

# Renaissance Banff: Mathematics, Music, Art, Culture

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## 1 Overview

Renaissance Banff was a full blown 4 -day conference on Mathematics and its connections to Art, Music, and Science. It was comprised of a 3-day conference in the international annual series of Bridges Conferences (<http://www.sckans.edu/~bridges/>) and a 4th day dedicated to the work and artistic influence of the famous Canadian geometer, H. S. M. (Donald) Coxeter. The conference was jointly sponsored by BIRS, PIMS, the Canadian Mathematical Society, and the Banff Centre. Physically it occupied all of the Max Bell Building at the Banff Centre, including the fish-bowl lounge which was used as a gallery for the artistic works associated with the conference. At times it had upwards of 200 participants. Thus, although Renaissance Banff was technically a BIRS workshop event, and indeed used the BIRS facilities to the full, it was in fact something quite different.

The conference was accompanied by a refereed and edited Proceedings that contains all the talks (some 80 of them) that were presented during the conference, and a CD on which the art exhibition, as well as the papers, are fully documented. Copies of the Proceedings and the CD are in the hands of BIRS and PIMS. Rather than simply summarizing this documented material, this report discusses the ideas that led to Renaissance Banff and tries to give some feel for the breadth and diversity of the events of the conference. We conclude with some personal feelings about the outcome of the conference and the outlook for the future.

## 2 Background

The Banff Centre is Canada's only center dedicated to the arts, leadership development, and mountain culture. The Center is also home to a world-class conference facility. BIRS is one of the leading centres in the world for workshops in the mathematical sciences, and its physical home is within the Banff Centre complex. It had always been hoped by the directors of BIRS, PIMS, and the Banff Centre that this convergence of facilities and cultures would lead to innovative experiments in bridging the unnatural and unhealthy gap between the arts and the sciences. Renaissance Banff was just such an experiment.

In antiquity and during the era of the Islamic art, artists regularly used mathematical ideas in creating new art and architecture, and the results were often of exquisite beauty. Likewise during the European

Renaissance, art, mathematics, architecture, science, and music flourished seamlessly side by side. Over the centuries this unity of purpose and thought was lost as disciplines became more specialized and their internal languages became more technical. Although many artists and scientists have been calling for ways to regain the lost ethos of mutual understanding, appreciation, and exchange, it has been hard to know how to create environments in which this can happen in a meaningful way.

An equally disturbing divide has evolved between mathematics and the general public. All human beings are fluent in recognizing and appreciating patterns, and all are able to deal effortlessly with the abstractions of language, music, visual art, and theatre. Yet most people think that they have an inherent inaptitude for mathematics and are largely unaware of how deeply embedded it is in the world around them. Still, we have seen over and over again how fascinated and excited people become when mathematical connections are presented in ways which relate to their experiences and trigger their natural curiosities and aesthetic sensibilities.

The Bridges Conferences, created in 1998 and running annually since, have provided a remarkable model of how these divides can be crossed. Here practicing mathematicians, scientists, artists, educators, musicians, writers, computer scientists, sculptors, dancers, playwrights, and model builders have come together in a lively and highly charged atmosphere of mutual exchange and encouragement. Important components of these conferences, apart from formal presentations, are gallery displays of visual art, working sessions with practitioners and artists who are crossing the mathematics-arts boundaries, and evenings of musical or theatrical events. Furthermore a lasting record of each Bridges Conference has been its Proceedings – a beautiful resource book of the papers and the visual presentations of the meeting.

It was a suggestion of David Eisenbud of the MSRI that led to the interaction of Reza Sarhangi and Robert Moody from which the idea for Renaissance Banff emerged. Reza Sarhangi is the founder of the Bridges Conferences and has organized each of the annual conferences as well as its Proceedings since its inception. The enthusiasm of the Canadian Mathematical Society, then under the presidency of Christiane Rousseau, PIMS under its then and subsequent directors Nassif Ghoussoub and Ivar Ekeland, and the Banff Centre through its CEO Mary Hofstetter, made the project feasible.

The conference was financed through grants of \$10,000 from the CMS, \$20,000 from PIMS, and of course by BIRS by its granting of a workshop, and hence the room and board for 48 participants. The conference required far more accommodation and working space than the BIRS facilities could offer. Here the Banff Centre contributed by offering reduced rates for accommodation, the full use of the Max Bell Building, and considerable help from its staff. Finally the conference was significantly funded by the registration fees paid by the participants themselves. In addition, except for invited speakers and organizers, all conference participants paid for their accommodation and meals.

