The Classical Holism-Reductionism Debate in Ecology

Introduction

Controversies between holism and reductionism are a familiar feature in many fields of inquiry besides ecology. Although seldom described in these terms[1], the issue has long played – and continues to play – a significant role in science, philosophy and political ideology; indeed, one could almost say that it has always existed. It played a major part, for example, in shaping the ideological conflicts between conservatism and liberalism in the nineteenth and twentieth centuries. Holistic ideas were present especially in "Lebensphilosophie" (philosophy of life) and in other philosophies critical of science, such as historicism, that shaped the zeitgeist at the time of ecology's emergence. Towards the end of the twentieth century, holism became a significant force in "political ecology". This is true not only of those strands of political ecology and related fields that are explicitly committed to the task of "renewing" the world view of their time, such as "Deep Ecology" (Naess 1973; Drengson and Inoue 1995) and the "New Age Movement" (Capra 1982); rather, the view of nature within all political ecology is essentially a holistic one. However, a range of conceptual figures associated with holism can be found in many older philosophies as well. The macro-microcosm figure, for example, appears as far back as Plato (cf. Schwarz 2003) and came to exert influence within modernity mainly through the world view that underlies Leibnizian rationalism (cf. Eisel 1991; Langthaler 1992). Nowadays research programmes in most of the natural sciences are shaped by reductionist ideas; they are linked primarily to neo-positivist philosophies and can be traced back to older empiricist philosophies, as well as to Cartesian rationalism.

The holism-reductionism debate in ecology can be properly understood only against this non-scientific backdrop, because what is at issue in ecology is more than just whether scientific theories of a certain type provide a correct description of certain natural phenomena. What these philosophical and political-ideological controversies demonstrate above all is that the issue is of relevance in areas that lie well beyond the confines of the discipline itself. It therefore appears justifiable to us to analyse a wide range of debates on the basis of the holism-reductionism complex, including those that are not explicitly about it at all.[2] The significance of the complex is by no means exhausted in the impact it has on ecology or on understandings of ecology.

The holism-reductionism controversy in ecology is all about the relationship between wholes and their parts. This is a major problem in many sciences – in physiology (the organism), geography (the landscape), psychology (the soul) and sociology (society), as well as in physics, linguistics and epistemology. However, the debate in ecology is of particular interest when it comes to understanding the way holistic and reductionist ideas about nature and society work in the context of political-ideological controversies. The ecological debate has one thing in particular in common with a very few sciences (with sociology above all, though not with other natural sciences), something that links it very closely to those ideological struggles, and that is this: ecology is one of those sciences whose objects of inquiry are constituted in such a

way that the parts are usually individuals and the whole a community. The contrast between reductionism and holism in ecology tends to take the form of an opposition between individualism and organicism. In turn, individualism, as a form of reductionism, is holistic in the sense that while individuals are thought of as wholes (as organisms), a community is not. "Community", according to individualism, is merely a name for a certain number of individuals, gathered together more or less at random by the scientist, who are considered to be "autonomous" and who alone are seen as being real. In organicism, by contrast, "community" is conceived of as an organic community or as a superorganism, in other words, the relationship between the part and the whole is conceptualised in analogy to the relationship between organ and organism. – Whenever organicism or the "organismic concept" is mentioned in ecology, the reference is to something different from what, in biological terms, is commonly called the "organismic approach" or "organismic biology". The idea entailed by the former is that a "Lebensgemeinschaft" (biotic community) is of the same character as an individual organism; in the latter, importance is generally attached instead to the level of the *individual organism*, the point here being to counter the tendency to focus solely on the molecular level.

