



# Evaluation Data Report

## Investigative Workshop: *Individual-based Ecology of Microbes*

June 8-10, 2011

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# *Individual-based Ecology of Microbes Workshop*

## Evaluation Data Report

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### Background

#### Introduction

This report contains evaluation data for a NIMBioS Investigative Workshop entitled “*Individual-based Ecology of Microbes*” (Microbes workshop), which took place at NIMBioS June 8-10, 2011. NIMBioS Investigative Workshops are relatively large (30-40 participants), focus on a broader topic or a set of related topics than Working Groups, attempt to summarize/synthesize the state of the art and identify future directions, and have potential for leading to one or more future Working Groups. Participants may include post-docs and graduate students with less experience in the particular topic than those participating in Working Groups.

The Microbes workshop comprised 37 participants, including co-organizers Ferdi L. Hellweger (Civil & Environmental Engineering, Northeastern Univ.), Jan-Ulrich Kreft (Centre for Systems Biology, Univ. of Birmingham), Caroline Plugge (Microbial Physiology, Wageningen Univ.), Andre Levchenko (Biomedical Engineering, Johns Hopkins).

#### Workshop Description

Microbe populations have traditionally been conceptualized as homogeneous collections of identical individuals. This is reflected in our observational approach: biomass is quantified using optical density (OD) or dry weight (mg/L); activity is characterized using bulk chemical measurements (e.g. dissolved oxygen community respiration). Our models also reflect this view. Microbes are described using population-level state variables (e.g. mg C/L) and differential equations (e.g.  $dC/dt = \text{growth, death, etc.}$ ). Growth is considered to be a chemical reaction between a “microbe molecule” and a nutrient molecule to make more microbe molecules. However, advances in single-cell observational techniques, like flow cytometry, microfluidics, fluorescence microprobes, and single-cell genomics, now allow for the observation of individuals within populations. At the same time, individual/agent-based models allow for individuals to be simulated. These new techniques form the foundation of individual-based ecology of microbes. The goal of this workshop was to bring together researchers interested in applying individual observational and/or modeling techniques to study microbial ecology. The workshop addressed several general questions:

- Microbes can now be studied using population-level or individual-based approaches. Are there fundamental differences in the results that can be expected?
- Microbe populations are typically numerous and even individual-based techniques will have to aggregate or upscale at some point (e.g. super-individual, representative area). Is there an appropriate level of aggregation?
- Can a generally-applicable method be developed to determine it?

- A future goal in the area may be to model whole communities of microbes, such as plankton in the world oceans or biofilms of a trickling filter, at the individual level. What specific mathematical or computational hurdles will have to be overcome to do this?
- What are the open biological questions that can be investigated more effectively using the individual-based approach?
- What prevents us from doing this now?

The workshop's central theme, *individual-based ecology of microbes*, is part of an ongoing trend to move from population-level to individual-based approaches in ecology. Early ecological models of organisms at higher trophic levels (e.g. wolves, fish) were based on populations (i.e. Lotka-Volterra). However, the individual-based approach is now well-established. With advances in computing and observing technology, the individual-based approach is now becoming feasible for microbes as well. We anticipate that the individual-based approach will become standard practice for microbes in the future. At present, however, the field is in its infancy. Several research groups have developed their own codes and approaches. Bringing together a number of researchers with interest in this area will accelerate the development of this new field.

## Evaluation Design

### Evaluation Questions

The evaluation of the workshop was both formative and summative in nature, in that the data collected from respondents was intended to both gain feedback from respondents about the quality of the current workshop and also to inform future similar meetings. The evaluation framework was guided by Kirkpatrick's Four Levels of Evaluation model for training and learning programs (Kirkpatrick, 1994<sup>1</sup>). Several questions constituted the foundation for the evaluation:

1. Were participants satisfied with the workshop overall?
2. Did the meeting meet participant expectations?
3. Do participants feel the workshop made adequate progress toward its stated goals?
4. Do participants feel they gained knowledge about the main issues related to the research problem?
5. Do participants feel they gained a better understanding of the research across disciplines related to the workshop's research problem?
6. What impact do participants feel the workshop will have on their future research?
7. What changes in accommodations, group format, and/or content would participants like to see at future similar meetings?