### 3 The Conference Events

The conference was organized around nine principal features: the plenary talks, the contributed talks, a public lecture, an art exhibition, a workshop on mathematics education within the context of mathematics and the arts, an art-in-progress exhibition, a theatrical presentation, a musical evening, and a model building event. We discuss each of these aspects of the conference in turn.

- (i) **The plenary talks** There were ten forty-five minute invited plenary talks during the conference.
- Greg N. Frederickson: *The Manifold Beauty of Piano-hinged Dissections* [Greg Frederickson, Prof. of Computer Science, Purdue Univ. Areas of interest include the analysis of graph and network algorithms, optimal algorithms for parametric search problems on trees, and fast algorithms for shortest path problems. Author of *Dissections Plane & Fancy* and *Hinged Dissections: Swinging & Twisting*, Camb. Univ. Press, 1997 and 2002. He was recognized in 2003-04 as one of the Top Ten Outstanding Teachers in Science at Purdue, and won the 2004 George Pólya Award from the Mathematical Association of America.]
  - Bart de Smit: *The Droste-Effect and the Exponential Transform* [Bart de Smit, Leiden University in the Netherlands. A number theorist known for his contributions to the 1995 Springer volume on Wiles's proof of Fermat's Last Theorem, and for his joint project with Hendrik Lenstra, which filled the famous white hole in Escher's lithograph *Print Gallery* <http://www.math.leidenuniv.nl/~desmit/abs-lms.html>.]

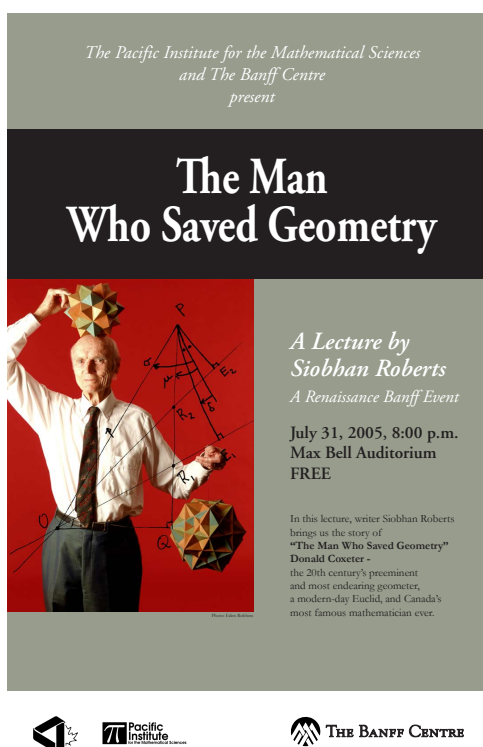


Figure 1: The poster advertizing *The Man Who Saved Geometry*

- Jan Zwicky: *Mathematical Analogy and Metaphorical Insight* [Jan Zwicky, University of Victoria, Poet, writer, philosopher, and musician. Author of *Wisdom and Metaphor*, *Songs for Relinquishing the Earth* (Governor-General's Award for Poetry), and *Robinson's Crossing*. Writing mentor and workshop leader.]
- Rinus Roelofs: *Three-Dimensional and Dynamic Constructions Based on Leonardo Grids* [Rinus Roelofs, sculptor, computer graphics artist, scientist, artist. His commissions come largely from municipalities, institutions and companies in the Netherlands, but his work has been exhibited further afield, including in Rome as part of the Escher Centennial celebrations in 1998. [www.rinusroelofs.nl/](http://www.rinusroelofs.nl/) .]
- Marcia Ascher: *Malekula Sand Tracings: A Case in Ethnomathematics* [Marcia Ascher is Professor Emerita of Mathematics at Ithaca College. She is the coauthor of *Code of the Quipu: A Study in Media, Mathematics, and Culture* and the author of *Ethnomathematics: A Multicultural View of Mathematical Ideas*.]
- Robert V. Moody: *Alice Boner and the Geometry of Temple Cave Art of India* [Robert Moody, mathematician, photographer, first Scientific Director of the Banff International Research Station, and arts enthusiast [www.math.ualberta.ca/~rvmoody/rvm/](http://www.math.ualberta.ca/~rvmoody/rvm/) .]
- Donald W. Crowe (with Dorothy K. Washburn): *Geometrical, Perceptual, and Cultural Perspectives on Figure/ Ground Differences in Bakuba Pattern* [Donald W. Crowe, Professor Emeritus of Mathematics at the University of Wisconsin-Madison; coauthor of *Symmetries of Culture: Theory and Practice of Plane Pattern Analysis* and a textbook titled *Excursion in Mathematics*.]
- Marjorie Senechal: *Coxetering Crystals* [Marjorie Senechal, Director of the Louise W. and Edmund J. Kahn Liberal Arts Institute at Smith College. Geometer, historian of science, writer of numerous books including *Quasicrystals and Geometry*, *Crystalline Symmetries*, and *Long Life to Your Children! A portrait of High Albania* (co-author). Founder of the Northampton Silk Project, Mathematical Communities Editor of the Mathematical Intelligencer [www.math.smith.edu/senechal/](http://www.math.smith.edu/senechal/) .]
- Carlo H. Séquin: *Symmetrical Hamiltonian Manifolds on Regular 3D and 4D Polytopes* [Carlo Séquin, Professor of Computer Science at the University of California, Berkeley; designer of abstract ge-