In the following we shall refer to only a few of the many variants of the holism-reductionism debate in ecology and to certain stages of their transformation. Our main concern is to reconstruct the *logic* of the debate and to determine the *conceptual structures* on which it is based. Given that the positions adopted address a problem that not only exists within science but is above all of a fundamental philosophical nature, we can interpret the actual emergence of such positions and their transformation in ecology in the following way. There are certain ways of conceptualising the relationship between parts and wholes, or between individuals and community – there is not an indefinite number of variants of these conceptual figures. What we are interested in are the conditions in which certain combinations of their elements and certain transformations in their structure are possible; above all, we are interested in the practical and ideological implications of these conceptual figures. We do not intend to present every single "important" theory that has ever made an appearance in the history of ecology; instead, our aim is to construct ideal types. These enable us to present the positions that were actually adopted throughout history and to compare them in a systematic way. Our main criterion for selecting the examples is less that they are considered, for whatever reasons, to be important in ecology – the fact that they have been influential, for example – but rather that they are suitable for explicating the ideal type constructions.

Numerous potential variants of holism and reductionism exist and can be found in biology. We mention this briefly at the start. The main point here is that the spectrum of potential variants is by no means exhausted by organicism and individualism. Then, we present reconstructions of ideal types of each in its classical form as they emerged during the first few decades of the twentieth century, using examples by way of illustration. Since the dispute between them cannot be resolved empirically, we inquire as to whether this might be possible at the methodological level. It proves to be difficult at this level as well. We choose an approach based on a theory of constitution, [3]which

enables us to regard both holism and reductionism as being "inspired" by certain world views. On this basis it becomes easier to understand the utterly different practical consequences entailed by holistic ecological theories on the one hand and reductionist theories on the other. We conclude with an example that describes the dynamic through which both approaches (usually in response to one another) change.

Variants of Holism and Reductionism

The literature refers to holism and reductionism in many very different ways.[4] In the following we take a few examples and explain briefly how they work conceptually on the basis of what is common to all forms of holism and reductionism. Our examples are restricted to those variants that play a role in biology, so they are about explaining "life".

It is probably true to say that what links all those things together that are referred to as holism is not much more than the principle that the "whole" has "priority" over the "parts" – whatever "priority" might mean exactly – and a set of reservations about any form of "simplification". On the reductionist side, the commonality between different positions probably consists above all in their emphasising that statements about phenomena of a complex nature should be derived from statements about phenomena of a simpler nature, and that science essentially consists in this kind of "reduction".

Different forms of holism and reductionism also come about depending on the aspects of the research object (or of the scientist's relationship to that object) to which these principles are applied. In other words, it is not only certain methods or research programmes that can be called holistic or reductionist, but also certain views about the "nature" of their objects. This means that whether a certain position appears to be holistic or not depends on the perspective taken. We shall discuss here just a few of the numerous permutations possible: "wholeness" can be taken to mean a variety of very different things (2.1); "simplification" can mean very different things (2.2); the assertion that something is reductionistic or holistic may be a reference – among other things – to the nature of reality or to how we should proceed in order to find something out about it (2.3).[5]

Aspects of the Concept of "Wholeness"

Those methods and theories that are termed holistic differ greatly according to which aspect of the concept of wholeness they highlight. In biology, such aspects include totality, gestalt, uniqueness, system character and "Lebendigkeit" (aliveness) – although often many of these aspects cannot be separated from one another.

In the case of "aliveness", the choice to focus on one or the other aspect has far-reaching methodological consequences. For example, the whole can be identified as an "inner essence" (e.g. "soul"); one point of access to this wholeness can be seen as being that the relationship between the inside, which remains hidden, and the outside, which is perceived, is one of the latter giving expression to the former. It then becomes possible to draw on methodologies from the human sciences whose aim is to "understand" this inner essence through its representation in the external world. External forms are largely understood in terms of a gestalt. Even if every view of the whole as a gestalt does not imply such a relationship of representation, this is

nonetheless very often the case. Examples include work by Portmann (e.g. 1948) and Troll (e.g. Wolf and Troll 1940; Troll 1941), who refer to the morphology of individual organisms. But even in relation to objects such as vegetation there are "physiognomic" approaches that correspond to this model. Of particular significance, historically speaking, is Grisebach's (1838) concept of formation, whose relationship to Humboldt's "Physiognomics of Plant Life" (Humboldt 1806) clearly places its origins in an approach based firmly on "Ausdrucksverstehen" (cf. Trepl 1987, pp. 103 ff.). The *gestalt* aspects of this are usually linked to other aspects of wholeness, such as the organic interaction of parts. Holistic positions of this kind refuse to conform – sometimes avowedly so – to scientific demands, insofar as they counter the latter with a "vivid and clear idea", [6] a holistic "Naturschau" (contemplation of nature, Thienemann 1954, p. 322) or a "contemplative look at nature of a morphological kind"[7] and declare these to be the goal of biology.[8]

