"Towards an Account of Individuality: The Case of Microbial Consortia"

We explore the notion of individuality using recent work in microbiology concerning microbial consortia. Such consortia seem at first glance to form integrated individuals. They maintain integrity with impressive fidelity across generations. However, they put a strain on accounts of biological individuality. We suggest that the nature of microbial consortia should cause us to revaluate the notions of replicator and interactor, notions that serve as the basis for prominent accounts of biological individuality. We argue for a more inclusive account of individuality that focuses on individuals being interactors.

The two examples of microbial consortia that we focus on are symbiotic consortia of organisms that work together to produce a result that would not be achieved if the organisms worked separately. One example is of two phylogenetically distinct lineages of organisms (*E. daidaleos* and *Chlorella* algae) that work together to produce an aerobic environment in anoxic water. The other example is core human gut consortia. Such consortia consist of multiple organisms that are introduced into a consortium throughout the life of a human. Each of these types of consortia are themselves replicated but they are not themselves replicators. In the first case, consortia consisting of *E. daidaleos* and *Chlorella* algae are replicated because the two lines of lineages are replicated. Yet there is fidelity in the reoccurrence of such a symbiotic relation, particularly in the outcome they are able to achieve together –turning toxic water into non-toxic water. In the second case, human gut consortia are replicated but they are not replicators. Furthermore, their replication is complicated by the fact that the parts of such consortia are introduced throughout the life of a human (when the human is a fetus, a baby, and an adult). In other words, a human gut consortium gains parts from its external environment throughout its existence. Nevertheless, the gut consortium maintains an impressive causal integrity throughout its life. And that integrity, the role the consortia plays in the digestion and health of humans, is replicated again and again in different humans.

The lessons learned from these two examples concerning the concept of individuality are twofold. First, the idea that an individual needs to be the entity that replicates itself should be abandoned. Biological individuals need to be replicated for natural selection to occur. But that

replication can be due to the replicating actions of an individual's parts or due to processes external to that individual. Philosophers of biology sometimes refer to the second type of replication as 'scaffolding.' Fidelity in replication is what is important for being a biological individual, not being a replicator. Second, the emphasis in the suggested account of individuality is the interaction of an individual's parts. Does the putative individual produce an outcome that is due to the interaction of its parts rather than the aggregate causal contribution of its parts? If yes, then it is an individual. If not, then it is not an individual. The challenge, though, is to make this intuitive idea more precise. We do so by employing Reichenbach's notion of screening-off. For a given outcome, the interaction of an individual's parts screens off the aggregated causal contribution of those parts. In other words, the interaction of the parts screens off the separate causal contributions of the parts; and, it screens off the aggregated causal contribution of the parts. That later is important in distinguishing instances of causal interaction from instances of separate but aggregated causal contributions. To further distinguish instances of causal interaction from aggregate causal contributions we employ Reichenbach's notion of mark transmission: the interaction between the parts of an individual transmit a mark; the different causal processes of non-interacting components do not transmit a mark. In Wesley Salmon's terminology: individuals are causal processes, aggregates are pseudo-processes.

Stepping back from these details, we think that the case of microbial consortia and the account of individuality being developed bear on prominent accounts of biological individuality in the following ways. Hull suggests that individuals in natural selection (the units of selection) are those entities that interact with the environment and differentially replicate. More recently, Godfrey-Smith characterizes biological individuals as those entities that reproduce and contain heritable traits that vary in fitness. The case of microbial consortia shows that the individuals of biology that are replicated can be distinct from what replicates them. What is important for biological individuality is that individuals be replicated not that they are replicators. The more salient element of being an individual is being an interactor. For Godfrey-Smith, microbial consortia are marginal individuals. The framework for interactor we suggest shows that such consortia are individuals. Though our account of individuality does not radically depart from Hull's and Godfrey-Smith's, it offers a more inclusive and we think a more precise framework for determining individuality.

The account of individuality we develop focuses on biological individuality. But we think it can be applied to individuals outside of biology as well. The requirement that biological individuals are replicated is based on a conception of individuality needed for natural selection to occur. If we drop that requirement, the account of individuality based on the notion of interactor suggested here extends well beyond biology.

(854 words)