ometrical sculptures; IEEE and ACM Fellow; Member of the Swiss Academy of Engineering Sciences  
www.cs.berkeley.edu/~sequin .]

- Robert J. MacG. Dawson: *Some New Tilings of the Sphere with Congruent Triangles* [Robert J. MacG. Dawson, Prof. of Mathematics, St. Mary's University, Halifax. mathematician with interests in discrete geometry, spherical tilings, and honeycombs. Editor-in-Chief, Canadian Mathematical Society Notes.]
- Doris Schattschneider: *Coxeter and the Artists: Two-Way Inspiration* [Combining her dual interests in mathematics and art, she has become internationally known for her work with tessellations of the plane and her exposition of M. C. Escher's art (*Visions of Symmetry*, Freeman and Co. 1990). She was Geometer and Senior Associate on the NSF-funded Visual Geometry Project that produced the software The Geometer's Sketchpad. She has served as a first vice president of the Mathematical Association of America. In 1991 she received the MAA's certificate of meritorious service, and in 1993 the MAA Award for Distinguished Teaching of College or University Mathematics.]

(ii) **The contributed talks.** There were sixty-eight contributed talks (given in parallel sessions). Here we refer the interested reader to the Proceedings for a complete documentation of all the talks. We list here just a sampling to give some idea of the variety of topics that were presented at the meeting.

- Hourieh Mashayekh: *Wisdom in Art: Mathematics in Islamic Architecture in Iran*
- Duncan J. Melville: *Aspects of Symmetry in Arpachiyah Pottery*
- Robert McDermott: *A Ukrainian Easter Egg Monument Stands for Thirty Years*
- Carlo Séquin: *Splitting Tori, Knots, and Möbius Bands*
- Richard J. Krantz and Jack Douthett: *Circular Distributions and Spectra Variations in Music. How Even Is Even?*
- F. Gómez, A. Melvin, D. Rappaport, G. T. Toussaint: *Mathematical Measures of Syncopation*
- Chris Bartlett: *Fairfield Porter's Secret Geometry*
- Craig S. Kaplan: *Aliasing Artifacts and Accidental Algorithmic Art*
- Akihiro Matsuura: *Strange Physical Motion of Balls in a Cylinder*
- Barbra Gregory: *The Complexity of the Musical Vocabulary of the Nzakara Harpists*
- Robert J. Krawczyk: *Fermats Spiral Mandalas*
- David A. Richter: *Two Results Concerning the Zome Model of the 600-Cell*
- Douglas Dunham: *H.S.M. Coxeter and Tony Bomford's Colored Hyperbolic Rugs*

(iii) **The public lecture** A very important component of the conference was the presentation of a lecture for the general public of Banff and the fellow artists and residents of the Banff Centre. This was an opportunity for a wider audience to come and see mathematics from a cultural perspective and to visit the conference art exhibition.

The speaker was the Toronto based journalist and science writer Siobhan Roberts and her talk, *The man who saved geometry*, was a delightful look at the life and impact of Donald Coxeter. Siobhan spent a lot of time with Coxeter during the last few years of his life and accompanied him to several conferences. The talk draws heavily from her biography *The King of Infinite Space : Donald Coxeter, The Man Who Saved Geometry* . This public lecture was well advertised around Banff and the Banff Centre. Over 250 people were on hand to listen to this engaging talk and to participate in a reception afterwards.

