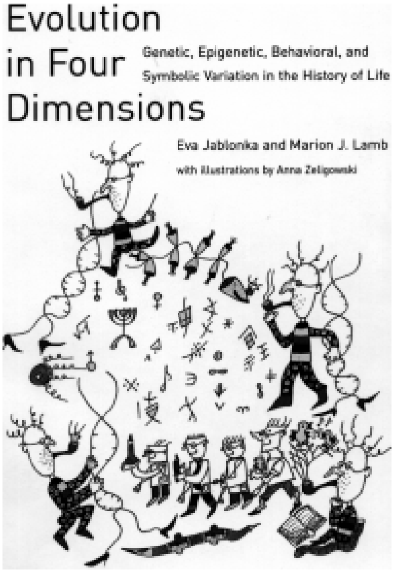
'... Lacks only, alas! the spiritual band.'

Evolution in Four Dimensions - Genetic, Epigenetic, Behavioral and Symbolic Variation in the History of Life by Eva Jablonka and Marion J. Lamb. pub: MIT Press, Cambridge 2005. ISBN 0-262-10107-6. £22.95 (UK)



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The editor of GM Watch (No. 150, www.gmwatch.org) commenting on the BBC TV *Horizon* programme about epigenetics in 2005 wrote: 'It showed a bunch of geneticists catching up with what's been obvious to most of us all along: that environmental factors cause heritable effects in humans'. In fact, epigenetic inheritance systems, i.e. systems for handing down biological changes apart from the genes seen as DNA sequences, first gained wider recognition amongst biologists in the 1970s. While the role of such systems in evolution is not yet universally accepted, Jablonka and Lamb argue a good case for epigenetics being the second dimension in evolution, genes being the first. They describe a number of processes outside the genome that pass on information such as altered expression of genes and particular states of cellular metabolism or structures. Ways in which it could occur at the molecular level include chromatin marking (DNA methylation), prions (proteins that can change shape and pass on the change to others) and interference RNA (gene silencing).

But it is harder to envisage epigenetic inheritance playing a part in organisms where the germ cells (eggs, sperm) are separated at birth from those of the rest of the body, as in animals. Recognition of this fact has allowed several generations of biologists to laugh at Lamarckism. With germline segregation, how could giraffes who stretched their necks more in order to reach more fodder pass on such an advantage to their offspring? But with experiments showing that maternal diet can affect coat colour in subsequent generations of mice of uniform genetic composition, inheritance of acquired characters is clearly possible at the physiological level even with germline segregation.

Less controversial is the inheritance of the two remaining dimensions: behaviour and the use of symbols. Genomic inherited behaviour is instinctive. But much animal behaviour, such as the opening of milk bottles by tits, has to be learned, handed down by a mixture of imitation and trial and error. Clearly something is being behaviourally inherited, as too are the non-instinctive parts of animal 'cultures' and the ecological niches which they occupy.

The fourth dimension, is the use of symbols. 'What makes the human species so different and special [...] is our ability to think and communicate through words and other types of symbols ...'. Language is passed from generation to generation. It is justifiably part of a person's inheritance.

Having identified the three plausible levels of extra-genomic inheritance the authors go on to show that these can have adaptive significance and can therefore contribute to evolution. This supplements genomic evolution which was traditionally seen by neo-Darwinism as *chance* mutation or recombination of genes leading to phenotypes (manifestations of the genes) which are then acted on by natural selection, eventually increasing or decreasing the frequency of particular genes in the population. Now, characters at levels of physiology, morphology, behaviour or language, whether acquired by chance or by some directed process, can not only play a part in evolution but also provide pathways where phenotypes can evolve far more rapidly than genotype alone would allow. The authors are unashamedly Lamarckian, but so, they point out, was Darwin in his section on the 'use and disuse of parts' in *The Origin of the Species*' (Chapter IV, 1st Edition).

How could a Lamarckian evolutionary process be reconciled with the neo-Darwinian? The authors gather several lines of evidence to show that epigenetic and behavioural inheritance can eventually be fixed or assimilated by the first dimension, namely by genetic inheritance. Selected variation, which was at first outside the genome, eventually becomes assimilated by the genome. This is hardest to picture with behaviour until we consider that the speed of learning a behaviour which has survival or mate selection value could be subject to genetic control and therefore be part of neo-Darwinian evolution. Once this is accepted, it is not difficult to extend it to language. Faster learning of language could allow some measure of genetic assimilation which could have adaptive benefits especially in the early stages of hominid evolution.