Ecological Metaphors in Microbiome Research

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Ecological concepts and metaphors abound in microbiome research

- “within each human body, intestinal and other microbiota along with the ‘host’ human cells, form a complex ecosystem that, as a whole, interactively performs various biological processes.” (Hattori and Taylor 2009)
- “Humans and their collective microbiota are segmented into many local communities, each comprising an individual human with his or her symbionts. This ecological pattern. . .is described as a metacommunity.” (Dethlefsen et al. 2007)
- “All plants and animals, including humans, can be considered super-organisms composed of many species -- animal, bacterial, archaeal, and viral.” (NRC 2007)
- “If humans are thought of as a composite of microbial and human cells . . . the picture that emerges is one of a human 'supra-organism'.” Turnbaugh et al. (2007).
- “The superorganism concept is an important paradigm shift in understanding human biology” (Rajendhran and Gunasekaran 2009).

Ecological science can do little to "fund" or explain these metaphors

- The history of ecology is characterized by a controversy over whether what are called communities are simply the species that happen to co-occur at a place (the Gleasonian and Aristotelian view) or whether they are organized into discrete, persistent entities (the Cementsian and Platonic view) and, if so, what is the nature of their integration or organization. No progress has been made in settling this controversy.
- Definitions of the ecological "community" or "system" are so vague and general that they are easily reduced to absurdity by counter-example.
- Ecological systems or communities constantly undergo change. No agreed-upon criteria exist to tell when a community or system remains the "same" (self-identical) through time and change and when it changes so much it segues into a "different" community or system. Philosophers say: "No entity without identity."

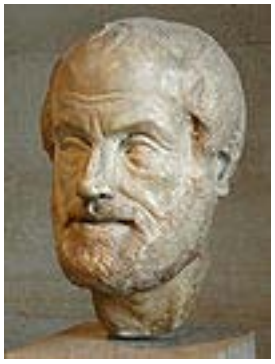
Ecological theory provides no normative analogy for microbiome research

- Ecological theory tends to exclude human influences and intentions from the natural ecosystem. “The ecosystem concept typically considers human activities as external disturbances . . . *Homo sapiens* is the only important species that is considered external from its ecosystem, deriving goods and services rather than participating in ecosystem dynamics.” (O’Neill 2001)
- There are pathogens and therefore “bad guys” in the microbiome but “there are no bad guys in ecosystems,” where that all that is “natural” is right (Juengst 2009).

An Aristotelian approach to conceptualizing the microbiome

Start with the four causes:

- Material Cause - chemical composition
- Formal Cause - arrangement or design
- Efficient Cause – what makes the thing or some property of it occur
- Final Cause - purpose or end



Material Cause of the human body

Element	Percent by mass	Atomic percent (calc.)
Oxygen	65	25.6
Carbon	18	9.5
Hydrogen	10	63
Nitrogen	3	1.3
Calcium	1.5	0.24
Phosphorus	1.2	0.24
Potassium	0.2	0.03
Sulfur	0.2	0.04
Chlorine	0.2	0.04
Sodium	0.1	0.03
Magnesium	0.05	0.01
Iron	3.8g in men, 2.3g in women	
Cobalt, Copper, Zinc, Iodine	< 0.05 each	
Selenium, Fluorine	< 0.01 each	

- (from Chang, Raymond (2007). *Chemistry, Ninth Edition*. McGraw-Hill. pp. p. 52.

Efficient or Formal Causality?

Microbiome research may emphasize the search for efficient or for formal causes --

Efficient cause: the way specific microbial differences correlate with differences in health; the attempt to understand the etiology of microbiome-related disease.

Formal cause: the design or integrated structure of a microbiome as a "system" or "community" and the attempt to discover the rules that govern it.

(Final cause -- the purpose or *telos* of the human individual -- is generally thought to be something the individual chooses for him or herself.)

Conclusion

- If microbiome research concerns efficient causes – if it studies case-by-case the etiology of relevant diseases – it may develop conceptions of microbial communities or systems that could inform ecology.
- If microbiome research concerns formal causality – if it seeks to describe a microbiome as an integrated, organized “community” or “system” -- it will get no help from ecological science, where these ideas remain puzzling, unproven, and controversial.
- Even if the human being is not part of the natural ecosystem, the natural ecosystem may be part of the human being. If so, microbiome research – more than ecology – will clarify ecological concepts.

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