### Evaluation Procedures

An electronic survey aligned to the evaluation questions was designed by the NIMBioS Evaluation Coordinator with input from the NIMBioS Director and Deputy Director. The final

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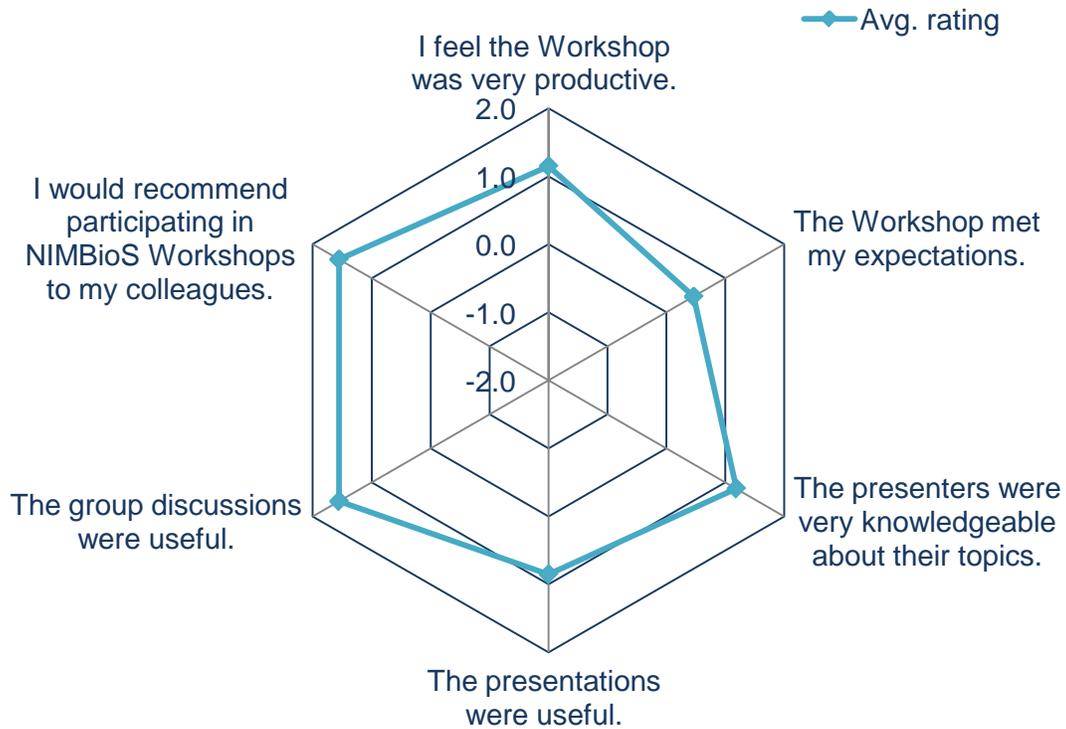
<sup>1</sup> From Kirkpatrick, D.L. (1994). *Evaluating Training Programs: The Four Levels*. San Francisco, CA: Berrett-Koehler.

instrument was hosted online via the University of Tennessee's online survey host mrInterview. Links to the survey were sent to 32 registered workshop participants on June 13, 2011 (co-organizers and NIMBioS affiliates were not included in the evaluation). Reminder emails were sent to non-responding participants on June 20 and 23, 2011. By June 30, 2011, 27 of the participants had given their feedback, for a response rate of 84%.