(iv) **The art exhibition** Every Bridges conference has an accompanying exhibition of art which is contributed from its many artistic participants. The Renaissance Banff exhibition was exceptionally attractive, particularly since it was mounted in the beautiful fish-bowl lounge of the Max Bell building, with its wonderful views and natural setting. The exhibition was organized by long-time Bridges enthusiast Robert Fathauer. The entire art display is available on the Renaissance Banff CD. We list here some of the artists whose works were on display at the conference, as well as some of their own personal statements.

- Bradford Hansen Smith: Paper sculpture, Beautiful spiral forms made only of paper. “In exploring the nature of Wholeness in the circle there has been, for fifteen years, only one rule, no cutting. Nothing is added or taken from the circle.” Author of *Folding Circle Tetrahedra*.
- Gerda de Vries, Department of Mathematical and Statistical Sciences, University of Alberta. Wonderful quilts based abstract geometric designs from a mathematician with great artistic skills. “My quilts reflect a structured approach to design, and are the brainchild of someone who has little choice but to think mathematically.”



Figure 2: Quilt by Gerda de Vries; paper spiral by Bradford Hansen Smith

- Dick Termes: Paintings on spheres: Dick uses a uniquely discovered system of perspective to paints total in-the-round views on the surfaces of large hanging spheres. His subjects often have Escher-esque feeling. “To take the interior of the Pantheon or Notre Dame and have it read correctly from any side of the spherical painting is my objective”.
- Dick Fischbeck: Polyhedral skeletal designs in metal, with an ultimate end of creating ultra low cost human shelters.
- Robert Fathauer (see below for more about him): Digital images printed on photographic paper based on tessellations, polyhex fractal tilings, complexity, and chaos.
- Barbara Setsu Pickett: “For the past twenty years I have used traditional velvet weaving techniques to explore symmetry and pattern design. I weave my silk velvets on either on an 16-shaft computerized loom at the University of Oregon where I head the Fibers Area in the Department of Art or on a manual Jacquard loom at the Foundation Lisio in Florence, Italy.”
- Robert Krawczyk, Dept. of Architecture, Illinois Institute of Technology: Spirals. Deeply involved in computer assisted art, his exhibits here were digitally created point patterns of spirals. Robert was also the designer of the 3-triangle logo of the conference.
- Irene Rousseau: Tessellations. An artist bridging the disciplines of art and mathematics with beautiful mosaic wall sculptures that are based on tessellated patterns from hyperbolic geometry.
- Robert Stowell: Paper sculptures. Sculptor and art instructor at the University of Calgary. Inspired by the work of Buckminster Fuller and his exploration of 3D geometric structures, he creates exquisite paper models of the Platonic and Archimedean polyhedra, made particularly organic by replacing straight edges with curved scoring that give rise to concave-convex surfaces.



Figure 3: Two hyperbolic tessellations: Irene Rousseau and Mary Williams

- Heath Carra: Clay sculpture. Originally a worker in sheet metal, Heath experiments with the construction of clay forms, specifically the platonic solids. "The process of creation is the true experiment; the completed box at the end is just the mark that it made."
- Susan Happersett: Ink on Paper. "My interest in mathematics and my love of visual arts has led me on a journey to build a link between mathematics and drawing. Developing a grid work and mapping process, I have plotted various numerical properties. These graphs allow me to examine the aesthetic characteristics of functions, sequences and series in a visual language."
- Richard Ahrens: Woven plastic sculpture. "H. S. M. Coxeter made a case for the inclusion of three infinite 'honeycombs' in the list of regular polyhedra. My models are woven representations of these 'honeycombs' . . . composed of plane, convex, closed loops. These infinite regular polyhedra seemed to present the possibility of making a genuinely three dimensional piece of basketry."



