

symmetry, and tested any embryo with this distinction explicitly in mind, except perhaps the cytoplasm scrambling experiments of Evsikov, Morozova & Solomko (1990). This may be because of the generally loose use of the word 'symmetry' in biology, as contrasted with its rigorous definition in crystallography and group theory (MacGillavry, 1965; Shubnikov & Koptsik, 1974). Thus, there has been a general lack of interest in such questions as:

"How did the cylindrical shape arise in the evolution of each species and in the development of individuals? This question really asks two historical questions in two very different time scales and opens the door for mechanical thinking in the areas of paleontology and developmental biology" (Wainwright, 1988).

#### **1.04 Wholeness through the Ruse of Organicism**

"What as yet, unfortunately, we know practically nothing about, is the arrangement and nature of organising relations above the molecular level. Until we can form some conception of the nature of these relations little progress will be possible in our understanding of how they come into being, and embryology will never become an exact science until embryologists take organisation seriously. For embryos are not made like plum-puddings, by a haphazard congregation of ingredients" (Needham, 1931b).

Physical explanations of Driesch's mysterious entelechy were made early on although they did not seem to divert him from his vitalist course:

"The well-known biologist Thomas H. Morgan (1909a) reviewed Driesch's [1908a] published lectures [cf. Driesch, 1929].... Taking issue particularly with Driesch's antimechanist views in biology, he too attacked their poor experimental basis and additionally presented some disproving evidence from the field of crystallography [cf. Whitman, 1888]. Here recent tests on fluid crystals had shown that 'there do exist machines of which any part can reproduce the whole form.' Although his long familiarity not only with Driesch's works but also with Driesch himself [cf. Driesch & Morgan, 1895a,b; Allen, 1978] apparently softened the tone of his criticism, he eventually concluded that 'the attempt to treat the entelechy as something apart from and yet controlling the material basis will seem to most readers, we fear, to come perilously close to mysticism'" (Freyhofer, 1987).

Haraway (1976) suggests that most embryologists in the 1930s made a switch to another paradigm (Kuhn, 1970), 'nonvitalist organicism':

"Theories of tropisms, physiology, biochemistry, developmental mechanics - all illustrate both the triumphs of work conducted under the mechanistic program and the strains leading to the new paradigm. The major long-standing dualities in biology - structure  $\leftrightarrow$  function, epigenesis  $\leftrightarrow$  preformation, form  $\leftrightarrow$  process - have all been reformulated as a result of the crisis.... The controversy that demonstrated most clearly the inadequacy of the simple machine analogy for biology centered around problems of determination and regulation in the embryo.... The sea urchin eggs of Driesch had done what a good machine should not: they had regulated themselves to form wholes from parts.... The machine paradigm had failed Driesch, but rather than abandon it, he resurrected the mechanic. His logic was impeccable, and until 1930 the embryological world occupied itself with trying to exorcise Driesch's demon. However, no spell was entirely effective until the concepts of regulation and of whole could be dealt with outside the machine paradigm. And perhaps this is the major contribution of the new organicism to embryology" (Haraway, 1976).

What is organicism? Here's the closest I found to a definition, a sort of scientific agnosticism:

"The old struggle between Vitalism and Mechanism has lost much of its acuteness. It has been recognized that it is unnecessary to decide *a priori* if the intimate processes of life are or are not resolvable in terms of our actual physical and chemical knowledge. The problems posed by early development have been faced with a complete spirit of objectivity, a philosophical climate which may be styled a pragmatic Organicism" (Dalcq, 1938).

Claiming that "the vast majority of biologists... advocate a middle position" between mechanism and vitalism, Gould (1985b) defines what seems to be organicism, without using the word:

"The middle position holds that life, as a result of its structural and functional complexity, cannot be taken apart into chemical constituents and explained in its entirety by physical and chemical laws working at the molecular level. But the middle way denies just as strenuously that this failure of reductionism records any mystical property of life, any special 'spark' that inheres in life alone. Life acquires its own principles from the hierarchical structure of nature. As levels of complexity mount along the hierarchy of atom, molecule, gene, cell, tissue, organism, and population, new properties arise as results of interactions and interconnections emerging at each new level. A higher level cannot be fully explained by taking it apart into

component elements and rendering their properties in the absence of these interactions. Thus, we need new, or 'emergent,' principles to encompass life's complexity; these principles are additional to, and consistent with, the physics and chemistry of atoms and molecules" (Gould, 1985b).

Thus organicism is still very much with us, as a challenge to reductionism:

"The terms 'organismal' and 'organicism' were apparently introduced by Ritter (1919) and are now rather widely used.... Jacob's (1973) concept of the integron is a particularly well-argued endorsement of organismic thinking.

"In contrast to the earlier holistic proposals which usually were more or less vitalistic, the newer ones are strictly materialistic. They stress that the units at higher hierarchical levels are more than the sums of their parts and, hence, that a dissection into parts always leaves an unresolved residue - in other words, that explanatory reduction is unsuccessful. More importantly, they stress the autonomous problems and theories of each level and ultimately the autonomy of biology as a whole. The philosophy of science can no longer afford to ignore the organismic concept of biology as being vitalistic and hence belonging to metaphysics. A philosophy of science restricted to that which can be observed in inanimate objects is deplorably incomplete" (Mayr, 1982).