# Evaluation Findings

## Overall Satisfaction

Figure 1. Satisfaction with various aspects of the workshop



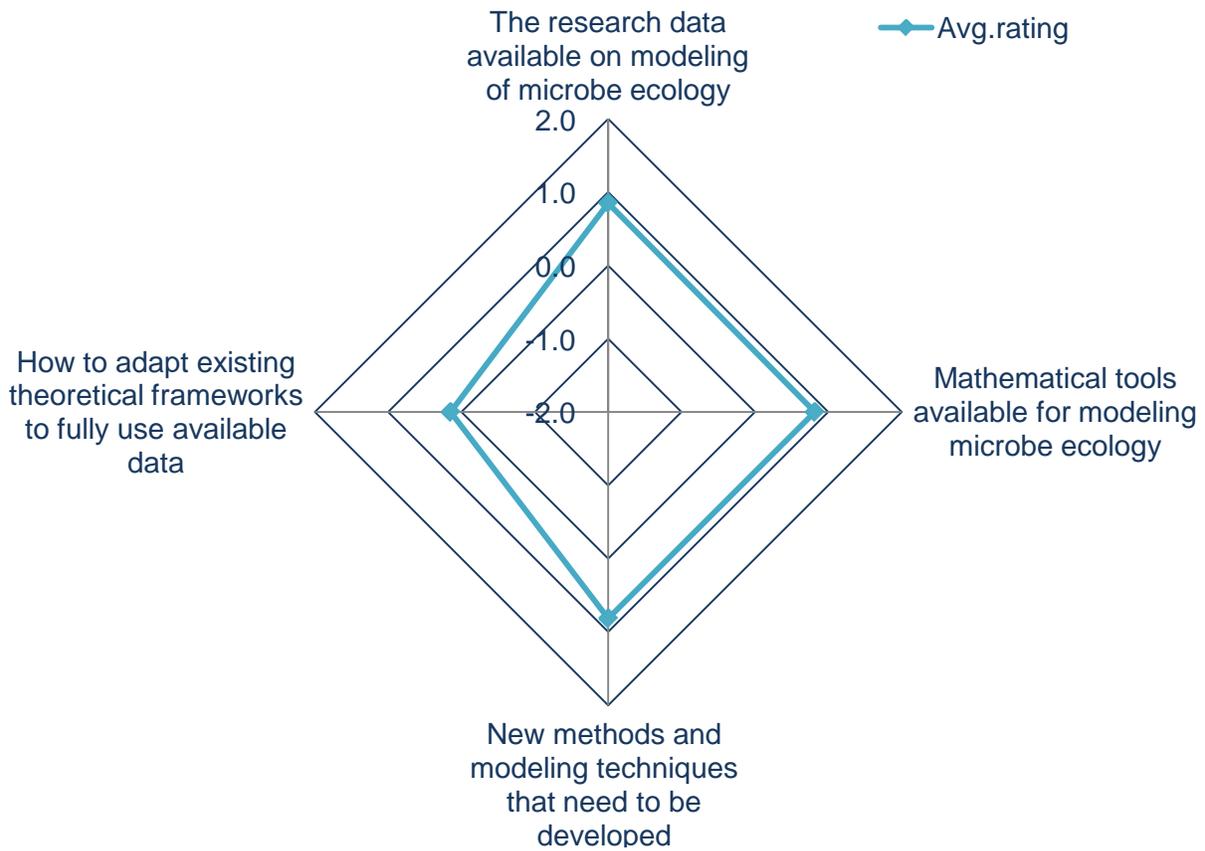
Scored on a 5-point Likert scale from -2 to 2 for “strongly disagree” to “strongly agree”

## Workshop Content and Format

### Participant Learning

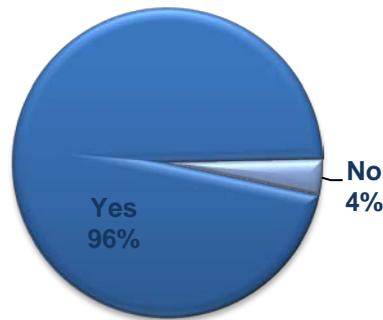
Figure 2. Participant learning

*As a result of attending this workshop, I have a better understanding of:*



Scored on a 5-point Likert scale from -2 to 2 for “strongly disagree” to “strongly agree”

**Figure 3. Do you feel that participating in the workshop helped you better understand the research going on in disciplines other than your own regarding ecology of microbes?**



### **Comments**

*I very much enjoyed the workshop and learned a lot from speaking to the scientists. I think we all struck up some potentially very useful relationships that would not have materialized without the coming together. I will be very keen to engage in any follow-on workshops that can build on what was achieved last week. I have mailed the group to this effect.*

*Generally, I think that the workshop provided an excellent chance for theoreticians and empiricists from a wide variety of fields to get acquainted. As such it was an excellent introduction to the platforms available and the approaches being used. There was really no time to work out more detail regarding where the opportunities and challenges lie in terms of matching measurements and theoretical/numerical tools. The true success of the workshop will depend on what happens after the workshop.*

*I already do some modeling, but came to this workshop hoping to learn more approaches to IBM's and more experimental techniques associated with single-cell culture. I don't think I learned more modeling, but I definitely learned more about how this modeling is used in microbiology. I did learn enough about single-cell culture to figure out it probably wasn't what I need for my research. So, I probably didn't learn as much as I had hoped from the strict workshop itself. On the other hand, the workshop included a bunch of really smart people and lots of time was provided for group and individual discussion. From this, I think I learned a great deal, both stuff that I could narrowly apply to my own research and broadly that I can transfer on in my teaching.*

