

Microbial communities: Energetics and dynamics across space and time

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Workshop description

This one-week workshop was aimed at developing an integrated theoretical and experimental framework that accounts for the energetics of microbial communities and their spatiotemporal dynamics. The key areas of discussion were planned to center around:

- Energy balances and quantitative measurement of metabolic fluxes in microbial communities
- Thermodynamic and physiological constraints at the community and species levels
- Spatial and temporal dynamics of species and metabolites

The workshop featured invited and participating speakers in each area. Talks were interspersed with ample discussion time, and participants were encouraged to examine the experimental challenges and explore possible theoretical approaches that can be applied.

Overall feedback from participants

It is fair to say that the workshop was a success. The overwhelming view of the participants expressed to organizers at the meeting that the workshop was useful and inspiring. In the evaluation questionnaire, filled during the workshop, 87% of participants strongly agreed that “attendance was worth their time”. See further details, e.g. on comments on workshop structure in the evaluation document.

Specific feedback - via personal statements and through the questionnaire - praised the mix of the topics presented and participant’s expertise. Even though the schedule allowed for ample discussion time, many participants suggested “more free time” for discussions. This shows that organizers were on the right path with inclusion of discussions, but could have done more to reduce numbers of talks. This is a hard trade-off to get right.

There were also comments on including pre-workshop learning exercises, tutorials, and chalk-talks that go deeper into specific research findings. These are good ideas, seconded by organisers, but they might be better suited to a more focused meeting around one or two subjects and their intersection. We will take this into consideration when thinking about a follow-up event for this workshop at NITMB.

Emerged themes

Many discussions - in small groups - were held among participants during set free times, and a facilitated discussion was held with most of the participants (see Figure 1). The former have led to the identification of new, more specific questions, while the latter highlighted themes that were broadly felt to be important. We try to capture some of the specific questions emerging, and list also those broad themes below. It is possible that us, as organizers, or some of the participants might consider a follow-on workshop in one (or multiple) of these areas.

Exemplar questions/topics emerging in small meetings:

- **Cyclic processes:** Interesting discussions, including the participating science writer Ben Martynoga, took place around the existence and role of “cycles” across biological scales from cellular metabolism to ecosystems. We wondered about the energetics of such cycles, where and why they are prevalent, and how to best analyse them from theoretical and experimental perspectives.

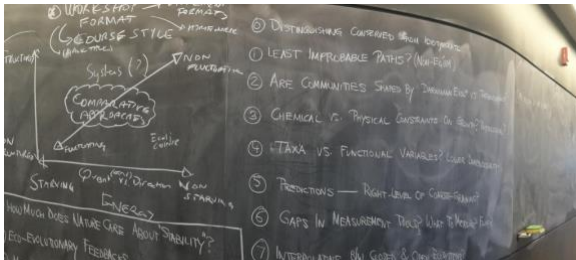


Figure 1. A snapshot of collated ideas from the whole-group discussion, with contributions from all participants.

- **What limits community growth:** Many different participants came with their own systems of interest and with different environmental conditions that were relevant. This led to several discussions about whether and how we can classify environments as those leading to energy-limitation vs. not (instead leading to other kinds of limitation, such as matter).

Themes emerging in whole group discussion:

A lively, whole-group discussion was organised and was relatively successful (in terms of attendance and participation). The discussion was led by Orkun, Akshit, and Wenying, who tried to capture the ideas brought forward on the chalk board (Figure 1). Some of the key aspects that had raised included:

- **Microbial communities “phase space”:** Would it be possible to consider microbial systems in a multi-dimensional parameter space? Would this space be reducible to few key parameters, perhaps those relating to spatial structure and energy levels?
- **Model systems:** Can we agree on, and develop, model systems for microbial ecology? In other words, could there be an “E.coli”, as in molecular biology, but for microbial ecology. How would this look like? Could we imagine model systems representative of different parts of the above phase space, e.g. a “model mat”, a “model gut”, etc. that provide systems with different energy levels or substrate flow (i.e. energy) or spatial structure or taxonomic composition.
- **Measurement gaps:** What are the key missing measurements and measurement tools? Talks with a more methodological spin, e.g. on spatial or isotope-based measurements raised quite a lot of interest, and more discussions took place about increasing method-focussed training and data analyses.
- **Theoretical gaps:** What key theoretical tools are missing and what new theoretical tools can be developed for microbial communities research? Many ideas revolved around the need of using more ideas/tools from “nonequilibrium thermodynamics”, but there was also concern raised about the difficulty / inaccessibility of nonequilibrium theories. It was broadly agreed that this could be a topic for further, focussed workshops.

Specific outcomes

It is too early to conclude / report on specific outcomes. The questionnaire responses showed that 88% of participants agreed that the workshop provided meaningful and new interactions. We

will have to see future activities to judge how those interactions develop. That said, there are already few outcomes that we are aware:

- Two participants told us of their developing collaboration following the workshop and their plans of possibly applying to NITMB for a short-visit fellowship.
- A subgroup of the participants are writing a review article on challenges for measurements for Current Opinion in Microbiology, and will acknowledge NITMB support.