Interactive Exercise: Perspectives on Microbial Communities

Summary: A brief (5-10 minute) introduction motivates the idea that microbial communities are important in medicine, but because of their complexity, ideas from landscape ecology have proven useful in making sense of different patterns in healthy vs. diseased individuals. After the brief introduction, participants divide up into 5 groups. Each group gets a scenario that illustrates one or more common patterns in microbial ecology. Each group talks amongst themselves (allow about 7 minutes), trying to work out what's happening in their scenario while the instructor circulates among the groups. The groups may optionally quantify changes using a table of bacterial types vs. samples (e.g. an OTU table). The groups come back together and discuss their ideas while the instructor brings up each scenario on the projector. The instructor reveals important human diseases that fit each pattern, and shows how the communities look if put into a table. Student's can take home a summary handout that restates the patterns from class in writing (for folks who prefer to read rather than hear the information).

Goals:

- Introduce the idea that it is natural to quantify microbial communities to understand how they affect health and disease.

- Introduce some common patterns in how microbial communities change in different types of disease.

- Emphasize that the main patterns that researchers look for in microbial communities are actually quite simple and easy to understand.

- Introduce the idea that we can also think about microbial communities from the point of view of microbe-microbe interactions.

- Introduce the specific ideas of examining microbial communities by looking for shifts in specific pathogens, community composition, cell counts, richness, evenness, or beta-diversity

Time: 45 minutes. Can be compressed to ½ hour with preparation. Could also be expanded to a longer exercise by discussing microbe-microbe interactions.

Students: Currently tested on about 20 (5 groups of 4). Larger classes could work, but you might want multiple groups working on the same scenario.

Materials:

20 color printed handouts (5 scenarios x 4 students per group). In larger groups, or if printing costs are limiting, students can share papers or access the raw image files online.

20 summary sheets (1 per student).

Required Participant Background: None required. I would usually build up to the exercise by first getting folks excited about the overall importance of the microbiome with the standard parade of really exciting recent discoveries (e.g. microbes and autism, Hawaiian Bobtail squids and camouflage by *Vibrio fischerii* symbionts). The exercise slides contain one short example based on inactivation of digoxin, an important cardiac drug, by *Eggtherella lenta* Actinobacteria in the human gut.

Required Instructor Background: Familiarity with Koch's postulates; and the ideas of richness, evenness, altered community composition, and beta-diversity.

Tips and Ideas:

- I try to emphasize the straight-forwardness, rather than the sophistication, of the methods in this exercise. The goal is to convey that participants now are familiar with most of the main hypotheses that are argued about in cutting-edge biomedical studies of the microbiome. There's always room to add complexity and nuance, but for now we're tying to get folks hooked on the topic and buying in to the idea that this is something that they can do.

- In some cases there are multiple valid patterns going on, not just the main one illustrated (e.g. changes in alpha-diversity also imply some changes in relative abundance). The goal is to affirm as many valid ideas as students come up with. If they don't get the intended pattern, its OK to just say, "Those are all good ideas that we can test using methods we'll talk about later. Another pattern that I was trying to highlight with this scenario was…."

- While you are circulating you may notice that some groups finish before others. In those cases, you can let groups know that there is another way of looking at the communities: in terms of microbe-microbe interactions. For example, the 'specific pathogen' scenario (Scenario 1), which is pretty easy to solve (red bacteria only appear in diseased patients), also has embedded within it a strong negative linear correlation between two bacteria (when one is abundant the other is rare). These patterns lead naturally into the next exercise on microbial interactions. Microbe-microbe interactions for Scenarios 1 (single pathogen/Koch's postulates) and Scenario 3 (richness) and are in the slides as 'bonus material'. NOTE: in this version of the materials I wasn't able to embed microbe-microbe interactions in ALL the scenarios, so I just targeted the ones where I thought the groups might finish really early.

- Participants might notice other patterns in the exercise. For example, one student noticed that some bacterial types were shown with a stacked spatial

arrangement (all the same angle) whereas others varied. I tend to encourage these kinds of ideas as long as they can point to what they're seeing in the data. This can lead in to discussions of what might affect different spatial arrangements of bacteria (for example) and how that might be tested.

- You can save a bit of time by arranging tables/chairs into groups ahead of time and putting a packet of scenarios on each table.

- You can distribute scenarios around the room (e.g. 1,5,3,4,2 rather than 1,2,3,4,5) to keep the discussion moving to different segments of the room rather than just left-to-right.

- The exercise could be adapted to use manipulables like M&Ms or 3-d printed bacterial miniatures. However, more time should be allowed for counting in this case, and it may end up being a LOT of manipulables (6 healthy samples + 6 diseased samples * 10 microbes each = 120 manipulables per scenario * 5 scenarios = 600 manipulables for the class!! Some students in testing expressed they preferred printed images, but it may depend on learning style.