*I feel that I did gain some basic knowledge about individual-based ecology of microbes, but did not feel that we got much applied understanding of the methods/processes.*

*I have especially gained an understanding regarding the empirical tools and experimental methods available to collect data to feed the models.*

*I learned a great deal from this workshop, and thoroughly enjoyed myself. I think that the main problem was the presentations. A participant would often detail research--often with little or no obvious connection to individual-based methods--and then ask the group "how can I use IBMs?" I think everyone would have done better to be clear on the point of the presentations, which I assume was to educate and raise possible points for collaborations. I was annoyed because I was the last presenter in a section in which most presenters ran long, and I got asked to hurry up after just a few minutes. I have background in lab (microscopy and image analysis) and theoretical (IBMs) approaches, and wanted to offer a brief intro into the empirical tools (which I think some other participants could have used) and raise some questions for the modelers. Instead, I got cut off, and didn't have a chance to answer questions or hear feedback.*

*I really appreciated the opportunity to talk at the workshop, as it helped those who know more about the field to give me feedback. However, I would have liked it if the experts had longer time slots to talk and those of us who are new to the field had shorter talks. Overall, I appreciated the organization of the workshop and found it informative. A little more time for group discussion would have been nice.*

*More introductory level presentations would be helpful.*

*Overall, I think the organization was nearly optimal considering the very diverse group of attendees.*

*Real exercises/data should be included in future meetings; however, the meeting was a success. Thanks for the invitation to participate.*

*The workshop provided a great face-to-face forum for exchange of individual expertise and experience in the field of individual-based microbial ecology. The ratio of modelers to experimentalists seemed appropriate.*

*The workshop provided something of a snapshot of the kind of work going on at the minute. However, due to the short nature of the presentations, often the talks were lacking on details, which is something I was expecting from the workshop.*

*The workshop was not exactly what I expected, although it was productive. I feel that perhaps if we had gotten a quick introduction IBMs in ecology and microbial ecology first, novices such as me might have been able to contribute more intelligently to the discussions.*

## Workshop Format

Figure 4. Effectiveness of workshop format



### **The format would have been more effective if:**

*More small groups, more focused questions, less diffuse talk of different biological systems.*

*Real modeling exercises were included more time for breakout sessions and less presentations more experienced modelers are invited group mini project/exercise included.*

*There was more time allotted for experts to introduce the topic and show examples of how it can be applied in microbial systems.*

*We had more time to discuss.*

### **Most Useful Aspects of Workshop**

*A couple of days of concentrated attention on a single topic with inputs from many different points of view.*

*Access to leading experts and their opinions.*

*All participants got the chance to speak. This was costly in terms of time, but it allowed participants to approach each other more easily. I like this much more than a tutorial at NIMBioS I attend some time ago.*

*Breakout discussions, participant presentations that were RELEVANT to individual-based methods (many simply were not.)*

*Bringing together people working on a diverse set of problems with a diverse set of tools. There are bound to be mismatches in expectations and understanding in such a situation, and people need to be brought together to realize this and make progress towards removing these barriers. Some participants said their expectations weren't met, but expectations can't be unified without meetings like this.*

*Discussion sessions as well as time during breaks to meet with others*

*Excellent to bring together experts from different disciplines. Good for contacts. For a new subject this is the best possible way forward.*

*Face to face interaction.*

*Group discussion. Individual interactions.*

*It was a good overview of the range of topics in microbial ecology that could be addressed by individual based approaches, and of the theoretical platforms available to address those questions.*

*Meeting like-minded people with similar problems and objectives to me.*

*Meeting people who work in similar fields of research*

*Networking. As always, conferences and workshops are the best places to get to know people and develop connections.*

