

# Mathematical Biology: From Molecules to Ecosystems: The Legacy of Lee Segel

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In July of this year, a BIRS 5 day workshop on Mathematical Biology, attracted 40 local and international participants. The main purpose of the workshop was to draw on the scientific contributions of a world-leader in applied and mathematical biology, Lee Segel, both in an historical context, and in the context of current day developments. Represented at this workshop were scientists across all ages (from graduate student to emeritus professors), with significant representation from both genders, and with a mixture of talks from novice and experts alike. A unifying common thread linking various contributions was the relationship (via collaboration, citation, extension, or simple admiration) to Prof Segel's numerous areas of expertise. The good grace and indulgence of our "guest of honor" permitted several opportunities for gentle fun and good humor, injected in and between the more formal aspects of the meeting. Setting the tone for the jovial atmosphere was the opening talk by Simon Levin (U Princeton) with a lighthearted review of Lee's illustrious career.

The formal workshop started on Sunday morning with a session on **Molecular Biology** chaired by George Oster (UC Berkeley) highlighting the motion of microorganisms, and physical and mathematical models of their shapes and movements. The shapes of Spiroplasma, of a swimming leech (generated by the Peskin method of immersed boundary), and the motion of a population of myxobacteria were described and analysed. Continuing this theme on Sunday evening, was the session on **Cellular Slime Moulds** (Chaired by Albert Goldbeter, U Bruxelles). The Keller-Segel model for chemotaxis (a set of partial differential equations) and the initiation of the instability that leads to aggregation of these social amoebae was frequently cited. Palsson talked about cell sorting and aggregation and Marée presented his simulation model for the culmination of fruiting body in *Dictyostelium discoideum*. An intense discussion ensued on the validity of Potts model formalism for simulating the motion of a cell aggregate. A point made by Oster and Odell is that this formalism is not grounded in Newtonian mechanics, and thus problematic in allowing for unrealistic mechanical effects. The discussion and valuable scientific exchange based on these comments continued informally, during meals, discussion groups, and over many day's worth of coffee. The most positive aspect of this exchange is that it revealed what must be done to put such models on a firmer footing, to the benefit of practitioners, (young and old) relying on this convenient, if problematic simulation method.

One of the focal points of the workshop was the opportunity presented to junior scientists to present their work. Talks were followed by ample and lively discussion, suggestions for aspects to consider, and ideas about extensions or simplifications of the models. The collegial group of participants, and the supportive senior researchers kept the atmosphere open, relaxed, and positive. Many new connections and important future contacts were forged during these five days.

A session on **Pattern formation** took place on Monday morning. Philip Maini (Oxford U) spoke

on Biological Pattern Formation, and Paulien Hogeweg (Utrecht) on development of multicellular “model” organisms. This was followed on the evening of the same day by the first session on **Perspectives on Ecology and Evolution** at which Marjorie Wonham (Killam Post-Doctoral fellow, U Alberta) presented work on the Invasion model for West Nile Virus.

Formal talks were scheduled on mornings and evenings, leaving afternoons open for outdoor activities, self-organized sessions, and informal discussions. Our group hike took place on Monday afternoon, at a leisurely pace along one of many trails by the river. We passed by the Fairmont Banff Springs Hotel, admired the Bow River Falls, and continued behind the gold course into woody trails.

Tuesday was a heavy day, with sessions on **Immunology**, chaired by Alan Perelson (Los Alamos), and **Ecology II**, chaired by Mark Lewis in the morning and evening. In the morning session, Prof Lee Segel spoke about his own recent research on “How the immune system can cope with its multiple overlapping and conflicting goals” (video available on BIRS website). A New Mexico contingent of theoretical immunologists (and computer scientists), Alan Perelson, Stephanie Forrest, and Christy Warrender presented their work. On Tuesday afternoon, we also held an informal session for contributed talks (organized and chaired by UBC graduate student, Adriana Dawes). Evening talks by Postdoctoral fellows Frithjof Lutscher and Christina Cobbold (U Alberta) were well-received, eliciting discussion and suggestions by Fred Adler.

The session on **Modelling Diseases** on Wednesday morning (Chaired by Fred Adler, Utah) featured a lecture by David Earn on the dynamics of childhood diseases. The puzzling features of data on periodic disease incidence, and the ability (or inability) of models to explain this data formed the main theme of this talk. A duet by Princeton trainees Joshua Plotkin and Jonathan Dushoff on the evolutionary ecology of influenza viruses followed. On Wednesday evening, we held a second session on **Immunology**, with emphasis on autoimmunity, and Type 1 diabetes (chaired by Rob de Boer, Utrecht). Two representatives of a MITACS team on biomedical modeling (Stan Maree, departing PDF from UBC, and Diane Finegood, SFU) presented results of a two-year effort on modeling autoimmune (Type 1) diabetes. (An afternoon MITACS working group meeting on type 1 diabetes preceded the evening session, with participation by researchers from four Alberta and British Columbia universities and discussions about how to coordinate future collaborative work on that subject). As a finale for this last evening together, we staged an impromptu session composed of limericks and “famous quotations” to recap and summarize workshop highlights.

Rebecca Tyson summarized our feelings succinctly with the following poem:

What a truly wondrous place,  
Where beneath the mountain’s face,  
Our math we share,  
With colleagues rare,  
See thoughts grow wings and fill the space!

I’ve learned to measure my distance from Lee,  
And hope that stage 2 I’ll soon see,  
To work quite late,  
Not to overload my plate,  
And make my talk equipment-free!

But jests aside I want to say:  
BIRS, thank you for a special stay,  
And to you each,  
It’s been a peach,  
I hope to see you soon some day.

One final session, held on Thursday morning, completed the circle with the return to **Molecular Biology** (Chaired by Gary Odell, U Washington). A thrilling expose by Odell on the robustness of genetic networks, and presentations on the cytoskeleton (by Mogilner, Cytrynbaum UC Davis)

brought this workshop to a final exciting ending.

We were sad to leave BIRS behind, but firm in our resolve to return to this wonderful place where science, nature, and mathematics are united as one whole. The spectacular scenery of Banff, lofty snow-capped mountains, wild flowers, warm summer skies, and graceful visiting families of elk made for a uniquely enchanting setting to this wonderful event. Added to this were the outstanding facilities and administrative assistance provided by BIRS and its staff. Especially noteworthy were the friendly and efficient assistance of Andrea Lundquist in administrative and organizational aspects, the comfortable dormitory rooms (equipped with computer terminals), and the excellent lecture room. Also remarkable were the Banff Center's dining facilities, and the excellent selection of buffet spreads enjoyed by one and all. The only complaint heard at the conclusion of this 5-day event was "Too many desserts!"

### **Statistics:**

Workshop included the following breakdown

**Status of participants:** Graduate students: 11; PDF's: 7, Junior scientists (assistant professors tenure track): 3, and senior scientists (Associate professors and above): 20.

**Gender:** Male: 27, Female 13 (four of which were graduate students)

**Nationality:** Canadians (Including landed immigrant): 16; USA: 13, International: 11 (from Israel, Holland, England, Belgium, and Germany)

**Expertise:** Mathematics: 18, Biology 11, Math-bio (Interdisciplinary) 7, other (including physics, computer science): 4.