Figure 4: Some of Dick Termes' spheres

(v) **Bridges for Teachers; Teachers for Bridges**, Workshop Series Art, music, models, games, and sculptures provide many opportunities for dramatically illustrating mathematical ideas and bringing their intuitive content to life. For this reason every Bridges Conference attracts many teachers from all levels from elementary schools to college institutions, and every Bridges Conference has a special workshop devoted to mathematics education. The math-education workshop at Renaissance Banff, *Bridges for Teachers, Teachers for Bridges*, was organized by Mara Alagic [Department of Curriculum and Instruction, Wichita State University, Kansas]. Talks in the workshop included:

- Cheryl Whitelaw: *A Thousand Cranes and Statistics*
- George W. Hart: *Paper polylinks*
- Virginia Usnick and Marilyn Sue Ford: *Connecting Gross-motor Movement, Dance, and Mathematics in the Elementary Curriculum.*
- John Belcher: *Playing Mathematics and Doing Music*
- Robert McDermott: *A Physical Proof for Five and Only Five Regular Solids*

(vi) **The Art-in-Progress Exhibit** One of the more interesting features of Renaissance Banff was what one might call a show-and-tell room: a room set aside for displaying hands-on things and works in progress. Above all Renaissance Banff, like all Bridges Conferences, was a place for people who are actually doing something creative with the mathematics-arts connection to interact with others of the same breed. And what better way to do that than to have a special room for them to show their stuff and interact on a one-one basis! As an example we show here the group assembly in which many people participated to form a geometric sculpture, one meter in diameter, from 180 laser-cut wooden interlocking components.



Figure 5: Work in Progress and Its Completion: a group affair led by George Hart

(vii) **Theatre evening** Many Bridges conferences have had stage readings of plays, either well established ones, or just recently written. Renaissance Banff was pleased to sponsor and host the first reading of a play in progress by New York playwright Ellen Maddow. *Delicious Rivers* is a play that came out of her extended dialogue with geometer Marjorie Senechal. It is based loosely on the life of the remarkable and eccentric Robert Ammann, a postal worker by trade, but surreptitiously a mathematician who

made notable contributions to the theory of aperiodic tilings. The play cleverly uses the theme of aperiodic repetition through its dialogue and music. This stage reading was directed by Paul Zimet, and performed by three professional musicians hired for the occasion, three professional actors, the son Isaac of Ellen and Paul Zimet, and the very much appreciated volunteer appearances of three of our participants: Craig Kaplan, Marjorie Senechal, and Jan Zwicky.

The play went on to be a considerable success as an off-Broadway production in New York during January and February of 2006: [www.lamama.org/ArchivesFolder/2006/DeliciousRiver.htm](http://www.lamama.org/ArchivesFolder/2006/DeliciousRiver.htm).

*"The Talking Band's newest music-theatre work, Delicious Rivers, may just be the most charming play happening in NYC right now." - Ross Peabody, NYTheatre.com*

(viii) **A musical evening** Music is always a part of every Bridges conference. As one can see from the titles of talks given above, there were a number of contributed sessions given over to the intricacies of music, musical styles, and rhythm. We were fortunate this year to have the very talented David Fulmer (Julliard), a young violinist with a reputation for promoting contemporary music, who organized our musical evening.

- Robert Craig: performance of a piano work by H. S. M. Coxeter.
- David Fulmer, Marian Moody, Diana Nuttall, and Jan Zwicky, string quartet: *Purcell fantasias, Bach Goldberg Variations, Macmillan Sketches on French-Canadian airs;*
- Trudy Morse: a reading of *Lewis Carroll's Jabberwocky* to David Fulmer's violin accompaniment
- Rachel Hall: folk tunes played on a small concertina;
- John Belcher: conga solo, followed by an impromptu duet with Rachel.



Figure 6: Delicious Rivers

(ix) **Model building for everyone** One of the most charming events, one that lasted almost the entirety of the conference, was the creation, in situ, of two colorful geometric constructions. In the words of Doris Schattschneider, "In the lobby outside the lecture hall, there were always a few children, participants, and spouses seated or kneeling on the floor, busy joining 3,720 ZomeTool connector balls to 10,680 struts in modules that each hour were added to two growing monster models, [3D] shadows of the 4D cantellated 600-cell. David Richter and Daniel Duddy orchestrated the project." One of the two models was donated by the ZomeTool people to BIRS where it has a permanent place in the Corbett Hall lounge.

## 4 Outcome of the Meeting

Renaissance Banff was the first event of this size or scope in Canada devoted to mathematics and the arts. It successfully brought together artists, mathematicians, writers, and computer scientists from Canada and





Figure 7: Community building of the 3D shadow of the cantellated 600-cell

around the world in a highly enjoyable, stimulating, and encouraging atmosphere of mutual exchange and appreciation. It had a public component (the art gallery, and the lecture on Coxeter) that drew a capacity crowd to the Max Bell auditorium. It sponsored an innovative new play that went on successfully to run as an off-Broadway production in January-February of 2006.