*The afternoon discussion sessions.*

*The afternoon discussions, particularly on the last day.*

*The breakout group discussions.*

*The breakout sessions where both modelers and microbiologist attended.*

*The diversity of presentations.*

*The group discussions.*

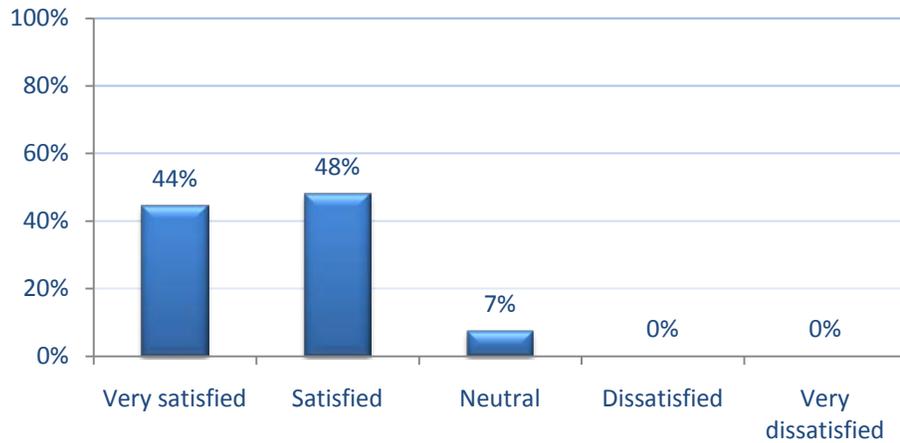
*The most important thing for me was to meet these people in person and talk about my and their research, see different approaches when solving problems. Also establishing contacts with other researchers for future corroboration has enormous value for me as young scientist.*

*The networking opportunity.*

*The open discussions that encouraged researchers with different backgrounds to communicate with each other.*

## Communication

**Figure 5. How satisfied were you with the opportunities provided during workshop presentations and discussions to ask questions and/or make comments?**



### Comments

*As this is the first workshop of its kind it was good to hear everyone speak; that helped a great deal to understand the range of applications people are currently addressing and the techniques they are, or plan to be, using. If it were followed up I think it would be good to narrow the focus, have fewer, possibly longer, talks and allow more time for technical ideas to be exchanged.*

*I appreciated the depth of discussion during the break-out sessions. I had wonderful collaborative conversations and made the best connections during this time. I would have liked more of this.*

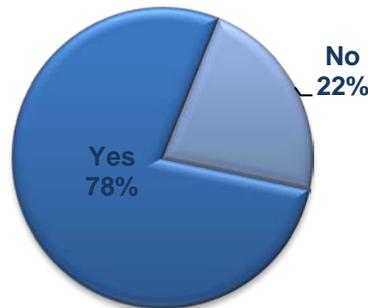
*I feel the workshop facilitated discussion well.*

*Less time devoted to presentations - more structured discussions. Maintain long breaks - these were the most useful discussion opportunities.*

*More specific breakout sessions for people with common interests might have been helpful.*

## Progress Toward Goals

**Figure 6. Do you feel the workshop made adequate progress toward finding a common language across disciplines for research on the workshop's topic?**



### Comments

*At the beginning of the workshop around half of the audience appeared to not fully get the purpose of modeling, let alone individual-based modeling. I think the workshop acted to introduce observationists to modelers, but I think that is about as far as it goes. Maybe one can't expect much more from such a short workshop. However, given the mixed background of the audience, I wonder whether the workshop might have benefited from two or three longer talks given by the more senior attendees describing what an IBM is, when one might use one, how one is designed, how one is built, where they have been used in the past etc. Of course, if the audience had all been individual-based modelers, this would probably not have been necessary.*

*Bridging theoretical and empirical aspects of science is hard. I think what the workshop has achieved is to make people from both sides aware of and understand, to some extent, each other.*

*I feel it would have been useful to define some vocabulary or give a quick overview of the two fields in the beginning.*

*I think the workshop was most useful in identifying the steps that need to be taken to find such a common language. The idea of a collaborative sort of white paper is an excellent first such step.*

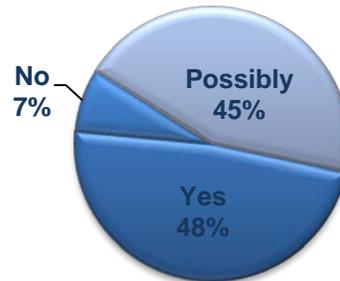
*I'm not sure quite what the question means, but there was certainly agreement about key issues that need to be addressed by (potentially) all disciplines.*

*It was great to see how IBS are being used by so many different disciplines.*

*It would be next to impossible to make any progress of this type in a couple of days.*

## Impact on Future Research Plans

Figure 7. Do you feel that the exchange of ideas that took place during the workshop will influence your future research?