Despite having what is, in principle, a similar conception of inner essence as a wholeness, others claim not to depart at all from the scientific methodological ideal. In neovitalism, for example, the specificity of life was seen in it being characterized by a "life force" (entelechy). This is not regarded as a physical force and certainly not one that can be measured scientifically; instead, it is seen as being a living, soul-like force, which is gestalt-forming and therefore holistic. Despite this, entelechy (known as "Factor E") is claimed to be "empirically real".[9] Vitalism has been accused of being dualistic by authors who have been described as holists in the history of biology (e.g. Bertalanffy, Haldane). Vitalism, they say, sees in the living organism only a sum of so many parts that are complemented and monitored by a kind of soul in the role of engineer, rather than seeing the essence of life in the interactive structure of the whole (Bertalanffy 1949, p. 30). It is this, namely, the organic interaction of the parts, that constitutes the holistic element in life. In this view, *biological* holism – that is, what was explicitly known as holism in the history of biology and in philosophies related to biology, as well as in systems theories with a holistic orientation in the tradition of Bertalanffy – is given when the key element of life is *not* seen to lie in an inner force inaccessible to scientific methods. Biological holism consists, instead, in the view that the characteristic of being alive can only be attributed to objects that are a whole, and that this whole exists in a special relationship to its parts that is not found in non-living objects. These wholes, so the theory goes, require an approach of their own that is different from that of physics. To the extent that holistic theories divide reality into different levels or autonomous wholes to which different scientific methods have to be applied respectively, they can be called pluralistic.

Different Kinds of Reduction

Reductionism is used to refer to a situation in which, during the course of development of a science, a requirement is made of all its theories that they should be based on the theories of a basic science. In biology, reduction is understood principally in terms of tracing back something that is living to something that is not living by means of a physical-chemical explanation of specific metabolic processes, for example. Reductionism essentially coincides with what is often called "mechanicism" (or "mechanism") or else "physicalism".[10]

Two forms need to be distinguished here in particular:

1. Some hold the view that the whole needs to be explained by acquiring knowledge about its *parts* (a "bottom up" approach). However, reduction is deemed to have been successful only when these parts have been reduced to certain "things", namely "fundamental units" ("atomistic" reductionism). These fundamental units are *not alive*; in other words, this form of reductionism assumes that even if the whole is an organism, there is always a subordinate level in the hierarchy (in the sense of a "nested hierarchy") at which the parts can no longer be considered to be living (subcellular level, molecular level). However, by conducting research on these, it is possible to obtain full knowledge of the whole, the living organism. Examples are superfluous here, as this approach constitutes the mainstream in biology. Indeed it was this form of reductionism, known as "mechanism" (cf. e.g. Roux 1895; Loeb 1916), which was discussed most among biologists during the period when ecology was emerging: the phenomena that could be observed in organisms could ultimately be explained causally at the molecular level. Both Darwinism and neo-Darwinism were also described in terms of mechanistic reductionism. In this case, however, the individual organism is not reduced to the molecular level; instead, in its mechanistic explanations of evolution, Darwinism always presupposes the organism as a whole. Events occurring at the molecular level only become relevant in terms of evolutionary biology when they are viewed in relation to the organism (e.g. as a contribution to its fitness). Evolution is explained mechanically on the basis of interactions between organisms[11] and of those between organisms and their abiotic environment.