It brought a new appreciation to Canadian mathematicians and artists, as well as ordinary citizens of this country, just how much these disciplines have to offer each other and just how approachable and fascinating mathematical ideas can be when they are put in settings which emphasize visual and auditory appreciation.

From the perspective of BIRS it represented a novel experiment. BIRS is primarily a facility for leading edge research in the mathematical sciences. But the recognition that the mathematical sciences and mathematical scientists who comprise it are a part of the larger intellectual and creative component of our society makes it natural for it to find ways to reach out to engage the greater public. The linking of arts and mathematics is proving to be one very successful way of doing it. And it has the larger function of creating interactions between creative people on both sides of the 'left-right' brain divide.

No doubt Renaissance Banff taxed the resources (and patience!) of both of BIRS and the Banff Centre. The organizers believe, however, that it was a fantastic success. With the hindsight of experience an even better and more exciting Renaissance Banff Conference could be held. With planning there could be far more mutual involvement of the organizers of the conference and the Banff Centre. For instance,

- The Foyer of the Max Bell building is itself an art gallery. It would be natural to schedule an art exhibit there that would match the theme and spirit of the conference.
- Each summer the Banff Centre has a music festival that brings many fine musicians onto the campus. It should be possible to integrate at least one event from the festival into the Renaissance Banff program.
- There is already a successful exchange between BIRS and Banff Centre writing workshops. It should be possible to have an event around poetry, or readings, that involve both communities.
- The Music and Sound department of the Banff Centre has a group that is very much involved with the technical and aesthetic aspects of recording of music. There is an opportunity for an interesting connection here.
- The Banff Centre has an advanced 3D immersion environment. This offers new opportunities for mathematical/artistic visualizations. One could easily imagine some of the beautiful computer-based 3D art of Rinus Roelofs presented in this setting.

The interest in the mathematics to Renaissance Banff and the subject of mathematics/arts connections can be gauged from:

- articles by Reza Sarhangi in the PIMS magazine *Pie-in-the-Sky* and the Notes of the Canadian Mathematical Society.
- Doris Schattschneider's article *Math and Art in the Mountains* in the *Mathematical Intelligencer*, vol. 28, no. 3.
- G. Hart's *Mathematical Connections in Art* (Renaissance Banff conference report), *Math Horizons*, February, 2006, p. 5 and inside front cover.

Copies of the Proceedings of Renaissance Banff are available at [www.mathartfun.com](http://www.mathartfun.com).

We note finally that the BIRS workshop *Innovations in Mathematics Education via the Arts*, scheduled for 2007, was a direct outcome of the Renaissance Banff conference.

## 5 Acknowledgments

The success of Renaissance Banff was due to many people who worked very hard behind the scenes.

- The Coxeter Day events were organized by Donald Crowe, Chandler Davis, Doris Schattschneider, and Marjorie Senechal.
- Robert Fathauer, a research scientist at NASA's Jet Propulsion Laboratory, artist, and owner of a small business dedicated to mathematical puzzles, art, and books, was the organizer and director of the Renaissance Banff Art Gallery.
- Chris Palmer, mathematician, artist, and genius of paper folding was the creator of the CD for Renaissance Banff.
- Shelley Alvarado, Chief Operations Officer of PIMS, super organizer, and our unflappable fail-safe backstop whenever everything started to fall apart.
- Katherine Woods, the BIRS Workshop Co-ordinator, who came over from Vancouver to enthusiastically take on the full chaotic onslaught of all the on-site pre-conference details.
- Luke Azevedo, Director of Operations & Technology, Media & Visual Arts and the Creative Electronic Environment at the Banff Centre, who did a fantastic hands-on job of coordinating the Renaissance Banff conference with the Banff Centre and all its technical and artistic resources.
- Brenda Shakotko, the ever cheerful and remarkably able BIRS Station Manager.
- Participant/actors Jan Zwicky, Marjorie Senechal, Craig Kaplan who gave up precious conference time to rehearse the play *Delicious Rivers*.
- Musicians David Fulmer, Diana Nutall, Jan Zwicky, and Marian Moody for an lovely string quartet performance.

**Photocredits:** Eden Robbins and the Banff Centre, Gerda de Vries, Bradford Hansen Smith, Irene Rousseau, Robert Moody, Carlo Séquin, George Hart, Doris Schattschneider.

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