

Directed Evolution Commentary on Wolfgang Schad's *Archäopteryx lithographica – eine Mosaikform?*

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With the publication of the anatomical details of the prehistoric bird *Archaeopteryx* Wolfgang Schad laid in 1980 the foundations of work that eventually led to his dissertation on the transitional forms of the vertebrate groups.

Other researchers had earlier noticed that, in these transitional forms, whereas the axial skeleton of head, vertebral column and trunk points to the ancestors, the limb skeleton points to the future of further evolution – just like in heterochrony which describes differential and distinguishable onsets of developmental impulses and their speeds.

What was new in Schad's work was his successful attempt to describe the 'anomalies' as resulting from the organism itself which integrates the past, present and future into a harmonic whole. The emergence of the human being follows the same pattern. It begins seven million years ago with hominids that walk upright, have a head with a projecting face, and a small skull. In accord with Steiner, Schad concludes that the human being has become human primarily through its limb system.

How are transitional forms explained? In Schad's view, the expression 'mosaic forms' leads into error: neither chance nor teleology can adequately explain the phenomenon. Chance is ruled out by an inner coherent order that permeates all the transitional forms in the entire phylogeny: the conservative axial skeleton and the progressive limb skeleton. Teleology, on the other hand, refers to a principle that implies intentions working from outside, as with a work of art or other artefact.

Other thinkers in the 1980s struck a new path between chance and teleology that attracted a broad following only with the pioneering success of the 'postgenomic' era. Today it has developed into a dynamic research area, namely epigenetics. The embryologist Conrad H. Waddington, who taught in Edinburgh, postulated that in evolution, besides chance genetic mutations, there are directed, contextual changes playing a part (*Waddington* 1975). His thoughts on industrial melanism of the peppered moth (*Biston betularia*), as an example of chance mutation, and on the development of forelimbs in gibbon and pangolin (scaly ant-eater), as examples of directed adaptation, are worth reading to this day. As early as the 1970s the biologists Marion *Lamb* and Eva *Jablonka* had begun researching epigenetic changes, initially in *Drosophila*. In their book *Evolution in Four Dimensions* (2005) they identified four levels at which the appearance of new forms in evolu-

tion takes place. These are the classical chance mutations; the epigenetic, directed modifications of DNA through methylation; changes through the inheritance of behavioural traits (social inheritance); and, finally, changes through symbolic (speech) inheritance in human culture.

Jean Piaget, the Swiss developmental psychologist, argued that the biochemical and genetic apparatus of the human being must show the same plasticity as the cognitive processes (*Piaget 1974*). As the latter are always characterised by imitation and internalisation of experience, this form of inheritance must also exist at the level of biological heredity. Mary Jane West Eberhard triggered a controversy by radically reversing the relationship of phenotype and genotype. It is not the genotype but the phenotype that determines evolutionary novelties, whereas at the level of DNA the novelties merely become fixed (*West-Eberhard 2003*).

Finally, Ernst Haeckel deserves a mention in this context. As an implication of his fundamental biogenetic law he concluded that novelties in the evolution of organisms can only arise at the end of and not at the beginning of ontogenetic development. Before that, development follows the path determined for it by the phylum. Haeckel's argument was for *Steiner* (1899) central for the confirmation of the monist evolutionary theory.

Today nobody doubts that epigenetic changes are inherited and thereby take part in evolutionary processes. This determines not the final goal of evolution but its direction. The original, absolute Lamarckism was 'relativized'. It achieves at the biological level what human beings so greatly value at the soul-spiritual level: in each living being there is a measure of autonomy, a measure of free play, that can lead to higher stages. The direction but not the goal is ensured – is this not also mirrored in the constitution of modern man?

Literatur / References

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