2. It is also possible to undertake a physical-chemical reduction quite independently of the issue of levels in a "nested hierarchy". One example of such a reduction is the "physicalisation" of the organism, for example by looking at blood circulation as a hydraulic system (Harvey in the seventeenth century). Unlike reduction to the molecular level, the whole here is reduced primarily not to its parts but to processes or characteristics of *all* its parts (e.g. flow speed). Measuring these is seen as a way of comprehending the whole. Parts of the system are addressed from a common *functional* perspective, where the function often lies in contributing towards maintaining particular processes. It is thus possible for an extreme form of reductionism to appear, from a different perspective, to be holism[12] insofar, for example, as everything about an object is expressed in energetic terms.

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[1] The term "reductionism", for example, became common only in the middle of the twentieth century, even though it covers older philosophical problems, which previously came under the rubric of "materialism" or "mechanism", and the methodology of specific sciences (cf. Stöckler 1992).

[2] Cf. Trepl (1994) and the critical response by Levins and Lewontin (1994).

[3] Constitution here is understood differently from the sense common in philosophy, that is, the way Kant, for example, used it. Instead, it refers to the idea that scientific theories are not simply generalised depictions of specific empirical observations but that they owe their existence to non-scientific conceptual structures already in existence. Thus, we can speak here of a "l´a priorí historique" (historical apriori) (Foucault 1969), of "bereitliegenden kulturellen Deutungsmustern" (cultural patterns of interpretation that are already available) or of "Konstitutionsideen" (ideas of constitution) (Eisel 2002, p. 130), which are the conditions of possibility – realized through culture – for scientific concepts and for their corresponding objective experiences. Indeed it is these

conditions which ensure that new facts do not destroy the old conceptions in general but consistently confirm the theory (or the paradigm) (Eisel 2002; cf. Kuhn 1962).

[4] Some examples of literature that takes this issue further include: (science in general) Nagel 1949, 1961; Bueno 1990; Agazzi 1991; (biology) Ayala 1974; Ayala and Dobzhansky 1974; Ruse 1973; Hull and Ruse 1998; Bock and Goode 1998; Looijen 2000; (ecology specifically) Saarinen 1982; Bergandi 1995; Bergandi and Blandin 1998; Keller and Golley 2000; Kirchhoff 2007; Voigt 2009.

[5] Other levels in addition to the ontological and methodological would be the epistemological level ("Erkenntnistheorie"), which is about the validity of knowledge, and the level of theory of science in the narrow sense ("Wissenschaftstheorie im engeren Sinne"), which is about the character of the empirical phenomenon of science. One might also add a level of theory of constitution, at which the independence of the ontological and the epistemological level disappears. One could, for example, describe the theory of Thomas Kuhn as on the level of theory of science holism in the narrower sense mentioned. Coherence theories of truth (e.g. the Duhem-Quine theory) might be called epistemological holism (cf. e.g. Oppenheim and Putnam 1958; Ayala 1974; Putnam 1987).

[6] "bildhafte, anschauliche Vorstellung" (Friederichs 1957, p. 120, cf. also 1937).

[7] "anschauende Naturbetrachtung morphologischer Art" (Thienemann 1954, p. 317).

[8] Cf. on biology as a whole: Köchy 1997, 2003; cf. on ecology: Trepl 1987; Jax 1998, 2002.

[9] "empirisch wirklich" (Driesch 1935, p. 75, cf. also Mocek 1974, 1998).

[10] The accusation of reductionism means that the simplification is carried out in such a way that it leads precisely to not explaining, or explaining wrongly, the matter to be explained, such as a living organism.

[11] The fact that in the context of Darwinism other levels – the individual gene or the population – are shifted to centre stage changes nothing of this fundamentally organism-centred structure of Darwinism. Even if individual genes are taken as a starting point, they nonetheless "want" something, as "selfish" genes (Dawkins 1976) and are not simply chemical-physical phenomena.

[12] "The thermodynamic approach is particularly well fitted as a tool to describe ecosystems from a holistic point of view because it is based on the macroscopic flows of energy and mass" (Jørgensen 2000, p. 113).