However, Hein (1971) places the organicists squarely in the vitalist camp, and Waddington (1957) seems to agree:

"...Needham (1936a) and L.J. Henderson (1917)... see organisation as one of the major categories 'which stand beside those of matter and energy'. This seems to imply a renunciation of any attempt to formulate the problems of organisation in terms of anything else but itself. It is surely premature to go so far as this until we are driven to" (Waddington, 1957).

Some critics of organicism went as far as to argue that...

"...Spemann's Nobel Prize should be revoked because organization did not seem to be a specific phenomenon describable in physical and chemical terms..." (Allen, 1975).

I do think that it is perhaps also premature to assume that "...the laws of biology, organismic laws, are primary and are not a specialization of the

laws of physics" (Elsasser, 1962). We are not yet done trying to apply physics to embryos (although this will undoubtedly mean physics beyond that of nineteenth century mechanics, as pointed out by Just, 1939a).

I disagree with the assessment of Elsasser (1975) that...

"...the essential property of organisms... is their *radical inhomogeneity*.... This inhomogeneity seems to resist any description in terms corresponding to a purely mechanistic point of view.... It is utterly obscure how any set of enzymes plus rules for their appearance or cessation could be appropriate by itself to give rise to the morphological pattern of an eye....

"This brings us now to a basic question. *What is the mechanism whereby hereditary transmission of morphological properties is effected?* The answer to this question must of necessity be blunt: Nothing whatever is known about such a mechanism; we have no trace of evidence as to what it would look like or whether it even exists. Now, one might say, such a mechanism not being known at the present time will be discovered in the future. But the situation is far more difficult than such a candid avowal of ignorance would indicate. *There is extensive evidence to the effect that such a mechanism does not exist.... Biology must remain a prescience, unless we introduce a postulate that exhibits a distinction between organisms and machines in formal terms.... The organismic properties, irreducibly intermingled with the mechanistic ones, connect skeletal chemistry with morphology.... Only part of the information is supplied by the mechanistic skeleton, the remainder is maintained or regenerated by the organismic function without continuity of the information in a mechanistic sense "* (Elsasser, 1975).

In contrast to these repeated statements of our inability to explain the basic phenomena of embryogenesis, I prefer to agree with Glaser (1939):

"Back of our morphological tokens, each good for so much visible structure, lies a stretch of development complicated by all the complexities of the cell; 'organ forming substances'; the entire apparatus of genes; and beyond, a world accessible only by the methods of physics and chemistry. Either the processes going on at these levels are the remote precursors of structures and events that follow, or they have no meaning for embryology. In that event the morphologist is concerned only with miracles.... We are now free to renew the offensive initiated long ago by D'Arcy Thompson (1917) toward a general physics of growth" (Glaser, 1939).

I also disagree with Gould's (1985b) concept of 'emergent principles', and will argue that we need new disciplines analogous to statistical mechanics to derive 'emergent' phenomena from those occurring at lower hierarchical levels (Proposition 194).

Organicism, then, seems to have only substituted the word 'organization' for 'entelechy', leaving both unexplained, and thus was in effect a continuation of vitalism. In order to include mechanics, Driesch added what we might be tempted to call a supernatural element to everyday physics to explain morphogenesis, while to avoid Driesch's dilemma, subsequent organicist embryologists extirpated physics itself:

"Vitalism and organicism share basic questions and positions. From a negative point of view, both maintain that the study of the parts does not suffice to explain the behavior of the whole. The methods and conclusions of other sciences, particularly physics and chemistry, are held to be applicable to organisms but radically insufficient.... Biology is an autonomous science, not a postscript to physics" (Haraway, 1976).

### **1.05 The Grip of Vitalism**

Perhaps a less genteel approach to vitalism is warranted, and it is indeed a...

"...dogmatic system, the chief actual representatives of which are the botanist Johannes Reinke [1901, 1911] and the metaphysician Hans Driesch. The vitalist writings of the latter, which are devoid of any grasp of historical development [but cf. Driesch, 1905], have gained a certain vogue through the extraordinary arrogance of their author and the obscurity of his mystic and contradictory speculations" (Haeckel, 1906). [Haeckel may have only been seeing his own faults in others: "Haeckel... was never shaken by doubt. No teaching altered his views" (Rádl, 1930). Nevertheless: "...Haeckel has undeniably contributed more than most; everything of value in his utterances has become permanent, while his blunders have been forgotten, as they deserve" Nordenskiöld, 1928.]

"Driesch and Roux differed greatly in philosophical viewpoints and technical approach, but both had studied with Ernst Haeckel. Driesch's interests were very broad, encompassing mathematics, physics and philosophy. Even as a doctoral candidate, Driesch had questioned the wisdom of his mentors; his work presented a direct challenge to August Weismann as well as to Haeckel and Roux. Eventually relations between Driesch and Haeckel deteriorated