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Biological Parts

Marie I. Kaiser

The view that the living world is divided into part-whole hierarchies can already be found in ancient philosophy (cf. Aristoteles' *De partibus animalium*) and it is deeply embedded in the biological sciences. Biologists represent objects as being constituted of a certain collection of organized parts. For example, cells are said to consist of a cell membrane that surrounds the cytoplasm that contains various organelles. Assumptions about part-whole relations are involved in classifications of biological objects into kinds (e.g., the assumption that fish have gills, whereas mammals have lungs). Furthermore, the methodological principle that one can understand the behavior of a biological object by decomposing it into its parts remains important for generating knowledge in the biological sciences (Bechtel/Richardson 2010).

Despite this ubiquity and importance of part-whole relations to biology, the philosophical question of what it means for an object *X* to be a *biological part* of another object *Y* is still disputed. Does biological parthood require only mereological parthood? Does it require that *X* is spatiotemporal part of *Y* (and how can this be specified)? Is one biological "whole" demarcated from another by the many and intense causal interactions among its parts? Must the behavior, activity, or operation of a part in a certain sense be relevant to the behavior or functioning of a whole?

An understanding of the conditions under which something is a biological part of some "whole" is relevant to the biological sciences since it might help to solve problematic cases: for example, when does a vesicle that is transported in a eukaryotic cell become a part of the Golgi apparatus? Is the case that is attached to the Caddisfly larva and that protects it against predators a part of the larva or does it belong to the larva's environment? How can the parts of the human genome be identified?

Philosophers have gone different ways in answering the question of biological parthood. Some try to develop a *monistic account*, that is, they seek to identify a single criterion or list of criteria that is universally applicable to all biological fields and that provides us with clear answers. Others adopt a *pluralistic position* and claim that in biological practice different "theoretical perspectives" (Wimsatt 2007, pp182) or "partitioning frames" (Winther 2006, pp475) can be found, which imply different criteria for individuating biological parts, and thus generate different decompositions. Some pluralists go even so far and argue that different decompositions of the same biological system often are not coincident and cannot be integrated into a single picture of what the system's parts are.

One way of seeking a monistic conception of biological parthood is to consult mereology. However, it quickly becomes clear that classical extensional mereology is insufficient to provide a criterion for *biological* parthood in particular (rather than for parthood in general). To see why, suppose you cut an earthworm with a scalpel into, let's say, five slices of arbitrary length. According to mereology, these slices count as "proper parts" (e.g., Simons 1987) of the earthworm since the relation between slices and earthworm satisfies the mereological principles of antisymmetry, irreflexivity, and transitivity. The same holds for the body wall or the nervous system of the earthworm. But even though the slices, the body wall, and the nervous system all are mereological parts of the earthworm, only the latter two are *biological* parts. The reason is that the body wall and the nervous system, but not the slices are things whose behaviors and properties biologists seek to explain and that are object of biological reasoning, prediction, and intervention.

Among those philosophers of biology who seek a monistic approach to biological parthood three major criteria are discussed: spatiotemporal inclusion, intensity of interactions, and causal relevance. Biological parts are frequently assumed to be *spatiotemporal parts* (e.g., Craver 2007, Leuridan 2012). But so far it has not been sufficiently analyzed what the requirements of spatial and temporal inclusion amount to (cf. Kaiser 2015, Chapter V).

Spatial inclusion seems to require the independent identification of a spatial boundary inside of which the parts must be located. Temporal inclusion is only possible if the relata of the parthood relation are not only continuants such as objects but temporally extended occurrents such as processes, states, or events.

Proponents of the *interactionist account* of biological parthood (e.g. Simon 1962; McShea 2000) argue that a set of parts can be picked out as a "whole" because the parts of the whole interact more frequently and more intensively with each other than with objects in the environment. In other words, the intensity and bandwidth of causal interactions is assumed to be the criterion for identifying part-whole relations (in biology and in other areas). Gillett (2013) holds a view that seems to combine the notion of a spatiotemporal part and the interactionist approach. His main thesis is that an individual object X is a biological part of an individual object Y iff X "is a member of a spatiotemporally related team of individuals *many* of whose members bear powerful *and/or productive* relations to each other" (2013, pp321).

Already van Inwagen (1990, pp81) has argued that biological parthood essentially involves *causation*. In the same spirit for instance Mellor characterizes biological parts as "working parts" (2008, pp68) and claims that parts must have significantly large effects on the properties of the whole. Even though both accounts refer to causal relations (or interactions) this view clearly differs from the interactionist account as it requires the behavior, activities, or operations of biological parts to be *causally relevant* to the behavior of functioning of the "whole". This holistic aspect, the reference to a behaving whole is missing in the interactionist account. Note that the assumption that causal relevance is the proper parthood criterion need not have the controversial implication that part-whole relations are a special kind of causal relations. Additional assumptions or additional criteria of biological parthood (such as the spatiotemporal inclusion criterion) can prevent this implication as they violate conditions that are said to be characteristic for causal relations (e.g. asymmetry, asimultaneity, independence). Craver avoids confounding part-whole and causal relations for instance by specifying the causal relevance criterion as “mutually manipulability” (2007, 141), which is a symmetrical relation between the parts of a mechanism and the behavior of the mechanism as a whole.[1]

Further Readings

Craver, C. F., 2007, *Explaining the Brain.* Mechanisms and the Mosaic Unity of Neuroscience, Oxford: Oxford University Press; Chapter 4.8 contains an interesting discussion of the problems of the intensity-of-interaction approach and introduces Craver’s own account of constitutive relevance.

Gillett, C., 2013, “Constitution, and Multiple Constitution, in the Sciences: Using the Neuron to Construct a Starting Framework”, *Minds and Machines* 23 (3): 309-337; the most recent attempt to specify the causal criterion for biological parthood.

Jansen, Ludger/ Schulz, Stefan (2014): “Crisp Islands in Vague Seas: Cases of Determinate Parthood Relations in Biological Objects”, in: Calosi, C./ Graziani, P. (eds.): *Mereology in the Sciences. Parts and Wholes in Contemporary Scientific Contexts*. Cham: Springer, 163-188; a very interesting attempt to bring together mereological considerations with the diversity of part-whole claims that are made in biological practice.

Winther, R. G., 2006, “Parts and theories in compositional biology”, in: *Biology and Philosophy* 21: 471-199; illustrates the importance of the concept of a part in the biological science.

Short Bibliography

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[1] Mutual manipulability means that a change in the behavior of the mechanism as a whole leads to a change on the levels of the parts and a change of the behavior of a part leads to a change in the behavior of the mechanism as a whole.

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