes themselves. Another reason to take this viewpoint is that each of the institutes has a slightly different mathematical perspective and there are variations in length of programs and in their advance planning period. This gives the whole much greater flexibility. When one adds in the unique missions of the Institute for Advanced Study and the American Institute of Mathematics (to which DMS gives substantial support), the Banff International Research Station (which we jointly cofund with Canadian provincial and national sources) as well as small amounts to both IHÉS and to Oberwolfach, we have managed to obtain a comprehensive portfolio in terms of individual missions and programmatic activities.

However, the institutes' mechanism is not the only means of providing group travel nor can even the expanded number we now support be expected to cope with the demand we are seeing. The Division currently offers partial support for over 100 small-scale conferences annually. We have always viewed this as an important activity, and we intend to ensure it has adequate funding. However, there is certainly room between the US$20,000 conference and the US$2–4M institute for further activities.

This year we started a new initiative designed to fit into this gap. On an annual basis we will accept proposals which comprise longer-term or larger-scale activities that more widely engage and connect the mathematical sciences community, such as special research years or semesters, multi-institutional regional meetings, and "summer schools". It should be emphasised that this list is meant to be illustrative, and the community is challenged to find innovative ways to provide more travel funds for research.

The institutes are a community asset and as such it is important for the community to be involved. In particular, program ideas and organisation are crucial elements for all institutes.

I noted in the initial paragraph that the modern institutes are relatively more faceless than the one in Samos, yet this does not mean that key individuals have not played a significant role. As the institutes have begun the process of better coordinating their efforts and resources, there have been tireless work and energy provided by both the program officers at the National Science Foundation and the institute directors. I would like to thank the various directors: Doug Arnold, Jim Berger, Brian Conrey, David Eisenbud, Avner Friedman, Mark Green, and Phil Griffiths, who are making the current reincarnation of Samos a jewel in the U.S. mathematical crown.