### Comments

*I better understand the requirements of individual modeling and hope to use it one day as the appropriate data becomes available.*

*I didn't understand how involved and time consuming IBM is, so although I have gained knowledge in this area I'm not sure if I will use this approach in my current research (perhaps in the future though).*

*I have a better concept of when to apply and when not to use IBM's.*

*I have been inspired by a number of experimental systems. The workshop has therefore given me ideas that I might use in determining my research directions.*

*I learned a lot and made new contacts, so yes, I think that will influence my future research.*

*I suspect I will stick more closely to the ODD protocol for describing IBMs in the future, as this was discussed at the workshop. So in that sense yes.*

*I think it more reinforces some of our current thinking, but the need to accommodate a wider user base is certainly something that has come out.*

*I will try to develop an IBM model for my system of interest.*

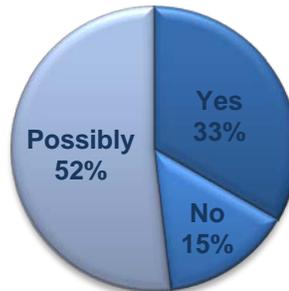
*I'd like to explore an IBM in conjunction with traditional models to see how they might augment each other.*

*It is always difficult to judge so soon after a workshop, but I think that contacts made may endure, and hence will influence future research.*

*The experimental possibilities were made more apparent to a computational modeler like me.*

## Impact on Future Collaborations

Figure 8. Did you develop plans for collaborative research with other workshop participants?



### Comments

*Joint publication on individual-based modeling of microbes - Working group on markup language.*

*I am not sure whether this exact tool will be useful for my current data set; however, I did meet researchers to collaborate with in the future.*

*I believe there are at least two papers which will come out of the workshop which I should be able to contribute towards. I also met several people interested in similar subject areas to my own that I had not met before. I hope to build collaborations with these people in the future.*

*I have agreed to remain in contact with a few participants. Whether we end up collaborating or not will depend on how our ideas develop.*

*I have developed network connections that may lead to work in the future.*

*I met several individuals who I plan to work with that I would probably not have met otherwise. In this sense the workshop was a great success for me.*

*I mostly planned collaborative research (or shared research methods) with fellow experimental researchers.*

*I went with the intention to collaborate with other researchers, but it seems the questions that interest me are not really compatible with IBMs.*

*I've made some preliminary plans to collaborate on the educational side of computational modeling.*

*It was extremely useful for me to see in person people, who are doing experiments, now I can contact them and ask questions, that I have as a modeler.*

*Also I think further cooperation is possible.*

*There were several modelers interested in the experimental setup our group uses, so in that sense the workshop was certainly a positive experience.*

*Two of the senior attendees agreed to contribute to a joint research project.*

## **Suggestions for Future workshops**

*Allocate more time to open but clearly targeted discussions.*

*Fewer, longer, and more focused presentations will be more helpful.*

*Have mixture of lectures, scientific presentation of experienced scientists, and short presentation of PhD students. Make sure PhD students follow a certain format instead of saying: "Well, I am not exactly what I am supposed to say here". Make sure that also professors stick to the schedule (here: 10 minutes for every talk) rather than talking for 25 or, as in one case, 40 minutes.*

**HOLD PRESENTERS TO TIME LIMITS.** *Presentations should be OPTIONAL, and method-oriented! Otherwise, you just get research presentations!*

*I think it would have been more useful if the "experts" were given more time to speak, and the others just a chance to present their study system, method, etc. I think this would allow for more discussion time after the presentation w/r/t appropriateness of an IBM approach, and facilitate discussion during breaks and outside of the conference.*

*I think it would have been useful to have identified some concrete examples of successful IbMs; this would involve abstracting the IbM rules for both the biology and physics inherent in those examples. This would have been useful both for the beginners and for those interested in building tools to support IbM development.*

*I think that perhaps more work could have been done up front to make us think about what we hoped to accomplish with this workshop. The two groups (modelers and single-cell culture) people learned a lot about each other, but weren't forced to think about "products" of the workshop until the last 30 minutes. I might also try to get more appropriate graduate students. Some of the graduate students were not a good match for the conference, although I think (and hope) that they still got a lot from it.*

*I will make it longer, in order to have more interaction between the participants.*

*I would give the experts more time to talk and give the novices shorter time slots.*

*I would have included a few more general, longer presentations regarding*

*individual-based modeling in order to get everybody on the same page.*

*I would have let everyone present, but shortened the time slots to 5 and cut people off at 5 minutes. Part of the reason we did not have more time to discuss was SEVERAL individuals talked for MUCH longer than their 10 minute slot. Moderators did not keep presentations on track and thus the discussion times were shortened. I also would have benefited from introductory presentations by modelers on the first day (not last).*

*I would have more structure in who presented when, so there was a general foundation built early and filled out later. I would also have been stricter about presentation length; participants took too many liberties in this area.*

*Maybe start with an introductory presentation on some basics, common terminology and the scope of the workshop. Then again, perhaps that would have restricted its direction.*

*More demonstration of how IBM works in comparison to other approaches.*

*More time for group discussions.*

*Not much. Perhaps more discussion. The questions around which discussion proceeded maybe could have been formulated better. They seemed too prescribed and repetitive, although the participants managed not to be too constrained by them.*

*Perhaps a single, longer introductory talk at the beginning might have been useful.*

*Possibly for this particular one there could have been an introduction to some aspects of computational modeling for the non-modelers.*

*Perhaps formulate and distribute a statement of purpose to attendees before the meeting so that expectations are met more broadly than they seem to have been during the past meeting (based on the discussion that we had).*

*Presentations could have been more concise.*

*The allocated time for the presentations compared with the discussions. also delegate somebody to follow and synthesize the discussions.*

*There was too much time devoted to student presentations and not enough discussion. Too many talks that exceeded their time slot (up to 400%). Aims of the workshop were not clear in advance.*

*Too much not-so-relevant presentations.*

*While I appreciate that everyone had a chance to talk about their research, I wish*

*we had spent less time on presentations and more in discussion.*

## **Additional Comments**

*Just a 'thank you' to the organizers, and NIMBioS, for arranging a very enjoyable and fruitful meeting.*

*Thank you for providing this opportunity.*

*Thank you! I enjoyed the workshop very much!!*

*Thank you!!! I need more like these workshops.*

*The organizers did a wonderful job trying to accommodate a group of people with an extremely wide skills set. I feel all levels learned something new.*

# Appendix

Individual-based Ecology of Microbes Workshop Evaluation Survey

## Individual-based Ecology of Microbes Workshop Survey

Thank you for taking a moment to complete this survey. Your responses will be used to improve the workshops hosted by the National Institute for Mathematical and Biological Synthesis. Information supplied on the survey will be confidential, and results will be reported only in the aggregate.

Please check the appropriate box to indicate your level of agreement with the following statements about this workshop: (Very satisfied, Satisfied, Neutral, Dissatisfied, Very dissatisfied)

- I feel the workshop was very productive.
- The workshop met my expectations.
- The presenters were very knowledgeable about their topics.
- The presentations were useful.
- The group discussions were useful
- I would recommend participating in NIMBioS workshops to my colleagues.

Please check the appropriate box to indicate your level of agreement with the following statements. As a result of participating in this workshop, I have a better understanding of: (Strongly agree, Agree, Neutral, Disagree, Strongly disagree)

- The research data available on modeling microbe ecology
- Mathematical tools available for modeling microbe ecology
- New methods and modeling techniques that need to be developed
- How to adapt existing theoretical frameworks to fully use available data

Do you feel participating in the workshop helped you better understand the research going on in disciplines other than your own?

- Yes
- No
- Comments:

Do you feel the workshop made adequate progress toward finding a common language across disciplines for research on the workshop's topic?

- Yes
- No
- Comments:

Do you feel that the exchange of ideas that took place during the workshop will influence your future research?

- Yes
- No

Possibly  
Comments:

Did you develop unanticipated plans for collaborative research with other workshop participants?

Yes  
No  
Possibly  
Comments:

What do you feel was the most useful aspect of the workshop?

What would you have changed about the workshop?

How do you feel about the format of the workshop?

This was a very effective format for achieving our goals  
This was not a very effective format for achieving our goals ->  
The workshop format would have been more effective if:

Please indicate your level of satisfaction with the workshop accommodations:  
(Very satisfied, Satisfied, Neutral, Dissatisfied, Very dissatisfied, Not applicable)

Travel arranged by NIMBioS  
Housing arranged by NIMBioS  
Comfort of the facility in which the workshop took place  
Resources of the facility in which the workshop took place

Please indicate any changes NIMBioS can make to improve the resources and/or accommodations available to workshop participants:

How satisfied were you with the opportunities provided during workshop presentations and discussions to ask questions and/or make comments?

Very satisfied  
Satisfied  
Neutral  
Dissatisfied  
Very Dissatisfied

Please indicate any suggestions you have for facilitating communication among participants during the workshop:

Please use this space for additional comments: